

ICR TREATMENT STUDY ANALYSIS

Base Analysis and Data Review Comments

Treatment Study ID	4007
Study Protocol	Two-Stage Pilot-Scale Membrane Study
Plant ICR Number	717
PWS Name	Pinellas County Utilities
City, State, Zip	Largo, FL 34648

General Comments:

1. This study was grandfathered into the ICR, and therefore does not meet all of the specific requirements listed in the ICR and rule-by-reference manuals. This pilot-scale study (study ID 4007) was conducted in conjunction another pilot-scale study (study ID 4008). Study 4007 was conducted from February 1990 through April 1991 while Study ID 4008 was conducted from July 1989 through January 1990.

NOTE: For Study 4007 the operational and water quality sampling dates do not match up within the two Sessions. Specifically, in Session 1 the reported operational data was collected from 2/6/90 through 2/1/91, while the reported water quality data was collected through 11/5/90. In Session 2 the reported operational data was collected from 2/4/91 through 4/25/91, while the reported water quality data was collected from 12/3/90 through 4/4/91. During data analysis the operational and water quality data from both sessions will be merged, thus these date discrepancies will not impact data analysis.

2. During this study, the FilmTec NF70 was evaluated. The membrane system was operated at 15 gfd and 60% recovery throughout this study. The experimental design for this study is listed in Table 6 of the Summary Report.
3. Cartridge filtration (5µm) with either acid or antiscalent addition was used as the membrane pretreatment. A summary of membrane operation is listed in Table 9 of the Summary Report. Section IV contains a description of the operation of the membrane system.
4. Cost estimates for 10 and 50 MGD groundwater nanofiltration plants are provided in Section IV of the Summary Report.
5. In October 1990, the last membrane from Stage 2 was replaced and sent to FilmTec for foulant analysis. The foulant, which was thought to be an iron sulfide precipitate, was never positively identified.

Water Quality Comments:

1. Six water quality outliers were identified and removed prior to base analysis.
2. The SDS conditions are summarized in the Analytical Methods section of the Summary Report. The reported target chlorination conditions were to dose the permeate and feed samples at 5 and 12.5 mg/L, respectively, at a pH of 7.6, and incubate the samples for 96 hours at 20°C. Note that the actual measured SDS times, pH and temperatures were not available. Although these conditions were chosen to represent SDS conditions, they were probably more similar to a Formation Potential test, as the reported residual ranged from 0.2 to 5.2 mg/L.
3. The following parameters were not measured during this study: ammonia, bromide, UV₂₅₄ and BCAA (thus HAA6).

Productivity Comments:

1. Two productivity outliers were identified and removed prior to base analysis.
2. Table 10 lists the various pretreatments used during each “period” of this study, (which vary between antiscalent and acid addition), and the associated slopes and projected cleaning intervals during each period.
3. The nanofiltration membrane was cleaned using either a 0.1% phosphoric acid solution inorganic foulants, or a 0.1% EDTA mixed with 0.1% NaOH solution for organic foulants. Details about when each cleaning solution was applied are listed in Section IV of the Summary Report.
4. An average cleaning interval of 133 days was projected during EPA data analysis, which is approximately 1 month shorter than the consultant’s projected average cleaning interval of 162 days, over that same operational cycles. Due to the short run-length of cycles 1 and 4, only the productivity data collected during the 2nd, 3rd, and 5th cycles was used.

ICR Information

ID / ICR#: FL6521405 / 717
 ICR Contact: Robert Powell
 Phone No.: 813-582-2302
 Period: 2/6/90 - 2/1/91 (360 days)

Membrane Information

Manufacturer: DOW USA, (FilmTec)
 Trade Name: NF-70
 Membrane Model: NF-70, 4040
 MWCO: 200 Daltons
 Element Size: 4" x 40"
 Element Area: 80.0 ft²
 Design Flux: 15.0 gfd
 Mfr. NDP: 70.0 psi
 Mfr. MTC_w: 0.350 (gfd/psi)
 Mfr. Temp: 25.0 °C
 Maximum Flow: 16.0 gpm
 Minimum Flow: 4.0 gpm
 Total Width : 12.0 ft
 Feed Spacer Thickness: 0.0025 ft
 840 Element Area 400.0 ft²
 840 Purchase Price: \$500

Design Parameters

Norm Temp: 24.0 °C
 Temp Norm MTC-w: 0.340 TavGC
 Design Recovery: 0.60
 Avg Sys Flux F_w: 15.0 gfd
 # of Elem in P.V.: 3
 # Pres Ves in Stg 1: 2
 # Pres Ves in Stg 2: 1
 Pres Ves in Stg 3: NA
 Design Flux: 15.0 gfd
 Recycle Ratio: 0.00
 Osmotic P Stage 1: 4.3 psi
 Osmotic P Stage 2: 7.0 psi
 Osmotic P Stage 3: NA

