Michael D. Norris *is the technical manager for the Bureau of Reclamation's Yuma Desalting Plant and the plant's Salinity Control Research program. He is the director of the Water Quality Improvement Center (WQIC), Reclamation's field test lab on the lower Colorado River. Mike has worked for Reclamation since 1991 in the area of plant engineering and water research. He earned a bachelor's degree in electronic engineering in 1984 from DeVry University.*

RESEARCHING WAYS TO STRETCH WESTERN WATER SUPPLIES

Michael D. Norris, Research Director
and
Angela Adams, Program Analyst
Water Quality Improvement Center
Bureau of Reclamation
Yuma, AZ 85364

HISTORY OF THE YUMA DESALTING PLANT AND WATER QUALITY IMPROVEMENT CENTER

In 1961, Wellton-Mohawk Irrigation and Drainage District (WMIDD) started discharging saline water from drainage wells (average salinity of 6,000 parts per million [p/m]) to the Gila River, which in turn drains into the Colorado River upstream of the Northerly International Boundary (NIB) with Mexico. Also at this time Reclamation was filling Lake Mead in anticipation of the completion of Glen Canyon Dam, so excess deliveries to Mexico were reduced and less water flowed down the Colorado River to dilute the WMIDD return flows. As a result of these actions, the salinity levels in water delivered to Mexico at the NIB increased to, at times, more than 2000 p/m. Mexico's objections to these high salinity levels led to negotiations and resulted in the Colorado River Basin Salinity Control Act. The Act contains two divisions: Title I, for measures taken below Imperial Dam; and Title II, for measures taken above Imperial Dam.

The Act intended to provide measures to ensure the salinity requirements of Minute No. 242 would be met without adversely impacting the seven Colorado River basin states, either in terms of dollars or water resources. The Act authorized, among other things, construction of the Yuma Desalting Plant (YDP) and

a research program into reducing the costs of operating and maintaining the YDP. Reclamation constructed the YDP between 1974 and 1992; salinity control research began at the YDP's test plant in 1989. In 1997, Reclamation expanded the test plant and renamed it the Water Quality Improvement Center (WQIC).

WHAT IS THE WATER QUALITY IMPROVEMENT CENTER?

The WQIC serves as a field site to investigate new and improved technologies, including pretreatment associated with desalination. The intent is to make pilot water research and field-testing more cost effective and practical for entities such as the U.S. Government, desalting researchers, universities, water treatment companies, municipalities, private industries, and foreign governments. The facility's mission is to advance the development and transfer of water purification technologies at its state-of-the-art facility through field tests, hands-on training, and implementation.

WQIC research pilot systems are designed to treat brackish water using both chemical and physical processes. In addition, the Center is configured to supply a variety of feed-waters dissolved-solids range to the pilot systems. These include Colorado surface water, brackish well water, and agricultural drainage water. Focus areas include suspended-solid gravity settling, lime-softening and coagulation, depth filtration, microfiltration, nanofiltration, ultrafiltration, reverse osmosis, and natural organic material precipitation.

WQIC RESEARCH GOALS

The three main goals of the WQIC are to reduce the costs of operating the Yuma Desalting Plant, to support the intention of the Technology Transfer Act, and to support the accomplishment of Reclamation's mission. Deliverables associated with those goals are the following:

- Operate a research and education program that conducts/supports activities that result in reduced YDP operating costs. Results of research are described in project reports published by Reclamation. Successful research is also incorporated into YDP's operations (i.e., high recovery testing identified a process that allows YDP to operate successfully at 80 percent recovery rather than the design-specified 70 percent; this means that for every 100 gallons of feed water, the YDP can recover 80 gallons rather than the original design specification of 70 gallons. This translates to a lower unit cost of production and more "wet" water available to users).
- Partner with other federal agencies, academia, municipalities, and private parties to conduct water quality research that reduces the cost of water treatment, encourages the adoption of desalination or other advanced water treatment technology developed using taxpayer dollars. This benefits the government by creating revenues that flow back to the government, and benefits the public by providing a return on their investment in the form of successfully developed technology put to good purpose.
- Support other federal and non-federal water research and planning activities that will result in a wider-spread adoption of advanced water treatment technologies, since these technologies are a tool of conservation and allow otherwise unusable waters to be recovered and put to beneficial use. By supporting desalination and water quality research and planning activities, the WQIC actively helps Reclamation meet its commitments to deliver water to contracted users.

