ICR Treatment Study Summary Report

Pilot-Scale Evaluation of Membranes Processes Information Collection Rule

Conducted from 5/28/98 to 3/1/99

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July, 1999

For:
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Pompano Beach Water Treatment Plant
ICR # 1080

Attachment: 1 Compact Disk containing the Data Collection Spreadsheets

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1.0 Introduction

The Information Collection Rule (ICR) for Public Water Systems (Subpart M or the National Primary Drinking Water Regulations, 141.141(e)) requires public water systems that meet certain applicability criteria to conduct disinfection byproduct (DBP) precursor removal studies. Those utilities that were subject to the ICR study requirements could select to conduct either a granular activated carbon (GAC) study or membrane filtration study. Depending on the population served by the utility, the type of study was either bench-scale or pilot scale. In order to meet ICR requirements, the City of Pompano Beach conducted a membrane pilot-scale from May 1998 to March 1999.

The City of Pompano Beach currently operates a conventional lime softening water treatment plant which provide the City with a production capacity of 40 MGD. The City of Pompano Beach has two wellfields, an Eastern Wellfield (also known as the Airport Wellfield) and the Western Wellfield (also known as the Palm Aire Wellfield). Both wellfields withdraw water from the surficial aquifer system (Biscayne Aquifer) for all of their raw water supply.

The Western Wellfield raw water was the focus of this pilot study as it is the primary raw water supply for the City. The Western Wellfield water has significantly higher concentrations of color, iron, and organics than the Eastern Wellfield.

1.1 Purpose and Scope

This report presents the City of Pompano Beach ICR study and summarizes the results. The main objectives of this report are to:

- Introduce the Pompano Beach Water Treatment Plant process and the raw water quality characteristics;
- Describe the pilot plant used in the City of Pompano Beach membrane pilot study;
- Discuss the analytical methods used in the membrane pilot study;
- Examine the removal of organic matter by the membrane pilot study columns; and
- Examine the effectiveness of membranes to reduce DBPs.

2.0 Background

The City of Pompano Beach is located along Florida's southeast coast, approximately ten minutes north of Ft. Lauderdale. The City operates a conventional lime softening water treatment plants that currently serve a permanent population of over 75,000. The City chose to conduct the required ICR study at the existing Pompano Beach Water Treatment Plant, where all the necessary components (i.e.: raw water, power and control and staff) were located. The City operates two wellfields with very different water quality, and the Pompano Plant can use either wellfield. During the ICR study, the Membrane Pilot was supplied exclusively from the Western Wellfield.

2.1 Raw Water Quality

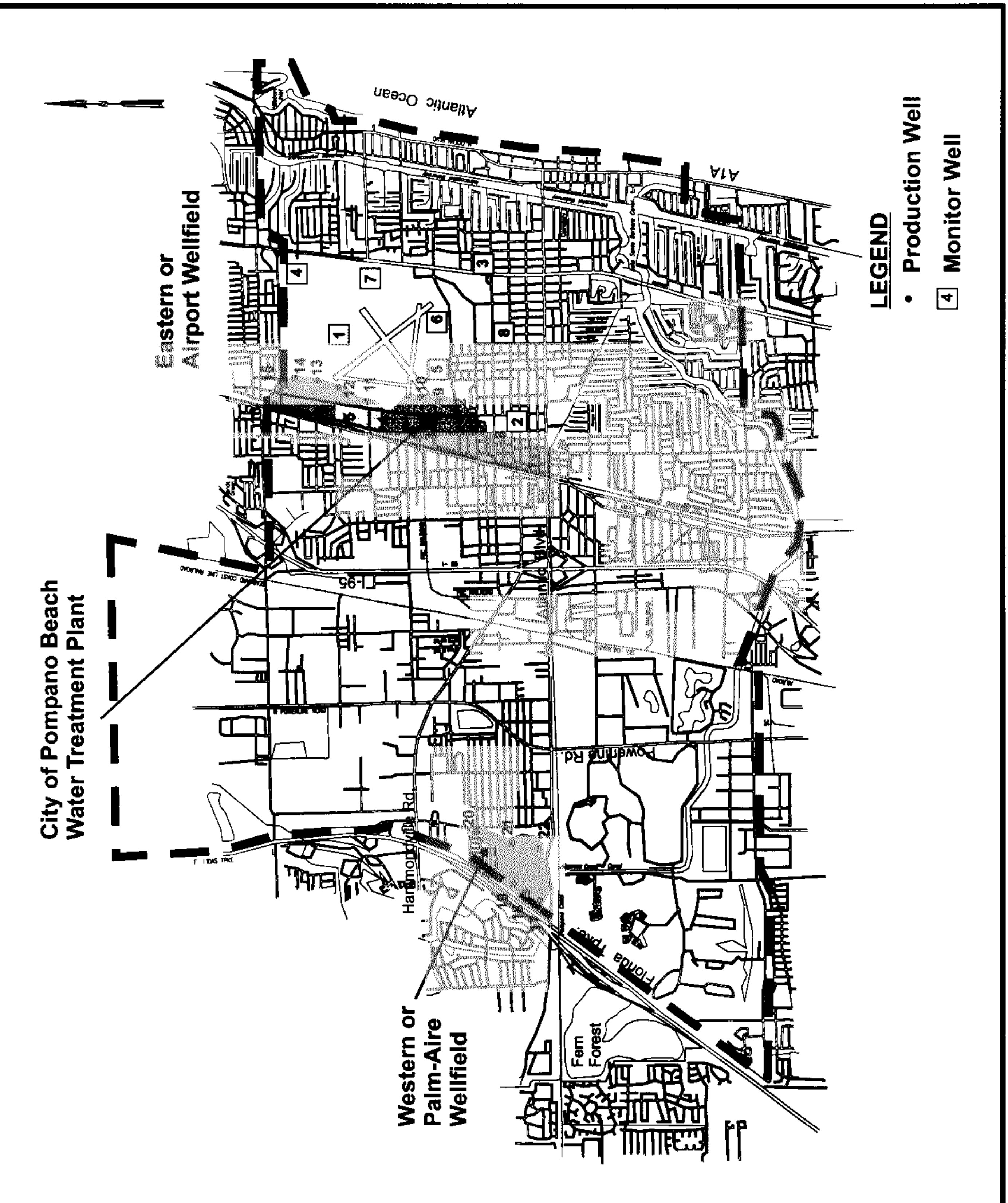
The Western Wellfield is situated east of the Florida Turnpike within the Palm Aire community. This wellfield consists of six production wells (PW-17 through PW-22), and has a total capacity of 18.3 MGD and a firm capacity of 14.8 MGD (assuming the largest well out of service). If the second largest well was out of service, the capacity would be reduced to 11.3 MGD. Figure 2-1 shows the City's general service area and the locations of the production wells for both wellfields.

A list of Western Wellfield raw water quality parameters is shown in Table 2-1. Data shown was collected during calendar year 1998.

Table 2-1 Western Wellfield Raw Water Quality, 1998

	AVERAGE	MIN	MAX	COUNT
pH	7.1	7.0	7.3	365
Temperature (°C)	28.5	28	29.5	365
Turbidity (NTU)	1.9	1.7	2.3	365
Total Hardness (mg/L)	262	255	273	365
Color (SCU)	55	15	75	365
Alkalinity (mg/L)	45	30	67	365
Bromide (ug/L)	0.01	0.005	0.003	12
TOC (mg/L)	27	13	55	12
UV-254 (1/cm)	0.68	0.10	1.32	12
SUVA (L/(mg*m))	3.52	2.98	5.68	12

Footnote: TOL = Total Organic Carbon
UV-254 = Ultraviolet Absorbance 254 nm/(cm^{-1})
SUBA = Specified Ultraviolet Absorbance (L/(mg*m))



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City of Pompano Beach Service Area and Wellfield Locations

HAZEN AND SAWYER
Environmental Engineers & Scientists

FIGURE 2-1

In general, the Western Wellfield is characterized by a neutral pH, low alkalinity, and high color. Total organic carbon content is in the range of 11 to 45 mg/L, with typical UV-254 values of 0.1 to 0.50 cm^{-1}.

2.2 Process Train

The Pompano Beach Water Treatment Plant is a lime softening upflow clairifier treatment process. Design information is shown on the next page, in Table 2-2. Originally built in the early 1960 with a capacity of 12 MGD, the plant was upgraded to 36 MGD in 1983. The upgrade consisted of new upflow clarifier unit, recarbonation basin and eight additional 3.4-MGD filters (based on 3.0 gpm/sf). The original filters were connected to the new process basins and the original process basins, except the existing filters, were abandoned. The upgrade resulted in a total plant rating of 40 MGD, based on a 3 gpm/sf filtration rate. A schematic of the plant is shown on Figure 2-2.

The City of Pompano feeds lime at a dosage range of 170 mg/L to 190 mg/L as a primary chemical at the Pompano Plant. Polymer (Leachem Anionic) is normally dosed at 0.18 mg/L. Water flow rate, chemical dosages, and solids recycle flow to each of the Accelators are estimated and manually controlled by plant staff.

