ICR TREATMENT STUDY ANALYSIS

Base Analysis and Data Review Comments

Treatment Study ID 4111

Study Protocol Two-Stage Pilot-Scale Membrane Study

Plant ICR Number 283

PWS Name City of Melbourne Water System

City, State, Zip Melbourne, FL 32934

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 4111) was conducted in conjunction with a pilot-scale study (study ID 4011) and a single-element study (study ID 4211). This study was part of a larger study conducted by the University of Central Florida for the USEPA Risk Reduction Engineering Laboratory, published in a report entitled "*Reduction of Disinfection By-Product Precursors by Nanofiltration*" in April 1992 (EPA/600/SR-92/023).

2. The Osmonics Desal DK4040F (formerly known as the Desal DS5) was evaluated during this study, using a surface water source with an average TOC of 20 mg/L. Due to the nature of this raw water source, advanced membrane pretreatment was needed. The resulting integrated membrane system included the following pretreatments: coagulation, sedimentation, rapid sand filtration, pH reduction, and microfiltration. A schematic of this integrated membrane system, including the 4-2 staged array nanofiltration system, is shown in Figure 2 of the Summary Report (Part 2)

3. This system was operated from February through May 1991.

4. Section 1 of the Summary Report (Part 2) lists the significant conclusions and recommendations from this study.

5. Cost information is provided in Section 4 and Tables 15 and 16 of the Summary Report (Part 2).

Water Quality Comments:

1. One water quality outlier was identified and removed prior to base analysis.

2. The reported target SDS conditions during this study were to dose and incubate the samples at 22°C, for 96 hours at a pH of 7.6, with a target residual of 0.2 mg/L. However, the chlorination procedure was more similar to a Formation Potential test, than a SDS test, since only a measurable residual (i.e., above 0.2 mg/L) after 96 hours was necessary for DBPs to be analyzed from that sample. No measured residuals were reported during this study – only the presence of a residual.

3. The following parameters were not measured during this study: ammonia, UV_{254}, bromide, and BCAA (thus HAA6).

Productivity Comments:

1. Three productivity outliers were identified and removed prior to base analysis.

2. This membrane system was operated between 10 and 15 gfd, at recoveries ranging from 45 to 65%. The experimental design for this study (denoted as the AC-DS5) is listed in Table 7 (Part 2).

3. The membrane system was cleaned every 2 to 4 weeks, as needed, with a phosphate detergent and NaOH solution.

4. During productivity analysis, the average slope and cleaning interval were calculated to be -2.33×10^{-3} gfd/psi/day and 65 days, respectively. This slope is similar to the average slope and reported by the researchers: -1.72×10^{-3} gfd/psi/day (the cleaning interval calculated from this slope is 73 days).

City of Melbourne Water System | **Pilot-Scale Membrane Treatment Study Summary** | **Session:** 1

ICR Information

ID / ICR#:	FL3051447 / 283
ICR Contact:	Mr. Ralph Sigman
Phone No.:	(407) 255-4623
Period:	2/3/91 - 4/14/91 (70 days)

Membrane Information

Manufacturer:	Osmonics Desal
Trade Name:	DS5
Membrane Model:	DK4040F
MWCO:	150 - 300 Daltons
Element Size:	4" X 40"
Element Area:	90.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	100.0 psi
Mfr. MTC_W:	0.200 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	12.0 gpm
Minimum Flow:	6.3 gpm
Total Width :	16.0 ft
Feed Spacer Thickness:	0.0028 ft
840 Element Area	350.0 ft^2
840 Purchase Price:	$1,500

Design Parameters

Norm Temp:	24.5 ^oC
Temp Norm MTC-w:	0.197 TavgC
Design Recovery:	0.65
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:	3.0 psi
Osmotic P Stage 2:	6.0 psi
Osmotic P Stage 3:	NA

