MEMORANDUM

To: Saqib Shirazi, P.E., Innovative Water Technologies, Texas Water Development Board (TWDB)

FROM: Lianfa Song, Ph.D., Texas Tech

SUBJECT: Demonstration of High Recovery and Energy Efficient RO System for Small-Scale Brackish Water Desalination – August 2011

DATE: March 1, 2012

CONTRACT: 1004831107

Recent Project Activities:

During the current quarter, the following project activities have been completed:

1. One additional fouling test has been conducted at a feed salt (NaCl) concentration of 2,500 mg/L (ppm) **and foulant concentration of 200 ppm** and a crossflow velocity of 0.2 meter per second (m/sec). This test was conducted to provide the same range of foulant concentrations for both 0.1 m/sec and 0.2 m/sec crossflow velocities.

   Results of all fouling tests conducted to date are presented below in Figures 1 through 4 on pages 2 and 3. Figures 1 and 2 plot pressure increase vs. recovery for various foulant concentrations at 0.1 m/sec and 0.2 m/sec. When pressure increase is plotted as a function of recovery, the relationships between crossflow velocity, foulant concentration and the onset of fouling are difficult to visualize. However, when pressure increase is plotted as a function of operating time, the impacts of foulant concentration and crossflow velocity are much easier to see. Figures 3 and 4 plot pressure increase as a function of elapsed test time.

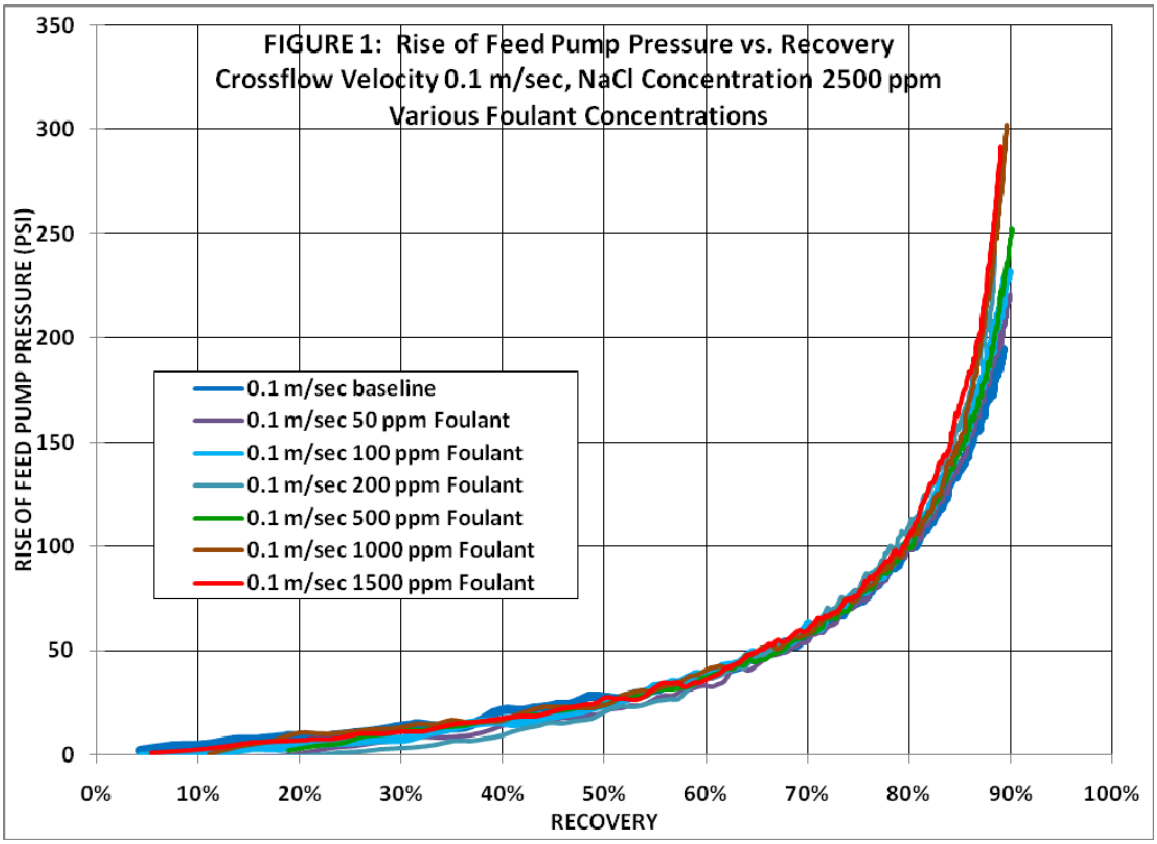
FIGURE 1: Rise of Feed Pump Pressure vs. Recovery
Crossflow Velocity 0.1 m/sec, NaCl Concentration 2500 ppm
Various Foulant Concentrations
RISE OF FEED PUMP PRESSURE (PSI)
RECOVERY
0.1 m/sec baseline
0.1 m/sec 50 ppm Foulant
0.1 m/sec 100 ppm Foulant
0.1 m/sec 200 ppm Foulant
0.1 m/sec 500 ppm Foulant
0.1 m/sec 1000 ppm Foulant
0.1 m/sec 1500 ppm Foulant
0
50
100
150
200
250
300
350
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

