



California Direct Potable Reuse Initiative

REPORTING ON SIGNIFICANT PROGRESS

Spring/Summer 2016



Background

The Foundation, in partnership with WaterReuse California, launched the Direct Potable Reuse (DPR) Initiative in June of 2012 to advance DPR as a water supply option in California. This was driven by the establishment of statewide goals for the use of recycled water, and a mandate from the California legislature to come up with a feasibility of DPR criteria study by 2016 to investigate developing uniform water recycling criteria for DPR.

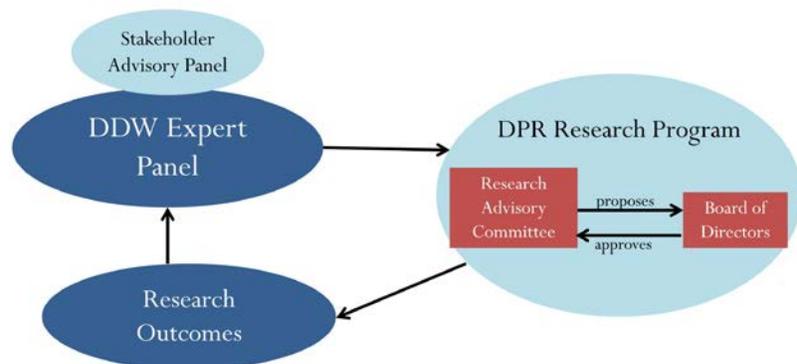
This Initiative was built upon a solid research program that started in 2011 when WRRF began funding research identified in WaterReuse's *Direct Potable Reuse: A Path Forward* publication. That insightful effort informed a DPR Research Needs meeting held in December 2012 which forged the framework of the Foundation's research agenda.

Since 2012, the DPR Initiative has raised over \$6 million for cutting edge DPR research. This includes \$500,000 in matching funds from the Metropolitan Water District of Southern California (MWD) and a partnership with Water Research Foundation for \$600,000. Not included in that total is a \$2.1 million grant from the Department of Water Resources and San Diego County Water Authority for a DPR demonstration project in San Diego launched in September, 2014.

Continued Success

To date, the Foundation has allocated over \$6 million to fund 34 DPR research projects. This important research to address the regulatory, technical, and community concerns facing DPR is valued at over \$20 million.

The California State Water Resources Control Board (SWRCB) has set up an [Expert Panel](#) under its new Division of Drinking Water Programs (DDW) to make a recommendation about the feasibility of developing DPR criteria by 2016. All of the research under our DPR Initiative is made available to the [DDW Expert Panel](#) for their consideration as they navigate the important task of making a recommendation to the State Board by 2016.



Since our last [update](#), there has been significant progress on ongoing and new DPR research projects, including the continuation of our DPR synthesis document to better summarize topics and key concepts for the DDW Expert Panel (WRRF-15-01). This will be key as the panel is now shifting its focus from the first part of their mission (developing criteria for surface water augmentation) to the second (determining the feasibility of DPR criteria).

Since the last update in September, there have been several noteworthy events:

- **Pending WRRF-WERF Merger.** On December 19th, the Boards of Directors of the Water Environment Research Foundation and WateReuse Research Foundation announced that they unanimously agreed to take the steps necessary to merge and integrate. Melissa Meeker was appointed as the Executive Director of WERF, and since has been working with the Boards of Directors to ensure the merger is completed as efficiently and quickly as possible. The announcement of the final decision will be made following a joint Board meeting on May 5/6th – stay tuned!



- **State Water Resources Control Board Research Needs Workshop on October 27-28.** SWRCB, in coordination with SCCWRP, NWRI, and WRRF, hosted a Research Needs Workshop that focused on the state of the science, monitoring techniques, and water treatment reliability for constituents of emerging concern (CECs). The overarching goal of the workshop was to help the State Water Board identify knowledge gaps to better identify and prioritize CEC monitoring and treatment activities that will ensure water supplies from recycled water are protective of public health and the environment. There were 36 research projects generated through expert presentations and breakout groups. Since then, SWRCB has ranked the projects to develop a priority list for potential funding through Prop 1 budget.