Water Quality Summary

	Feed (System)				Permeate (System)				Concentrate (System)			
Summary	**Mean**	**SD**	**Count**	**Min/Max**	**Mean**	**SD**	**Count**	**Min/Max**	**Mean**	**SD**	**Count**	**Min/Max**
pH	6.0	2.2	3	3.5 - 7.3	2.9	0.3	3	2.7 - 3.3	4.1	1.3	3	3.2 - 5.5
Temp	19.6	1.4	3	18.3 - 21.1	19.6	1.4	3	18.3 - 21.1	19.6	1.4	3	18.3 - 21.1
Alk	NA	NA	0	0 - 0	0	0	3	0 - 0	3	5	3	0 - 9
TDS	**477**	**21**	**3**	**460 - 500**	**143**	**21**	**3**	**120 - 160**	**870**	**225**	**3**	**650 - 1100**
TotHard	200	10	3	190 - 210	21	6	3	14 - 26	407	100	3	310 - 510
CaHard	147	6	3	140 - 150	13	3	3	9 - 15	323	75	3	250 - 400
Turb	0.33	0.2	3	0.20 - 0.60	0.00	0.0	3	0.00 - 0.00	15.13	25.9	3	0.20 - 45.00
Amm	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	0.0 - 0.0
TOC	**7.6**	**1.8**	**3**	**6.2 - 9.7**	**0.4**	**0.3**	**3**	**0.3 - 0.8**	**15.0**	**5.2**	**3**	**12.0 - 21.0**
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	**1250**	**328**	**3**	**950 - 1600**	**73**	**1**	**3**	**73 - 74**				
CHCl3	156.7	45.1	3	110.0 - 200.0	4.0	0.0	3	4.0 - 4.0	**Mass Balance**			
BDCM	92.3	4.0	3	88.0 - 96.0	10.7	1.2	3	10.0 - 12.0	**Closure Errors (%)**			
DBCM	43.0	5.2	3	40.0 - 49.0	20.0	2.6	3	18.0 - 23.0	WQP	Count	Avg	SD/RD
CHBr3	14.0	2.6	3	11.0 - 16.0	14.0	1.0	3	13.0 - 15.0	Alk	0	n/a	n/a
THM4	**306.0**	**37.0**	**3**	**270.0 - 344.0**	**48.7**	**4.6**	**3**	**46.0 - 54.0**	TDS	3	-7	9
MCAA	15.3	5.0	3	10.0 - 20.0	7.7	5.0	3	3.0 - 13.0	TotHard	3	-7	6
DCAA	112.7	16.2	3	98.0 - 130.0	3.7	0.6	3	3.0 - 4.0	CaHard	3	0	5
TCAA	120.0	10.0	3	110.0 - 130.0	1.0	0.0	3	1.0 - 1.0	Turb	0	n/a	n/a
MBAA	4.3	1.5	3	3.0 - 6.0	0.7	0.6	3	0.0 - 1.0	Amm	0	n/a	n/a
DBAA	11.0	2.0	3	9.0 - 13.0	5.7	0.6	3	5.0 - 6.0	TOC	2	-8	10
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	TDSt	2	-6	14
DCBAA	NA	NA	0	NA	NA	NA	0	NA	**Comments:**			
HAA5	**263.3**	**26.3**	**3**	**243.0 - 293.0**	**18.7**	**5.0**	**3**	**14.0 - 24.0**				
HAA6	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	0.20	0.00	6	0.20 - 0.20
Temp (^oC)	22.0	0.0	6	22.0 - 22.0
pH (unit)	7.6	0.0	6	7.6 - 7.6
Time (hr)	96.0	0.0	6	96.0 - 96.0

Pretreatment Information

Process	**Description**	**Scale**
Alum Coagulation	Aluminum sulfate dose: 151.4 mg/L	Full-scale
Sedimentation	Circular clarifier	Full-scale
Dual Media Filtration	Sand/anthracite	Full-scale
Sulfuric Acid Feed	Approx. 85 mg/L to pH 3.5 to 4.5	Pilot-scale
Microfiltration	5um filter Filter Specialists Bag Filter	Pilot-scale

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 Perm	5.6%	1.9%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	**-17.5%**	**16.5%**

Stage Summary

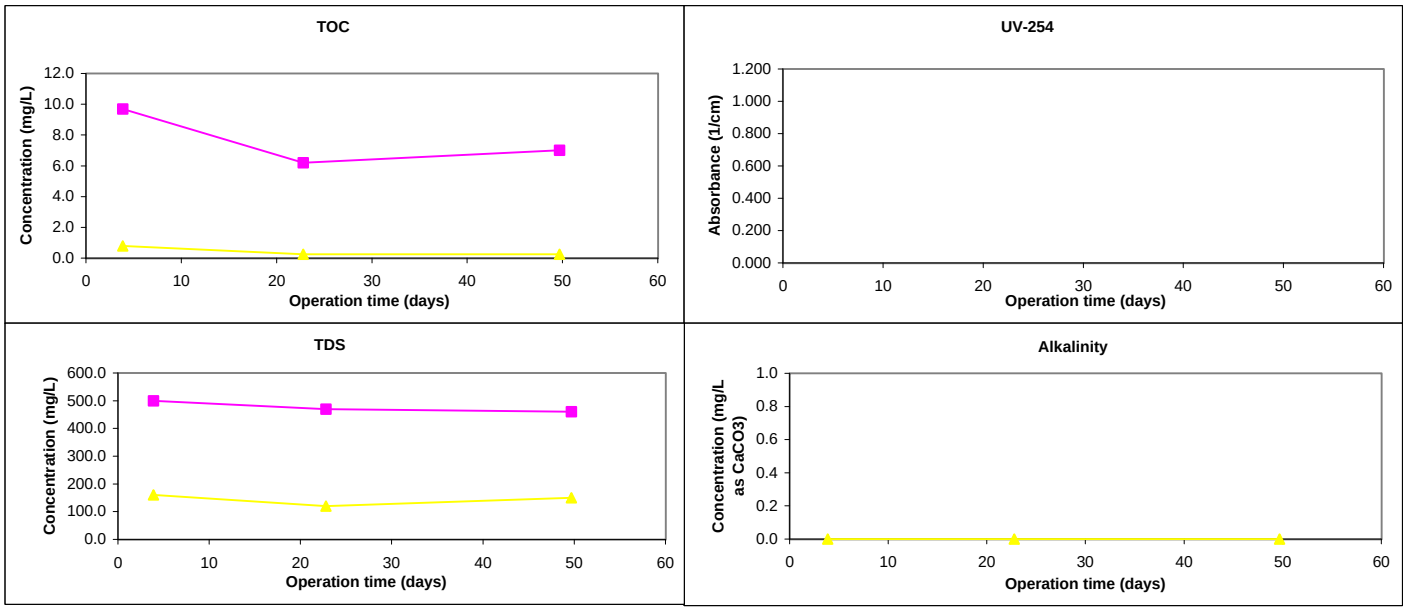
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.35**	**0.07**	**3**	**0.27 - 0.41**					
pH	6.0	4.1	6.0	2.2	3	3.5 - 7.3	2.9	3.6	0.1	3	3.5 - 3.6
Temp	19.6	19.6	19.6	1.4	3	18.3 - 21.1	19.6	19.6	1.4	3	18.3 - 21.1
Alk	NA	3	NA	NA	0	0 - 0	0	0	0	3	0 - 0
TDS	**477**	**870**	477	**21**	**3**	**460 - 500**	**143**	**170**	**62**	**3**	**120 - 240**
TotHard	200	407	200	10	3	190 - 210	21	20	2	3	19 - 22
CaHard	147	323	147	6	3	140 - 150	13	14	2	3	12 - 16
Turb	0.33	15.13	0.33	0	3	0.20 - 0.60	0.00	0.00	0.00	3	0 - 0
TOC	**7.6**	**15.0**	7.6	**1.8**	**3**	**6.2 - 9.7**	**0.4**	**0.4**	**0.3**	**3**	**0.3 - 0.7**
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			**0.30**	**0.09**	**3**	**0.19 - 0.35**					
pH	6.0	4.1	3.7	0.1	3	3.6 - 3.8	2.9	3.5	0.2	3	3.3 - 3.7
Temp	19.6	19.6	19.6	1.4	3	18.3 - 21.1	19.6	19.6	1.4	3	18.3 - 21.1
Alk	NA	3	**0**	0	3	0 - 0	0	0	0	3	0 - 0
TDS	**477**	**870**	647	**85**	**3**	**560 - 730**	**143**	**180**	**46**	**3**	**130 - 220**
TotHard	200	407	280	36	3	250 - 320	21	25	9	3	17 - 34
CaHard	147	323	220	26	3	200 - 250	13	15	5	3	**11 - 21**
Turb	0.33	15.13	2.57	4	3	0.00 - 7.60	0.00	0.00	0.00	3	0 - 0
TOC	**7.6**	**15.0**	12.0	**2.0**	**3**	**10.0 - 14.0**	**0.4**	**0.9**	**0.9**	**3**	**0.3 - 2.0**
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