Water Quality Summary

Summary	Feed (System)				Permeate (System)				Concentrate (System)			
	Mean	SD	Count	Min/Max	Mean	SD	Count	Min/Max	Mean	SD	Count	Min/Max
pH	6.8	0.7	6	5.8 - 7.5	6.3	0.6	6	5.7 - 6.9	6.4	0.5	6	5.7 - 6.8
Temp	24.0	0.0	6	24.0 - 24.0	NA	NA	0	0.0 - 0.0	NA	NA	0	0.0 - 0.0
Alk	175	54	6	98 - 230	51	7	6	41 - 59	335	148	6	160 - 480
TDS	293	49	6	240 - 350	77	5	6	69 - 82	593	99	6	480 - 720
TotHard	210	11	6	200 - 230	50	6	6	41 - 58	443	29	6	400 - 470
CaHard	202	23	6	180 - 240	46	4	6	41 - 52	398	37	6	340 - 440
Turb	0.27	0.1	6	0.18 - 0.44	0.15	0.1	6	0.06 - 0.30	0.39	0.2	6	0.18 - 0.64
Amm	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	0.0 - 0.0
TOC	3.5	0.4	6	3.0 - 3.9	0.3	0.1	6	0.3 - 0.5	8.9	1.2	6	7.8 - 11.0
UV254	NA	NA	0	0.000 - 0.000	NA	NA	0	0.000 - 0.000	NA	NA	0	0.000 - 0.000
SUVA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA
Bromide	NA	NA	0	0 - 0	NA	NA	0	0 - 0				
TOX	417	77	6	280 - 510	48	46	6	13 - 140				
CHCl3	93.5	33.7	6	31.0 - 120.0	4.3	2.4	6	2.0 - 8.0	Mass Balance			
BDCM	16.5	3.3	6	12.0 - 20.0	3.8	1.9	6	2.0 - 7.0	Closure Errors (%)			
DBCM	0.8	1.3	6	0.0 - 3.0	1.7	1.9	6	0.0 - 5.0	WQP	Count	Avg	SD/RD
CHBr3	0.0	0.0	6	0.0 - 0.0	0.0	0.0	6	0.0 - 0.0	Alk	6	-13	27
THM4	110.8	35.1	6	43.0 - 135.0	9.8	5.2	6	4.0 - 17.0	TDS	6	-5	9
MCAA	4.5	5.5	6	0.0 - 13.0	0.3	0.8	6	0.0 - 2.0	TotHard	6	-2	6
DCAA	29.3	20.5	6	5.0 - 56.0	2.5	2.3	6	0.0 - 6.0	CaHard	6	-11	15
TCAA	29.3	13.6	6	10.0 - 46.0	1.5	0.5	6	1.0 - 2.0	Turb	6	5	50
MBAA	0.0	0.0	6	0.0 - 0.0	0.0	0.0	6	0.0 - 0.0	Amm	0	n/a	n/a
DBAA	0.0	0.0	6	0.0 - 0.0	0.0	0.0	6	0.0 - 0.0	TOC	5	8	9
BCAA	NA	NA	0	NA	NA	NA	0	NA	UV254	0	n/a	n/a
TBAA	NA	NA	0	NA	NA	NA	0	NA				
CDBAA	NA	NA	0	NA	NA	NA	0	NA	TDS _t	99	-8	22
DCBAA	NA	NA	0	NA	NA	NA	0	NA	Comments:			
HAA5	63.2	33.6	6	17.0 - 102.0	4.3	3.1	6	1.0 - 8.0				
HAA6	NA	NA	0	NA	NA	NA	0	NA				
HAA9	NA	NA	0	NA	NA	NA	0	NA				
SDS Conditions					Pretreatment Information							
WQP	Avg	SD	Count	Min - Max	Process		Description			Scale		
Res (0)	2.70	1.55	12	0.20 - 5.20	Cartridge filtration		5 mm exclusion size			Pilot-scale		
Temp (°C)	20.0	0.0	12	20.0 - 20.0	Sulfuric acid addition		approx. dose 110 mg/L to pH = 6.0			Pilot-scale		
pH (unit)	7.6	0.0	12	7.6 - 7.6	(or) Flocon 100, anti-scalent		2 ppm			Pilot-scale		
Time (hr)	96.0	0.0	12	96.0 - 96.0								

Mass Balance Errors

Pressure	RPD	SD	Flow	RPD	SD	TDS	RPD	SD
System Inf - Stg 1 Inf	0.0%	0.0%	System Inf - Stg 1 Inf	0.0%	0.0%	System Inf - Stg 1 Inf	0.0%	0.0%
Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	0.0%	0.0%
Stg 1 Conc - Stg 2 Inf	0.0%	0.0%	Stg 1 Conc - Stg 2 Inf	0.0%	0.0%	Stg 1 Conc - Stg 2 Inf	0.0%	0.0%
Sys Perm - Avg Stg Perr	0.0%	0.0%	Sys Perm - Sum Stg Per	0.0%	0.0%	Sys Perm - Avg Stg Perm	-6.6%	9.5%

Stage Summary

	Stage 1 Influent						Stage 1 Permeate				
WQP	Sys Feed	Sys Conc	Mean	SD	Count	Min/Max	Sys Perm	Mean	SD	Count	Min/Max
Recovery			0.41	0.01	6	0.39 - 0.43					
pH	6.8	6.4	6.8	0.7	6	5.8 - 7.5	6.3	7.1	1.0	6	5.7 - 7.8
Temp	24.0	NA	24.0	0.0	6	24.0 - 24.0	NA	NA	NA	0	0.0 - 0.0
Alk	175	335	175	54	6	98 - 230	51	43	9	6	33 - 56
TDS	293	593	293	49	6	240 - 350	77	63	17	6	52 - 96
TotHard	210	443	210	11	6	200 - 230	50	52	20	6	38 - 83
CaHard	202	398	202	23	6	180 - 240	46	46	20	6	33 - 76
Turb	0.27	0.39	0.27	0	6	0.18 - 0.44	0.15	0.23	0.17	6	0 - 1
TOC	3.5	8.9	3.5	0.4	6	3.0 - 3.9	0.3	0.3	0.0	6	0.3 - 0.3
UV254	NA	NA	NA	NA	0	0.000 - 0.000	NA	NA	NA	0	0.000 - 0.000
SUVA	NA	NA	NA	NA	0	NA	NA	NA	NA	0	NA

