ICR Treatment Study Summary Report

Evaluation of Membrane Technology Using A Pilot Scale System for Compliance with the Information Collection Rule

Conducted during the period of July 16, 1997 through October 26, 1998

Prepared by:

Environmental Systems Engineering Institute
Department of Civil and Environmental Engineering
University of Central Florida
Orlando, FL. 32816
Dr. James Taylor, PhD

FOR

Tampa Water Department
7125 N. 30th Street
Tampa, Florida 33610

In June 1999

PWSID# FL6290327
Plant ICR # 311

Attachments: Three (3) *diskettes containing the Data Collection Spreadsheets*

CITY OF TAMPA Water Department

Production Division

October 4, 1999

Steven C. Allgeier
ICR Treatment Study Coordinator
U.S. Environmental Protection Agency
Technical Support Center (MS140)
26 West Martin Luther King Drive
Cincinnati, OH. 45268

Dear Mr. Allgeier,

Pleased find enclosed a floppy diskette containing a revised copy of the ICR Treatment Study Summary Report which has been revised a second time to include QA/QC data on TOX and UV254. These analyses were performed by Jim Taylor's group at UCF, and the QA/QC data was not available on the last revised spreadsheet sent you on September 30, 1999. I have also included a NF productivity summary for the ICR report period. This table was in the original ICR Treatment Report text on page 19, however, it was not delineated by run hours. I had Robert Riess include run hours to show cutoff periods between experiments. This should help explain some of the confusion in trending of the spreadsheet data, as experimental conditions were changed frequently. This pilot study was very extensive and difficult to review under the confines of the ICR protocol. A final research project report from Dr. Taylor is currently under PAC review in EPA and should be available early next year. I believe this extensive report will fill in all the gaps.

Should you have any questions feel free to contact me at 813-231-5255.

Sincerely,

James M. Gianatasio,
Plant Operations Supervisor

7125 N. 30th Street ● Tampa, Florida 33610 ● Ph. 813/231-5238
● Fax 813/231-5283

Table 2. NF productivity summary.

Nanofilter	Pretreatment	Experiment	Date	Operational Time (hours)	Week No.	NF Flux (gfd)	NF Recovery (%)	NH_2Cl?	Cleaning cycle (days)
CALP (NF1)	CSF	1	7/16/97-7/24	0-179	1-10	7	65	No	156
		2	9/3/97-9/9	179-317	1-10	7	65	No	No fouling
		3	9/10/97-9/17	341-511	1-10	7	85	No	No fouling
		4	9/18/97-9/23	543-653	1-10	14	60	No	416
		5	9/24/97-9/30	677-821	11-20	14	75	No	No fouling
	ZMF	1	10/1/97-10/9	846-1035	11-20	7	65	No	NF failure
		2	11/5/97-11/12	1035-1200	11-20	7	65	No	NF failure
		3	1/21/98-2/9	1171-1546	21-30	7	65	Yes	125
		4	2/11/98-3/2	1353-1796	31-40	7	85	Yes	31
		5	3/3/98-3/18	1823-2157	31-40	7	65	Yes	No fouling
		6	3/19/98-3/30	2181-2440	31-40	7	85	Yes	30
		7	3/31/98-4/9	2465-2752	31-40	14	75	Yes	26
		8	4/13/98-4/27	2873-3189	31-40	14	85	Yes	69
	MMF	1	4/28/98-5/11	3213-3525	41-50	7	65	Yes	54
		2	5/12/98-5/26	3549-3805	41-50	7	85	Yes	No fouling
		3	5/27/98-6/10	3830-4161	41-50	14	75	Yes	No fouling
		4	6/11/98-6/24	4185-4436	41-50	14	85	Yes	123
	C/ZMF	1	6/25/98-7/7	4435-4430	41-50	7	65	Yes	59
		2	7/8/98-7/20	4430-4427	41-50	7	85	Yes	107
		3	DATA NOT	PROVIDED		14	75	Yes	22
		4	DATA NOT	PROVIDED		14	85	Yes	No fouling
		5	DATA NOT	PROVIDED		14	85	Yes	No fouling
		6	DATA NOT	PROVIDED		14	90	Yes	No fouling
		7	DATA NOT	PROVIDED		14	90	Yes	No fouling
	C/MMF	1	DATA NOT	PROVIDED		7	65	Yes	56
		2	DATA NOT	PROVIDED		7	85	Yes	13

Table 1. NF productivity summary.

Nanofilter	Pretreatment	Experiment	Date	Operational Time (hours)	Week No.	NF Flux (gfd)	NF Recovery (%)	NH_2Cl?	Cleaning cycle (days)
ESNA (NF2)	CSF	1	7/17/97-8/5	28-388	1-10	7	65	No	13
		2	8/7/97-8/20	391-693	1-10	7	65	No	No fouling
		3	8/21/97-9/2	718-1002	1-10	7	85	No	24
		4	9/3/97-9/17	1024-1357	1-10	14	65	No	34
		5	9/18/97-9/30	1389-1667	11-20	14	85	No	20
LFC1 (NF2)	MMF	1	3/4/98-3/18	3858-4185	31-41	7	65	No	8
		2	3/19/98-3/26	4208-4373	31-41	7	85	No	5
		3	3/26/98-3/30	4373-4464	31-41	7	85	No	4
		4	3/31/98-4/2	4485-4630	31-41	14	65	No	15
		5	4/2/98-4/7/98	4532-4630	31-41	14	65	No	9
		6	4/8/98-4/14	4633-4744	31-41	14	65	No	5
		7	4/15/98-4/20	4768-4883	31-41	14	85	No	2
		8	4/20/98-4/21	4883-4900	31-41	14	85	Yes	5
		9	4/21/98-4/27	4900-5038	31-41	14	85	Yes	5
	ZMF	1	4/28/98-5/11	5062-5374	42-51	7	65	Yes	No fouling
		2	5/12/98-5/26	5398-5707	42-51	7	85	Yes	21
		3	5/27/98-6/8	5726-5971	42-51	14	75	Yes	No fouling
		4	6/11/98-6/22	5996-6220	42-51	14	85	Yes	5
		5	DATA NOT	PROVIDED		7	65	No	No fouling
		6	DATA NOT	PROVIDED		14	85	No	3
	CSF	1	6/25/98-7/7	6292-6576	42-51	7	65	No	No fouling
		2	7/8/98-7/20	6601-6876	42-51	14	85	No	20
		3	DATA NOT	PROVIDED		7	65	Yes	99
		4	DATA NOT	PROVIDED		14	85	Yes	No fouling
	C/MMF	1	DATA NOT	PROVIDED		14	85	No	80
		2	DATA NOT	PROVIDED		14	85	Yes	8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268
Office of Ground Water and Drinking Water
Technical Support Center

October 28, 1999

Mike Bennett
Tampa Water Department
7125 N. 30th Street
Tampa, FL 33610

Re: DBP data form ICR Membrane Treatment Study for PWSID# FL6290327, Plant ICR# 311

Dear Mr. Bennett:

EPA has received your responses to our review comments on your ICR membrane treatment study. Your response to our comments was thorough and has addressed most of our concerns. However, one major outstanding issue is the inconsistent DBP results from the SDS tests. Some examples of these inconsistencies follow:

1. During quarters 3 and 4 of testing with the Fluid Systems membrane, the feed HAA6 results were significantly higher than the feed THM4 and TOX results. In all other ICR treatment study data sets, the HAA6 concentrations were much closer to the THM4 concentrations and always lower than the TOX concentrations. We suspect either an error in reporting the HAA results or a problem with the HAA analysis.
2. During quarter 4 of testing with the Fluid Systems membrane, the feed THM4 concentrations are significantly higher than the THM4 concentrations reported for quarters 3 and 5.
3. During quarter 5 of testing with the Fluid Systems membrane, there are cases in which the THM4 and HAA6 concentrations are greater than the TOX concentrations. This should not occur since THM4 and HAA6 are subsets of TOX.
4. During all quarters of testing with the Hydranautics ESNA and LFC membranes, there were very large ranges in the feed THM4, HAA6 and TOX concentrations. Also, during this testing the THM4 and HAA6 concentrations were often higher than the TOX concentrations; as stated previously, this is physically impossible.

In your response, you indicated that some of this variability may be due to frequent changes in experimental conditions over the course of the study, and you have verified this data as correct. However, we still have concerns with respect to the TOX data that is reported as significantly lower than the THM4 and HAA6 concentrations; and we have concerns with respect to the many case in which HAA6 data is reported as being significantly higher than THM4 concentrations.

We request your assistance in further verification of this anomalous data. If we cannot resolve these outstanding issues we will be forced to remove much of this data from analysis since it is inconsistent with established trends in DBP formation chemistry. This would be a very unfortunate lose due to the potential wealth of information available from this study. It may

be necessary to go back one or two QC levels beyond the raw data to determine if there was a systematic error in the analysis or reporting of this data.

We request your response to these major outstanding issues, and where possible, we ask that you make appropriate revisions to your data and resubmit your *Data Collection Spreadsheets*. The deadline for this response is **November 17, 1999.**

Thank you for your assistance in ensuring that we have accurate and complete data from your study. If you have any questions regarding these comments, please call me at 513 569-7131.

Sincerely yours,

S Steve Allgeier

Steven C. Allgeier
ICR Treatment Study Coordinator

Enclosures

CITY OF TAMPA Water Department

Production Division

November 18, 1999

Steven C. Allgeier
ICR Treatment Study Coorinator
U.S.E.P.A.
Office of Ground Water and Drinking Water
Technical Support Center
Cincinnati, Ohio 45268

Dear Mr. Allgeier,

I have received your letter of October 28, 1999 regarding our DBP data submittal for our ICR Membrane Treatment Study for PWS#FL6290327, Plant ICR #311. As we have previously discussed, this project was part of a larger membrane project in conjunction with Jim Taylor at the University of Central Florida. I have forwarded a copy of your letter to Jim as his group had performed all of the TOX analysis for this project. I have also reviewed the data in question and have found some surprising circumstances.

I have reviewed SDS data for the period of week 33 to 51. Data for the SDS DBP's cannot be correlated directly without first converting all data to a standard unit. This is done in performing a "mass balance". To relate TOX, THM, and HAA data all individual species must be converted to a standard weight as the molecular weights of the individual species are very different. Reporting TOX as ug Cl / L, cannot be related to CHCl3 measured in ug/L since the molecular weights are different. To normalize all data to ug Cl / L, you must use a multiplier determined by comparison of the molecular weight of chlorine to the molecular weight of the species being measured. For chloroform that multiplier would be 35/119.39 or 0.293. All chloroform data in ug/L must be multiplied by this factor to be compared to TOX measured as ug Cl / L. This must be done for all individual species of DBP's before a comparison of concentrations can be performed. You cannot look simply at THM4 or HAA5 and compare the concentrations to TOX with first performing the individual species conversion to Cl and then summing the values. I have attached a table of multiplier values for all DBP's measured. When I applied these multipliers and summed the THM4 and HAA5 concentrations as Cl I found that for the weeks in question for the Fluid Systems membrane experiments that all but one feed TOX were higher that the other DBP summed concentrations after conversion.

For the membrane feed water for weeks 35 to 51, all TOX concentrations were higher than the combined THM4+HAA5 concentrations. In week 33 the TOX concentration was 738 ug Cl /L and the sum of the THM4+HAA5 concentrations was 937 ug Cl / L. This is a 27% difference. The error may be accounted for in the DBP analysis dilution factor. In working with DBP's of such high concentrations it is necessary to dilute samples by 50 to 100 times to bring them back onto

7125 N. 30th Street • Tampa, Florida 33610 • Ph. 813/231-5238
• Fax 813/231-5283

the standard curve. Most DBP's have an upper linear range in analysis of 20 ppb. The standard deviation for most DBP analysis was in the 5-10% range. Applying this SD in conjunction with the dilution factor necessary for analysis the difference in this one analysis is not significant. It may be necessary to delete this one analysis. Comparing TOX and DBP concentrations for weeks 33 to 51 in the permeate samples, I find that all TOX concentrations are higher than the sum of the DBP's converted to standard units of Cl. I have not performed a mass balance on the Hydranautics membrane analysis but I suspect you will find most data is acceptable when properly converted for comparison.

The range in concentration of the DBP data is directly related to the change in experimental conditions. Wherever feed TOC is above 10 ppb C the membrane system was being feed raw untreated river water. Concentrations of TOC feed below 10 ppb C indicate the feed for the membrane system was either CSF water (coagulated, settled, and filtered), or possibly some combination of pretreated water from one of the microfiltration units being run in conjunction with the nanofiltration membranes, i.e., Memcor or Zenon unit. The experimental breakdown submitted previously and the operation log for the sampling dates will supply this information.

Finally, in comparing THM4 and HAA5 a similar conversion to a standard unit of measure is necessary to perform a mass balance. Within table 1 I have performed the necessary data conversion of THM and HAA species for weeks 33 to 51 for the Fluid systems membranes t o reflect ug Cl /L for comparison. In most instances the HAA5 concentrations exceed the THM4 levels. However, this is not an unusual circumstance. Our in house database on THM's and HAA's have found this relationship many times dependant upon our treatment point for pH adjustment in relation to chlorine disinfection and the raw water characteristics at different times of the season. Other utilities in Florida have found similar results. I have also attached a copy of our past four quarter DBP's analysis.

I hope I have answered all the questions of your letter of October 28, 1999. If I can be of any further assistance please feel free to contact me at (813) 231-5255.

Sincerely,

James M.. Gianatasio
Plant Operations Supervisor

7125 N. 30th Street ● Tampa, Florida 33610 ● Ph. 813/231-5238
● Fax 813/231-5283

SYSTEM AND STAGE WATER QUALITY DATA
NF1- FLUID SYSTEMS MEMBRANES

week#	DATE	STAGE	TOC PPM C	TOX PPB CL	THM4 PPB	HAA5 PPB	SDS-CL DOSE PPM	THM4 as CL PPB CL	HAA5 as CL PPB CL	THM4 + HAA5 as PPB CL	STAGE	TOC PPM C	TOX PPB CL	THM4 PPB	HAA5 PPB	SDS-CL DOSE PPM	THM4 as CL PPB CL	HAA5 as CL PPB CL	THM4 + HAA5 as PPB CL
33	3/2/98	FEED	14.7	738	1047	2683	31	305	631	937	PERM	1.1	57	113	92	4	32	23	55
35	3/18/98	FEED	15.1	668	881	1727	26	256	421	677	PERM	BMDL	34	46	44	3	12	12	24
37	3/30/98	FEED	13.5	1002	953	2369	31	278	559	837	PERM	0.8	91	70	104	4	19	26	45
39	4/13/98	FEED	14	702	1131	1422	27	328	346	673	PERM	0.5	13	BMDL	17	3	ND	5	5
39D	4/13/98	FEED	14	740	1235	1379	26				PERM	BMDL	11	25	16	3			
41	4/27/98	FEED	13.5	768	975	1554	21	282	368	650	PERM	BMDL	37	44	33	3	11	10	20
43	5/11/98	FEED	10.7	628	897	740	20	259	184	442	PERM	BMDL	15	43	25	3	10	7	17
45	5/26/98	FEED	6.6	481	1023	428	14	257	107	364	PERM	0.5	21	50	21	3	12	7	18
47	6/8/98	FEED	4.9	260	325	204	9	91	54	145	PERM	0.5	10	20	11	2	4	4	8
49	6/22/98	FEED	3.3	106	196	200	8	54	52	106	PERM	BMDL	11	28	11	8	6	4	10
49D	6/22/98	FEED	3.4	132	260	166	8				PERM	BMDL	9	27	13	2			
51	7/6/98	FEED	2.9	135	110	85	7	29	23	52	PERM	BMDL	19	27	11	2	6	4	9

COMPOUND	MOLECULAR WEIGHT	MULTIPLIER TO CONVERT TO Cl
TOX	35	1
CHCl3	119.39	0.293
BDCM	163.83	0.214
DBCM	208.29	0.168
CHBr3	252.75	0.138
MCAA	94.4	0.25
DCAA	128.9	0.27
TCAA	163.4	0.214
MBAA	138.9	0.25
DBAA	217.8	0.16
BCAA	173.4	0.2

Results of TWD DBP

Distribution sites used for compliance reporting

	Location			Q398		Q498		Q199		Q299		Q399	
				TTHM	HAA5	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5
1	Bay Crest		MB	85.50	93.25	97.00	64.01	41.90	30.70	56.00	30.57	75.50	62.02
2	Picnic Island		HR	77.00	84.74	90.40	35.33	46.40	35.60	77.00	36.27	62.10	58.72
3	Davis Blvd		HR	69.40	93.60	73.70	53.06	32.90	43.90	72.20	29.09	48.60	61.42
4	Pendola Pt.		HR	67.00	91.72	93.10	64.95	54.00	38.00	61.40	26.14	48.50	46.55
5	Faulkenburg		HR	82.40	94.02	80.50	63.33	45.20	37.10	78.20	35.62	47.10	53.57
6	Habana		MB	72.10	82.28	75.90	59.23	57.50	46.80	25.20	25.84	75.00	63.47
7	Skipper		MB	69.90	102.76	86.40	66.93	43.10	56.70	13.10	19.68	74.80	59.72
8	Lake Ellen		MB	83.60	89.71	86.00	63.67	42.80	31.60	35.00	25.19	90.80	58.28
	Qtr average			75.9	91.5	85.4	59.6	45.5	40.1	52.3	28.6	65.3	58.0

All values reported as ppb

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SECTION 1
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The runtime of microfiltration processes is a function of operating conditions such as flux and recovery.
2. Fouling of microfiltration processes was susceptible to organic adsorption.
3. Addition of aluminum is needed to improve the performances of the Zenon pretreatment.
4. Addition of PACl is necessary to improve the performances of the Memtec pretreatment.
5. Addition of Alum resulted in failure of the Memtec MF.
6. Long term operation of nanofiltration systems to treat the Hillsborough River was demonstrated.
7. Advanced pretreatment processes were necessary for sustained operation and included:
   - Coagulation, sedimentation, filtration (CSF);
   - Memcor microfiltration (MMF);
   - Zenon microfiltration (ZMF);
   - In-line coagulation, Memcor microfiltration (C/MMF); and
   - In-line coagulation, Zenon microfiltration (C/ZMF).
8. Acid and antiscalent addition adequately controlled scaling of the nanofiltration units.
9. The advanced pretreatment systems reduced turbidity to less than 0.2 NTU and seemingly controlled particle plugging of the nanofiltration units.
10. The Fluid Systems CALP cellulose acetate nanofilter was susceptible to biodegradation and membrane failure and required use of a biocide.
11. Using a biocide, the CALP was capable of sustained operation and was not affected by organic adsorption fouling.
12. Composite thin film membrane membranes were susceptible to organic adsorption and biological fouling.
13. The Hydranautics ESNA fouled irreversibly and could not be used at this site.
14. Addition of monochloramine to the Hydranautics LFC1 minimized biofouling but caused oxidation of the thin film and loss of performance. This membrane would only be viable at this site if a non oxidizing biocide were available.
15. Generally, fouling increased with increasing recovery and flux.
16. The order of nanofilter performance, with respect to sustained operation, was CALP>LFC1>ESNA.
17. Water quality from all IMSs exceeded that of conventional CSF treatment.
18. All three nanofilters reduced TOC to less than 1 mg/L in the permeate.
19. The CALP nanofilter met proposed 80/60 Stage 2 D/DBPR MCLs when feed TOC concentrations were less than 5.5 mg/L.
20. The CALP is expected to meet proposed 80/60 Stage 2 MCLs when a coagulant based pretreatment is used or when monochloramine disinfection is employed.

21. The composite thin film nanofilters reduced TOC to less than 0.5 mg/L and met proposed 80/60 Stage 2 MCLs in all cases.
22. Inorganic rejection was high for both composite thin film membranes (>80%).
23. CALP inorganic rejection was significantly less than the ESNA and LFC1 (30-60%) but adequate for softening of this surface water.
24. The order of NF rejection was LFC1>ESNA>CALP.

Recommendations

1. Development and NSF approval of non oxidative biocides should be pursed.
2. Manufacturing improvements in membrane films should target reducing the surface roughness and surface charge, to minimize particle and biological fouling and organic adsorption, respectively.
3. The development of lower pressure, higher rejection membrane films should continue.
4. Research characterizing the mechanisms of particle and pathogen passage through spiral wound membrane elements and log removal capabilities should be pursued.
5. Alternative membrane designs and configurations capable of higher recovery should be developed. Water recovery rates for IMSs are prohibitively low for some sources with limited yield. Disposal of concentrate quality and quantity may impact feasibility of membrane implementation in many areas of the country.

SECTION 2
BACKGROUND INFORMATION

The Hillsborough River Water Treatment Plant (HRWTP) is located in eastern Hillsborough County, Florida and serves approximately 440,000 people in the City of Tampa and surrounding areas. The plant was constructed in **1924** and has undergone major upgrades in **1946, 1960, and 1974**. A schematic of the plant unit processes is shown in Figure 1. As shown, the plant utilizes conventional coagulation, sedimentation, and filtration (CSF) processes. Ferric sulfate is used for coagulation. Potassium permanganate is used year-round for taste and odor control. Powdered activated carbon is added periodically, as necessary, for additional taste and odor control. Treatment plant design data are shown in Table 1.

The source water, the Hillsborough River, is spring fed. However, watershed runoff contributes high levels of color and total organic carbon. Source water quality is shown in Table 2. Finished water quality is shown in Table 3. As shown, the current coagulation process removes over **80** percent of TOC. Current treatment processes meet the D/DBP Stage One levels for both TTHM's and HAA5.

Given the issues of organics removal at this site, membrane processes were selected for assessment. This pilot study was conducted in collaboration with the University of Central Florida, funded by USEPA to assess Integrated Membrane Systems (IMS) for surface water treatment. IMS selection was performed based on the following objectives:

1. Compliance with D/DBPR Stage 2 proposed 80/60 MCLs, using free chlorine; and
2. Minimize nanofilter fouling.

IMSs were designed to address nanofilter fouling mechanisms, shown in Table 4. Pretreatment processes and their impact on fouling are shown in Table 5. Pretreatment processes were selected as follows:

1. CSF (existing plant);
2. Microfiltration (MF); and
3. In-line coagulation – microfiltration (C/MF).

For nanofiltration, a cellulose acetate (CA) and a composite thin film (CTF) membrane were selected. CA membranes typically have lower surface charge and a smoother surface therefore may foul less than CTF membranes. However, CA nanofilters typically have lower rejection capabilities, compared to CTF. Thus both were selected for evaluation.

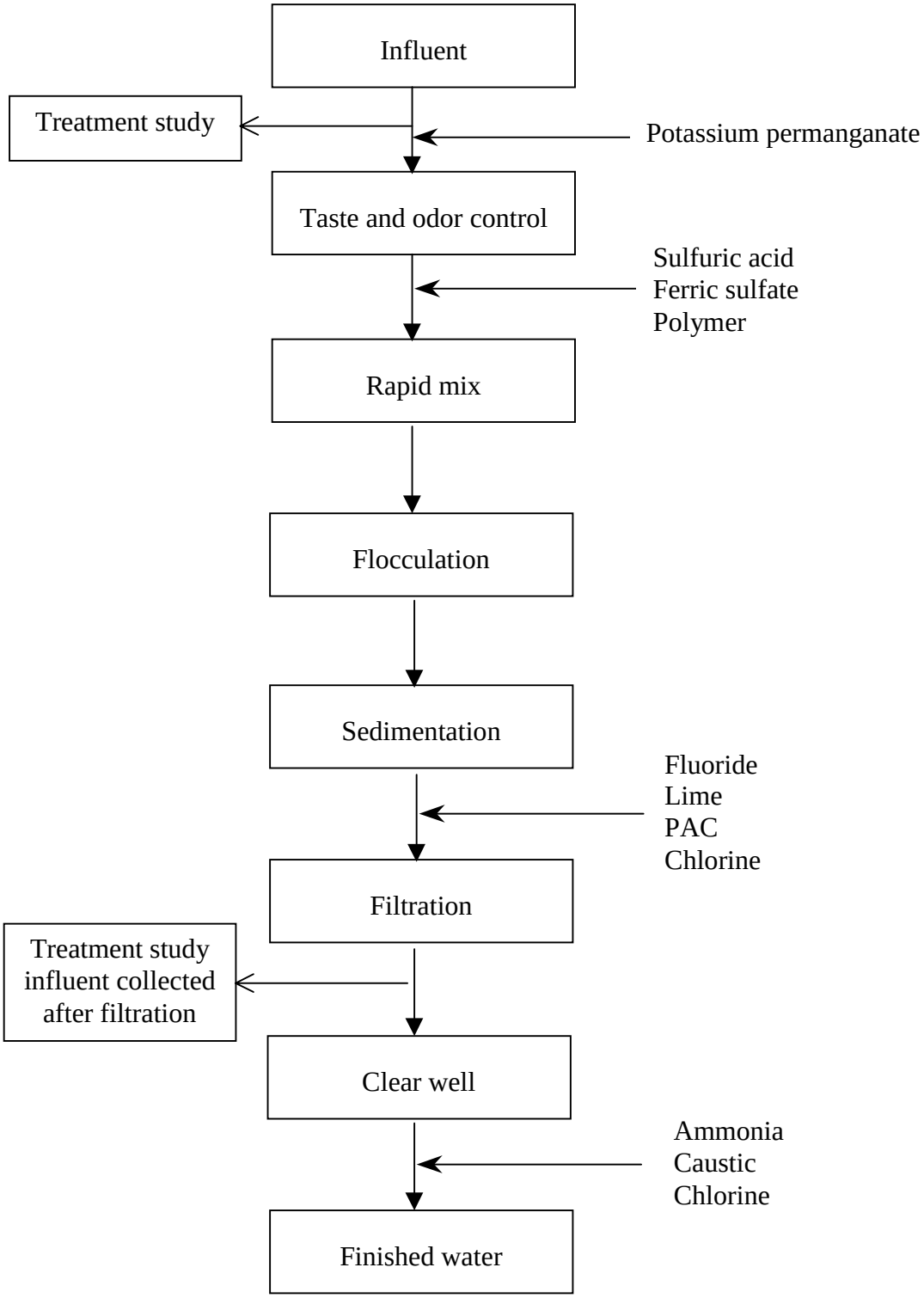


Figure 1. Hillsborough River Water Treatment Plant Schematic

Table 1. Treatment Plant Design Data

Unit process	**Process description**
Flocculation	Basin volume: 1,053,000 gal Mixing stages: 4 Detention time: 15 min HDT Rated capacity: 101.09 MGD
Sedimentation	Basin volume: 7,185,600 gal Surface area: 60,000 ft^2 Basin depth: 16 ft Loading rate: 1 gpm/ft^2 Rated capacity: 86.40 MGD
Filtration	Total filter surface area: 23,936 ft^2 Number of filters: 30 Total volume above the filters: 716,165 gal Media type: Dual – Anthracite/Sand Disinfectant applied: chlorine Required CT: 10 Loading rate: 3 gpm/ft^2 Rated capacity: 96.51 MGD
Disinfection	Clearwell volume: 20,000,000 gal Disinfectant applied: chloramines Required CT: 250 Detention time: 58 min

Table 2. Hillsborough River Water Quality 1997-1998

Water Quality Parameter	**Average Yearly Concentration**	**Standard Deviation**	**Minimum Yearly Value**	**Maximum Yearly Value**
Temperature (^oC)	25	6.2	20	29
pH	7.59	1.2	6.81	8.48
Turbidity (NTU)	2.10	0.77	0.98	5.61
Alkalinity (mg/L as $CaCO_3$)	77	34	30	178
Total Hardness (mg/L as $CaCO_3$)	106	38	50	184
Chloride (mg/L)	12	3	6	17
TOC (mg/L)	17.0	6.4	4.0	27.5
Color (CPU)	163	74	34	297
THM (µg/L)	1258	566	199	2581
HAA (µg/L)	1897	1087	254	5822

Table 3. Finished Water Quality

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Minimum Yearly Value	Maximum Yearly Value
Temperature (^{o}C)	23.9	4.4	15.6	31.1
pH	7.5	0.2	7.1	8.0
Turbidity (NTU)	0.16	0.08	0.06	0.40
Alkalinity (mg/L as $CaCO_3$)	79	30	32	136
Total Hardness (mg/L as $CaCO_3$)	158	46	72	240
Chloride (mg/L)	21	4	11	31
TOC (mg/L)	2.6	0.6	1.2	3.9
Color (CPU)	5	1	4	7
THM (µg/L)	21	62	26	91.5
HAA (µg/L)	60	19	29	85.4

Table 4. Nanofilter Fouling Mechanisms

Fouling Mechanism	Cause	Analytical Parameter
Precipitation	Sparingly soluble salts	Speciated anions and cations
Plugging	Solids	Turbidity Total suspended solids (TSS) Silt density index (SDI) Particle counts
Organic Adsorption	Organic matter	Total organic carbon (TOC) UV-254
Biofouling	Attached bacterial growth	Total organic carbon (TOC) Assimilable organic carbon (AOC) Biologically degradable organic carbon (BDOC) Heterotrophic plate counts (HPC)

Table 5. Pretreatment Methods by Fouling Mechanism

Fouling Mechanism	A/AS	F	CSF	MF/UF	C-MF/UF	CS-MF/UF	Biocide
Precipitation	√						
Plugging		√	√	√	√	√	
Organic Adsorption			√		√	√	
Biofouling							√

A/AS: acid and/or antiscalent
F: media filtration
CSF: coagulation, sedimentation, filtration
MF/UF: microfiltration or ultrafiltration
C-MF/UF: In-line coagulation of microfiltration or ultrafiltration
CS-MF/UF: coagulation, sedimentation, microfiltration or ultrafiltration

SECTION 3
METHODS AND MATERIALS

3.1 PRETREATMENT EQUIPMENT

Three different pretreatments were used prior to the membrane process. These are:

- Coagulation-sedimentation-filtration
- Microfiltration
- Coagulation-Microfiltration

Two different microfiltration processes were tested. These are from:

- US Filter/Memtec
- Zenon Environment.