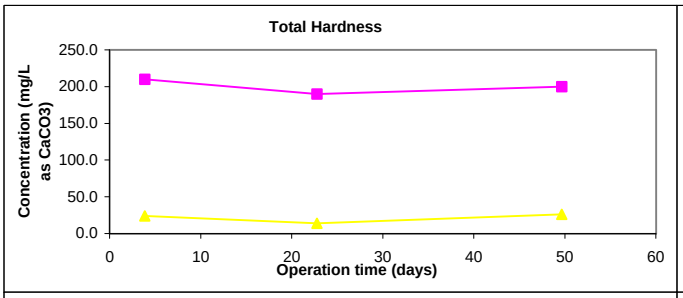
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage study.					
TDS											
TotHard											
CaHard											
Turb											
TOC											
UV254											
SUVA											

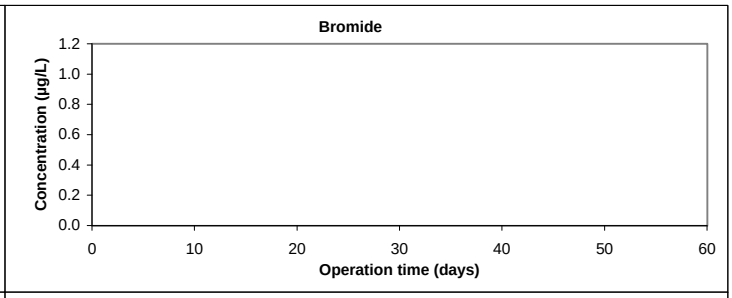
Chart Legend:
Feed (System)
Permeate (System)

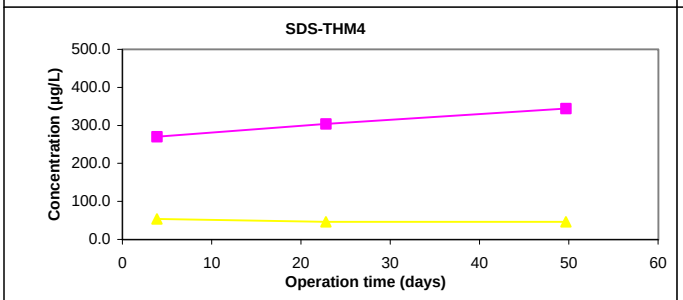
Water Quality Parameter Graphs

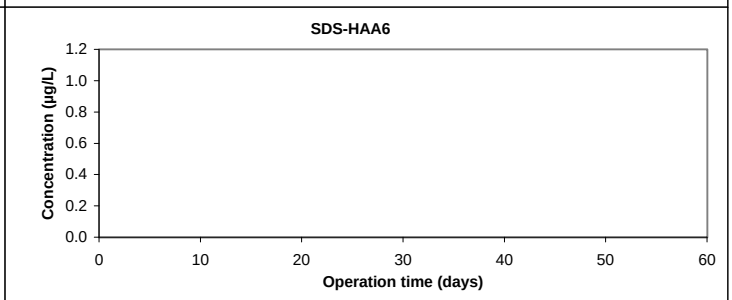


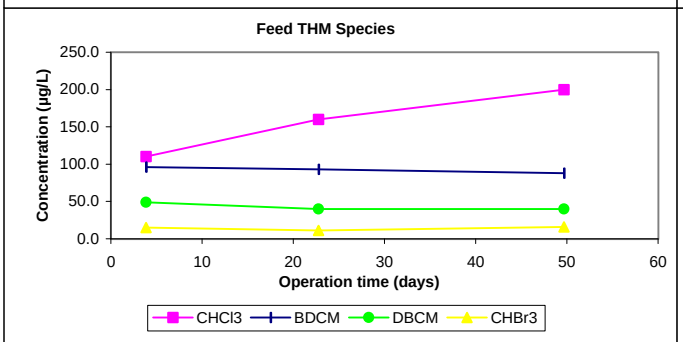
Water Quality Graphs (Continued)