	Stage 2 Influent						Stage 2 Permeate				
WQP	Sys Feed	Sys Conc	Mean	SD	Count	Min/Max	Sys Perm	Mean	SD	Count	Min/Max
Recovery			0.33	0.04	6	0.26 - 0.38					
pH	6.8	6.4	6.7	0.3	6	6.1 - 7.0	6.3	6.5	0.4	6	6.0 - 6.9
Temp	24.0	NA	NA	NA	0	0.0 - 0.0	NA	NA	NA	0	0.0 - 0.0
Alk	175	335	267	93	6	140 - 360	51	66	17	6	42 - 84
TDS	293	593	398	88	6	260 - 510	77	93	20	6	58 - 110
TotHard	210	443	320	20	6	300 - 350	50	71	8	6	62 - 84
CaHard	202	398	280	14	6	260 - 300	46	63	6	6	55 - 74
Turb	0.27	0.39	0.42	0	6	0.18 - 0.86	0.15	0.50	0.60	6	0 - 2
TOC	3.5	8.9	6.0	1.1	6	4.8 - 7.8	0.3	0.4	0.2	6	0.3 - 0.6
UV254	NA	NA	NA	NA	0	0.000 - 0.000	NA	NA	NA	0	0.000 - 0.000
SUVA	NA	NA	NA	NA	0.00	NA	NA	NA	NA	0.00	NA

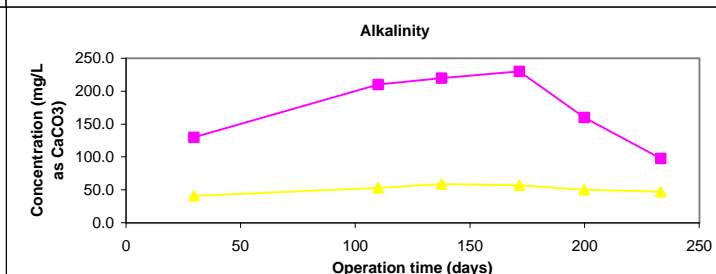
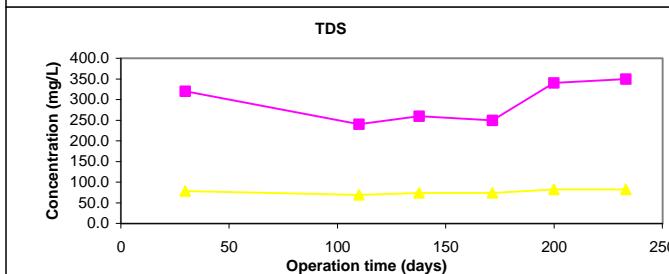
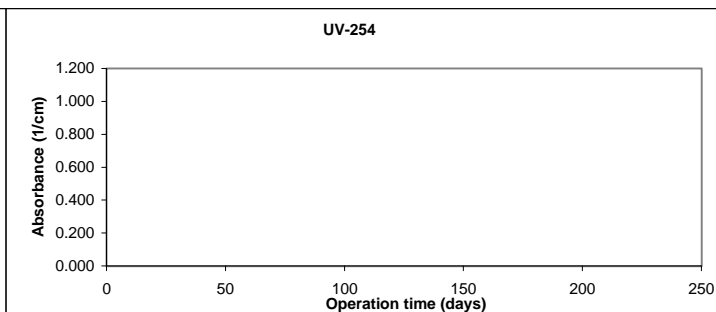
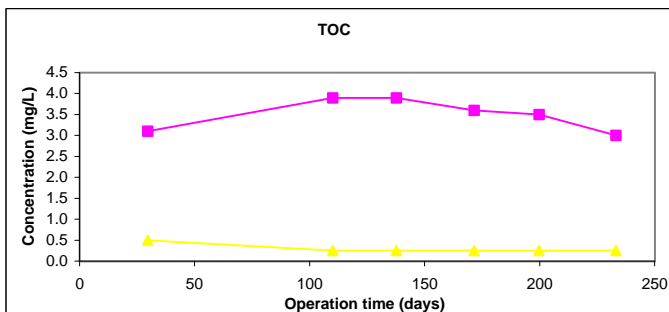
	Stage 3 Influent						Stage 3 Permeate				
WQP	Sys Feed	Sys Conc	Mean	SD	Count	Min/Max	Sys Perm	Mean	SD	Count	Min/Max
Recovery											
pH											
Temp											
Alk											
TDS											
TotHard											
CaHard											
Turb											
TOC											
UV254											
SUVA											

This was only a two stage study.

