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October 16, 2007

Kenneth Flatt
Utilities Director
Dare County Regional Water System
600 S. Mustian Street
Kill Devil Hills, NC, 27948

Subject: **Final Report ~ RWS and Frisco Pilot Testing**

Dear Ken:

We are pleased to provide you with the subject final report. The changes and corrections resulting from staff review of the draft have been addressed.

As you know, the final task in this contract is the preparation of preliminary design reports (PDR) for both locations. This work has been started, and the draft PDR for RWS should be ready for staff review early in November.

Yours truly,

Ian C. Watson, PE
RosTek Associates, Inc.

cc:

File:06-012.

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DARE COUNTY, N. CAROLINA
REGIONAL WATER SYSTEM

NANOFILTRATION PILOT PROGRAM

RODANTHE-WAVES-SALVO WTP
SOUTH HATTERAS ISLAND WTP

FINAL REPORT

October 2007

Prepared by

ROSTEK ASSOCIATES, INC.
TAMPA, FLORIDA

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DARE COUNTY, N. CAROLINA REGIONAL WATER SYSTEM

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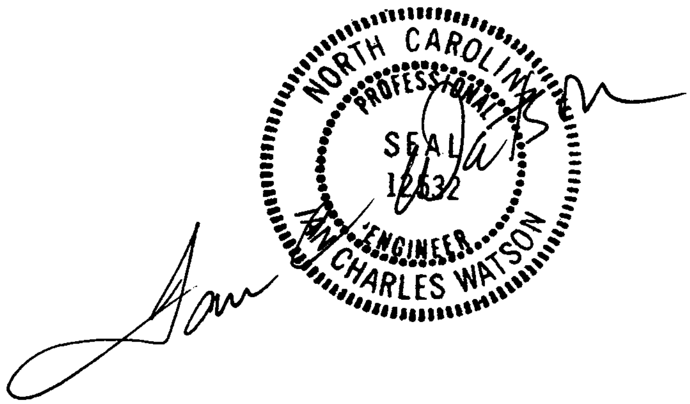
CERTIFICATION

The undersigned certifies that this report has been prepared by him, or under his direct supervision.



Ian C. Watson, PE

October 1, 2007
Date

12532
NC Registration #

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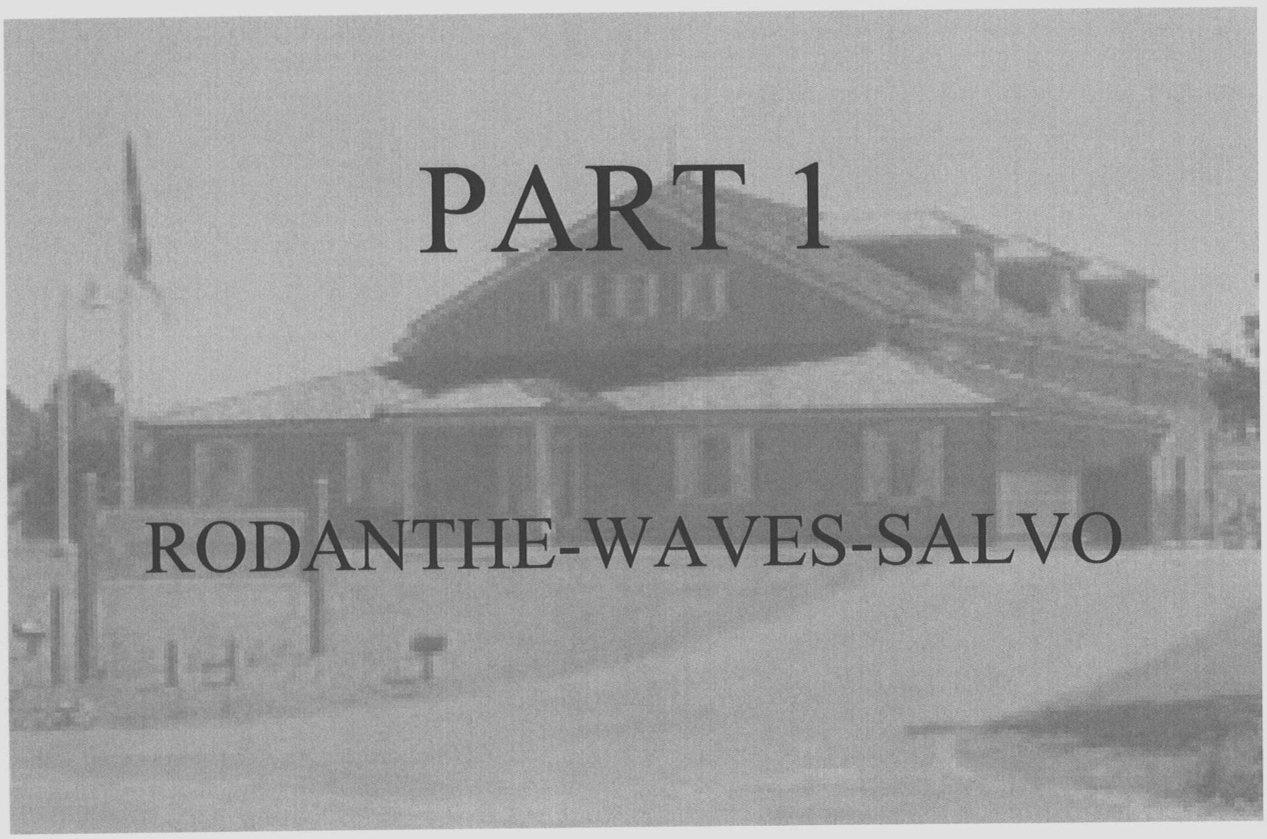


PART 1

RODANTHE-WAVES-SALVO

SECTION 1-1. INTRODUCTION.

The Dare County Regional Water System operates a 1.0 MGD reverse osmosis (RO) water treatment plant to serve the villages of Rodanthe, Waves and Salvo. The plant, located in Rodanthe on Highway 12, takes its feed water from two brackish wells, one located on the plant property, and the other located at the elevated water storage tank in Rodanthe. The average water quality data for these two wells are shown in Table 1.1 below.

Table 1.1. Average Feed Water Quality

Cations, mg/l		Anions, mg/l	
Calcium	12.0	Bicarbonate	598.3
Magnesium	18.3	Sulphate	12.9
Sodium	510.0	Chloride	515.8
Potassium	27.5	Fluoride	1.8
Strontium	NR	Nitrate	0.01
Barium	NR	Phosphate	0.25
Iron	0.06		
Manganese	0.03		
UV-254		0.210	
TDS, mg/l		1324.2	
Conductivity, μSms		2890	
Color, PCU		9.0	
TOC mg/l		6.9	
pH		7.8	
Temperature °C		18.8	
Silica, mg/l		15.3	

The RO plant consists of two trains, with provision for bypassing part of the wellwater to blend with the RO permeate. Currently this blend is limited because of the presence of a significant concentration of total organic carbon (TOC) in the feedwater. Although the RO treatment process removes virtually all of the TOC, the blended water must comply with state drinking water primary standards for trihalomethanes (THM) and haloacetic acids (HAA), both of which are formed by the chlorination of organic matter in the water. By removing the organic material in the blend water, the blend ratio could be increased, thus increasing the plant's capacity, and reducing the finished water production cost.

In 2007, the Rodanthe-Waves-Salvo plant (RWS) experienced a peak day demand of 711,000 GPD for the first time since the plant was commissioned. This triggered the state requirement for planning for plant expansion, which in turn led to the pilot plant program. If the testing could demonstrate reliable and effective TOC reduction to a very low level, together with some TDS reduction, the blend ratio could be increased sufficiently to raise the finished water production capacity to 1.2 MGD.

To demonstrate the technical feasibility of using "loose" NF membranes to remove TOC from the wellwater, and to develop design input for scale-up to full size, a pilot test program was designed for the RWS location. The protocol can be reviewed in Appendix A. Partway through the test, it became clear that the membrane selected, the Koch SR-2, would not provide sufficient organics rejection to satisfy the primary goal of the test program, which was to reduce the disinfection byproduct formation potential of the blend water. Since the membranes that had been planned for the testing at the Frisco sight, Koch's TFCS membrane, was on hand, it was decided that these would be loaded at RWS and be operated for the final ~ 800 hours of the test program.

This report tabulates the results of the test program, discusses the results of both the SR-2 and TFCS tests, and provides some very preliminary ideas for integration of these membranes into the existing RO system.

SECTION 1-2. PILOT PLANT SETUP.

The pilot plant was leased from Koch Membrane Systems. As delivered to the site at RWS, it was equipped with six four-element pressure vessels arranged in a 2:2:1:1 array. In order to simulate full scale arrangement as accurately as possible, the first and third stage vessels were loaded with three elements and a spacer, while the second and fourth stage vessels were loaded with four elements. This arrangement simulates a 2:1 array using seven-element vessels. Such a full scale array was anticipated from implementation and would permit permeate recovery up to 90% of the feedwater.

The initial membrane loading was done with the Koch SR-2 membrane. This membrane is designed as a loose nanofiltration membrane with sodium chloride (NaCl) rejection of 10-30%, but good rejection of organics with a molecular weight of >300-400, and divalent ions such as calcium, magnesium and sulphate. The membrane has a very high specific flux or ~0.6 gfd/psi net. It was anticipated that if this membrane exhibited the level of organics and dissolved mineral rejection needed to significantly increase the blend ratio, the high specific flux would permit full scale system to be designed using only well pressure to drive the system.

Since the pilot plant was equipped with both acid and scale inhibitor feed systems, an existing tap on the raw water line for the RO plant, located after of the chemical injection point, was used to supply feedwater to the pilot plant. The concentrate and permeate were combined after all flow, pressure and conductivity measuring devices, and discharged to the existing RO concentrate disposal piping.

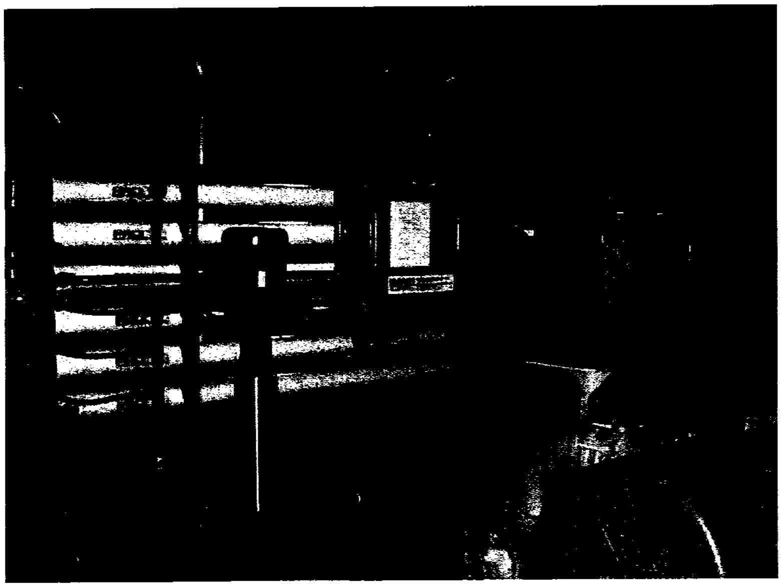


Figure 1-1. Pilot Plant Setup in the RWS Process Room.

SECTION 1-3. DISCUSSION OF RESULTS.

As stated previously, the primary goal of the RWS pilot test was to evaluate the potential for increasing the blend percentage by reducing the organics constituting trihalomethanes formation potential (THMFP) and haloacetic acid formation potential (HAAFP). The relatively high organic content of the RWS feedwater (9-10 mg/l typical) is the controlling factor which currently limits the blend ratio to less than 10%. Given the relatively low TDS of the raw water, absent the organics the blend ratio could be increased, thus increasing the plant capacity. If the TDS, particularly sodium chloride, is also reduced somewhat, increasing the blend ratio and plant capacity could be achieved without significantly changing the mineral quality of the water currently distributed to the three villages.

Tables 1-2 and 1-3 show the results of the pilot plant operation on permeate quality over a twelve week period. It is clear from the data covering the first nine weeks of operation of the pilot plant that the average organics removal by the SR-2 membrane was ~56%. (Table 1-2) This is confirmed by inspection of the UV-254 results.

However, changing the membrane to a much tighter NF membrane, Koch's TFCS, showed organics rejection of almost 90%, again confirmed by UV-254 results. The TOC concentrations can also be viewed graphically in Figure 1-2

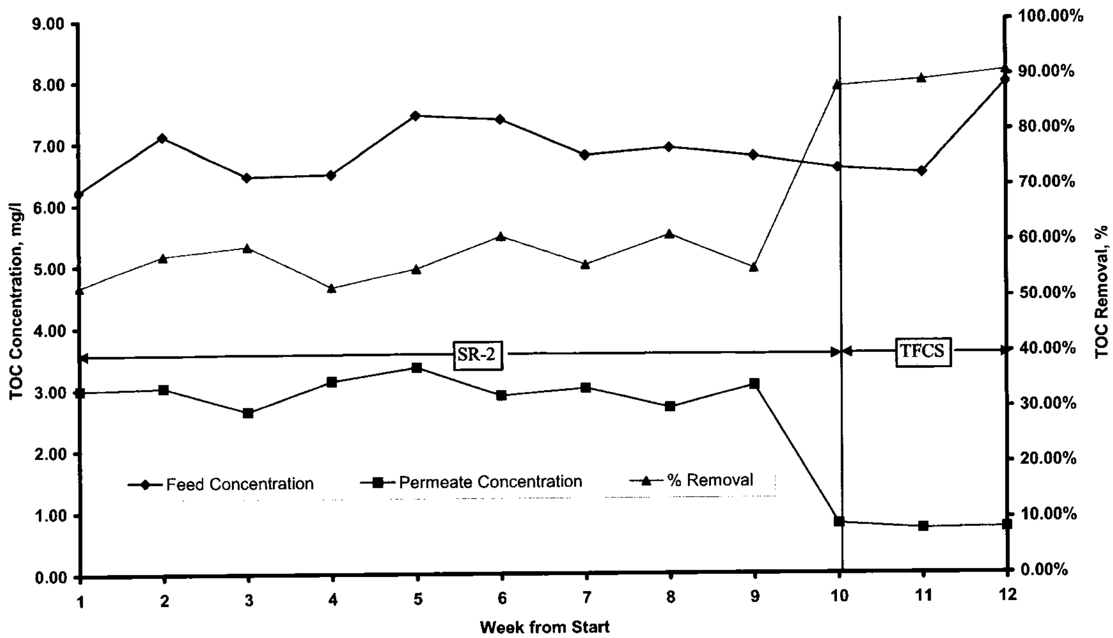


Figure 1-2. TOC Concentrations and Removal for SR-2 and TFCS

Table 1-2. Results of Analysis Performed by Outside Laboratory

Week	TOC (mg/L). From Frisco Lab			TOC Removal	HPC (CFU/mL) From NRO Lab	Silica, Total (From Envirochem)		Silica, Reactive (From Envirochem)		Barium (From Envirochem)	Strontium (From Envirochem)
	Feed	1st Stage	Permeate		Feed	Feed	Permeate	Feed	Permeate	Feed	Feed
1	6.22	3.79	2.99	51.93%	0.00						
2	7.12	3.67	3.03	57.44%	0.00			11.4mg/l	10.6mg/l	0.097mg/l	0.725mg/l
3	6.46	3.61	2.64	59.13%	0.00	SR-2 Membrane					
4	6.49	3.85	3.13	51.77%	0.00						
5	7.45	4.00	3.35	55.03%	0.00						
6	7.38	3.67	2.89	60.84%	0.00						
7	6.79	3.88	3.01	55.67%	0.00						
8	6.91	3.78	2.69	61.07%	0.00						
9	6.77	3.72	3.05	54.95%	0.00						
10	6.57	0.92	0.80	87.82%	0.00	TFCS Membrane					
11	6.49	0.81	0.72	88.98%	0.00						
12	7.97	1.01	0.74	90.73%	0.00						
Average	**6.84**	**3.77**	**2.98**	**56.52%**							
Max.	**7.45**	**4.00**	**3.35**	**55.03%**							
Min.	**6.22**	**3.61**	**2.64**	**57.56%**							
Average	**7.01**	**0.91**	**0.75**	**89.28%**							
Max.	**7.97**	**1.01**	**0.80**	**89.96%**							
Min.	**6.49**	**0.81**	**0.72**	**88.98%**							

Table 1-3. Results of Analysis Performed by County Laboratory

Week	T.H. mg/l as CaCO3		TDS		Alkalinity mg/l as CaCO3		Calcium		Magnesium		Fluoride		Chloride		Sodium		UV - 254		Iron (Total)		Sulfate		Phosphate		Potassium	
	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate
1	108	96	1330	1290	488	488	12.00	9.60	18.95	17.50	1.80	1.51	540	540	586	528	0.214	0.104	0.085	0.029	9.00	2.00	0.25	0.32	4.60	4.60
2	116	92	1290	1260	492	492	9.60	8.80	22.36	17.01	1.77	1.51	550	550	520	537	0.210	0.099	SR-2 Membrane							
3	96	94	1370	1330	496	444	10.40	9.60	17.01	17.01	1.56	1.33	520	520	528	487	0.217	0.097								
4	108	96	1340	1330	504	460	11.20	10.40	19.44	17.01	1.78	1.59	540	540	522	506	0.212	0.096								
5	106	96	1350	1320	504	460	10.40	9.60	19.44	17.50	1.75	1.50	540	540	521	504	0.214	0.093								
6	108	100	1410	1330	500	428	12.00	11.50	18.95	17.50	2.00	1.82	540	540	522	492	0.208	0.096								
7	88	80	1140	1100	492	460	12.80	9.60	13.60	13.60	1.91	1.70	420	420	449	449	0.206	0.095								
8	104	98	1330	1300	508	440	11.20	11.20	18.47	17.01	1.87	1.64	530	530	518	491	0.210	0.091								
9	110	98	1360	1310	512	428	11.20	9.60	19.93	17.98	1.69	1.50	530	530	502	460	0.202	0.094								
10	92	22	1190	380	464	76	10.40	1.60	16.04	4.37	1.94	0.59	440	180	454	137	0.199	0.010	TFCS Membrane							
11	106	14	1350	425	472	80	12.00	0.80	18.47	2.92	1.95	0.50	520	200	494	123	0.214	0.021								
12	96	16	1430	448	456	80	10.40	0.80	17.01	3.40	1.89	0.59	520	200	497	155	0.217	0.016	0.047	0.017	16.90	0.00	0.22	0.07	23.00	5.00
Average	105	94	1324	1069	500	456	11	10	19	13.57	1.79	1.57	523	523	519	495	0.21	0.096	0.085	0.029	9.00	2.00	0.25	0.32	4.60	4.60
Max.	116	100	1430	1330	512	492	13	12	22	17.98	2.00	1.82	550	550	586	537	0.22	0.104	0.085	0.029	9.00	2.00	0.25	0.32	4.60	4.60
Min.	88	80	1140	380	488	428	10	9	14	2.92	1.56	1.33	420	420	449	449	0.20	0.091	0.085	0.029	9.00	2.00	0.25	0.32	4.60	4.60
Average	98	17	1323	418	464	79	11	1	17	3.56	1.93	0.56	493	193	482	138	0.21	0.016	0.047	0.017	16.90	0.00	0.22	0.07	23.00	5.00
Max.	106	22	1430	448	472	80	12	2	18	4.37	1.95	0.59	520	200	497	155	0.22	0.021	0.047	0.017	16.90	0.00	0.22	0.07	23.00	5.00
Min.	92	14	1190	380	456	76	10	1	16	2.92	1.89	0.50	440	180	454	123	0.20	0.010	0.047	0.017	16.90	0.00	0.22	0.07	23.00	5.00

Table 1-3 also compares feed and permeate concentrations for the common inorganic ions. It will be noted that there is virtually no reduction in total dissolved solids with the SR-2 membrane, but the TFCS membrane (weeks 10 through 12) gave about 68% overall salt rejection. As expected, the rejection of divalent ions was high, and sodium and chloride rejection was low. TDS rejection for both membranes is displayed graphically in Figure 1-3.

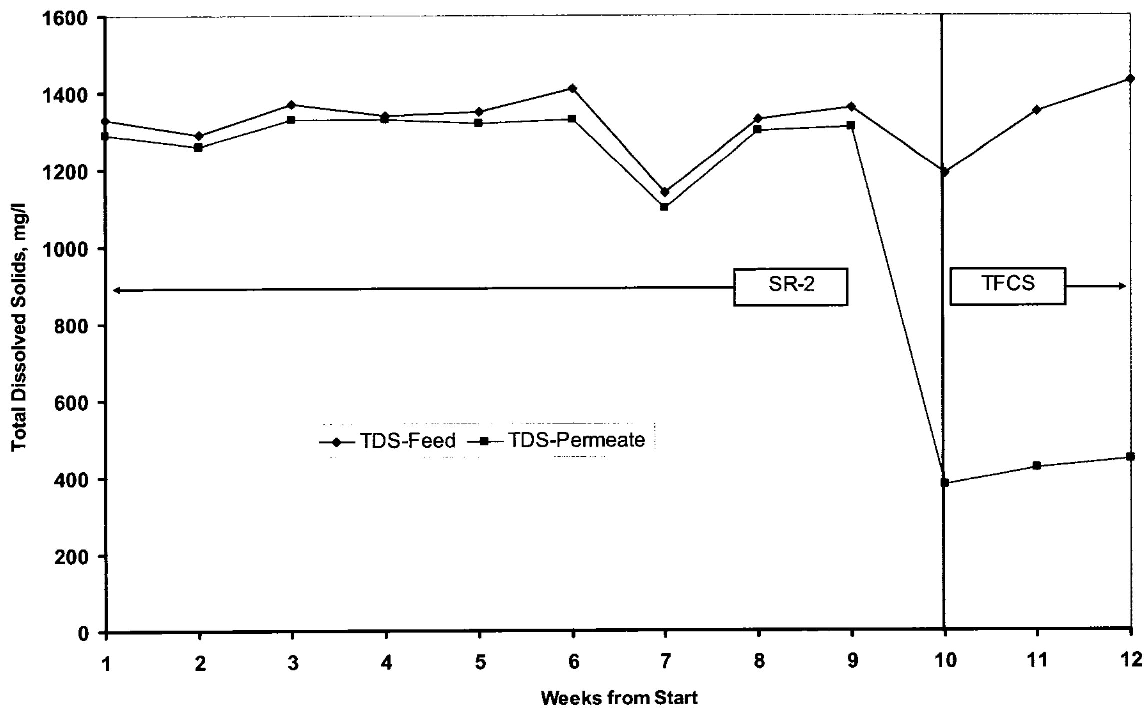


Figure 1-3. TDS rejection for SR-2 and TFCS Membranes

In terms of membrane process performance, both the SR-2 and TFCS membranes performed well. This was expected, since the RO plant operation at this site has historically been relatively trouble-free, particularly with respect to membrane fouling. Consequently fouling of the pilot test membranes was not expected, and did not occur.

Figure 1-4 shows the SR-2 flux during the test. At approximately 500 hours, the flux was increased, and remained stable for the remainder of the SR-2 test. The normalized flux shows some oscillation possibly due to normalization anomalies, connected with the apparent temperature variability, but the overall trend is flat.