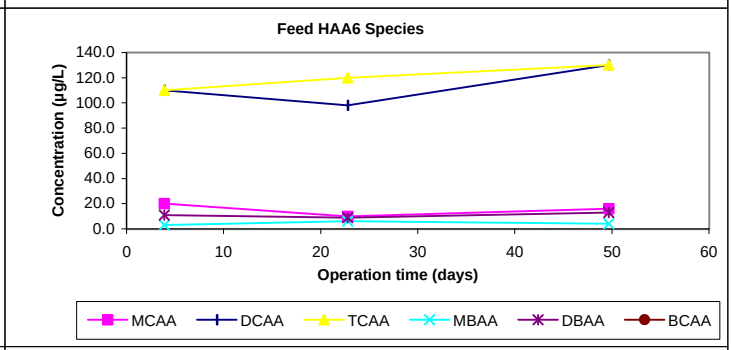


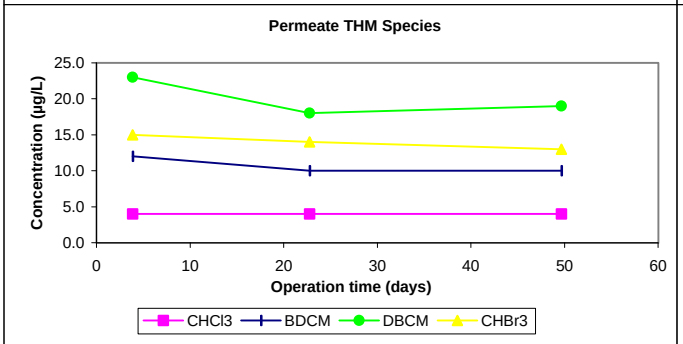


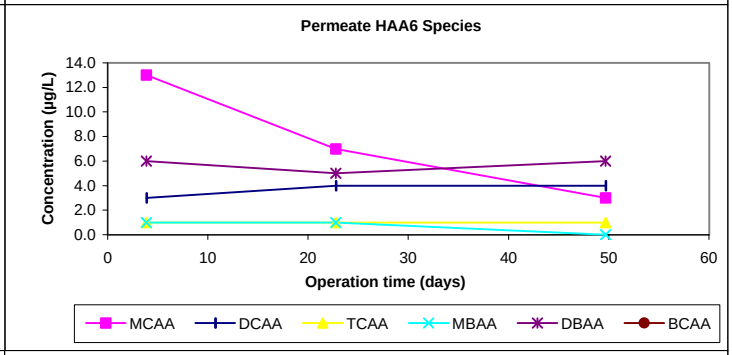


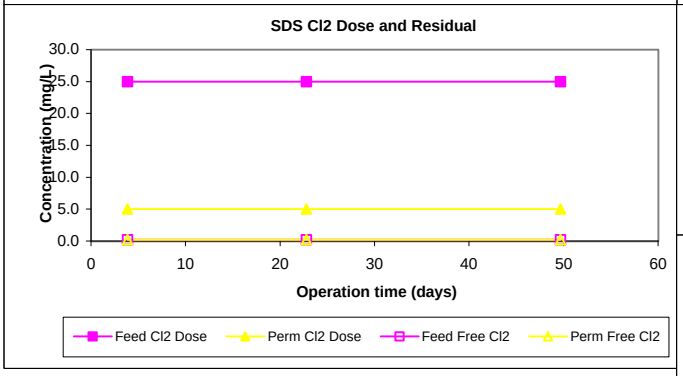


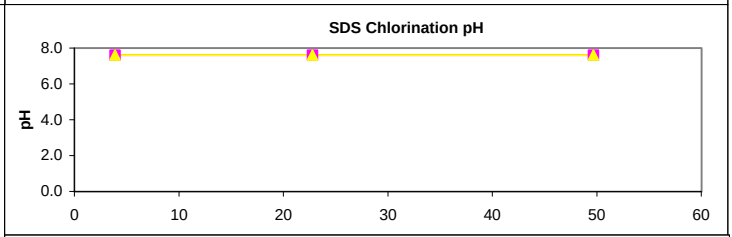


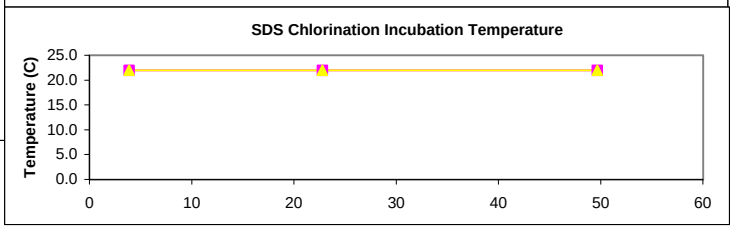




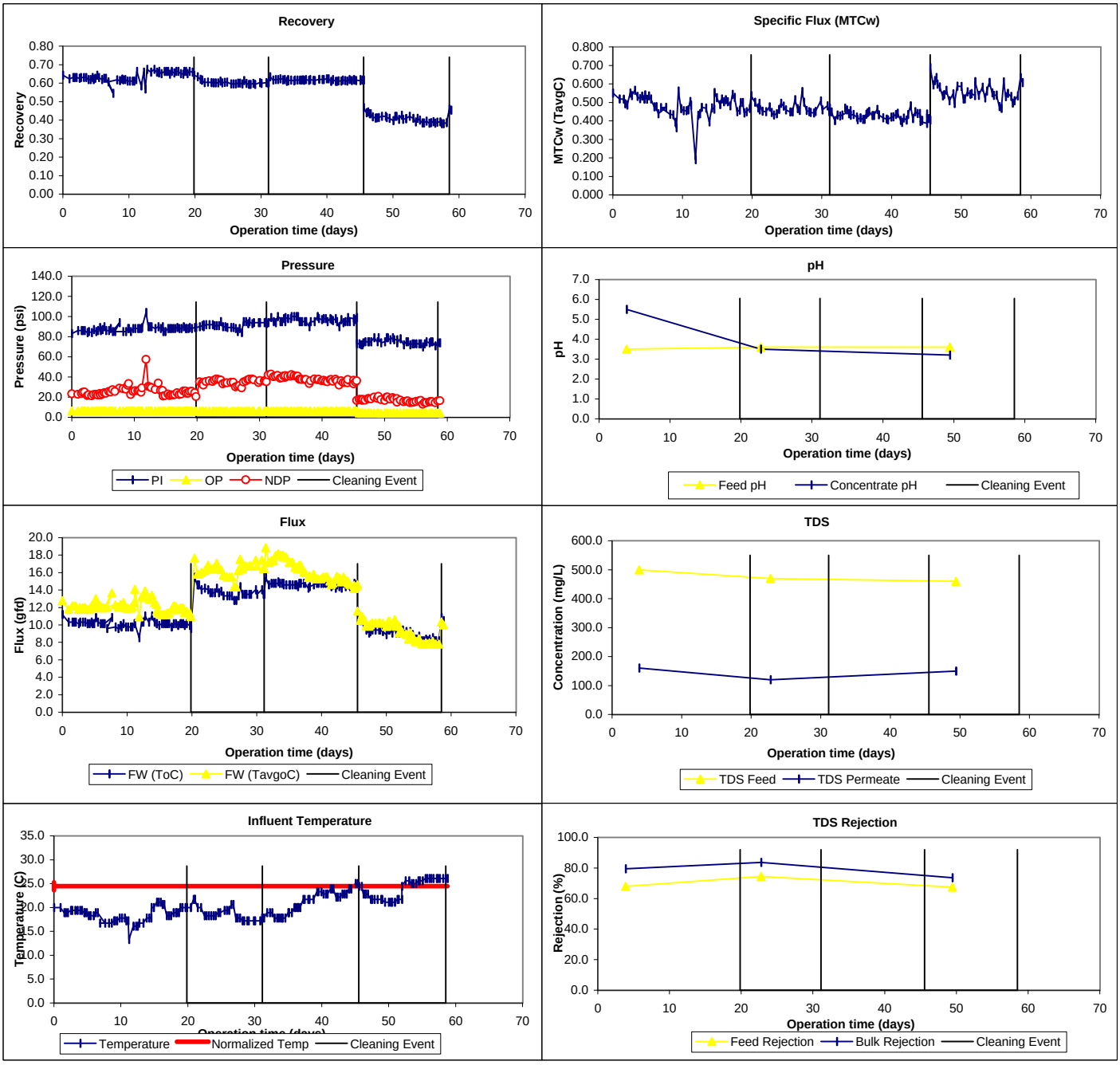








Productivity Graphs



City of Melbourne Water System | **Pilot-Scale Membrane Treatment Study Summary** | **Session:** 2

ICR Information

ID / ICR#:	FL3051447 / 283
ICR Contact:	Mr. Ralph Sigman
Phone No.:	(407) 255-4623
Period:	4/15/91 - 5/26/91 (41 days)

Membrane Information

Manufacturer:	Osmonics Desal
Trade Name:	DS5
Membrane Model:	DK4040F
MWCO:	150 - 300 Daltons
Element Size:	4" X 40"
Element Area:	90.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	100.0 psi
Mfr. MTC_w:	0.200 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	12.0 gpm
Minimum Flow:	6.3 gpm
Total Width :	16.0 ft
Feed Spacer Thickness:	0.0028 ft
840 Element Area	350.0 ft^2
840 Purchase Price:	$1,500

Design Parameters

Norm Temp:	24.5 ^oC
Temp Norm MTC-w:	0.197 TavgC
Design Recovery:	0.65
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:	3.0 psi
Osmotic P Stage 2:	6.0 psi
Osmotic P Stage 3:	NA