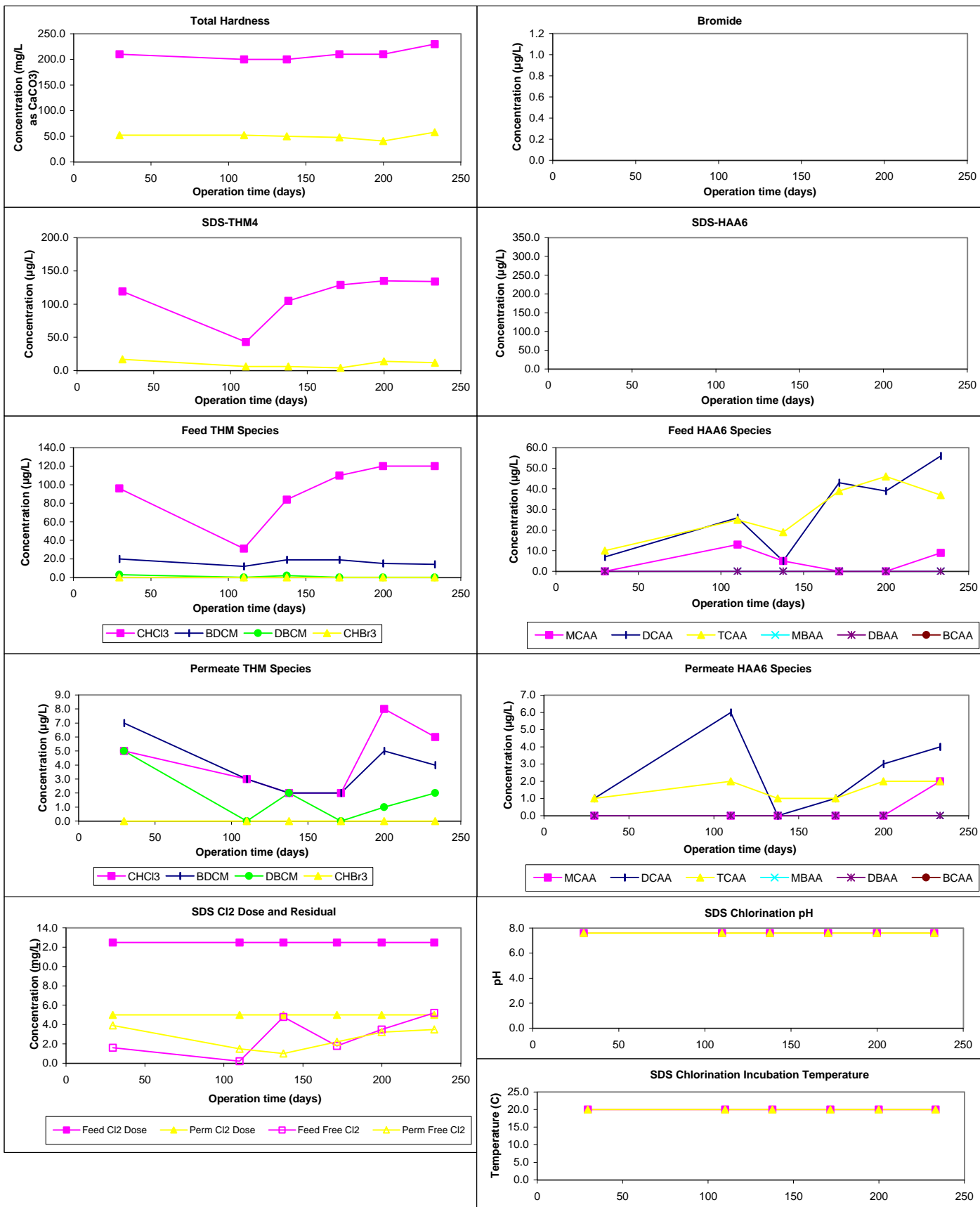
Water Quality Parameter Graphs

Chart Legend:

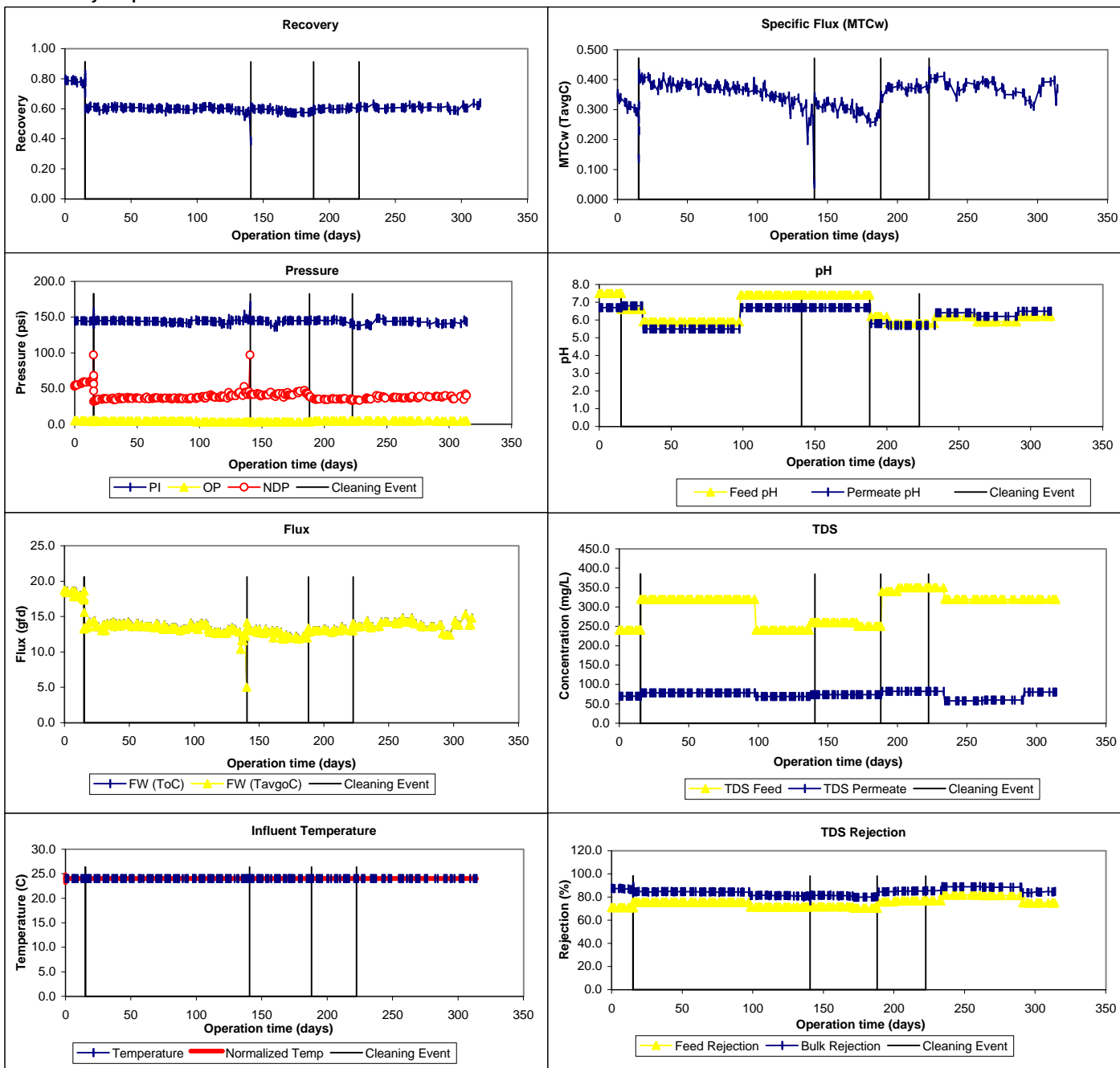
- Feed (System)
- Permeate (System)