3.1.1 Coagulation-sedimentation-filtration

The coagulation-sedimentation-filtration pretreatment from the full-scale treatment plant was used. The description is presented in section II.

3.1.2 Memtec microfiltration pilot

The Memtec microfiltration pilot is a filtration process that allows continuous filtration to 0.2 μm. The system uses hollow fiber membranes in either direct flow or crossflow configuration to produce treated water. A differential pressure across the membrane allows filtration to occur. Clean filtrate passes through the fiber wall, along the hollow center of the fiber, and out the filtrate port. Eventually, impurities will build up on the membrane surface, differential pressure will increase and filtrate rate will decrease. An air backwash is used to maintain filtration flow rates. The backwash relies on a rapid expansion of gas through the wall of the fiber to remove contaminants from the surface of the fiber, as well as from the porous membrane matrix. The microfiltration membrane has an inner surface area of 438 ft^2 and a capacity of 15 to 30 gpm. A simplified flow diagram is shown in Figure 2.

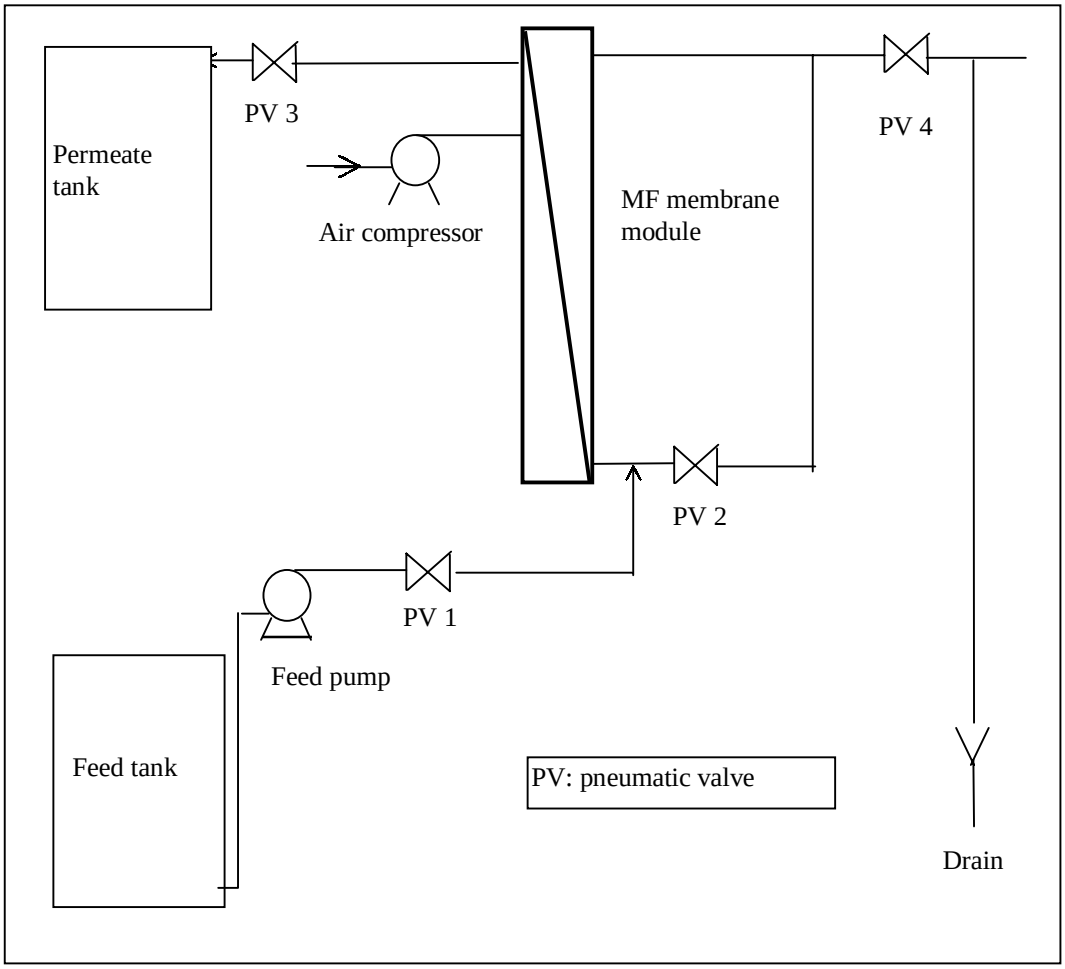


Figure 2. **Memtec microfiltration pilot plant diagram**

3.1.3 Zenon microfiltration pilot

The Zenon microfiltration pilot is similar to the Memtec pilot in terms of flow configuration. The membranes are directly installed in a tank wherein feed water has been concentrated from 75% to 98 % (as desired). A vacuum pressure produces the filtrate from the tank. To maintain 90% concentrated water, a certain amount of concentrated water is drained: 1 gal of concentrate for 9 gallons of filtrate, if the process works at 90% of recovery. A backpulse using filtrate (from the CIP tank) is applied every 10 or 15 minutes to remove solids accumulated on the membranes. Air is consistently blown along the fibers to keep them apart and to remove some of the solids accumulated on the fibers. The air flow rate was 17 cubic feet per minute (cfm). The pilot plant flow configuration is shown in Figure 3.

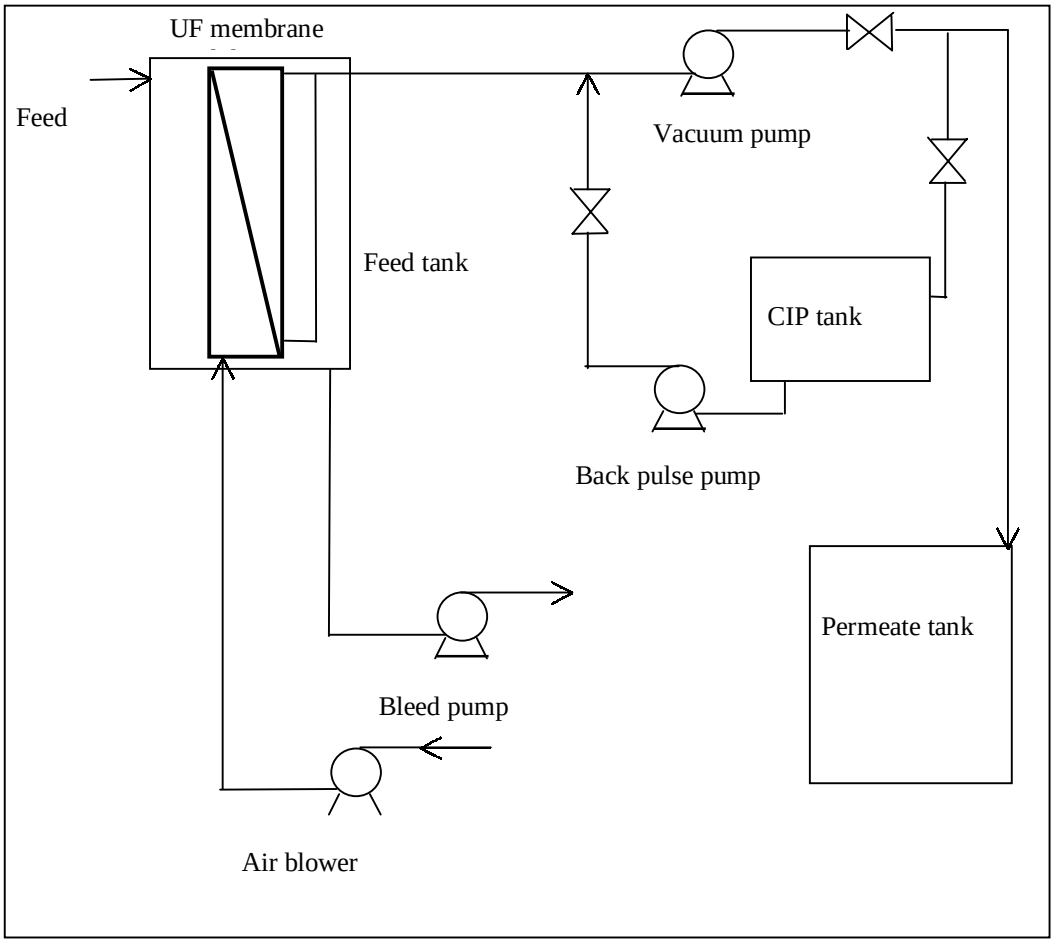


Figure 3. **Zenon microfiltration pilot plant diagram**

The coagulation-microfiltration pretreatment consisted of adding a coagulant prior to microfiltration.

3.2 NANOFILTRATION EQUIPMENT

Two nanofiltration systems were used at the Tampa site and were housed in a 30-foot by 8-foot trailer. Each system was 2-1 array configuration and contained a total of 9 – 4040 elements or 6 – 4060 elements. These two systems were designated NF1 and NF2. Design data for the NF systems is shown in Table 6.

Table 6. NF system design data.

Design Data	Units	NF System 1	NF System 2
Total No. Pressure Vessels	-	3	3
No. Pressure Vessels Stage 1	-	2	2
No. Pressure Vessels Stage 2	-	1	1
Pressure Vessel Length	inches	120	120
Pressure Vessel ID	inches	4	4
Material of construction	-	stainless steel	stainless steel
Maximum Pressure	psi	400	400
Booster pump	hp	10	10
Prefilter	-	30 inch bag	30 inch bag
Prefilter pore size	micron	5	5
Maximum flow	gpm	limited by membrane not system	limited by membrane not system
Recycle	-	Yes	Yes
Low Pressure Shutoff	-	Yes	Yes

Feed water to the two NF systems was either Memcor or Zenon microfiltered water, or coagulated, settled filtered (CSF) water from the full-scale water treatment plant. Feed water from the Memcor or Zenon unit was supplied to the nanofiltration units by 1 hp centrifugal pumps drawing from 55-gallon filtration tanks associated with each unit.

Coagulated/settled/filtered water was obtained from the full-scale WTP. Coagulation/ sedimentation conditions (chemical doses, loading rates, etc.) were a function of the needs of the full-scale WTP and were not controllable for this pilot study. The raw water was dosed with ferric sulfate at an average of 170 mg/L (2.6 meq/L) during the 15 months of testing. The CSF water contained 0.1 to 0.2 mg/L of free chlorine, which was removed via granular activated carbon filtration. The GAC filter was exhausted for TOC removal, as was desired, but effectively removed the chlorine residual. Filtered effluent from the Hillsborough River water treatment plant was pumped via a 2 hp centrifugal pump from the filter gallery to the 7 sf granular activated carbon (GAC) filter. The dechlorinated CSF water was then fed to the appropriate nanofiltration system.

Following pretreatment, conventional membrane pretreatment was performed and consisted of acidification and/or antiscalent dosing and filtration with a static 5 μm cartridge filter following which the water was treated via nanofiltration. Acid and/or antiscalent was used to inhibit precipitation in the NF unit. Argo Scientific UL 200 antiscalent was dosed at 5.0 mg/L for recovery of 65% and 2.5 mg/L for recovery of 85%. Acid was dosed to achieve a pH of 5.5.

3.3 EXPERIMENTAL DESIGN

Membrane treatment trains identified for testing included CSF-NF, MF-NF and C/MF-NF as shown in Figure 4. A sampling and gauge location diagram is shown in Figure 5. Both Memcor and Zenon MF units were evaluated. During operation of the IMSs, the test objectives included evaluation of:

- Nanofilter flux and recovery
- Efficiency of CSF, MF and C/MF to pretreat raw water to reduce NF fouling rate
- Cleaning efficiency
- Finished water quality

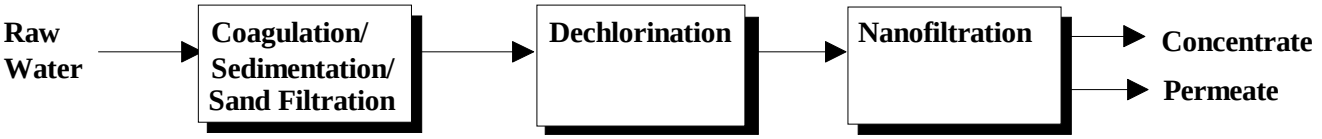
Experimental Settings and Duration. The nanofilter experimental matrices are presented in Table 7. Flux was set at 7 and 14 gfd. Recovery was set at 65 and 85%. These settings resulted in a matrix of four experiments. Each of the experiments consisted of two weeks of operation. If the nanofilter productivity, as measured by the water mass transfer coefficient, decreased by 25 to 50 percent of its original mass transfer coefficient, the unit was chemically cleaned and restarted.

Table 7. NF Experimental Matrix

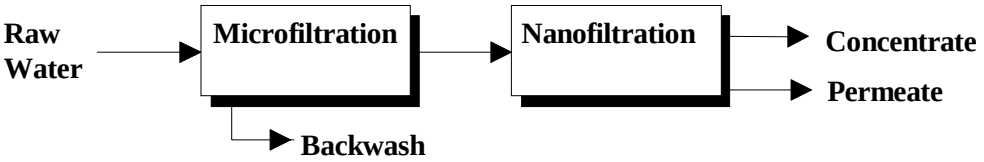
Experiment	Flux (gfd)		Recovery (%)	
	7	14	65	85
1	X		X	
2	X			X
3		X	X	
4		X		X

Chemical Cleanings. Each system was chemically cleaned based upon a 25 to 50 percent decline in initial water mass transfer coefficient. All elements within a single system (NF1 or NF2) were cleaned at the same time. Cleaning solutions consisted of citric acid if scaling was suspected or various combinations of sodium hydroxide, sodium tripolyphosphate, sodium dodecylbenzene sulfonate and/or tetrasodium EDTA if organic fouling was suspected. All chemical cleaning solutions and procedures followed manufacturer protocols. Cleaning regimes consisted of 15 to 60 minutes of recirculation followed by a 1 to 2 hour soak period, finalized by 15 to 60 minutes of recirculation.

CSF-NF



MF-NF



C-MF-NF

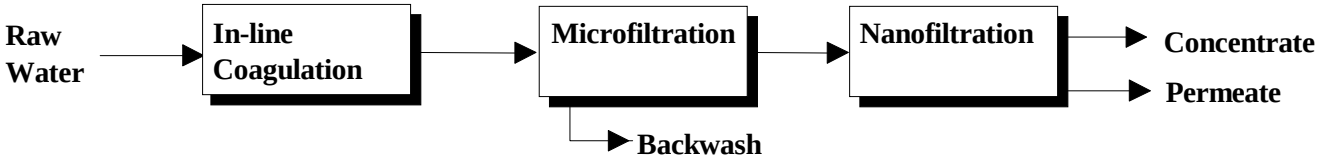


Figure 4. Pilot study process trains

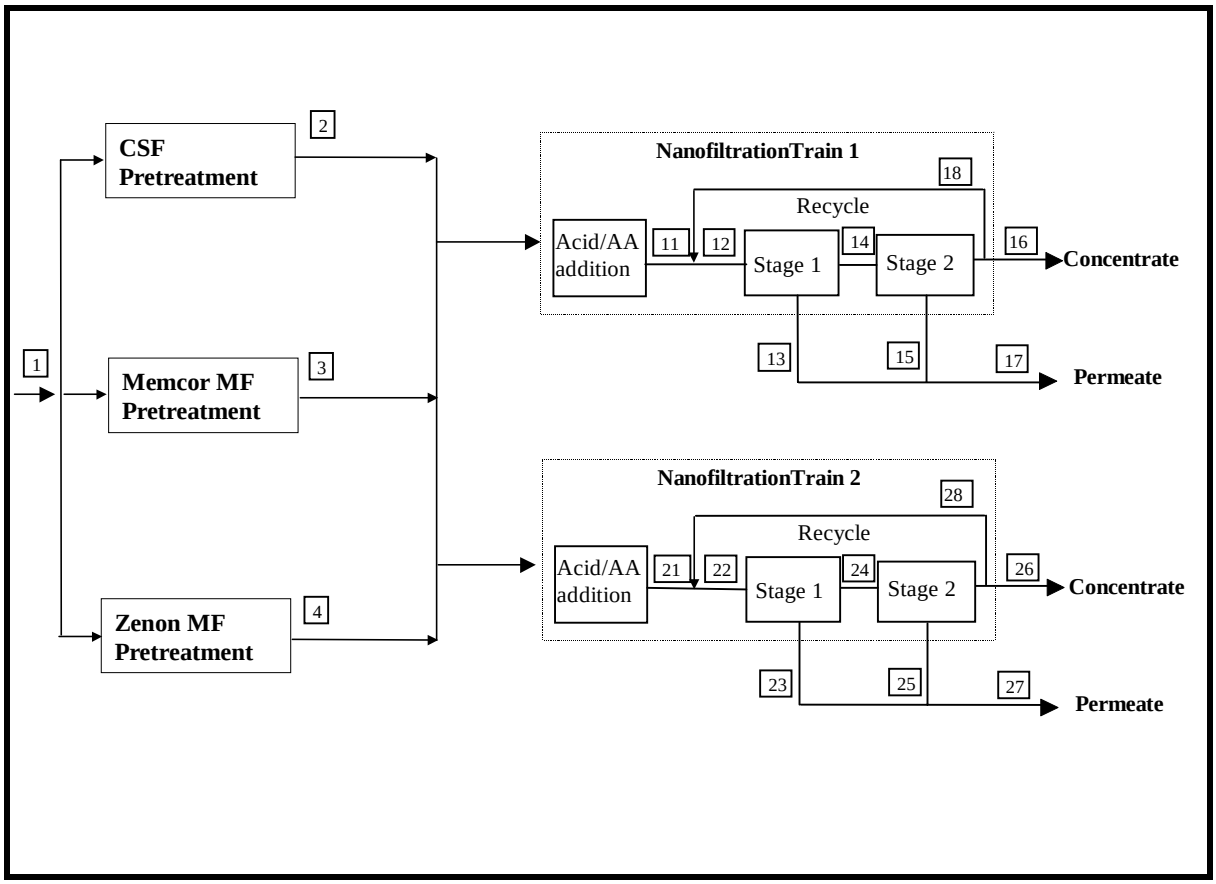


Figure 5. Sampling/Gauge Location Diagram.

3.4 ANALYTICAL METHODS

The analyses were performed at the Tampa Water Department (TWD) laboratory and at the laboratory of Environmental Systems Engineering Institute (ESEI) at the University of Central Florida (UCF). The analytical methods used as well as the minimum reporting levels (MRLs) are presented in Table 8.

Table 8. Analytical Methods and MRLS

Analyte	Method	Minimum Reporting Level
TWD		
Turbidity	SM 2130 B	0.1 NTU
TSS	SM2540 D	1 mg/L
TDS	SM2540 C	1 mg/L
Chlorine Residual	SM 4500 C/D	0.1 mg/L
pH	EPA 150.1	0.1 unit
Chlorides	EPA 300.0	0.1 mg/L
Bromides	EPA 300.0	0.01 mg/L
Nitrates	EPA 300.0	0.01 mg/L
Sulfates	EPA 300.0	0.1 mg/L
Sodium	EPA 200.7	0.1 mg/L
Iron	EPA 200.7	0.01 mg/L
Calcium	EPA 200.7	0.1 mg/L
Total Harness	SM 2340 B	20 mg/L
Alkalinity	SM 2320 B	1 mg/L
Ammonia	SM 4500 D	0.06 mg/L
Silica	EPA 4500 S:B	0.1 mg/L
TOC	SM 5310 C	0.5 mg/L
$CHCl_3$, BDCM, DBCM, $CHBr_3$	EPA 524.2	0.3 µg/L each
BCAA, DBAA, DCAA MBAA, MCAA, TCAA	EPA 552	0.3 µg/L each
ESEI/UCF		
UV254	SM 5910	0.009 cm^{-1}
Color	SM 2120 B	5 PCU
TOX	SM 5320 B	1 µg/L

SECTION 4
RESULTS AND DISCUSSION

4.1 PRODUCTIVITY

4.1.1 Microfiltration assessment

Table 9 summarizes the runtimes between chemical cleanings in days for the Memtec and Zenon processes in the different conditions.

Table 9. Runtimes of Memtec and Zenon processes

Membrane system	Treatment system	Runtime (days)
Memtec	Raw water	2 to 216
	In-line coagulation (ILC) with aluminum sulfate	2 to 30
	In-line coagulation with PACl	37 to 478
Zenon	Raw water	2 to 417
	In-line coagulation with ferric sulfate	2 to 12
	In-line coagulation with aluminum sulfate	31 to no fouling

4.1.1.1 Memtec summary

Raw water ⟶ Memtec

1. The runtime increases when TOC concentration decreases
2. The runtime increases when flux decreases.
3. The runtime increases when the BW frequency decreases.
4. 216 day runtime was measured for a flux of 16 gfd, a BW frequency of 20 minutes and a TOC of 4.1 mg/L
5. 3 day runtime was observed for a flux of 40 gfd, a BW frequency of 20 minutes and a TOC of 20 mg/L

Raw water ⟶ Alum ILC ⟶ Memtec

1. The in-line coagulation using aluminum did not improve the runtime compared to no coagulation.
2. The Memtec MF failed due to the accrual of aluminum solids.
3. The runtime increases when TOC decreases within aluminum experiments.
4. The runtime decreases when the coagulation sludge loading in the module increases

Raw water ⟶ PACl ILC ⟶ Memtec

1. The in-line coagulation using PACl improved the runtime compared to no coagulation.
2. The runtime increases when TOC decreases within PACl experiments.

4.1.1.2 Zenon Summary

Raw water ⟶ Zenon

1. The runtime depends on the flux and the recovery of the system.
2. The runtime increases when the flux decreases.
3. The runtime increases when the recovery decreases.

Raw water ⟶ Ferric sulfate ILC ⟶ Zenon

1. The in-line coagulation using ferric sulfate did not improve the runtime.

Raw water ⟶ Aluminum sulfate ILC ⟶ Zenon

1. The in-line coagulation using aluminum sulfate significantly improved the runtime.
2. No fouling was observed at 32 gfd and 98% of recovery using a dose of 3 meq/L.
3. Runtime increases when TOC decreases.
4. Runtime increases when suspended solid concentration increases

4.1.2 Nanofiltration

A summary of operational conditions and resulting cleaning cycles is presented in Table 10 below. Runtimes are based on linear regression of the water mass transfer coefficient over time and a 15 percent decline criterion. Operational parameters consisted of flux, recovery, and monochloramine addition. Use of monochloramine was instituted following determination that biological fouling was a primary contributor to fouling. A discussion of fouling results for each membrane follows this table. Average runtimes determined in these sections are based on average K_w decline rates (slopes) for each experiment and are then reconverted to runtimes based on a 15% decline. The log of plot study notes is provided in Appendix A.

Table 10. NF productivity summary

Nanofilter	Pretreatment	Experiment	NF Flux (gfd)	NF Recovery (%)	NH_2Cl?	Runtime (days)
ESNA (NF2)	CSF	1	7	65	No	13
		2	7	65	No	No fouling
		3	7	85	No	24
		4	14	65	No	34
		5	14	85	No	20
LFC1 (NF2)	MMF	1	7	65	No	8
		2	7	85	No	5
		3	7	85	No	4
		4	14	65	No	15
		5	14	65	No	9
		6	14	65	No	5
		7	14	85	No	2
		8	14	85	Yes	5
		9	14	85	Yes	5
	ZMF	1	7	65	Yes	No fouling
		2	7	85	Yes	21
		3	14	75	Yes	No fouling
		4	14	85	Yes	5
		5	7	65	No	No fouling
		6	14	85	No	3
	CSF	1	7	65	No	No fouling
		2	14	85	No	20
		3	7	65	Yes	99
		4	14	85	Yes	No fouling
	C/MMF	1	14	85	No	80
		2	14	85	Yes	8
CALP (NF1)	CSF	1	7	65	No	156
		2	7	65	No	No fouling
		3	7	85	No	No fouling
		4	14	60	No	416
		5	14	75	No	No fouling
	ZMF	1	7	65	No	NF failure
		2	7	65	No	NF failure
		3	7	65	Yes	125
		4	7	85	Yes	31
		5	7	65	Yes	No fouling
		6	7	85	Yes	30
		7	14	75	Yes	26
		8	14	85	Yes	69
	MMF	1	7	65	Yes	54
		2	7	85	Yes	No fouling
		3	14	75	Yes	No fouling
		4	14	85	Yes	123
	C/ZMF	1	7	65	Yes	59
		2	7	85	Yes	107
		3	14	75	Yes	22
		4	14	85	Yes	No fouling
		5	14	85	Yes	No fouling
		6	14	90	Yes	No fouling
		7	14	90	Yes	No fouling
	C/MMF	1	7	65	Yes	56
		2	7	85	Yes	13

Table 2. NF productivity summary.

Nanofilter	Pretreatment	Experiment	Date	Operational Time (hours)	Week No.	NF Flux (gfd)	NF Recovery (%)	NH_2Cl?	Cleaning cycle (days)
CALP (NF1)	CSF	1	7/16/97-7/24	0-179	1-10	7	65	No	156
		2	9/3/97-9/9	179-317	1-10	7	65	No	No fouling
		3	9/10/97-9/17	341-511	1-10	7	85	No	No fouling
		4	9/18/97-9/23	543-653	1-10	14	60	No	416
		5	9/24/97-9/30	677-821	11-20	14	75	No	No fouling
	ZMF	1	10/1/97-10/9	846-1035	11-20	7	65	No	NF failure
		2	11/5/97-11/12	1035-1200	11-20	7	65	No	NF failure
		3	1/21/98-2/9	1171-1546	21-30	7	65	Yes	125
		4	2/11/98-3/2	1353-1796	31-40	7	85	Yes	31
		5	3/3/98-3/18	1823-2157	31-40	7	65	Yes	No fouling
		6	3/19/98-3/30	2181-2440	31-40	7	85	Yes	30
		7	3/31/98-4/9	2465-2752	31-40	14	75	Yes	26
		8	4/13/98-4/27	2873-3189	31-40	14	85	Yes	69
	MMF	1	4/28/98-5/11	3213-3525	41-50	7	65	Yes	54
		2	5/12/98-5/26	3549-3805	41-50	7	85	Yes	No fouling
		3	5/27/98-6/10	3830-4161	41-50	14	75	Yes	No fouling
		4	6/11/98-6/24	4185-4436	41-50	14	85	Yes	123
	C/ZMF	1	6/25/98-7/7	4435-4430	41-50	7	65	Yes	59
		2	7/8/98-7/20	4430-4427	41-50	7	85	Yes	107
		3	DATA NOT	PROVIDED		14	75	Yes	22
		4	DATA NOT	PROVIDED		14	85	Yes	No fouling
		5	DATA NOT	PROVIDED		14	85	Yes	No fouling
		6	DATA NOT	PROVIDED		14	90	Yes	No fouling
		7	DATA NOT	PROVIDED		14	90	Yes	No fouling
	C/MMF	1	DATA NOT	PROVIDED		7	65	Yes	56
		2	DATA NOT	PROVIDED		7	85	Yes	13

Table 1. NF productivity summary.