Water Quality Summary

	Feed (System)				Permeate (System)				Concentrate (System)			
Summary	**Mean**	**SD**	**Count**	**Min/Max**	**Mean**	**SD**	**Count**	**Min/Max**	**Mean**	**SD**	**Count**	**Min/Max**
pH	7.3	NA	1	7.3 - 7.3	4.4	NA	1	4.4 - 4.4	4.4	NA	1	4.4 - 4.4
Temp	27.8	NA	1	27.8 - 27.8	27.8	NA	1	27.8 - 27.8	27.8	NA	1	27.8 - 27.8
Alk	NA	NA	0	0 - 0	0	NA	1	0 - 0	0	NA	1	0 - 0
TDS	**410**	**NA**	**1**	**410 - 410**	**220**	**NA**	**1**	**220 - 220**	**590**	**NA**	**1**	**590 - 590**
TotHard	180	NA	1	180 - 180	44	NA	1	44 - 44	280	NA	1	280 - 280
CaHard	130	NA	1	130 - 130	34	NA	1	34 - 34	210	NA	1	210 - 210
Turb	0.20	NA	1	0.20 - 0.20	0.00	NA	1	0.00 - 0.00	0.20	NA	1	0.20 - 0.20
Amm	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	0.0 - 0.0
TOC	**9.0**	**NA**	**1**	**9.0 - 9.0**	**0.6**	**NA**	**1**	**0.6 - 0.6**	**15.0**	**NA**	**1**	**15.0 - 15.0**
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	**1200**	**NA**	**1**	**1200 - 1200**	**77**	**NA**	**1**	**77 - 77**				
CHCl3	210.0	NA	1	210.0 - 210.0	4.0	NA	1	4.0 - 4.0				
BDCM	77.0	NA	1	77.0 - 77.0	12.0	NA	1	12.0 - 12.0				
DBCM	26.0	NA	1	26.0 - 26.0	21.0	NA	1	21.0 - 21.0				
CHBr3	10.0	NA	1	10.0 - 10.0	12.0	NA	1	12.0 - 12.0				
THM4	**323.0**	**NA**	**1**	**323.0 - 323.0**	**49.0**	**NA**	**1**	**49.0 - 49.0**				
MCAA	8.0	NA	1	8.0 - 8.0	3.0	NA	1	3.0 - 3.0				
DCAA	98.0	NA	1	98.0 - 98.0	5.0	NA	1	5.0 - 5.0				
TCAA	140.0	NA	1	140.0 - 140.0	1.0	NA	1	1.0 - 1.0				
MBAA	3.0	NA	1	3.0 - 3.0	0.0	NA	1	0.0 - 0.0				
DBAA	9.0	NA	1	9.0 - 9.0	8.0	NA	1	8.0 - 8.0				
BCAA	NA	NA	0	NA	NA	NA	0	NA				
TBAA	NA	NA	0	NA	NA	NA	0	NA				
CDBAA	NA	NA	0	NA	NA	NA	0	NA				
DCBAA	NA	NA	0	NA	NA	NA	0	NA				
HAA5	**258.0**	**NA**	**1**	**258.0 - 258.0**	**17.0**	**NA**	**1**	**17.0 - 17.0**				
HAA6	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	0	n/a	n/a
TDS	1	5	n/a
TotHard	1	-2	n/a
CaHard	1	2	n/a
Turb	0	n/a	n/a
Amm	0	n/a	n/a
TOC	1	-4	n/a
UV254	0	n/a	n/a
TDSt	1	5	#DIV/0!

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	0.20	0.00	2	0.20 - 0.20
Temp (^oC)	22.0	0.0	2	22.0 - 22.0
pH (unit)	7.6	0.0	2	7.6 - 7.6
Time (hr)	96.0	0.0	2	96.0 - 96.0

Pretreatment Information

Process	**Description**	**Scale**
Alum Coagulation	Aluminum sulfate dose: 151.4 mg/L	Full-scale
Sedimentation	Circular clarifier	Full-scale
Dual Media Filtration	Sand/anthracite	Full-scale
Sulfuric Acid Feed	Approx. 85 mg/L to pH 3.5 to 4.5	Pilot-scale
Microfiltration	5um filter Filter Specialists Bag Filter	Pilot-scale

Mass Balance Errors

Pressure	**RPD**	**SD**	**Flow**	**RPD**	**SD**	**TDS**	**RPD**	**SD**
System Inf - Stg 1 Inf	0.1%	1.3%	System Inf - Stg 1 Inf	0.0%	0.0%	System Inf - Stg 1 Inf	0.0%	#DIV/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%	#DIV/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%	#DIV/0!
Sys Perm - Avg Stg Perm	10.0%	3.4%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	-6.6%	#DIV/0!