- **Second Bioassay Workshop held.** On February 16-17, WateReuse lead a workshop for WRRF-14-15 *Use of in vitro Bioassays to Assess the Safety of Recycled Water and Drinking Water*. Through this interactive workshop facilitated by NWRI, the group



determined projects that will help shape the use of bioassays for the short term (water quality monitoring) and long term (linkage to health effects). The first workshop was held last year in Australia, and the next will be during Singapore International Water Week and facilitated by Ian Law.

- **EPA meeting on potable reuse.** On March 30, WateReuse was invited to EPA to meet with the Office of Ground Water and Drinking Water, including Director Peter Gravatt. They are very interested in our DPR research and the implementation at the state level. Several EPA staff members are participating as PAC members of critical DPR projects, including Phil Oshida on WRRF-15-01. We will continue to engage them, and are pleased that Peter Grevatt is the keynote of our 20th Annual Research Conference on May 23 in Denver.

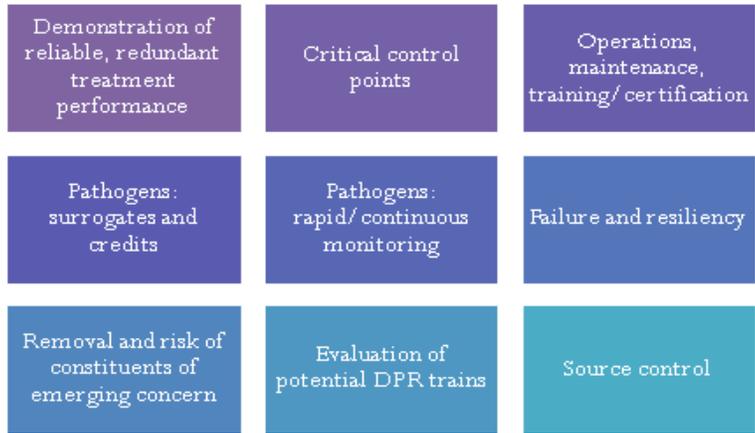
- **Tailored Collaboration Program.** We received many strong pre-proposals in response to our call in the beginning of 2016, including several on potable reuse. This new program will be shared once approved by the Board in early May.

Upcoming Activity

- **20th Annual WaterReuse Research Conference.** This annual event takes place in Denver, CO on May 22-24. Registration is open (advanced closes on May 9th) for this event featuring a strong program of over 45 presentations, 4 panel discussions, and 2 Sunday workshops. Over 50% covers DPR related topics. Keynote speakers are Peter Grevatt (EPA, OGWDW) and Anne Shortell (ED of St. Johns River Water Management District).
- **DPR Principal Investigator meeting.** On May 24, a group of PIs will gather in Denver to discuss the DPR research they are leading and the commonalities and collaborative opportunities between the research. This will be the eighth such meeting, which takes place twice a year.

WRRF-15-01 Status

The goal of this project is to summarize and synthesize DPR results, pulling from outside research where needed, and package this information by topic into a cohesive document. NWRI is administering the project, and George Tchobanoglous is the technical lead and head editor. Expert authors have been assigned to one DPR topic (listed at right) and recently submitted draft chapters that have been reviewed by the PAC and NWRI team and presented to the DDW Expert Panel.



WATER REUSE Direct Potable Reuse Research: Synthesis of Findings

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INTRODUCTION AND OBJECTIVE

- In response to stressed water supplies in some regions of the United States, some communities are looking toward direct potable reuse (DPR), where treated wastewater is used to augment potable water supplies. As interest in DPR grows, there is a need for providing guidance for DPR. To respond, the California Legislature is requiring a report on the feasibility of developing treatment trains for DPR based on a review by an Expert Panel.
- To inform this panel, the WaterReuse Research Foundation launched the DPR Research Initiative in 2012 to advance DPR as a water supply option. This initiative includes 34 research projects valued at over \$20 million.
- The Expert Panel is scheduled to produce a draft report on the "Feasibility of Developing Criteria for Direct Potable Reuse" in 2016. To fulfill its charge and fields the report, the Panel will need the most up-to-date information on current research and activities pertaining to DPR in the United States.