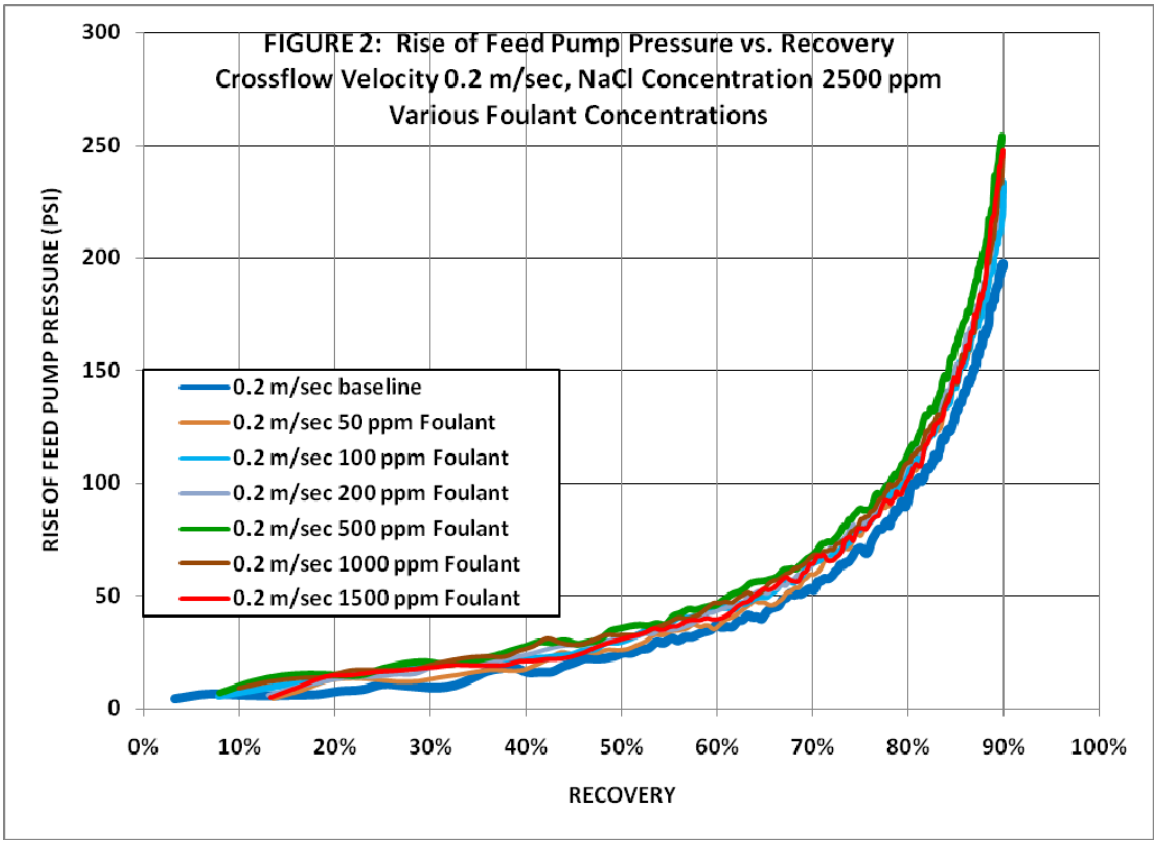
FIGURE 2: Rise of Feed Pump Pressure vs. Recovery
Crossflow Velocity 0.2 m/sec, NaCl Concentration 2500 ppm
Various Foulant Concentrations
RISE OF FEED PUMP PRESSURE (PSI)
RECOVERY
0.2 m/sec baseline
0.2 m/sec 50 ppm Foulant
0.2 m/sec 100 ppm Foulant
0.2 m/sec 200 ppm Foulant
0.2 m/sec 500 ppm Foulant
0.2 m/sec 1000 ppm Foulant
0.2 m/sec 1500 ppm Foulant
0
50
100
150
200
250
300
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