Stage Summary

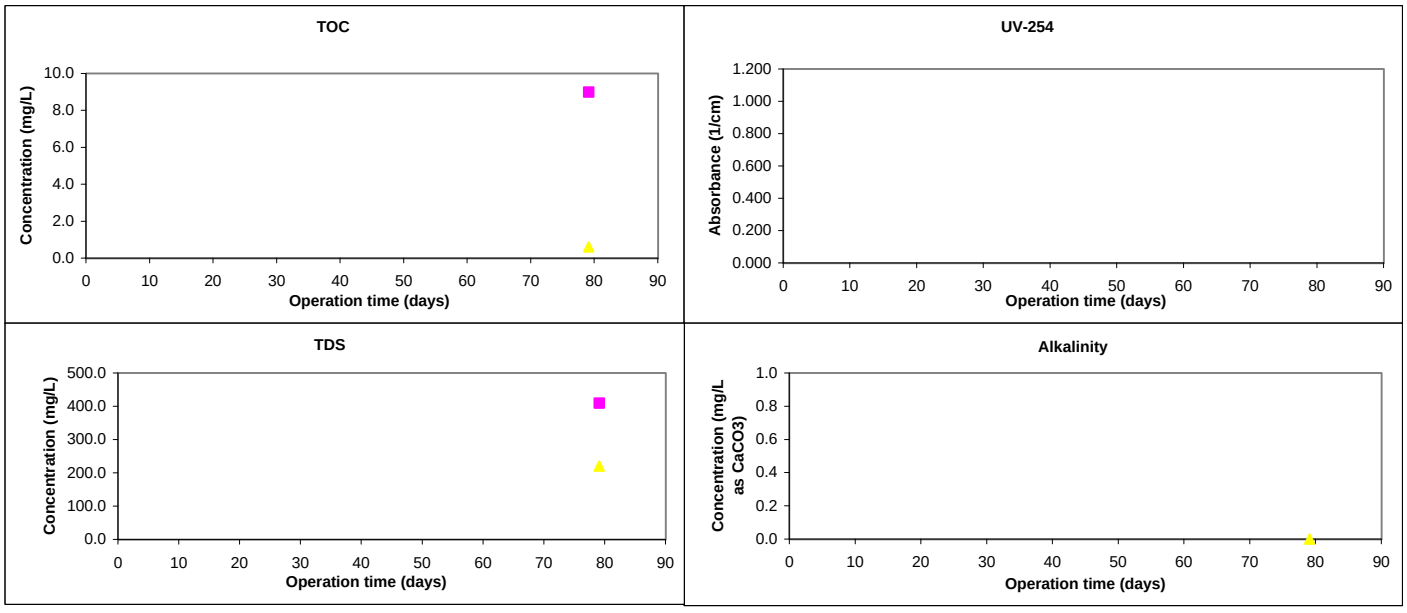
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.30**	**NA**	**1**	**0.30 - 0.30**					
pH	7.3	4.4	7.3	NA	1	7.3 - 7.3	4.4	4.5	NA	1	4.5 - 4.5
Temp	27.8	27.8	27.8	NA	1	27.8 - 27.8	27.8	27.8	NA	1	27.8 - 27.8
Alk	NA	0	NA	NA	0	0 - 0	0	0	NA	1	0 - 0
TDS	**410**	**590**	410	**NA**	**1**	**410 - 410**	**220**	**200**	**NA**	**1**	**200 - 200**
TotHard	180	280	180	NA	1	180 - 180	44	36	NA	1	36 - 36
CaHard	130	210	130	NA	1	130 - 130	34	29	NA	1	29 - 29
Turb	0.20	0.20	0.20	NA	1	0.20 - 0.20	0.00	0.00	NA	1	0 - 0
TOC	**9.0**	**15.0**	9.0	**NA**	**1**	**9.0 - 9.0**	**0.6**	**0.5**	**NA**	**1**	**0.5 - 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	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			**0.21**	**NA**	**1**	**0.21 - 0.21**					
pH	7.3	4.4	4.4	NA	1	4.4 - 4.4	4.4	4.7	NA	1	4.7 - 4.7
Temp	27.8	27.8	27.8	NA	1	27.8 - 27.8	27.8	27.8	NA	1	27.8 - 27.8
Alk	NA	0	0	NA	1	0 - 0	0	0	NA	1	0 - 0
TDS	**410**	**590**	520	**NA**	**1**	**520 - 520**	**220**	**270**	**NA**	**1**	**270 - 270**
TotHard	180	280	220	NA	1	220 - 220	44	61	NA	1	61 - 61
CaHard	130	210	170	NA	1	170 - 170	34	50	NA	1	50 - 50
Turb	0.20	0.20	**0.30**	NA	1	0.30 - 0.30	0.00	0.00	NA	1	0 - 0
TOC	**9.0**	**15.0**	12.0	**NA**	**1**	**12.0 - 12.0**	**0.6**	**0.8**	**NA**	**1**	**0.8 - 0.8**
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

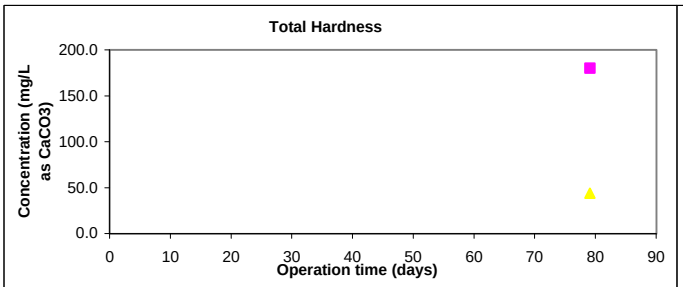
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard											
Turb											
TOC											
UV254											
SUVA											

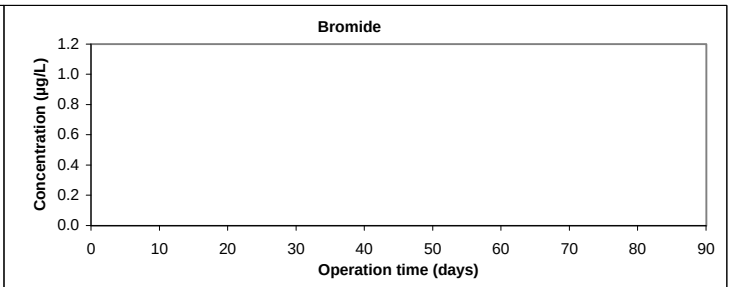
Chart Legend:
Feed (System)
Permeate (System)