Water Quality Graphs (Continued)



Productivity Graphs



ICR Information

ID / ICR#: FL6521405 / 717
 ICR Contact: Robert Powell
 Phone No.: 813-582-2302
 Period: 2/4/91 - 4/25/91 (80 days)

Membrane Information

Manufacturer: DOW USA, (FilmTec)
 Trade Name: NF-70
 Membrane Model: NF-70, 4040
 MWCO: 200 Daltons
 Element Size: 4" x 40"
 Element Area: 80.0 ft²
 Design Flux: 15.0 gfd
 Mfr. NDP: 70.0 psi
 Mfr. MTC_w: 0.350 (gfd/psi)
 Mfr. Temp: 25.0 °C
 Maximum Flow: 16.0 gpm
 Minimum Flow: 4.0 gpm
 Total Width : 12.0 ft
 Feed Spacer Thickness: 0.0025 ft
 840 Element Area 400.0 ft²
 840 Purchase Price: \$500

Design Parameters

Norm Temp: 24.0 °C
 Temp Norm MTC-w: 0.340 TavGC
 Design Recovery: 0.60
 Avg Sys Flux F_w: 15.0 gfd
 # of Elem in P.V.: 3
 # Pres Ves in Stg 1: 2
 # Pres Ves in Stg 2: 1
 Pres Ves in Stg 3: NA
 Design Flux: 15.0 gfd
 Recycle Ratio: 0.00
 Osmotic P Stage 1: 4.3 psi
 Osmotic P Stage 2: 7.0 psi
 Osmotic P Stage 3: NA