The softened water from the Accelator flows by gravity to the re-carbonation basin where carbon dioxide can be added to reduce the pH (if needed). Currently, pH adjustment is not needed and therefore carbon dioxide is not added. Ammonia and chlorine are also added at the re-carbonation basin to form chloramines for disinfection.

Process water from the re-carbonation basin is then filtered through multimedia filters for the removal of particulate impurities. After filtration, the finished water continues to flow by gravity to the transfer pumping station clearwell. The finished water can then either flow by gravity to the high service pump clearwell or be pumped to the ground storage tanks (two existing five (5) million gallon (MG) tanks). The finished water is then pumped to the distribution system.

The City of Pompano Beach elected to test membranes for the ICR study. Installing the membrane pilot test to treat the raw water from the Western Wellfield is the most feasible treatment process to meet impending regulations.

As shown in the WTP schematic, a sidestream was piped to the membrane pilot plant from the Western Wellfield prior to chemical addition. During the ICR test period, plant production generally ranged from 10 to 20 MGD, with an average flow of 16 MGD. The membrane pilot plant is described in Section 3.

Table 2-2 Pompano Beach WTP Design Data

Rating **Facility**	40 MGD **Pompano Beach Plant**	
Eastern and Western Raw Water Wells Capacity (MGD)	30.3 MGD	
Sedimentation Basins Number	2	
Diameter (ft)	100	
Sidewater Depth (ft)	21.5	
Overflow Rate (gpm/sf)	2.19	
Sludge Removal	Continuous	
Filters	**New Filters (1981)**	**Original Filters (1977)**
Number	8	6
Surface Area (sf)	6,400	4,320
Rate (gpm/sf)	3	2
Backwash Method	Air scour followed	Water backwash with
	by water wash	surface wash
Media Depth		
Anthracite (in)	36	12
Sand (in)	12	15
Gravel (in)	12	12
Finished Water Storage Type	Unbaffled Aboveground Tank	
Number	3	
Total Volume (MG)	14	

2.3 Finished Water Quality

The Pompano Beach Plant has been producing high-quality water since its construction in 1960. A summary of 1998 finished water quality is shown in Table 2-3.

Table 2-3 Pompano Beach WTP Finished Water Quality

	AVERAGE	MIN	MAX	COUNT
pH	8.3	8.0	8.7	364
Temperature (°C)	24.5	23	26	364
Turbidity (NTU)	0.10	0.05	0.75	365
TOC (mg/L)	25	22	35	12
TOC (% Removal)	10	8	15	12
UV-254 (1/cm)	0.10	0.06	0.25	12
SUVA (L/(mg*m))	0.25	0.16	0.35	12
Dist. System THM-4 (ug/L)	100	90	120	4
Dist. System HAA-6 (ug/L)	80	75	90	4

3.0 Materials and Methods

The pilot plant used in the City of Pompano Beach was constructed according to the guidelines in the EPA publication entitled ICR Manual for Bench- and Pilot-Scale Treatment Studies (EPA 814-B-96-003, April 1996). The design and the materials of construction were approved before the study was begun.

3.1 Membrane Pilot Plant Unit

A schematic of the membrane pilot plant is shown below in Figure 3-1. Pilot plant was designed to produce 23,000 gallons per day of permeate flow at recoveries ranging from 80 to 90 percent. The self-contained plant was constructed as a three stage treatment unit. The unit was designed with 4-inch diameter by 40-inch long elements for the first and second stages and 2.5-inch diameter by 40-inch long elements for the third stage. The unit was configured with a 2:1:1 array. As shown in Figure 3-1, sample taps and field mounted instruments were provided throughout the entire pilot unit.

The pilot unit was equipped with Fluid System Corporation thin-film composite membrane elements. The first and second stages were loaded with membrane model numbers 2540 TFCS and the third stage with model number 4921 TFCS.

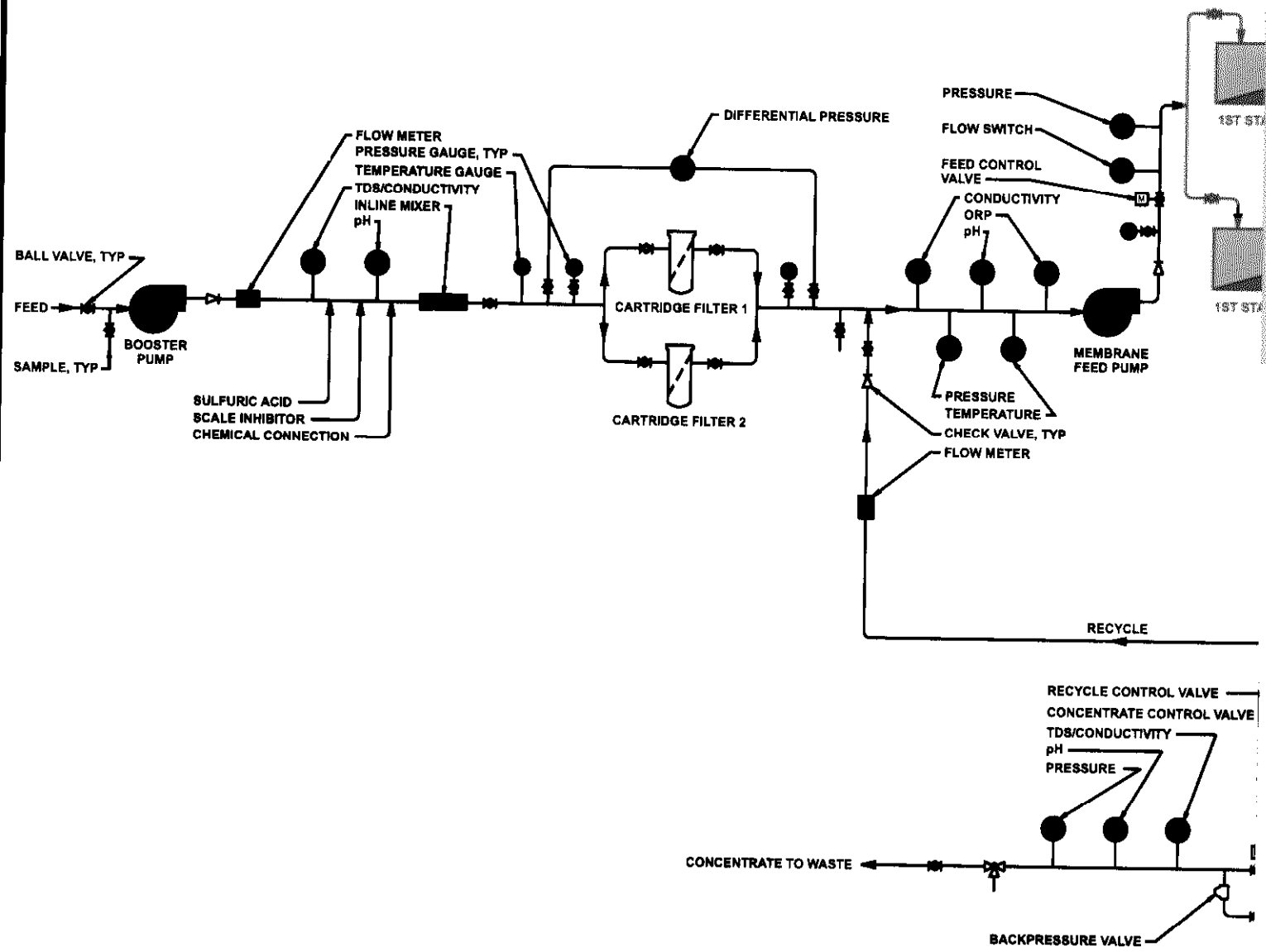
3.2 Pilot Unit Operation

The pilot unit was operated in accordance with the ICR guidance manual. The pilot ran for 6,719 hours, with minimum interruptions for maintenance and high silt density index (SDI) values.