TOPICS ADDRESSED

- UTILITY CONCERNS** (19 projects): How do we address the economic and technical feasibility of DPR? How do we train operators to run these advanced systems?
- REGULATORY CONCERNS** (23 projects): How do we manage treatment and process reliability through redundancy, robustness, and resilience?
- COMMUNITY CONCERNS** (6 projects): How do we increase public awareness of the water cycle and restore the value of DPR to local residents?

KEY ISSUES | FINDINGS BY TOPIC

SOURCE CONTROL PROGRAM

- Identify contaminant sources, business, and industry
- Minimize sources of toxic compounds or protect the watershed
- Evaluate contaminant sources outside those investigated as part of the existing wastewater treatment program
- Contaminant limits found in source waters often times do not match those from commercial or residential sources, such as dairy, metals, NDMA, bromates, and disinfection byproducts

MONITORING OF PATHOGENS

Rapid and continuous monitoring for pathogen detection is a key challenge due to small flow rate, method specificity and the low concentrations of pathogens.

Limited options available for rapid online pathogen monitoring with minimal pathogens in the development of adaptive, intelligent or detecting sensors in water due to size and cost of sensitive technologies, limiting the credits awarded to wastewater reusers.

Smart systems needed include high specificity, rapid time to online capability, high sensitivity, accuracy, and robustness with low false alarm using with verified and validated by the operation and maintenance.

OPERATIONS AND MAINTENANCE

- Early operations activities include startup testing, commissioning, operator training, and final acceptance
- Regulation for operations plans with action and response procedures are needed to support facility flexibility
- Standards for maintenance plans that preserve and manage performance of facilities, equipment, and monitoring are lacking
- Knowledge gaps exist in operator training and certification programs that adequately address wastewater, water treatment, and water distribution within their using a coordinated regulatory approach

POTENTIAL DPR TREATMENT TRAINS

Determine DPR treatment trains based on the following:

- Characterization of source water including variations in flow and load
- Location of design and operation of the WWTP including conditions that can degrade treatment quality for advanced treatment
- Identification of water quality goals and aesthetic requirements
- Identification of multiple treatment barriers for pathogens and organic to meet regulatory requirements and water quality goals
- Costs meet the reliability and redundancy criteria for treatment process, including the ability to address WWTP upsets
- Determine required system security based on WWTP effluent compared to raw water production goals
- Identify water disposal constraints in shipping of high salinity waste
- Determine of space constraints for the construction of treatment train
- Estimate capital and operating costs

CHEMICALS

- Occurrence**
 - Concentrations of Emerging Contaminants (ECs) are present in secondary and tertiary treated recycled water
 - New ECs are expected to be found in the future
- Treatment**
 - Current treatment processes have different efficacy in removing ECs
 - Advanced water treatment does an excellent job in removing the majority of known ECs to achieve detection limits
- Risk**
 - The risks associated with ECs likely come from very low concentrations
 - Devaluation of the risks associated with ECs is greater than the actual risk

FAILURE AND RESILIENCE

- The application of "fail-safe" practices to engineered systems is a relatively new endeavor
- The two required functions of modern systems are (1) recognition of an O/G condition or condition of failure
- With respect to potable reuse, the two main components of failure resilience are (1) failure detection and (2) failure mitigation

PATHOGENS

Improved understanding of pathogen treatment can be made on the following areas:

- Methods to quickly determine the concentration of pathogens or identify serotypes
- Greater understanding of pathogen levels in untreated wastewater and their inactivation/removal through advanced treatment processes
- Improved methods to verify pathogen inactivation and/or removal to have more accurate log removal values or log-inactivation credits
- Improved understanding of the impact of finished water on the presence of opportunistic pathogens in drinking water distribution systems

MONITORING DPR SYSTEMS AND THE CRITICAL CONTROL POINT APPROACH

The transition from indirect potable reuse (IPR) to DPR results in a decreased response time to detect system upset quality.

The critical control point (CCP) approach is a systematic way to identify the risk to human health through monitoring and control of complex water treatment processes for acute health risk and operational parameters.