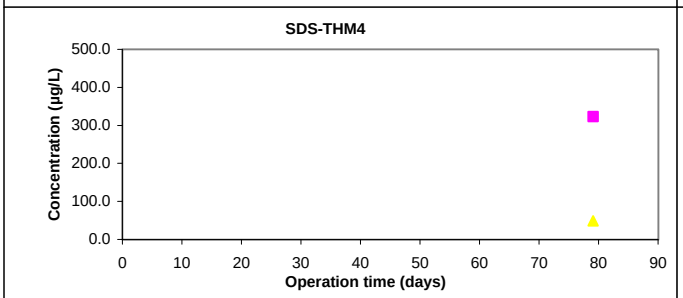
Water Quality Parameter Graphs

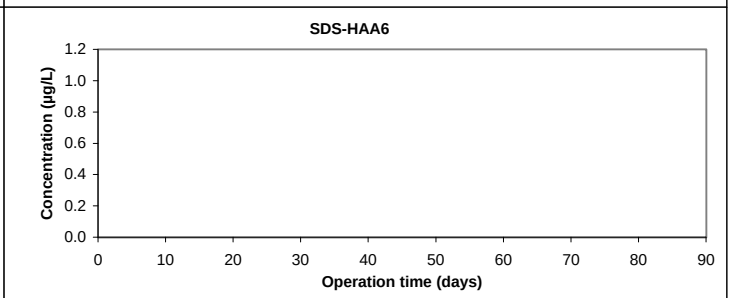


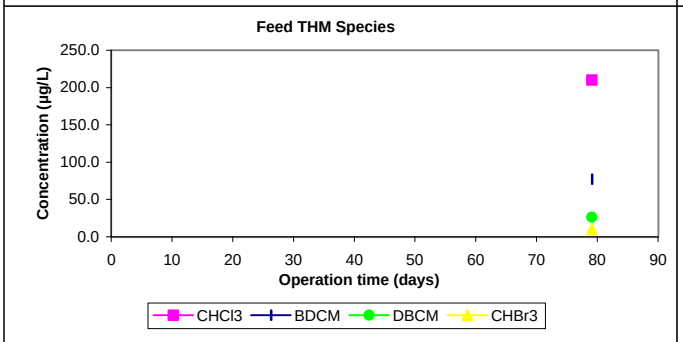
Water Quality Graphs (Continued)

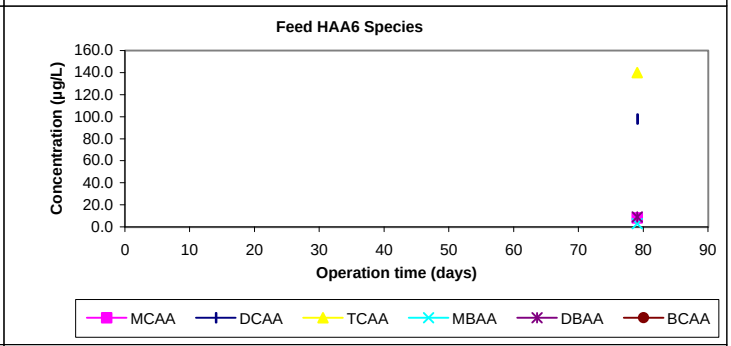


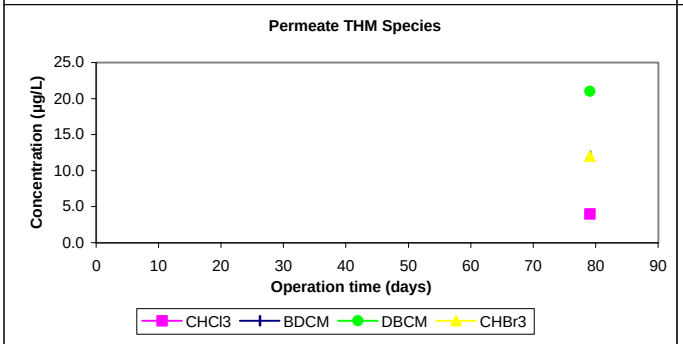


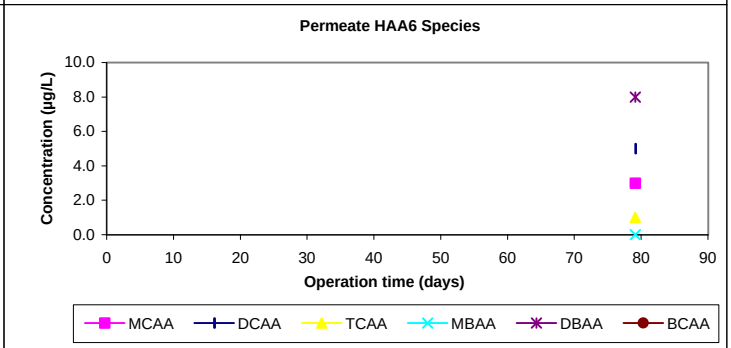


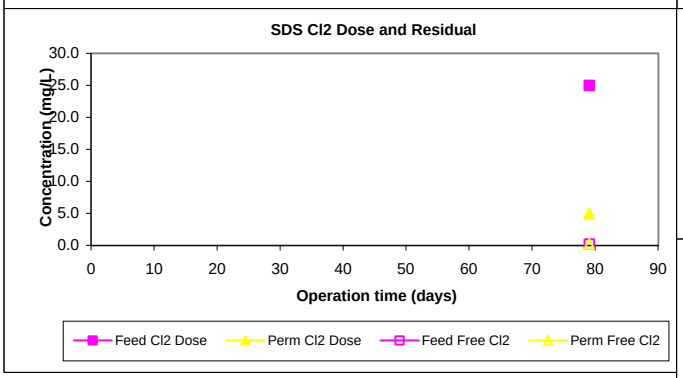


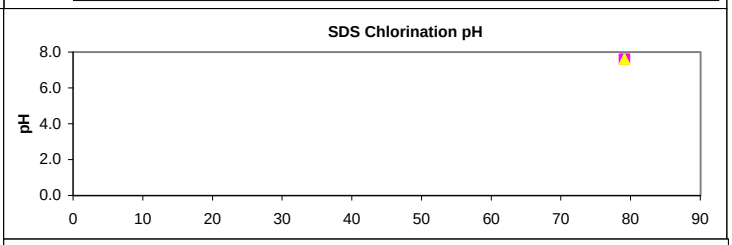


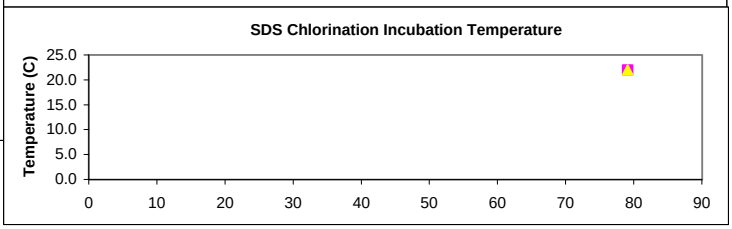












Productivity Graphs