Nanofilter	Pretreatment	Experiment	Date	Operational Time (hours)	Week No.	NF Flux (gfd)	NF Recovery (%)	NH_2Cl?	Cleaning cycle (days)
ESNA (NF2)	CSF	1	7/17/97-8/5	28-388	1-10	7	65	No	13
		2	8/7/97-8/20	391-693	1-10	7	65	No	No fouling
		3	8/21/97-9/2	718-1002	1-10	7	85	No	24
		4	9/3/97-9/17	1024-1357	1-10	14	65	No	34
		5	9/18/97-9/30	1389-1667	11-20	14	85	No	20
LFC1 (NF2)	MMF	1	3/4/98-3/18	3858-4185	31-41	7	65	No	8
		2	3/19/98-3/26	4208-4373	31-41	7	85	No	5
		3	3/26/98-3/30	4373-4464	31-41	7	85	No	4
		4	3/31/98-4/2	4485-4630	31-41	14	65	No	15
		5	4/2/98-4/7/98	4532-4630	31-41	14	65	No	9
		6	4/8/98-4/14	4633-4744	31-41	14	65	No	5
		7	4/15/98-4/20	4768-4883	31-41	14	85	No	2
		8	4/20/98-4/21	4883-4900	31-41	14	85	Yes	5
		9	4/21/98-4/27	4900-5038	31-41	14	85	Yes	5
	ZMF	1	4/28/98-5/11	5062-5374	42-51	7	65	Yes	No fouling
		2	5/12/98-5/26	5398-5707	42-51	7	85	Yes	21
		3	5/27/98-6/8	5726-5971	42-51	14	75	Yes	No fouling
		4	6/11/98-6/22	5996-6220	42-51	14	85	Yes	5
		5	DATA NOT	PROVIDED		7	65	No	No fouling
		6	DATA NOT	PROVIDED		14	85	No	3
	CSF	1	6/25/98-7/7	6292-6576	42-51	7	65	No	No fouling
		2	7/8/98-7/20	6601-6876	42-51	14	85	No	20
		3	DATA NOT	PROVIDED		7	65	Yes	99
		4	DATA NOT	PROVIDED		14	85	Yes	No fouling
	C/MMF	1	DATA NOT	PROVIDED		14	85	No	80
		2	DATA NOT	PROVIDED		14	85	Yes	8

4.1.2.1 ESNA Productivity Summary

The ESNA membrane was tested with CSF pretreatment in a 2-1 array configuration. Productivity declined from initiation of the first experiment. Runtimes were estimated between 13 days to no fouling observed. Decline rates appear independent of flux but not recovery, as shown in Table 11. Higher recovery resulted in shorter runtimes.

Table 11. ESNA productivity summary

Factor	Setting	No. of Experiments	Average Runtime (days)
Flux	7 gfd	3	25
	14 gfd	2	25
Recovery	65%	3	28
	85%	2	22

The CSF-ESNA system was operated without a bioinhibitor. Therefore it is highly probable that attached biological growth contributed to fouling. Most importantly, once fouled, the ESNA membrane could not be chemically cleaned. Following an extensive cleaning assessment, including attempts in the factory by the manufacturer to restore productivity, it was concluded that the ESNA was irreversibly fouled and is not suitable for this site. A replacement membrane, the Hydranautics LFC1, was selected as a replacement for the remainder of the testing at Tampa. The LFC1 was presented as a low fouling, monochloramine tolerant polyamide composite nanofilter thus was amenable to surface water applications, with appropriate pretreatment.

4.1.2.2 LFC1 Productivity Summary

The LFC1 was tested using MMF, ZMF, CSF, and C/MMF pretreatment. Runtimes ranged from 2 days to no fouling observed. Fouling increased with increasing flux and increasing recovery. Monochloramine addition improved performance. The order of pretreatment process, from most to least effective, was CSF>C/MMF>MMF≅ZMF. These effects are quantified as shown in Table 12. The runtime could be doubled by adding monochloramine, reducing flux from 14 to 7 gfd, or reducing recovery from 85 to 65 percent. In summary, this membrane has the potential for application at this site, however, a non-oxidizing biocide would be necessary as discussed below.

Table 12. LFC1 productivity summary

Factor	Setting	No. of Experiments	Average Runtime (days)
Biocide	No	12	7
	Yes	9	12
Flux	7 gfd	8	13
	14 gfd	13	7
Recovery	65%	8	16
	85%	12	7
Pretreatment[1]	CSF	1	No fouling
	MMF	2	5
	ZMF	1	5
	C/MMF	1	8

[1] – Based only on conditions of 14 gfd flux, 85% recovery and monochloramine addition.

LFC1 and monochloramine. Estimates of runtimes determined for each individual experiment via linear regression of K_w with operational time generally showed a decline in K_w for most experiments. However, review of the LFC1 performance over the entire 5,000 hour period of testing shows a general trend upward (Figure 6). The LFC1 appears to have "loosened" with time. This can be observed for initial K_w values, following cleaning, as well as during operational periods in which cleanings were not performed. Initial K_w values, following cleaning, show degradation of the membrane as the cleaned membrane K_w values increased above the new membrane K_w of 0.12-0.13 gfd/psi. Following the final cleaning at 4,700 hours, the K_w was 0.22 gfd/psi, representing almost a doubling of productivity. Additionally, during the period from 1,900 to 4,100 hours, no cleanings were performed yet K_w increased from 0.13 gfd/psi to a high of 0.19 gfd/psi. The LFC1 may have suffered from oxidation and degradation due to monochloramine addition or other unknown cause.

If damage were occurring, rejection would be expected to decrease with the increase in K_w. Therefore TDS, as measured by probe, and K_w are plotted in Figure 6. Note the TDS probe measures in increments of 10 mg/L therefore a reading of 0 mg/L represents values from 0-5 mg/L. Stage 1 blended feed TDS concentrations ranged from 90 to 790 mg/L over the period of operation. Stage 2 feed TDS ranged from 130 to 1,050 mg/L. As shown, during the first 1,400 hours of operation, TDS rejection was 100%, representing complete removal and a permeate measurement of 0 mg/L. Following this, TDS rejection decreased to a low of 85% and appears to follow the inverse of K_w. This also supports degradation of the membrane.

Assessing TDS rejection for individual experiments, it appears that rejection increased as the system fouled, during the final four experiments. This suggests that accumulating foulants

effectively reduced the molecular pore size of the fouling layer/membrane surface and allowed less TDS to pass into the permeate.

More importantly, the overall trend shows a decline in rejection associated with an increase in K_w, representing a "loosening" of the membrane. It is suspected that this is due to oxidation and damage to the membrane film surface from the monochloramine addition. The degradation appears to have started in conjunction with the introduction of monochloramine at 1,050 hours of operation. For this membrane, a non-oxidizing biocide is recommended. Such products may not be currently available for potable water applications thus may preclude use of this membrane at this site.

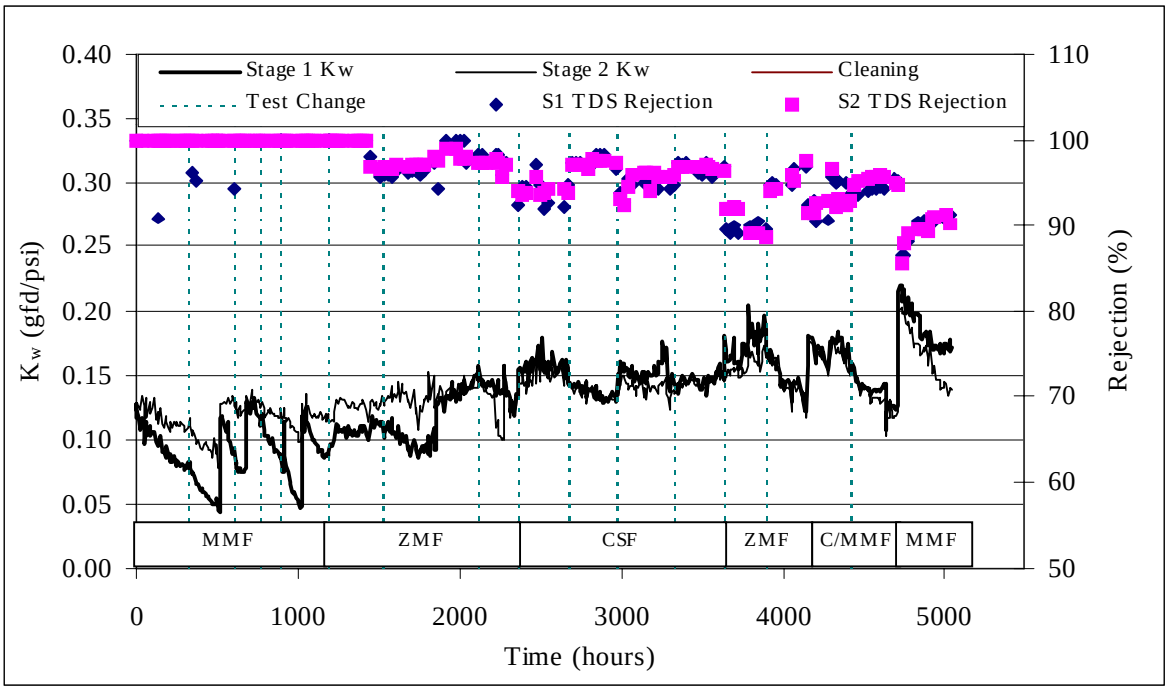


Figure 6. LFC1 K_w and TDS Rejection

4.1.2.3 CALP Productivity Summary

The CALP membrane was tested using CSF, ZMF, MMF, C/ZMF and C/MMF pretreated feed waters. The impacts of flux, recovery, and pretreatment are shown in Table 13. The data shows fouling decreases as flux decreases, which is contrary to what might be expected. This could potentially be due to the inherent variability of the data at shallow declines in productivity (K_w). As the slope of the productivity decline curve approaches zero (horizontal), the natural variability in measured readings (pressure and flow) is amplified. Thus the difference between a 5 and 10 day runtime estimate would be more reliable than the difference between a 50 and 100 day runtime estimate. Since minimal fouling was observed for the CALP membrane, compared to the ESNA and LFC1, there is a greater impact of data variability on the accuracy of the runtime estimates. Never the less, this data shows less fouling at lower flux. Additionally, less fouling is observed for lower recovery, which is

expected. Finally, the effect of pretreatment was evaluated. Given the above discussion of data variability, a conservative ranking of pretreatment performance is CSF>ZMF≅MMF≅C/ZMF>C/MMF. Clearly CSF outperformed the other pretreatment processes whereas C/MMF under performed. Inspection of Figure 7 for all experiments indicates the CALP runtime would be approximately 9 months between cleanings. In summary, the CALP performance was excellent and resulted in minimal fouling. However, biological degradation was an issue as discussed below.

Table 13. CALP productivity summary

Factor	Setting	No. of Experiments	Average Runtime (days)
Flux	7 gfd	13	59
	14 gfd	12	101
Recovery	65%	8	103
	85%	11	57
Pretreatment	CSF	5	567
	MMF	4	150
	ZMF	6	47
	C/MMF	2	21
	C/ZMF	7	98

Biodegradation. A total of three sets of CALP elements were used. Initially, CSF pretreatment was evaluated, without use of a bioinhibitor. CSF pretreatment resulted in essentially no fouling at flux and recovery as high as 14 gfd and 85%, respectively. The CSF pretreatment was then replaced by ZMF pretreatment. ZMF pretreatment resulted in catastrophic failure of the CALP elements after approximately 7 days of operation and was traced to biological damage. The cellulose composition of the CALP elements is a food source for bacteria thus the integrity of the membrane film was breached following attached bacterial growth on the film surface. This phenomena was confirmed with a second set of elements which also failed after 7 days of operation using ZMF pretreatment. A biocide is necessary for use of this membrane to protect from biofouling and, more importantly, biodegradation. However, the cellulose acetate material is oxidant-tolerant, therefore is compatible with monochloramine, which was selected for use.

A third and final set of CALP elements was used with monochloramine addition to evaluate ZMF, MMF, C/ZMF and C/MMF feed waters. Runtimes ranged from 13 days to no fouling, based on linear regression of data for each 14-day experiment. However, despite the linear regressions that projected run times of as short as 13 days, the system operated for over 5,200 hours (217 days) before chemical cleaning. This suggests that the data variability surrounding a fairly stable K_w may have resulted in slight upward and slight downward trends that are not fully representative of fouling. The productivity for the final set of CALP membranes is presented in Figure 5. As shown, the only period that clearly shows fouling was during the

period of operation at 90 percent recovery, though linear regression shows a positive slope (no fouling) during the individual experiments. This is likely due to the data variability in an individual 14 day period. Given that protection from biological degradation is provided, the CALP membrane was highly effective over a long period of operation.

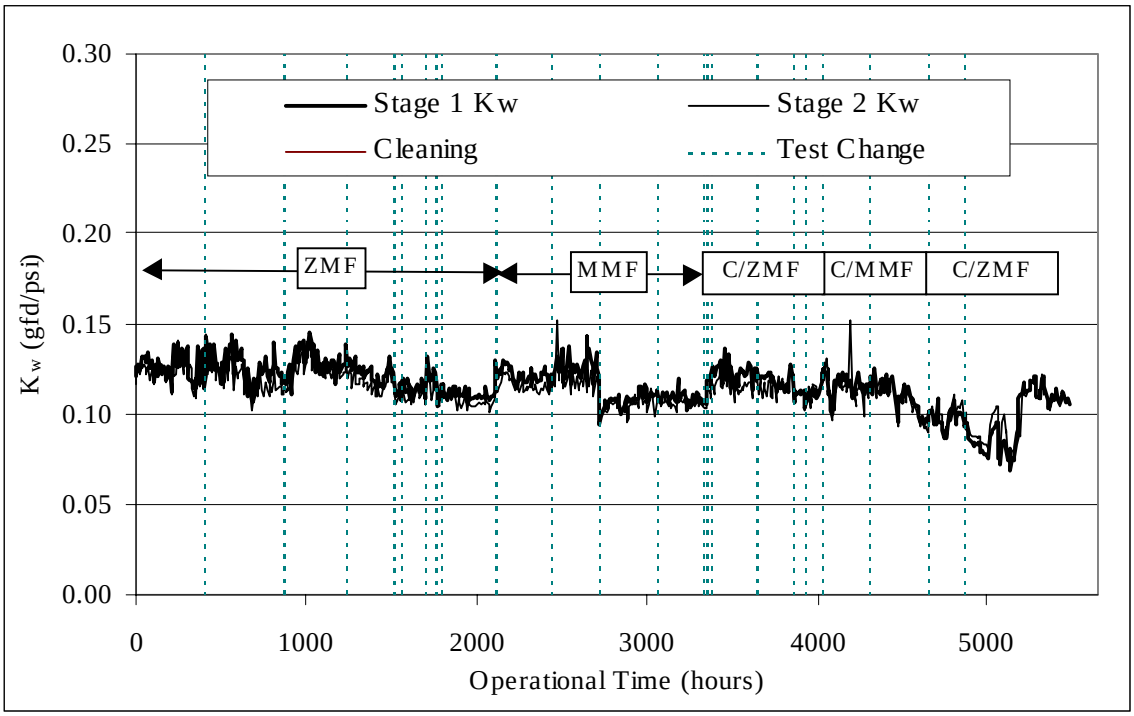


Figure 7. CALP Productivity with monochloramine

4.1.3 NF Assessment.

1. Acid and antiscalent were added to all NF systems to prohibit NF fouling due to precipitation of limiting salts.
2. Pretreatment processes selected for evaluation were CSF, MMF, ZMF, C/MMF and C/ZMF. These processes all reduced turbidity to less than 0.2 NTU therefore particle fouling was considered an unlikely cause of NF fouling in this study.
3. Primary fouling mechanisms of concern were biological fouling and organic adsorption.
4. The Hydranautics ESNA composite thin film membrane was tested using CSF pretreatment and without a biocide. Both biofouling and organic adsorption are likely fouling mechanisms. Fouling increased with recovery but was independent of flux.
5. The ESNA fouled irreversibly at this site and required replacement with a different membrane.
6. The Hydranautics LFC1 composite thin film membrane is reportedly monochloramine tolerant and was tested with and without monochloramine for biological control.
7. The LFC1 fouled less with:
   - addition of monochloramine;

- decreasing flux; and
- decreasing recovery.

8. Fouling of the LFC1 was reversible with chemical cleaning.
9. The order of pretreatment performance, in terms of reducing NF fouling, is CSF>C/MMF>MMF≅ZMF.
10. The LFC1 was damaged due to monochloramine addition as evidenced by increasing K_w and decreasing TDS rejection. This membrane would be viable at this site only if a non oxidizing biocide were available.
11. The Fluid Systems CALP cellulose acetate membrane was tested with and without monochloramine addition. A biocide is necessary as shown by biological degradation and membrane failure when monochloramine was not used.
12. The CALP membrane fouled less with:
    - increasing flux; and
    - decreasing recovery.
13. The CALP membrane operated for extended periods of time (> 7 months) without chemical cleaning. Individual experiments resulted in estimated runtimes of less than 7 months, however cleaning was not required and the shorter runtime estimates may have been due to data variability associated with relatively shallow declines in productivity.
14. CALP fouling was reversible with chemical cleaning.
15. The order of performance by NF was CALP>LFC1>ESNA.

4.2 WATER QUALITY

4.2.1 Pretreatment

Table presents the water quality of the two microfiltration systems in terms of turbidity and organics: TOC, THM, and HAA. The turbidity of the microfiltration permeate is less than 0.2 NTU whatever the turbidity of the raw water. Turbidity of the raw water ranged from 1 to 4 NTU. As expected the microfiltration do not remove any organics unless coagulation is used as a pretreatment. However, the THM and HAA levels exceed the proposed 80/60 levels of the Stage 2 D/DBP rule.

Table 14. Microfiltration water quality

Contaminant	Regulation	MF
Turbidity	0.3 NTU	MFs meet the regulation with a turbidity < 0.2 NTU
TOC HAA THM	 30µg/L (Stage II) 40µg/L (Stage II)	No rejection of TOC, THM, and HAA by MF unless coagulation was used prior to the system. However, the coagulation did not meet the regulation

4.2.2 Integrated membrane systems

IMS water quality results are summarized in Table 15.

Organics

IMS organics removal was assessed via measurement of THM, HAA, and TOC concentrations. Results are presented in Table 15. As shown, raw water TOC ranged from an average of 6.2 mg/L during MMF-CALP testing to 22.2 mgL during C/MMF-LFC1 testing. All pretreated waters exceeded proposed D/DBPR Stage 2 MCLs for THMs and HAAs. Thus nanofiltration or other further treatment of this water source would be required to meet the proposed Stage 2 requirements if free chlorine were used for disinfection.

ESNA. The ESNA was tested only with CSF pretreatment. The CSF pretreatment reduced TOC by 85% to 2.8 mg/L. The ESNA reduced TOC to 0.2 mg/L. SDS-THMs and HAAs were impacted by preformed THMs and HAAs present in the CSF water due to prechlorination of the filters in the full-scale WTP. Therefore, though the ESNA SDS-THMs exceeded the proposed Stage 2 MCL, this number is considered high due to preformed THMs. The permeate TOC of 0.2 mg/L is sufficiently low that proposed Stage 2 MCLs should be met, based on previous SDS research. SDS-HAAs were less than proposed proposed Stage 2 MCLs. In summary, the organic rejection for the ESNA was high and is expected to meet proposed Stage 2 MCLs.

LFC1. The LFC1 nanofilter produced less than 0.5 mg/L TOC regardless of feed TOC concentration. THMs and HAAs were below proposed 80/60 Stage 2 MCLs irrespective of pretreatment process. THMs were less than 6 μg/L for all systems and HAAs were less than 27 μg/L. The LFC1 nanofilter is expected to meet all current and proposed regulations, for all operational conditions and pretreatment processes.

CALP. The CALP nanofilter, though the least fouling membrane as presented previously, had lower rejection than the ESNA and LFC1 for all parameters tested. CALP THMs only met the proposed Stage 2 MCL of 40 μg/L when feed TOC averaged 5.5 mg/L or less. CALP HAAs followed the same trend and only met the proposed Stage 2 MCL of 30 μg/L at feed TOC concentrations less than 5.5 mg/L. For this source water, which averages TOC over 10 mg/L, the CALP nanofilter would only be capable of meeting proposed Stage 2 MCLs if a coagulant-based pretreatment were used. This includes consideration of the regulatory allowance of a rolling quarterly average. Nevertheless, the CALP achieved a TOC of less than 1 mg/L for all feed water concentrations and is significantly higher quality than that of CSF treatment. The CALP should readily meet proposed Stage 2 MCLs via use of monochloramine disinfection or use of a coagulant-based pretreatment. Given its ability to meet proposed Stage 2 MCLs, under these conditions, and its low fouling potential, the CALP nanofilter may be suitable for surface water applications. No assessment of the effect of varying flux and recovery on permeate concentration was made via this data, due to variations

in feed concentration. However, if TOC removal is controlled by diffusion, there may be an operational range in which permeate THM and HAA concentrations may be minimized.

Table 15. IMS Organic Water Quality Summary

IMS	TOC (mg/L)			SDS-THM (µg/L)			SDS-HAA (µg/L)		
	Raw	PTMT	NF	Raw	PTMT	NF	Raw	PTMT	NF
CSF-ESNA	19.8	2.8	0.2	1556	83[1]	46[1]	1628	39[1]	4[1]
CSF-LFC1	12.6	2.0	<0.5	1070	47	3	1124	40	4
MMF-LFC1	17.0	15.3	<0.5	1280	1093	4	1891	1920	27
ZMF-LFC1	11.1	10.8	<0.5	873	696	6	1897	1011	9
C/MMF-LFC1	22.2	18.4	<0.5	1347	1017	7	2434	2122	5
CSF-CALP	20.7	3.2	0.5	1556	124[1]	57[1]	1628	51[1]	19[1]
MMF-CALP	6.2	5.5	0.5	469	443	34	591	362	23
ZMF-CALP	17.4	15.0	0.8	1352	1037	60	2313	1868	57
C/MMF-CALP	19.7	16.8	0.7	1518	1157	59	4116	1927	49
C/ZMF-CALP	15.5	4.2	0.8	1032	152	35	1469	683	21

[1] – Unrepresentatively high due to preformed DBPs from prechlorination of sand filters, which would not occur if IMS treatment were used at full scale.

Inorganics

IMS organics removal was assessed via measurement of total hardness (TH), sulfate and chloride concentrations. As measurements of divalent ions, total hardness and sulfate rejection is expected to be higher than chloride, a monovalent ion. Results are presented in Table 16. As shown, raw water TH ranged from an average of 75 mg/L as $CaCO_3$ during C/MMF-LFC1 testing to 168 mg/L as $CaCO_3$ during MMF-CALP testing. Seven of the ten pretreated waters exceed the common target TH goal of less than 100 mg/L as $CaCO_3$. Thus nanofiltration or other softening treatment of this water would be desirable. Additionally, removal of sulfate introduced in the ferric CSF or C/ZMF process would be desirable. Finally, removal of chloride introduced in the polyaluminum chloride C/MMF process and from the hydrochloride acid feed to the NF systems would be beneficial.

ESNA. The ESNA was tested only with CSF pretreatment. All inorganic parameters (total hardness, sulfate, and chloride) were reduced to below 20 mg/L. Chloride rejection was the lowest, as expected for a monovalent ion. The level of softening and inorganic rejection by the ESNA is high and suitable for surface water applications. Addition stabilization might be needed in a full-scale application due to the high rejection.

LFC1. The LFC1 nanofilter produced less than 20 mg/L total hardness, less than 1 mg/L sulfate, and less than 8 mg/L chloride, for all IMSs tested. This was the highest rejection NF tested and would require stabilization. However, its high rejection capabilities would enable removal of inorganic contaminants of concern.

CALP. The CALP nanofilter, though the least fouling membrane as presented previously, had lower rejection than the ESNA and LFC1 for all parameters tested. Permeate total hardness ranged from 26 to 61 mg/L as $CaCO_3$, representing approximately 50-60% rejection.

Sulfate rejection was higher with permeate concentrations ranging from 14 to <1 mg/L, representing 80-90% rejection. As expected, chloride rejection was the lowest and resulted in permeate concentrations from 14 to 63 mg/L. Though water from the CALP membrane would have moderate to low hardness, as is desired, corrosivity would still need to be assessed and stabilization practiced as necessary.

Table 16. IMS Inorganic Water Quality Summary

IMS	Total hardness (mg/L as $CaCO_3$)			Sulfate (mg/L)			Chloride (μg/L)		
	Raw	PTMT	NF	Raw	PTMT	NF	Raw	PTMT	NF
CSF-ESNA	110	175	17	16	99	5	13	17	5
CSF-LFC1	137	172	16	30	95	<1	14	16	6
MMF-LFC1	86	84	1	11	11	<1	10	10	1
ZMF-LFC1	144	138	16	25	33	<1	15	14	5
C/MMF-LFC1	75	70	8	10	7	<1	10	11	8
CSF-CALP	114	181	61	15	109	14	13	16	14
MMF-CALP	168	163	75	35	34	4	16	64	45
ZMF-CALP	81	78	26	10	11	1	10	36	25
C/MMF-CALP	103	101	51	10	10	<1	13	96	64
C/ZMF-CALP	116	116	50	18	111	14	13	46	38

4.2.3 IMS Assessment.

1. The ESNA reduced TOC to 0.2 mg/L and is expected to meet proposed Stage 2 MCLs.
2. The LFC1 produced less than 0.5 mg/L of TOC and met proposed Stage 2 MCLs for all IMSs tested.
3. The CALP produced less than 1 mg/L of TOC for all IMSs tested.
4. CALP SDS-THM and SDS-HAA concentrations met proposed Stage 2 D/DBPR MCLs when feed TOC concentrations were less than 5.5 mg/L.
5. The CALP is expected to meet Stage 2 MCLs when a coagulant based pretreatment is used or when monochloramine disinfection is employed.
6. Inorganic rejection was high for both composite thin film membranes, the ESNA and LFC1. Permeate total hardness concentrations were less than 30 mg/L, sulfate less than 5 mg/L and chloride less than 8 mg/L, for all systems tested.
7. CALP inorganic rejection was significantly less than the ESNA and LFC1 but adequate for softening of this surface water.
8. The order of NF rejection was LFC1>ESNA>CALP.
9. All nanofilters produced a higher water quality than conventional CSF treatment.

SECTION 5
QA/QC SUMMARY

The Quality Control/Quality Assurance data is provided on disk using the Excel spreadsheets provided by EPA. All methods used were approved Standard Methods, EPA Methods or ICR methods. Work was performed by the University of Central Florida ESEI Laboratory and the Tampa Water Department Water Quality Laboratory and Operations staff. Methods and MRL's are summarized in Table 8.

Appendix A

Pilot Study Log Book Notes

8/25/97

0730-- Calibrated pH and TDS meters.

1100-- Making new spreadsheet - entering data

1430-- NF-2 Antiscalent at 8 gallons which would have 78637 mg. of actual AS in tank. Will add 205 ml
of AS to fill tank to 31 gallons.

1440-- NF-2 AS tank full now.

8/25/97

1530-- Aquasource flow dropped to zero. Increased feed pump speed to 31.43 to get flow back to 2.2 gpm. Feed pressure is now at 7.0 psi.

8/26/97

0100-- COI called me at home to inform me that the flow was low on the Aquasource and that when he increased the speed of the feed pump the Aquasource shut down on "High Module Pressure".
I had the COI turn off the blue pump at the Aquasource and shut down NF-3 per S.O.P.

8/26/97

0730-- I talked to Robert Reiss and he wanted me to keep Aquasource and NF-3 O/O/S until the Aquasource could be cleaned sometime this week.

1220-- Zenon unit shutdown for maintenance personnel to perform P.M. on feed pump compressor.

1500-- Zenon unit back in service.

8/27/97

0900-- Calculated NF-2 antiscalent pump is pumping 12.19 ml/minute. This is based on NF-2 running 7140 minutes (4 days, 23 hours) and using 87055 mls (23 gallons) which equals the 12.19 ml/minute.

8/27/97

1000-- Calculated NF-3 antiscalent pump is pumping 11.80 ml/min. This is based on NF-3 running 7700
minutes (5 days, 8 hours, 20 minutes) and using 90840 (24 gallons) which equals the 11.80 ml/min. Filled antiscalent tank for NF-3 up to 32 gallons but only added 20 ml of AS to compensate for speed of pump.

1145-- Started cleaning Aquasource (UF)

1430-- Start up AQS pilot (UF). Flow = 1.7 gpm and BW frequency is 30 minutes.

