CASE STUDY: Reverse Osmosis Pre-Treatment Technology Pilot Trials for Wastewater Recycling at City of Palo Alto Regional Water Quality Control Plant

PURPOSE: The Regional Water Quality Control Plant (RWQCP) produces Title 22, tertiary-treated recycled water for non-potable reuse within California’s Silicon Valley. The RWQCP is planning to reduce recycled water salinity, measured by total dissolved solids, to enable further use of the recycled water for irrigation on salt sensitive landscaping. The RWQCP conducted a feasibility study in 2017 that recommended reverse osmosis for salinity reduction - “Revised Final Advanced Water Purification System Feasibility Study, May 2017” at the City’s Regional Water Quality Control Plant.

This pilot study was conducted to evaluate pre-treatment technologies for future application upstream of reverse osmosis membranes.

PROJECT TEAM:
Phase I: ReNew Water, LLC (Project Sponsor) in collaboration with RWQCP, & Stanford University,
Phase II: Carollo Engineers, Inc. and H2O Innovation, Inc. joined the project team.
Phase III: RWQCP and ReNew Water, LLC

LOCATION: RWQCP, Palo Alto, CA, USA.

TIME FRAME: November 2016 - June 2018.

REVERSE OSMOSIS SYSTEM TESTED: In this pilot, an Ampac USA model AP10K-LX 10,000 GPD brackish water RO system was used for RO testing. This system normally ran at 25% recovery with a short flush every hour during the tests.

PHASE I – CHEMICAL AND OTHER: Done in consultation with Stanford University. Tested combinations of sediment filters, chemical treatment, granular activated carbon and ion exchange that are common on brackish water treatment RO systems.

KEY TASKS PERFORMED: RWQCP tertiary-treated final effluent was treated with stabilized hydrogen peroxide in various concentrations. Sediment filtration, ion exchange and granulated activated carbon were tested.

PHASE I - RESULTS AND SUMMARY: Trials confirmed that ion exchange and granular activated carbon were unsuitable pre-treatment technologies due to significant bio-fouling. Microfiltration and ultrafiltration pre-treatment technologies should be evaluated further.

INITIAL LESSONS LEARNED: Wastewater pre-treatment requires intensive particulate filtering before RO.

PHASE II – MF/UF TESTING:
This part of the trial was done in consultation with Carollo Engineers, (Carollo) and H2O Innovation, Inc. H2O Innovation’s FIBERFLEX™ pilot test skid was used for the open platform MF/UF pilot test. The FIBERFLEX™ open-platform pilot system allows for simultaneous evaluation of different MF/UF modules. H2O Innovation Inc.’s, FIBERFLEX™ Pilot system was controlled by a Rockwell Automation PLC & HMI and data historian, with custom programming to run the test program remotely.

Three hollow-fiber membrane modules loaned to ReNew Water were tested simultaneously:
- MF1, Hydranautics, HYDRAcap Max 60
- UF2, Toray, HFUG-2020AN
- UF3, Toray HFU-2020N

H2O Innovation, FIBERFLEX™
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SUSTAINABLE FLUX RATE FOR EACH MEMBRANE:
Test Cases:
• Low feed turbidity/high flux (no ferric)
• Low feed turbidity/high flux (w/ ferric)
• Variable turbidity/moderate flux (no ferric)
• Variable turbidity/moderate flux (w/ ferric)

IMPACT OF FEED WATER QUALITY ON MEMBRANE PERFORMANCE AND FOULING:
Turbidity above 1.0 NTU resulted in rapid fouling, particularly at elevated flux rates.

METHODS TO ADDRESS PERIODIC WATER QUALITY SPIKES:
Ferric chloride helped manage trans membrane pressure rise during feed turbidity fluctuations.

PHASE II - RESULTS AND SUMMARY:
• The flux ranges of the three systems varied from 20 to 45 gal/ft²/day (gfd). Sustainable flux for each of the three membranes was based upon maintaining a maximum TMP rise of 1 psi/day and keeping MC’s to 3 days per week.
• With low feed turbidity (1 NTU or less) and 2 mg/L ferric chloride addition, all membranes were able to perform at 35 gfd.
• Sustainable fluxes to be considered (low end w/out ferric, high end w/ low feed turbidity and/or ferric feed):
  o MF1, Hydranautics, 20-25 gfd
  o UF2, Toray HFUG-2020AN, 30-35 gfd
  o UF3, Toray HFU-2020N, 25-30 gfd
• For the test duration, the three tested membranes provided a robust barrier to protozoan pathogens (Giardia and Cryptosporidium), with 4 to >5 log reduction with only a few reduced values.
• The new Toray HFUG-2020AN membrane slightly outperformed the other two membranes. Both UF membranes (both Toray) outperformed the one MF membrane (Hydranautics).

PHASE III - RESULTS AND SUMMARY:
The successful toxicity tests provided RWQCP with valuable data for design of the full sized plant. More information can be found in the RO Toxicity Report.

INTERNET OF THINGS (IoT):
Another goal of the pilot trials was to determine what best IoT technology could be used to reliably link the data stream system online.

Some success was achieved by using a cloud platform and a custom application program interface with a website dashboard displaying process data and analytics. Data spikes from the RO’s microprocessor controller’s communication card was a stability issue. At the time of testing the custom cloud platform did not have a data historian interface. As a result, data was duplicated by a Sensaphone™ data logger during the pilot trial.

For info or copy of the complete report contact:
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Final effluent was pre-screened with an Amiad® TAF series strainer. This strainer’s self-cleaning mechanism worked flawlessly and should be used on the full scale project.