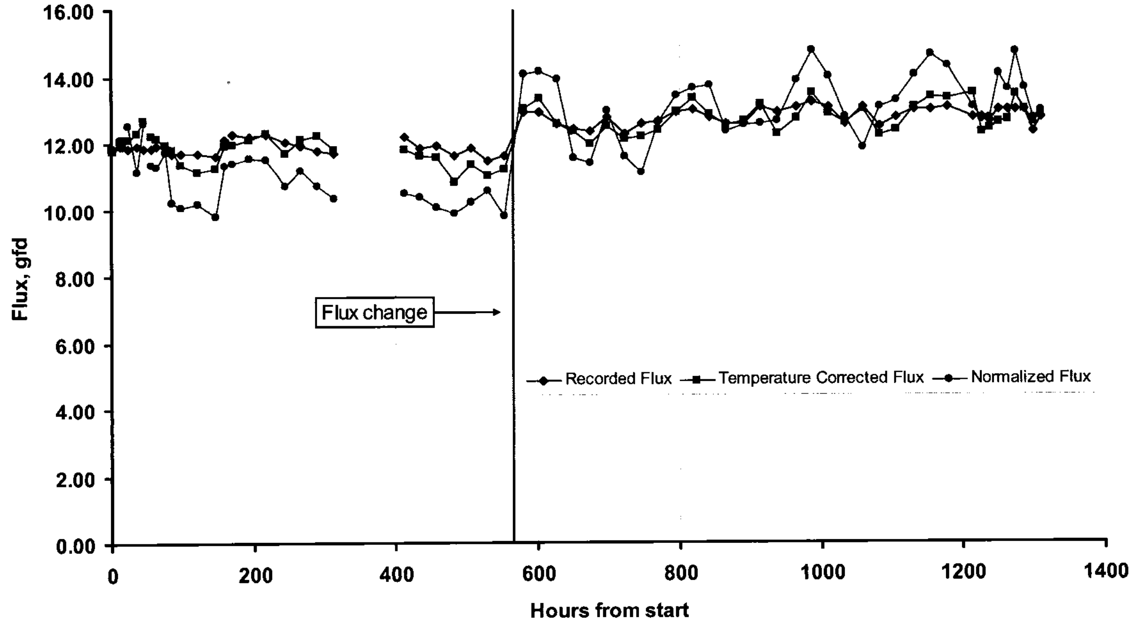


Figure 1-4. Fluxes. SR-2 Test

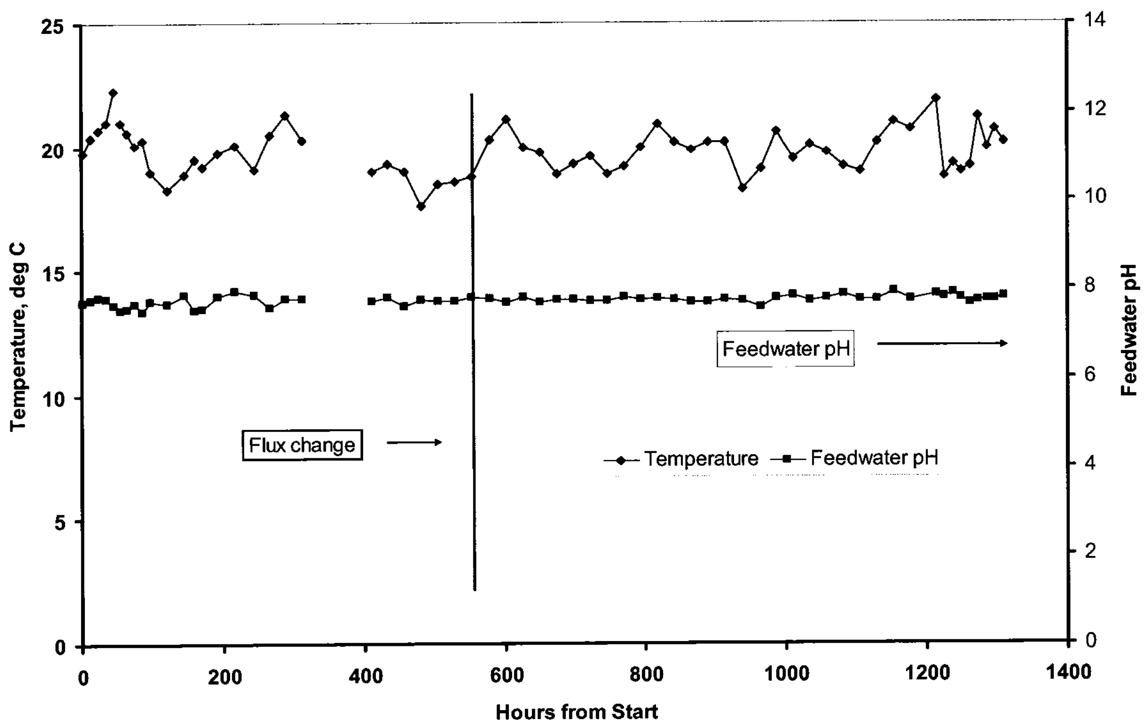


Figure 1-5. Temperature and pH. SR-2 Test

Figure 1-5 shows the temperature and pH during the test.

As mentioned earlier, the temperature showed some unexpected variability during the test. The pH remained stable at about 7.8, with only a small decrease from natural pH because of the small acid dose being applied to the feedwater. A decision not to increase the acid dose was made when it became apparent that the SR-2 membrane was exhibiting low TOC rejection, and additional sulphate ion was unlikely to improve the rejection of TOC. Therefore, the small acid dose and scale inhibitor was added during the SR-2 test, and also during the TFCS test, the latter because the good TOC rejection did not warrant the additional sulphate ion addition, and resultant TDS reduction.

Figure 1-6 shows the system pressure during the SR-2 test, together with the net pressure. The net pressure was calculated using the formula:

$$P_{NET} = P_{FEED} - (\pi_{AVE} + dP/2 + P_{PERM})$$

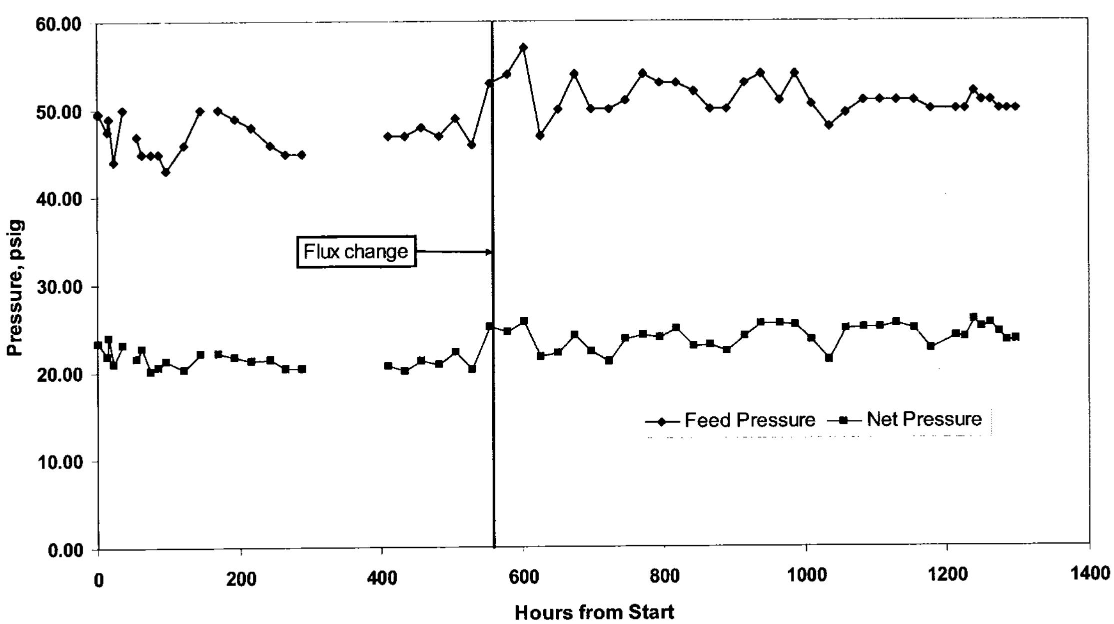


Figure 1-6. System and Net Driving Pressure, SR-2 Test

The assumptions made to calculate the osmotic pressure of the various flow streams are:

Feedwater	Conductivity to TDS	0.4620
	TDS to π	0.0105
Concentrate	Conductivity to TDS	0.4617
	TDS to π	0.011
Permeate	Conductivity to TDS	0.4621
	TDS to π	0.01

As with the flux data, it can be seen that both the feed pressure and the net pressure demonstrate a flat trend, indicating a stable membrane performance.

Figures 1-7 through 9- display graphically for the TFCS test the process data previously discussed for the SR-2 test. The raw data was normalized using the Koch software "NormPro", since the membrane type was listed in the data base of the software, whereas the SR-2 membrane was not listed.

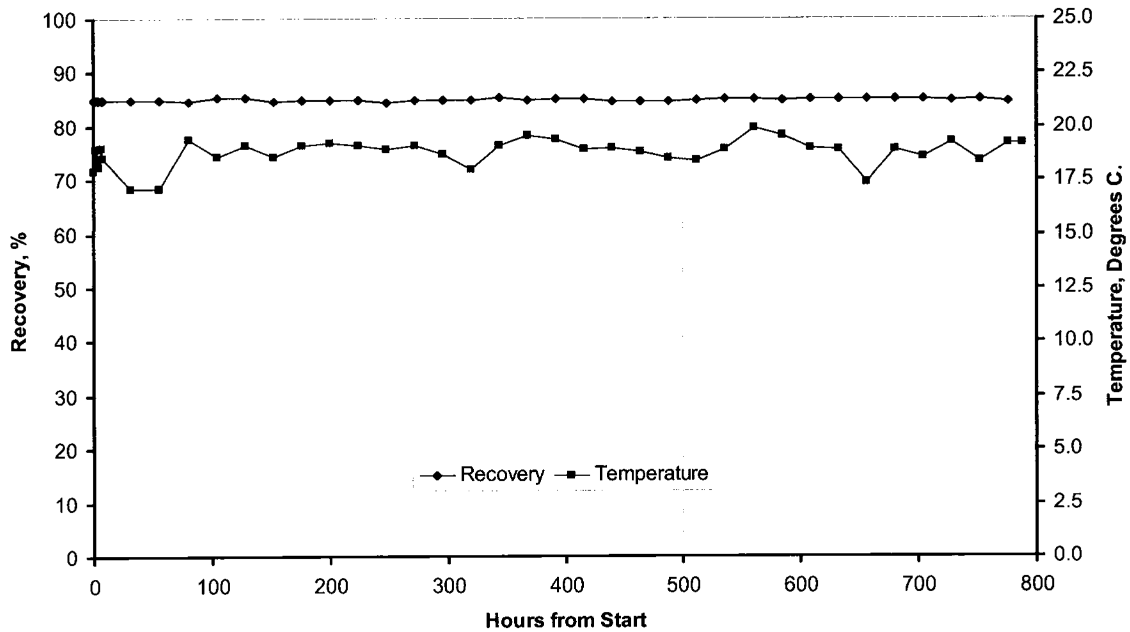


Figure 1-7. Temperature and Recovery, TFCS Test

As can be seen, the recovery during the test was held at 85%. This would be the minimum recovery to be incorporated into the design of a full scale RO plant addition, because of the need to conserve well water. As in the SR-2 test, the temperature still shows more variability than was expected from the operation of the RO plant. It is possible that this variability was connected somehow to the temperature change within the building, and its impact on the temperature of the water flowing in the PVC piping connecting the pilot to the raw water source. While this temperature variation may account for the oscillation in the normalized flux, it is expected that this will not impact the full scale design.

Figure 1-8 shows the system and normalized flux for the TFCS test. The system flux was held at a relatively high value for an NF membrane, but could be justified because of the very low fouling potential of the raw water. Once again as with the SR-2 test, the normalized flux demonstrates some oscillation.

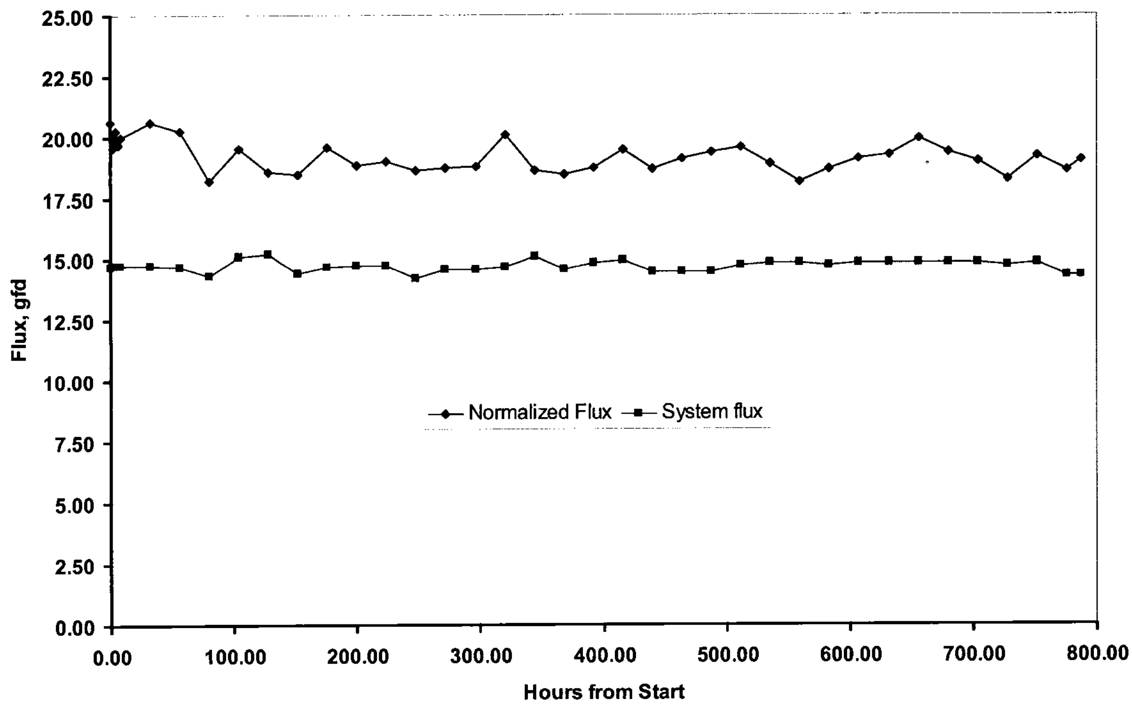


Figure 1-8. System and Normalized Flux, TFCS Test.

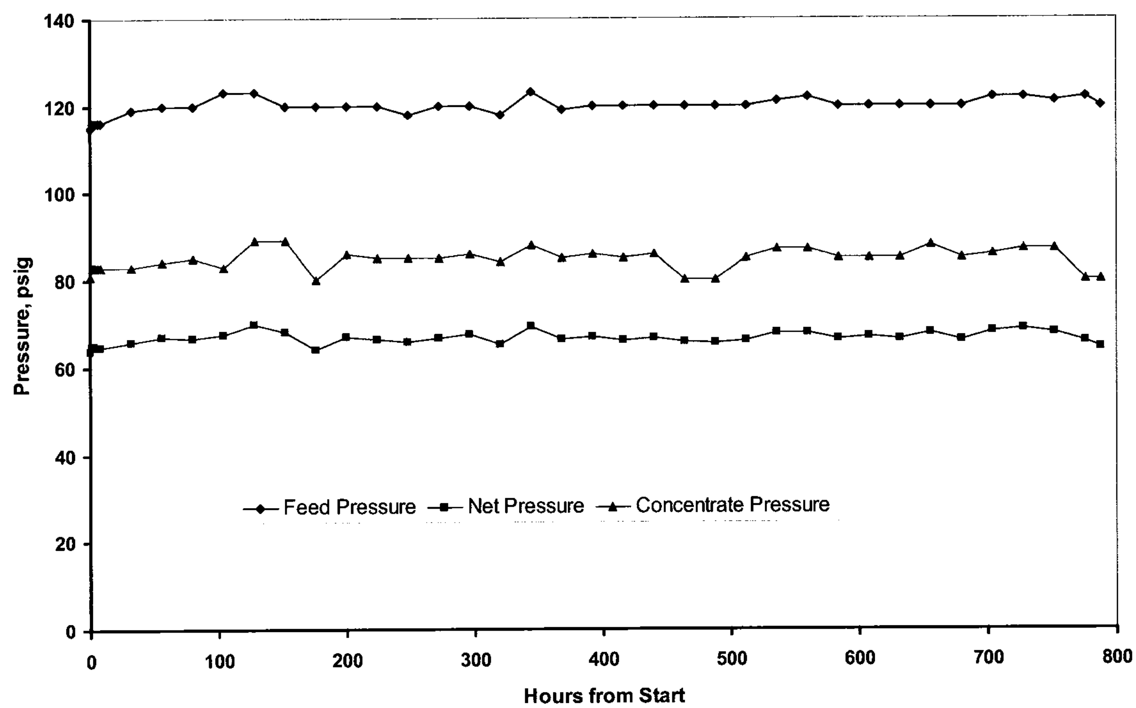


Figure 1-9. System and Net Pressures, TFCS Test.

Comparing Figure 1-6 with Figure 1-9, it can be seen that the feed pressure required to drive the TFCS membrane is more than twice that required for the SR-2 membrane, demonstrating both the lower specific flux, the impact of higher sodium chloride rejection, and the resultant higher average osmotic pressure in the system. From the net pressure plot, the same flat trend as the SR-2 can be seen, again reflecting the lack of fouling potential in this feedwater.

SECTION 1-4. CONCLUSIONS AND RECOMMENDATIONS.

From observation of the test results for the SR-2 membrane, it is clear that although there was some separation of the TOC, the average removal over the course of the test was only about fifty six percent, which is insufficient to significantly increase the potential blend ratio while maintaining the THMFP and HAAFP at or below the current primary standard. While there are other manufacturers who have similar products to the SR-2, it is believed that similar results would be obtained. In addition, there was virtually no TDS rejection with the SR-2 membrane, again impacting the potential for increasing the blend ratio. Therefore it must be concluded that installing a blend water membrane treatment system using the SR-2 or similar membrane is not a feasible option.

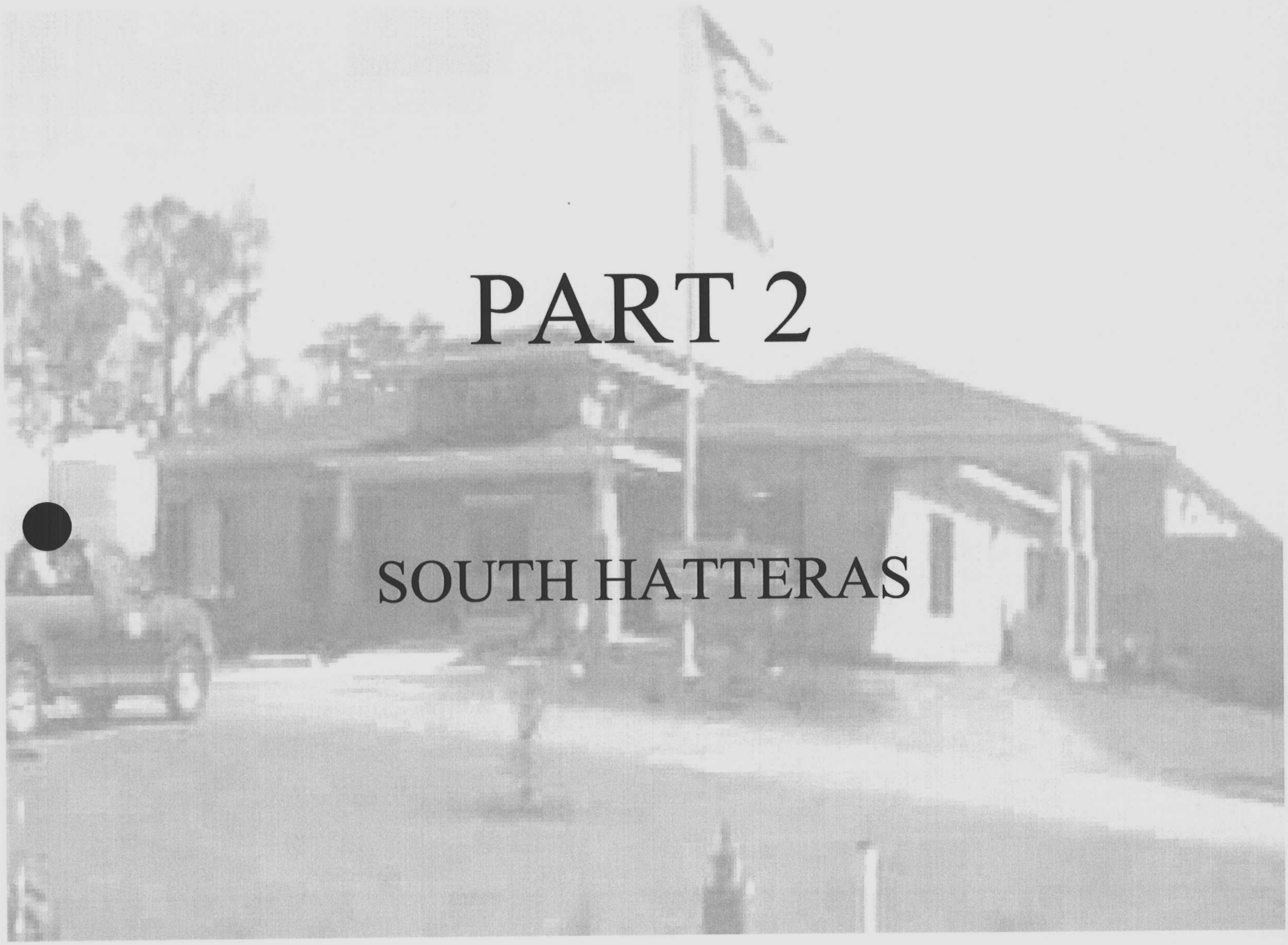
The TFCS membrane, however, provided very good TOC rejection, averaging almost 90%. In addition, this membrane, which is a fairly "tight" membrane compared to its competitors, exhibited reasonable overall TDS rejection compared to the SR-2, which would allow for a worthwhile increase in blend ratio without significantly changing the finished water quality which is currently produced at the RWS facility. The average feed TDS of 1323 mg/l was reduced to a permeate TDS of 418 mg/l, about a 70% reduction. Based on these results, it can be concluded that a blend water treatment system using the Koch TFCS, or similar membrane, is worthy of more detailed evaluation as a means of increasing the blend ratio, and the overall production capacity of the treatment plant.

Both membrane types performed well in terms of flux maintenance (Figures 1-4 and 1-8) with virtually no indication of fouling. Given the operating history of the main RO plant this was to be expected. Pressure requirements for the membranes were however quite different, the SR-2 requiring a considerably lower pressure than the TFCS, which is as expected given the higher rejecting capability of the TFCS membrane. The net driving pressure for the SR-2 was fairly constant at around 20 psi for the lower flux at the start of the test, and 25psi for the higher flux at the end. In comparison, the TFCS driving pressure was around 65-68 psi for the whole TFCS test, at an observed flux of 15 gfd.

The protocol that was used to establish the parameters of the membrane test program was modified to accommodate the actual conditions experienced during the test, including the on-site decision to test the TFCS membrane, originally planned for the South Hatteras test only. The TFCS test at Rodanthe was too short to make change of conditions worthwhile, but this test was run at a flux that is considered relatively high for nanofiltration membranes.

Based on these results, it is reasonable to assume that a full scale TFCS-type system to treat the blend water, given the constant temperature and stable raw water quality, would operate without significant flux decline due to fouling. It should also be noted that the TFCS system, because of the higher rejection of the TDS, would be subject to carbonate scaling. However, this was not observed during what was a fairly short test, indicating that the scale inhibitor used throughout was adequately controlling the scaling potential.

Based on the test results, it is recommended that the feasibility of using a nanofiltration membrane system to pretreat the blend water for both organics reduction and TDS reduction be studied as the second part of the RWS study, and that the low pressure SR-2 membrane type no longer be considered for implementation.