1700-- NF-3 appears to be completely fouled, permeate flow is almost zero and there is no permeate pressure. Christophe will clean it overnight with caustic. Steve and I will finish the cleaning in the morning. (Caustic cleaning--pH=10.5 NaOH 50%, Recirculation from 17:15 to 18:00.

8/28/97

0705-- Draining the cleaning tank.

0710-- Filled cleaning tank with permeate and am recirculating through NF-3.

0800-- NF-3 flushed and ready to start. Flushed cleaning tank with permeate.

0905-- Started NF-3. Permeate flow too low-permeate pressure at 1 psi.

0915-- Shutdown NF-3.

1100-- Filling chemical tank with permeate to acid wash NF-3 per Robert Reiss.

1225--Chemical tank heated to 41 oC and 8.5# of citric acid added. pH now at 2.20, added NaOH until we got a pH of 4.02. Approximately 1.26 liters of NaOH was added.

1230-- Recirculating acid through NF-3.

1400-- Stopped acid wash

1410-- NF-3 on, regained some recovery.

1510-- NF-3 off to soak overnight in acid solution per Robert Reiss.

8/29/97

0700-- Draining cleaning tank and will fill with permeate to flush NF-3.

0710-- Flushing NF-3 with permeate

0730-- Started NF-3

1230-- NF-2 antiscalent is at 14 gallons. Filling NF-2 AS container up to 31 gallons and adding 152 mls of concentrated antiscalent to keep a 2 mg/l dose.

9/1/97

1400-- Calibrated pH and TDS meters and performed daily tests. Took portable pH meter in to operations control room and used the 7.41 pH standard and the portable meter read 7.32.

9/2/97

1130-1330-- Bi-weekly samples taken from NF-2, NF-3, Aquasource, and Zenon. Robert Reiss is here to help with sampling.

1430-- Performed calcium hardness tests on NF-3. Results are as follows:
Feed (31) = 92 ppm of Calcium hardness as CaCO3
Blended Feed (32) = 330 ppm of Calcium hardness as CaCO3
Concentrate (36) = 380 ppm of Calcium hardness as CaCO3
Permeate (37) = 8 ppm of Calcium hardness as CaCO3.

9/3/97

0700-- Shutdown NF-2 for the installation of NF-1 pump.

1100-- New parameters for project. Please refer to actual logbook for details.

9/4/97

0345-- NF-3 went down of low feed pressure.

0715-- I restarted NF-3

0800-- I noticed that the Aquasource permeate tank was not full (only had 90 gallons in it).

0900-- Aquasource has only 65 gallons of permeate in tank. Called Robert to see if he want me to go up on speed of feed pump.

0910-- NF-3 shut down on "low feed pressure".

0957-- Unit back on.

0957-- (UF) Aquasource shut down to perform drop test for NF-3.

1027-- (UF) Aquasource back on - set feed flow at 2.3 gpm, pressure at 5.4 psi.
***NF-3 is using 1.36 gpm according to drop test of Aquasource permeate tank. NF-3 should only be using 1.2 gpm.

9/5/97

0700-- I noticed that NF-3 was off and the low feed pressure alarm light was on. I looked at the Aquasource and it only had a feed flow of 1.1 gpm, not enough for NF-3. I didn't raise the Aquasource feed flow because I wanted to do the daily tests on the Aquasource and get advice from Robert on what he wanted to do about the Aquasource.

1000-- Aquasource down for cleaning per Robert Reiss. NF-3 is also still down. Adjusting NF-1 antiscalent feed. The AS tank for NF-1 has only dropped 1 gallon in the last 24 hours.

1300-- Aquasource aback on and set at 2.0 gpm feed flow. Feed pressure is at 3.1 psi.

1600-- NF-1 AS pump changed out. I am now using the yellow pump (LMI). I calibrated it to 8 ml/min.

1615-- NF-3 on - MTC @ .07143. I talked to Robert and he wanted me to do an acid cleaning.

1715-- NF-3 off - filling cleaning tank with permeate and running through heater will add acid when when tank reaches approximately 41oC.

1915-- Started acid wash through NF-3. Cleaning water has a 3.94 pH, 1630 TDS, and is 41 oC.

2015-- Stopped acid wash - will let NF-3 soak overnight in acid per Robert Reiss.

9/6/97

1545-- Flushing NF-3 with permeate. Water quality in NF-3 was pH=4.01, TDS=1320

1600-- Turned Aquasource pump up higher to obtain a 2.3 gpm feed flow to cushion NF-3.Topped off bleach container.

1605-- Started NF-3 - emptied cleaning tank to waste.

1640-- NF-3 readings taken - MTC = .19184

1725-- NF-3 Water quality TDS - Perm=0, Blended Feed=270, Concentrate=310, Feed (31)=120

9/7/97

1430-- I called Robby McGlynn to have him check on the Aquasource for me. Feed flow was down to 1.5 gpm. I had him increase feed flow output to achieve a 2.2 gpm flow rate to make sure NF-3 wouldn't
shut down on "low pressure".

9/8/97

0710-- I increased flow at the Aquasource to achieve 1.8 gpm = 7.6 psi.

1330-- Antiscalent levles as follows NF-1=19 gls., NF-2=7 gls., and NF-3=16 gls. Topped off all containers with correct amount of AS and CSF water.

9/9/97

0700-- NF-3 Shutdown sometime oveernight due to low flow from Aquasource.

0900-- Aquasource down for cleaning.

1100-1200-- NF-1 sampling

1130-- *Per Robert Reiss - AS dosage for 85% recovery = 2.5 mg/l 65% = 5 mg/l

1300-- Aquasource restarted

1500-- Cleaning the Zenon unit as instructed by CRR & UCF. Chlorine and caustic cleaning = 1 hour recircualation at 3 gpm permeate rate, backpulse every 12 minutes for 20 seconds. Will soak overnight with just the air running at 25 cfm.

1645-- NF-3 on

1700-- NF-1 reset to second set of parameters. Antiscalent adjusted so that 503 mls of AS is needed for 30 gallons @ 8 ml/min. I drained NF-1 AS tank down to 11.3 gallons and refilled with CFS water. S1 Perm = 2.3 gpm, S2 Perm = 1.2 gpm, Conc-Waste = 37 gph, Recycle = 3.7 gpm

1740-- Zenon water being recirculated - water quality - pH =10.6 with 2 gallons of bleach added to tank.

1840-- Zenon shutdown to soak except for the blower which is running at 5 cfm overnight to clean.

9/10/97

0715-- Zenon drained and refilled with finished water (pH was 7.40).

0950-- Clean water flux done for one hour, vacuum pressure was at 5.0"

1100-- Draining Zeeweed tank of finished water

1120-- Filling zeeweed tank with raw water

1210-- Zenon unit started at 9.3 gpm, air at 15 cfm, backpulse for 20 seconds every 12 minutes. Concentrating to 90% recovery-which will be at 20:55.

1210-- Nf-3 off to be cleaned using method #3 with Dodecylbenzene. Cleaning tank heating up w/permeate.

1300-- Added one pound of Dodecylbenzene and added 8.5 # of sodium tripolyphosphate to the cleaning tank.

1330-- Started caustic wash through NF-3. I also had to adjust pH to 11.00 with NaOH.

1445-- Stopped caustic cleaning - will flush NF-3 with permeate.

1450-- NF-3 on.

9/12/97

0915-- NF-3 went down sometime before 0355 this morning. Flow rate on the Aquasource is way down to 1.5 to 1.7 gpm. Increased pump speed to 2.0 gpm flow to keep NF-3 running.

9/13/97

0430-- I increased the pump speed on the Aquasource to 2.0 gpm - pressure is now at 7.0 psi.

9/16/97

*** Please Note Antiscalent info in log book. i.e.- date, quantity of csf water added, quanitity of AS added, etc..

All Day-- Biweekly sampling performed on all three filter trains

9/17/97

All Day-- Spent the day doing spore spiking on Zenon, Aquasource and all three filter trains. John Gordy and Robert Reiss.

1300-- NF-3 had to be shutdown for about one hour to perform the Aquasource spiking. Samples

were taken to the lab immediately for culturing.

End of Day-- Reset NF-1, NF-2, and NF-3 flows as follows.

	NF-1	**NF-2**	**NF-3**
S1Perm->	4.7	4.7	46.7 Perm
S2Perm->	2.3	2.3	8.2 Conc.
Conc.--->	3.8	1.2	3.4 recycle
Recycle->	4.8	7.3	

*****Various AS figures are in logbook****

9/18/97

0930-- All systems including the Aquasource and Zenon were shutdown per operations. The entire plant is being shutdown for ~ 1 hour. No CSF water will be available.

1215-- Aquasource, Zenon and NF-3 powered back up. CSF will remain down a few more hours. NF-1 and NF-2 will need to remain down.

1615-- NF-1 and NF-2 turned back on. Panel was finished and I could turn on the CSF pump. (Based on TDS data it appears that the concentrate valve that was not in use on NF1 was erroneously opened to approximately 1.2 gpm. The valve was found at this flow rate on 9/30/97. TDS mass balance indicates the problem began on 9/18/97)

9/19/97

0910-- NF-3 went down this morning sometime. I checked the Aquasource and it was down and alarming.
EV-2 solenoid failure, will reset on alarm acknowledge but immediately fails when unit is turned back on. I turned off the break pump, fortunately it had not gone dry.

9/22/97

1100-- pH meter appears to be dying or needs new batteries. I could not calibrate to pH of 10.0 and at the end of the water quality analysis it was giving an unusually high pH. Checked pH 7 standard and it was reading a pH of 14.00.

9/23/97

0800-- Replaced batteries in both the pH and TDS meters. Standardized both pH and TDS meters. pH meter appears to be working fine now.

0945-1100-- NF-1 sampling (weekly sampling).

1325-- 4 gallons of AS for NF-2 left. Adding 364 mls. of AS and filling to 30 gallons with CSF water.

1335-- Changed NF-1 settings to last set of settings per log book request. (Same run settings as NF-2).

1430-- AS figures in logbook.

9/24/97

0900-- Zenon off for cleaning. Also replacing leaky smaple tap for raw water.

1045-- Aquasource on - seems to be running fine but pressure is high. Waiting to hear from Robert on status of cleaning it.

1145-- Recirculating water through Zenon unit - added 2 gallons of bleach and adjusted pH to 10.4.

1150-- Recirculating water through cleaning tank until 41oC is reached. This is for cleaning of NF-3.

1350-- Zenon just blowing air now @ 5 cfm. Will let do this overnight.

1400-- Added 1# of Dodecyl and 8.5# of sodium tripolyphosphate to cleaning tank. Temp. @ 42 oC. Starting caustic cleaning wash to NF-3.

1500-- Stopped circulation of NF-3. Will let soak overnight until Aquasource is cleaned tomorrow per R.R.

9/25/97

0710-- Zenon off - draining tank.

0900-- Aquasource off to do cleaning.

0905-- Filling Zenon tank with tap water to flush with.

0940-- Started clean water flux on the Zenon unit.

0950-- After running cleaning solution (U43) through Aquasource. Will let soak one hour.

1010-- Clean water (permeate) flush on NF-3.

1130-- Aquasource back on at 2.0 gpm and at 3.1 psi.

1225-- NF-3 on - using "top" concentrate rotometer.

1300-- Zenon on - Bleed needs to be opened at 21:45 by COI.

1400-- NF-3 feed pressure up to 152 psi per Robert to try to increase perm flow through NF-3.

09/26/97

0830-- NF-3 off for acid cleaning at pH of 3.0.

0835-- Started acid wash through NF-3. Water is at 41oC and pH of 3.01. Will get NF-3 backup about 12:00.

Zenon running at 90%, bleed opened at 21:45 on 9/25/97.

0930-- NF-3 wash stopped - letting soak at pH of 3.01.

1230-- NF-1 down to repair leaking 1/4 "T".

1240-- NF-1 up and running.

1245-- NF-3 flushed with permeate.

1255-- NF-3 on and running.

1500-- Topped off AS for NF-1 and NF-2. NF-1 was at 22 gallons - I added 280 mls. of AS + 8 gallons of CSF water. NF-2 Calculated pumping rate of 12.4 mls/min. This would require 646 mls/30 gallons.

I already have 210 mls in NF-2 barrel at 15 gallons. Will add 436 mls. of AS to barrell + 15 gallons of CSF.

9/29/97

0425-- COI noticed Aquasource and NF-3 were off. Blue pump on Aquasource left on. I turned it off.

0710-- Aquasource started. No alarm was lit but I had to press "Alarm Acknowledge" to get it to run. I started it at 2.0 gpm. No apparent damage to blue pump was noticed.

0735-- NF-3 back on.

1430-- NF-2 getting noisey and a little hot. Had Bernie Menendez check it out. He added some grease and hopefully the pump will last long enough to get bi-weekly smaples tomorrow.

1640-- Aquasource and NF-1 down momentarily for transformer switching in plant.

1642-- Aquasource and NF-1 back on.

9/30/97

0700-- Aquasource shutdown overnight again. It was noticed down at 04:45. NF-3 down also. Both units were isolated. *** NF-2 pump is noisier***

0715-- Aquasource on.

0730-- NF-3 on.

1100-1230-- Bi-weekly samples

1230-- NF-1 off - NF-1 prefilter changed- old one was black and non-slimy.

1430-- NF-1 on with Zenon permeate feeding the NF-1 unit. New settings as follows.

NF-1 S1 perm = 2.3 gpm, S2 perm = 1.2 gpm, Conc (waste) = 1.9 gpm, Recycle = 2.4 gpm with a 65% recovery and a 5 mg/l dose. NF-2 and Aquasource running at same settings. Waiting for formaldahyde.

NF-1 AS tank has 20 gallons in it which would have 700 mg of AS. Need 1507 mg of AS for 30 gallons. Added 807 mg of AS to NF-1 tank and filled to 30 gallons with permeate.

1500-1645--TH and Alk testing in lab.

1730-- NF-3 has 5 gallons in AS tank. Will add 68 mg of AS to achieve concentration of 81 mg of AS

per 30 gallons at 11 ml/min - .915 gpm - 2.5 mg/l dose.

1740-- Performed water quality tests on NF-1.

10/01/97

0820-- NF-2 Down - Bad (noisy) pump.

1505-- Formaldahyde + Sodium Bisulfite came in. Will clean NF-2 tomorrow.

10/02/97

0700-- Found NF-3 off (low feed pressure). I increased speed of pump to Aquasource.

0705-- NF-3 started.

1015-- After heating cleaning tank permeate water to 41 oC, I added 8.5# of Tripolyphosphate, 1.1# of Dodecyl and then adjusted pH to 11.10.

1020-- jStarted caustic cleaning of NF-2.

1130-- Finished caustic cleaning (water very dark).

1145-- NF-2 on long enough to get readings.

1200-- NF-2 off.

1205-- Heating permeate (fresh) in cleaning tank.

1225-- Maintenance here to pull NF-2 pump.

1245-- NF-2 pump gone now.

1315-- Added citric acid to obtain a pH of 2.97 in cleaning tank. Started acid wash through NF-2.

1420-- Flushed NF-2 with permeate.

1430-- Made 1% solution of formaldahyde and permeate. 1/2 gallon of 25% Formalin solution + 50 gallons of permeate.

1440-- Flushing NF-2 with permeate and formaldahyde solution.

1450-- Stopped flushing NF2 with pickling solution. Closed NF-2 F23, F25, F26 (both valves), pump inlet valve and NF-2 stage 2 exit valves. All closed

10/03/97

0715-- NF-3 off on low suction. Aquasource at 0 gpm but still on barely.

0730-- Aquasource off - getting ready for cleaning.

0845-- Preparing Aquasource for cleaning.

0930-- Solenoid valve on Aquasource is not working. EV-2 Valve won't open.

1145-- EV-2 solenoid valve repaired with spare solenoid. Making U-43 solution for Aquasource cleaning.

1200-- Running U-43 cleaning solution through Aquasource.

1245-- Stopped U-43 circulation. Letting soak one hour.

1400-- Starting Aquasource with raw water to get readings.

1430-- Aquasource off

1445-- After mixing up U-59 solution I am running it through the Aquasource.

1500-- U-59 cleaning done. Letting soak one hour.

1610-- Starting up in production mode (already did B/wash cycle) @ 2.0 gpm.

1615-- NF-1 AS tank at 23 gallons. Added 350 ml/AS and added 7 gallons of permeate water assuming a 7.0 ml/min pumping rate @5.0 mg/l dose.

1630-- Got readings on Aquasource.

1631-- Shutdown Aquasource. Mixing solution of 1% BiSulfite.

1710-- Aquasource unit being pickled with 1% BiSulfite solution.

10/04/97

'2140-- NF-1 pressured indicate this unit is off. This was not noticed until the next day in the morning

when R.R. was notified. I, Steve, wasn't notified. Unit was shut down properly and small pump was off next to Zenon. Reason for shutdown was unkown. Zenon was running fine, may have been a power outage.

10/06/97

0730-- NF-1 on.

0740-- NF-2 wired up and rotation checked. Turned pump on and it was still very noisy. Will notify maint.

0926-- NF-1 seems to be operating as it was before it shutdown Saturday night - little or no fouling. Water quality from NF-1 appears to be the same pretty much as when fed with CSF.

1056-- Steve called to say that NF-2 pump will be removed by maint. and shipped out to be repaired as the NF-1 pump was. James Nauman will board up the Aquasource for shipping on Wednesday, Oct. 8, 1997.

1145-- Made formaldahyde solution for pickling of NF-2.

1200-- Started circulation of pickling solution through NF-2.

1230-- Stopped circulation through NF-2.

1245-- Hooked up GAC-CSF water into (UF) Aquasource permeate tank. Water is overflowing to drain.

1315-- Emptied NF-2 AS tank.

10/07/97

0730-- Added 50 gallons of permeate water to cleaning tank. Heating to 35 oC. This is in preparation of cleaning of NF-3. This cleaning m;ethod is at Robert's request.

0750-- Added 1893 mls. (1/2 gallon) of 50% caustic solution AND 172 mls (50ppm) of 5.5% bleach to cleaning tank. Water turned black.

0815-- Running cleaning tank solution through NF-3. Water quality of cleaning tank is pH=11.81 and the chlorine residual is 30 ppm of free chlorine.

0845-- Cleaning tank water quality is pH=-11.84 and chlorine=11 ppm free chlorine.

0945-- Cleaning tank water quality pH=11.86 chlorine=7 ppm

1015-- Cleaning tank water quality pH=11.81 chlorine=

1016-- Stopped NF-3 circulation.

1020-- Draining cleaning tank. Filling with permeate to flush NF-3.

1035-- Started flushing NF-3 with permeate.

1105-- Stopped flushing NF-3.

1115-- Started production on NF-3 with CSF feed water. Perm=46.7 gph, Conc.=8.2 gph, Recycle=3.4 gpm.

10/08/97

1140-- Flushing NF-3 through concentrae line with CSF water in preparation of shutdown of NF-3.

1145-- NF-3 off.

1200-- CSF water not going to Aquasource anymore.

1210-- I placed extra (1) solenoid for Aquasource in cabinet that needs the key (where solenoids are).

1300-- Aquasource being dismantled and getting ready to be boarded up.

1420-- Making formaldehyde pickling solution for NF-3.

1430-- Running formaldehyde solution through NF-3.

1500-- Stopped recirculation on NF-3.

10/09/97

0830-- NF-1 MTC has doubled from .173 (mtc1) on 10/08/97 @ 07:00, to .345 on 10/09/97 @ 07:30.

Will notify RR. All valves were in correct positions when I got here this morning.

845-- Zenon off for cleaning. NF-1 down due to Zenon cleaning. Flushed NF-1 by opening concentrate valve for five minutes before shutting it down.

1150-- Zenon raw water tank (big tank) filled with tap water. Added caustic and two gallons of bleach. The ph of the cleaning solution in the tank is 9.93.

1215-- Running the cleaning solution through Zenon unit.

1315-- Stopped circulation of cleaning solution.

1320-- Started blower to let Zenon soak overnight.

1400-- Installed sample taps on permeate of both vessels of NF-1, stage 1.

10/10/97

0710-- Shut Zenon unit blower off. Draining tank.

0740-- Filling tank with tap waer - Blower on while filling.

0810-- Drained tank back down.

0840-- Filling tank with tap water to conduct clean water flux.

1050-- Clean water flux results = 5.7" vacuum at 10.0 gpm permeate flow.

1055-- Draining tank.

1120-- Filling tank with raw water.

1130-- Memcor arrived and is on the back dock.

1215-- Zenon unit on - bleed will need to be opened at (21:00). Will let COI know.

1305-- Check Zenon permeate tank for cl2. No free or mono cl2 present.

1310-- Started NF-1 at perm-1=2.3, perm-2=1.2, conc.=1.9, rec.=2.4.

1430-- Mass balance is 1.0 on NF-1. MTC=.39. Will call Robert Reiss and notify.

1610-- NF-1 "pickled" with formaldehyde (put formaldehyde in Zenon permeate tank and ran through NF-1). Nf-1 off. These instructions per RR.

1615-- COI instructed to open bleed to 1.0 gpm at 21:00.

2100-- Jim Graham (COI) opened bleed on Zenon to 1.0 gpm.

10/13/97

0715-- Standardized pH and TDS probes.

2200-- Testing NF-1 membranes in NF-3 train. NF-1 membranes aren't rejecting any TDS.

10/14/97

All Day-- Hooking up Memcor unit, getting air hoses, shipped one membrane from NF-1 to Fluid Systems in San Diego.

10/15/97

1350-- Pickled NF-1 with formaldehyde and CSF water (no permeate available).

10/16/97

0415-- Zenon off - COI said low suction alarm was on.

0700-- Filling Zenon tank with raw water - tank siphoned down about half way down.

0710-- Zenon on.

0830-- Memcor guy here to hook up Memcor unit.

1300-- Memcor on at 12 gpm. *** Rwe water pumps cannot supply more than 25 gpm to pilot plant units. Jim G. to talk with M. Bennett about this problem. Don not go higher than 12.0 gpm on unit.

10/20/97

0730-- Standardized pH and TDS meters.

1030-- Raw water off to Zenon and Memcor units while maint. checks out raw water intake screen.

1150-- Screen at intakes plugged about 70%.

1330-- NF-2 pump in - waiting to be hooked up electrically.

1500-- NF-2 pump in, but leaks. Maint. will repair tomorrow a.m.

10/21/97

****Zenon unit shuts off intermittently due to low level in tank. Memcor using 12 gpm, Zenon using 9.4 gpm (perm), 1.0 gpm (bleed).

0945-1030-- Biweekly samples taken on Memcor and Zenon.

1100-1500-- Adjusting air pressure to raw water pumps to solve insufficient water problem. NF-2 pump sealed again where it was leaking. Will try to run it tomorrow morning.

All Day-- Bucket tested rotameters and performed tracer study on Memcor unit.

10/22/97

0800-0930-- Spore spiking on Zenon and Memcor units.

1225-- Raw water feed off to units while maint. works on raw water pumps. Zenon and Memcor off.

1230-- Draining Zenon unit. Getting ready to clean Zenon.

1345-- Filling Zenon with tap water. (already rinsed tank out)

1545-- Put 2 gallons of bleach and enough caustic to get a 10.0 pH in cleaning tank.

1550-- Started Zenon in recirculation cleaning mode.

1650-- Stopped Zenon recirculation - will start blower at (5cfm) and let soak overnight.

10/23/97

0710-- Turned Zenon unit off. Draining tank.

0725-- Filling Zenon with tap water for clean water flux.

0930-- Started finished water flux through Zenon unit. Only 6" of vacuum @ 10.0 gpm.

1030-- Relabeled all concentrate valves. Higher flow rotameters = (x)A Lower flow rotameters = (x)B.

1100-- Finished water flux stopped on Zenon Unit.

1445-- Zenon on at 9.4 gpm, no bleed. COI will open bleed valve to 1.0 gpm at 21:30 tonight.

1615-- Zenon and Memcor were both down. Zenon showed high pressure alarm turned it back and it was O.K. until backpulse afterwhich it high pressure alarmed again. Turned unit back on and is running now.. The Memcor went down but I don't know why. It came right back on.

10/24/97

0620-- Filled cleaning tank with CSF water and 1 liter of formaldehyde.

0630-- Running "pickling" solution through NF-2.

0650-- Stopped recirculation of pickling solution.

0655-- Drained cleaning tank.

10/27/97

0900-- Memcor unit down. Been down since 10/24/97 @ 1945. Low air light is on, unit will not come back up.

10/28/97

0855-- Zenon unit was off, High pressure alarm on the backpulse. Alarm was silenced and unit was powered up again. Memcor still down and still will not start.

1245-- Memcor unit started. Air pressure back on to the unit using plant air.

1400-- Maintenance installing NF-2 pump - will try it tomorrow.

10/29/97

0800-- Emptied NF-1 antiscalent.

0900-- Started NF-2 with CSF water. Pump does NOT leak now. Letting NF-2 run long enough to get some readings for Robert Reiss.

0930-- Changed batteries in TDS meter. Recalibrated meter.

0940-- NF-2 off.

1000-- NF-2 on to make 50 gallons of permeate for cleaning tank.

1010-- NF-2 off - heating up cleaning tank water. Starting pH=7.30 TDS=100 before NaOH

1020-- Added 946 mls. of NaOH. pH=12.22 TDS>2000

1200-- Cleaning tank water at 35oC - Started recirculating caustic solution through NF-2.

1400-- Stopped recirculation pH=12.10 TDS>2000

1405-- Flushing with CSF water.

1410-- NF-2 unit on

1455-- Will leave NF-2 on with CSF water as feed until tomorrow. Will clean NF-2 with Cl2 (50 ppm) and caustic tomorrow.

1610 NF-2 off to perform bucket test on F26 rotameter. Check in log book for results.

1625-- NF-2 unit back on.

10/30/97

0800-- Heating up permeate water to 35oC for preparation of NaOH and Cl2 cleaning of NF-2.

0930-- Stopped NF-2.

0932-- Added 172 mls. of 5.5% bleach and 946 mls. of 50% caustic to cleaning tank. pH=12.17 Cl2= 36 ppm.

0940-- Started cleaning tank water recirculating through NF-2.

1010-- Cleaning tank water quality pH=12.08 Cl2=10 ppm

1105-- Cleaning tank water quality pH=12.04 Cl2=10 ppm

1115-- Performed Memcor membrane test. 2 min.=14.5 psi 4 min.=14.3 psi.

1140-- Stopped recirculation of cleaning solution. Water quality pH=11.97 Cl2=7.2 ppm.

1145-- Flushing NF-2 with CSF water.

1230-- NF-2 on with CSF as feed water.

1400-- MTC on NF-2 is .154 MB=79%.

1505-- Made AS solution for NF-2 assuming 12.4 ml/min pumping rate, 8.2 gpm flow @2.5 ppm of AS equaling 258 mls of AS needed to 12 gallons of permeate. As pump is pumping.

10/31/97

1010-- NF-2 off to perform bucket testing.

1100-1400-- Bucket testing recycle meters. Results in log book.

1400-- Made up solution of formaldehyde (1 liter) and 50 gallons of CSF water.

1410-- Recirculating pickling solution through NF-2.

1430-- Stopped NF-2 recirculation.

1500-- Poured some pickling solution on NF-3 membrane - put back in vessel and sealed it up.

11/3/97

0100-- Raw water off to Memcor and Zenon units. Units off.

0730-- Raw water back on. Units on.

0800-- pH meter not working well. Used operations pH meter. Standardized TDS meter. Will use spare pH meter tomorrow.

11/4/97

0500-- Zenon off due to low raw water flow.

0700-- Zenon on.

0705-- Heating CSF water in cleaning tank. (50 gallons)

0750-0810-- BiWeekly sampling.

0815-- Zenon off to be cleaned. Draining tank.

0830-- Added 1.0# fo EDTA, 1.0# of Ultra Biz for Stains, and 1893 mls. of 50% NaOH to the cleaning tank.

Temperature only at 31oC. Will go to 35oC.

0845-- Flushed NF-2 with regular CSF water to get pickling solution out of membrane.

0900-- Stopped flushing of NF-2 with CSF water. Started recirculating cleaning solution through NF-2. pH=12.56.

0910-- Filling Zenon with tap water.

0945-- Added 2 gallons of 5.5% bleach and enough caustic to achieve pH of 9.97 in Zenon tank.

0950-- Started recirculating cleaning solution through Zenon tank.

1050-- Stopped Zenon recirculation - Started blower @ 5 cfm and letting soak overnight.

1100-- Stopped "Biz" cleaning on NF-2. pH=12.50. Flushing with CSF water.