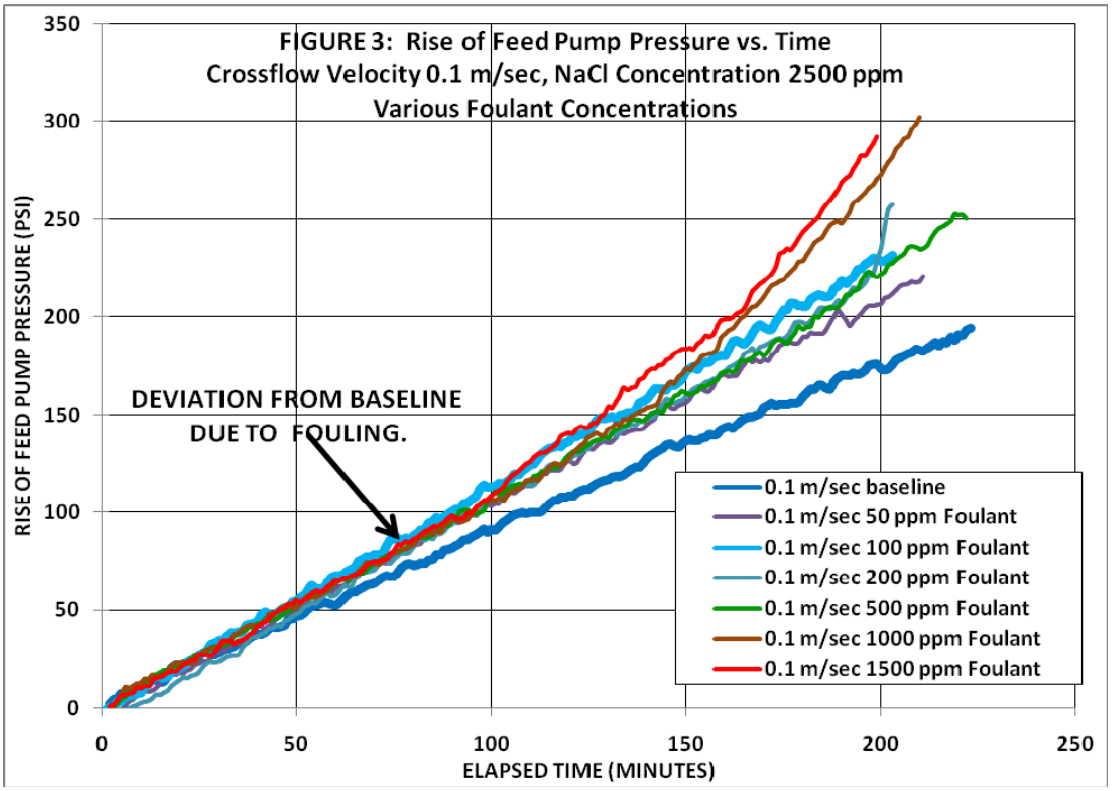
FIGURE 3: Rise of Feed Pump Pressure vs. Time
Crossflow Velocity 0.1 m/sec, NaCl Concentration 2500 ppm
Various Foulant Concentrations
RISE OF FEED PUMP PRESSURE (PSI)
ELAPSED TIME (MINUTES)
DEVIATION FROM BASELINE
DUE TO FOULING.
0.1 m/sec baseline
0.1 m/sec 50 ppm Foulant
0.1 m/sec 100 ppm Foulant
0.1 m/sec 200 ppm Foulant
0.1 m/sec 500 ppm Foulant
0.1 m/sec 1000 ppm Foulant
0.1 m/sec 1500 ppm Foulant