- Monitoring strategies are now available for DPR, increasing confidence and providing opportunity for improved efficiency

DEMONSTRATION OF RELIABLE, REDUNDANT TREATMENT PERFORMANCE

- Production of high quality advanced treated water can only be achieved through the coupling of reliable and redundant treatment processes
- To achieve relative performance, individual treatment processes must be selected that are known to target specific contaminants for removal
- To achieve redundancy, the entire treatment system must contain multiple barriers for any given contaminant
- A barrier can be technical, operational, or managerial in nature
- Verification of whether a barrier can be used to mitigate or reduce identified human health risks of critical importance. The two main components of failure resilience are (1) failure detection and (2) mitigation

CONCLUSION, NEXT STEPS, AND ACKNOWLEDGEMENTS

- Initial draft of the synthesis findings was presented to the Expert Panel in March 2016. The Board is reviewing the initial draft submission of the research. An updated draft will be submitted in August 2016.
- This synthesis report of all the topics will be completed in August 2016.
- The information will be used to inform regulatory updates in the U.S. and advance research in understanding DPR as a source of water supply.

ACKNOWLEDGEMENT: WaterReuse acknowledges the funding support of Singapore Public Utilities Board as well as the California State Water Resources Control Board under Contract No. 15-05-02 to use the direction of the SWRCB Project Manager, Claire Waggoner.

Outreach on WRRF-15-01

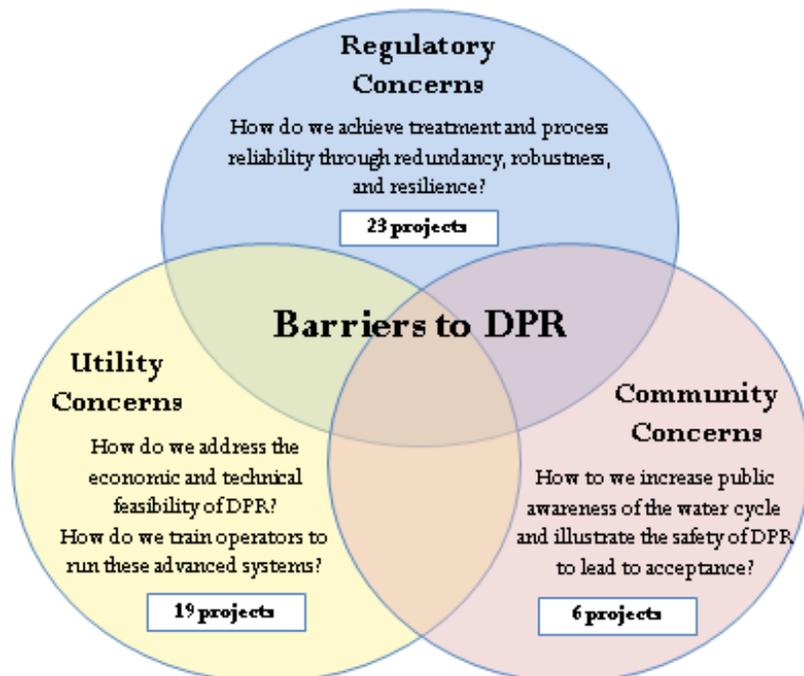
- On March 15, Jeff Mosher presented on the Expert Panel and 15-01 status at the WRCA annual conference in Santa Rosa.
- Melissa Meeker will be presenting a poster summarizing key findings at the Singapore International Water Week in June 2015.
- We will hold a series of webcasts this summer, presenting on 2-3 topics per webcast – please look out for the announcement.

Thank you PAC members:
 Jim Crook, *Consultant*
 Bob Hultquist, *Retired CDPH*
 Jing-Tying Chao, *SWRCB DDW*
 Mark Wong, *Singapore PUB*
 Claire Waggoner, *SWRCB*
 Mike Wehner, *OCWD*
 Serge Haddad, *LADWP*
 Amy Dorman, *San Diego*
 Katie Henderson, *WRF*

**** Thanks to SWRCB & PUB for funding support****

WRRF Research

WRRF has funded numerous DPR projects addressing regulatory (23), utility (19), and community (6) concerns.