PART 2

SOUTH HATTERAS

SECTION 2-1. INTRODUCTION.

The Dare County Regional Water System operates a 1.4 MGD reverse osmosis (RO) water treatment plant and a 0.6 MGD shallow groundwater ion exchange (IX) and iron removal system to serve the south end of Hatteras Island, and the village of Avon. The plant, located in Frisco on Water Plant Road, takes its RO feed water from four brackish wells, and the feedwater for the IX/filtration system from 19 shallow wells located in an area to the east of the plant known as Buxton Woods. The pilot test that was conducted at this site focused only on treatment of the shallow groundwater. The average water quality data for these shallow wells are shown in Table 1.1 below.

Table 2.1. Average Feed Water Quality

Cations, mg/l		Anions, mg/l	
Calcium	70.0	Bicarbonate	148.0
Magnesium	26.8	Sulphate	<5.0
Sodium	93.0	Chloride	50.0
Potassium	36.0	Fluoride	0.38
Strontium	NR	Nitrate	0.01
Barium	NR	Phosphate	0.38
Iron	0.98		
Manganese	0.076		
TDS, mg/l		429.8	
Conductivity, μSms		684	
Color, PCU			
TOC mg/l		14.1	
pH		7.25	
Temperature °C		15.6	
Silica, mg/l		1.9	

Current plant operation consists of two RO trains, the permeate from which is blended with the treated shallow groundwater. The original design was planned for adding a third RO train, and increasing the capacity of the shallow groundwater treatment system to bring the build out capacity of the plant to 3.0 MGD. However, the brackish ground has risen in TDS, and additional well sites have proven difficult to find at the required locations. Consequently, the decision was made to explore the possibility of using the third RO train space in the plant for an alternate shallow groundwater treatment system, since it would be almost impossible to increase the capacity of the existing IX/filtration system to the 1.6 MGD needed for the buildout capacity. Since the RO plant produces permeate which is almost completely lacking calcium hardness and bicarbonate alkalinity, an alternate treatment system needs to preserve some of these two components so that the resulting blended finished water has the stability needed to be in compliance with the Lead and Copper Rule. The candidate process therefore is nanofiltration, which historically has been used, primarily in Florida but also in North Carolina, for the removal of TOC and for partial softening of reasonably hard waters. As can be seen from the table above the shallow groundwater is rich in TOC, and has a total hardness of about 285 mg/l, making it a good candidate water for treatment by nanofiltration.

Nanofiltration membranes are available in a fairly wide range of rejection capability for mono and divalent ions, and the true nanofilters all exhibit very good TOC rejection if the TOC consists of Natural Organic Material (NOM), basically humic and tannic acids typical of groundwater found in heavily vegetated areas, such as Buxton Woods. The objective of the South Hatteras pilot test was therefore to evaluate the rejection capability of a typical "tight" nanofiltration membrane, the Koch TFCS, and to determine the operating characteristics that are important for scale up to a full size train. Of particular interest in this test were flux maintenance and operating pressure.

SECTION 2-2. PILOT PLANT SETUP.

The pilot plant, leased from Koch Membrane Systems, was moved from the RWS site in March, 2007, and set up in the Frisco plant process room. Although the membranes had been changed to the TFCS type for the final few weeks at RWS, it was not necessary to clean the membranes prior to start up at Frisco. The membrane arrangement, simulating a 2:1 array using seven-element vessels, was not changed for the Frisco test, since it was anticipated that a recovery of 80-85%, typical for nanofiltration operations, would be feasible at this site. This array in full scale would permit permeate recovery up to 90% of the feedwater.

Figure 2-1. Frisco Pilot Setup, Showing Back of Unit

The test protocol developed for the Frisco pilot anticipated four segments, each scheduled for three weeks duration. Two tests were designed for natural pH, at flux rates of 13 and 14 gfd, and recoveries of 75% and 80%and two tests were to be conducted at lower pH, at flux rates of 14 and 15 gfd, and at 85% recovery.

The pilot plant was equipped with both acid and scale inhibitor feed systems. A tap on the existing shallow wellwater inlet piping supplied the raw water, and the tests were conducted using one well, so that feedwater variability was kept to a minimum. The concentrate and permeate were combined after all flow, pressure and conductivity measuring devices, and discharged to the existing RO concentrate disposal piping.

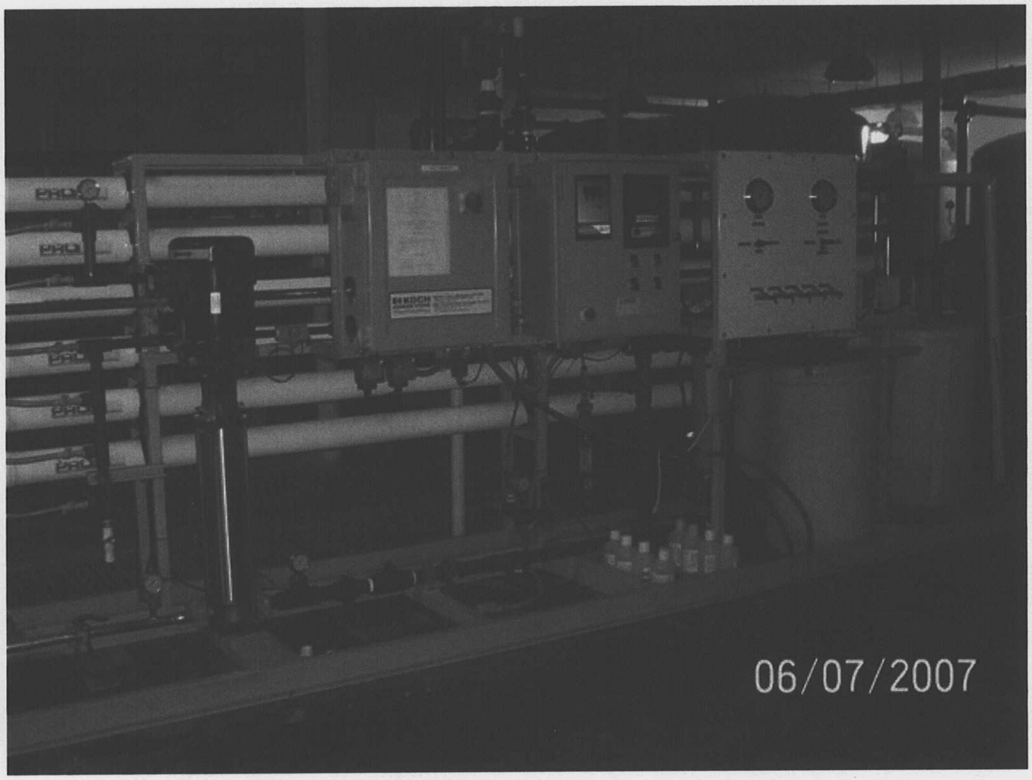


Figure 2-2. Frisco Pilot Setup, Showing Front of Unit

SECTION 2-3. DISCUSSION OF RESULTS.

As stated previously, the primary goals of the Frisco pilot test were to evaluate the feasibility of using nanofiltration (NF) membranes to treat the shallow groundwater for trihalomethanes formation potential (THMFP) and haloacetic acid formation potential (HAAFP), provide partial softening, and reduce iron and manganese. NF has been demonstrated to be a good process choice for this treatment scenario, but one aspect of its performance is that the rejection of iron is typically not as high as RO. This was to be evaluated during the test program. There was also some concern that the physical quality of the shallow wellwater, in terms of turbidity and Silt Density Index (measured as 2.1) may result in frequent cleanings. There was some discussion of the possible need to install a pre-filtration unit, but this was not done during the pilot test, and although as will be seen later there was some flux decline. A periodic flush with raw water at low flow and pressure seemed to be somewhat successful in controlling this flux decline.

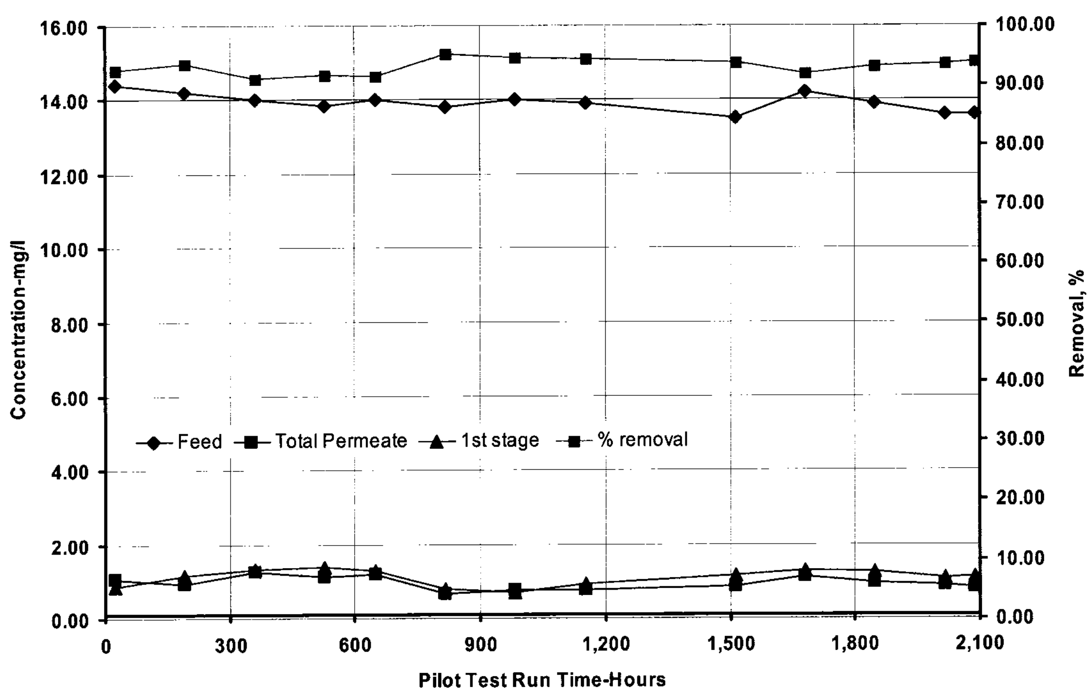


Figure 2-3. TOC Concentrations and Removal.

The TOC values can be seen graphically in Figure 2-3. It can be seen that there was very little difference in the TOC concentration of the permeate from the first stage, and the total permeate. This indicates that the average feed-brine concentration of the TOC may not be the mechanism that drives separation, but rather the sieving capability of the membrane. That is the membrane pore size will permit only a certain fraction of the

TOC to pass through, regardless of the average concentration on the "dirty" side of the membrane. This is different from the separation of ionized solutes, for which average feed-brine concentration determines the amount of passage through the membrane.

Table 2-2 shows the result of the pilot plant operation on permeate quality over the test period. Total run time was approximately 2,100 hours, almost thirteen weeks. It can be seen that the TOC rejection averaged better than 90%, and was reasonably consistent over the entire test period. The total hardness (TH) in the permeate was also very consistent, with an average rejection of approximately 80%. The TDS rejection was a little less, as would be expected, at about 73%.

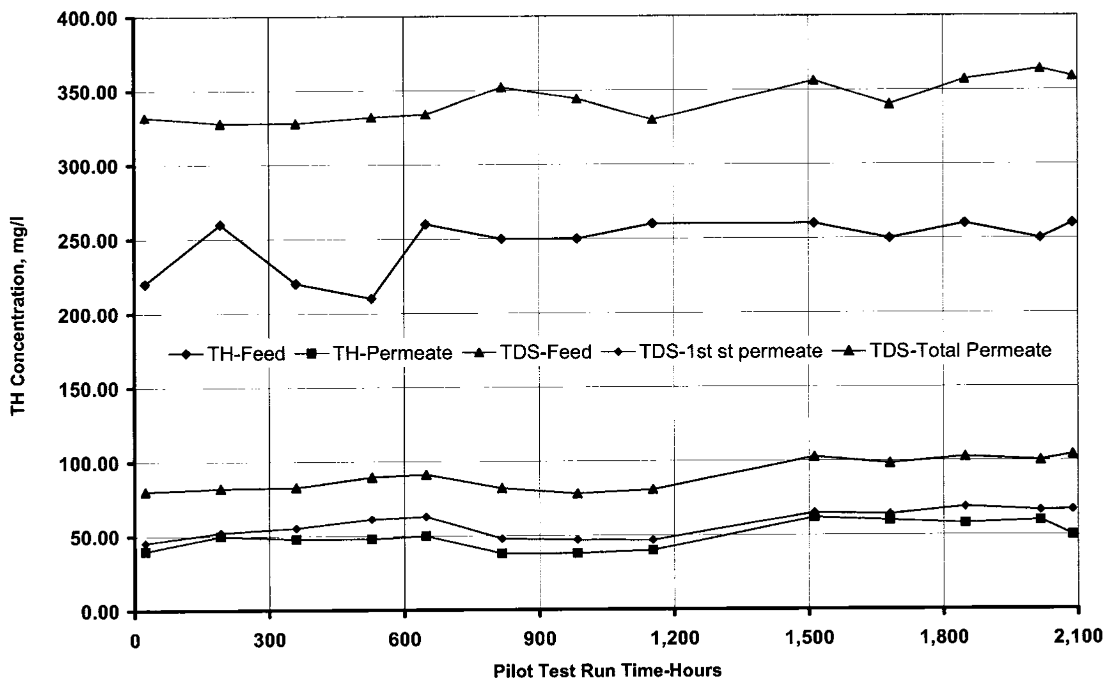


Figure 2-4. Total Hardness and TDS Reduction

It can be seen in Figure 2-4 that the TDS of the first stage permeate is about half the value of the total permeate TDS, confirming the earlier discussion about the different separation mechanisms for TOC and inorganic solutes.

Figure 2-5 shows the feed and permeate values for iron and manganese. These are significant results, since the concentration of these two metals varies considerably from well to well. It will be critical during preliminary design to pay particular attention to this variability, to make sure that the NF permeate has low enough concentrations of iron and manganese so that when blended with RO permeate and IX/filtered shallow groundwater, the secondary MCLs are not exceeded.

Table 2-2. Results of Analysis Performed by Dare County Laboratory (condensed to one/week)

DARE COUNTY CAPE HATTERAS WATER TREATMENT FACILITY
Report of Chemical Analysis for CHWP Pilot Project
In-House Lab

Date	Hours	Total Hardness (mg/l as CaCO3)		TDS			Chlorides			Iron			Manganese			TOC			% removal
		Feed	Permeate	Feed	1st Stage	Permeate	Feed	1st stage	Permeate	Feed	Permeate	% Removed	Feed	Permeate	% Removed	Feed	1s Stage	Permeate	Permeate
3/8/2007	24	220.00	40.00	332.00	45.70	80.10	50.00	15.00	20.00	0.78	0.08	89.74	0.059	0.005	91.53	14.40	0.865	1.07	92.60
3/15/2007	192	260.00	50.00	328.00	52.50	82.00	50.00	15.00	20.00	0.99	0.17	82.83	0.072	0.019	73.61	14.20	1.170	0.913	93.60
3/22/2007	360	220.00	48.00	328.00	55.30	82.90	40.00	10.00	20.00	1.01	0.18	82.18	0.068	0.005	92.65	14.00	1.320	1.270	91.00
3/29/2007	528	210.00	48.00	332.00	61.30	89.60	50.00	20.00	20.00	1.06	0.19	82.08	0.074	0.026	64.86	13.85	1.400	1.140	91.80
4/3/2007	648	260.00	50.00	334.00	63.00	91.40	50.00	20.00	25.00	1.07	0.22	79.44	0.078	0.027	65.38	14.00	1.280	1.190	91.50
4/11/200	816	250.00	38.00	352.00	48.10	82.10	60.00	20.00	25.00	1.01	0.16	84.16	0.060	0.008	86.67	13.80	0.786	0.663	95.20
4/18/2007	984	250.00	38.00	344.00	47.10	78.20	60.00	20.00	20.00	0.99	0.12	87.88	0.071	0.010	85.92	14.00	0.711	0.748	94.70
4/25/2007	1,152	260.00	40.00	330.00	46.90	80.90	50.00	20.00	20.00	1.16	0.15	87.07	0.069	0.008	88.41	13.90	0.916	0.769	94.50
5/10/2007	1,512	260.00	62.00	356.00	65.10	102.80	50.00	20.00	20.00	0.31	0.03	90.32	0.047	0.017	63.83	13.50	1.160	0.859	93.70
5/17/2007	1,680	250.00	60.00	340.00	64.10	98.40	50.00	20.00	20.00	1.11	0.18	83.78	0.061	0.020	67.21	14.20	1.280	1.140	92.00
5/24/2007	1,848	260.00	58.00	357.00	68.90	102.70	60.00	30.00	30.00	1.02	0.24	76.47	0.079	0.024	69.62	13.90	1.250	0.952	93.20
5/31/2007	2,016	250.00	60.00	364.00	66.60	100.50	60.00	30.00	30.00	0.48	0.08	83.33	0.060	0.012	80.00	13.60	1.090	0.897	93.50
6/3/2007	2,088	260.00	50.00	359.00	67.00	104.20	60.00	30.00	30.00	0.91	0.09	90.11	0.083	0.019	77.11	13.60	1.120	0.834	93.90
Average		**246.92**	**49.38**	**342.77**	**57.82**	**90.45**	**53.08**	**20.77**	**23.08**	**0.92**	**0.15**	**84.57**	**0.07**	**0.02**	**77.45**	**13.92**	**1.10**	**0.96**	**93.17**

Note: Data for 5-3-07 not included. TOC analyzer malfunctioned during this period

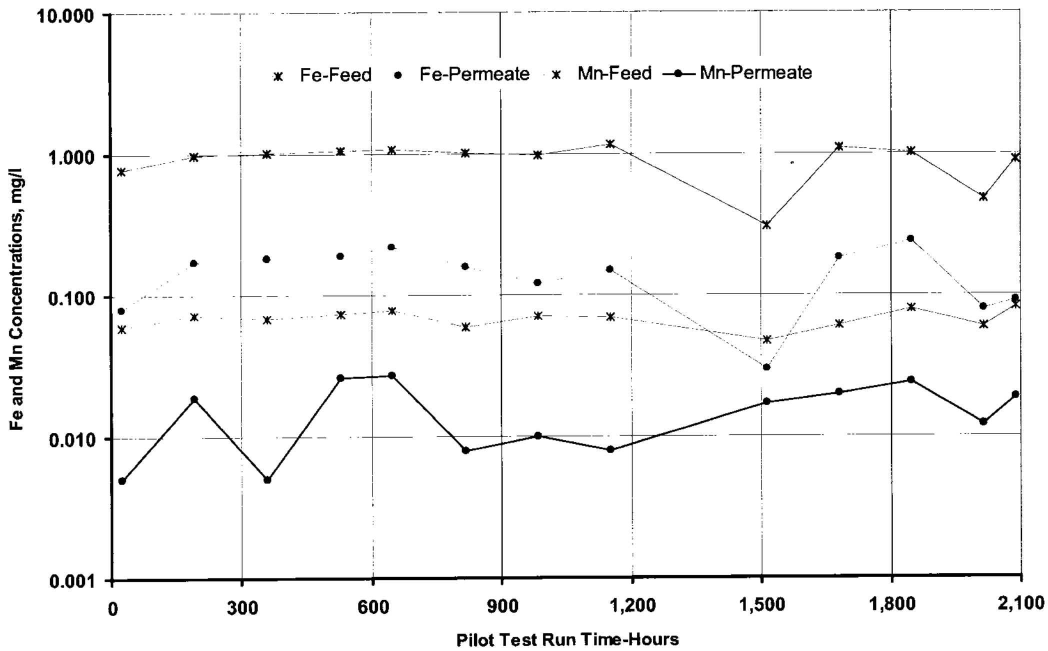


Figure 2-5. Iron and Manganese Feed and Permeate Concentrations

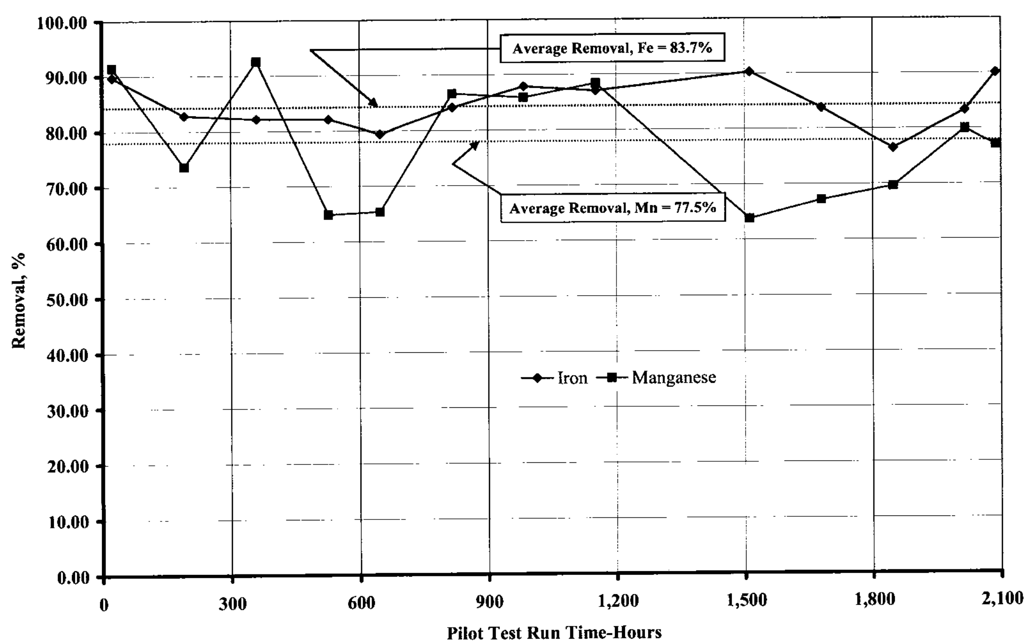


Figure 2-6. Iron and Manganese Removals

Figure 2-6 shows the removal percentages for iron and manganese. It can bee seen from this figure that there is some inconsistency, but generally the iron removal was slightly higher than that for manganese. The arithmetic average removal for iron was 83.7% and 77.5% for manganese.

From Table 2-2, it can be seen that the average chloride rejection is about 57%, which is a little higher than the 50% expected from earlier projections.

The performance of the pilot in terms of flux maintenance and pressure was normalized using NORMPRO®, the Koch software. Figure 2-7 shows the pressure performance. During the pilot the recovery was changed twice, from 85% to 80% and back to 85%. The observed flux was also changed during the pilot test.