1200-- Started NF-2 to get readings.

1340-- NF-2 off.

11/5/97

0710-- Zenon blower off - Draining tank.

0715-- Heating CSF water in cleaning tank to prepare for acid cleaning of NF-2 per R.R.

0815-- Added 8.5# of Critric acid to 50 gallons of CSF water in cleaning tank. pH=2.17 Temp=app.30oC.

No adjustment to pH needed per R.R.

0900-- Water quality in cleaning tank = pH@ 2.53

0930-- pH = 2.68 in cleaning tank.

1000-- Changed membranes in NF-1 (New membranes installed).

1040-- Cleaning stopped on NF-2.

1115-- NF-2 on for readings with CSF water. (.10 MTC)

1230-- NF-1 on with CSF water - AS made 7 mls/min = 1507 mls of AS in 30 gls. of permeate.

Switched NF-1 over to Zenon permeate to feed NF-1.

1500-- Turned second pump on at the raw intakes (pumphouse).

11/6/97

0740-- Memcor turned off - high pressure difference and low air pressure..

0750-- Heating up 50 gallons of permeate in cleaning tank.

0900-- Memocr on. Air pressure up to 90 psi now. Bypassing air dryer in operations.

1130-- Added 8.5# of citric acid and app. 1500 mls. of NH4OH (ammonium hydroxide) to cleaning tank.

pH @ 3.98 now. Started cleaning solution through NF-2.

1330-- Stopped NF-2 cleaning.

1335-- NF-2 on with CSF water feeding it.

1355-- NF-2 off per R.R. MTC=.09 + .11.

11/7/97

0400-- Approximate time NF-1 went down on "low suction". NF-1 was running fine at 03:45.

0700-- NF-1 on now.

0750-- Opened concentrate valve to flush NF-1.

0800-- NF-1, Zenon, and Memcor off to perform flow test on raw water line.

1030-- jAll units back on and running.

1230-- Added 50 gallons of permeate to cleaning tank.

1245-- Added 1 liter of formaldehyde to cleaning tank.. Started recirculation of pickling solution through NF-2.

1300-- Stopped NF-2 pickling.

1855-- NF-1 off (low suction pressure)

2000-- NF-1 on - Suction pressure increased to 40 psi while running.
2020-- Suction pressure increased to 43 psi.

11/8/97

0630-- All units off for raw water suction repair.
1500-- All units back on.
1800-- Zenon down - High backwash pressure alarm.
1845-- Zenon back on - adjusted (lowered) backwash pressure to 6.0 psi from 7.0 psi.

11/10/97

0330-- NF-1 down "low suction pressure".
0700-- NF-1 on.
1030-- Raw water off - All units off - Maint. tieing in new discharge line.
1250-- Raw water on - All units on. Can get 66 gpm from both raw pumps at 85 psi.

11/12/97

0315-- NF-1 was off "low suction pressure".
0705-- NF-1 on - higher permeate pressure than normal (36 psi on perm!).
0800-- NF-1 MTC=.171 MTC2=.162 TDS in perm1 + perm2 = 80. Conc. TDS=120 Permeate water is slightly colored.
0825-- Calling R.R. to notify of NF-1 problem.
1025-- Talked with Dr. Taylor and notified him of problem with NF-1. He told me to shut NF-1 down and let CSF water flush through the membranes.
1030-- NF-1 down per Dr. Taylor.
1035-- CSF water not available due to raw water to plant was shutdown at 9:00 a.m.
1045-- Turned Csf pump off. Pump was hot.
1400-- CSF water pump on now - Circulating CSF water through NF-1.

11/13/97

0705-- NF-2 on with CSF water to get readings.
0725-- NF-2 off - after cleaning tank was filled with permeate water.
0730-- Heating cleaning tank water.
0740-- Zenon off - to be drained and cleaned.
0830-- Memcor off to hookup air compressor.
0850-- Memcor on with new A/C.
0945-- Added 1893 mls of 50% NaOH + 344 mls of cl2 bleach (5.5%) to cleaning tank.
1000-- Started recirculating cleaning tank solution through NF-2. pH=12.22 CL2=55ppm.
1005-- filling Zenon tank with tap water.
1025-- Adjusted pH in Zenon tank to 10.31 + added 2 gallons of 5.5% bleach.
1030-- Started Zenon with caustic + bleach solution in tank. Will circulate for 1 hour.
1130-- Stopped Zenon recirculation - Started blower at 5 CFM and will let soak overnight.
1200-- Stopped NF-2 circulation - Draining cleaning tank. pH=12.24 CL2=29 ppm.
1210-- Flushing NF-2 with CSF water.
1211-- NF-2 on with CSF water.
1230-- NF-2 off.
1240-- NF-2 being fed from Memcor now - flushing NF-2 with Memcor permeate.
1300-- 194 mls of AS in NF-2 AS tank already. Will add 610 mls/AS for a total of 804 mls of AS in 30 gallons of permeate water.
1315-- NF-2 started with MEmcor as feed water to NF-2 unit. Perm1=2.1 Perm2=1.1 Conc=1.9 Recycle=2.4 this is at a 65% recovery.
1400-- NF-2 water quality #21=90 TDS, #23=50 TDS, #25=20 TDS.

11/14/97

0730-- Stopped Zenon blower - draining tank.

0830-- Filling Zenon with tap water.

-- Started Zenon with clean water recirculation to get readings. 6.2" vacuum at 10.0 gpm.

1045-- Zenon off.

1215-- Zenon on with raw water - Bleed will be opened to 1.0 gpm at 21:00 tonight by COI.

11/17/97

0500-- Zenon off - high backpressure on backwash.

0705-- Zenon on - pressure on Backwash adjusted to 5.8 psi.

1015-- Performed membrane test on Memcor unit. 2min.=14.5 psi 4 min.=14.2 psi.

11/18/97

0700-- Noticed Zenon "permeate pump" light was blinking. No apparent reason. Zenon was running fine.

Hit the alarm reset. Zenon O.K.

0815-0930-- BiWeekly samples taken on Zenon, Memcor, and NF-2.

1415-- Added 636 mls of Antiscalent to NF-2 AS tank. Also added 22 gallons of permeate. NF-2 AS pump

is pumping 11.50 ml/min.

11/19/97

0745-- Raw water off for air compressor preventive maintenance. All units off.

0805-- Raw water on - All units on.

1000-- Zenon permeate at 7.0 gpm, Bleed at .7 gpm to keep unit from failing until tomorrow.

11/20/97

0700-- NF-3 membrane taken out and put in PVC storgage in formaldehyde solution.

1545-- Zenon off for blower repair

1600-- Memcor off to be cleaned NF-2 off also.

1630-- Zenon unit on for tap water flux.

1646-- Zenon off f or 200 ppm cl2 cleaning.

1925-- Zenon on for clean water flux.

1940-- Zenon off for cl2 cleaning.

1955-- Memcor on after acid cleaning of pH=2.40.

2010-- Memcor off for caustic cleaning.

2140-- Zenon on for clean water flush.

2156-- Zenon off for cl2 cleaning.

2210-- Memcor on after pH=12.58 caustic cleaning. 15 gpm flow going to NF-2 also.

2235-- Zenon on for clean water flux.

2345-- Zenon unit off - bubbling with blower overnight.

11/21/97

0800-- Zenon off.

0900-- Zenon cleaning started with MC-1 acid cleaner pH=2.30

1445-- Zenon on.

11/22/97

0715-- Power failure - all units off.

1215-- All units on.

11/23/97

1130-- Came in to run SDS cl2 residuals and quench samples.

11/24/97

1030-- Added 694 mls/AS + 24 gls. of permeate to NF-2 AS tank. Pump is pumping at 11.5 ml/min.

1130-1400-- Setting up chemical feed pumps to NF-3.

11/25/97

1000-1500-- Hooking up NF-3 chemical pumps.

1530-- NF-3 on with Zenon as feed to it. Perm=33 gph, Conc.=18 gph, Recycle=2.25 gph. NF-3 AS= 25 ml?as to 30 gals. of permeate at 65% recovery.

1600-- Raised Zenon backpulse pressure cutoff to 10.5 psi.

1700-- Zenon - reset flows to perm=6.4, bleed=2.0

2200-- Told J. Johnson to raise acid in 1% increments to achieve pH<6.5.

11/26/97

Sometime after 310 a.m.-- NF-3 unit shut off "low suction".

0650-- NF-3 on.

0700-- pH of 3.28 - Acid pump was at 25 speed - lowered to 9 speed.

0720-- NF-3 pH=5.20 -O.K>

0900-- Cl2 in NF-3: 31-.7, 36=.5, 37=.6. Cl2 in tank=210 ppm at pH6.57

1230-- Acid tank level approximately 51~52 gls.

1300-- Added 74 mls/AS to NF-2 AS tank + 9 gals. of permeate water. Assuming 4.0 gpm flow @ 65% recovery and 11.5 ml/min pumping rate.

1310-- Performed Memcor membrane test. Loss of .2 psi.

11/27/97

1210-- Howard Hunt (COI) called ;me at home and notified me that the Zenon unit was alarming on permeate pump". I told him to reset it. Zenon back on. Too much time had elapsed and the Zenon permeate break tank went empty causing NF-3 to shut down.

1640-- I turned on NF-3 and am checking chemicals.

1700-- NF-3 pH=5.98 cl2=0 ppm

1710-- Cl2 in Cl2 tank =35 ppm added 50 grams of NH4Cl + 650 mls. of HCL and pH after mixed=10.11.

1730-- Cl2 in tank = 450 ppm mono free=0

1800-- Cl2 pump settings 25=speed, stroke=28 acid speed=40, stroke=9 pH at tap #31=5.58.

11/29/97

1030-- Doing lab tests on NF-2, NF-3. All O.K. except NF-2 perm stage 1 TDS coming up. Also had to raise acid - 40 gls. left in acid tank.

1130-- Cl2 in cl2 tank =405 ppm. 1.8 ppm residual in #31 feed. Lowered to .8 residual in #31 and .7 residual in NF-3 permeate. R. McGlynn had problems with pH meter (too high). I calibrated meter.

1200-- NF-3 pump settings cl2 speed=15, stroke=28, acid speed=20, stroke=27, pressure=85 pH(31)=5.56.

1205-- S. Johnson out.

1700-- pH of #31=6.94 on portable pH probe per COI and a pH=2.68 on lab probe. COI reduced acid.

1930-- #31 pH=6.34.

12/1/97

0710-- Std. pH probe - it read 7.01 on 7.0 buffer before standardizing it. Can not find problem with meter.

1215-- Adding AS to NF-2. Pumping 11.5 ml/min - will need 424 mls/AS + 21 gls. of permeate to AS tank.

1220-- Adding AS to NF-3 - Already have 167 mls/AS in tank. Need 168 mls in AS tank at a pumping rate
of 9.87 mls/min on NF-3 AS pump. Will just add permeate up to 30 gallon mark.

1230-- Adding 650 mls/HOCL to monochloramine tank. pH=8.37 before addition of Cl2. pH=10.48 after
25.5 gallons of permeate added to tank.

1235-- Added 50 grams of NH4Cl to Cl2 tank. pH=10.14 after mixing solution.

1245-- pH=10.13 monocl2=515 ppm in tank. 0=free cl2.

1315-- NF-3 Feed ##1=.8 ppm monocl2.

12/2/97

0845-0930-- Biweekly samples taken on NF-2.

1235-- NF-3 TDS---> Feed=130, Perm=90, Conc.=230.

12/3/97

0900-- HPC samples taken on NF-3.

1350-- NF-2 off.

1400-- First element (feed) on NF-2, stage 2, taken out and being sent to Hydranautics. 1% sodium bisulfite solution poured through membrane.

1415-- NF-2 on - NF-2 stage 2 permeate rate maxed out at .6 gpm. Redings taken.

1435-- NF-2, stage 2 TDS=30.

12/4/97

0845-- Cl2 off to NF-3.

0850-- NF-2 down for Memcor cleaning.

0900-- Memcor off for caustic cleaning.

0905-- Raw water level in Memcor tank at middle level switch. Added 3.8 liters of Memclean EXA2.

0907-- Started cleaning cycle on Memcor.

0910-- pH in Memcor=12.18. Water turning very dark.

1040-- Memcor unit back on.

1500-- Memcor flow increased to 30 gpm.

12/5/97

0405-- NF-3 unit off - I had H.H. turn off Zenon break pump and close valve to NF-3.

0650-- NF-3 on - adjusting pH.

1230-- Put app. 4000 mls/HCL into acid tank. Will adjust acid pump.

1245-- Added 290 mls/AS to NF-2 Antiscalent tank + 16 gls. of permeate. Assuming 3.2 gpm rate, 5 mg/l dose, + 11.5 pumping rate.

1250-- Added 58 ml/AS to NF-3 AS tank + 10 gls. of permeate assuming 9.87 ml/min, .88 gpm flow, 5 mg/l dose.

1350-- NF-3 cut off "low pressure" setting @12 psi.

12/7/97

1230-- Zenon off (permeate pump alarm). NF-3 off.

1700-- S. Johnson in - Zenon + NF-3 on.

12/8/97

0700-- Batteies on pH meter low. Spare batteries dead. Will use pH meter as is. Still holds within .1 pH unit.

0845-- HPC samples for NF-3 taken.

1230-- Memcor + NF-2 off - Memcor to be cleaned.

1240-- Added 3800 mls/Memclean to 40 gallons of raw water in Memcor unit. Started cleaning cycle.

1350-- Memcor unit back on at 15.0 gpm + 40 minute backwash cycles (per R.R.).

1430-- Raw water pumps separate now. Only one air pump feeding R/O pilot - other pump goes to permenant
pilot in chemical building due to Memcor oscillation. One pump seems to be sufficient.

12/9/97

0400-- All units off - Raw water pump problem.

0730-- Units back on - only using one raw water suction pipe.

1200-- Installed new batteries on pH meter - recalibrated pH and TDS meters.

12/10/97

0845-- Mass balance ---> NF-2=1.10, NF-3=1.01.

12/11/97

0945-- Added 410 mls./AS + 23 gls. of permeate to NF-2 AS tank. Assuming pumping rate=10.36 mls/min,
and 2.85 gpm flow, and 5 ppm AS dose.

0900-- Added 130 mls/AS + 15 gls./permeate to NF-3 AS tank. Assuming 7.89 ml/min pumping rate,
a .88 gpm. flow, and a 5 ppm As dose.

0915-- Electricians adjusted breaker for Zenon permeate pump. Pump runs at 4.5 amps max is 6.5 amps.

1030-- Memcor membrane test = .2 psi loss @ 2-4 minutes.

12/12/97

0830-- HPC samples taken on NF-3 feed, concentrate and permeate.

12/13/97

0830-- I was called and told units were down due to low flow.

0935-- I switched from west raw pump (it was pumping air) to east pump through both lines up the hill. I got
about 56 gpm doing this. Wrote W/R to have east pump rebuilt.

10-1030-- All units back on.

12/14/97

1430-- Jim Graham (COI) called and siad there wasn't enough water on back dock and all units were down
except the Memcor.

1720-- I got here and timed water through 1 1/2" meter. 1 minute of flow=47 gpm. I don't know why there were water problems.

1740-- All units up a dn running again.

12/15/97

0700-- Standardized pH and TDS meters.

0800-- West raw water pump repaired. West pump ONLY is feeding back dock @ 42 gpm.

1200-- Memcor rate down to 7.0 gpm and app. 15 psi pressure difference.

1215-- Making monochloramines for next experiment on NF-3.

1220-- Adding 650 mls/NaHOCl to 30 gallons of permeate in NF-3 Cl2. tank. pH=7.22.

1230-- Added caustic to obtain 10.20 pH then added 50 grams of NH4Cl to NF-3 cl2 tank.

1235-- pH=6.3 in Cl2 tank - added caustic to pH=9.70 and a 310 mg/l residual of monocl2. 0=free cl2.

1255-- NF-3 cl2 tank pH=9.70 and 310 ppm monocl2 residual.

1310-- Acid off to NF-3 - Cl2 on @ .5-2.0 mg/l residual.

12/16/97

0700-- Zenon "low level" alrming. Probably low for about 15 minutes. Reset alrm. 42 gpm total at back dock.

0725-- West raw water pump muffler is packed with ice. Cleaned out. Pumping o.k. now.

0830-0930-- Biweekly sampling of NF-2, raw, Zenon, and Memcor.

1000-- NF-2 off for Memcor cleaning.

1010-- Memcor off.

1015-- Added 3.8 liters of Memclean + 1 liter of Hydrogen peroxide to Memcor unit for cleaning.

1017-- Started cleaning Memcor unit - pH=12.22.

1135-- Memcor unit back on - 6.2 pressure differential at 15.0 gpm.

1230-- Memcor shutdown overnight for raw water flow testing + NF-2 off.

1230-- Zenon shutdown to replace float valve, raw water testing.

2200-- Zenon restarted.

12/17/97

All day-- repiping Zenon to 1 1/2", repiping Memcor unit to have float valve + also adding ferric injection point.

Also took HPC samples on NF-3 and did spore spiking on Zenon, Memcor, and NF-2.

1515-- Memcor and Zenon off.

12/18/97

All day-- Troubleshooting Memcor valve problems.

12/19/97

0800-- Took HPC samples on NF-3.

All Day-- Working on Memcor float valve problems.

0945-- Repaired leaking raw water valve by 1 1/2" meter.

1000-- Filled monochloramine tank up to 30 gallon mark with permeate. Added 650 mls/HOCl. pH=11.02. Added 50 grams/NH4Cl. pH=9.90 now. No caustic was needed, pH was already high enough.

1020-- Cl2 tank pH=9.86, Free Cl2=0, MonoCl2=625 mg/l.

1215-- Filled NF-2 AS tank up to 30 gallon mark with permeate. I added 343 mls/AS assuming 197 mls/AS already in tank, pumping rate=9.76 mls/min, 2.7 gpm flow, and a 5 mg/l dose.

1220-- I filled NF-3 AS tank up to 30 gallon mark with permeate. I added 157 ml/AS assuming 73 ml/AS already in tank, pumping rate=7.48 mls/min, .88 gpm flow, and 5 mg/l dose.

1230-- Quenched SDS samples from 12/2/97 and 12/16/97.

1440-- Added 1 liter of formaldehyde to 50 gallons of permeate in cleaning tank.

1445-- Running "pickling" solution through NF-2 per R.R. (very dark water).

1500-- Stopped "pickling" recirculation of NF-2.

12/22/97

0710-- Standardized pH and TDS meters.

0800-- HPC samples taken on NF-3.

12/23/97

0840-- Mass balance on NF-3 = 1.0.

1000-- Filled cleaning tank with 100 gallons of CSF water. Added 7.0# of EDTA, 1400 mls/5.5% bleach,
and 1893 mls/50% NaOH. pH=12.50, 48 ppm FRee Cl2 residual and 26oC.
Could not get hold of Robert to see if I should add more bleach to obtain higher residual. Will leave solution as-is
for this first cleaning.

1030-- Started recirculating through NF-2 after F28 closed, F23 + F25 partially opened, F26-A opened all the
way, F26-b closed. CU21 + CU22 opened after other PVC concentrate valve closed + blue gate (feed) valve closed.

1040-- Water very, very dark - looks like Coke.

1045-- Sampled cleaning tank water in 1/2 gallon jug. pH=12.45, with 0 free cl2 residual.

1050-- Added another 1400 mls/5.5% bleach.

1052-- P22=21 psi, P26=11 psi, P24=18 psi, P23=6 psi, P25=5 psi.

1100-- Cleaning tank water - pH=12.41, 45 ppm free cl2 residual.

1135-- Cleaning tank water - pH=12.46, 6.5 pm free cl2 residual.

1140-- Draining cleaning tank - stopped NF-2 recirculation.

1200-- Added 100 gls./CSF water, 1400 mls/5.5% bleach, 1893 mls/50% NaOH, and 7.0# Edta to cleaning tank.
The pH=12.53, and 165 ppm of free Cl2 residual. All valves the same as the last cleaning.

1215-- Started recirculation cleaning through NF-2.

1345-- Stopped NF-2 cleaning - draining and flushing cleaning tank.

1400-- Working on Memcor.

1500-- Added 1 liter of formaldehyde to 50 gallons of CSF water and started pickling NF-2.

1520-- Done pickling NF-2.

12/26/97

1030-- Daily tests on NF-3.

1100-- Added 9.7 gallons of Fe2SO4 + 43 gallons of CSF water to Ferric tank for Memcor.

1130-- Started Memcor at 15 gpm @ 40 gpm and 40 minute backwash intervals, with a 25 mg/l Fe dose.

1200-- Increased NF-3 AS pump to 7.50 ml/min. Was pumping 3.5 ml/min.

1220-- Added 650 ml/HOCl to Cl2 tank filled with permeate. pH=8.20, added NaOH, ph=11.00.
Added 50 grams of NH4Cl, pH=10.76, 0 mg/l free cl2, 455 mg/l monochloramine residual.

1230-- Flushing NF-2 with memcor permeate water.

1245-- NF-2 on at Perm1=2.1 gpm, Perm2=1.1 gpm, Recycle=2.4 gpm, Concentrate=1.9 gpm, with
a 5 mg/l dose of antiscalent.
1420-- Levels seem to be O.K. in both the Zenon and Memcor units at these lower flows.

1515-- Cl2 off to NF-3 per Dr. Taylor.

1530-- Bleed off on Zenon unit - Will be opened at 00:15 on 12-27-97 to .6 gpm.

1540-- Adding 100 gallons of CSF water + 7.0# of EDTA + 1893 mls/NaOH to cleaning tank.

1545-- NF-2 off.

1550-- Recirculating cleaning tank solution through NF-2.

1610-- Stopped NF-2 recirculation. Will let NF-2 soak overnight in solution.

1700-- Both raw water pumps feeding R/O plant so Memcor can backwash correctly.

12/27/97

0015-- COI opened bleed on Zenon.

0815-- Flushing NF-2 with CSF water.

0830-- Filling cleaning tank with CSF water + 7.0# EDTA + 1893 mls/NaOH + 1400 mls/5.5% bleach.

0835-- Started cleaning solution through NF-2 pH=12.57, with 95 ppm cl2.

0850-- Cleaning solution Cl2=50 ppm - added 700 mls/5.5% bleach

0905-- Cleaning solution has 135 mg/l free cl2 residual.

0940-- NF-3 AS tank didn't go down - pulled AS feed line off and timed it as feeding 7.8 mls/min. Hooked
back up and will moitor.

0950-- Will call Dr. Taylor about poor performance on Memcor unit.

1030-- Had to re-install float in Memcor unit. Piping came loose.

1100-- Memcor off and MV-4 valve switched to tank. Drained down to middle level switch and
added 3.8 liters of Memclean and pressed the cleaning cycle and start button to start cleaning of Memcor.

1115-- NF-2 being fed with CSF water now- flushing system.

1120-- NF-2 on with CSF water as feed.

1230-- Memcor on at 15 gpm at 40 minute backwash cycles + 5 mg/l ferric dose.

1235-- NF-2 TDS as follows + Feed=100, Blend=110, Perm1=110, Perm2=100, Comb.perm=120, conc.=120.
Will keep NF-2 on with CSF water per Dr. Taylor.

12/29/97

0710-- Standardized pH + TDS meters.

0900-- NF-2 antiscalent pump was airlocked - bled air out and appears to be pumping o.k.

0905-- NF-3 antiscalent backflow preventer appears to be plugged. Switched AS to old acid feed point. Feed points relabled.

1300-- HPC samples taken on NF-3.

12/30/97

0830-- Biweekly samples taken on raw, Zenon, Memcor, and NF-2. Blind dupe=27.

1000-- Increased NF-2 AS pumping rate.

1015-- MEmcor off to be cleaned. Ferric off also.

1200-- Memcor on at 8 psi difference.

1400-- Got biweekly sample on CSF.

1430-- Memcor off for acid cleaning - added 10.0# of citric acid pH=2.26, adjusted with NaOH pH=2.86.

1440-- Started Memcor cleaning. Will let soak overnight without the three backwashes on end of cleaning cycle.

12/31/97

0800-- Memcor doing the three backwashes.

0810-- Memcor on at 6.8 psi difference.

0930-- HPC samples taken on NF-3.

1955-- NF-2 shutdown on low pressure.

1/2/98

0930-- HPC samples taken on NF-3.

1200-- NF-2 antiscalent tank filled to 30 gallon mark and I added 921 mls/AS assuming 7.89 ml/min pumping rate, 5.1 gpm flow rate, 5 mg/l AS dose, and 342 mls/AS already in tank.

1215-- NF-3 antiscalent tank filled to 30 gallon mark and I added 186 ml/AS assuming 5.91 ml/min pumping
rate, .88 gpm flow, 5 mg/l AS dose, and 104 ml/AS already in tank.

1900-- Raw water pump stopped - air stopped then restarted. pump is pumping now.

1/3/98

1110-- NF-2 off "low suction pressure". No apparent cause.

1515-- NF-2 on - Influent pressure increased to 30 psi.

1/4/98

1200-- NF-2 down per J.J. I had him isolate NF-2 and leave off until tomorrow.

1/5/98

0140-- Raw water pump problem - Zenon + NF-3 off.

0720-- Zenon on + NF-3 on.

0730-- NF-2 on.

0740-- Standardized pH + TDS meters.

0900-- Second raw water pump on now. Feeding through both raw lines.

1200-- HPC samples taken on NF-3.

1/7/98

0400-- NF-2 down "low suction pressure".

0700-- NF-2 on.

0815-- NF-2 down. NF-2 prefilter changed filter dark and plugged.

0820-- NF-2 on - pressure difference negligable. 34 psi in - 34 psi out.

1050-- HPC samples taken on NF-3. Color=8 on NF-3 permeate.

1/8/98

0830-- NF-3 perm TDS = 25. Will continue to monitor. TDS has been at 20.

1000-- NF-3 perm TDS = 30. No significant pressure changes yet.

1410-- MTC=.18 on NF-3 - slight increase in permeate pressure.

1430-- HPC samples on NF-3 taken.

1/9/98

0945-- HPC samples on NF-3 taken.

1000-- NF-2 AS tank filled with 22.5 gls/permeate, plus 505 ml/AS, assuming pumping rate=10.84 ml/min, 5 ppm dose, and 4.55 gpm flow and 315 ml/AS already in tank.

1015-- NF-3 AS tank filled with 14 gallons of permeate + 125 ml/AS. Assuming pumping rate=6.13 ml/min,
5 ppm dose, .88 gpm flow, and 125 ml/AS already in tank.

1100-- NF-3 permeate color=27.

1/12/98

** Flow correction curves for NF-3 are in the log book.

0800-0900-- Biweekly samples on NF-2, Zenon, and Memcor.

1900-- NF-3 off - element changed to new Hydranautics element.

2000-- NF-3 on.

2000-- MEmcor on - installed NF-1 membranes.

1/13/98

0830-0930-- Spore spiking on NF-3, Zenon, and Memcor.

1300-- NF-3 off.

1415-- NF-3 on with Memcor as feed + acid + antiscalent.

1/14/98

0720-- Zenon off to be cleaned.- Doing cl2 (688 mls) + caustic adjustment to 10.5 pH.

1225-- NF-2 off - HRWTP off - No CSF water.

1235-- Clean water flux on Zenon unit - 16" @ 5 gpm.

1245-- Zenon off for MC-1 cleaning.

1430-- Zenon on with clean water flux. Zenon unit still has high vacuum. Shut Zenon off and left it filled with water without blower on.

1/15/98

0720-- Zenon blower on.

0815-- Made AS in NF-2 AS tank. Added 24 gls/permeate, + 485 mls/AS asssuming pumping rate=10.84 mls/min
a 3.6 gpm flow, + 5 mg/l dose + 164 ml/AS already in tank. I added 21.6 ml/AS per gallon.

0830-- <ade AS in NF-3 AS tank. Added 20 gallons of permeate + 122 mls/AS assuming 7.9 ml/min pumping
rate, + .87 gpm flow, + 5 mg/l dose, + 93 ml/AS already in tank. I added 7.2 ml/AS per gallon of permeate.

0900-- Added 5 gallons of 5.5% bleach to concentrate tank on Zenon unit per R.R. Blower on at 5 cfm. Will let
soak unitl 14:00. This equals a 500 ppm solution.

1330-- JTurbidimeter being standardized at the lab.

1430-- Adding 5 more gallons of bleach to Zenon tank. Will let soak overnight.

1/16/98

0700-- Started Zenon unit - still has 13.5" of vacuum. No MC-1 left to clean Zenon unit. Called and notified R.R.