Most of the work is in progress; however several reports have been published and are available now. With the new website, each project has a dedicated page providing details on the project and a link to download the report (if available).

Below is a table of research themes identified by the DDW Expert Panel, and the Foundation research that is addressing these important topics.

Project #	DPR vs. alternatives, Economics	Evaluation of potential DPR trains	Demonstration of reliable, redundant treatment performance	Critical Control Points	Pathogens: surrogates, credits	Pathogens: Rapid /continuous monitoring	Failure and resiliency	Public perception and acceptance	CEC removal and risk	Operations Training, Framework	Source Control
WRRF-11-01		x	x		X	x					
WRRF-11-02		x	x		X				X		
WRRF-11-05			x								
WRRF-11-10		x	x				x				
WRRF-12-06		x	x		X	x		x			
WRRF-12-07			x								
WRRF-13-02								x			
WRRF-13-03		x	x	x	X		x				
WRRF-13-12											x
WRRF-13-13							x			x	
WRF4508*			x		X	x			X		
WRF4536*					X						
WRRF-14-01			x		X	x					
WRRF-14-02					X						
WRRF-14-03	x	x									
WRRF-14-08	x										
WRRF-14-10		x	x	x	X	x					
WRRF-14-12	x	x	x	x	X		x		X		
WRA-14-01										x	
WRRF-14-13		x	x		X		x				
WRRF-14-14									X		
WRRF-14-15									X		
WRRF-14-16		x	x	x	X	x	x			x	
WRRF-14-17			x		X	x					
WRRF-14-18					X	x					
WRRF-14-19			x						X		
WRRF-15-01	x	x	x	x	X	x	x	x	X	x	x
WRRF-15-02									X		
WRRF-15-04		x	x								
WRRF-15-05							x			x	
WRRF-15-07					X	x					
WRRF-15-10		x	x				x				
WRRF-15-11		x	x				x				
WRRF-15-13									X		

*funded and managed by Water Research Foundation

Project Status Summaries

Prior to the DPR Initiative's start, the Foundation funded 6 projects valued at \$4M, 4 of which are ongoing.

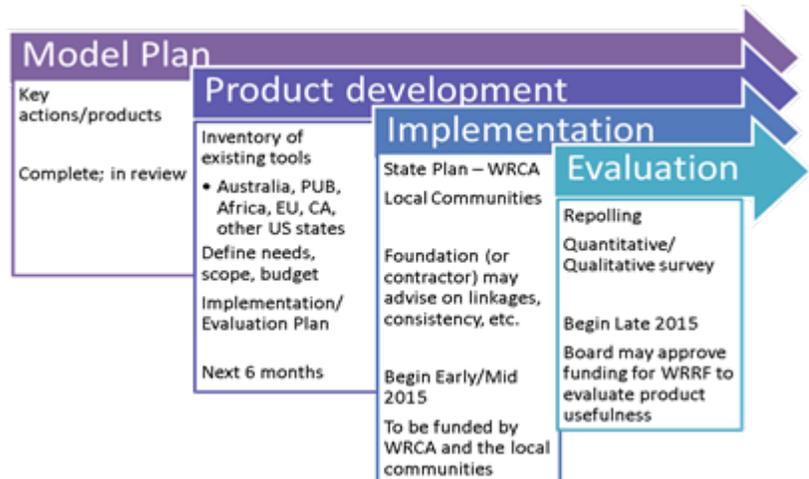
Project #	Research Project Title	Principal Investigator	Expected Publication
WRRF-11-01	Monitoring for Reliability and Process Control of Potable Reuse Applications	Ian Pepper, University of Arizona	Jun-2016
WRRF-11-02	Equivalency of Advanced Treatment Trains for Potable Reuse (early reports: Examining the Criteria for DPR; Potable Reuse: State of the Science Report; Treatment Train Toolbox)	Rhodes Trussell, Trussell Technologies	Jun-2016
WRRF-11-05	Demonstrating the Benefits of Engineered DPR versus Unintentional Indirect Potable Reuse Systems	Glen Boyd, The Cadmus Group Inc	published May-2014
WRRF-11-10	Risk Reduction Principles for DPR	Andy Salveson, Carollo	published Jul-2014
WRRF-12-06	Guidelines for Engineered Storage for Direct Potable Reuse	Andy Salveson, Carollo	Nov-2015
WRRF-12-07	Methods for Integrity Testing of NF and RO Membranes	Joe Jacangelo, MWH	Sept-2016