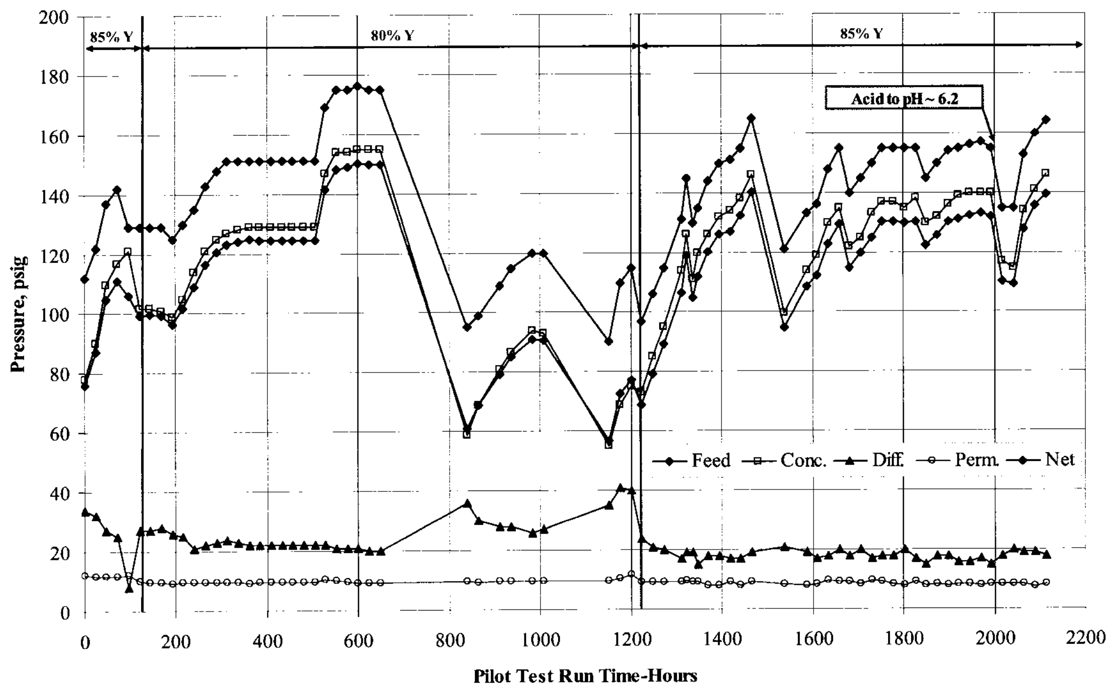


Figure 2-7. Pilot Plant Pressure Profiles

It can be seen in Figure 2-7 that the net driving pressure shows a considerable amount of change over the course of the test. Because the osmotic pressure of the shallow groundwater is very low, the net driving pressure consists primarily of the pressure required to compensate for friction losses in the membrane array, and the pressure required to operate at the selected flux. The fact that the net pressure shows a significant increase over the first six hundred or so hours of operation is a strong indication that some fouling and or scaling is taking place. However, when considering the differential pressure, there is little or no indication that a build-up of any kind of material is taking place within the membranes. At about six hundred hours, a flushing program was instituted, which showed an immediate reduction in net pressure. This flushing regime was continued for the rest of the test. In spite of the flush however, the net pressure again starts to increase when the recovery was increased back to 85% recovery at about twelve hundred hours. It is interesting that when a short test with feed acidification took place, the net pressure went down significantly, only to increase again when acidification was terminated. Given the high recovery, relatively low exit concentrate velocity, and the predominance of calcium and bicarbonate in the water, it can be hypothesized that there was some carbonate scaling taking place, partially controlled at 80% recovery by the combination of scale inhibitor addition, flushing, and higher concentrate exit velocity, but becoming more pronounced as the recovery increased and the concentrate velocity declined.

Figure 2-8 shows an increase in recorded feedwater temperature at about 1150 hours into the test. The reason for this is not known, but the ambient temperature was increasing during this time, and the higher temperature may have caused an increase in the water temperature from the shallow wells.

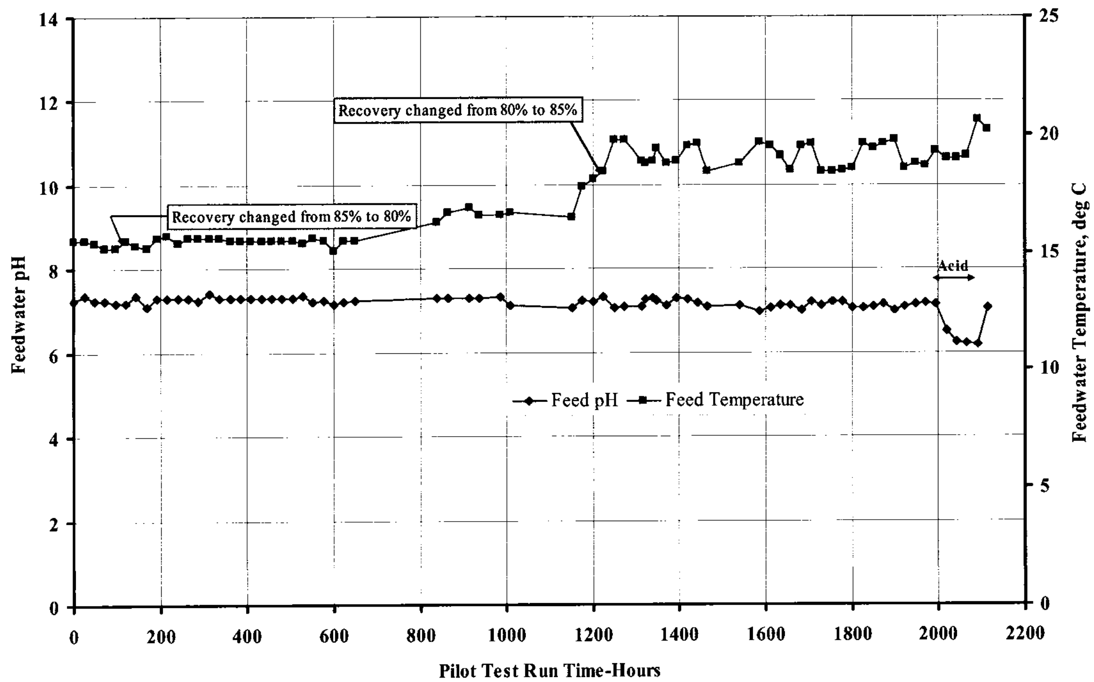


Figure 2-8. Temperature and pH.

As mentioned earlier, the temperature showed some unexpected variability during the test, averaging about 17 degrees C during the first part of the test, and about 19 degrees C during the second part of the test, with peaks of close to 20 degrees C. Why this change took place is unknown, but it is possible that with the increasing ambient temperature from the start to the conclusion of the test, sufficient heat gain took place within the building where the ductile iron piping is exposed to cause this increase. It is interesting to note that when looking at the temperature data and the pressure data (Figure 2-7) together, the feed pressure increased with increasing temperature, which is the opposite of what would be expected. This is further indication that some fouling or scaling was taking place in the membrane causing the pressure increase.

The pH remained stable for the bulk of the test run time, being adjusted with acid for a short run at the end. Again comparing the net pressure with the pH change, there is a distinct reduction in net pressure when the acidification started, and a return to a higher pressure when acidification was terminated. This is also an indication that possible carbonate scaling was occurring at the higher recovery.

Figure 2.9 shows the system flux profiles. The pilot was operated basically at two fluxes, 13gfd and 15gfd.

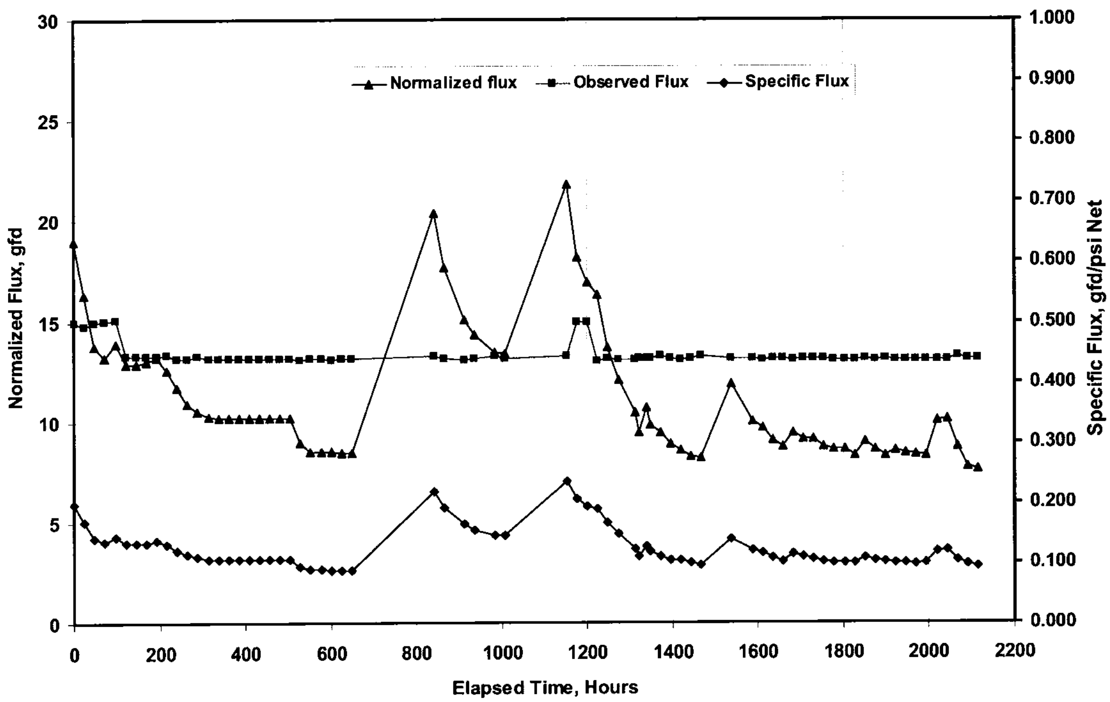


Figure 2-9. Flux Profiles

Comparison of the flux trends with the pressure trends shows definite correlation in the mid point of the test, where the pressure data show two distinct dips, and the flux data show two distinct peaks. This correlation cannot be explained by any normal operating event, although some of the pressure dip was undoubtedly caused by the flushing regime. If this data is ignored, however, both the specific flux, and the normalized flux demonstrate a slight decline in value over the course of the test period. If the pressure trend is compared to the flux profile, it would appear that the unit performed better at the lower flux, even though operation at 15 gfd was limited only to a few days.

SECTION 2-4. CONCLUSIONS AND RECOMMENDATIONS.

From observation of the test results for the TFCS membrane, membrane provided very good TOC rejection, averaging over 90%, slightly better than the results at RWS. In addition, this membrane, which is a fairly "tight" membrane compared to its competitors, exhibited reasonably high overall hardness and TDS rejection. The average feed TDS of 350 mg/l was reduced to a permeate TDS of 90-100 mg/l, about a 70% reduction. This is very comparable to the RWS result for TDS rejection, even though the water composition is quite different. Based on these results, it can be concluded that a shallow groundwater treatment system using the Koch TFCS or similar membrane, is capable of producing a permeate that can be easily blended with the RO permeate, and IX/filtered water to produce an acceptable finished water quality.

There was a significant flux decline during the course of the pilot test. Whether or not this was caused by fouling by the organics, partially oxidized iron and manganese, carbonate scaling, or a combination of circumstances could not be determined. What can be deduced from the test data is that acidification reversed the flux decline for the short period that it was in effect. It is also reasonable to assume that at least part of the fouling/scaling problems experienced in this test were due to the extremely low concentrate flows that were prevalent throughout the test.

The protocol that was used to establish the parameters of the membrane test program was modified to accommodate the actual conditions experienced during the test. Acid was used at this site for only a short period of time, so its influence on the performance of the membranes could not be fully evaluated. However, it appeared from the data recorded that the addition of acid had a fairly significant effect on the rate of flux decline, which is a fact that must be considered during full-scale design.

Based on these results, it is reasonable to assume that for a full scale nanofiltration system to treat the shallow groundwater water, a design based on lower flux, higher concentrate exit velocity, and acidification would operate satisfactorily at 85% recovery. Prefiltration may very well improve the cleaning frequency, but since testing was not possible during the nanofiltration pilot test, this cannot be stated with certainty.

Based on the test results, it is recommended that the feasibility of using a nanofiltration membrane system to treat the shallow groundwater from the Buxton Woods wellfield for both organics reduction and hardness reduction be studied as the second part of the South Hatteras study. The design will be based on 85% recovery and an average flux of 12 gfd.

It is also strongly recommended that the filtration system discussed earlier in this program, but not implemented during the pilot test, be acquired and tested, with particular emphasis on turbidity, iron, manganese and SDI reduction.

APPENDIX A

PILOT PLANT PROTOCOL

DARE COUNTY REGIONAL WATER SYSTEM

COUNTY OF DARE, NORTH CAROLINA

RWS AND SOUTH HATTERAS WTPs

Nanofiltration (NF) Pilot Test Plan and Protocol

August 25, 2006

Prepared by

ROSTEK ASSOCIATES, INC.

TAMPA, FLORIDA.

DARE COUNTY REGIONAL WATER SYSTEM
COUNTY OF DARE, NORTH CAROLINA

RWS AND SOUTH HATTERAS WTPs

Nanofiltration (NF) Pilot Test Plan and Protocol

CERTIFICATION

I hereby certify that this Document has been prepared by me, or under my direct supervision, for the County of Dare Water Department

Signed and Sealed this 19th day of September, 2006

by: ____________________

Ian C. Watson, PE

NC License #12532
Expires December 31st, 2006

RWS AND SOUTH HATTERAS WTPs

Nanofiltration (NF) Pilot Test Plan and Protocol

TABLE OF CONTENTS

1.0 Introduction

A Nanofiltration (NF) Pilot Study at the RWS and Frisco Water Treatment Plants (WTPs) will be conducted to evaluate the NF process for increasing the capacity of the two existing water treatment plants, while minimizing the cost of infrastructure improvements associated with expansion. The results of the pilot study, if applicable, will contribute to establishing the NF system operating parameters, configuration and criteria to be used for the design of plant modifications at both locations.

NF has traditionally been used to remove the dissolved salts that cause hardness in water, and for the reduction/removal of the organic precursors of trihalomethanes (THMs) and halo-acetic acids (HAAs) from groundwater. NF has been extensively applied to shallow ground waters in the state of Florida for this purpose, with good success. The largest membrane plant in Florida, located at Boca Raton, is of this type and has a capacity of 40.0 MGD.

The RWS pilot testing is being conducted primarily for organics removal from the blend water. The volume of raw water that can currently be blended with RO permeate is limited by the resultant THM and HAA formation potential in the blended finished water. By reducing the organics from the blend water prior to blending and chlorination, the blend volume can be increased significantly. Preliminary calculations indicate that the capacity of the existing plant can be increased from the current 1.0 MGD to about 1.2 MGD with this modification.

The Frisco pilot test will be conducted to demonstrate the feasibility of using NF with the shallow groundwater currently treated by ion exchange and filtration for softening and organics removal. If successful, it has been proposed that a 0.7 MGD train be installed adjacent to the two existing RO trains, in parallel with the existing shallow well treatment system. The finished water will then be a blend of RO and NF permeate, and the treated shallow groundwater.

Pilot testing will be conducted for approximately 90 days each at location. The RWS plant currently receives low TDS brackish water, rich in sodium bicarbonate, form two existing wells. The Frisco plant receives shallow groundwater from nineteen existing wells, is high in total hardness, and contains varying amounts of iron and TOC.

This Test Plan summarizes the pilot test program, including testing objectives, description of the test unit and the two different membrane types that will be tested, the Koch Membrane Systems SR-2 at RWS, and the Koch Membrane Systems TFCS at Frisco, an outline of the program sequence, and the sampling and monitoring plan.

2.0 Study Objectives

The objectives for the pilot study include the following:

- Achieve the treatment goals established for the RWS and Frisco sites.
- Combine blend water treatment and the alternatives for increasing the capacity of the existing RO trains at the RWS WTP,
- Accumulate data for use in developing design and operating parameters for full-scale expansion of the Frisco WTP.

2.1 Source Water Quality

The pilot systems will be supplied with well water from existing wells. The incoming feedwater piping will be tapped at a convenient location at both locations. The water quality from these wells based on a recent analysis is summarized in Table 1.

Table 1. Source Water Quality

Parameters	RWS	S. Hatteras
Alkalinity (mg/L as $CaCO_3$)	350	320
Bicarbonate, mg/l	427	390
Barium (mg/L)		
Calcium (mg/L)	9.6	70
Chloride (mg/L)	460	70
Conductivity (mhos/cm)	4230	728
Copper (mg/L)	<0.07	<0.07
Fluoride (mg/L)	1.88	0.4
Iron (mg/L)	0.06	0.44
Manganese (mg/l)	0.3	0.08
Magnesium (mg/L)	21.4	26.8
Phosphate (mg/L)	0.5	0.4
Potassium (mg/L)	27.5	36
Silica (mg/L)	15.3	1.9
Sodium (mg/L)	269	186
Strontium (mg/L)		
Sulfate (mg/L)	5.7	1.0
Sulfide (mg/L as H_2S)	0	0
Color	9	42
TDS (mg/l)	2540	420
pH (s.u.)	7.3	7.2
Temperature (^oF)	70	70
Hardness (mg/l, as CaCO3)	112	290
Turbidity, NTU	0.44	0.23

Water quality sampling performed during the pilot testing will be used to enhance this data and fill any data gaps required for establishing design criteria in the Preliminary Design Report (PDR).

2.2 Operational Parameters

The target operational parameters for this study are:

1. RWS. TOC removal, membrane flux rate and system recovery. The primary purpose of this pilot program is to reduce/remove the TOC in the blend water, so that the blend ratio can be increased without violating the Drinking Water Standard for THMs and HAAs. The tset will also examine flux rate and the potential impacts to treatment performance and potential limitations on other process components. In addition to flux, the test will examine recovery, so that the best solution is found for full scale design in terms of minimizing discharges without compromising permeate quality.

2. Hatteras. The main objective of the Hatteras pilot is to examine hardness, TOC, and iron rejection. In addition, the testing will examine flux rates for the purpose of minimizing membrane surface area while minimizing potential iron fouling. Since the feed water is coming from a limited resource, it is in the best interests of the test to establish the maximum safe recovery.

The goal of this pilot study is to produce a set of operating conditions that will economically and reliably produce a potable drinking water that meets all current and future drinking water regulations, and to establish the guidelines for full scale design of the two plant expansions.

3.0 Pilot Plant Treatment Process and Equipment Description

NF pilot test systems will be leased from Koch Membrane Systems (Wilmington, MA) and temporarily installed first at the RWS site, and then moved to the Frisco site. The NF pilots will be evaluated using unchlorinated well water, supplied as a composite of water from existing wells. Since the units will be drawing feed water from the two existing feed water systems, it is anticipated that the pilot operation will not be continuous, particularly at the RWS site. However, it would be advantageous for the pilot units to operate as consistently as possible. Therefore it is suggested that the pilot testing and the normal plant operation be integrated as much as possible to provide the maximum run time hours without causing undue inconvenience to the two plants' operating staff. It is suggested that prior to starting the test, a schedule of operation be worked out which will both meet the water production necessary to meet demand, and provide the best possible operating window for the pilots.

3.1 NF Membrane Treatment

The NF pilot system will be operated as a two-stage system. Concentrate recycle is not installed on the leased units. Recovery will therefore be limited to about 80% maximum. The County may wish to consider piping a recycle system, so that higher recovery can be examined. Initial operation at both test sites will be 75%. The pilot unit is equipped with interstage boost pumping capability, which can be bypassed if desired. A boost pressure protocol will be developed for each site when installation and startup occurs.

Each pilot system consists of a high pressure pump feeding an array of four-inch diameter pressure vessels. Each vessel is capable of holding three, four-inch diameter elements. Each pilot system will comprise of 18, 4-inch diameter, 40-inch long (4040) spiral-wound NF elements. The NF pilot systems are configured to a 2-2-1-1 tapered array system as shown in the attached P&ID. There will be 12 elements in Stage 1 and 6 elements in stage 2. The NF elements will be thin-film composite, polyamide membranes as described previously. The tapered, two-stage NF pilots systems will allow recoveries up to 80% without concentrate recycle.

Concentrate flow can be manually adjusted to maintain a flow set point (and recovery set point) using the concentrate control valve. Permeate flow is manually adjusted to a set point by adjusting the feedwater valve.

The NF feed water flow range for each pilot system will be in the range of 15 to 20 gpm The NF permeate and NF brine will be combined and discharged. The actual disposition of the waste water is to be determined.

The NF pilot system will be equipped will sample taps to sample NF feed, interstage, permeate and concentrate streams. Field measurements will be recorded to asses the performance of the pilot system during operation (discussed in Section 5.0 below). For example, pressure gauges will be available to measure headloss across the NF membranes. When the headloss becomes excessive, the NF productivity would decline, necessitating cleaning of the membranes. The NF pilot system is supplied with a cleaning skid to clean the NF membranes if and when that becomes necessary.

The pilot unit P&ID is attached for reference.

3.2 NF Pretreatment

Pretreatment will consist of pH adjustment (optional), scale inhibitor addition and cartridge filtration.

The NF feed water will be filtered using 5 μm cartridge filters. The cartridge filters will remove fine particles that may foul the NF membranes. The NF pilot systems will have the ability to add acid (sulfuric acid) and scale inhibitor. The addition of acid and antiscalant to the NF feed water assists in controlling membrane scaling from sparingly soluble salts (e.g. calcium carbonate, strontium sulfate)

Scale inhibitor and acid addition points are located upstream of the cartridge filter. Scale inhibitor addition equipment will include a day tank and chemical metering pump. Dose adjustment will be manual as the NF operation is continuous and will be maintained to flow set points. The initial dose is anticipated to be 3 mg/l.

4.0 Pilot Test Program

The pilot testing program is designed to facilitate the test objectives as specified in Section 2.0.

4.1 Operating Plan

Two types of NF membranes will be evaluated for permeate water quality and feed pressure at the two sites. At RWS, the membrane will be Koch Membrane Systems SR-2 membrane, designed for high organics rejection but fairly low inorganics rejection. At the Frisco site, the membrane will be Koch Membrane Systems TFCS membrane, which has good organics rejection, and somewhat higher inorganics rejection than the SR-2 membrane.

During the pilot test two flux rates and two recovery rates will be evaluated for each pilot system.

The baseline condition during the pilot testing will be established using a flux of 13 GFD, a permeate recovery of 75%, no pH adjustment of the NF feedwater, and an antiscalant dose of 3 mg/L. Other combinations of conditions will be tested during the program.

NF Operating Ranges

	RWS	**Frisco**
Membrane Element Model	SR-2	TFCS
Total quantity of elements	21	21
Array Staging (ratio of vessels in each stage)	2:2:1:1	2:2:1:1
Nominal Membrane Area (ft^2)	80	80
Permeate Flow Range (gpm)	15-17	
Flux (GFD)	13-16	
NF Recovery	75-80	
NF Feed Water pH	7.3 to 6.8	7.3-6.5
SI Dose (mg/l)	1-3	

Once the system has shown a stable performance at the baseline condition, the flux and recovery rates will be modified to evaluate optimal system performance. Four combinations of flux and recovery rates will be evaluated over the duration of the pilot testing. The pilot system will be run in a constant flux and variable pressure mode for a minimum of two weeks before altering the flux and recovery combination. The two charts following identify the ranges of operating parameters that will be evaluated during the pilot testing and the preliminary schedule for modifying the operating parameters.

NF Operating Parameters

	RWS	Frisco	Duration	pH Adj.
Membrane Element Model	SR-2	TFCS		
Initial: Flux (GFD) / NF Recovery (%)	13/75		3-weeks	No pH Adjustment
Step 1: Flux (GFD) / NF Recovery (%)	14/80		3 weeks	No pH Adjustment
Step 2: Flux (GFD) / NF Recovery (%)	14/85		3 weeks	pH 6.8
Step 3: Flux (GFD) / NF Recovery (%)	15/85		3 weeks	pH 6.5

Particularly at the Frisco site, iron fouling of the membranes is possible. At both sites, monitoring the headloss across the NF membranes will be a critical operator function to indicate if a membrane cleaning is necessary. The NF membranes will be cleaned when one of the following conditions occur:

- Differential pressure (feed pressure minus reject pressure) increases from start-up values by 15-20%, per stage.
- Normalized permeate flow decreases by 15-20%, or feed pressure increases by 15-20%.

The NF membrane cleaning could involve the following steps

- Recirculate 2% citric acid solution of pH 4 for 2 hours. This low pH cleaning will remove iron and some inorganic scale present on the NF membranes.
- Flush water through the NF system until the cleaning solution is completely flushed out.
- Re-circulate 0.1% caustic solution of pH 11.5 for 2 hours. This high pH cleaning solution will remove organic foulants, colloidal and biological materials.
- Flush water through the NF system until the cleaning solution is completely flushed out.