0710-- NF-3 AS lost prime - no AS pumped in last 24 hours. Reprimed AS pump.

1015-- Filling Zenon tank with tap water. Will adjust to pH of 2.0 with citric acid.

1030-1045-- Added 8000 ml/HCL to acid tank + appox. 45 gallons of tap water. NF-3 acid off during this time.

1035-- Turbidimeter brought back after being standardized.

1050-- Added 8000 ml/Citric acid crystals to Zenon tank. pH=2.47

1400-- Zenon on - still 10.5" vacuum. Draining tank.

1430-- Filling Zenon with tap water. Letting soak with blower on.

1505-- Added 1 gallon of 5.5% bleach. letting soak over weekend. no blower.

1/19/98

1340-- Started Zenon unit - no improvement.

1350-- Zenon off - adding 5 gallons of bleach (5.5%) letting soak overnight. no blower.

1/20/98

0710-- Std. pH and TDS meters.

0830-- Quenched SDS samples. Total of 165 elapsed hours elapsed since first dosed.

1/21/98

0700-- Zenon on for clean water flux - 6.5" vacuum was lowest.

0710-- Zenon off and draining.

0735-- Filling Zenon with raw water to rinse off membranes and then drain water off.

0900-- Added 650 ml/HOCL to monocl2 tank pH=3.36. Added NaOH - pH=11.09 - then added 50 grams
of NH4Cl and mixed together pH=9.48 now.

0905-- Filling Zenon tank with raw water again for startup.

0915-- Started Zenon with raw water. Permeate=6.25 gpm and bleed will be opened in 3 hours, 20 minutes
to 2.0 gpm.

1000-- Monocl23 tank - Free=0, Monocl2=98 mg/l

1010-- I added another 650 ml/HOCL to cl2 tank. pH=11.32. I then added 50 grams/NH4CL. pH=9.72

1030-- Cl2 tank - Free=0 mono=650 mg/l

1100-- Filling NF-1 with Zenon water and did a Cl2 test on Zenon perm Cl2=0.

1210-- NF-1 on with acid, cl2, and AS with Zenon as raw feed. St1perm=2.0 gpm, St2perm=1.0 gpm,

Concentrate=1.9 gpm, Recycle=2.4 gpm, cl2= .5-2.0 residual, pH=4.5-6.5.

1235-- Posted correct shutdown procedures.

1236-- Zenon bleed opened to 2.0 gpm.

1350-- NF-1 feed cl2=.5 pH=5.82.

1/22/98

1200-- Added 96 ml/AS + 18 gallons/permeate to NF-3 AS tank assuming a pumping rate = 9.3 ml/min, and a .87 gpm flow, 5 mg/l AS dose, and 86 ml/AS already in tank. Equated to adding 6.1 ml/gallon.

1215-- Added 650 ml/HOCL + 17 gls/permeate to strengthen cl2 dose in cl2 tank pH=10.68 now.

1220-- Added 50 grams/NH4CL to cl2 tank pH=9.12 Free=0 Monocl2=700 mg/l.

1/23/98

0810-- NF-3 off for Memcor cleaning.

0815-- Memcor off and being cleaned.

1010-- Memcor on - 6.2 psi difference.

1045-- Added 1950 mls/HOCL to cl2 tank pH=8.2. Added NaOH pH=11.02. Added 150 grams/NH4CL
to cl2 tank. pH=8.88 Free cl2=10 Monocl2=1040.

1330-- Added 650 ml/HOCL to 1 1/2 gallon bucket of water then added 150 grams/NH4CL to preform monocl2.

1340-- Added monocl2 solution to cl2 tank - added NaOH to pH=9.02.

1350-- Added 30 gls/tapwater + 7 liters of HCL to acid tank.

1/25/98

1300-- Mono cl2 tank empty - added 3250 ml/HOCL pH=11.20 added 250 grmas/NH4CL pH=9.12
Tank free cl2=10 monocl2=2470 sample tap #11=1.0 mg/l of monocl2.

1400-- Sample tap #11=1.0 mg/l monocl2 #17=.8 mg/l #16=.5 mg/l

1/26/98

0330-- NF-1 down on "low feed pressure".

0715-- NF-1 on.

0725-- Standardized pH + TDS meters.

1/27/98

0800-1100-- Biweekly sampling of Raw, Zenon, Memcor, NF-1,2, +3.

1200-- Added 583 mls/AS to NF-1 +2 AS tank + 27 gallons of permeate assuming 21.6 ml/min pumping rate
plus the same flows.

1215-- Added 8000 ml/HCL + 45 gallons of tap water to acid tank.

1315-- Added 30 gallons tap water to cl2 tank then added 500 grams/NH4CL pH=4.62, Adjusted pH=7.86.

1320-- Added 5.0 liters of Sodium Hypochlorite to cl2 tank - pH=9.45.

1325-- Cl2 tank free cl2=20 monocl2=4960.

1335-- Added a little more (20 grams) of NH4CL to cl2 tank.

1400-1700-- Doing alkalinities and TH at the lab.

1700-- NF-1 perm =.6 mg/l of monocl2.

1/28/98

1000-- FedEx'ed Memcor water (14 gls) to Desalination systems.

1030-- Lowered NF-1 feed pressure to 32 psi so NF-1 acid pump could pump easier against it. NF-1 acid
can only pump up to 50 psi.

1/29/98

0700-- Monocl2 tank had strong chlorine smell. pH=2.06 in tank, monocl2=0 raised pH in tank to stop smell.

0945-- NF-1 off on low pressure. NF-3 off to clean.

0950-- Added 50 gallons of permeate to cleaning tank. Then added 8.5#/Sodium tripolyphosphate Then added 1.1# of Dodecyl. Adjusted pH from a 8.76 to a 10.42. No time to let heater warmup. No temperature adjustment. Temp -22oC now. Will let hot water recirculate while it is cleaning.

1000-- Hooked up cleaning hose from CU01 to CU31 and CU93 to CU32. Valves CV95, CV96, CV31, CV97, CH1, CV93 open. Recycle is closed.

1010-- Started recirculation of cleaning solution through NF-3.

1015-- Added 30 gal/tap water to monocl2 tank . Then added 375 grams/NF4CL to cl2 tank. pH=7.12 adjusted pH to 8.46.

1025-- Added 3.75 liters of sodium hypochlorite to cl2 tank. pH=9.76.

1045-- Cleaning tank pH=9.77.

1100-- Added 162 ml/AS to NF-3 AS tank + 20 gallons permeate assuming 61 ml/AS already in tank, .87 gpm flow, 5 mg/l dose,. Equates to 7.4 mg/gallon.

1105-- NF-1 on. Cl2 on also.

1108-- Mono cl2 tank Free=20 Monocl2=3200.

1145-- Stopped cleaning tank recirculation through NF-3, pH=9.72 Temp=25oC.

1150-- flushing NF-3 with Memcor permeate water.

1151-- NF-3 on.

1250-- "De-iced" raw water pump air mufflers. Got batteries and changed them for turbidimeter.

1/30/98

0400-- Zenon unit off on "high b/w pressure" NF-1 down.

0700-- Zenon and NF-1 units on.

1100-- NF-3 off - put 2 new membranes in NF-3 and will acid clean them.

1110-- Raw pressure lower "de-iced" raw pumps fine now.

1115-- Acid cleaning 2 new membranes in NF-3. Used 8.5# of citric acid + 50 gls/permeate in cleaning tank.

1230-- Added 6000 mls/HCL to acid tank + 40 gls/tapwater.

1245-- Added 518 mls/AS to NF-1 + 2 AS tank, assuming a 3.6 gpm flow, 10.84 ml/in pumping rate, and 5 ppm. There was 130 ml/AS already in tank. Equates to 21.6 ml/gal.

1330-- NF-3 off for X-20 membrane tie-in.

1340-- X-? membrane in NF-3 and X-20 membrane in the little plant.

1350-1700-- Working on piping in small R/O unit.

1705-- NF-1 off to be pickled - no NH4CL to make monocl2.

1710-- Added 2 liters + 50 gls/permeate to cleaning tank.

1715-- Recirculating "pickling" solution through NF-1.

1730-- Pickling of NF-1 done.

1735-- NF-3 on and small unit on.

1/31/98

1300-- Zenon down "low level".

1400-- Took both mufflers off of raw water pumps - Icing problem even with heaters on them.

1430-- Raw water pressure and flow back to normal.

1440-- Zenon unit on.

1450-- Adjusted X-20 unit concentrate from 0 to .17 gpm. Rotamater was on bottom of scale.

2/2/98

0700-- Standardized pH and TDS meters.

1245-- Added 30 gls./permeate + 651 mls/AS to NF-1 AS tank. Assuming a 14.7 ml/min pumping rate, a 4.9 gpm flow, and 5 mg/l dose. 21.7 ml AS/gal.of permeate.

1310-- Added 30 gallons of tapwater to monocl2 tank. Then added 500 grams of NF4CL. pH=6.27. Adjusted pH to 8.17. Then added 5000 mls/10% bleach. pH=9.08, Free cl2=20, Monocl2=4740 mg/l.

1330-- Running Zenon pereate through NF-1 to fill it up and rinse formaldehyde out.

1335-- NF-1 on with acid, monocl2, and AS.

1440-- NF-1 perm monocl2=.9, conc.=.5 mg/l of monocl2.

2/3/98

0930-- Monocl2 tank pH=8.06, raised to 8.90 pH. Monocl2=3000 mg/l residual.

1000-- Added 209 ml/AS to NF-3 AS tank assuming 16 ml/AS already in tank, a flow of .87 gpm, 5 ppm
AS dose, and a pumping rate of 15.11 ml/min.

1130-1450-- Working on ICR data.

2/4/98

1400-- Calibrated X-20 conc. line .2 gpm=.20 gpm (bucket test).

1410-- Added 8000 mls/HCL and topped off acid tank with tap water.

1420-- Monocl2 tank pH=7.17 cl2=1960 ppm.

1450-- Working on Bi-weekly data.

2/5/98

0930-- Monocl2 tank pH=2.10 monocl2=0 ppm

0940-- Adding 15 gls/tap water to cl2 tank. Then added 250 grams of NH4CL. pH=6.76 adjusted pH to 8.59.
Then added 3000 mls/HOCL. pH=9.06 Free cl2=20 monocl2=5100.

1030-- NF-1 permeate monocl2=.8 conc.=.5

2/6/98

0830-- Memcor off for cleaning. NF-3 and X-20 machine off also.

0845-- Added 4 liters of MEmclean to memcor after being rinsed for 15 minutes with MV4 valved switched
and drained down to middle level switch.

0850-- Memcor cleaning initiated.

1030-- Memcor back on.

1040-- Added app. 40 gallons of tap water + 10000 mls/acid (HCL) to acid tank.

1055-- Added 120 mls/AS to NF-3 AS tank. Already had 105 ml/AS in tank. Assuming 15.11 pumping rate,
a 5 ppm dose, and 1.74 gpm flow rate.

1100-- Added 586 ml/AS to NF-1 AS tank laready had 325 ml/AS in tank. Assuming pumping rate=10.51 ml/min,
a 5 ppm dose, and 4.9 gpm flow rate. 30.4 ml/gal.

1110-- NF-3 and X-20 machine on.

1125-- Repaired leak on NF-1 feed pressure gage line.

1530-- Added 30 gallons of tap water to cl2 tank + 500 grams/NH4CL. pH=6.86 added NaOH pH=8.37.
Then added 5 leters of HOCL pH=9.33 adjusted pH to 9.72. Free cl2=20 Monocl2=4280.

1715-- NF-1 perm cl2=1.0 conc.=.7.

2/8/98

1330-- Monocl2 tank pH=9.11 Free cl2=20 Monocl2=2920. Adjusted pH to 9.72 NF-1 perm cl2=.7, NF-1 conc. cl2=.4 Have just enough (13 gallons) to make it until tomorrow.

2/9/98

0710-- Standardized pH + TDS meters.

0830-- Bi-Weekly samples on Raw, Zenon,Memcor, And NF-1 + NF-2.

1140-- Added 8000 mls/HCL + 45 gallson of tap water to acid tank.

1530-- Added 500 grams/NH4Cl to cl2 tank. pH=7.27 - adjusted up to 8.36. Then added 5 liters of HOCL 10% .
pH=9.22 free cl2=20, Monocl2=4400.

2/10/98

0800-1000-- spore spiked Zenon, Memcor, + NF-1.

1230-- New Settings on NF-1 perm1=2.0 perm2=1.1 conc.=39 gph, recycle=3.7, 2.5 mg/l AS dose. Actual feed rate=4.1 gpm. Lowered NF-1 AS tank to 12.5 gallons then added 17.5 gls/permeate to get correct AS dose.

1330-- Added 30 gals/Tapwater to NH3 tan then added 500 grams of NH4CL>

1335-- Added 30 gls/tapwater to free cl2 tank then added 5 liters of HOCL 10%.

1340-- Started feeding NH3 + CL solutions to NF-1 before prefilter.

1430-- Added nother 5 liters of HOCL to cl2 tank and added 500 grams to NH3 tank. Did not get a residual in #17.

1530-- #17=.4 #16=.2 ppm cl2 residual.

2/11/98

0830-- Monocl2 in NF-1 perm=2.6 conc=2.2 Topped off cl2 and NH3 barrells with tapwater to dilute solutions so residuals will come down.

1230-- Added 461 ml/AS to NF-2 AS tank - assuming a 10.0 ml/min puming rate, 5 ppm dose, and a 2.8 gpm
flow rate. Already have 86 ml/AS in tank. 18.2 ml/gl.

1245-- Added 110 ml/AS to NF-3 AS tank assuming a 15.77 ml/min. pumping rate, 5 ppm dose, 1.746 gpm
flow and already have 106 ml/AS in tank. 7.2 ml/gallon.

1430-- X-20 unit off to clean the X-20 membrane.

2/12/98

0730-- Heating up 50 gallons of permeate in cleaning tank.

0830-- NF-3 off to be cleaned.

0845-- Installed X-20 membrane in NF-3.

0850-- Added 8.5# of tripolyphosphate, then added 1.1# of Dodecyl. Temp@ 36oC, ph=8.68 added NaOH
pH now is 10.48.

0900-- Started cleaning NF-3.

1130-- Stopped cleaning NF-3.

1200-- Quenching samples from 1-27, and 2-10.

1330-- Installing X-20 membrane small unit.

1400-- NF-3 + X-20 startd up.

1450-- NF-3 TDS=20 X-20 TDS=0

2/13/98

0910-- Made acid solution--Added 10 liters of HCL + filled acid tank with tapwater.

1400-- Added 250 grams/NH4Cl to NH3 tank.Also added 2.5 liters to Cl2 tank.

2/15/98

0715-- Power failure at plant. All units down except Zenon unit.

1300-- Called by R. McGlynn about units being down.

1345-- Steve Johnson in.

1400-- All units back on - reset flows - chemical on. Acid and Cl2 o.k.

2/16/98

0800-- Standardized pH and TDS meters.

2/17/98

0350-- Zenon unit + NF-1 off.

0730-- Cleaned raw strainer for raw water pumps.

0800-- Zenon + NF-1 back on. Raw water O.K>

1100-- Added 8 liters of HCL + 50 gallons of tapwater to acid tank.

1400-- Adjusted Zenon unit. B/W up to 6.2 psi.

2/18/98

0815-- Turbidimeter reads .67 for .50 standard + 1.33 for 1.00 standard. Will call lab to get it standardized.

1010-- Memcor off to be cleaned - NF-3 + X-20 off.

1015-- Started Memcor cleaning.

1120-- Added 25 gallons/permeate + 418 ml/AS to NF-1. Also added 24 gls/permeate + 437 mls/AS to NF-2.

2/19/98

0900-- Added 27 gls/permeate + 341 mls/AS to NF-3 AS tank. Assuming 1.75 gpm flow, 5 mg/l dose, a 9.42 ml/min pumping rate, and 22 mls/AS already in the tank.

0915-- Performed NH3 +NH4 residual test using aquarium test kit. #11 feed=1.0-1.5 mg/l #17 perm=1.0-1.5 mg/l.
Sped CL2 pump up 5%.

1050-- John Gordy recalibrated turbidimeter.

2/20/98

0950-- Added 8 liters of HCL + 50 gls/tapwater to acid tank.

1130-- Added 30 gls/tapwater + 10 liters/NaOCL to cl2 tank. Then added 30 gls/tapwater + 1000 grams of NH4CL to ammonia tank.

1150-- Just a trace of Monocl2 in #17 permeate tap. Increased speed to double the speed.

1230-- #17=4.8 monocl2 - went down on speed to only 15% of original speed (now nh3=20% cl2=30%)

1320-- #17= 6.5 monocl2 - went down on speed to 1/2 of original speed.

1440-- #17= .1 monocl2 - increased speed to 125% of both.

1510-- #17=.3- wnet up on speed to cl2=30% nh3=40%

1540-- #17=.6 #16=.3 - left it this way . Will have R.McGlynn check it tomorrow.

2/21/98

0930-- Zenon unit shut down several times on high pressure after backwash. The regulator psi was adjusted
and that corrected problem.

1030-- NF-1 went off about 07:00 today due to Zenon problems. S. Johnson gave R.M. instructions and then
came in to check things out. NF-1 was restarted and Zenon pressure lowered for backwashes.

2/23/98

0720-- Standardized pH and TDS meters.

0850-- Repaired pinhole leak on HF3 line spraying onto X-20 unit.

2/24/98

1030-- NF-1 down for leaky hose repair to #13.

1130-- NF-1 back on.

1230-- Added 8 liters of HCL + 50 gls/tapwater to acid tank.

1245-- Added 329 ml/AS to NF-1 assuming 4.1 gpm flow, 2.5 ppm dose, 9.53 pumping rate + 184 ml/AS
already in tank. 28.0 ml/gal.

1255-- Added 398 ml/AS to NF-2 assuming 2.9 gpm flow, 5 ppm dose, 11.17 ml/min puming rate + 109 ml/AS
already in tank. 16.9 ml/gallon.

1305-- Added 186 ml/AS to NF-3 assuming 1.75 gpm flow, 5 ppm dose, 11.17 ml/min pumping rate, + 120 ml/AS
already in tank. 10.2 ml/gallon.

2/25/98

0950-- Cleaned raw pump strainers.

2/26/98

0730-- NF-2, NF-3, and X-20 all off per R.R. Will clean X-20 with NF-3 NF-70 membrane. Pulling NF-2
membranes out so they can be replaced with new Hydranautics coated membranes.

1000-- Added + mixed 50 gals/permeate + 8.5# of sodium tripolyphosphate + 1.1# of Dedecyl in cleaning
tank and heating up. Adjusted pH to 10.3.

1015-- Started cleaning NF-70 and X-20 membranes in NF-3 train. Water was very, very, dark then cleared
up in about 5 minutes.

1040-- Added 3 gls/tapwater to cl2 + NH3 tanks. Then added 50 grams/NH4CL to NH# tank and then added 500 mls/NaOCL to Cl2 tank.

1220-- Stopped NF-3 cleaning.

1240-- Adding 50 gls/fresh permeate + 1 liter of formaldehyde to cleaning tank.

1300-- Recirculating "pickling" solution through NF-3.

1320-- Stopped pickling solution through NF-3.

1950-- F. Snyder turned NF2 pump on w/out feed open

2/27/98

0700-- Turned NF-2 pump off-had maint take pump out to be repaired

1200-- added 10 liters of 10% sodium hypchlorite to 30 gal of tap water, added 1200ml of ammonium chloride to NH3 tank with 29 gal of tap water

3/1/98

1200-- Cleaned "Y" strainer on suction line at river intake.

3/2/98

0820-- Std. pH and TDS meters.

0830-0915-- Biweekly sampling on raw, Zenon, Memcor, and NF-1. #17 = dupe.

0920-- Cl2 and NF3 off for SDS sampling.

0950-- Sampled for SDS on #11, #17, and #99 without chloramine feed.

1000-- Cl2 and NH3 back on.

1420-- Reset NF-1 flows to perm1=2.0, perm2=1.0, Conc.=1.9, Recycle=2.4. Totals 5.4 gpf after

taking in to account the rotameter corrections. Added 71 ml/AS to AS tank to correct dose of 5 ppm. Adjusted cl2 + nh3 + acid.

3/3/98

1300-- NF-1 down on power flicker
1310-- NF-1 up.
1400-- Added 1107 ml of AS to NF1 AS tank. Added 8 liters of HCL + 50 gls/tapwater to acid tank.

3/4/98

0725-- Started Memcor cleaning.
0830-- Changed out NF-2 pre-filter.
0930-- Memcor unit done cleaning
0940--Memcor started @ 12.0 gpm @ 15 min B/washes
1145--Replaced turbidimeter with nes batteries
1230-- Lowered Zenon B/wash pressure to 6 psi @ 3 gals
1300--NF-2 pump installed
1330-1420-- Installed new Hydranautics PVA membrames in NF-2
1430-- NF-2 on exp #1 perm 1=2.1 perm 2=1.0
Conc =1.9 Recycle=2.4 5 mg/l 65% recovery - added 307 ml/AS to NF-2 AS tank
PH adjustment with acid to keep 4.5-6.5 ph at tap #21

3/5/98

Added 10 literes of 10% sodium hypochlorite to tank with tap water to fill barrel
Added 1200 milliliters of Amminium Chloride to tank with tap water to fill barrel

3/7/98

Added 6720 milliliters of Hydrochloric Acid to 42gals of tap water for acid tank

3/8/98

Added 756 milliliters of Antiscalent to NF-2 tank

3/9/98

Maintenance repaired a cracked pvc bushing for psi gage on discharge of east air pump

3/10/98

1700-- Added 7520 ml/HCL to 47 gallons of tap water for acid tank.

3/11/98

1600-- Cleaned "y" strainer on suction line of air pumps.
1730-- Added 885 mls/AS to 24 gals in NF-1 tank.
1745-- Added 10 liters of NaOCL to cl2 barrel with 30 gls/tap water. Added 1200 mls/NH4Cl to NH3 barrel.

3/12/98

1300-- Shutdown Zenon unit for membrane cleaning. Drained nd cleaned reactor tank. Added 2 gallons of 10% NaOCL and adjusted the pH to 10.5 in the backwash tank. Backpulsed 25 gallons through the reactor tank when it was empty and waited 15 minutes. We backpulsed the remaining solution while reactor was full
of tap water -- NF-2 membrane has pickling solution added.

3/13/98

1030-- Robert Reiss put Zenon unit back in service along with NF-1.

3/14/98

0900-- Added 8 liters of HCL to 50 gallons of tap water.

3/15/98

0830-- NF-2 acid pump lost feed and reflected a pH value of 7.11. I found air in the suction line and removed the strainer on the suction line causting the problem. The pump stroke and speed were adjusted accordingly for a pH of 5.95. Added 819 mls/AS to 26 gal of permeate water to NF-2 AS tank.

3/16/98

1700-- Added 6.33 liters of 10% NaOCL with 19 gallons of tap water in cl2 tank. Also added 1200 mls/NH4Cl
to 25 gls/tapwater for NH3 tank. Added 5.6 liters of HCL to 35 gallons of tap water for acid tank.

3/18/98

0815-- Started collecting Bi-weekly samples. Dupe = 27

0845-- Done collecting bi-weekly samples - turned off Cl2 and NH3 for SDS samples. Started collecting
SDI samples.

0925-- Cl2 and NH3 back on.

1030-- Increased Zenon backwash pressure.

1445-- Switched NF-1 and NF-2 to experimental settings #2. Adjusted AS, cl2 + nh3, and acid settings.

3/19/98

0800--1000-- Spore spiking Zenon, Memcor, NF-1 + 2. Cl2 and NH3 off while spiking NF-1. Used acid
feed points to inject spores.

3/20/98

0345-- Zenon off due to "low low level" alarm - NF-1 turned off.

0645-- Cleaned "Y" strainer on raw suction - checked raw pumps.

0700-- Zenon and NF-1 back on.

0815-- Added 8 liters/HCL + 50 gls/tap water to acid tank.

0820-- Added 5 liters/NaOCL + 15 gls/tap water to cl2 tank. Added 600 mls/NH4CL + 15 gls/tap water to NH# tank.

3/21/98

1145-1230-- Quenched the 3-19-98 SDS samples.

3/23/98

0640-- Found NF-1 off on "Low suction pressure".

0650-- NF-1 back on.

0705-- Standardized pH + TDS meters.

0800-- Added 8 liters/HCL + 45 gls/tapwater.

0900-- Performed Membrane test on Memcor. .2 psi loss for 2 minutes.

0910-- Adjusted Zenon B/W pressure to 6.2 psi.

1030-- Cleaned strainer on raw water pumps.

3/25/98

1200-- Memcor off + NF-2 off for Memcor cleaning.

1210-- Started Memcor cleaning with 3.8 liters of Memclean.

1215-- Added 12 liters/NaOCL to cl2 tank + 30 gls/tap water. Added 1200 ml/NH4Cl to NH3 tank +

30 gls/tapwtr.

3/26/98

0700-- NH3 tank not feeding due to air in the suction line. Reprimed pump.

0830-- Added 24 gls/permeate + 368 mls/AS to NF-1 AS tank. Assuming 9.10 ml/min pumping rate, and 73 mls/AS already in tank, a 2.5 ppm dose, and a 4.1 gpm flow. 14.7 ml/gal.

0840-- Scution for NF-2 AS came undone (out of water) again. Put weight back on it.

0850-- Aded 252 mls/AS + 15 gls/permeate to NF-2 AS tank. Assuming a 8.87 ml/min pumping rate, and 200 mls/AS already in tank, a 2.5 ppm dose, and a 4.1 gpm flow rate. 15.1 ml/gal.

1530-- Added 50 gls/permeate to cleaning tank and heating it to 35oC.

1540-- NF-2 off for cleaning.

1600-- Added 8.5#/sodium tripolyphosphate + 1.0# of Dodecyl to cleaning tank. pH=9.09 - added NaOH - pH=10.92.

1615-- Started cleaning solution through NF-2.

1620-- Cleaning solution pH=10.26 - Added more NaOH to pH=10.77.

1650-- Stopped cleaning recirculation - letting soak for 2 hours.

1845-- Started cleaning recirculation again.

1915-- Stopped cleaning recirculation - started flushing NF-2 with Memcor permeate.

1920-- NF-2 on.

1950-- TDS---> #23=0 #25=0

3/27/98

0645-- Found NF-1 NH3 tank pump discharge hose broken and spraying all over electrical outlet and plugs for cl2 and nh3 pumps. Will have electrician check it out.

0800-- Added 8 liters/HCL + 45 gals/tap water to acid tank.

0825-- Added 3 liters/NaOCL + 10 gls/tap water to NH3 tank. Added 360 mls/NH4Cl + 10 gls/tapwater to nh3 tank.

3/30/98

0245-- NF-2 off + Memcor off ---Low Suction pressure.

0630-- NF-2 + Memcor on. Will change pre-filter after Bi-weekly sampling.

0640-- Standardizing pH + TDS meters.

0730-0830-- Bi-weekly sampling on Raw, Zenon, Memcor, NF-1, NF-2. Dupe=27.

0750-- Cl2 + NH3 off for SDS sampling.

0830-- Cl2 + NH3 on.

0945-- NF-2 off to change pre-filter.

1000-- NF-2 back on.

1600-- Adjusted MMF to 13 gpm - NF-2 needs 11 gpm. Adjusted ZMF to 12.6 gpm perm, 4.0 gpm for bleed. - NF-1 needs 11 gpm.

1700-- Adjusted NF-1 and NF-2 to experiment #3 flows. Cl2, NH3, and AS adjusted.

3/31/98

0715-- Added 16 liters/HCL + 50 gls/tapwater to acid tank.

1540-- NF-2 off on "low suction pressure".

1545-- NF-2 back on.

1610-- Filling cleaning tank with 50 gls/permeate + 1 liter of formaldehyde.

1615-- NF-1 off for "pickling". Zenon cleaning.

1620-- Zenon off for cleaning - reinsing out.

1625-- Started recirculating pickling solution through NF-1.

1700-- Stopped pickling NF-1. Filling Zenon with tap water.

1730-- Added 2 gls/NaOCL 10% to Zenon tank. Started recirculation for 1 hour. Also adjusted pH to 10.81.

1830-- Zenon blower only on to be left to soak overnight.

4/1/98

0700-- Filling Zenon with clean water.

0745-- Clean water flux =7" at 10 gpm.

0800-- Draining Zenon + filling with raw water.

1040-- Zenon on with raw water. Will open bleed at 14:00 to 4.0 gpm.

1300-- NF-1 on.