Projects Initiated in 2013 – funded by the DPR Initiative and the Metropolitan Water District

WRRF-13-02: Communication Plans Increasing Awareness and Fostering Acceptance of DPR

The Foundation and WRCA are taking a three-phased approach to gain public acceptance of DPR in California:

1. Develop Strategic Communication Plans (state and local)
2. Develop Messaging Material and Methods
3. Implement, Evaluate and Refine Plan



As part of Phase I, focus groups and surveys were conducted mid-2014 to develop key messages critical to educational, awareness and outreach efforts. This phase has been accomplished, and the local and statewide communication plans were published in January 2015.

Phase II of this project is to develop and refine outreach tools and informational collateral materials as outlined in the Plans. These products will be available for utilities and other groups for use with their constituents, to educate and inform, and to expand their outreach and awareness programs. Several items are currently available on the website, including a brochure, fact sheets, timeline, guidance and tips for outreach. The global map tool and “think and drink” videos, developed with the Australian Water Recycling Centre of Excellence, is now available on the website. This is an ongoing effort for the Foundation, and additional materials are expected to be developed.

WRRF-13-03: Critical Control Point Assessment to Quantify Robustness and Reliability of Multiple Treatment Barriers of DPR Scheme

Duration: December 2013 – April 2016

The **Hazen and Sawyer** project team (led by Troy Walker and Ben Stanford) is well underway:

To date, the project has followed in the sequence of the HACCP process with a HACCP team convened and critical control points identified in a workshop for both the full advanced treatment

Objectives:

1. Conduct hazard assessment for key unit operations for two or more direct potable reuse (DPR) treatment trains, including the following:
 - a. MF/UF – RO – UV/H₂O₂ – Cl₂ – Engineered Storage
 - b. O₃ – BAC – GAC – UV – Cl₂ – Engineered Storage
2. Develop best design, monitoring, and operational practices by evaluating critical process control points in each of the DPR treatment trains evaluated to meet overall system robustness and reliability.
3. Develop standard design approaches and response strategies (i.e., operations plan and standard operating procedures) to mitigate upset events to strive towards ‘fail-safe’ operation of a DPR plant.

(MF-RO-AOP-Cl₂-Engineered Storage) and alternate non-RO (Ozone/BAC-GAC-UV-Cl₂-Engineered Storage) treatment trains.

A Monte Carlo analysis has been conducted using data from a number of participating utilities including Orange County, Goreangab Namibia, West Basin, and Scottsdale. The project team has developed probability distribution functions for numerous data, and conducted Monte Carlo analysis to determine expected removal distribution across CCP barriers. Full-scale challenge testing was completed at the Scottsdale Water campus with testing conditions and analyses consistent with the procedures described in the original project proposal.

A final report has been submitted and is expected to be published early this summer.

WRRF-13-12: Evaluation of Source Water Control Options and the Impact of Selected Strategies on DPR

The goals are to evaluate upstream wastewater treatment impacts (e.g. N/dN-nitrification/denitrification, industrial source control) on DPR source water quality and DPR process, and to evaluate impact of hydraulic control mechanisms (e.g. flow equalization and source water storage buffers) on influent water quality and flow variations that "stress" the DPR process.

Duration: July 2014 – June 2016

This project kicked off in July 2015, and the **Black & Veatch** project team (PI Alan Rimer) is currently focused on completing the draft report, including literature review and case studies. All four case studies have been completed and are being reviewed by the PAC. A webcast is being planned for the summer.

WRRF-13-13: Development of Operation and Maintenance Plan and Training and Certification Framework for DPR Systems

Duration: May 2014 – April 2016

The contractor-led portion of the project officially commenced on May 5, 2014. The **Hazen and Sawyer** project team is led by Troy Walker and Ben Stanford. The project started with providing detailed reviews of both the local Californian code of regulations and certification & training requirements, respectively. This has provided a useful set of gap analyses prior to engagement directly with utilities to develop case studies on managing within the existing regulatory framework.