Also, when the headloss across the cartridge filters reaches 15 psi greater than the clean condition, the cartridge filters will be replaced with new filters

At the engineer's discretion the NF membrane may be replaced by an alternate NF membrane.

A daily operating log will be maintained for the duration of the pilot study. An operating log book will be kept on site at both locations to document any changes made to the pilot units and/or unexpected circumstances (pilot unit shut down/restart).

Start-up data has been derived for each site based upon projections made with Koch Membrane Systems software, "ROPRO". This is contained in the following table:

Predicted Start-up Conditions

Parameter	RWS				Frisco			
Test No.	1	2	3	4	1	2	3	3
Flux, gfd	13	14	14	15	13	14	14	15
Recovery, %	75	80	85	85	75	80	85	85
Feed P, psig	40-50				95	99	99	103
Permeate P, psig	12				10			
Concentrate P, psig	25-30				54	62	68	70
Feed Q, gpm	20				23	23	22	23
Permeate Q, gpm	15	16	16	17	17.3	18.4	18.7	19.6
Concentrate Q, gpm	5	4	4	3	5.7	4.6	3.3	3.4
Feed pH	7.2	7.2	6.8	6.8	7.2	7.2	6.8	6.8
Permeate TDS(1), mg/l	1000	1100	1100	1200	164.8	170.5	200.7	193.3

(1) Permeate TDS for the SR-2 test at RWS is based on empiric data derived from experiments conducted with a low TDS feedwater. The ion passage will most likely be different when operating with the RWS feedwater.

4.2 Sampling and Monitoring

The sampling plan associated with the pilot test program is designed to facilitate the test objectives as specified in Section 2.0. The pilot study consists of field measurements and lab analyses. Field measurements will be conducted on site with hand-held analyzers. Lab samples will be collected and sent to the appropriate contract lab for analysis.

To ensure the accuracy of all collected data, consistent sampling methods with respect to location, timing, and technique must be maintained. Additionally, for samples analyzed at off-site laboratories, consistency in sample preservation, packaging and shipping is required. Membrane operational parameters such as flow and pressure will be recorded at the time of sampling. All analyses will be performed according to Standard Methods.

The sampling locations (SL) for the pilot systems are identified on the P&ID.

4.2.1 Field Measurements

The field parameters and analyzers associated with each measurement are shown below.

Parameter	Raw	Pretreated
Temperature	√	
pH	√	√
TDS		√
Conductivity	√	√
Silt Density Index		√
Turbidity	√	√

Flow rate and pressure will also be recorded during the study. Flow rate measurements will be recorded for NF permeate, and NF concentrate from FE-1 and FE-2 (P&ID). Pressure will be recorded from the following locations:

- Cartridge filter inlet
- Cartridge filter outlet
- NF Feed
- Interstage (between stages 1 and 2)
- NF Permeate
- NF Concentrate

Chemical dosing tank levels and pump flow rates will be checked on a daily basis to ensure that the proper chemical dose is applied throughout the pilot study.

To ensure the accuracy of the field measurements any hand-held analyzers will be calibrated at the beginning of the study and as required per the manufacturer's recommendations throughout the study.

4.2.2 Lab Analyses

Table 2 shows the lab analysis parameters, frequency of sampling, and total number of samples for each pilot unit. The number of samples in Table 2 assumes a 12-week pilot study duration, at each site.

NF membrane integrity is monitored by on-line conductivity measurement of NF permeate. Additionally, conductivity profiles will be performed on the individual NF vessel permeate streams weekly.

Table 2. Lab analyses and frequency of sampling

Parameter	Sampling Frequency	No. of Samples per Pilot Site			Test Location
		Feed	I'stage	Perm	
Total Hardness (mg/L as CaCO3)	1/week	12		12	RWS
TDS (mg/L)	1/week	12	12	12	NRO
TOC (mg/L)	1/week	12	12	12	Frisco
HPC (CFU/mL)	1/week	12			NRO
Alkalinity (mg/L as $CaCO_3$)	1/week	12		12	RWS
Calcium (Ca^{2+})	1/week	12		12	RWS
Magnesium (Mg^{2+})	1/week	12		12	RWS
Sodium (Na^{+})	2/pilot	12		12	RWS
Potassium (K^{+})	2/pilot	12		12	RWS
Barium (Ba^{2+})	2/pilot	2			Outside lab
Strontium (Sr^{2+})	2/pilot	2			Outside lab
Iron: total (Fe^{2+})(1)	1/week	12		12	RWS
Iron: dissolved (Fe^{2+})(1)	1/week	12			RWS
Manganese (Mn^{2+})(2)	1/week	12		12	RWS
Bicarbonate (HCO_3^-)	1/week	From Alkalinity			RWS
Sulfate (SO_4^{2-})	2/pilot	2		2	RWS
Chloride (Cl^-)	1/week	12	12	12	RWS/Frisco
Fluoride (Fl^-)(3)	1/week	12		12	RWS
Phosphate (PO_4^{3-})	2/pilot	2		2	RWS
Silica: total (SiO_2)(4)	2/pilot	2		2	Outside lab
Silica: reactive (SiO_2)(4)	2/pilot	2		2	Outside lab

(1) Required for Frisco only. RWS should be done 2 times during pilot
(2) Required for Frisco only. RWS should be done 2 times during pilot
(3) Required for Frisco only. RWS should be done 2 times during pilot
(4) Silica testing for Frisco should be done more frequently, unless the well combinations have consistent silica

4.3 Data Handling Protocol

Successful implementation of the performance testing will require coordination between all testing participants. All performance testing activities will be thoroughly documented. Documentation will include field logbooks, photographs, data sheets, electronic databases and chain-of-custody forms.

Original field sheets and chain-of-custody forms will accompany all samples shipped to the analytical laboratory. Copies of field sheets and chain-of-custody forms for all samples will be maintained in the project files. The data management system used in the pilot testing program will involve the use of computer spreadsheets and manual recording of operational parameters for the membrane equipment on a daily basis.

Daily measurements of all values will be recorded on specially-prepared data log sheets, which is attached for reference. An operating logbook maintained by the operator will include a record of events (equipment starts, stops, maintenance, and instrument calibrations) and description of any problems or issues. Photocopies will be made of each data-log and operating logbook page. The original sheets will be stored on-site; one photocopy will be forwarded to the engineer (RosTek Associates, Inc) at least once per week during each testing phase, to be placed in the project file. This protocol will not only facilitate referencing the original data, but offer protection of the original record of results.

4.4 Responsibilities

The management of the sampling and resulting data will involve a great deal of coordination. Some analyses will be conducted on-site at the pilot plants, and at the appropriate Dare County Water System labs, while some samples must be collected, preserved and shipped to an off-site laboratory.

This Pilot Testing Program is under the management of Dare County Water Department and RosTek Associates, Inc. Dare County has the overall responsibility of managing day-to-day coordination of the sample activities, establishing and communicating the sample schedule, and maintaining the operating data logs and logbooks. Maintenance of the project database and analysis of the operating data will be the responsibility of RosTek Associates, Inc.

5.0 Performance Evaluation

The following calculated parameters, together with the data collection described in Section 4.2, will be used for evaluation of performance of the membrane systems.

- Specific Flux (GFD/psi)
- Normalized Feed Pressure (psi)
- Normalized Differential Pressure (psi)
- Normalized Permeate Conductivity (µmhos/cm)

6.0 Reporting

At the conclusion of the testing, RosTek Associates, Inc will compile the entire data set and prepare a final report. The report will summarize the testing results, including an evaluation of each membrane's performance in terms of the test program goals. The data will be used to prepare a preliminary design report for each of the two WTPs.

7.0 Quality Assurance/Quality Control

Quality assurance and quality control of the operation of the membrane equipment and the measured water quality parameters will be maintained during the Pilot Testing Program.

When specific items of equipment or instruments are used, the objective is to maintain the operation of the equipment or instruments within the ranges specified by the manufacturer or by Standard Methods[1]. Maintenance of strict QA/QC procedures is important, in that if a question arises when analyzing or interpreting data collected for a given experiment, it will be possible to verify exact conditions at the time of testing.

Equipment flow rates and associated signals will be documented and recorded on a routine basis. A routine daily walk through during testing should be conducted to verify that each piece of equipment or instrumentation is operating properly. Particular care will be taken to confirm that any chemicals are being fed at the defined flow rate into a flow stream that is operating at the expected flow rate, such that the chemical concentrations are correct. This will be accomplished through chemical drawdown measurements. In-line monitoring equipment such as flow meters, etc. will be checked to confirm that the readout matches with the actual measurement (i.e. flow rate) and that the signal being recorded is correct. Flow measurement accuracy will be confirmed twice during each test program by stopwatch-and-bucket techniques. The accuracy of some on-line water quality instruments will be verified monthly by comparison to grab sample results.

Reference: American Public Health Association, American Water Works Association, Water Environment Federation. Standard Methods for the Examination of Water and Waste water. Current Edition.

APPENDIX B
MEMBRANE DATA SHEETS

KOCH MEMBRANE SYSTEMS

FLUID SYSTEMS® TFC® - SR®2 4" ELEMENTS

Low Pressure, Selective Rejection Elements

PRODUCT DESCRIPTION

Membrane Chemistry:	Proprietary TFC® membrane
Membrane Type:	TFC®-SR®2 membrane
Construction:	Spiral wound with fiberglass outerwrap
Applications:	Separation of higher molecular weight components (>300-400 dalton) and multivalent ions from solution
Feed spacer thickness:	31 mil (0.8 mm)

* Consult KMS Process Technology for specific applications

SPECIFICATIONS

Part Number	Model	Permeate Flow gpd	Permeate Flow (m^3/d)	Rejection % Chloride	Rejection % Hardness	Membrane Area ft²	Membrane Area (m^2)
8472000	4720 SR®2-N1	2,400	(9.1)	10-30*	97**	79	(7.3)

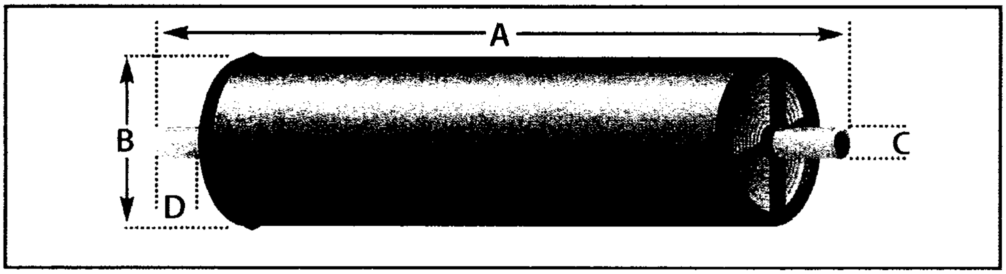
* Test Conditions: 2,000 mg/l NaCl solution at 75 psi (518 kPa) applied pressure (50 psi (345 kPa) net pressure), 15% recovery (20% recovery for Magnum® elements), 77°F (25°C) and pH 7.5.

** Test Conditions: 2,000 mg/l $MgSO_4$ in deionized water at 55 psi (380 kPa) applied pressure (50 psi (345 kPa) net pressure), 15% recovery (20% recovery for Magnum® elements), 77°F (25°C) and pH 7.5.

RECOMMENDED OPERATING LIMITS*

Typical operating pressure:	50 – 100 psi (345 - 690 kPa)
Maximum operating pressure:	350 psi (2,410 kPa)
Maximum operating temperature:	113°F (45°C)
Maximum cleaning temperature:	113°F (45°C)
Maximum continuous free chlorine:	<0.1 mg/l
pH range – continuous operation:	4 – 9
pH range – short term cleaning:	2.5 – 9
Maximum differential pressure per element:	10 psi (69 kPa)
Maximum differential pressure per vessel:	60 psi (414 kPa)
Maximum feed turbidity:	1 NTU
Maximum feed SDI (15 minute):	5

PRODUCT DIMENSIONS



Model	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)	Weight lbs (kg)	Part Numbers Interconnector	O-ring	Brine Seal
4720 SR®2-N1	40 (1,016)	4 (101.6)	0.75 (19.0)	1.0 (25.4)	10 (4.5)	0035267	0035458	0035702

Performance:

Performance specifications shown on the front side of this document are nominal values. Individual element permeate flows may vary +20/-15% from the values shown. Minimum hardness rejection is 92% at the conditions shown.

Selective Rejection (SR®2) nanofiltration membrane performance is highly dependent on water chemistry, temperature, pH and solution concentration. Performance can only be accurately known through pilot study. KMS strongly recommends that the appropriate pilot studies are conducted to determine suitability for a given application.

System operating data should be normalized and key performance parameters tracked using KMS' NORMPRO® software.

Operating Limits:

- **Operating Pressure**: Maximum operating pressure is 350 psi (2,410 kPa). Typical operating pressure for TFC®-SR2 systems is in the range of 50-100 psi (345-690 kPa). Actual operating pressure is dependent upon system flux rate (appropriate for feed source) as well as feed salinity, recovery and temperature conditions.
- **Permeate Pressure**: Permeate pressure should not exceed feed-concentrate pressure by more than 5 psi (34 kPa) at any time (on-line, off-line and during transition).
- **Differential Pressure**: Maximum differential pressure limits are 10 psi (69 kPa) for a 40" (1,016 mm) long element. Maximum differential pressure for any length pressure vessel is 60 psi (414 kPa).
- **Temperature**: Maximum operating temperature is 113°F (45°C). Maximum cleaning temperature is 113°F (45°C).
- **pH**: Recommended range for continuous operation is pH 4-9. Allowable range for short term cleaning is pH 2.5-9.
- **Turbidity and SDI**: Maximum feed turbidity is 1 NTU. Maximum feed Silt Density Index (SDI) is 5.0 (15 minute test). Experience has shown that feedwater with turbidity greater than 0.2 NTU generally results in frequent cleanings.
- **Recovery**: Maximum recovery is site and application specific. In general, single element recovery is approximately 15% for 40" (1,016 mm) long elements. Recovery limits should be determined using KMS' ROPRO program.

Chemical Tolerance:

- **Chlorine**: Intentional exposure of TFC-SR2 membrane to free chlorine or other oxidizing agents such as permanganate, ozone, bromine and iodine is not recommended. TFC-SR2 membrane has a free chlorine tolerance of approximately 1,000 ppm-hours based on testing at 77°F (25°C), pH 8. This tolerance may be significantly reduced if catalyzing metals such as iron are present or if the pH and/or temperature are different. Sodium metabisulfite (without catalysts such as cobalt) is the preferred reducing agent. TFC-SR2 membrane has a chloramine tolerance of approximately 60,000 ppm-hours in the absence of free chlorine based on testing at 77°F (25°C), pH 8.
- **Cationic (Positively Charged) Polymers and Surfactants**: TFC-SR2 membrane may be irreversibly fouled if exposed to cationic (positively charged) polymers or surfactants. Exposure to these chemicals during operation or cleaning is not recommended.

Lubricants:

For element loading, use only approved silicone lubricant, water, or glycerin to lubricate O-rings and brine seals. The use of petroleum based lubricants or vegetable based oils may damage the element and void the warranty.

Service and Ongoing Technical Support:

KMS has an experienced staff of professionals available to assist endusers, and OEM's for optimization of existing systems and support with the development of new applications. Along with the availability of supplemental technical bulletins, KMS also offers a complete line of KOCHTREAT® and KOCHKLEEN® RO pretreatment and maintenance chemicals.

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gton, Massachusetts • San Diego, California • Aachen & Dusseldorf, Germany • Lyon, France • Madrid, Spain • Milan, Italy • Wijnegem, Belgium • Beijing & Shanghai, China • Mumbai, India • Melbourne, Australia • China • Singapore • San Jose dos Campos, Brazil

FLUID SYSTEMS® TFC® - S 4" ELEMENT

Softening, Low Pressure RO Element

PRODUCT DESCRIPTION

Membrane Chemistry: Proprietary TFC polyamide
Membrane Type: TFC-S membrane
Construction: Spiral wound with fiberglass outerwrap
Applications: Municipal water treatment when softening and THMFP reduction are the main objectives

SPECIFICATIONS

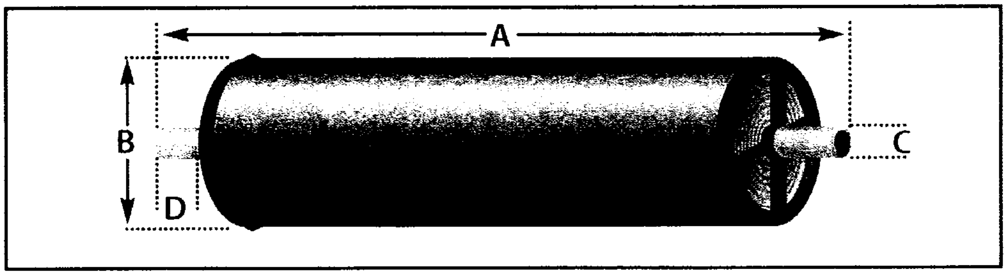
Part Numbers	Model	Permeate Flow gpd	Permeate Flow (m^3/d)	Rejection % Chloride	Rejection % Total Hardness	Rejection % $MgSO_4$	Membrane Area ft^2	Membrane Area (m^2)
8492000	4920 S	2,180	(8.25)	90*	98.5*	99**	85	(7.9)

* Test Conditions: mixed feed with 700 mg/l TDS of which at least 45% is monovalent, at 80 psi (552 kPa), applied pressure, 15% recovery, 77°F (25°C) and pH 7.5.
** Test Conditions: 1,000 mg/l $MgSO_4$ in deionized water, at 80 psi (550 kPa) applied pressure, 15% recovery, 77°F (25°C) and pH 7.5.

OPERATING & DESIGN INFORMATION

Typical operating pressure:	80 psi (552 kPa)
Maximum operating pressure:	350 psi (2,410 kPa)
Maximum operating temperature:	113°F (45°C)
Maximum cleaning temperature:	113°F (45°C)
Maximum continuous free chlorine:	<0.1 mg/l
Allowable pH – continuous operation:	4 – 11
Allowable pH – short term cleaning:	2.5 – 11
Maximum differential pressure per element:	10 psi (69 kPa)
Maximum differential pressure per vessel:	60 psi (414 kPa)
Maximum feed turbidity:	1 NTU
Maximum feed SDI (15 minute):	5
Feed spacer thickness:	28 mil (0.71 mm)

PRODUCT DIMENSIONS AND WEIGHT



Model	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)	Weight lbs (kg)	Part Numbers Interconnector	Part Numbers O-ring	Part Numbers Brine Seal
4920 S	40 (1,016)	4 (101.6)	0.75 (19.0)	1.0 (25.4)	10 (4.5)	0035267	0035458	0035702

Performance:

Performance specifications shown on the front side of this document are nominal values. Individual element permeate flows may vary +20/-15% from the values shown. Minimum chloride ion rejection is 85%, and minimum total hardness rejection is 94% at the mixed feed conditions shown. Minimum $MgSO_4$ rejection is 95% at the $MgSO_4$ conditions shown.

System performance should be predicted using KMS' ROPRO® design software. Element performance is based on the nominal values shown.

System operating data should be normalized and key performance parameters tracked using KMS' NORMPRO® software.

Operating Limits:

- **Operating Pressure**: Maximum operating pressure is 350 psi (2,410 kPa). Typical operating pressure for TFC-S systems is in the range of 80 psi (552 kPa). Actual operating pressure is dependent upon system flux rate (appropriate for feed source) as well as feed salinity, recovery and temperature conditions.
- **Permeate Pressure**: Permeate pressure should not exceed feed-concentrate pressure by more than 5 psi (34 kPa) at any time (on-line, off-line and during transition).
- **Differential Pressure**: Maximum differential pressure is 10 psi (69 kPa) for a 40" (1,016 mm) long element. Maximum differential pressure for any length pressure vessel is 60 psi (414 kPa).
- **Temperature**: Maximum operating temperature is 113°F (45°C). Maximum cleaning temperature is 113°F (45°C).
- **pH**: Allowable range for continuous operation is pH 4-11. Allowable range for short term cleaning is pH 2.5-11.
- **Turbidity and SDI**: Maximum feed turbidity is 1 NTU. Maximum feed Silt Density Index (SDI) is 5.0 (15 minute test). Experience has shown that feedwater with turbidity greater than 0.2 NTU generally results in frequent cleanings.
- **Recovery:** Maximum recovery is site and application specific. In general, single element recovery is approximately 15%. Recovery limits should be determined using KMS' ROPRO® program.

Chemical Tolerance:

- **Chlorine**: Intentional exposure of TFC-S membrane to free chlorine or other oxidizing agents such as permanganate, ozone, bromine and iodine is not recommended. TFC-S membrane has a free chlorine tolerance of approximately 1,000 ppm-hours based on testing at 77°F (25°C), pH 8. This tolerance may be significantly reduced if catalyzing metals such as iron are present or if the pH and/or temperature are different. Sodium metabisulfite (without catalysts such as cobalt) is the preferred reducing agent. TFC-S membrane has a chloramine tolerance of approximately 60,000 ppm-hours in the absence of free chlorine based on testing at 77°F (25°C), pH 8.
- **Cationic (Positively Charged) Polymers and Surfactants**: TFC-S membrane may be irreversibly fouled if exposed to cationic (positively charged) polymers or surfactants. Exposure to these chemicals during operation or cleaning is not recommended.

Lubricants:

For element loading, use only approved silicone lubricant (or approved equivalent), water, or glycerin to lubricate O-rings and brine seals. The use of petroleum based lubricants or vegetable based oils may damage the element and void the warranty.

Service and Ongoing Technical Support:

KMS has an experienced staff of professionals available to assist endusers, and OEM's for optimization of existing systems and support with the development of new applications. Along with the availability of supplemental technical bulletins, KMS also offers a complete line of KOCHTREAT® and KOCHKLEEN® RO pretreatment and maintenance chemicals.