1400-- Bleed open to 4.0 gpm.

4/2/98

0815-- Added 1736 mls/AS to NF-1 AS tank + 20 gls/permeate. Assuming 8.54 ml/min pumping rate, 5 ppm
AS dose, 735 mls/AS already in tank, + 10.8 gpm flow. 82.4 mls/gal.

0830-- Added 1702mls/AS to NF-2 AS tank + 27 gls/permeate. Assuming 10.95 pumping rate, 5 ppm dose,
and 225 mls/AS already in tank, and 10.8 gpm flow. 64.2 mls/gal.

0950-- Added 50 gls/permeate + 1 liter of formaldehyde to cleaning tank.

1000-- NF-1 off - started pickling NF-1.

1010-- Zenon off to be cleaned again. - draining Zenon tank.

1025-- Stopped pickling NF-1.

1030-- Filling Zenon with tapwater.

1145-- NF-2 off to be cleaned with Dodecyl.

1200-- Filling cleaning tank with 50 gls/permeate water.

1345-- Added 1.0# of Dodecyl + 8.5# of tripolyphosphate. Adjusted pH to 10.89.

1400-- Started cleaning solution through NF-2.

1445-- Stopped cleaning solution through NF-2. Will let soak for 2 hours.

1645-- Started cleaning solution through NF-2 again for 1/2 hour.

1715-- Stopped NF-2 cleaning. Flushing NF-2 now.

1735-- NF-2 on.

1800-- Drained 4 gallons from NF-1 AS tank + replaced with pemeate water. 71 ml/gal now in preparation
for new startup flows for NF-1.

4/3/98

0710-- Drained Zenon - filling with tapwater.

0815-- Zenon on with tapwater for clean water flux - vacuum=6.5".

0830-- Zenon off to drain - filling with raw water.

0845-- Added 6 liters/HCL + 30 gls/tapwater to acid tank.

0850-- Added 720 mls/NH4Cl + 18 gls/tapwater to NH3 tank. Also added 5 liters/NaOCL + 15 gls/tapwater
to the Cl2 tank.

09:00-- Zenon on with raw as feed. Perm=10.5 bleed = 3.5. Will open bleed at 12:20 to 3.5 gpm.

0945-- Started NF-1.

4/8/98

0605-- Found NF-1 off.

0615-- NF-1 on.

0715-- Set up Memcor for cleaning - added 3.8 liters/Memclean to Memcor tank.

0720-- Started Memcor cleaning.

0820-- Added 16 liters/HCL + 40 gls/tapwater to acid tank.

0855-- Memcor done cleaning.

0900-- Memcor on.

1010-- NF-2 on - no acid feed per R.R.

4/9/98

0745-- Added 1200 mls/NH4Cl + 27 gls/tapwater to NH3 tank. Also added 10/liters of NaOCL + 24 gls/tap
water to cl2 tank.

0800-- Added 7 liters/HCL + 13 gls/tapwater to acid tank to slow feed rate for long weekend.

0820-- Added 1349 mls/AS + 19 gls/permeate to NF-1 AS tank assuming 8.54 mls/min pumping rate, a 5 ppm dose, 781 mls/AS already in tank, and 9.3 gpm flow rate. 71 mls/AS per gallon.

0830-- Added 1027 mls/AS + 16 gls/permeate to NF-2 AS tank. Assuming 10.95 mls/min pumping rate,
a 5 ppm dose, 899 mls/AS already in tank, + 10.8 gpm flow rate. 64.2 mls/AS per gallon.

4/11/98

0430-- NF-2 off on "low feed pressure".

1750-- NF-2 on - changed prefilter.

1800-- NF-1 off to be pickled. (Zenon cleaning).

1802-- Zenon off.

1805-- Added 50 gallons/permeate + 1.0 liter of formaldehyde to cleaning tank.

1845-- Started pickling NF-1.

1850-- Started filling Zenon tank with tapwater for clean water flux.

1910-- Stopped pickling NF-1.

1915-- Started clean water flux on Zenon 10 gpm=11".

1925-- Added 2 gallons/10% NaOCL to Zenon cleaning tank then adjusted pH to 10.81 in Zenon tank. Started Zenon to mix water.

2005-- Stopped Zenon - letting soak overnight with blower on.

4/12/98

1000-- Stopped Zenon blower and draining tank + gilling with tapwater for clean water flux.

1100-- Clean water flux - 10 gpm=6.7" vacuum.

1200-- Started Zenon with raw water. Will open bleed to 4.0 gpm @ 15:20.

1230-- NF-1 on at experiment #3. Reset all chemicals.

4/13/98

0800-- Started Bi-weekly sampling Dupe=#17. Zenon,Memcor, NF-1+2.

0915-- Cl2 and NH3 off.

0945-- Sampled #11 and #17 for SDS.

0950-- Cl2 and NH3 on.

1220-- Changed to experiment #4 on NF-1. All chemicals reset.

1700-- NF-1 off to be pickled. Added 1 gallon of formaldehyde in 50 gallons of permeate.

1715-- Flushed for 5 minutes.

1720-- Closed all NF-1 valves.

1745-- Stopped Zenon and started cleaning. Clean water flux is 9"@10 gpm.

1900-- Added 2 gallons of bleach +150 mls/NaOH pH=10.78.

1910-- Letting Zenon soak overnight.

4/14/98

0800-- Clean water flux on Zenon=6.2.

1000-- Started Zenon @ 9 gpm with raw water. Bleed will be opened at 13:00 to 3.0 gpm.

1250-- NF-1 on at experiment #4. Chemicals already were adjusted.

1255-- NF-2 setting changed to experiment #4. Took AS tank down to 12 gls. then filled to top with

permeate. Pumping rate=10.95 mls/min, 8.2 gpm flow, 2.5 ppm dose. 24.4 mls/gal.
1300-- Bleed opened to 3.0 gpm.

4/15/98

0830-- Spore spiking units. Cl2 and NH3 off.
0920-- Cl2 and NH3 back on.
1030-- Done spore spiking.

4/15/98

0830-- Spore spiking units. Cl2 and NH3 off.
0920-- Cl2 and NH3 back on.
1030-- Done spore spiking.
1240-- Adding 50 gls/permeate to cleaning tank.
1250-- Added 1.1#/Dodecyl + 8.5#/Tripolyphosphate to cleaning tank. Adjusted pH to 10.87.
1255-- NF-2 off to be cleaned.
1300-- Started cleaning solution through heater to heat to 35oC.
1325-- Started cleaning recirculation through NF-2.
1355-- Stopped NF-2 recirculation. Will let soak for 2 hours.
1555-- Stopped NF-2 recirculation - will let soak for 2 hours.
1625-- Stopped recirculation + flushed.
1630-- NF-2 unit on.

4/16/98

0745-- Added 6 liters/HCL + 12 gls/tapwater to acid tank.
1650-- Power failure - Memcor and Zenon off.
1755-- Memcor and Zenon on.

4/17/98

1230-- Added 1200 mls/NH4Cl to 30 gals/tapwater. Also added 10 liters/NaOCL to 30 gls/tapwater in cl2 tank.

4/20/98

0650-- Standardizing pH + TDS meters. "10.0" standard would not take. Will get new pH meter.
0900-- Added 50 gls/permeate to cleaning tank and started heating water up for upcoming NF-2 cleaning.
1030-- Added 8.5#/Tripolyphosphate + 1.1# /Dodecyl - adjusted pH to 10.84.
1045-- NF-2 off.
1100-- Started cleaning for 1/2 hour recirculation on NF-2.
1130-- NF-2 unit off to soak for 4 hours.
1530-- NF-2 unit cleaning pump on for 1/2 hour.
1600-- Cleaning pump off.
1700-- NF-2 unit on with AS on after pre-filter. Cl2 + NH3 on before prefilter - **Had to unplug NF-1 AS
so I could use the double plug on NF-2. Will get new a new double plug tomorrow.
1810-- #27 CL2=1.8 #26 CL2=1.3.

4/21/98

0650-- Primed NF-2 AS pump - pump must have lost prime.
0730-- NF-2 Cl2 pump fell over pinching the dishcarge hose. Put pump back up and secured.
0800-- NF-1 AS on (got a new multiplug).
0820-- #27 cl2=1.0 #26=.5
0930-- Added 8.5#/Citric Acid + 50 gls/permeate to cleaning tank.

1035-- NF-2 off.

1100-- Started acid wash through NF-2.

1130-- Acid wash stopped - letting soak for 4 hours.

1530-- Acid wash started again on NF-2.

1600-- Acid wash off.

1630-- NF-2 on.

1650-- TDS on #27=0

4/23/98

0800-- Added 720 ml/AS + 25 gls/permeate to NF-1 AS tank assuming 156 mls/AS already in tank, an 8.2 gpm flow, a 9.14 ml/min pumping rate and 2.5 ppm dose. 29.2 ml/gallon

0810-- Added 1011 ml/AS + 26 gls/permeate to NF-2 AS tank assuming 117 mls/AS already in tank, an 8.2 gpm flow, a 7.10 ml/min pumping rate, and a 2.5 ppm dose. 37.6 ml/gallon.

4/24/98

0820-- Added 10 liters/NaOCL + 27 gls/tapwater to cl2 tank. Added 1000 ml/NH4Cl + 23 gals/tapwater to NH3 tank. Added 12 liters/HCL + 35 gls/tapwater to acid tank.

4/27/98

0810-0910-- Bi-weekly sampling - #27=dupe.

0845-- Cl2 and NH3 off on NF-1 + 2.

0915-- CL2 and NH3 on.

1000-- Increased stroke on both cl2 pumps - cl2 in cl2 tank = 5160 mg/l.

1430-- Switched Memcor to NF-1 and Zenon to NF-2. Adjusted acid in NF-1 + cl2 doses. NF-1 + 2 were off momentarily to do this.

1500-- Continued adjusting cl2 doses to both membranes.

1550-- Zenon flows down to 6.8 in perm, 2.3 gpm for bleed.

1600-- Added 371 ml/AS + 17 gls/permeate into NF-2 AS tank, assuming 12.27 ml/min pumping rate, 489 ml/AS already in tank, 5.4 gpm flow, and 5 ppm dose. 28.7 ml/gallon.

1600-- Added 566 ml/AS + 15 gls/permeate to NF-1 AS tank. Assuming a 10.51 pumping rate, 438 mls/AS already in tank, a 5 ppm dose, and a 5.4 gpm flow. 33.5 ml/gallon.

4/28/98

0800-- Added 1200ml/NH4Cl + 29 gls/tapwater to NH3 tank. Added 12 liters/HCL + 45 gls/tapwater to acid tank. Adjusted cl2 for NF-1 + 2. #17=.8 mg/l residual #27=.5 mg/l residual (both monochloramines).

4/28/98

0800-- Added 1200ml/NH4Cl + 29 gls/tapwater to NH3 tank. Added 12 liters/HCL + 45 gls/tapwater to acid tank. Adjusted cl2 for NF-1 + 2. #17=.8 mg/l residual #27=.5 mg/l residual (both monochloramines).

4/28/98

0800-- Added 1200ml/NH4Cl + 29 gls/tapwater to NH3 tank. Added 12 liters/HCL + 45 gls/tapwater to acid tank. Adjusted cl2 for NF-1 + 2. #17=.8 mg/l residual #27=.5 mg/l residual (both monochloramines).

4/30/98

1000-- HPC samples taken on all NF-1 + 2 sample taps (14 taps).

1030-- Quenched SDS samples.

5/1/98

0800-- Added 840 grams/NH4CL + 21 gals/tapwater to NH3 tank. Added 10 liters/NaOCL + 26 gls/tapwater
to cl2 tank. Also added 12 liters/HCL + 38 gls/tapwater to acid tank.

0840-- Added 357 ml/AS + 15 gls/permeate to NF-1 AS tank assuming a 12.27 ml/min pumping rate, 5.4 gpm flow,
and 503 ml/AS already in tank. 28.7 ml/gallon.

0845-- Added 429 ml/AS + 15 gls/permeate to NF-2 AS tank assuming a 12.27 ml/min rate, 5.4 gpm flow, 431 mls/AS
already in tank. 28.7 ml/gallon.

1000-- Cl2 in #17=1.6 #27=.3

5/4/98

0845-- Added 16 liters/HCl + 50 gls./tapwater to acid tank.

5/5/98

0830-- Added 1000mls/NH4Cl + 25 gls/tapwater to NH3 tank. Added 10 liters/NaOCL + 27 gls/tapwater to cl2 tank.

100-1200-- Trying to dial in NF-2 cl2 - cl2 pump does not adjust well.

1300-- #27 cl2 = .3 mg/l residual of monocl2.

5/7/98

0800-- Adjusting monocl2 on NF-1.

0900-1400-- Discovered that cl2 residual could barely be established when injecting cl2 before pre-filters on
NF-1 + 2. I started injecting cl2 after pre-filters and cl2 residual increased dramatically. Will leave like this and
call to notify R.R. to see if this is O.K.

1000-- HPC samples taken on taps #21-#27.

1330-- Added 804 mls/AS + 24 gls/permeate to NF-1 AS tank assuming 172 mls/AS already in tank, 10.81 mls/min
pumping rate, 5 ppm dose, and 5.4 gpm flow. 32.5 ml/gallon.

1340-- Added 804 mls/AS + 24 gls/permeate to NF-1 AS tank assuming 172 mls/AS already in tank, 10.81 mls/min
pumping rate, 5 ppm dose, and 5.4 gpm flow. 32.5 ml/gallon.

1430-- Added 16 gallons/HCL + 50 gals/tapwater to acid tank.

5/8/98

0800-- Added 4 liters/HCL + 10 gls/tapwater to acid tank.

0810-- Added 1 gl/NaOCL + 12 gls/tapwater to cl2 tank. Also added 880 ml/NH4CL + 22 gls/tapwater to NH3 tank.

5/11/98

0700-- Standardized pH and TDS meters.

0800-- Bi-weekly sampling - Zenon, Memcor., NF-1 + 2 Dupe=#27.

0915-- Cl2 and NH3 back on.

0940-- Changed NF-1 + 2 flows to experiment #2. Changed flows and adjusted AS (both have 10.5 ml/gallon now)
and I also adjusted the cl2 and nh3.

5/12/98

0800-1030-- Spore spiking all units. Cl2 and NH3 off while spiking NF-1 and 2.

1030-- Added 14 liters/HCL + 50 gls/tapwater to acid tank. Also added 960 mls/NH4Cl + 24 gls/tapwater to NH# tank.

5/13/98

1210-- Memcor and NF-2 off for Memcor tracer study.

1215-- NF-1 pickled with formaldehyde.

1420-- Memcor and NF-1 on.

5/14/98

1600-- Added 5.7 liters/NaOCL + 17 gls/tapwater to cl2 tank. also added 480 mls/NH4Cl + 12 gls/tapwater to Nh3 tank.

5/15/98

1700-- Added 208 mls/AS + 20 gls/tapwater to NF-1 AS tank assuming a 4.1 gpm flow, 105 mls/AS already in
tank, a 10.81 ml/min pumping rate, and a 2.5 ppm dose. 10.4 ml/gallon.

1710-- Added 208 mls/AS + 20 gls/tapwater to NF-2 AS tank assuming a 4.1 gpm flow, 105 mls/AS already in
tank, a 10.81 ml/min pumping rate, and a 2.5 ppm dose. 10.4 ml/gallon.

1730-- Added 8 liters/HCL + 25 gls/tapwater to acid tank.

5/18/98

0650-- Standardized pH and TDS meters - Had to use new pH meter - old one would not take 7.0 standard.

0820-- Re-standardized pH meter once more - then doublechecked it again with all the buffers. O.K. now.

1000-- Memcor flow down to 7.0 gpm while raw water pumps are repaired.

5/19/98

0800-- Memcor flow up to 10.0 gpm again.

0810-- Added 1200 ml/NH4Cl + 27 gls/tapwater to NH3 tank.

5/20/98

0715-- NF-1 off.

0720-- Memcor off - started cleaning with 3.8 liters/Memclean.

0730-- Added 1 liter/formaldehyde + 50 gallons/permeate to cleaning tank.

0740-0800-- Ran pickling solution through NF-1

0810-- Added 16 liters/HCL + 50 gals/tapwater to acid tank.

5/22/98

0735-- Changed prefilter on NF-2.

740-- Added 355 ml/AS to NF-2 AS tank. 4.1 gpm flow, 10.81 ml/min. pumping rate

745-- Added 255 ml/AS to NF-1 AS tank. 4.1 gpm flow, 10.81 ml/min. pumping rate

5/23/98

1410-- NF-2 off + Zenon off for Zenon cleaning. Started draining Zenon tank.

1430-- NF-1 on.

1500-- Had to bleed air from NF-1 cl2 pump to establish monochloramine residual.

5/24/98

1445-- Clean water flux on Zenon - 7.2" vacuum.

1600-- Zenon on with raw water - bleed to be opened in 4 hours at 20:00.

1620-- Added 8 liters/NaOCL + 26 gls/tapwater to cl2 tank.

5/26/98

0710-0800-- Bi-Weekly samples tanken on Zenon, Memcor, NF-1 + 2 no SDI samples. Dupe=17.

0805-0830-- Cl2 and NH3 off while getting SDS samples.

1000-- Added 50 gls/permeate + 1.1# dodecyl + 8.5#/tripolyphosphate to cleaning tank and heated it up.

1055-- NF-2 off

1100-- Started cleaning NF-2.

1200-- Started soaking NF-2

1615-- NF-1 flows reset and chemicals adjusted.

1700-- NF-2 flows reset and chemicals adjusted.

5/27/98

0705-- Acid was empty - added 20gls/tapwater + 8 liters/HCL. I need to order more acid today for delivery ASAP.

5/28/98

1330-1500-- Power failure - air pumps OOS due to electrical panel damage caused by leak on discharge line.

1730-- Temporary repairs made and back in service, NF-1 feed pump damaged by running empty prior to my
arrival from school.

1800-- Raw feed stopped - cleaned both strainers plugged with material from heavy rainfall.

2000-- PSI switch on NF-1 cutoff adjusted to 5 psi because of low discharge psi on feed pump.

5/29/98

0730-- Zenon and Memcor shutdown for repairs on NF-1 feed pump replacement and air pump discharge.

1200-- All units back in service.

1300-- Quenching completed.

1330-- All units OOS for new electrical panel at intake.

1500-- All units back in service.

1630-- NF-1 cl2 pump lost prime

1730-- Added 10 liters/NaOCL to 30 gls/tapwater. Added 1300 mls/NH4Cl to 30 gals/tapwater. Added 16 liters
of HCL to 50 gls/tapwater.

2100-- NF-1 cl2 pump failed with no spare pumps for replacement. The feed pump used for pH adjustment will
be used for cl2 feed per R.R.

5/30/98

0830-1030-- Attempted to repair all spare feed pumps with no success.

6/1/98

0700-- Using different pH meter (ozone) for tests. Seems slow to react. Will locate new pH meter today.

0845-- Added 1125 mls/AS to NF-1 + 2 assuming both had 225 mls/AS already, 4 ppm dose, 10.81 ml/min pumping rate, and a 9.3 gpm flow. 45 ml/gallon

6/2/98

0700-- Cl2 solution out - made new batch. Added 10 liters/NaOCL + 30 gls/tapwater to cl2 tank. Also added 1000 mls/NH4CL + 25 gls/tapwater to NH3 tank.

0710-- Standardized pH meter (new meter) + TDS probe (new standards).

1200-- All units shutdown per electrical panel replacement.

1400-- all units back in service.

6/3/98

0650-- All units off for air compressor p.m.

0850-- All units back on.

1000-- Added 50 gls/permeate + 1 liter/formaldehyde to cleaning tank.

1020-- Started pickling solution through NF-2.

1100-- Stopped pickling NF-2.

1600-- Draining Zenon unit.

1625-- New chemical pumps in - Acid, cl2, nh3, and AS feeding to NF-1 now. Monocl2=1.0 at #17 tap.

1630-- Filling Zenon with tapwater for clean water flux.

6/4/98

0700-- Running solution through Zenon again.

0800-- Drained and filled with tapwater.

0845-- Clean water flux = 7.2"

0900-- Draining Zenon and filling with raw water.

1100-- Zenon on at 10.5 gpm permeate - bleed will be opened to 3.5 gpm in 2 hours 37 minutes.

1340-- Bleed opened on Zenon to 3.5 gpm.

1530-- NF-2 on.

6/5/98

0810-- Went up on NF-2 monocl2 dose to get 2.0 mg/l.

0815-- Added 20 liters/HCL + 50 gls/tapwater to acid tank.

0825-- Added 5 liters/NaOCL + 15 gls/tapwater to cl2 tank. Added 900 mls/NH4CL + 10 gls/tapwater to NH3 tank.

0930-- Added 995 mls/AS to NF-1 AS tank + 17 gls/permeate assuming a 9.3 gpm flow, 10.81 mls/min pumping rate, 4.0 mg/l dose, and 585 mls/AS already in tank. 53 mls/gallon.

0940-- Added 535 mls/AS to NF-2 AS tank + 12 gls/permeate assuming a 9.3 gpm flow, 10.81 ml/min pumping rate,
a 4.0 mg/l dose, and 810 mls/AS already in tank. 45 mls/gallon

6/8/98

0845-0920-- Bi-weekly sampling of Zenon, Memcor, NF-1 + 2. Cl2 and NH3 off for SDS sampling.

1200-- Added 50 gls/permeate + 1 liter to cleaning tank.

1230-- NF-2 and Zenon off.

1245-- Started pickling NF-2.

1700-- Drained Zenon and filling with clean water.

1750-- Zenon on at 10 gpm - vacuum=18.5" Added 2 gls/10% NaOCL and letting run for one hour.

1850-- Zenon soaking overnight with blower on.

6/9/98

0830-0930-- Spore spiking NF-1 and Memcor only. Cl2 and NH3 off during this process.

1000-- Zenon filled with clean tapwater then started at 10 gpm - vacuum=6"

1400-- Added 2 more gls/10% NaOCL to Zenon clean water tank then changed air blower vanes.

1450-- Started blower on Zenon to soak overnight.

6/10/98

0845-- Zenon on with new clean water - vacuum=6".

1030-- Zenon on with raw water - perm=9.2 gpm, Bleed will be opened to 3.0 gpm at 13:30.

1200-- changed flows to experiment #4. chemicals adjusted also.

6/11/98

0800-- Lowered cl2 in NF-2 - Cl2 now is 2.3 mg/l of monocl2.

6/14/98

1900-- NF-2 off - no apparent reason.

6/15/98

0650-- NF-2 back on.

1250-- NF-1 off for Memcor testing.

1300- Memcor off to be cleaned.

1310-- Started pickling solution of 1 liter/formaldehyde + 50 gls/tapwater through NF-1.

1340-- Stopped pickling NF-1.

6/16/98

0800-1130-- Memcor challenge.

1300-- Memcor back on

1430-- NF-1 back on.

1440-- Added 7.7 liters/NaOCL + 23 gls/tapwater to cl2 tank. Also added 800 mls/NH4Cl + 18 gls/tapwater
to the NH3 tank.

6/17/98

0800-- NF-2 off for Zenon cleaning.

0900-- Added 1 liter/formaldehyde + 50 gls/permeate to cleaning tank.

0950-- Started pickling NF-2.

1030-- Stopped pickling NF-2.

1045-- Zenon off and draining - then filling with clean water for flux test.

1200-- Added 597 mls/AS to NF-1 AS tank assuming 165 ml/AS already in tank, 2.5 ppm dose, 8.2 gpm
flow and 10.51 ml/min pumping rate. 25.4 ml/gallon.

1210-- Added 672 ml/AS to NF-2 AS tank assuming 178 mls/AS already in tank, 2.5 gpm dose, 8.2 gpm
flow and a 9.42 pumping rate. 28.3 ml/gallon.

1235-- Added 24 liters/HCL + 46 gls/tapwater to acid tank.

1340-- Letting Zenon soak overnight with 3 gls/10% NaOCL and pH=10.94.

6/18/98

0030-- Raw water pumps are both broken. Shut down all units.

0830-- Drained Zenon and filled with clean water. Started Zenon and had 5.3" of vacuum.

1130-- Zenon started with raw water at 9.2 gpm on the permeate, bleed to be opened at 2:33 p.m. @ 3.0 gpm.

1140-- Memcor and NF-1 back on.

1200-- NF-2 on with acid feed at 4.25 pH for now.

6/19/98

1015-- HCP samples taken on NF-1 + 2.

1400-- Added 6 gls/HCL + 36 gls/tapwater to acid tank. Also added 7.5 liters/NaOCL + 15 gls/tapwater
to cl2 tank. Added 900 mls/NH4CL + 15 gls/tapwater to NH3 tank.

6/22/98

0800-1015-- Bi-weekly sampling Zenon, Memcor, NF-1 + 2. Cl2 and NH3 off for SDS samples. Dupe=27

All Day-- Zenon off and NF-2 off. NF-2 also pickled cleaned Zenon with 3 gls/10% NaOCL and pH= 10.86
Also soaked overnight in that solution.

6/23/98

0630-- Started Al2SO4 feed to Memcor unit.

1300-- Started NF-2 on SCF water - no cl2 or NH3. Acid on both nanofilters being fed straight from HCL barrel.
NF-2 at new experiment #1 settings. Setting up Zenon with ferric addition to feed tank.

1700-- Zenon foulded out due to ferric addition for sludge generation. Drained Zenon and added tapwater
and 3 gls/NaOCL and soaked overnight.

6/23/98

0630-- Started Al2SO4 feed to Memcor unit.

1300-- Started NF-2 on SCF water - no cl2 or NH3. Acid on both nanofilters being fed straight from HCL barrel.
NF-2 at new experiment #1 settings. Setting up Zenon with ferric addition to feed tank.

1700-- Zenon foulded out due to ferric addition for sludge generation. Drained Zenon and added tapwater
and 3 gls/NaOCL and soaked overnight.

6/24/98

0900-- Changed NF-1 to experiment #1.

1300-- Added 45#/citric acid to tank on Zenon. pH=2.48. Bubbling overnight due to plugged zenon membranes.

6/25/98

0510-- Memcor and NF-1 off due to power flicker.

0730-- Units back on.

1140-- Filling Zenon with raw water - 50% speed on chemical pump - cut back to 25% when full.

1200-- Started Zenon at 8 gpm=permeate and 2.0 gpm=bleed. Chemical pump at 25%. Will open bleed to 2.0 gpm at 1635.

1315-- HCP samples collected on NF-1 + 2.

6/26/98

0730-- CSF water off due to power problems with supply pump near #17 filter. NF-2 off due to this.

1000-- Added 25 gls/Alum + 25 gls/tapwater to Alum tank for Memcor.

1030-- NF-2 back on.

1200-- Added 150 mls/AS to NF-1 + 12 gls/permeate. Also added 148 mls/AS to NF-2 + 13 gls/permeate.

6/29/98

0650-- Standardized pH and TDS meters.

0840-- Memcor Al2 pump had air bubble - purged line and seems o.k. according to pH value.

0850-- Switched/replaced acid (HCL) barrel with another full acid barrel.

1300-- Memcor off for challenge test.

6/30/98

1200-- Added 10 liters/NaOCL + 20 gls/tapwater to cl2 tank. Also added 1500 mls/NH4CL + 25 gls/tapwater
to the NH3 tank.

1230-- Memcor unit back on at 10.0 gpm and 40 minute backwashes.

7/1/98

0700-- NF-2 acid pump lost prime - reprimed.

0830-- Alum and Ferric pumps both needed sped up due to increased raw pressure from Memcor testing.
Lowered pressure and increased pumps to try to obtain same pH as when pumps were running o.k.

7/2/98

0715-- NF-1 and 2 off - NF-1 had leak where acid feeds into prefilter. NF-2 off to repair 1" leaking B.V.

0730-- NF-2 on.

0900-- NF-1 on.

0940-- Added 842 mls/AS + 26 gls/permeate to NF-1 AS tank assuming 50 mls/AS already in tank, a 5.4 gpm flow, 11.83 ml/min pumping rate, and a 5 mg/l dose. 29.7 ml/gallon.

0950-- Added 958 mls/AS + 26 gallons/permeate to NF-2 AS tank assuming 46 mls/AS already in tank, a 5.4 gpm flow, 10.51 ml/min pumping rate, and a 5 mg/l dose. 33.5 ml/gallon.

7/4/98

2100-- Floyd Sneider called and said NF-1 and Zenon off. I told him to keep it off until I restart tomorrow.

7/5/98

1630-- Zenon and NF-1 back on.