The objective of this project is to develop a standard operations and maintenance plan for various DPR treatment processes, including appropriate portions of the upstream secondary wastewater treatment processes providing feedwater to the DPR processes. A DPR Training and Certification framework for DPR system operators will also be developed.

A workshop has been conducted with the City of Los Angeles Bureau of Sanitation at their Terminal Island Facility to both act as a review of our recommendations on DPR regulation and to provide valuable information as to the current operations framework, important items to consider for DPR, and operator certification and training program. The continued development of the operational framework based on review of existing IPR plans (Australia and Orange County). The project team has incorporated modifications to the treatment process schemes as a result of the critical control point (WRRF 13-03) project that is beginning to finish. In addition, this project is coordinating with ongoing efforts from the CA/NV section of AWWA who have an ongoing committee looking at advanced water treatment certification.

A draft report for this project has been submitted and is under review by the Project Advisory Committee.

WRF 4508: Assessment of techniques for evaluating and demonstrating safety of DPR product water

Duration: October 2014 – December 2016

The objectives of this project are to evaluate known techniques/methodologies (and potentially develop new technologies) for the assessment of DPR water safety (work with public outreach group to identify key criteria by which public would evaluate safety); to evaluate the effectiveness of currently accepted and alternative treatment trains for the production of DPR water using the developed techniques; and to develop tools and methods for utilities to demonstrate water safety to the public, elected officials, etc.

This project lead by **University of Arizona and CDM Smith** has been underway for well over a year. A workshop was held in Orange County to evaluate the suite of potential techniques and methodologies for removing microbial and chemical constituents from advanced treated water. The draft report is scheduled for July of 2016 with the final complete by December 2016.

The literature review for this project will be published as a separate document and is expected to be completed early this summer.

WRF 4536: Blending Requirements for Water from DPR Treatment Facilities

Duration: October 2014 – August 2016

This project lead by Andrew Salveson at **Carollo Engineers** has just completed it fifth quarterly report and is in the process of continuing bench testing and operating a pilot facility in Ventura, CA. The project team is also developing a utility survey to gather utility perspectives. The draft report is expected August of 2016 and the final report later in the year.

The objective of this project is to optimize with respect to water quality, the blending of DPR water with existing water supplies based on existing information. Phase II will conduct case studies of selected blending strategies.

Projects Initiated in 2014 – funded by DPR Initiative

There were two rounds of **2014 DPR projects** approved by the Board last year. Two projects have already been published (WRRF-14-08 and 14-20), and all projects are contracted or underway, with the exception of one (14-15).

WRRF-14-01: Integrated Management of Sensor Data for Real Time Decision Making and Response

Duration: May 2015 – November 2017

The objectives of this project are to develop an operations support tool that integrates sensors within the treatment process for immediate feedback/alerts. Existing sensors will be integrated into an early warning system for a Direct Potable Reuse (DPR) treatment process. This will provide a real time sensor network for tracking system performance and key quality parameters using a tool for early detection of system anomalies prior to any compromise in water quality.

An award for this project was made in April 2015 to **Black and Veatch** with a team lead by Jeff Neeman. A contract has been signed and work will begin in May. The second progress report

was recently submitted detailing work on the available software systems, with effort focusing on critical control points (CCP) and critical operating points (COP). Work is continuing on the data requirements and then how this ties into the critical control points and critical operating points. The project team has also met with the City of San Diego to discuss using their PureWater advanced water purification demonstration facility for part of the full-scale demonstration. A brief workshop is being planned by the project team for late April or May.

WRRF-14-02: Establishing additional log reduction credits for WWTPs

Duration: May 2015 – April 2018

The objectives are as follows:

- Obtain more accurate picture of the microbial treatment requirements by addressing the major source of uncertainty—the concentration of pathogens in raw wastewater and secondary effluent.
- Establish if there is any correlation between the number of pathogens in raw wastewater and secondary effluent.
- Establish removal credit for biological treatment provided (e.g., activated sludge) for protozoa, bacteria, and viruses.
- Determine validity of pathogen log-removal requirements identified by CA for potable reuse projects.