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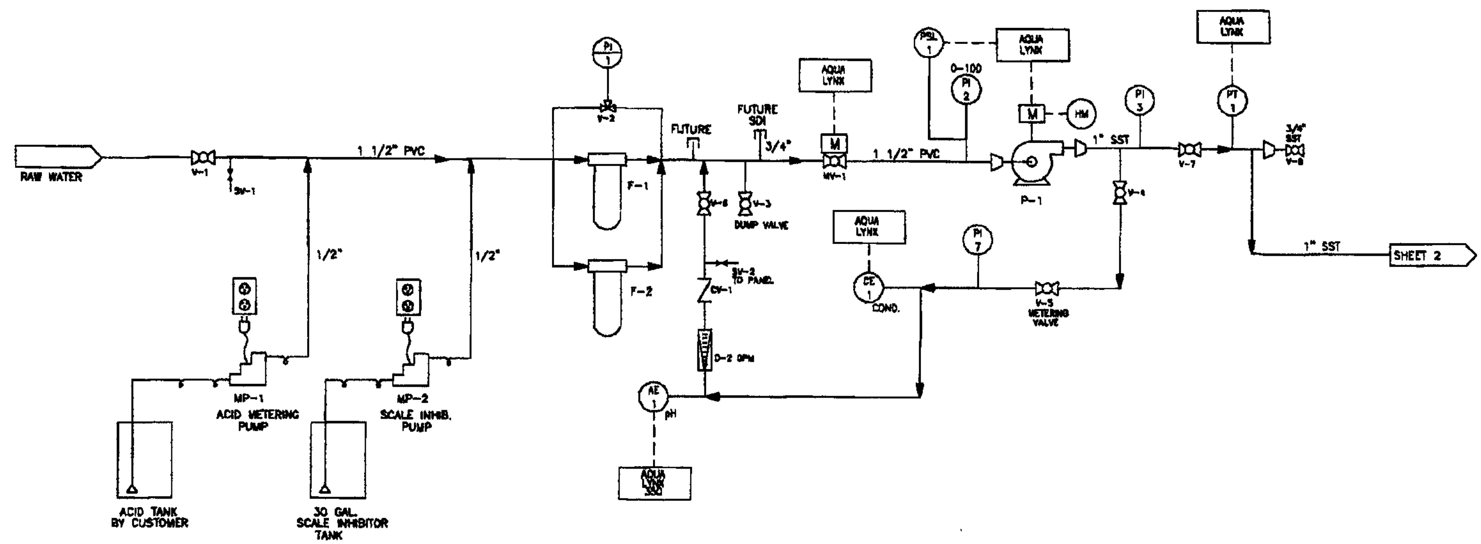
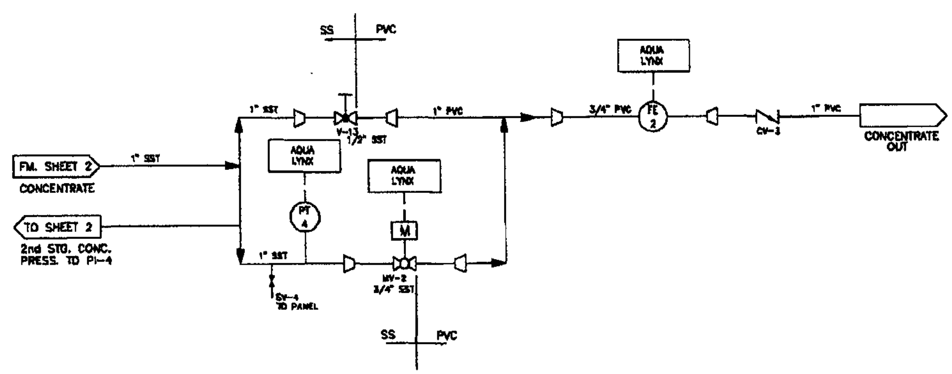
APPENDIX C

TEST UNIT P&IDS



	KOCH MEMBRANE SYSTEMS SAN DIEGO, CALIFORNIA
	PILOT SYSTEM
	RO UNIT NO. 1
DRAWN BY E.V. DATE 10 MAY 05	PIPING AND INSTRUMENTATION DRAWING
	SIZE D — KMS001 — REV —
	SCALE: NONE — KMS001A — SHEET 1 OF 4



KOCH MEMBRANE SYSTEMS
SAN DIEGO, CALIFORNIA

PILOT SYSTEM

RO UNIT NO. 1

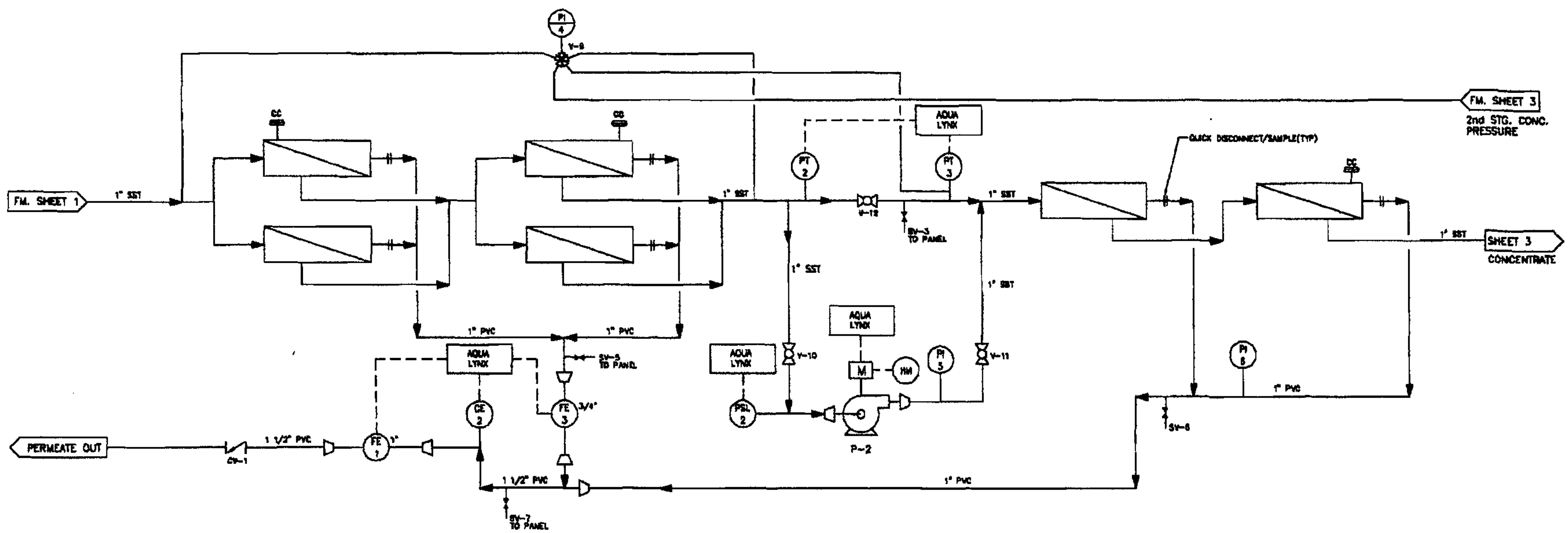
PIPING AND INSTRUMENTATION DRAWING

SIZE D | KMS001 | REV —

SCALE: NONE | KMS001C | SHEET 3 OF 4

DRAWN BY I/V | DATE 10 MAY 05

7/1/05



LTR	DESCRIPTION	DATE

REVISIONS

KOCH MEMBRANE SYSTEMS
SAN DIEGO, CALIFORNIA

PILOT SYSTEM

RO UNIT NO. 1

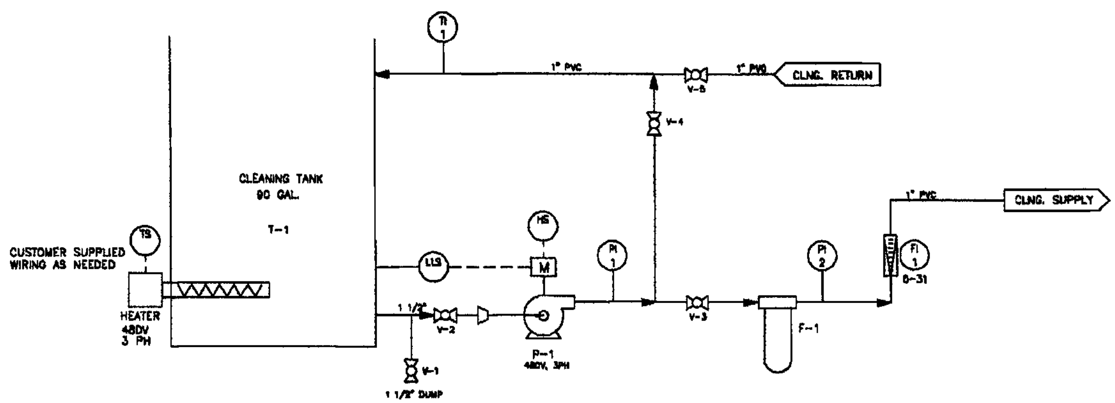
PIPING AND INSTRUMENTATION DRAWING

DRAWN BY EJV DATE 10 MAY 05

SIZE D — KMS001 — REV —

SCALE: NONE — SHEET 2 OF 4

7/1/05



LTR	DESCRIPTION	DATE

REVISIONS

KOCH MEMBRANE SYSTEMS
SAN DIEGO, CALIFORNIA

PILOT SYSTEM CLEANING

PIPING AND INSTRUMENTATION DRAWING

DRAWN BY EJV DATE 10 MAY 08

SIZE B | KMS001 | REV —

SCALE: NONE | SHEET 4 OF 4

1 7/1/08

APPENDIX D

RODANTHE-WAVES-SALVO RAW DATA

PILOT TEST PROGRAM

Rodanthe-Waves-Salvo
Month:

Membrane	SR-2	Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	Operator Initial
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Day	Time																				
14-Nov	1530	20	19.5	20		48	35	35	22	10	11.9	14.7	3.6	2870		1530	3320				IW
	1640	20	20	20		49.5	35	35	22	10	11.9	14.7	3.6	2860		2760	3280	7.68	7.73	19.8	SS
15-Nov	700	19.5	19.5	20		49.5	35	35	22	10	11.9	14.8	3.5	2850		2760	3260	7.74	7.72	20.4	GW
	900	20	19.5	20		47.5	35	35	21	10	11.9	14.8	3.5	2860	3050	2760	3260				IW
	1700	18	18	19		49	33	33	19	7.5	11.8	14.7	3.6	2870	3050	2760	3250	7.8	7.75	20.7	GW
16-Nov	700	17	17	17		44	32	30	16	6.5	11.9	14.8	3.6	2870	3050	2760	3260	7.77	7.75	21	GS
	1700	23	23	23		50	35	35	20	9.5	11.9	14.7	3.6	2860	3050	2760	3230	7.63	7.7	22.3	GS
	SHUTDOWN FOR STORM @ 1700 ON 16 NOV -- RESTART @ 0900 ON 17 NOV																				
17-Nov	900	20	20	21		47	35	35	20	9.5	11.9	14.7	3.5	2870	3060	2760	3240	7.52	7.52	21	GS
	1700	21	21	21		47	35	35	20	9.5	11.9	14.8	3.6	2870	3050	2770	3250	7.54	7.72	20.6	KM
18-Nov	700	19	19	19		45	32	32	18	6.5	11.9	14.8	3.6	2860	3030	2770	3200	7.65	7.71	20.1	SS
	1700	20	20	20		45	35	34	20	10	11.8	14.5	3.5	2880	3060	2770	3240	7.5	7.52	20.3	GS
19-Nov	700	22	22	22		45	35	35	20	10	11.8	14.5	3.5	2880	3040	2770	3040	7.72	7.78	19	GS
	1700	20	20	20		45	35	30	20	9.5	11.7	14.4	3.4	2880	3040	2780	3220	7.52	7.54	19.4	GS
20-Nov	700	20	20	20		43	30	30	17	6.5	11.8	14.5	3.5	2870	3040	2780	3210	7.66	7.79	18.3	GW/SS
	1700	23	23	23		48	35	35	21	10.5	12.3	15	3.6	2870	3040	2780	3230	7.94	7.91	19.6	GW/SS
21-Nov	700	23.5	23	23		46	34	34	20	10.5	11.8	14.4	3.4	2880	3030	2780	3200	7.85	7.71	18.9	GW
	1700	20	20	20		46	34	34	19	10	11.9	14.5	3.4	2880	3040	2780	3220	7.54	7.5	20	GW/KW
1	SHUTDOWN FOR STORM @ 1700 ON 16 NOV -- RESTART @ 0900 ON 17 NC						25-Nov														
25-Nov	900	20	20	20		50	35	35	20	10.5	12.2	15	3.5	2730	2900	2590	3060	7.51	7.51	19.5	GS/SS
	1700	20	20	20		50	35	35	20	10.5	12.4	15.4	3.7	2730	2890	2590	3040	7.56	7.54	20.1	GS
	25 NOV -- RAN 2 WELLS ALL DAY UNTIL 1700 -- THEN BACK TO ONE WELL																				
26-Nov	730	23	23	23		50	35	35	20	10.5	12.3	15.2	3.6	2900	3040	2780	3230	7.54	7.54	19.2	SS
	1700	21	21	21		49	35	35	20	10.5	12.2	15	3.6	2880	3030	2800	3230	7.52	7.48	20.4	SS/GS
27-Nov	700	23.5	23.5	24		50	35	35	21	11	12.3	15.1	3.6	2880	3030	2770	3220	7.83	7.75	19.8	GW
	1700	23.5	23.5	24		50	35	35	21	11	12.3	15.1	3.6	2840	3030	2770	3210	7.73	7.67	20.3	GW/SS
28-Nov	700	23.5	23	24		49	35	35	21	11	12.2	15.2	3.6	2860	3020	2770	3210	7.94	7.75	20.1	GW/SS

NOTES

PILOT TEST PROGRAM

Rodanthe-Waves-Salvo
Month: Nov 06/ Dec 06

Membrane	SR-2	Flux	Recovery	pH
TEST CONDITIONS		13	80	7.8

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	Operator Initial
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Day	Time																				
29-Nov	1100	23	23	23		48	35	35	20	10.5	12.1	14.9	3.7	2870	3020	2770	3190	7.86	7.80	19.1	GW
	1700	22	22	23		47	35	35	20	10.0	12.1	14.8	3.6	2860	3020	2770	3190	7.81	7.72	21.5	GW
30-Nov	800	21.5	21	22		46	34	34	20	9.5	12.0	14.8	3.6	2810	3020	2770	3170	7.57	7.50	20.5	GW
	1700	230	22.5	23.5		45	32	32	18	8.5	11.8	14.5	3.6	2830	3010	2760	3180	7.76	7.71	21.6	GW
1-Dec	700	23	23	23		45	33.5	33	18	9.0	11.9	14.6	3.6	2850	3020	2770	3170	7.78	7.78	21.3	GS
	1700	23	23	23		45	34	33	18	9.0	12.0	14.6	3.6	2850	3000	2760	3180	7.69	7.77	22.1	GS
2-Dec	700	23	23	23		45	32	30	18	9.0	11.9	14.5	3.6	2840	3000	2770	3170	7.77	7.78	20.3	GS
	1700	22	22	22		45	32	30	20	9.6	11.7	14.3	3.6	2680	2870	2590	3040	7.63	7.47	20.8	GS
	Shut down. Broken port. Restarted 12/5 KenM																				
6-Dec	930	20.5	20.5	20.5		47	35	35	20	11.0	12.2	15.1	3.7	2870	3040	2780	3060	7.72	7.82	19.0	Len
	1700	20	19.5	20		47	35	35	18	10.0	12.0	14.7	3.6	2880	3030	2780	3190	7.75	7.71	20.0	GW
7-Dec	700	20	19.5	20		47	35	35	19	10.0	12.0	14.7	3.6	2880	3030	2780	3200	7.80	7.74	19.3	GW
8-Dec	700	21	21	21		47	35	35	20	11.0	12.0	14.8	3.6	2870	3030	2770	3220	7.61	7.57	19.0	GS
	1700	20	20	20		48	35	31	17	10.0	11.8	14.4	3.5	2890	3030	2770	3210	7.53	7.52	19.4	GS
9=Dec	700	22	22	22		48	35	30	20	10.5	11.6	14.4	3.6	2890	3030	2770	3190	7.74	7.76	17.6	GS
	1700	20.5	20	20		46	34	32	17	10.0	11.8	14.2	3.5	2860	3060	2780	3180	7.73	7.77	18.9	GS
10-Dec	700	20	20	20		47	35	34	20	10.5	11.9	14.7	3.6	2820	3030	2780	3200	7.71	7.79	18.5	GS
	1700	20	20	20		47	35	34	20	10.4	11.9	14.6	3.6	2880	3040	2780	3200	7.72	7.76	19.8	GS
11-Dec	700	20	20	20		49	35	33	20	10.0	11.8	14.2	3.5	2880	3030	2790	3190	7.72	7.79	18.6	SS
	1700	20	20	20		49	35	33	18	10.0	11.8	14.3	3.5	2880	3040	2790	3200	7.69	7.68	19.8	SS
12-Dec	700	20	20	20		46	34	33	19	10.0	11.7	14.4	3.6	2880	3040	2790	3200	7.81	7.76	18.8	GW
	1700	21.5	21	21		49	35	35	17	7.0	12.7	15.8	3.9	2880	3050	2780	3250	7.83	7.76	20.8	GW
13-Dec	815	21.5	21	22		53	39	39	24	11.0	12.7	16.0	4	2870	3040	2770	3250	7.77	7.78	20.3	GW
	1700	21	21	21		54	39	37	21	11.0	12.9	15.9	3.9	2870	3040	2770	3240	7.66	7.75	20.9	GW
14-Dec	700	21	21	21		54	38	38	22	11.0	12.9	16.0	3.9	2870	3040	2770	3240	7.70	7.74	21.1	GW
	1700	23	22.5	23		53	38	38	23	10.5	12.8	15.9	3.9	2870	3040	2770	3230	7.75	7.75	21.7	GW
15-Dec	700	23	23	23		57	38	38	20	10.5	12.6	15.6	3.8	2890	3060	2770	3210	7.80	7.78	20.0	SS
	1700	22	22	22		50	35	34	20	9.0	12.5	15.8	3.8	2870	3040	2780	3230	7.75	7.75	20.3	SS
16-Dec	700	20	20	20		47	33	30	16	6.7	12.5	15.4	3.8	2860	3030	2770	3530	7.68	7.76	19.8	GS
	1700	22	22	22		50	36	36	20	10.5	12.4	15.3	3.8	2880	3050	2780	3220	7.72	7.78	20.1	GS

NOTES

PILOT TEST PROGRAM

Rodanthe-Waves-Salvo
Month: 6-Dec

Membrane	SR-2	Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	Operator Initial
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Day	Time																				
17-Dec	0700	22	21.5	22		50	36	36	20	10.5	12.3	15.3	3.8	2880	3040	2780	3220	7.75	7.74	18.9	GW
	1500	22	22	22		55	40	40	23	11.2	12.9	16.0	3.9	2860	3050	2770	3240	7.74	7.80	20.0	GS
18-Dec	0700	22	22	22		54	39	37	21	11.0	12.8	15.8	3.9	2870	3050	2770	3230	7.74	7.78	19.3	GS
	1700	22	22	22		54	40	38	22	10.5	12.8	16.0	4.0	2870	3040	2780	3230	7.75	7.76	19.8	SS
19-Dec	0700	21	21	21		50	36	35	20	10.5	12.3	15.2	3.8	2880	3050	2780	3210	7.73	7.74	19.6	GS
	1700	21	21	21		51	40	40	23	11.5	12.8	16.1	4.0	2880	3040	2780	3220	7.83	7.84	19.2	SS
20-Dec	0700	22	21	21		50	38	35	20	11.5	12.7	15.6	3.8	2890	3040	2770	3220	7.72	7.83	18.9	SS
	1700	21	21	21		51	40	40	25	11.5	12.8	16.1	4.0	2890	3050	2780	3220	7.76	7.82	19.3	SS
21-Dec	0700	21	21	21		51	39	37	23	11.0	12.8	15.7	3.9	2870	3050	2780	3230	7.80	7.85	19.2	SS
	Switch to well #2 at 0900																				
	1700	20	20	20		53	39	39	21	10.5	12.9	16.0	4.0	2480	2660	2380	2890	7.78	7.79	19.6	GW
22-Dec	0700	20	19.5	20		54	39	39	21	11.0	12.8	16.0	4.0	2500	2660	2380	2880	7.74	7.78	20.0	GW
	1700	20	20	20		54	39	39	24	11.0	12.9	16.2	4.0	2490	2660	2380	2880	7.78	7.79	20.5	GW
23-Dec	0700	20.5	20	20		53	38	36	20	10.5	12.8	16.1	3.9	2470	2660	2380	2850	7.78	7.83	20.9	gw
	1700	22.5	22	22		54	38	38	21	10.5	13.0	16.3	4.0	2440	2660	2380	2880	7.47	7.48	20.5	GW
24-Dec	0700	20.5	20	21		53	39	39	23	11.0	12.6	15.8	3.9	2440	2640	2380	2850	7.74	7.79	20.2	GW
	Switch to well #1 at 0800																				
	1700	20	19.5	20		50.5	38	36	20	11.0	12.7	15.7	3.9	2850	3050	2770	3220	7.71	7.77	20.2	GS
25-Dec	0700	20	21	20		52	38	35	20	10.8	12.7	15.6	3.8	2870	3050	2770	3220	7.70	7.79	19.9	GS
	1700	21.5	21.5	21.5		50.5	37	35	20	10.5	12.7	15.7	3.8	2880	3040	2760	3200	7.66	7.68	20.5	GS
26-Dec	0700	22	22	22		50	35	32	15	7.2	12.8	15.6	3.8	2840	3030	2760	3210	7.70	7.77	20.2	GS
	1700	21.5	22	21		50	35	34	17	7.5	12.8	15.8	3.9	2860	3040	2760	3220	7.74	7.76	20.1	GS
27-Dec	0700	22	22	21.5		50	35	35	20	8.0	13.8	16.2	4.0	3860	3040	2760	3220	7.74	7.75	20.2	SS
	1700	20	21	20		50	35	36	17	10.5	13.0	16.4	4.0	2860	3050	2780	3240	7.62	7.63	19.7	SS
28-Dec	0700	22.5	22	22		53	39	38	22	11.3	12.8	16.0	3.9	2870	3050	2780	3240	7.73	7.79	18.3	GW
	Switch to well #2 at 0745																				
	1700	21	20.5	21		53	37	36	21	11.0	12.8	16.0	3.9	2470	2660	2390	2900	7.47	7.43	20.3	GW
	Did not run from 1700 12/28 to 1000 12/29																				
29-Dec	1000	23	23	23		54	40	40	24	11.3	13.0	16.2	4.0	2510	2670	2390	2900	7.56	7.57	19.1	GW
	1700	22	21.5	22		54	39	39	23	11.3	13.1	16.3	4.0	2470	2660	2390	2890	7.56	7.51	20.6	GW

NOTES

PILOT TEST PROGRAM

Rodanthe-Waves-Salvo
Month: Dec 06/Jan 07

Membrane	SR-2	Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	Operator Initial
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Day	Time																				
Well #2																					
30-Dec	0700	23.5	23.0	18.0		51.0	36.0	36.0	20.0	7.8	13.1	16.4	4.1	2490	2670	2390	2890	7.78	7.76	20.6	GW
Both wells #1 & #2 starting at 1045																					
	1700	21.0	21.0	22.0		54.0	39.0	39.0	22.0	11.0	12.9	16.2	4.0	2730	2870	2600	3080	7.55	7.51	20.4	GW
Well #2																					
31-Dec	0700	22.5	22.0	23.0		54.0	39.0	39.0	23.0	11.0	12.9	16.2	4.0	2470	2670	2390	2890	7.84	7.89	19.5	GW
	1700	22.5	22.0	22.0		50.5	37.0	35.0	22.0	11.0	12.7	15.8	3.9	2480	2670	2390	2860	7.74	7.81	20.2	GS
Well #1 & #2																					
1-Jan	0700	22.5	22.0	22.0		50.5	37.0	35.0	22.0	10.5	12.7	15.6	3.8	2500	2660	2390	2850	7.72	7.80	20.1	GS
	1700	22.5	22.0	23.0		50.5	37.0	35.0	20.0	10.4	12.8	16.0	3.9	2490	2670	2390	2870	7.64	7.86	21.3	GS
Well #2																					
2-Jan	0700	22.0	22.0	22.0		48.0	35.0	32.0	20.0	10.3	12.8	16.2	2.8	2490	2670	2390	2960	7.77	7.82	19.8	GS
	1600	22.0	22.0	22.0		48.0	35.0	35.0	24.0	7.5	12.6	16.1	2.8	2490	2670	2400	2970	7.86	7.85	19.2	Ken
3-Jan	0700	22.0	22.0	22.0		49.5	35.0	35.0	20.0	7.5	12.3	15.5	2.7	2490	2670	2400	2940	7.86	7.86	19.2	SS
Switch to Well #1																					
	1700	21.0	21.0	21.0		49.0	35.0	30.0	24.0	10.0	12.4	15.9	2.7	2890	3070	2810	3340	7.56	7.51	19.9	SS
4-Jan	0700	20.5	20.0	21.0		51.0	39.0	39.0	26.0	11.0	12.5	15.8	2.7	2890	0.07	2800	3350	7.76	7.77	19.0	GW
	1700	20.0	19.5	20.0		51.0	39.0	39.0	26.0	11.0	12.6	16.1	2.8	2890	3070	2800	3340	7.63	7.65	21.1	GW
5-Jan	0700	20.0	19.5	20.0		51.0	39.0	39.0	26.0	11.0	12.6	16.1	2.8	2880	3060	2790	3340	7.75	7.67	20.2	GW
	1700	21.5	21.0	22.0		51.0	39.0	39.0	26.0	10.5	12.6	16.1	2.8	2880	3060	2790	3340	7.64	7.70	21.9	GW
6-Jan	0700	21.5	21.0	22.0		51.0	39.0	39.0	26.0	10.5	12.6	16.1	2.8	2890	3050	2790	3330	7.93	7.95	21.0	GW
	1700	23.0	22.5	23.0		51.0	39.0	39.0	26.0	10.5	12.6	16.2	2.8	2870	3050	2780	3340	7.65	7.64	21.7	GW
7-Jan	0700	23.0	22.5	23.0		51.0	39.0	39.0	26.0	11.0	12.6	16.2	2.8	2880	3050	2780	3330	7.74	7.76	20.7	GW
	no run																				
8-Jan	1700	21.0	20.0	20.0		50.0	38.0	31.0	21.0	10.5	12.6	15.8	2.7	2840	3030	2770	3300	7.87	7.84	21.9	GS
9-Jan	0700	22.0	21.0	22.0		50.0	38.0	33.0	25.0	11.0	12.6	15.8	2.7	2880	3060	2780	3300	7.79	7.84	18.8	GS
	1700	21.0	21.0	21.0		51.0	39.0	39.0	28.0	12.0	12.8	16.4	2.8	2880	3070	2790	3380	7.80	7.85	19.7	Ken
10-Jan	0700	21.0	21.0	21.0		50.0	38.0	38.0	27.0	12.0	12.4	15.7	2.7	2910	3060	2790	3340	7.90	7.82	19.3	SS
	1700	21.0	21.0	21.0		50.0	38.0	36.0	26.0	11.0	12.5	15.7	2.7	2870	3070	2790	3360	7.65	7.60	19.3	SS
11-Jan	0700	22.5	22.0	22.5		52.0	40.0	40.0	28.0	11.5	12.6	16.1	2.8	2890	3070	2790	3350	7.78	7.83	19.0	GW
	1700	23.0	22.5	23.0		50.0	38.0	38.0	25.0	11.0	12.4	15.5	2.7	2880	3060	2800	3330	7.76	7.79	19.2	SS