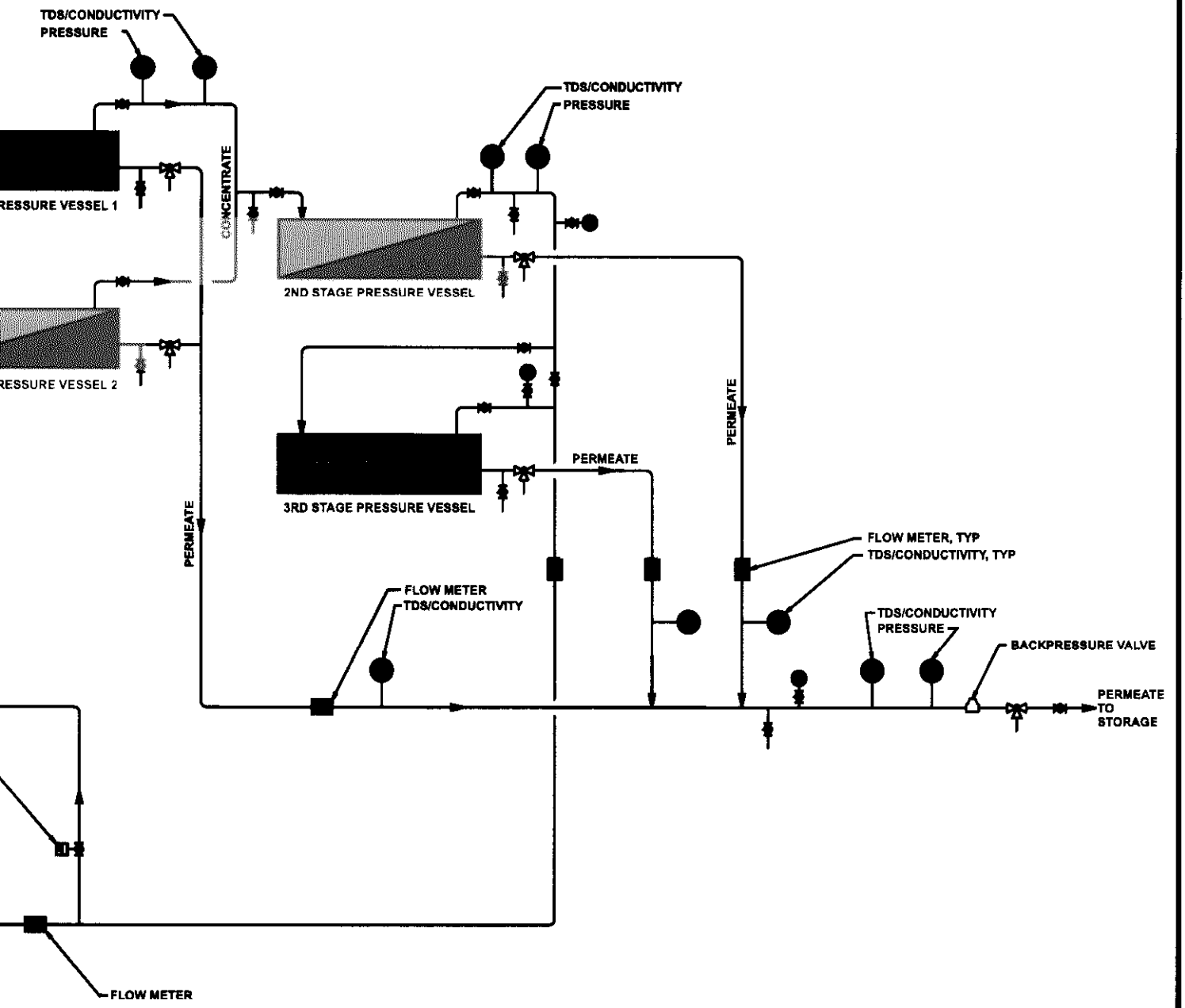
Samples were collected from sample points in accordance with the sampling schedule as described in Section 6.3.5 of the ICR guidance manual. A total of twenty- two (22), bi-weekly sample set were collected over the course the yearlong pilot study. A duplicate sample set was taken every fifth, resulting in four (4) sets of duplicate samples.

3.3 Sample Analysis

At the scheduled intervals, the City of Pompano Beach lab personnel collected samples form the nine (9) sample locations on the membrane pilot unit. The sample bottles were packed in ice, and one was transported to the City of Pompano laboratory, while the other was sent to Spectrum Laboratories, Inc. Table 3-1 shows the analyses each


BALL VALVE, TYP
FEED
SAMPLE, TYP
BOOSTER PUMP
FLOW METER
PRESSURE GAUGE, TYP
TEMPERATURE GAUGE
TDS/CONDUCTIVITY
INLINE MIXER
pH
SULFURIC ACID
SCALE INHIBITOR
CHEMICAL CONNECTION
DIFFERENTIAL PRESSURE
CARTRIDGE FILTER 1
CARTRIDGE FILTER 2
PRESSURE
FLOW SWITCH
FEED CONTROL VALVE
CONDUCTIVITY
ORP
pH
MEMBRANE FEED PUMP
PRESSURE
TEMPERATURE
CHECK VALVE, TYP
FLOW METER
RECYCLE
1ST ST
1ST ST

RECYCLE CONTROL VALVE
CONCENTRATE CONTROL VALVE
TDS/CONDUCTIVITY
pH
PRESSURE
CONCENTRATE TO WASTE
BACKPRESSURE VALVE



City of Pompano Beach Pilot Plant Process Flow Schematic

FIGURE 3-1

laboratory was responsible for. A detailed list of laboratory QA/QC data can be found in the back of this report in Appendix I.

Table 3-1 Laboratories Responsible for ICR Analyses

LABORATORY	ANALYSES
City of Pompano Beach WTP Laboratory Pompano Beach, FL	Alkalinity, Ammonia, Calcium hardness, pH, Temperature, Total Hardness, Turbidity, UV-254, THM4
Spectrun Laboratories Inc. Fort Lauderdale, FL	Bromide, HAA-6, THM4, TOC, Bromide, SDS Setup, including chlorine analyses

The SDS test was conducted at a pH of 8.5, temperature of 24.5 °C, and incubated for 72 hours. Initial raw water samples were dosed with 5.0 mg/L chlorine, and contained a 0.2 to 0.85 mg/L free chlorine residual at the end of incubation. Halfway through the study, the dosage was increased to 8.5 mg/L chlorine, which was closer to the actual plant dosage. Residuals after the increase of chlorine generally ranged between 1.2 mg/L to 2.2 mg/L free chlorine. The membrane permeate samples were usually dosed with 5.0 mg/L chlorine throughout the study, and generally had a free chlorine residual of 3.5 to 4.0 mg/L free chlorine at the end of 24 hours. This procedure was also modified about halfway through the study, the dosage was increased to 8.5 mg/L chlorine, which generally matched the plant. After this change, the chlorine residual generally ranged between 7.5 mg/L to 8.5 mg/L. After incubation, the SDS samples were “quenched” with preservative and analyzed for trihalomethane (THM) and haloacetic acid (HAA-6) content. Each laboratory was pre-certified to conduct their respective analyses.

4.0 Results and Discussion

The membrane pilot test was conducted from May 28, 1998 to March 1, 1999. A total of 22 samples were collected from each sample point at regular intervals during the test. On four occasions, duplicate samples were collected from the sample points, in accordance with ICR guidelines. The pilot test was stopped when the required samples were collected and the pilot unit had operated for a minimum of 6,600 hours. Results of the pilot test are discussed in this section.

4.1 Pilot Plant Operation-Problems Encountered

The pilot unit was operated for 6,719 hours with very few operational problems. During the initial commissioning of the pilot plant, the membrane elements experienced organic fouling. The organic fouling of the membranes was believed to be attributed to feeding scale inhibitor into the feedwater in conjunction with sulfuric acid. After the pilot unit was chemically cleaned, the addition of scale inhibitor was eliminated from the feed and sulfuric acid addition was increased to maintain a target feed pH that ranged between 5.6 to 5.8.

In addition to the shut-downs detailed above, there was a slight problem with the slit and organic material in the raw water mains from the Western Wellfield. When the lime softening plant required addition flow production from the wellfield, the velocity would increase from 0.5 fps to 2.5 fps when the flow was increased to the plant. The increased velocity allowed, the material that was deposited in the mains to be scoured from the pipelines and delivered this material to the treatment plant. During these operational flow changes, the membrane pilot plant would experience silt density index (SDI) greater than 6.0.

From August 23 – 30, 1998, the City performed wellhead maintenance on the all the Western wells, because of the maintenance personnel turning the wells on/off, the pilot plant was shutdown during period. The cumulative effective downtime reported to EPA was 168 hours.

The pilot was again shut down on September 3, 4, 10, 15 and 25, 1998 the shut downs were all attributed to wellfield maintenance. The 40 hours of downtime brings the total downtime of the unit to 232 hours.

4.2 Sample Analysis-Problems Encountered

Sample analyses were split between the City of Pompano Beach laboratory and Spectrum Laboratories. The preliminary review of the pilot study data by EPA in early September 1998, pointed out a problem with our SDS protocol. Based on the EPA review, the SDS-chlorine dosage appeared to be to low in our feedwater sample. The SDS-dosage that was used was not providing a free chlorine of 0.5 to 1.0 mg/L at the end of the SDS incubation period. The procedure was modified and the chlorine dosage

was increase to 7.0 to 8.5 mg/L, to satisfy the free chlorine requirements for the SDS procedures.

During the initial operation of the pilot plant, the influent TOC content was on the order of 13.9 mg/L, and permeate from each stage was less than 5.0 mg/L. to determine whether the numbers were erroneous, samples from each point were collected, split, and sent to different laboratories for analysis. The split sampling did reveal TOC discrepancies between different laboratories. To attempt to correct the problem, the Spectrum laboratory made new TOC standards and recalibrated their instrument. At the end of September, TOC values returned to expect levels, and appeared consistent throughout the remainder of the pilot test.

4.3 Membrane Pilot Plant Influent Water Quality

The influent water quality was relatively stable throughout the pilot-test period, with most parameters varying within a small range. Temperature varied with seasonal changes and was slightly lower towards the end of the pilot run. Pilot plant influent TOC did not appear to significantly vary throughout the pilot test, however, influent UV-254 appeared to trend downward throughout the pilot test. Pilot plant influent water quality is summarized in Table 4-1.