Water Quality Summary

Summary	Feed (System)				Permeate (System)				Concentrate (System)					
	Mean	SD	Count	Min/Max	Mean	SD	Count	Min/Max	Mean	SD	Count	Min/Max		
pH	6.0	0.2	5	5.9 - 6.2	5.6	0.2	5	5.4 - 5.8	6.3	0.2	5	6.1 - 6.5		
Temp	24.0	0.0	5	24.0 - 24.0	NA	NA	0	0.0 - 0.0	NA	NA	0	0.0 - 0.0		
Alk	94	22	5	76 - 130	35	8	5	28 - 48	194	45	5	160 - 270		
TDS	320	7	5	310 - 330	65	10	5	55 - 80	734	35	5	680 - 770		
TotHard	216	9	5	210 - 230	41	7	5	35 - 53	500	19	5	470 - 520		
CaHard	196	9	5	190 - 210	34	4	5	29 - 39	456	11	5	440 - 470		
Turb	1.66	2.0	5	0.12 - 4.30	0.17	0.1	5	0.00 - 0.38	1.90	3.0	5	0.22 - 7.20		
Amm	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	0.0 - 0.0		
TOC	2.7	0.4	5	2.1 - 3.0	0.3	0.0	5	0.3 - 0.3	7.5	0.6	5	7.0 - 8.4		
UV254	NA	NA	0	0.000 - 0.000	NA	NA	0	0.000 - 0.000	NA	NA	0	0.000 - 0.000		
SUVA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA		
Bromide	NA	NA	0	0 - 0	NA	NA	0	0 - 0						
TOX	444	87	5	350 - 580	40	11	5	28 - 49						
CHCl3	72.0	7.3	4	66.0 - 82.0	5.8	3.3	5	3.0 - 11.0	Mass Balance					
BDCM	14.5	2.6	4	11.0 - 17.0	4.2	1.6	5	3.0 - 6.0	Closure Errors (%)					
DBCM	1.6	0.5	5	1.0 - 2.0	1.8	1.1	5	0.0 - 3.0	WQP	Count	Avg	SD/RD		
CHBr3	0.0	0.0	5	0.0 - 0.0	0.4	0.9	5	0.0 - 2.0	Alk	5	-1	5		
THM4	88.3	9.9	4	79.0 - 101.0	12.2	5.8	5	7.0 - 19.0	TDS	5	-4	5		
MCAA	7.2	7.7	5	0.0 - 16.0	6.0	8.3	5	0.0 - 17.0	TotHard	5	-4	6		
DCAA	35.0	10.0	5	22.0 - 49.0	2.2	0.4	5	2.0 - 3.0	CaHard	5	-5	4		
TCAA	46.6	15.3	5	26.0 - 61.0	1.0	0.0	5	1.0 - 1.0	Turb	4	-940	2019		
MBAA	0.4	0.9	5	0.0 - 2.0	0.0	0.0	5	0.0 - 0.0	Amm	0	n/a	n/a		
DBAA	0.0	0.0	5	0.0 - 0.0	0.6	0.5	5	0.0 - 1.0	TOC	1	11	n/a		
BCAA	NA	NA	0	NA	NA	NA	0	NA	UV254	0	n/a	n/a		
TBAA	NA	NA	0	NA	NA	NA	0	NA						
CDBAA	NA	NA	0	NA	NA	NA	0	NA	TDS _t	44	-1	2		
DCBAA	NA	NA	0	NA	NA	NA	0	NA	Comments:					
HAA5	89.2	27.9	5	51.0 - 113.0	9.8	8.5	5	3.0 - 21.0						
HAA6	NA	NA	0	NA	NA	NA	0	NA						
HAA9	NA	NA	0	NA	NA	NA	0	NA						
SDS Conditions					Pretreatment Information									
WQP	Avg	SD	Count	Min - Max	Process		Description				Scale			
Res (0)	2.25	1.36	10	0.30 - 5.00	Cartridge filtration		5 mm exclusion size				Pilot-scale			
Temp (°C)	20.0	0.0	10	20.0 - 20.0	Sulfuric acid addition		approx. dose 110 mg/L to pH = 6.0				Pilot-scale			
pH (unit)	7.6	0.0	10	7.6 - 7.6	(or) Flocon 100, anti-scalent		2 ppm				Pilot-scale			
Time (hr)	96.0	0.0	10	96.0 - 96.0										

Mass Balance Errors

Pressure	RPD	SD	Flow	RPD	SD	TDS	RPD	SD
System Inf - Stg 1 Inf	0.0%	0.0%	System Inf - Stg 1 Inf	0.0%	0.0%	System Inf - Stg 1 Inf	0.0%	0.0%
Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	0.0%	0.0%
Stg 1 Conc - Stg 2 Inf	0.0%	0.0%	Stg 1 Conc - Stg 2 Inf	0.0%	0.0%	Stg 1 Conc - Stg 2 Inf	0.0%	0.0%
Sys Perm - Avg Stg Perr	0.0%	0.0%	Sys Perm - Sum Stg Per	0.0%	0.0%	Sys Perm - Avg Stg Perm	-4.0%	2.4%

Stage Summary

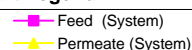
WQP	Stage 1 Influent						Stage 1 Permeate				
	Sys Feed	Sys Conc	Mean	SD	Count	Min/Max	Sys Perm	Mean	SD	Count	Min/Max
Recovery			0.42	0.01	5	0.40 - 0.43					
pH	6.0	6.3	6.0	0.2	5	5.9 - 6.2	5.6	5.5	0.1	5	5.4 - 5.7
Temp	24.0	NA	24.0	0.0	5	24.0 - 24.0	NA	NA	NA	0	0.0 - 0.0
Alk	94	194	94	22	5	76 - 130	35	26	4	5	23 - 32
TDS	320	734	320	7	5	310 - 330	65	44	10	5	34 - 58
TotHard	216	500	216	9	5	210 - 230	41	29	4	5	26 - 34
CaHard	196	456	196	9	5	190 - 210	34	25	2	5	23 - 27
Turb	1.66	1.90	1.66	2	5	0.12 - 4.30	0.17	0.30	0.56	5	0 - 1
TOC	2.7	7.5	2.7	0.4	5	2.1 - 3.0	0.3	0.3	0.0	5	0.3 - 0.3
UV254	NA	NA	NA	NA	0	0.000 - 0.000	NA	NA	NA	0	0.000 - 0.000
SUVA	NA	NA	NA	NA	0	NA	NA	NA	NA	0	NA

WQP	Stage 2 Influent						Stage 2 Permeate				
	Sys Feed	Sys Conc	Mean	SD	Count	Min/Max	Sys Perm	Mean	SD	Count	Min/Max
Recovery			0.37	0.02	5	0.34 - 0.38					
pH	6.0	6.3	5.6	0.2	5	5.4 - 5.9	5.6	6.1	0.2	5	5.9 - 6.4
Temp	24.0	NA	NA	NA	0	0.0 - 0.0	NA	NA	NA	0	0.0 - 0.0
Alk	94	194	136	30	5	100 - 180	35	50	13	5	36 - 68
TDS	320	734	502	28	5	480 - 550	65	94	9	5	78 - 100
TotHard	216	500	330	19	5	310 - 360	41	60	8	5	51 - 72
CaHard	196	456	294	23	5	270 - 330	34	52	6	5	46 - 61
Turb	1.66	1.90	0.99	2	5	0.12 - 3.70	0.17	0.94	1.06	5	0 - 2
TOC	2.7	7.5	4.6	0.5	5	3.7 - 5.2	0.3	0.3	0.1	5	0.3 - 0.5
UV254	NA	NA	NA	NA	0	0.000 - 0.000	NA	NA	NA	0	0.000 - 0.000
SUVA	NA	NA	NA	NA	0.00	NA	NA	NA	NA	0.00	NA