NOTES

PILOT TEST PROGRAM

Rodanthe-Waves-Salvo
Month: 7-Jan

Membrane	SR-2	Flux	Recovery	pH
TEST CONDITIONS		16.1	85%	7.8

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	Operator Initial
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Day	Time																				
12-Jan	700	22	22	22		51	39	39	27	11.5	12.6	16.1	2.8	2880	3060	2790	3340	7.66	7.73	19.2	GW
	1700	22.5	22	23		51	39	39	27	11	12.6	16.1	2.8	2870	3070	2800	3350	7.71	7.77	20.3	GW
13-Jan	700	22.5	22	22.5		51	39	39	27	11	12.6	16.1	2.8	2880	3070	2790	3350	7.72	7..74	21.2	GW
	1700	22	21.5	22		51	39	39	27	11	12.6	16.1	2.8	2870	3070	2800	3350	7.72	7.79	19.7	GW
14-Jan	700	21.5	21	22		50	38	38	26	11	12.5	16.1	2.8	2890	3060	2800	3350	7.76	7.79	20	GW
	1700	22	21	22		50	36	34	21	10.4	12.3	15.4	2.6	2880	3060	2790	3300	7.72	7.79	21.4	GS
15-Jan	700	22	22	22		50	36	32	23	10.5	12.3	15.3	2.6	2880	3070	2780	3310	7.75	7.89	20.7	SS
	1700	20	20	20.5		50	36	36	26	10	12.5	15.9	2.8	2870	3070	2790	3350	7.65	7.6	21	SS
16-Jan	700	22	21	22		50	35	30	15	10.5	12.4	15.8	2.7	2880	3050	2790	3310	7.8	7.76	20.2	SS

NOTES

APPENDIX E

RODANTHE-WAVES-SALVO ANALYTICAL DATA

DARE COUNTY RWS WATER TREATMENT FACILITY 04-28-035
Report of Chemical Analysis for RWS Organic Removal Pilot Project - November, 2006 - February, 2007
Analyses Results From Outside Labs

Week	TOC (mg/L) (From Frisco Lab)			% TOC Removal	HPC (CFU/mL) (From NRO Lab)	Silica, Total (From Envirochem)		Silica, Reactive (From Envirochem)		Barium (From Envirochem)	Stronium (From Envirochem)
	Feed	1st Stage	Permeate		Feed	Feed	Permeate	Feed	Permeate	Feed	Feed
1	6.22	3.79	2.99	0.52	0.00						
2	7.12	3.67	3.03	0.57	0.00			11.4mg/l	10.6mg/l	.097mg/l	.725mg/l
3	6.46	3.61	2.64	0.59	0.00						
4	6.49	3.85	3.13	0.52	0.00						
5	7.45	4.00	3.35	0.55	0.00						
6	7.38	3.67	2.89	0.61	0.00						
7	6.79	3.88	3.01	0.56	0.00						
8	6.91	3.78	2.69	0.04	0.00						
9	6.77	3.72	3.05	0.55	0.00						
10	6.57	0.92	0.80	0.88	0.00						
11	6.49	0.81	0.72	0.89	0.00						
12	7.97	1.01	0.74	0.91	0.00						
Average											
Max.											
Min.											

RWS Feed 7.12 ppm RWS RO 467 ppb
Week #5 RWS Well#2

Jan18 2007 membrane change

DARE COUNTY RWS WATER TREATMENT FACILITY 04-28-035

Report of Chemical Analysis for RWS Organic Removal Pilot Project - November, 2006 - February, 2007

In-House Lab

Week	Total Hardness (mg/l as CaCO3)		TDS			Alkalinity (mg/l asCaCO3)		Bicarbonate (From Alkalinity)		Calcium		Magnesium		Fluoride		Chloride			Sodium		UV - 254		Iron (Total)		Iron (Ferrous)		Manganese		Sulfate		Phosphate		Potassium	
	Feed	Permeate	Feed	1st Stage	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	1s Stage	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate	Feed	Permeate
1	108	96	1330	1300	1290	488	488	595	595	12.00	9.60	18.95	17.50	1.80	1.51	540	540	540	586	528	0.214	0.104	0.085	0.029	0.015	0.057	0.029	-0.005	9.00	2.00	0.250	0.320	4.60	4.60
2	116	92	1290	1300	1260	492	492	600	600	9.60	8.80	22.36	17.01	1.77	1.51	550	550	550	520	537	0.210	0.099												
3	96	94	1370	1330	1330	496	444	605	541	10.40	9.60	17.01	17.01	1.56	1.33	520	520	520	528	487	0.217	0.097												
4	108	96	1340	1330	1330	504	460	614	560	11.20	10.40	19.44	17.01	1.78	1.59	540	540	540	522	506	0.212	0.096												
5	106	96	1350	1440	1320	504	460	614	560	10.40	9.60	19.44	17.50	1.75	1.50	540	540	540	521	504	0.214	0.093												
6	108	100	1410	1330	1330	500	428	610	522	12.00	11.50	18.95	17.50	2.00	1.82	540	540	540	522	492	0.208	0.096												
7	88	80	1140	1100	1100	492	460	600	561	12.80	9.60	13.60	13.60	1.91	1.70	420	420	420	449	449	0.206	0.095												
8	104	98	1330	1300	1300	508	440	620	537	11.20	11.20	18.47	17.01	1.87	1.64	530	530	530	518	491	0.210	0.091												
9	110	98	1360	1310	1310	512	428	624	522	11.20	9.60	19.93	17.98	1.69	1.50	530	530	530	502	460	0.202	0.094												
10	92	22	1190	248	380	464	76	566	90	10.40	1.60	16.04	4.37	1.94	0.59	440	130	180	454	137	0.199	0.010												
11	106	14	1350	275	425	472	80	576	96	12.00	0.80	18.47	2.92	1.95	0.50	520	130	200	494	23	0.214	0.021												
12	96	16	1430	276	448	456	80	556	96	10.40	0.80	17.01	3.40	1.89	0.59	520	130	200	497	155	0.217	0.016	0.05	0.02	0.02	0.01	0.00	0.01	16.90	0.00	0.22	0.07	23.00	5.00
Average	103.167	75.167	1324.167	1044.917	1068.583	490.667	361.333	598.333	440.000	11.133	7.758	18.306	13.568	1.826	1.315	515.833	425.000	440.833	509.375	397.417	0.210	0.076	0.066	0.023	0.017	0.033	0.016	0.000	12.950	1.000	0.234	0.197	13.800	4.800
Max.	116.000	100.000	1430.000	1440.000	1330.000	512.000	492.000	624.000	600.000	12.800	11.500	22.360	17.980	2.000	1.820	550.000	550.000	550.000	586.000	537.000	0.217	0.104	0.085	0.029	0.018	0.057	0.029	0.005	16.900	2.000	0.250	0.320	23.000	5.000
Min.	88.000	14.000	1140.000	248.000	380.000	456.000	76.000	556.000	90.000	9.600	0.800	13.600	2.920	1.560	0.500	420.000	130.000	180.000	448.500	23.000	0.199	0.010	0.047	0.017	0.015	0.009	0.002	-0.005	9.000	0.000	0.218	0.074	4.600	4.600

APPENDIX F

SOUTH HATTERAS RAW DATA

PILOT TEST PROGRAM

FRISCO WATER PLANT

Month:

Membrane		Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	Well #
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Date	Time																				
7-Mar	1500	33	32.5	32.5	300	112	92		78	12	12.2	17	2.9	681	1511	158.2	3730	7.24	7.08	13.5	15
8-Mar	730	35	30.5	30.5	300	118	99		85	11.5	13.2	17	3.0	683	1705	169.9	3060	7.29	7.18	15.6	15
8-Mar	1530	35	30	30	295	122	103		90	11.5	13.6	16.8	3	693	1819	174.4	3020	7.37	7.41	15.5	15
9-Mar	0730	35	32	32	290	133	115		105	11.5	14.6	17	2.9	680	2060	171.7	3010	7.21	7.29	15.2	15
9-Mar	1500	35	32	32	295	137	120		110	11.5	14.7	17	3	682	2012	172.1	3005	7.25	7.31	15.4	15
10-Mar	0730	35	32	32	300	140	125		115	11.5	15.1	17.1	3	683	2019	173.9	3003	7.22	7.13	15.5	15
10-Mar	1530	34	32	33	300	142	127		117	11.5	15.3	17.1	3.1	682	2015	172.8	3005	7.25	7.25	15.2	15
11-Mar	0730	35	34	34	300	144	128		119	11.5	15.3	17.1	3	682	2024	170.2	2095	7.22	7.16	15.2	15
11-Mar	1530	35	33	33	300	146	129		121	12	15.5	17.2	3	677	2027	172.3	2097	7.2	7.25	15.2	15
12-Mar	0730	35	34	34	300	149	130		125	12	15.5	17	3	678	2029	179.6	2091	7.22	7.2	15.3	15
12-Mar	1530	36	35	35	301	129	114	see note	102	10	13.8	15.1	3.7	680	1996	168.4	2470	7.2	7.17	15.5	15
13-Mar	0730	36	35	35	301	129	115		102	10.5	13.8	15.1	3.7	681	1976	170.5	2390	7.29	7.21	15.5	15
13-Mar	1530	36	35	35	301	129	115		102	9.5	13.7	15.1	3.7	673	1981	185.6	2390	7.36	7.25	15.3	15
14-Mar	0740	36	35	35	301	129	115		102	9.8	13.8	15.1	3.7	680	1991	173.4	2400	7.21	7.07	15.1	15
14-Mar	1515	36	35	35	301	129	114		101	9.5	13.8	15.1	3.7	680	1990	171.6	2401	7.09	7.1	15.2	15
15-Mar	0750	37	36	36	302	125	111		99	9.5	13.8	15.1	3.7	684	1975	191.5	2401	7.29	7.31	15.7	15
15-Mar	1530	36	35	35	301	125	110		99	9.2	13.7	15.1	3.7	681	1982	171.6	2380	7.32	7.19	15.6	15
16-Mar	0725	36	35	36	301	125	110		99	9.2	13.6	15	3.7	684	1969	176.8	2390	7.36	7.19	15.5	15
16-Mar	1530	36	35	35	301	130	115		105	9.5	13.7	15.2	3.7	679	1984	172.6	2330	7.31	7.35	15.7	15
17-Mar	0700	36	35	35	301	134	119		110	9.5	13.7	15	3.7	682	2000	175.2	2031	7.3	7.15	15.7	15
17-Mar	1530	37	36	36	301	135	120		114	9.5	13.8	15	3.7	684	1984	176.6	2360	7.32	7.19	15.4	15
18-Mar	0700	37	36	36	301	140	125		119	10	13.7	15	3.7	683	2011	175.3	2037	7.27	7.17	15.6	15
18-Mar	1530	37	36	36	301	143	130		121	9.5	13.7	15	3.7	682	2001	176.4	2360	7.3	7.12	15.6	15
19-Mar	0700	37	36	36	301	145	134		123	9.5	13.8	15	3.7	684	2012	174.1	2400	7.17	7.11	15.7	15
19-Mar	1530	37	36	36	304	148	137		125	9.5	13.7	15.1	3.7	683	2002	176.4	2400	7.25	7.15	15.6	15
20-Mar	0730	37	36	36	304	150	138		126	9.9	13.7	15	3.7	676	1997	191.1	2360	7.24	7.16	15.4	15
20-Mar	1530	37	36	37	304	151	139		127	9.5	13.7	15	3.7	680	1985	173.8	2340	7.41	7.12	15.6	15
21-Mar	0730	37	36	37	304	151	139		128	9.5	13.7	15	3.7	679	1984	175.9	2340	7.38	7.18	15.3	15
21-Mar	1530	37	36	37	304	151	139		128	9.5	13.7	15	3.7	682	1988	176.3	2340	7.31	7.16	15.6	15
22-Mar	0730	38	37	37	305	151	140		129	10	13.7	15	3.7	680	1973	188.5	2350	7.35	7.14	15.7	15

NOTES 12 March 1500 reduced recovery to 80% 15 gpm total permeate

PILOT TEST PROGRAM

FRISCO WATER PLANT

Month: March

Membrane		Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	Well #
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Date	Time																				
23-Mar	0730	38	37	38	304	151	140		129	10	13.7	15	3.7	682	2001	185.5	2380	7.21	7.12	15.6	15
23-Mar	1515	37	36	37	304	150	140		128	9	13.8	15	3.7	682	2001	180.5	2380	7.14	7.24	15.8	15
24-Mar	0730	38	37	36	304	150	139		128	9.5	13.8	15	3.7	681	1995	180.4	2350	7.21	7.22	15.8	15
24-Mar	1530	37	36.5	37.5	304	151	140		129	9	13.8	15	3.7	679	1987	179.2	2340	7.28	7.24	15.9	15
25-Mar	0700	38	37	38	305	155	142		130	9	13.8	15	3.7	676	1986	183.1	2340	7.27	7.25	15.6	15
25-Mar	1545	37	36.5	38	304	160	149		135	10	13.8	15	3.8	678	1987	183.1	2340	7.31	7.25	15.5	15
26-Mar	0700	38	37.5	38	305	162	150		139	11.5	13.8	15	3.7	678	1988	182.1	2310	7.07	7.23	15.7	15
26-Mar	1530	37.5	37	38	304	162	150		140	9	13.8	15	3.7	681	1989	182.1	2330	7.11	7.12	15.9	15
27-Mar	0730	38	37.5	38	305	165	154		143	9	13.7	15	3.7	679	1991	184.3	2310	7.28	7.19	15.8	15
27-Mar	1530	38	37	38.5	305	166	155		145	9	13.7	14.9	3.7	681	1992	183.1	2320	7.21	7.12	15.6	15
28-Mar	0730	19.5	38.5	39	310	167	155		145	10.7	13.7	14.9	3.7	687	1992	203	2340	7.3	7.21	15.6	15
28-Mar	1520	39	38	39	305	166	155		145	9	13.7	14.9	3.7	688	1999	210	2340	7.22	7.19	15.6	15
29-Mar	0830	39.5	39	39.5	310	167	155		145	9	13.8	14.9	3.7	686	1997	207	2341	7.26	7.2	15.3	15
29-Mar	1600	39.5	39	39.5	307	169	158		147	10.5	13.7	14.9	3.7	697	1980	205	2350	7.36	7.17	15.4	15
30-Mar	0715	39.5	39	39.5	306	171	164		153	10.5	13.8	14.9	3.7	685	2010	187.4	2360	7.25	7.15	15.3	15
30-Mar	1530	39	38.5	39	304	175	164		154	10	13.9	15	3.7	680	2020	184.7	2370	7.21	7.06	15.6	15
31-Mar	0720	39	39	40	305	175	165		154	10.5	13.9	15	3.7	701	2040	184.3	2370	7.29	7.25	15.2	15
31-Mar	1530	39	38	40	305	175	165		154	9.5	13.9	15	3.7	682	1989	186.3	2360	7.25	7.22	15.5	15
1-Apr	0715	39.5	38.5	39	305	176	166		155	9.5	13.8	15	3.7	681	2010	185.4	2340	7.22	7.04	15.4	15
1-Apr	1535	39	38	39	305	176	166		155	9	13.8	14.9	3.7	680	2000	187.7	2340	7.15	7.01	15.1	15
2-Apr	0740	39	38	39	305	176	166		155	9	13.9	15	3.7	682	2010	186.6	2350	7.21	7.1	15.2	15
2-Apr	1530	39	38	39	305	175	166		155	9	13.8	15	3.7	680	2010	187	2360	7.21	7.05	15.5	15
3-Apr	0720	39	38	39	305	175	165		155	9	13.9	15	3.7	682	2010	186.6	2350	7.24	7.06	15.5	15
3-Apr	1530	41	40	40	305	175	165		155	9	13.8	15	3.7	675	1999	189.4	2330	7.26	7.11	15.5	15
11-Apr	1540	37	36	36.5	301	95	76		59	9.5	11.2	15.1	3.7	700	1447	160.7	2560	7.3	7.13	16.3	15
12-Apr	0715	37	36	37	302	96	80		65	9	11.7	15	3.7	682	1544	163.2	2390	7.09	6.99	16.9	15
12-Apr	1540	37	36	37	302	99	81		69	9	12	15	3.7	690	1607	163.7	2410	7.31	7.26	16.7	15
13-Apr	0745	38.5	37	37	301	100	85		73	9	12.5	15	3.7	683	1669	180.7	2400	7.19	7.21	16.3	15
14-Apr	0730	38.5	37	37.5	301	105	89		77	9	12.8	14.8	3.7	694	1671	171.1	2408	7.2	7.17	16.9	15
14-Apr	1530	37.5	36.5	37	303	109	93		81	9.5	13	14.9	3.7	687	1791	189.5	2400	7.32	7.2	16.9	15
15-Apr	0730	38	36.5	37	302	115	98		87	9.5	13.4	15	3.4	689	1889	182.4	2370	7.19	7.26	16.7	15

PILOT TEST PROGRAM

FRISCO WATER PLANT

Month: APRIL

Membrane		Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	Well #
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Date	Time																				
15-Apr	1500	38	36	37	302	115	99		87	9.5	13.5	15	3.4	686	1922	181.6	2382	7.3	7.19	16.6	15
16-Apr	0730	38.5	37	37	302	114	97		87	9	13.5	15.1	3.7	685	1919	167.9	2380	7.21	7.1	16.1	15
17-Apr	0715	38.5	36.5	36	303	126	112		100	9.5	13.5	15	3.7	690	1975	165.6	2400	7.03	7.14	16.5	15
17-Apr	1530	38	37	36.5	301	120	104		94	9.5	13.6	15.1	3.7	683	1968	163.2	2420	7.35	7.56	16.6	15
18-Apr	0735	38	36	36	302	120	105		94	9.5	13.7	15.1	3.7	681	1971	162.9	2410	7.33	7.32	16.2	15
18-Apr	1535	38	36	36	301	120	105		93	9.5	13.5	15	3.7	679	1975	163.9	2400	7.14	7.29	16.7	15
19-Apr	0725	39	36.5	36.5	303	120	105		94	9.5	13.6	15	3.7	683	1993	165.4	2420	7.17	7.21	16.2	15
24-Apr	1630	37	36	37	300	90	70		55	9.5	11.1	15.1	3.6	705	1526	193.6	2390	7.06	7.2	16.5	15
25-Apr	0730	38.5	37	37.5	302	91	73		56	9.5	11.3	15	3.7	685	1470	171.9	2410	7.11	7.3	16.7	15
25-Apr	1615	35.5	33.5	34	294	110	87		69	10.5	13	17	4.2	683	1515	158.3	2420	7.26	7.09	17.8	15
26-Apr	0710	36.5	34	35	295	110	90		75	10.5	13.5	17	4.2	682	1595	150.9	2390	7.42	7.16	18.1	15
26-Apr	1520	35.5	33	34	295	115	90		75	11.5	13.7	17	4.2	683	1590	159.2	2440	7.21	7.09	18.1	15
27-Apr	0730	36	33	34	290	113	91		75	11.5	13.6	17.1	4.2	689	1605	167.3	2480	7.28	7.11	18.5	15
27-Apr	1530	39.5	36.5	37.5	306	97	82		73	9	12.3	14.8	2.8	691	1590	162.4	2490	7.35	7.21	18.4	15
28-Apr	0730	40	36.5	37.5	305	104	90		81	9	13.2	15	2.6	691	1964	188.5	2770	7.21	7.32	20.3	15
28-Apr	1530	40	36.5	38	305	106	92		85	9	13.3	15	2.6	689	1924	176.2	2715	7.07	7.29	19.8	15
29-Apr	0730	40	37	37.5	306	110	97		90	9	13.5	15	2.7	692	2300	189.5	2850	7.02	7.12	19.9	15
29-Apr	1530	40	36.5	37.5	306	115	103		95	9	13.5	14.9	2.7	688	2350	198.2	2830	7.11	7.09	19.8	15
30-Apr	0745	38.5	35.5	36	305	126	116		109	9	14	15	2.6	621	2420	219	2760	7.01	7.07	19.9	15
1-May	0730	39.5	35	35.5	305	131	121		114	9	13.9	14.9	2.6	699	2490	198.7	2910	7.09	7.31	18.9	15
1-May	1520	39	34.5	35.5	304	145	134		126	9.5	14	15	2.6	686	2480	195.9	2900	7.27	7.21	18.8	15
2-May	0725	39	35	36	305	155	145		140	9	14.2	15.1	2.6	685	2460	201	2900	7.29	7.09	18.5	15
2-May	0830	39	35	36	304	130	120		111	9	14	15	2.7	691	2360	213	2740	7.31	7.21	18.9	15
2-May	1530	39	34	36	305	135	125		120	9	14.3	15	2.5	678	2520	212	2930	7.25	7.23	19.4	15
3-May	0715	39.5	35.5	36	305	140	130		124	10	14.2	14.9	2.6	685	2520	212	2880	7.09	7.07	18.9	15
3-May	1515	39	35	36	305	144	133		126	8	14.4	15.1	2.6	723	2510	248	2850	7.14	7.15	18.8	15
4-May	0720	39	35	36	305	148	138		130	8	14.4	15	2.6	723	2500	248	2820	7.21	7.09	18.8	15
4-May	1600	39	35	36	305	150	140		132	8	14.4	15	2.6	712	2509	240	2800	7.32	7.11	18.9	15
5-May	0730	39	36	36.5	305	150	140		133	9	14.2	14.9	2.6	720	2510	212	2840	7.28	7.1	18.7	15
5-May	1530	39.5	35.5	36.5	305	151	141		134	9	14.2	14.9	2.6	689	2480	218	2800	7.29	7.12	19.5	15