Table 4-1 Influent Water Quality for the Pilot-scale Membrane Plant

	AVERAGE	SD	COUNT
pH	6.06	0.20	30
Turbidity (NTU)	0.56	1.64	30
Alkalinity (mg/L, $CaCO_3$)	44.6	15.8	22
T-Hardness (mg/L, $CaCO_3$)	279.7	17.0	22
Ca-hardness (mg/L, $CaCO_3$)	261.9	19.5	22
Bromide (ug/L)	BMRL	-	-
TOC (mg/L)	26.8	17.1	21
UV254 (cm^{-1})	0.68	0.75	21
SUVA (L/(mg*m)	2.8	1.3	21
SDS-THM4 (mg/L)	144.9	39.9	18
SDS-HAA5 (mg/L)	476.6	510.4	19
SDS-HAA6 (mg/L)	515.9	537	19

Footnote: BMRL: Below Minimum Recorded Limit

SD: Standard Deviation

4.4 Membrane Pilot Operating Performance

The membrane pilot plant operating performance (i.e., monitoring and data collection) was conducted in accordance with ICR guidelines. Overall operation of the plant was very successful; the plant experienced minimal fouling without major changes to five key operating parameters. These operating parameters included; 1) membrane flux 2) differential pressure 3) permeate water total dissolved solids 4) recovery and 5) permeate flow.

The membrane flux is used to determine the quantity of feedwater that is produced per square foot of active membrane area. Based on the initial projections for the pilot unit, the unit was designed to operate with and average flux of 14.0 gfd. Figure 4-1 presented the membrane flux for each individual stage and the overall system flux. As shown on this figure the flux for the first and second stage ranged between 13.0 – 14.5 gfd, whereas the third stage initially produced a flux of 12.0 gfd and was adjusted to operator to the design range of 10 – 11 gfd.

The differential pressure across each stage in the membrane process is another tool in trending the fouling potential of the feedwater. Figure 4-2 shows the overall differential pressure across the system ranged between 70 – 90 psig, with the unit operating at 80 psig for most of the pilot test. The expected differential pressure for the entire system was projected to range between 50 – 60 psig, however with the early fouling of the system the third stage and did not respond to the cleaning of the membrane elements. After the third stage was cleaned the differential pressure could not be reduced below 40 psig. However, the first and second stage differential pressure operated within the projected range of 15 –17 psig.

The permeate total dissolved solids (TDS) data is one method for analyzing the performance based on the quality of the finished permeate water. Figure 4-3 presents the permeate TDS for each individual stage, as projected the overall TDS for the system range between 35 – 40 mg/L, with the permeate TDS from the first and second stages ranging between 20 - 30 mg/L. The performance from the third stage was lower than predicted with the permeate TDS ranging between 100 – 120 mg/L, this was approximately 30 percent higher than the expected permeate TDS for this stage. Again, this could be attributed to the early fouling of the unit during the initial startup of the system.

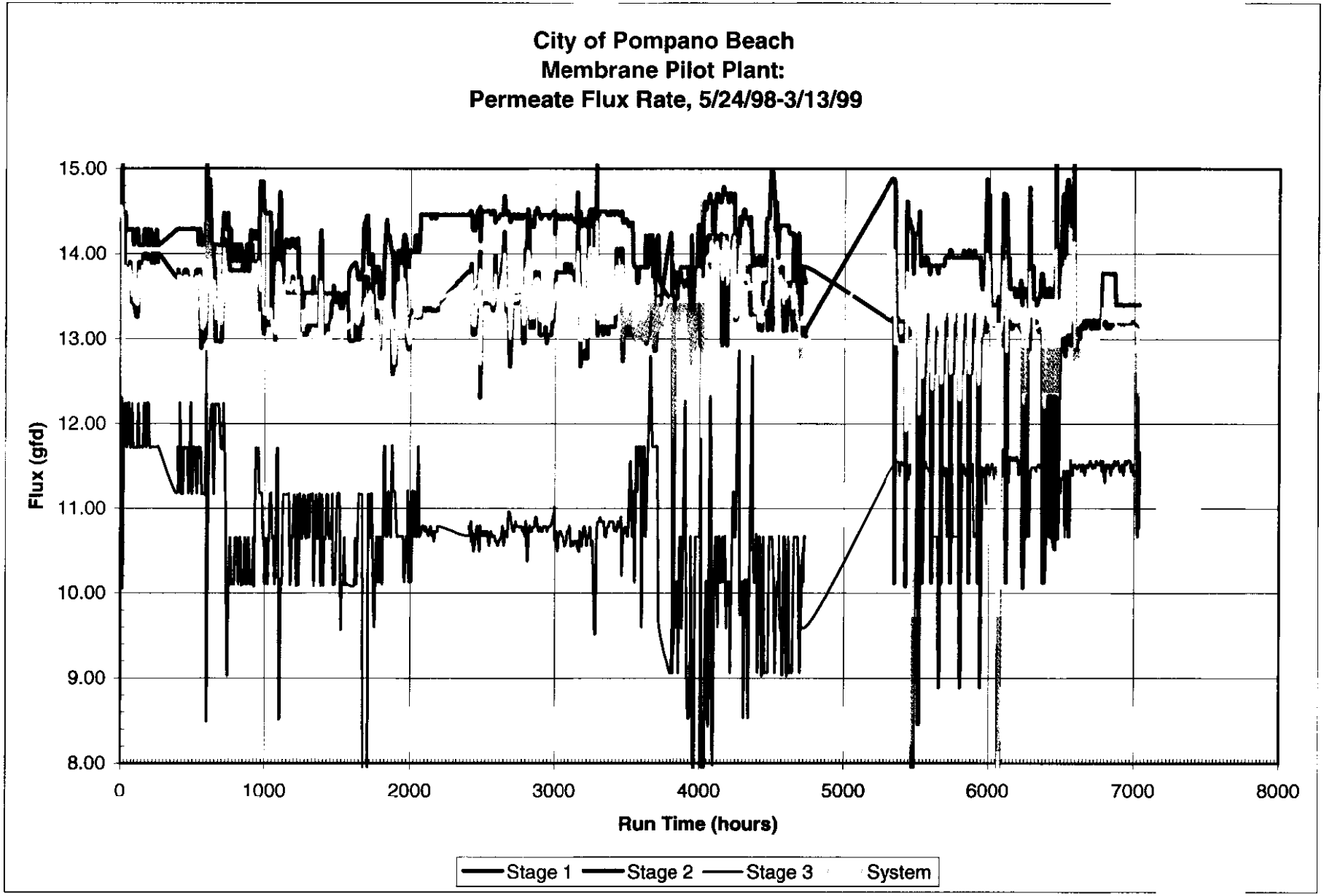

City of Pompano Beach
Membrane Pilot Plant:
Permeate Flux Rate, 5/24/98-3/13/99
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
Flux (gfd)
0
1000
2000
3000
4000
5000
6000
7000
8000
Run Time (hours)
Stage 1
Stage 2
Stage 3
System