PUBLICALLY FUNDED LABS WORKING WITH PRIVATE INDUSTRY

The WQIC is a National Center for Water Treatment Technology, initiated by the Bureau of Reclamation, the National Water Research Institute (NWRI), and the U.S. Army. Through the National Centers affiliation, the WQIC opened its doors to the public to conduct water treatment research. Through this public research, Reclamation leverages the WQIC to accelerate improvements in water treatment technology and decreases the federal investment required to conduct research that will benefit the YDP and other reverse osmosis desalination plants.

The essence of the national centers program is the establishment of a network of facilities across the United States accessible to researchers who need a place to test their projects at the demonstration or a pilot-scale level. So far the program has inaugurated seven national centers.

The National Centers' program seeks to advance knowledge about water treatment through more

unified research efforts in the public and private sector. To that end, the program provides financial support to academia, municipalities, federal agencies, and private entities to accomplish water research projects that contribute to improved knowledge about water and wastewater treatment. Researchers can apply for grants of up to $10,000 at any time of the year – NWRI will fund eligible research projects until money for a particular year runs out. Projects should have an environmental, municipal, or industrial application. Researchers must conduct their tests at one of the seven designated national centers across the United States.

CRADAS MAKE PARTNERING EASY

WQIC uses Cooperative Research and Development Agreements (CRADA) to facilitate work with non-federal parties and the government to stretch their research budgets. A CRADA is a relatively simple vehicle and has a streamlined government review process.

A CRADA enables the government and the collaborating partner to share patent and patent rights. This would result in royalties being paid to the collaborating partner, the government, and any federal inventor(s). The partner will retain all rights to the invention if the government is not involved with the development of the invention (i.e., the government only tests the invention).

CRADAs also provide a means for sharing technical expertise, ideas, and information in a protected environment. The federal government will protect from disclosure any information brought into the CRADA by the partner that is identified as proprietary. A CRADA permits the federal government to protect information emerging from the CRADA from disclosure for up to five years, if this is desired by the collaborating partner.

Entering into a CRADA with the government can enable the government to cost-share individual projects. Collaborating partners agree to provide resources that may consist of funds, personnel, services, facilities, equipment, funds, or other resources needed to conduct a specific research or development activity. The federal government agrees to provide similar resources but no funds can be transferred directly to the partner. However, grants, contracts, and other types of cooperative agreements can be entered into with the federal government in which the government can provide funds to the partner. Research and development activities at the WQIC are also offered on a cost reimbursement basis in which the partner agrees to reimburse the government for services, facilities, or other resources provided by the government.

WQIC LABORATORY FACILITIES

The Yuma Desalting Plant Laboratory (YDP Laboratory) operates an onsite, fully staffed and state licensed water laboratory. The lab can conduct drinking water and waste water analyses, bacteriological analyses, and analyses of major inorganic constituents of water. The laboratory is licensed by the Arizona Department of Health Services for drinking water and wastewater inorganic analyses. The laboratory is also EPA certified in Arizona. The lab has the capacity to process more than 10,000 water samples per year. The YDP Laboratory participates in the U.S. Geological Survey, the U.S. Environmental Protection Agency, and Environmental Resource Associates quality control programs.

IN-HOUSE AND PARTNERED PROJECTS

YDP Aluminum-Bronze Life Analysis - High-pressure, low pH flows appear to be corroding YDP equipment fabricated from aluminum-bronze. This equipment includes process piping, pumps, and valves. This project evaluates the ability of various high-carbide stainless steels, high-nickel alloys, and aluminum-bronze to stand up to conditions that occur at the YDP and other brackish water desalting plants. The findings from this study will be used to calculate the expected life of aluminum-bronze fluid-handling equipment at YDP, and will provide information about suitable replacement materials.

Nontoxic Storage of YDP RO Elements - RO membranes stored for use at the YDP are subject to damage by microbiological agents such as bacteria, fungi, and chemicals, cutting short their useful life and increasing plant operating costs. One method of arresting this damage is to store membranes in a biocide. However, this method of storage has problems at all stages – from prep for storage to post-storage handling. This project evaluates the effectiveness of gamma irradiation in providing non-damaging

sterilization of Fluid Systems 12-inch membranes. Results have been promising enough that staff are planning to patent the process.