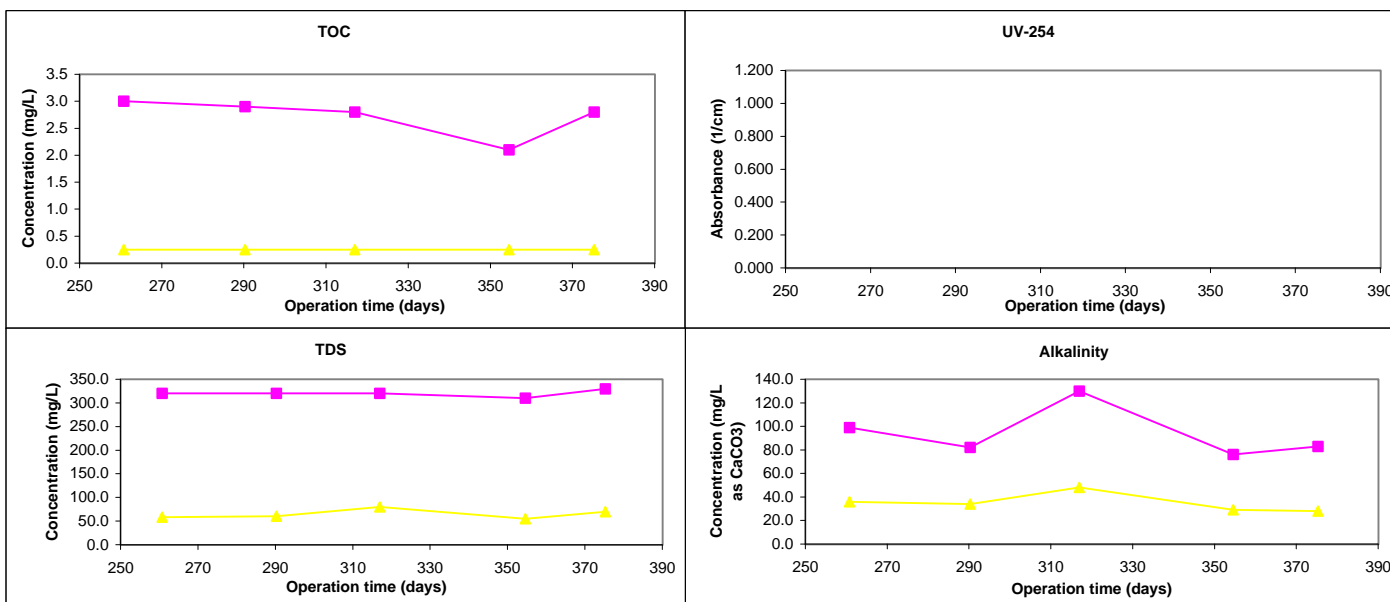
WQP	Stage 3 Influent						Stage 3 Permeate				
	Sys Feed	Sys Conc	Mean	SD	Count	Min/Max	Sys Perm	Mean	SD	Count	Min/Max
Recovery											
pH											
Temp											
Alk											
TDS											
TotHard											
CaHard											
Turb											
TOC											
UV254											
SUVA											

This was only a two stage study.