Figure 4-1

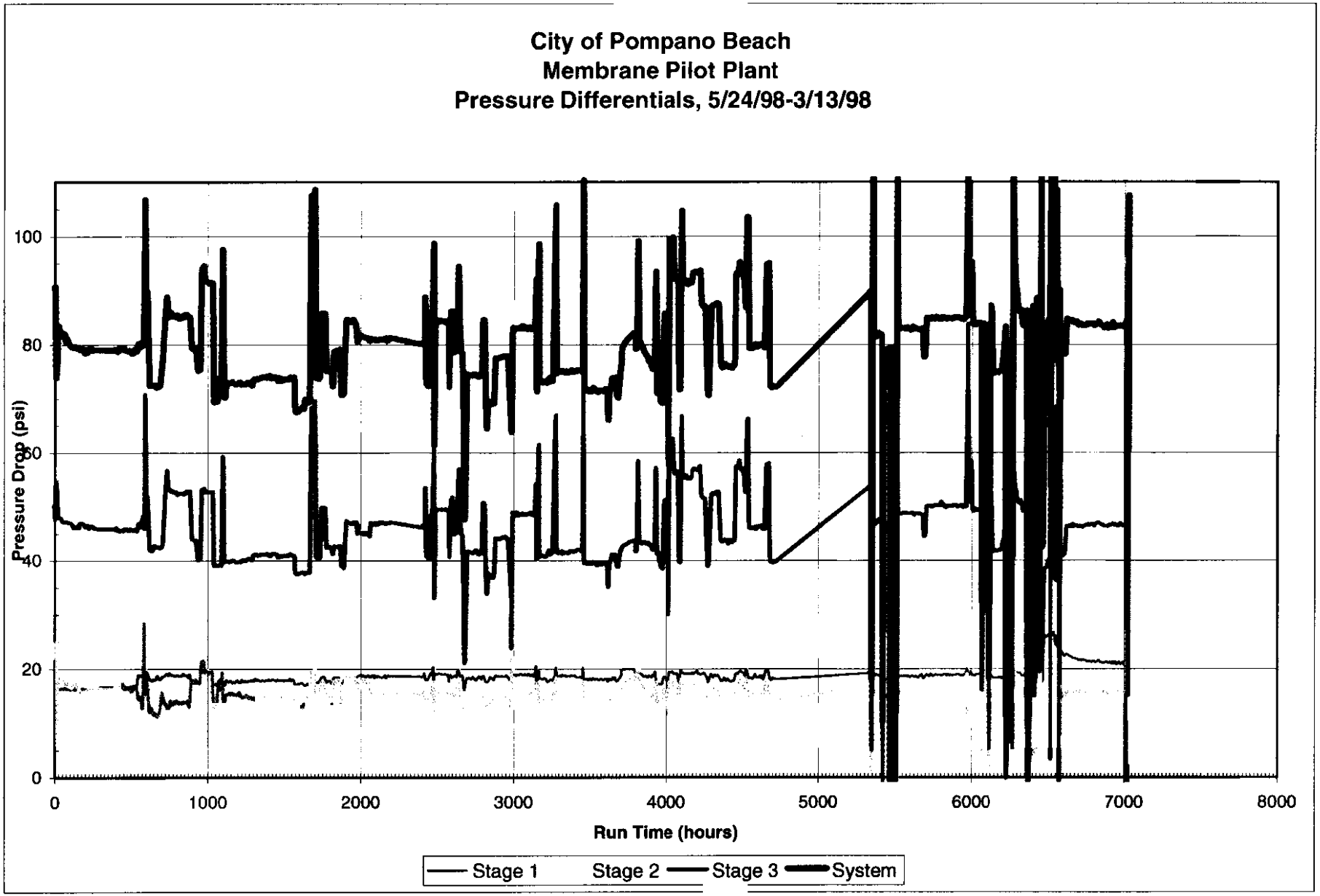

City of Pompano Beach
Membrane Pilot Plant
Pressure Differentials, 5/24/98-3/13/98
Pressure Drop (psi)
0
20
40
60
80
100
0
1000
2000
3000
4000
5000
6000
7000
8000
Run Time (hours)
Stage 1
Stage 2
Stage 3
System

Figure 4-2

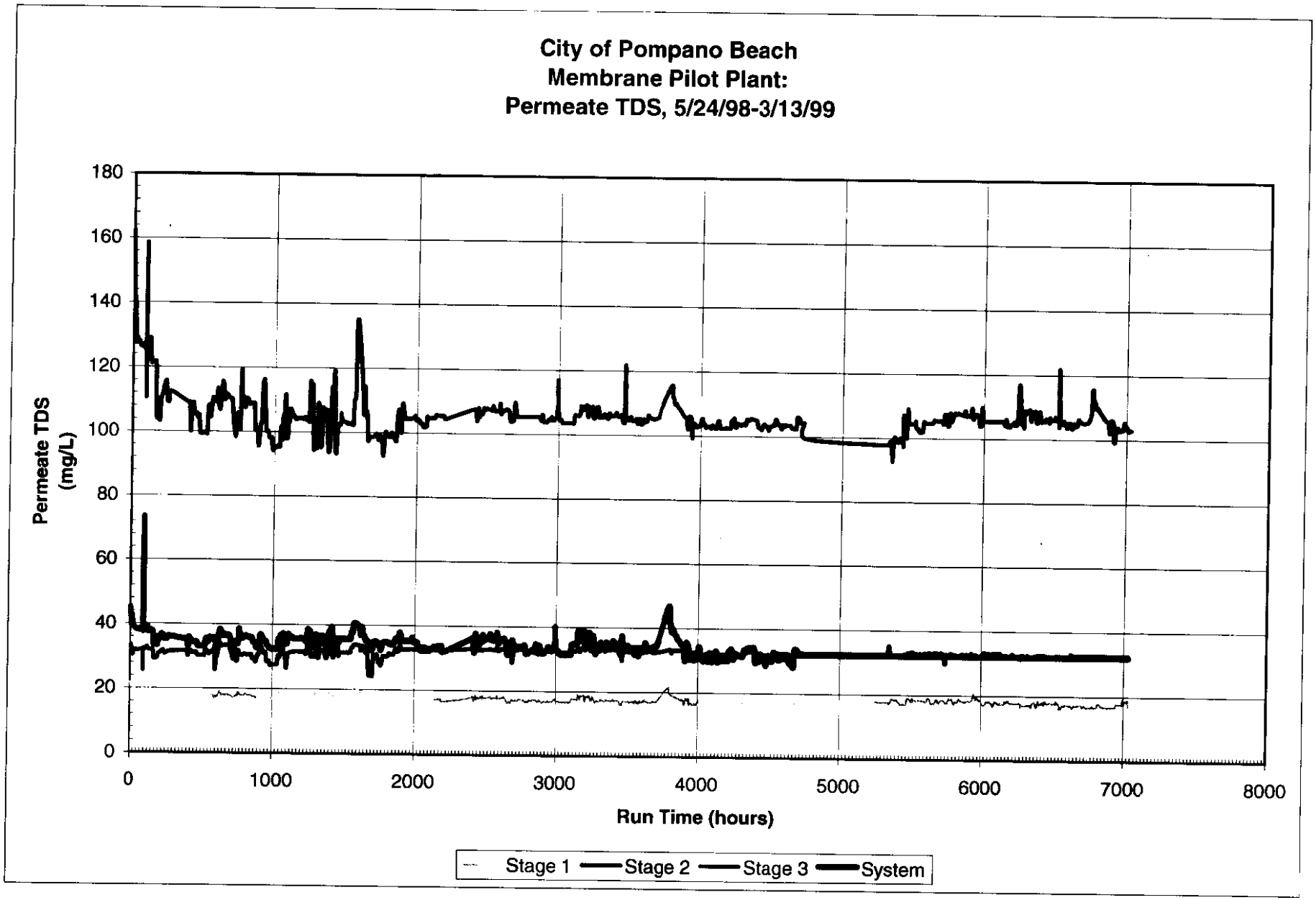

City of Pompano Beach
Membrane Pilot Plant:
Permeate TDS, 5/24/98-3/13/99
Permeate TDS (mg/L)
180
160
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Run Time (hours)
Stage 1
Stage 2
Stage 3
System

Figure 4-3

The system recovery is the basis for qualifying the performance of a membrane system. Figure 4-4 shows how each individual stage performed as well as the overall system. The system recovery was projected to range between 80 to 85 percent, based on the operating date the average recovery for the system was 82 percent. The first and second stages produce recoveries of 45 percent and 25 percent, respectfully. While the third stage recovered rate was 8 percent of the feedwater.

The permeate flow correlates very closely to the recoveries of the system, however this data provides immediate indication of the performance with only a small change in the permeate production from each stage. Figure 4-5 presents the permeate flow from each stage and the combined system permeate. The first and second stages permeate flow were 8.5 gpm and 4.5 gpm, with the third stage producing 1.35 gpm. The combine permeate flow from the system ranged between 14.0 to 14.8 gpm, for a total average production per day of 20,700 gpd.

4.5 Membrane SDS-DBP Collection and Analysis

The City of Pompano Beach laboratory performed the collection and prepare the membrane SDS – DBP's samples. The City performed the Total Trihalomethanes THM's analysis at their laboratory while the outside lab provided the analysis for the Total Haloacetic Acids (HAA's). The SDS – DBP's samples were collected every two weeks and every fifth sample was taken as a duplicate as required by or as suggested in the ICR manual. Table 4-2 presents the data collected in four ten week quarters.

Table 4-2 Pilot Unit SDS-DBP Levels

Week Sampled	Feed C_{F-sys} TTHM-4 (ug/L)	Permeate C_{P-sys} TTHM-4 (ug/L)	Feed C_{F-sys} THAA-6 (ug/L)	Permeate C_{P-sys} THAA-6 (ug/L)
05-27-98	67.39	33.44	799.9	43.93
06-07-98	67.39	27.92	1067.84	74.23
06-23-98	136.8	39.92	152.68	11.56
07-07-98	151.53	43.23	459.27	85.93
07-07-98	158.32	48.3	1327.1	26.93
07-22-98	153.25	8.59	21.16	6.25
08-04-98	255.43	8.12	1858.15	35.13
08-18-98	46.25	51.56	1345.75	13.21
09-01-98	128.35	79.29	1010.39	444.61
09-18-98	124.48	19.15	89.9	16.83
09-30-98	127.8	72.83	81.56	2.92
10-13-98	121.2	77.83	91.55	11.52