PILOT TEST PROGRAM

FRISCO WATER PLANT

Month: MA Y

Membrane		Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	Well #
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Date	Time																				
6-May	0745	39.5	35.5	36	305	155	145		137	8	14.4	15	2.6	688	2490	244	2810	7.01	7.06	19.3	15
6-May	1515	40	36	36	305	155	145		138	8	14.4	15	2.6	681	2496	246	2819	7.18	7.21	19.6	15
7-May	0730	40.5	36.5	36	305	157	148		140	9	14.1	14.9	2.6	694	2500	239	2860	7.08	7.14	18	15
7-May	1540	40	36	37	305	165	155		146	9	14.5	15.1	2.6	681	2505	246	2870	7.09	7.1	18.4	15
10-May	1530	35	30	30.5	300	121	109		100	8.5	14	15	2.6	741	2510	217	3040	7.12	7.01	18.8	15
12-May	0800	32.5	26	27	295	133	120		114	10	14.1	15	2.6	708	2540	210	2980	7.02	6.99	18.9	15
12-May	1530	32	27	28	295	133	121		114	8	14.5	15	2.6	730	2680	248	3010	6.98	6.89	19.7	15
13-May	0730	30	25	26	295	133	123		115	9	14.4	15	2.6	700	2590	205	2970	7.1	7.01	19.2	15
13-May	1530	30	25.5	26	295	136	126		119	8.5	14.3	14.9	2.7	697	2560	204	2910	7.06	7.1	19.5	15
14-May	0730	30	26	26	295	145	135		129	9.5	14.6	15.1	2.6	697	2580	249	2830	7.03	7.14	18.6	15
14-May	1600	30	26	26	295	148	137		130	9.5	14.4	15	2.6	695	2590	236	2810	7.12	7.08	19.1	15
15-May	0720	30	26	27	295	150	140		132	9.5	14.3	15	2.6	694	2560	207	2870	7.2	6.79	18.6	15
15-May	1520	41	37	38	315	155	145		135	9	14.3	15	2.6	695	2565	230	2810	7.12	7.14	18.5	15
16-May	0730	38.5	24	25	293	153	143		136	9	14.4	15.1	2.6	690	2580	212	3070	7.11	7.06	19	15
16-May	1530	40	36	37	305	140	130		122	9	14.2	14.9	2.6	734	2590	231	3040	7.01	6.96	19.5	15
17-May	1725	28	24	25	295	145	135		125	8.5	14.5	15	2.6	688	2550	216	2930	7.22	6.95	19.6	15
17-May	1515	28	23.5	25	300	150	135		130	8.5	14.4	15	2.6	727	2670	227	3010	7.23	7.09	19.5	15
18-May	0742	28.5	24	25	29.4	149	139		131	8.5	14.4	15	2.6	734	2730	225	3020	7.07	7.22	18.5	15
18-May	1535	40	36	37	305	150	140		133	9.5	14.4	15	2.6	731	2730	225	3060	7.12	7.07	18.4	15
19-May	0730	30.5	26	26	295	154	144		134	9.5	14.5	15	2.6	705	2590	251	3040	7.16	7.19	18.2	15
19-May	1525	30	26	26	295	155	145		137	9.2	14.4	15	2.6	721	2610	259	3010	7.21	7.02	18.4	15
20-May	0730	32.5	28	29	298	154	144		136	9	14.4	15	2.6	693	2570	214	2900	7.09	7.11	18.3	15
20-May	1530	32	28	28.5	297	155	145		137	8.5	14.3	14.9	2.6	730	2720	227	3080	7.22	7.16	18.5	15
21-May	0730	31.5	27	28	298	154	145		137	8	14.4	15	2.6	713	2580	280	3050	7.19	7.21	18.8	15
21-May	1545	31	27	28	300	155	145		135	8	14.3	14.9	2.6	727	2650	234	3040	7.08	7.16	18.6	15
22-May	0730	32	27.5	28.5	299.5	155	145		138	9	14.3	15	2.6	727	2710	231	3050	7.21	7.18	19	15
22-May	1530	31.5	27.5	28.5	299.5	155	145		138	9	14.2	14.9	2.6	736	2670	238	3000	7.06	7.1	19.6	15
23-May	0720	32	28	30	300	155	145		135	9	14.4	15	2.6	730	2655	235	3030	7.08	7.16	19.1	15
23-May	1600	33	28.5	30	300	145	135		130	8	14.6	15	2.6	732	2625	234	3030	7.09	7.18	19.4	15
24-May	0800	33	28	29	297	150	139		131	9	14.3	14.9	2.7	704	2690	213	3010	7.19	7.11	19.7	15
24-May	1530	33	28	29.5	299.5	150	140		132	8.5	14.3	14.9	2.7	711	2700	220	3010	7.16	7.14	19.6	15

PILOT TEST PROGRAM

FRISCO WATER PLANT
Month: MA Y

Membrane		Flux	Recovery	pH
TEST CONDITIONS				

PARAMETER		PRESSURE									FLOW, AquaLynx			CONDUCTIVITY, AquaLynx				pH		TEMP.	
LOCATION		Cart In	Cart Out	Pump inlet	Pump Out	Feed	1st St out	2nd St feed	Conc	Permeate	1st St Perm	Total Perm	Conc	Feed	Interstage	Permeate	Conc.	Feed	Permeate	Feed	Well #
INSTRUMENT		PI-1		PI-2	PI-3	PI-4				PI-6	FE-3	FE-1	FE-2	CE-1	SV-5	CE-2	SV-4	AE-1	SV-7	SV-1	
UNITS		pounds/sq.in. PSI									gallons/minute, GPM			Microsiemens, µS						Deg C	
Date	Time																				
25-May	0740	32	27	28	297	151	140		134	8	14.4	15	2.6	713	2630	242	3000	7.17	7.21	19.2	15
25-May	1525	31	27	36	297	154	145		136	8	14.4	15	2.6	721	2616	256	3100	7.02	7.14	19.8	15
26-May	0725	32.5	28	29	298	154	143		135	9	14.4	15	2.6	701	2620	209	3000	7.05	7.24	18.9	15
26-May	1525	32	28	29	298	155	146		139	8.5	14.3	14.9	2.6	732	2750	219	3050	7.11	7	18.6	15
27-May	0715	32	28	29	298	156	146		139.5	8.5	14.3	14.9	2.6	731	2740	220	3070	7.2	7.11	18.6	15
27-May	1530	32	28	29	298	156	147		140	8.5	14.3	14.9	2.6	730	2730	220	3030	7.17	7.22	18.8	15
28-May	0730	32	28	29	298	156	147		140	7.9	14.2	15	2.6	727	2750	219	3050	7.04	7.19	18.9	15
28-May	1525	32	28	29	298	157	149		140	8	14.3	15	2.6	732	2740	221	3040	7.2	7.21	18.7	15
29-May	0720	32	28	30	300	155	149		140	7.5	14.3	15	2.6	729	2730	225	3050	7.35	7.27	18.9	15
29-May	1540	32	28	30	300	155	148		140	8.5	14.3	14.9	2.6	722	2740	220	3040	7.17	7.24	19.3	15
30-May	1530	28	24	25	294	135	124		117	8.5	14.3	14.9	2.6	747	2690	219	3080	6.51	6.05	19	15
31-May	0725	28	23	24	295	135	125		115	8.5	14.3	14.9	2.6	742	2740	212	3110	6.34	6.3	19	15
31-May	1550	28	23	24	295	135	125		115	8.5	14.3	14.9	2.6	740	2730	220	3100	6.25	6.3	19	15
1-Jun	0740	31.5	25	26	294	142	131		124	9	14.4	15	2.6	701	2650	195.5	2950	6.79	6.56	19.4	15
1-Jun	1540	31	24	25.5	294	153	142		134	8.5	14.5	15.1	2.6	735	2710	218	2990	6.24	6.31	19.1	15
2-Jun	0745	30.5	24	25	295	154	143		135	8	14.5	15	2.6	714	2590	227	3090	6.27	6.32	20.1	15
2-Jun	1530	30	23	24	293	160	150		141	7.7	14.5	15	2.6	739	2610	224	3080	6.21	6.3	20.6	15
3-Jun	0745	30	23	24	293	162	151		145	7.5	14.3	15	2.6	741	2640	221	3090	7.06	7.01	19.8	15
3-Jun	1520	30	23	24	293	164	154		146	8.2	14.3	15	2.6	736	2660	223	3070	7.22	7.07	20.2	15

APPENDIX G

SOUTH HATTERAS ANALYTICAL DATA

DARE COUNTY CAPE HATTERAS WATER TREATMENT FACILITY
Report of Chemical Analysis for CHWP Pilot Project
In-House Lab

Date	Total Hardness (mg/l as CaCO3)		TDS			Chlorides			Iron		Manganese		TOC			% removal
	Feed	Permeate	Feed	1st Stage	Permeate	Feed	1st stage	Permeate	Feed	Permeate	Feed	Permeate	Feed	1s Stage	Permeate	
3/8/2007	220.00	40.00	332.00	45.70	80.10	50.00	15.00	20.00	0.78	0.08	0.059	0.005	14.40	0.865	1.07	92.60
3/9/2007	240.00	42.00	335.00	46.20	82.10	50.00	15.00	20.00	0.91	0.15	0.086	0.011	14.20	0.962	1.23	91.34
3/10/2007	190.00	44.00	332.00	46.30	81.60	50.00	15.00	20.00	1.06	0.15	0.099	0.016	13.90	1.30	1.14	91.80
3/11/2007	180.00	44.00	332.00	46.20	82.10	50.00	15.00	20.00	0.90	0.15	0.091	0.012	13.90	0.974	0.948	93.20
3/12/2007	180.00	42.00	331.00	50.80	84.40	50.00	15.00	20.00	1.07	0.15	0.075	0.016	14.00	1.060	0.982	93.00
3/13/2007	180.00	48.00	327.00	51.50	79.80	50.00	15.00	20.00	1.03	0.20	0.069	0.018	14.00	1.030	0.863	93.90
3/14/2007	170.00	50.00	327.00	50.60	80.60	50.00	15.00	20.00	0.97	0.22	0.072	0.017	14.10	1.320	0.915	93.60
3/15/2007	160.00	50.00	328.00	52.50	82.00	50.00	15.00	20.00	0.99	0.17	0.072	0.019	14.20	1.170	0.913	93.60
3/16/2007	180.00	48.00	334.00	53.30	84.10	50.00	15.00	20.00	1.01	0.16	0.075	0.018	14.00	0.918	0.854	93.90
3/17/2007	180.00	52.00	333.00	54.70	83.60	50.00	15.00	20.00	0.78	0.14	0.091	0.011	13.90	1.210	1.010	92.80
3/18/2007	180.00	50.00	329.00	54.80	83.50	50.00	15.00	20.00	1.13	0.18	0.076	0.015	14.10	1.190	1.030	92.70
3/19/2007	180.00	64.00	333.00	54.80	82.70	50.00	15.00	20.00	1.09	0.180	0.080	0.015	14.00	1.180	1.110	92.10
3/20/2007	200.00	60.00	327.00	54.30	82.00	50.00	15.00	20.00	1.02	0.17	0.081	0.023	14.10	1.100	1.170	91.80
3/21/2007	220.00	54.00	326.00	55.50	83.40	50.00	10.00	20.00	1.06	0.20	0.062	0.013	14.10	1.120	1.150	91.90
3/22/2007	220.00	48.00	328.00	55.30	82.90	40.00	10.00	20.00	1.01	0.18	0.068	0.005	14.00	1.320	1.270	91.00
3/23/2007	200.00	40.00	332.00	57.40	85.60	50.00	15.00	20.00	1.15	0.19	0.062	0.004	13.90	1.350	1.330	90.50
3/24/2007	240.00	46.00	331.00	57.50	85.90	50.00	20.00	25.00	1.16	0.21	0.078	0.017	14.10	1.180	1.270	91.00
3/25/2007	240.00	46.00	326.00	59.40	87.50	50.00	15.00	25.00	1.22	0.21	0.079	0.017	13.90	1.410	1.130	91.90
3/26/2007	240.00	48.00	329.00	59.20	87.20	50.00	20.00	25.00	1.09	0.19	0.075	0.017	14.10	1.330	1.290	90.90
3/27/2007	230.00	42.00	330.00	58.10	87.40	40.00	20.00	20.00	1.06	0.20	0.075	0.016	14.00	1.320	1.180	91.60
3/28/2007	240.00	44.00	332.00	61.20	89.70	50.00	20.00	20.00	1.01	0.17	0.079	0.028	13.90	1.300	1.210	91.30
3/29/2007	210.00	48.00	332.00	61.30	89.60	50.00	20.00	20.00	1.06	0.19	0.074	0.026	13.85	1.400	1.140	91.80
3/30/2007	280.00	50.00	334.00	61.30	89.30	50.00	20.00	25.00	1.08	0.22	0.075	0.015	14.00	1.220	1.160	91.80
3/31/2007	250.00	50.00	334.00	61.20	88.00	50.00	20.00	20.00	1.08	0.19	0.076	0.016	13.90	1.280	1.170	91.60
4/1/2007	260.00	48.00	332.00	61.10	88.20	50.00	20.00	25.00	1.11	0.20	0.077	0.014	14.10	1.320	1.230	91.30
4/2/2007	280.00	48.00	331.00	61.30	89.70	50.00	20.00	25.00	1.16	0.17	0.077	0.011	14.00	1.320	1.190	91.50
4/3/2007	260.00	50.00	334.00	63.00	91.40	50.00	20.00	25.00	1.07	0.22	0.078	0.027	14.00	1.280	1.190	91.50
4/11/2007	250.00	38.00	352.00	48.10	82.10	60.00	20.00	25.00	1.01	0.16	0.060	0.008	13.80	0.786	0.663	95.20
4/12/2007	250.00	36.00	332.00	45.20	77.80	60.00	20.00	25.00	0.99	0.14	0.078	0.014	14.00	0.882	0.786	94.40
4/13/2007	210.00	46.00	334.00	47.20	80.20	50.00	20.00	20.00	0.82	0.14	0.076	0.013	13.50	0.972	0.707	94.80
Average	217.333	47.200	331.633	54.500	84.483	50.000	16.833	21.500	1.029	0.176	0.076	0.015	13.998	1.169	1.077	92.345
Max.	280.000	64.000	352.000	63.000	91.400	60.000	20.000	25.000	1.220	0.220	0.099	0.028	14.400	1.410	1.330	95.200
Min.	160.000	36.000	326.000	45.200	77.800	40.000	10.000	20.000	0.780	0.080	0.059	0.004	13.500	0.786	0.663	90.500

DARE COUNTY CAPE HATTERAS WATER TREATMENT FACILITY
Report of Chemical Analysis for CHWP Pilot Project
In-House Lab

Date	Total Hardness (mg/l as CaCO3)		TDS			Chlorides			Iron		Manganese		TOC			% removal
	Feed	Permeate	Feed	1st Stage	Permeate	Feed	1st stage	Permeate	Feed	Permeate	Feed	Permeate	Feed	1s Stage	Permeate	
4/14/2007	230.00	40.00	335.00	46.30	81.20	50.00	20.00	20.00	0.94	0.12	0.068	0.009	14.00	0.751	0.679	95.20
4/15/2007	220.00	44.00	336.00	46.70	78.90	50.00	20.00	20.00	1.00	0.14	0.085	0.015	13.80	0.731	0.677	95.10
4/16/2007	240.00	38.00	341.00	49.10	84.10	60.00	20.00	20.00	0.98	0.18	0.072	0.011	13.90	0.724	0.658	95.30
4/17/2007	250.00	40.00	334.00	46.40	78.40	55.00	20.00	20.00	1.03	0.13	0.077	0.009	13.80	0.726	0.684	95.10
4/18/2007	250.00	38.00	344.00	47.10	78.20	60.00	20.00	20.00	0.99	0.12	0.071	0.010	14.00	0.711	0.748	94.70
4/25/2007	260.00	40.00	330.00	46.90	80.90	50.00	20.00	20.00	1.16	0.15	0.069	0.008	13.90	0.916	0.769	94.50
4/26/2007	234.00	42.00	334.00	42.20	72.80	50.00	20.00	20.00	0.99	0.16	0.070	0.011		0.788	0.582	
4/27/2007	250.00	40.00	337.00	41.80	74.40	50.00	20.00	20.00	1.05	0.13	0.076	0.006		0.673	0.545	
4/28/2007	220.00	42.00	335.00	50.20	88.60	50.00	20.00	20.00	0.98	0.12	0.081	0.005	6.59	0.960	0.665	90.00
4/29/2007	260.00	38.00	337.00	51.70	89.60	50.00	20.00	20.00	0.96	0.17	0.079	0.009	6.63	0.924	0.854	87.20
4/30/2007	280.00	52.00	334.00	54.80	93.50	50.00	20.00	20.00	1.01	0.17	0.082	0.007	6.83	0.811	0.785	88.60
5/1/2007	250.00	50.00	334.00	56.80	95.00	50.00	20.00	20.00	1.01	0.180	0.080	0.013	6.75	0.762	0.774	88.60
5/2/2007	250.00	44.00	334.00	66.60	101.80	50.00	20.00	20.00	1.01	0.28	0.075	0.016	6.67	1.330	1.270	81.00
5/3/2007	270.00	52.00	335.00	69.20	102.10	50.00	20.00	20.00	1.04	0.22	0.083	0.015	6.67	1.290	1.190	82.20
5/4/2007	240.00	62.00	331.00	68.40	102.30	50.00	20.00	20.00	0.83	0.13	0.073	0.027	6.86	1.480	1.220	82.30
5/5/2007	260.00	56.00	336.00	69.10	102.40	60.00	20.00	20.00	1.03	0.16	0.081	0.012	6.88	1.320	1.210	82.50
5/6/2007	240.00	60.00	338.00	70.90	104.00	50.00	20.00	20.00	0.98	0.19	0.079	0.014	6.88	1.540	1.230	82.20
5/7/2007	250.00	52.00	336.00	68.30	101.80	50.00	20.00	20.00	1.02	0.21	0.079	0.018	6.90	1.340	1.190	82.80
5/10/2007	260.00	62.00	356.00	65.10	102.80	50.00	20.00	20.00	0.31	0.03	0.047	0.017	13.50	1.160	0.859	93.70
5/12/2007	240.00	54.00	356.00	64.60	100.90	60.00	20.00	20.00	0.49	0.04	0.062	0.019	13.60	1.100	0.848	93.80
5/13/2007	250.00	58.00	355.00	66.40	101.80	50.00	20.00	20.00	0.33	0.06	0.049	0.020	14.00	1.140	0.905	93.50
5/14/2007	240.00	52.00	340.00	63.40	97.10	50.00	20.00	20.00	0.39	0.05	0.061	0.017	14.20	1.280	0.923	93.50
5/15/2007	250.00	58.00	333.00	63.90	101.10	50.00	20.00	20.00	1.13	0.02	0.062	0.010	14.40	1.010	0.947	93.40
5/16/2007	250.00	60.00	338.00	63.00	98.60	50.00	20.00	20.00	1.08	0.20	0.071	0.021	14.50	1.310	0.920	93.70
5/17/2007	250.00	60.00	340.00	64.10	98.40	50.00	20.00	20.00	1.11	0.18	0.061	0.020	14.20	1.280	1.140	92.00
5/18/2007	300.00	60.00	356.00	73.30	108.50	70.00	20.00	20.00	0.49	0.10	0.070	0.017	13.50	1.260	1.190	91.20
5/19/2007	280.00	62.00	334.00	67.40	99.90	50.00	20.00	20.00	1.09	0.15	0.081	0.022	14.30	1.450	1.190	91.70
5/20/2007	270.00	62.00	345.00	69.00	103.40	70.00	20.00	20.00	0.89	0.19	0.065	0.021	14.00	1.220	1.160	91.80
5/21/2007	280.00	62.00	336.00	69.40	103.00	60.00	20.00	20.00	0.86	0.21	0.081	0.023	14.20	1.510	1.170	91.80
5/22/2007	270.00	60.00	340.00	69.10	102.60	60.00	30.00	30.00	0.81	0.18	0.071	0.023	13.60	1.510	1.120	91.80
AVG	253.133	51.333	339.000	59.707	94.270	53.500	20.333	20.333	0.900	0.146	0.072	0.015	11.395	1.100	0.937	90.329
MAX	300.000	62.000	356.000	73.300	108.500	70.000	30.000	30.000	1.160	0.280	0.085	0.027	14.500	1.540	1.270	95.300
MIN	220.000	38.000	330.000	41.800	72.800	50.000	20.000	20.000	0.310	0.017	0.047	0.005	6.590	0.673	0.545	81.000

DARE COUNTY CAPE HATTERAS WATER TREATMENT FACILITY
Report of Chemical Analysis for CHWP Pilot Project
In-House Lab

Date	Total Hardness (mg/l as CaCO3)		TDS			Chlorides			Iron		Manganese		TOC			% removal
	Feed	Permeate	Feed	1st Stage	Permeate	Feed	1st stage	Permeate	Feed	Permeate	Feed	Permeate	Feed	1s Stage	Permeate	
5/23/2007	270.00	60.00	273.00	70.10	103.90	60.00	30.00	30.00	1.10	0.22	0.168	0.049	14.20	1.270	1.200	91.60
5/24/2007	260.00	58.00	357.00	68.90	102.70	60.00	30.00	30.00	1.02	0.24	0.079	0.024	13.90	1.250	0.952	93.20
5/25/2007	270.00	60.00	356.00	68.00	104.40	60.00	30.00	30.00	1.06	0.21	0.087	0.029	13.50	1.180	0.914	93.30
5/26/2007	250.00	54.00	338.00	64.30	99.50	60.00	25.00	25.00	0.92	0.18	0.086	0.018	14.30	1.060	0.987	93.10
5/27/2007	260.00	56.00	356.00	68.70	105.70	60.00	30.00	30.00	0.50	0.07	0.065	0.015	13.50	0.993	0.924	93.20
5/28/2007	240.00	54.00	359.00	67.80	102.90	60.00	30.00	30.00	0.87	0.12	0.069	0.016	13.60	1.210	0.930	93.20
5/29/2007	260.00	56.00	358.00	68.60	105.90	60.00	30.00	30.00	0.44	0.06	0.071	0.018	13.40	0.985	0.981	92.70
5/31/2007	250.00	60.00	364.00	66.60	100.50	60.00	30.00	30.00	0.48	0.08	0.060	0.012	13.60	1.090	0.897	93.50
6/1/2007	260.00	50.00	65.60	60.40	93.30	60.00	30.00	30.00	0.98	0.08	0.088	0.018	14.50	0.912	0.926	93.70
6/2/2007	240.00	50.00	359.00	65.60	101.60	60.00	30.00	30.00	0.82	0.10	0.079	0.016	13.70	1.090	0.838	93.90
6/3/2007	260.00	50.00	359.00	67.00	104.20	60.00	30.00	30.00	0.91	0.09	0.830	0.019	13.60	1.120	0.834	93.90
AVG	256.364	55.273	322.236	66.909	102.236	60.000	29.545	29.545	0.827	0.132	0.153	0.021	13.800	1.105	0.944	93.209
MAX	270.000	60.000	364.000	70.100	105.900	60.000	30.000	30.000	1.100	0.240	0.830	0.049	14.500	1.270	1.200	93.900
MIN	240.000	50.000	65.600	60.400	93.300	60.000	25.000	25.000	0.440	0.060	0.060	0.012	13.400	0.912	0.834	91.600