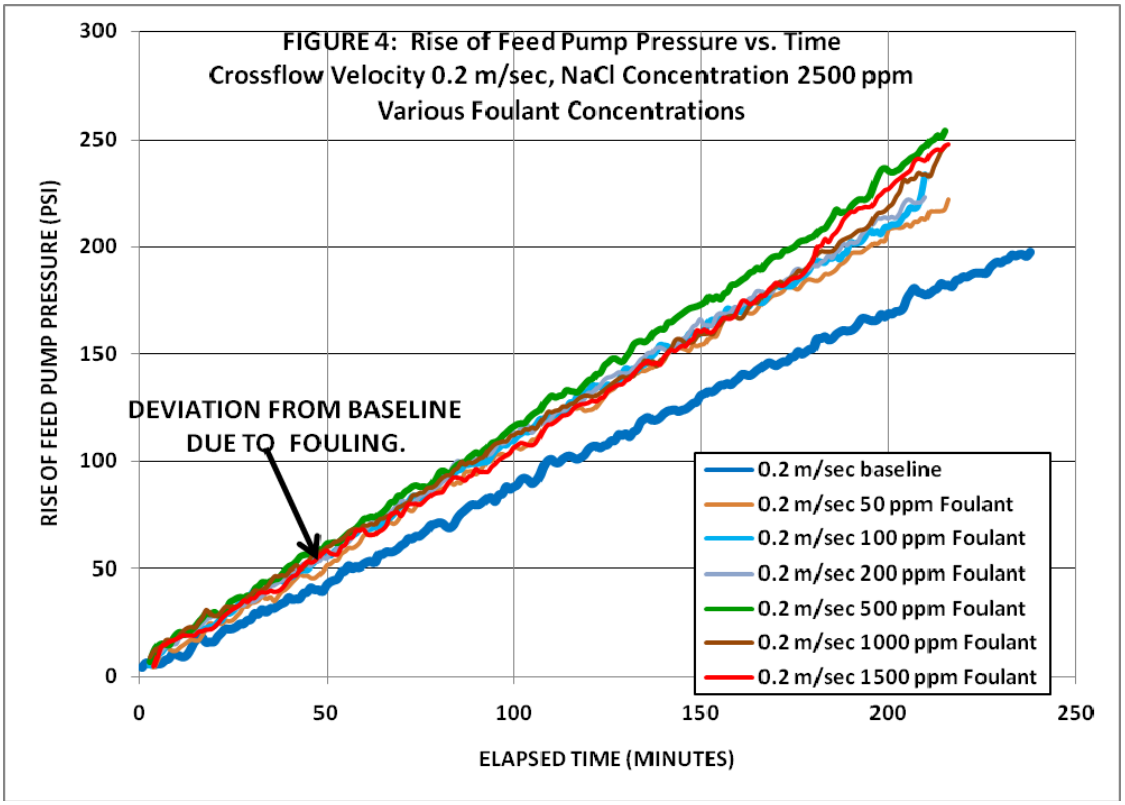
FIGURE 4: Rise of Feed Pump Pressure vs. Time
Crossflow Velocity 0.2 m/sec, NaCl Concentration 2500 ppm
Various Foulant Concentrations
RISE OF FEED PUMP PRESSURE (PSI)
ELAPSED TIME (MINUTES)
DEVIATION FROM BASELINE
DUE TO FOULING.
0.2 m/sec baseline
0.2 m/sec 50 ppm Foulant
0.2 m/sec 100 ppm Foulant
0.2 m/sec 200 ppm Foulant
0.2 m/sec 500 ppm Foulant
0.2 m/sec 1000 ppm Foulant
0.2 m/sec 1500 ppm Foulant

Because raw pressure data is extremely "noisy", 3-minute averaging of pressure readings has been used to present the data. The onset of fouling at both crossflow velocities is marked by a deviation from the baseline pressure (no foulant added) over time. Although deviation from baseline appears to occur slightly earlier in the tests at the higher crossflow velocity (0.2 m/sec), the severity of the deviation and the apparent effects of fouling are much worse after a period of about 3 hours in tests at the lower crossflow velocity (0.1 m/sec). This agrees with what one would expect regarding the impact of crossflow velocity on fouling severity.

The effect of foulant concentration on severity of fouling at the lower crossflow velocity becomes noticeable after about 2 hours, while the effect of foulant concentration at the higher crossflow velocity becomes noticeable after about 3 hours.

Feed pressure increases at 0.1 m/sec crossflow velocity appear to be larger for the test solutions containing 100 ppm and 200 ppm foulant than for the solution containing 500 ppm foulant. One explanation for this anomalous behavior might be increased contact between foulant particles at 500 ppm creating even larger particles and preventing the foulant from entering the void spaces within the membranes. Similar behavior is observed for the test solution containing 500 ppm foulant at the higher crossflow velocity, i.e., 0.2 m/sec. This solution demonstrates greater fouling potential than test solutions containing 1,000 ppm and 1,500 ppm foulant at the higher crossflow velocity.

2. A paper summarizing specific energy data for the experimental RO system and comparing experimental data with published specific energy values for large-scale RO systems is being finalized for journal submission. As described in previous reports, tests have been conducted on feed salt levels of 1,000 ppm, 2,500 ppm and 5,000 ppm NaCl. Feed/permeate flowrates have been varied from 0.4 gpm to 1.0 gpm and recirculation flowrates have been varied from 1.6 gpm to 5.0 gpm.

3. Planning has also been underway for field testing of the RO system at the Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico, using local brackish groundwater.

Issues Encountered:

1. As reported in the previous progress report, the introduction of foulant into the RO system affects its ability to maintain target permeate and feed flowrates. When test solutions contain only dissolved NaCl, the measured permeate flowrate, which equals the target feed flowrate, is within +/- 10% of the target feed flowrate set by the operator. When foulant is introduced, the measured permeate flowrate varies within a much wider range, i.e., +/- 20% of the target feed flowrate.

Items to be Addressed and Anticipated Project Activities:

1. It is anticipated that results of energy consumption studies for the experimental RO system will be submitted to the appropriate journal for publication.

2. Planning for field tests proposed for Summer 2012 at BGNDRF will be completed and testing dates finalized.