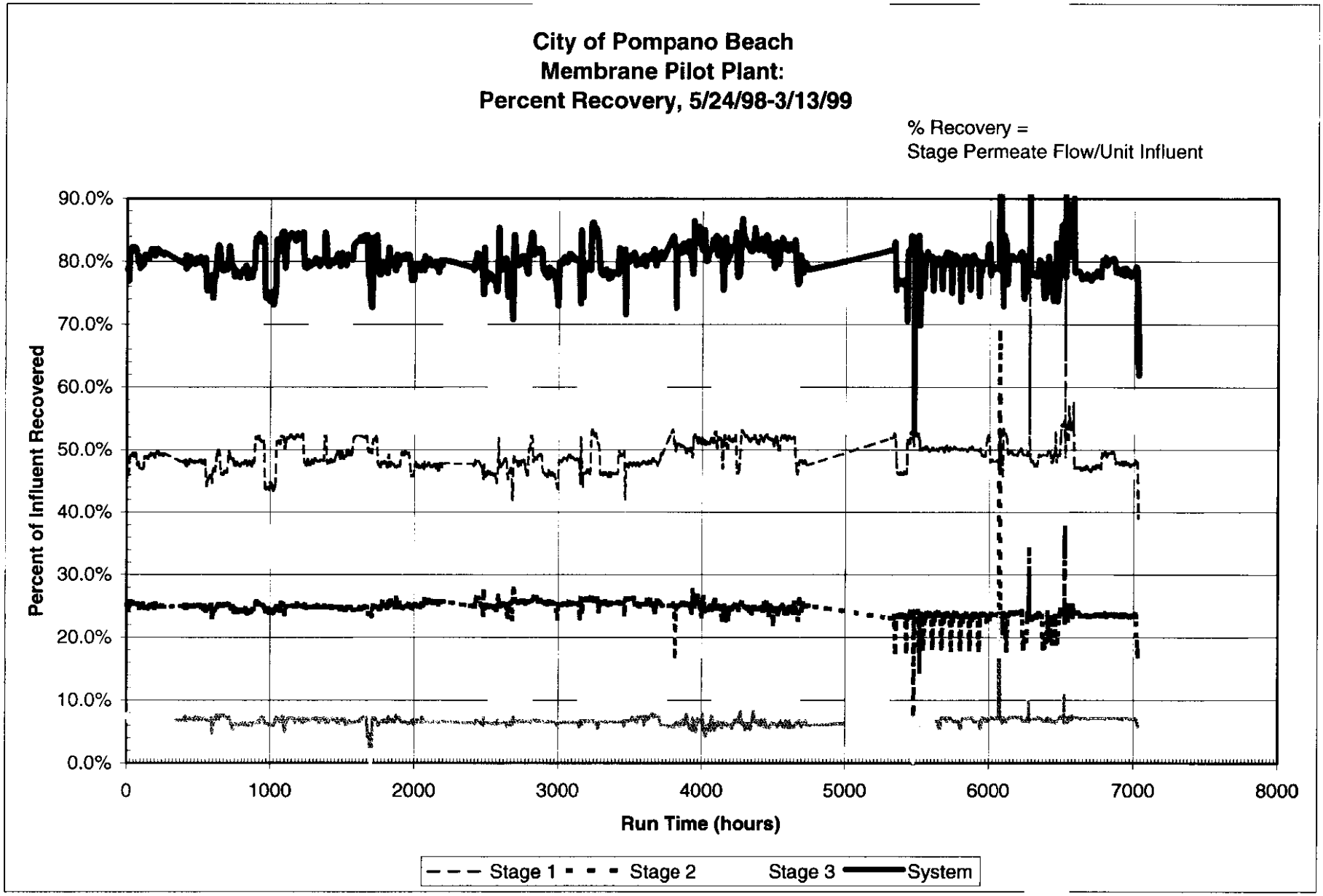

City of Pompano Beach
Membrane Pilot Plant:
Percent Recovery, 5/24/98-3/13/99
% Recovery =
Stage Permeate Flow/Unit Influent
Percent of Influent Recovered
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0
1000
2000
3000
4000
5000
6000
7000
8000
Run Time (hours)
Stage 1
Stage 2
Stage 3
System

Figure 4-4

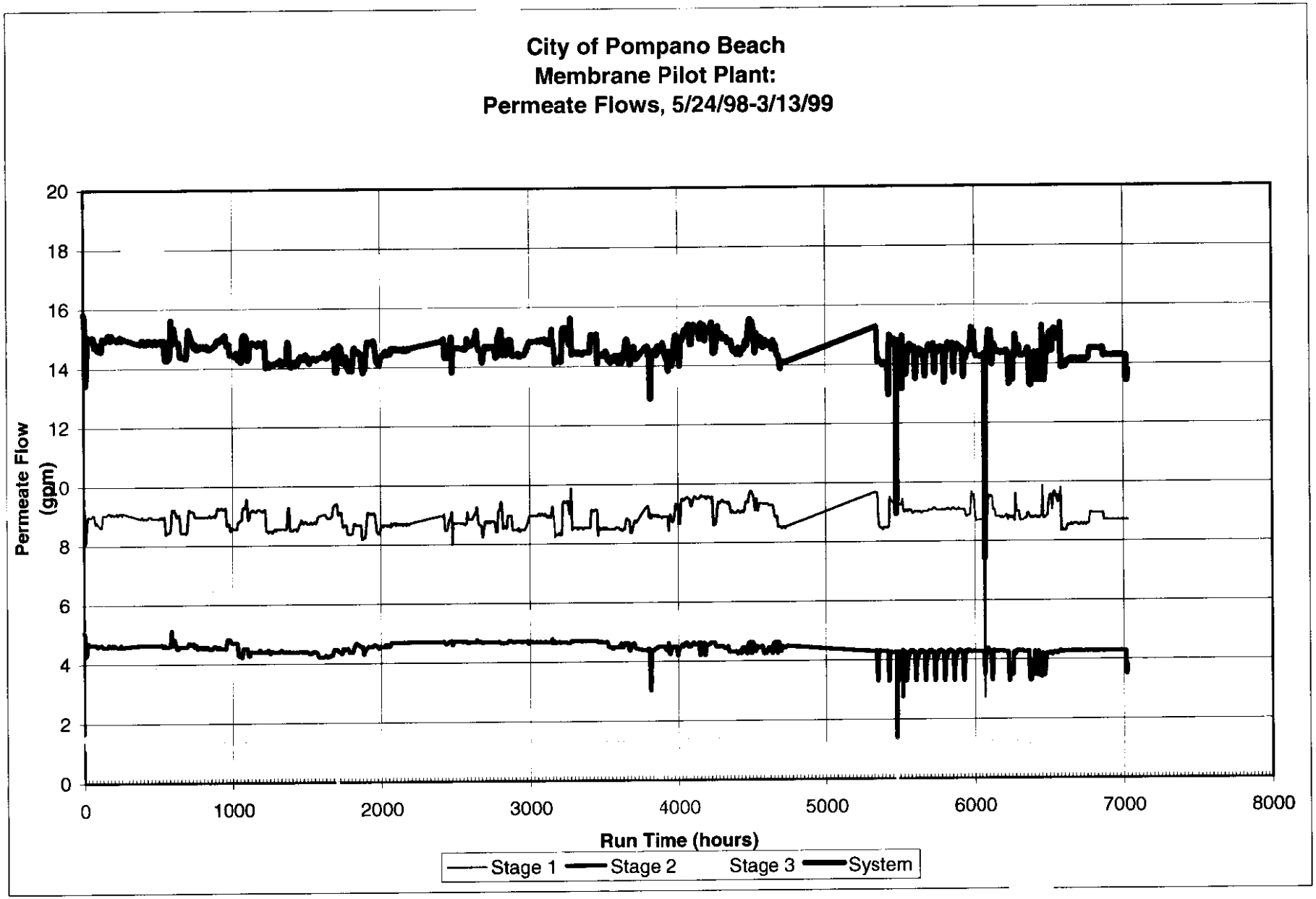

City of Pompano Beach
Membrane Pilot Plant:
Permeate Flows, 5/24/98-3/13/99
Permeate Flow (gpm)
20
18
16
14
12
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Run Time (hours)
Stage 1
Stage 2
Stage 3
System

Figure 4-5

Table 4-2 Pilot Unit SDS-DBP Levels

(**continued**)

Week Sampled	Feed C_F- sys TTHM-4 (ug/L)	Permeate C_P- sys TTHM-4 (ug/L)	Feed C_F- sys THAA-6 (ug/L)	Permeate C_P- sys THAA-6 (ug/L)
10-29-98	203.94	46.28	555	8.32
11-10-98	141.17	54.76	180.22	46.63
11-28-98	128.3	43.45	90.05	8.96
12-08-98	133.62	40.35	90.05	8.31
12-24-98	113.39	42.55	225.48	4.34
12-24-98	146.69	41.52	225.48	4.34
01-06-99	196.08	58.41	152.12	110.69
01-20-99	170.1	68.84	105.43	9.52
02-04-99	41.16	17.1	1178.68	8.43
02-22-99	285.12	50.75	315.86	39.58

Figure 4-1 presents the overall results of the formation of TTHM's and THAA's for the feed and permeate flow streams. The results are further presented on Figures 4-6, 4-7 and 4-8, respectively. As shown on these graphs, the results of the samples vary from week to week. The information shows some positive trends, but further control testing may be warranted due to the variations. In general, reduction of disinfection byproducts (i.e. TTHM's and THAA's) were noticed throughout the testing period. However, due to complexity associated with the sampling procedure and the subsequent analysis, variations were anticipated.

4.6 Membrane Pilot Total Organic Carbon Reduction

Total organic carbon was a primary indicator of membrane pilot plant performance. As expected the membrane process produced very favorable results on removing the total organic carbon from the raw water from the Western Wellfield. The TOC samples were collected every two weeks and every fifth sample was taken as a duplicate as in the ICR manual. Table 4-3 presents the TOC data collected in four ten-week quarters.