Maintaining YDP Pretreatment and RO Technologies - When the YDP was designed in the 1970s, the design was based on the most reliable water treatment and desalting technologies available. YDP uses RO desalting and "conventional" pretreatment: partial-lime softening-clarification and gravity filtration. Over the past 20 years, an array of advances in RO pretreatment and RO systems has occurred. These technologies need to be evaluated to determine how suitable they would be for use at the YDP. This research enables YDP not only to comply with legislation on finding ways to run the plant cost-efficiently, but in satisfying that legislation, YDP satisfies its responsibility to taxpayers to protect their investment in the plant.

Chlorine Resistant PA Membrane Study - PA membranes have the disadvantage that chlorine and other oxidizing biocides used in the feedwater can result in irreversible oxidation damage. Chlorine, the most common biocide for water and very effective, must be neutralized to safe levels before contacting such membranes. Commercial PA membranes use 1,3,5 -benzenetricarboxylic acid chloride and m-phenylenediamine with interfacial polymerization to make membranes. By building PA membranes using other acid chlorides and/or amines, chlorine resistance can be designed into membranes on a molecular level resulting in a superior product. The overall goals of the project are:

- Learn how to make acid chloride reproducibly and practically.
- Design supercritical equipment for the *in situ* production of above.

High Purity High Rejection CA membranes (Title I & S&T) - Cellulose acetate membranes continue to hold promise, if certain shortcomings can be overcome, as the preferred polymer for the next generation of reverse osmosis membranes. First of all, the superiority of CA must be recognized over other polymer systems due to its hydrophilic nature and smooth surfaces, which minimize bio-attachment. Also, the polymer is more chlorine resistant than PA membranes and is a less-expensive commercial product. CA membranes are in use with operational pressures of 200 psi. The shortcomings with current CA membranes are due to salt passage that result from irregularities with the polymer.

Data generated thus far clearly demonstrates that a superior CA film can be produced that we believe will have the needed properties to make a higher-rejection membrane. Additional support that our approach is correct can be found in the fact that multiple layers of CA thin films overlaid on each other improved salt rejection from the low values of 94.4 percent to improved values of 99.0 percent. Indeed, this paper reports a salt rejection on one membrane sample tested of 99.81 percent compared with 99.83 percent calculated from Eq. 4 (see paper: Riley, R.L., H.K. Lonsdale, C.R. Lyons, and U. Merten, *J. Appl.Polym. Sci*., 11:2143-2158 (1967).

Desalination Research with Metropolitan Water District (MWD) - MWD's mission is to provide its service area (17+ million consumers in Southern California) with adequate and reliable supplies of high quality water to meet present and future needs in an environmentally and economically responsible way. The Colorado River is a major source of water for MWD. A planning goal at MWD is to meet or exceed the 500 mg/L total dissolved solids secondary USEPA non-health standard. One way to accomplish this goal is through desalination. Since the district is planning to use desalination equipment similar to that used at the Yuma Desalting Plant, Reclamation benefits by partnering with them.

MWD is conducting research associated with various aspects of membrane water treatment. These aspects consist of:

- Evaluation of new, high-performance reverse osmosis (RO) membranes;
- Investigation of hybrid-membrane processes (i.e., combining RO and nanofiltration (NF) membranes) to achieve 90 percent total water recovery;
- Evaluation of high-voltage, capacitor-based technology to prevent colloidal, biological, and precipitative fouling;
- Develop a pilot-scale, membrane crystallizer to minimize brine residuals.

The research project is expected to last for one year. MWD will also be supplying supplemental equipment. Burns & Roe Services Corporation will provide operations and maintenance services.

Somerton Surface and Groundwater Blending Study - In some locations such as Tucson and the Yuma County Foothills area, corrosion problems have

been reported when Colorado River water has been blended with existing well water sources. The City of Somerton is planning to blend Colorado River water with Somerton well water in the near future. This study investigates corrosion issues of the blended water in order to anticipate possible problem areas. The corrosion properties of various materials of construction in the water treatment, distribution, and customer piping areas will be studied. City of Somerton well water, Colorado River water, and blended water will be used to investigate corrosion rates under static and dynamic conditions. The goal of this project is to evaluate the corrosion characteristics of typical materials of construction with City of Somerton water supplies and blends. The effectiveness of water treatment with the addition of corrosion inhibitors and other chemicals will be determined.