7/6/98

0900-1015-- Biweekly samples taken on Zenon, Memcor, NF-1 + 2 and CSF.. Dupe = #17. Cl2 and NH3 off for SDS samples.

1200-- Repaired Memcor alum pump with new fittings to increase al2 flow to unit. Seems to be working now.

7/7/98

0800-- Cl2 and NF3 off on NF-1 in preparation of spore spiking of NF-1 and Memcor and Zenon.

1000-- Cl2 and NH3 back on.

1315-- Added 45 mls/AS + 18 gls/permeate to NF-1 AS tank. Assuming 356 mls/AS already in tank, a 10.0 ml/min. pumping rate, 2.5 ppm dose, and 4.1 gpm flow. 13.5 ml/gallon.

1315-- Added 500 mls/AS + 21 gls/permeate to NF-2 AS tank assuming 801 mls/AS already in tank, a 10.0 ml/min. pumping rate, 2.5 ppm dose, and 8.2 gpm flow. 26.7 ml/gallon.

7/9/98

1400-- Quenched biweekly samples.

1420-- Added 12 liters/NaOCL + 2.5 gls/tapwater to cl2 tank. Added 1400/mls/NH4Cl + 24 gls/tapwater
to the NH3 tank.

7/10/98

0800-- ***TURBIDIMETER IS READING HIGH, I THINK. WILL TAKE TO LAB TODAY TO HAVE TURBIDIMETER CALIBRATED.

0840-- NF-1 off due to Zenon going to be cleaned today.

0850-- Zenon off and draining.

0855-- Added 1 liter/formaldehyde + 50 gls/permeate to cleaning tank. Started pickling solution ~ NF-1.

0920-- Stopped pickling of NF-1.

1200-- Added 123 mls/AS + 14 gls/permeate to NF-1 AS tank assuming 216 mls/AS already in tank, 2.5 ppm
dose, 4.1 gpm flow and 11.83 ml/min pumping rate. 11.3 ml/gallon.

1220-- Added 223 mls/AS + 13 gls/permeate to NF-2 AS tank assuming 454 mls/AS already in tank, 2.5 ppm
dose, 8.2 gpm flow, and 11.83 ml/min pumping rate. 22.6 ml/gallon.

1222-- Filling Zenon with clean water to perform flux test.

7/11/98

0900-- No change in Zenon - awaiting instructions.

0910-- Changed al2 pump with different pump. Level at 43 gls/alum.

2359-- NF-2 off - prefilter pressure loss.

7/12/98

1205-- NF-2 on after changing prefilter.

1245-- Added 2.5 gls/10% NaOCL to Zenon tank and bubbled overnight.

7/13/98

0710-- Memcor off due to >20psi difference.

1200-- Zenon on with clean water -- 9" vacuum. Added NaOH to pH=10.88 -- letting soak and bubble overnight.

1300-- Turbidimeter came back from the lab after being recalibrated.

7/14/98

1030-- Zenon vacuum at 6.8". Added 2.5 gls/NaOCL 10% and bubbled overnight.

7/15/98

0730-- Zenon on with clean water - 4.8" bacuum. Started draining to fill with raw water.

0840-- Started filling Zenon with raw water. Set pump speed to new setting to achieve 5 gls/day and will leave there after Zenon is running.

0900-- Will have turbidimeter recalibrated again. Reading about .08 higher than it should.

0900-- Zenon on at 8.0 gpm permeate. Will open bleed to 2.0 gpm at 13:35.

1230-- NF-1 on.

7/16/98

0900-- Increased ferric pump by 1.5 x 50% speed to try and get 5 gpd flow.

1015-- Added 520 mls/AS + 23 gls/permeate to NF-2 AS tank. Same flows as last time.

1030-- Sampled NF-2 for HPC's.

2230-- Acid stopped on NF-2 - told COI I would correct problem tomorrow morning.

7/17/98

0645-- Acid back on to NF-2.

0830-- Switched Memcor to new experiment of 14 gpm, and 20 minuter/backwash.

1400-- Added 3.1 gls/ferric + 28 gls/tapwater to ferric tank for Zenon.

7/20/98

0800-- Standardized pH and TDS meters.

0900-- Biweekly samples - cl2 and NH3 off during SDS sampling.

1230-- Changed NF-2 to experiment #1 and added 599 mls/AS and added 17 gls/permeate @11.83 pumping rate.

7/21/98

1000-- Added 1084 mls/AS to NF-1 AS tank, assuming 45 mls/already in tank, 9.3 gpm flow, and 12.88 rate,
and a 4 mg/l dose. 37.6 mls/gallon.

1010-- Changed flows on NF-1 to experiment #3. Also changed flows on Zenon to 10 gpm and 2.5 gpm bleed.

1100-- Added 15 liters/NaOCL + 27 gls/tapwater to cl2 tank. Also added 1800 mls/NH4CL + 27 gls/tapwater
to NH3 tank. Also added 5 gls/HCL to acid tank.

7/22/98

0700-- Increasing NF-2 cl2 to 4.0 mg/l residual. NF-2 acid pump lost prime -- reprimed and is o.k.

1230-- Added 402 mls/AS + 9 gls/permeate to NF-1 AS tank assuming 827 mls/AS already in tank,
a 9.3 gpm flow, 11.83 ml/min pumping rate, and 4 mg/l dose. 41.mls/gal.

1240-- Added 372 mls/AS + 13 gls/permeate to NF-2 AS tank, assuming 520 mls/already in tank,
a 5.4 gpm flow, 11.83 pumping rate, and 5 mg/l dose. 29.7 mls/gallon.

7/23/98

1350-- Added 5.6 gls/Naocl + 22 gls/tapwater to cl2 tank. Also added 2700 mls/NH4Cl + 22 gls/tapwater
to the NH3 tank.

7/24/98

1050-- Added 5.5 gls/ferric + 39 gls/tapwater to ferric tank for Zenon unit.

2000-- NF-2 off on low suction pressure.

7/25/98

1000-- Zenon off due to fouling and high vacuum. Ferric was turned off last night by COI accidentally when
shutting down NF-1.

1030-- Pickled NF-1

7/25/98

1430-- Draining Zenon tank. Will fill with clean water for clean water flux.

1500-- Flux test - could only get 5 gpm @ >20" vacuum. Added NaOH to PH=10.68. Letting bubble overnight.

7/26/98

1800-- Draining Zenon to do clean water flux test. Lots of sludge on membrame fibers still.

1915-- Zenon had 15.5" of vacuum still. Added 500 mg/l of NaOCL and let soak overnight.

7/27/98

0740-- Zenon at 9" of vacuum -- letting soak further.

0930-1030-- Replace gate valves on NF-1 + 2. NF-2 off for this.

1400-- Added 4000 mls/NH4CL + 25 gls/tapwater to NH3 tank.

1430-- Added MC-1 to Zenon clean water to saok overnight at pH of 2.73.

7/28/98

0800-- Draining Zenon to do clean water test on Zenon after MC-1 cleaning.

1040-- Vacuum at 5.0" on Zenon -- letting sit there until unit is repiped for ferric feed detention tank.

7/29/98

1030-- Added 773 mls/AS to NF-2 tank + 26 gls/permeate. Same flows as last time. 29.7 ml/gallon

7/30/98

0830-- Collected NF-2 HPC samples.

7/31/98

0830-- Cl2 hose popped out above cl2 level in cl2 tank. I repositioned hose and is feeding again. Also the HCL acid line was airlocked on discharge of HCL pump. I purged air from line and is ok now.

0845-- Added 21 gls/tapwater + 2600 mls/NH4CL to NH3 tank.

8/3/98

0730-- NF-2 NH3 feed pump was airlocked (not pumping). Increased speed long enough to get it primed again.

This caused a 3.8 free chlorine residual in NF-2 for probably the last 24 hours. NH3 is now feeding with monocl2 of 3.7.

0830-0930-- Biweekly samples + SDS samples. Cl2 and NH3 off during the SDS sampling.

1000-- Memcor off due to high pressure loss.

1400-1700-- Cleaning Memcor unit.

8/4/98

0830-0930-- Spore spiking memcor and NF-2 only.

1030-- Switched NF-2 to experiment #4. changed chemicals to reflect new feed rate.

1040-- Drained 15 gls/AS out of NF-1 AS tank and filled with permeate, 11.83 rate, 22.6 ml/gallon.

1215-- Zenon unit on at 9.0 gpm, 2.3 gpm bleed. Will leave bleed closed for 4 hours.

1400-- Added NaOH (1000 mls) into 10 gls/permeate for caustic feed to NF-1. No acid needed for NF-1.

1615-- Zenon bleed opened.

8/5/98

1000-- NF-2 HPC samples taken.

8/6/98

0730-- Turned caustic pump off to NF-1. Zenon permeate pH=7.45. Have 15" of vacuum. Will call to see

if I should start acid on NF-1 or pickle NF-1.

0830-- Added 15 liters/NaOCL + 15 gls/tapwater to cl2 tank. Added 4000 mls/NH4CL + 26 gls/tapwater to

the NH3 tank. Refilled acid barrel.

0840-- Added 113 mls/AS + 5 gls/permeate to NF-1 AS tank. Added 158 mls/AS + 7 gls/permeate to NF-2 AS tank.

1030-- Zenon + NF-1 off. NF-1 pickled. Zenon being filled with tapwater and pH adjusted to 10.78.

8/7/98

1200-- Clean water flux on Zenon Vacuum pressure at 9".

1600-- Zenon being filled with tapwater and 2 gallons NaOCL.

8/8/98

1300-- Clean water flux on Zenon. Vacuum at 6". Zenon being filled with raw water and Ferric and NaOH. Added 3.5 gallons ferric + 75 gls/tapwater.

8/9/98

2100-- Memcor tripped and lost power due to storm. Reset Memcor.

8/10/98

0730-- Added 30 liters of NaOCL to 30 gls/tapwater. Added 4000 mls/NH4CL to 30 gls/tapwater.

1200-- Memcor off for challenge test.

8/11/98

1000-- Zenon off to be cleaned.

1230-- Zenon has 15.5" vacuum -- will add caustic to clean.

1240-- Added caustic to Zenon to pH=10.62.

1500-- Memcor unit back on at 10 gpm, 20 minute b/w, and with al2 feed on.

8/12/98

0930-- Flux test on Zenon= 9.5" of vacuum at 10.0 gpm.

0940-- Draining Zenon and filling with tapwater + 2.5 gls. of 10% NaOCL and will let soak overnight.

0950-- Added 565 mls/AS + 25 gls/permeate to NF-2 AS tank. 22.6 mls/gallon.

8/13/98

0800-- Memcor guys here (Britt and Dan) to work on Memcor. Added 6000 mls/Nh4Cl to NH3 tank +18 gls/water.

1200-- NF-1 pickled.

1600-- Zenon on with 300 mg/l of alum + caustic pH adjustment to 5.5 pH. Bleed opened to 2.3 gpm at 20:00.

8/14/98

0800-- Added 15 liters/NaOCL + 15 gls/tapwater to cl2 tank.

1300-- Added 10 gls/NaOH + 10 gls/tapwater to zenon caustic tank.

1430-- Zenon unit off until sun or monday per R.R.

8/16/98

1615-- Zenon and NF-1 on with Zenon feeding NF-1 Cl2 and NH3 and AS on to NF-1. No acid pump for NF-1 but
pH of zenon mixing chamber = 5.72.

8/17/98

0730-- Std pH and TDS meters.

0915-1015-- Collecting bi-weekly samples - Raw, Zenon, Memcor, and NF-1 and 2. Dupe = #17. Performed a
pressure decay test on Memcor before sampling. Cl2 and NH3 off during SDS sampling.

1030-- Increased Memcor alum flow. Was only feeding .7 gpd so I increased flow to hopefully get 1.5 gpd.

1200-- Zenon off and drained - filled with raw water.

1500-- Zenon on with no coagulant or NaOH. Bleed to be opened at 21:00 ato 1.8 gpm. Also switched so that
Zenon is feeding NF-2 and Memcor is feeding NF-1.

1630-- No acid feed to NF-1.

1645-- Added 372 mls/AS to NF-1 and added 689 mls/AS to NF-2. After changing flows to experiment #1.

1930-2300-- NF-1 and Memcor off due to power failure.

8/19/98

0945-- Pressure decay test on Memcor = 2.0 psi from 2-4 minutes.

1000-- Memcor and NF-1 off - pickled NF-1. Also changed NF-1 pre-filter.

8/20/98

1010-- Britt here to change memcor modules.

1015-- Added 776 mls/AS to NF-1 AS tank + 7 gls/permeate =48.6 mls/gallon @ 7.23 rate, 5.4 gpm flow, 5 mg/l dose.

1030-- Added 327 ml/AS + 11 gls/permeate to NF-2 tank = 11.83 rate, 5 mg/l dose, 29.7 ml/gal, 5.4 gpm flow.

8/21/98

1200-- Memcor back on with new modules. PACL feed at 1.5 gpd.

1530-- NF-1 on. Acid on, pH=3.28 per R.R. to decreae al2 scaling in membranes. Monocl2 on also.

8/22/98

1430-- Acid down on NF-1 to pH=5.5 range.

8/23/98

1230-- Zenon alarm - high pressure _NF-2 down. Robbie reset Zenon

1530-- Zenon high B/W pressure adjusted down from 8.7 to 7.0 psi. NF-2 turned back on.

8/24/98

0900-- TDS in NF-1 up in the permeates. Notified R.R.

1300-- Added 25 liters/NaOCL + 25 gls/tapwater to cl2 tank.

8/25/98

1200-- HPC's and TOC's on NF-1. HPC's on NF-2.

1500-- Standardized pH and TDS meters. No big changes.

8/26/98

0830-- Added 832 ml/AS + 28 gls/permeate to NF-2 tank = 11.83 rate, 5 mg/l dose, 29.7 ml/gal, 5.4 gpm flow.

0845-- Added 624 ml/AS + 21 gls/permeate to NF-2 tank = 11.83 rate, 5 mg/l dose, 29.7 ml/gal, 5.4 gpm flow.

0930-- Changed acid barrel out.

1030-- Zenon + NF-2 off. NF-2 pickled. Maintenance repairing NF-2 pump end cap.

1400-- Performed clean water flux test on Zenon. Vacuum=19.0" at 10 gpm. Added NaOH to pH=10.79
and will let bubble overnight.

8/27/98

0840-- Zenon on for flux test. 13.0"=vacuum at 10 gpm. Drained and filled with tapwater + 2.5 gls/NaOCL.

1230-- Memcor PDT performed. 2-4 minutes=.1 psi drop.

1400-- Started NF-2 on CSF water to test pump. Pump still leaked. Re-Pickled NF-2.

8/28/98

0830-- Zenon on to test vacuum. Vacuum=6.7" at 10 gpm. Drained Zenon. Filling with MC-1 for soak.

0850-- Added 18 liters/NaOCL + 18 gls/tapwater to cl2 tank. Also added 3200 mls/NH4Cl + 24 gls/tapwater
to the NH3 tank.

1000-- Zenon unit soaking in tapwater and MC-1 at a pH=2.83

1330-- Tried NF-2 pump again. Leaks still. will tie rag around pump when starting tomorrow. Repickled NF-2.

8/29/98

0915-- Started Zenon for flux test. Vacuum=4.5" at 10 gpm.

0935-- Rinsed and filled Zenon with raw water.

1000-- Zenon on at 7.0 gpm on permeate and bleed will be 1.8 gpm at 80% recovery.

1030-- NF-2 on +acid +AS.

8/31/98

0800-1030-- Bi-weekly sampling - Zenon, Memcor, and NF-1 + 2. Blind Dupe=#27. cl2 and NH3 off for SDS sampling.

1300-- Changed NF-1 and 2 to NF-1=experiment#2, and NF-2=experiment #4. Changed chemicals.

1315-- Added 101 mls/AS +permeate up to 30 gls. mark. 11.3 mls/gallon.

1315-- Added 24 mls/AS +permeate up to 30 gls. mark. 22.6 mls/gallon.

1400-- Changed Zenon flow to 9.5 gpm + 2.4 gpm bleed.

1410-- Changed NF-2 settings to experiment #4.

9/1/98

0830-- Spore spiking NF-1, Zenon, and Memcor.

0845-- NF-2 off due to leaking fitting. Maint. to work on pump.

1400-- Pickled NF-2 -- needed to be off overnight anyway so pump glue could dry.

9/2/98

1400-- NF-2 back on. Pump leaks a little but is o.k.

9/3/98

0830-- Added 30 liters/NaOCL + 26 gls/tapwater to cl2 tank. Added 3000mls/NH4CL + 22 gls/tapwater to NH3 tank.

1250-- Quenched SDS samples.

9/4/98

0730-- HPC samples taken.

0830-- Added 262 mls/AS + 16 gls/permeate to NF-1 AS tank assuming 158 mls/AS already in tank, a 2.5 dose, 9.53 pumping rate, and 4.1 gpm flow.

0835-- Added 572 mls/AS + 11 gls/permeate to NF-2 AS tank assuming 429 mls/AS already in tank, a 2.5 dose, 8.01 pumping rate, and 8.2 gpm flow.

0840-- Changed to new acid barrel.

9/8/98

0700-- Standardized pH and TDS meters.

0830-- NF-2 off - started pickling NF-2.

0835-- Zenon off to be cleaned - draining and flushing out Zenon.

0900-- Stopped pickling NF-2.

1000-- Zenon filled with tapwater - clean water flux=16" of vacuum.

1010-- Added NaOH to pH=10.87. Letting bubble overnight.

9/9/98

0830-- Draining Zenon - adding new tapwater - Zenon vacuum = 9.0" with new water. Then added 2.5 gls/NaOCL
and will let soak overnight.

0845-- Added 241 mls/AS to NF-1 tank assuming 339 mls/AS already in tank, 2.5 dose, 11.83 rate, and a 4.1 gpm flow. 11.3 mls/gal.

0850-- Added 276 mls/AS to NF-2 tank assuming 401 mls/AS already in tank, 2.5 dose, 11.83 rate, and a 8.2 gpm flow. 22.6 mls/gal.

1245-- Bob valve on Memcor broke. Memcor and NF-1 off.

1330-- Bob valve replaced. Memcor and NF-1 on.

1400-- Added 21 liters/NaOCL + 22 gls/tapwater to cl2 tank. Also added 3000 mls/NH4CL + 23 gls/tapwater
to the NH3 tank.

9/10/98

0800-- Flux test on Zenon - Vacuum=6.2". Drained Zenon, filled with raw water.

0930-- Started Zenon at 9.5 gpm. will open bleed to 2.4 gpm at 13:20.

9/14/98

0900-- Bi-weekly sampling -- Zenon, Memcor, and NF-1+2. Cl2 and NH3 off during SDS sampling.

1000-- Zenon and NF-2 off - NF-2 pickled.

9/15/98

1000-- Added 1.1# of Dedecyl + 50 gls/permeate + 8.5# of tripolyphosphate in cleaning tank and heated up to 40oC.

1145-- Started cleaning solution through NF-2.

1230-- Stopped cleaning solution -- letting soak.

1500-- Started cleaning solutioon through NF-2.

1530-- Added 429 mls/AS to NF-2 AS tank + 19 gls/permeate. 22.6 mls/gl.

1540-- Stopped cleaning solution through NF-2. flushed NF-2 with memcor water.

1640-- NF-2 on with memcor water -- NF-1 off and pickled.

9/16/98

0915-- Added 4.3 gls/Pacl + 43 gls/tapwater to pacl tank.

2000-- Zenon on with no bleed - zenon people here to bleed.

9/17/98

0915-- Memcor off to clean - NF-2 off also. Added citric acid to memcor to pH=2.24. Started acid clean.

1250-- Performing caustic cleaning on Memcor.

1510-- Started Memcor up at 15 gpm + Pacl.

9/19/98

0720-- Added 7.5 liters/NaOCL + 30 gls/tapwater to cl2 tank. Added 4000 mls/NH4Cl + 30 gls/tapwater
to NH3 tank. Added 609 mls/AS + 24 gls/permeate to NF-1 AS tank assuming 68 mls/AS already in tank, 2.5 dose, 8.2
gpm flow, and 11.83 pumping rate.

0800-- NF-1 started on Zenon water.

9/20/98

????-- Memcor off due to power failure sometime in afternoon.

9/22/98

0345-- Zenon and NF-1 off due to Zenon high pressure switch coming on.

0415-- Units restarted by Chief Operator I. Acid not feeding or monochloramine.

0830-- Changed hose out on NF-1 acid line. Acid back on.

1000-- Chlorine pump on NF-1 was airlocked - reprimed pump.

1645-- Found alum pump not working.

1700-- Replaced alum pump with Zenon's spare pump. Float ball will not seat properly when Zenon is off.

1705-- Reset backwash pressure alarm on Zenon to 14.5 psi.

1730-- Found NF-2 acid airlocked. Reprimed pump.

9/23/98

1130-- Added 468 mls/AS + 18 gls/permeate into NF-1 AS tank assuming 142 mls/AS already in tank, a 2.5 dose, 13.14 pumping rate, and an 8.2 gpm flow. 20.3 ml/gallon.

1135-- Added 823 mls/AS + 28 gls/permeate into NF-2 AS tank assuming 24 mls/AS already in tank, a 2.5 dose, 9.46 pumping rate, and an 8.2 gpm flow. 28.2 ml/gallon.

1430-- Started running bleed straight from tank to drain by timing flow. flow is now .54 gpm.

9/24/98

0730-- Grabbed NF-2 HPC samples.

0800-- Zenon bleed still won't hold steady flow. Needs reset frequently.

9/25/98

0830-- All units off due to hurricane threat. Zenon pickled with cl2. NF-1 and 2 pickled with formaldehyde.
Memcor pickled in Memclean solution.

9/28/98

0830-- Memcor and NF-2 on.

1300-- Added 12 gls/NaOH + 12 gls/water to caustic tank.

1200-- Zenon on @ 10.8 gpm - bleed left closed until tomorrow at 6:20.

9/29/98

0620-- Bleed opened to .54 gpm.

0845-0945-- Biweekly samples on Zenon, Memcor, NF-1 + 2. Cl2 and NH3 off for SDS sampling. Dupe=17.

1230-- Started monocl2 feed to NF-2 keeping 5-6 mg/l residual.

9/30/98

0830-1030-- Spore spiking Zenon, Memcor, and NF-1 + 2.

10/1/98

0710-- NF-1 suctin cl2 on NF-1 was out of cl2. Added 7.5 gls/NaOCL + 26 gls/water to cl2 tank. Added
4000 mls/NH4CL + 24 gls/water to NH3 tank.

1600-- Added bleed pump to Zenon.

1700-- Added 284 mls/AS to NF-1 + filled with permeate @ 7.8 gpm, 13.80 rate, 12.9 mls/gallon. 1.75 dose.
Also added 433 mls/AS to NF-2 + filled with permeate at 8.2 gpm, 11.2 rate, 23.8 mls/gallon.

10/2/98

0850-- Memcor membrane test = .2 psi loss from 2-4 minute time frame.

10/5/98

1000-- Memcor membrane test = .2 psi loss from 2-4 minute time frame.

1300-- Added 2640 mls/NH4CL + 21 gls/water to NH3 tank. Also added 5.5 gls/NaOCL + 22 gls/water to cl2 tank.

1445-- Found NF-2 off.

1500-- NF-2 on.

10/6/98

0830-- Added 271 mlsAS to NF-1 + 21 gls/permeate. Also added 430 mls/AS + 18 gls/permeate to NF-2 AS tank.

0900-- Delivery of alum arrived. Filled up three 55 gallon drums.

10/7/98

0830-- Added 12 gls/NaOH + 12 gls/tapwater to caustic tank (Zenon).

1045-- Zenon bleed changed to .22 gpm -- Alum dose 150% higher. Also Memcor flow down to 12 gpm.

10/8/98

0810-- Added 5 gls/NaOCL + 20 gls/tapwater to cl2 tank. Also added 2000 mls/NH4CL + 15 gls/water to NH3 tank.

0845-- Added 4 gls/PACL + 40 gls/tapwater to PACL tank for Memcor.

10/9/98

0730-- Alum out on Zenon - replaced barrel. Increased raw water pressure to see if alum will not pump down as
fast and overfeed. PACL had same problem.

1015-- pH in nanofilters down to 3.5 overnight per R.R.

1040-- Added 314 mls/AS + 15 gls/permeate to NF-1 AS tank assuming 7.8 gpm, 15.77 rate, 1.75 dose, 194 mls/AS
in tank already. Also added 151 mls/AS + 15 gls/permeate to NF-2 AS tank assuming 8.2 gpm, 15.77 rate, 2.5 dose,
and 357 mls/AS already in tank.

10/12/98

0830-0930-- Biweekly samples on NF-1 + 2, Zenon, and Memcor. Cl2 and NH3 off for SDS samples.

10/13/98

0730-- Cl2 feed hose was above cl2 level (4 gls. in tank). Refilled cl2 tank with 7.5 gls/NaOCL + 26 gls/water.
Also cut cl2 hose so hose sits on bottom. Also added 2500 mls/NH4CL + 18 gls/water to NH3 tank.

0840-- Added 50 gls/permeate 1.1# Dodecyl, 8.5#/tripolyphosphate, and adjusted pH with NaOH to 10.54.

1000-- Started cleaning solution through NF-2.

1000-- Memcor off and started cleaning with memclean.

1300-- Memcor on without PACL - Backwash set at 36 minutes.

1500-- NF-2 on.

1530-- TDS higher in permeates of NF-2.

10/14/98

0830-- Heating up 50 gls/permeate in cleaning tank. Added 17#tripolyphosphate + 6.6# of EDTA, and added about 1 liter of HCL to adjust pH to 7.86.

1030-- NF-1 off.

1045-- Started cl2 solution through NF-1.

1215-- Stopped NF-1 recirculation - letting soak.

1415-- Added 262 mls/AS + 23 gls/permeate to NF-1 AS tank assuming 147 mls/AS already in tank, 13.05 rate,
a 7.8 gpm flow, 1.75 dose. 13.7 mls/gallon. Also added 531 mls/AS + 20 gls/AS to NF-2 AS tank assuming 170 mls/AS
already in tank, 2.5 dose, 8.2 gpm, and 11.42 rate. 23 mls/gallon.

1420-- Started NF-1 recirculation again.

1450-- Stopped NF-1 recirculation.

1500-- Started NF-1 on Memcor water.

10/15/98

0750-- HPC samples collected on NF-2.

10/16/98

0945-- Replaced acid barrel with new barrel.

1015-- Added 5 gls/NaOCL + 20 gls/tapwater to cl2 barrel. Also added 2ltrs/NH4CL + 15 gls/water to NH3 tank.

10/17/98

0730-- All units off and pickled due to electrical shutdown.

1230-- All units back on.

10/20/98

0830-- Added 7.5 gls/NaOCL + 26 gls/tapwater to cl2 tank. Added 2000 mls/NH4CL + 15 gls/water to NH3 tank.

0845-- Lowered alum speed to 70 to decrease alum feed. Started feeding too high at 10 gpd. Was at about 5.5 gpd.
Hopefully lowering speed almost in half will correct feed rate.

1030-- Cl2 and NH3 off momentarily to check TDS in permeate of NF-2. TDS went to 40 in permeate.

1300-1730-- changed flows on NF-1 + 2 for TOC experiments.

10/22/98

0845-- Added 10 gls/NaOH + 10 gls/tapwater to NaOH tank.

1000-1020-- Zenon off due to raw water pump problems.

1100-- Switched out HCL barrel.

1230-- Took HPC samples on NF-2.

10/23/98

0845-- Added 355 mls/AS + 18 gls/permeate to NF-1 @ 22 mls/gal., 9.86 rate, 7.8 gpm, 1.75 dose. Also

added 899 mls/AS + 15 gls/permeate to NF-2 @ 8.2 gpm, 7.8 rate, 2.5 dose, and 34 mls/gal.

1000-- Added 5 gls/NaOCL + 20 gls/tapwater to cl2 barrel. Also added 2000 mls/NH4Cl + 15 gls/tapwater
to the NH3 tank.

1230-- Changed out Alum to new barrel.

1300-- Running Cl2 samples and quenching samples.

10/24/98

1100-- Replaced NF-2 acid pump head screw - HCL was leaking out on every stroke - pH came down in range.

10/26/98

0900-1000-- Biweekly samples on Raw, Zenon, Memcor, and NF-1 + 2. Dupe = 27.

1300-- Zenon down to 95% recovery - Up on alum to 3 milliequivilents.

1300-- Memcor at 12 gpm and PaCL on at 3 gpd.

10/27/98

0800-1000-- Spore spiking.

1045-- NF-1 + 2 off for permanent shutdown.