Table 4-3 Pilot Unit TOC Levels

Week Sampled	Feed C_{F-sys} TOC mg/L	Permeate C_{P-sys} TOC mg/L
05-27-98	14	0
06-07-98	13.6	3.07
06-23-98	10.6	0
07-07-98	12.4	0
07-07-98	12.4	0
07-22-98	18.4	1
08-04-98	17.1	1.35
08-18-98	24.5	8.46
09-01-98	32.1	0
09-18-98	19.8	4.9
09-30-98	18	4.9
10-13-98	38.2	10.1
10-29-98	24.7	12.6
11-10-98	29.5	27.2
11-28-98	12.3	15.7
12-08-98	13.3	12.4
12-24-98	13	8
12-24-98	19.8	8.61
01-06-99	15.7	0
01-20-99	26	0.5
02-04-99	37.9	1.14
02-22-99	13	0.01

Based on our result from the pilot test the four quarter running average for influent Total Organic Carbon was 19.83 mg/L and the effluent permeate was 5.45 mg/L. This represents a 73 percent reduction in the influent TOC. Based on the influent TOC, this facility would be required to remove a minimum of 30 percent. Figure 4-9 presents a summary of the TOC results, the TOC again showed trends during the beginning and end of the test. However, during the middle two-thirds of the test the permeate TOC results changed dramatically from week to week.

4.7 Summary of Results

The membrane pilot test operated for over 6,600 hours and produced very positive results showing significant TOC and UV-254 reduction occurred throughout the entire test. The pilot operated without any pretreatment problem and only required minimum maintenance during the yearlong study. The pilot plant has proven to be very effective in treating the water from the Western Wellfield.

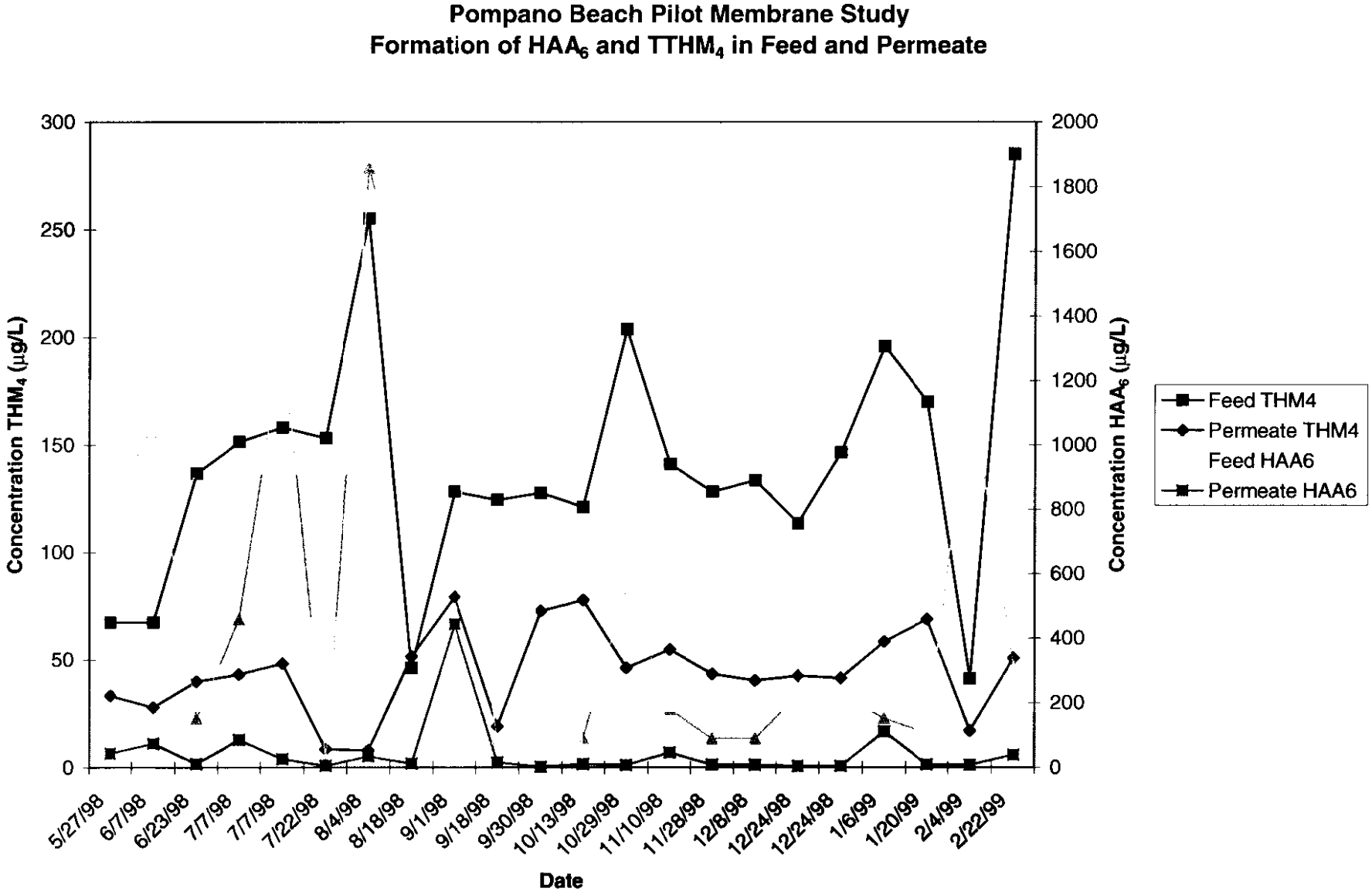

Pompano Beach Pilot Membrane Study
Formation of HAA6 and TTHM4 in Feed and Permeate
Concentration THM4 (µg/L)
Concentration HAA6 (µg/L)
300
250
200
150
100
50
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Feed THM4
Permeate THM4
Feed HAA6
Permeate HAA6
5/27/98
6/7/98
6/23/98
7/7/98
7/7/98
7/22/98
8/4/98
8/18/98
9/1/98
9/18/98
9/30/98
10/13/98
10/29/98
11/10/98
11/28/98
12/8/98
12/24/98
12/24/98
1/6/99
1/20/99
2/4/99
2/22/99
Date

FIGURE 4-6

Pompano Beach Pilot Membrane Study
Formation of SDS-TTHM$_4$ in Feed and Permeate