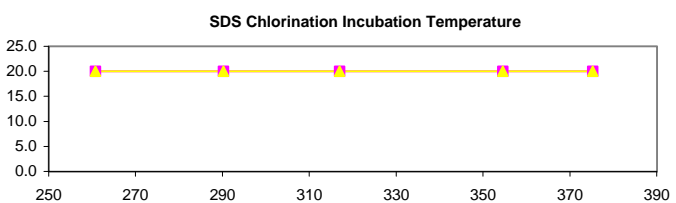
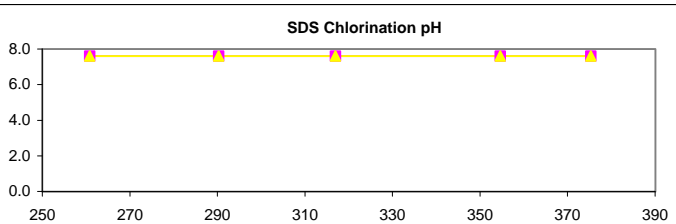
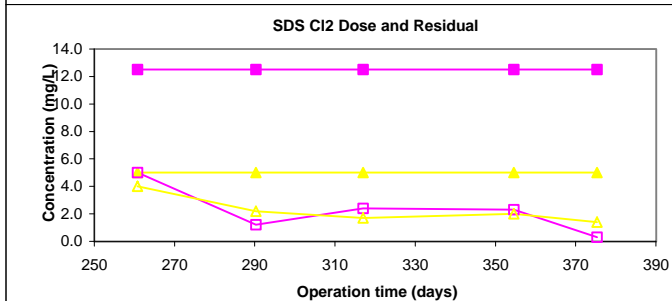
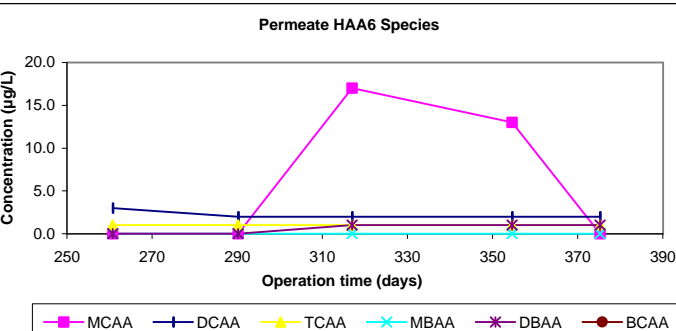
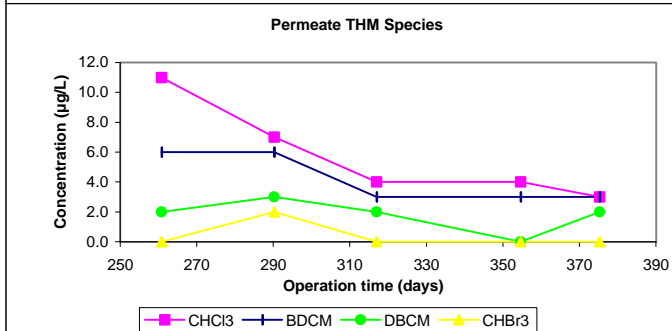
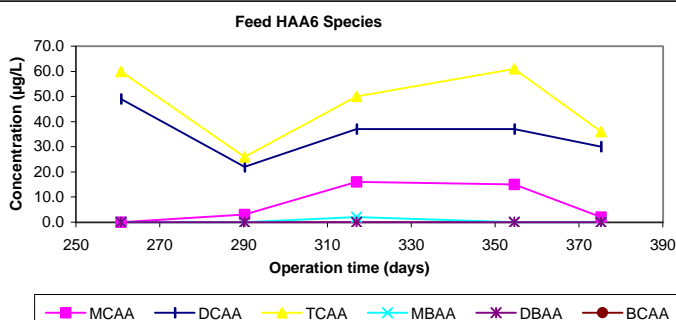
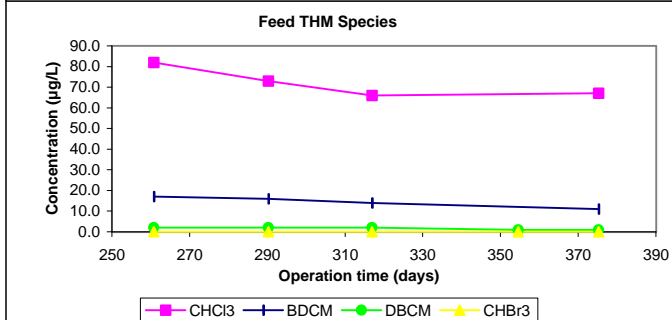
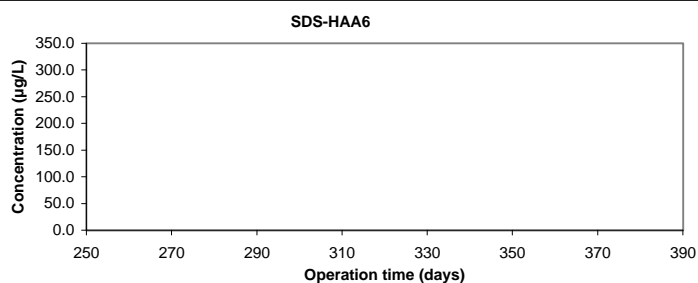
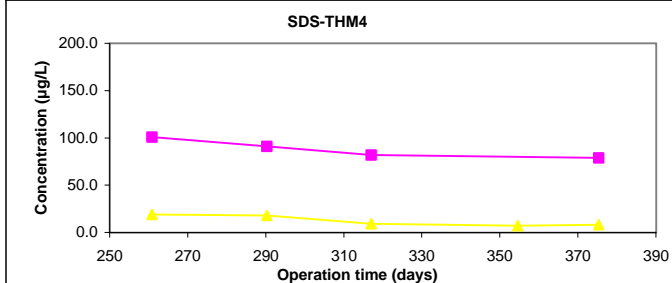
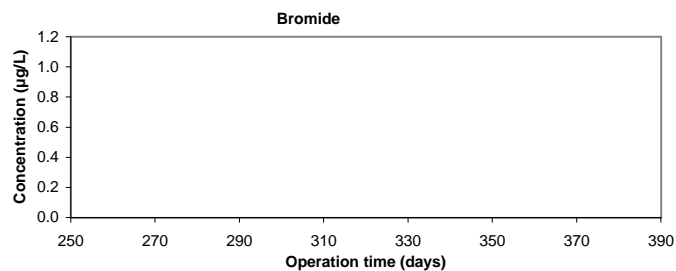
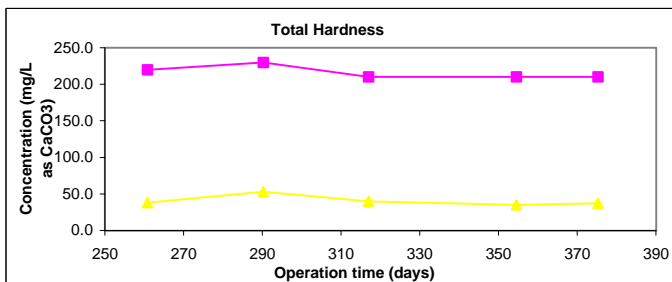
Chart Legend:



Water Quality Parameter Graphs



Water Quality Graphs (Continued)



Productivity Graphs