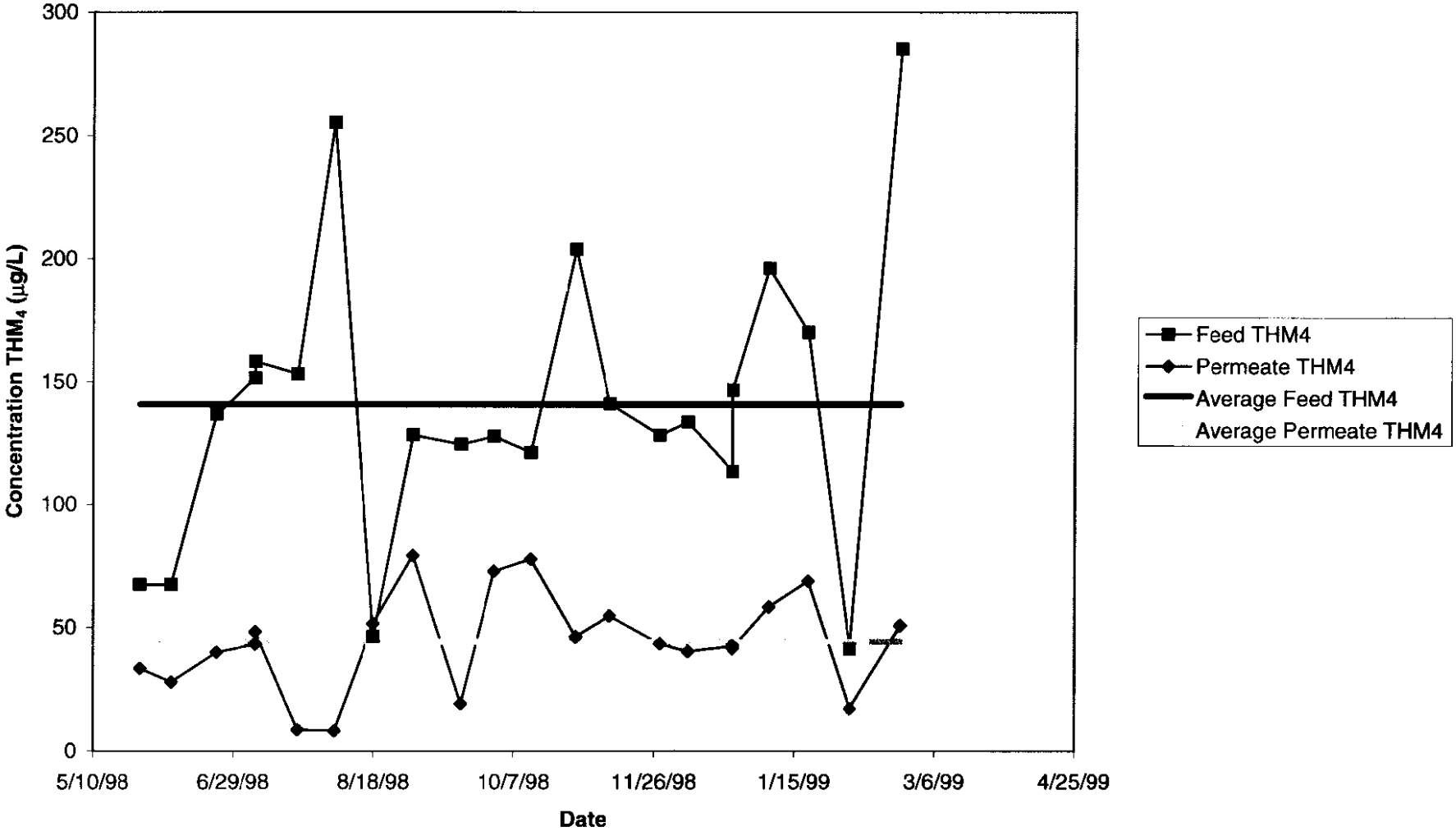


FIGURE 4-7

Pompano Beach Pilot Membrane Study
Formation of HAA_6 in Feed and Permeate

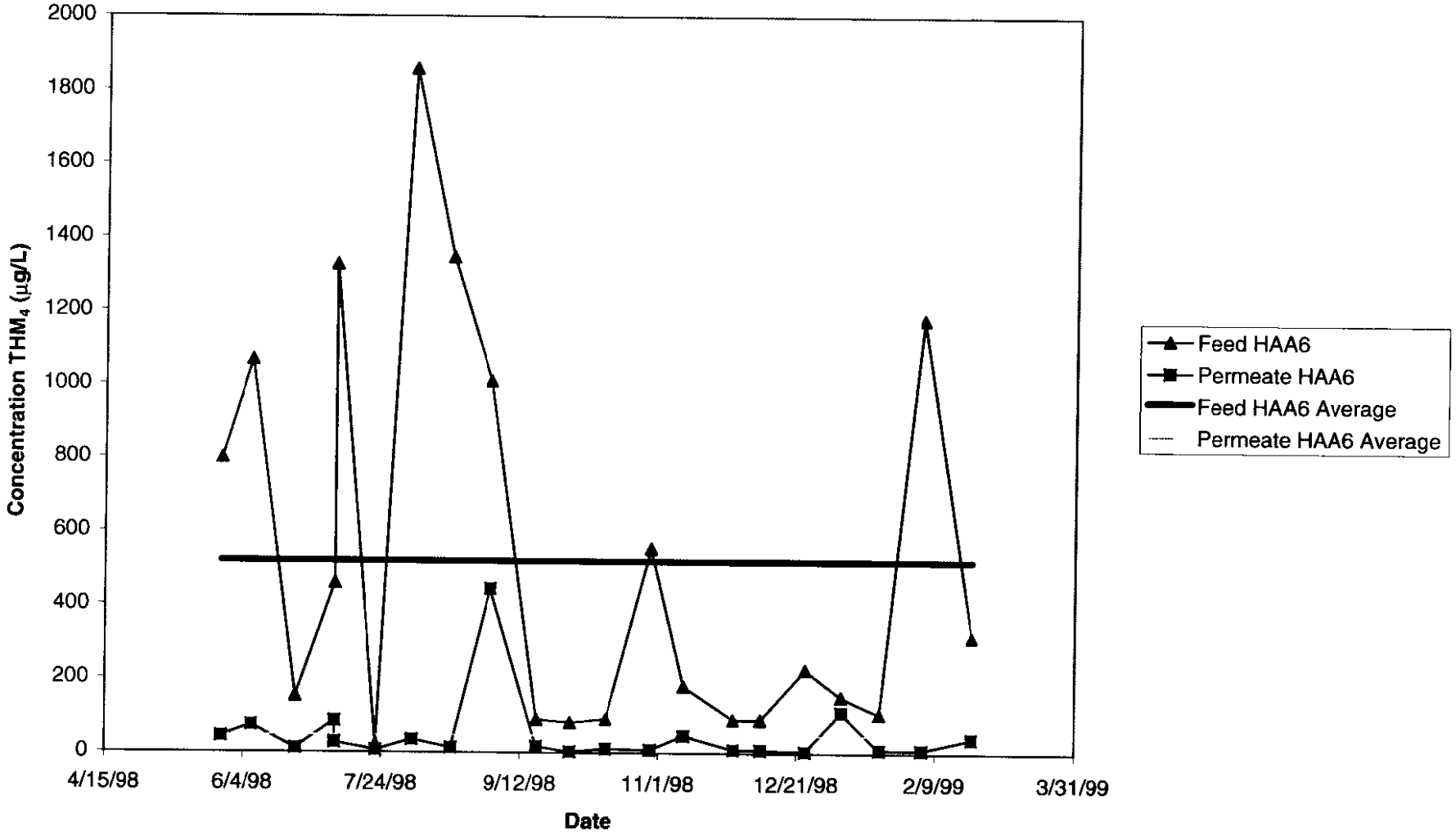


FIGURE 4-8

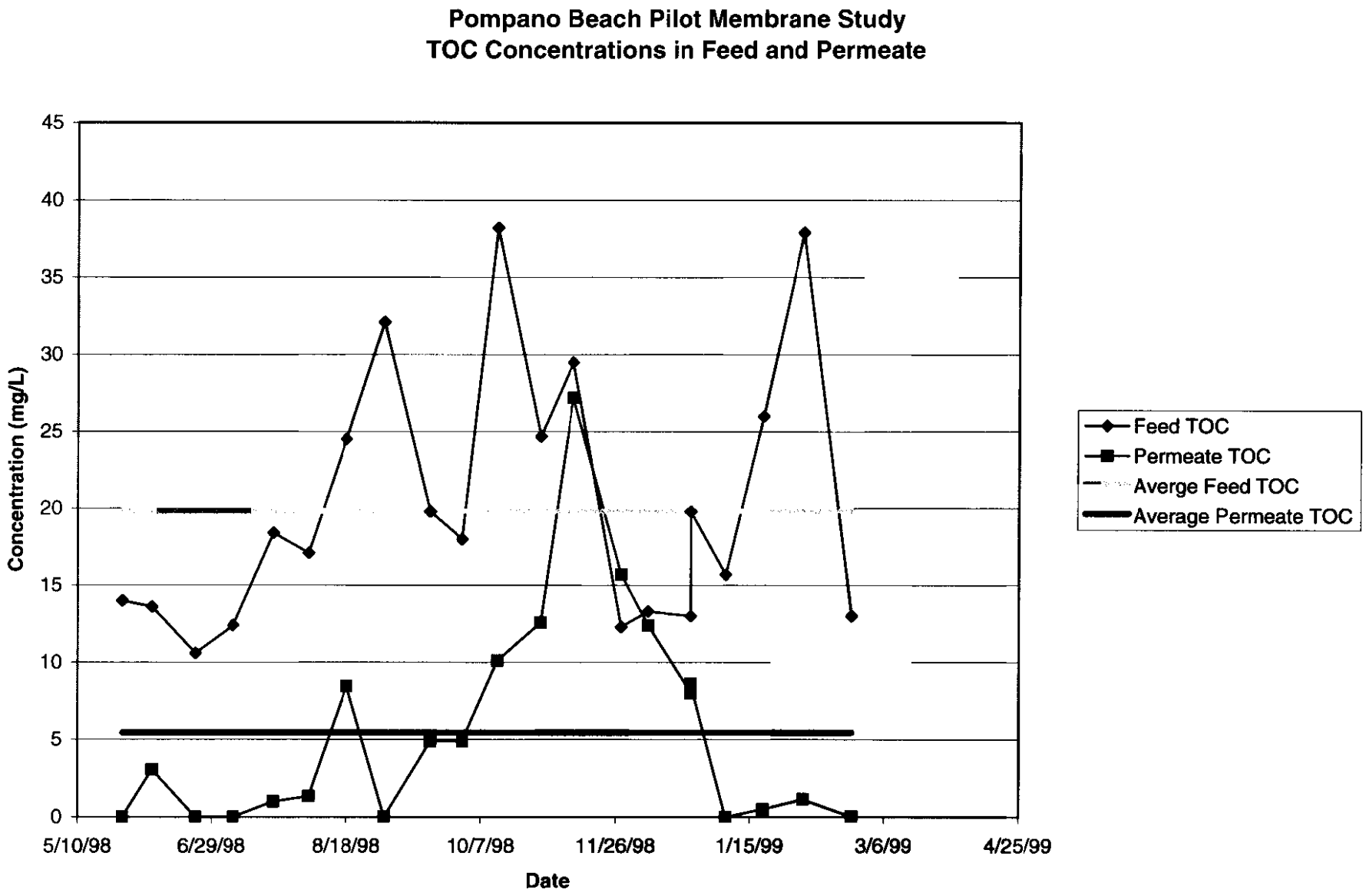

Pompano Beach Pilot Membrane Study
TOC Concentrations in Feed and Permeate
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
5/10/98
6/29/98
8/18/98
10/7/98
11/26/98
1/15/99
3/6/99
4/25/99
Date
Feed TOC
Permeate TOC
Averge Feed TOC
Average Permeate TOC

FIGURE 4-9

Appendix A