An award for this project was made in April 2015 to **American Water** with PI Zia Bukhari. The project officially kicked off on May 1. During this quarter the team continued work on the literature review for the database development, which is due to be completed next quarter. Bench scale work on methods optimization is in progress for two protozoan parasites, and the team is working with the PAC to select sampling sites for the next task in the project.

WRRF-14-03: Methodology for a comprehensive (fiscal/triple bottom line) analysis of alternative water supply projects compared to DPR

Duration: January 2015 – December 2016

An award for this project was made in January 2015 to **Hazen and Sawyer** with a team lead by Ben Stanford along with the University of New South Wales. A workshop was convened on

The objective of this project is to develop and demonstrate an assessment method (spreadsheet, database, or other) to provide information to decision makers in considering the full economic, social, and environmental impacts of a DPR water supply versus other alternative supplies.

Jan 24 in Long Beach, CA, and included US utility partners, project personnel from the US, and Dr. Michalis Hadjikakou from UNSW in Sydney. The workshop provided a valuable opportunity

to present the framework and methodology to our partners, solicit feedback on the criteria being selected to evaluate the water supply options, and discuss what other areas of the model would need to be added to capture the range of diverse utility needs and water supply options. The project team is now focused on developing the triple-bottom line tool and presenting it the case study partners so they can begin completing the analysis of their water supply options.

WRRF-14-08: The Opportunities and Economics of Direct Potable Reuse

The objective of this project is to determine how much DPR will cost in comparison to other sources of water. In addition, this project also looks at the amount of water in California that is potentially available for potable reuse.

Duration: April 2014 – November 2014

This project began in April and was conducted by **Bob Raucher of Stratus Consulting** and **George Tchobanoglous**. The result of this project was a [white paper](#) in which DPR is described and compared – in terms of cost,

technical feasibility, reliability, energy requirements, carbon footprint, and potential yields – to other water supply alternatives. Case study information is also provided, to indicate typical “complete advanced treatment” process flow diagrams and indicate costs and site-specific factors in field applications at the municipal utility scale. This white paper was completed and is available on our website.

WRRF-14-10: Enhanced Pathogen and Pollutant Monitoring of the Colorado Water Municipal Water District Raw Water Production Facility at Big Spring, Texas

Duration: August 2014 – November 2016

Objectives:

- To expand the project scope and statistical accuracy of the state-of-the art sampling campaign for the DPR plant at Big Spring, including trace chemical analyses for pharmaceuticals, hormones, and other compounds of interest, a full suite of pathogens (virus, protozoa, and bacteria), and a comprehensive set of both chemical and microbial indicators and surrogates.
- This large data set will enable the creation of a comprehensive, technically sound, and independent verification that potable reuse, as implemented at Big Spring and proposed by others, can be a safe and reliable source of high-quality drinking water.

This project, led by Eva Steinle-Darling at **Carollo Engineers**, began in August. The project will provide an evaluation of the current treatment process and develop a testing protocol (part of the TWDB funded project).

Four sample events have been conducted per the approved sample protocol, in July 2014, February 2015, June 2015, and September 2015. Summary tables and graphs for the majority of the data collected have been compiled and are being reviewed by the PAC.

WRRF-14-12: Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse

This project will develop and examine a conceptual framework for a DPR facility for the Department of Drinking Water (DDW) and Expert Panel at the City of San Diego's newly upgraded Advanced Water Purification Demonstration Facility (AWPF). This conceptual framework will address issues beyond the treatment plant, such as source control, required operator training and certification, product water delivery and mixing strategies/requirements, as well as a plan to provide an alternative potable water supply in emergency scenarios and to ensure that extreme events do not compromise public health.

Duration: September 2014 – November 2016

A main initial deliverable of this seminal project lead by **Trussell Technologies** is a comprehensive test plan for DPR, which was developed by an Independent Advisory Committee. The DPR demo has been operating for 1 year (April 1 anniversary) at San Diego's Advanced Water Purification Demonstration Facility.

WRRF-14-13: From Collection System to Tap: Resiliency of Treatment Processes for Direct Potable Reuse

An award for this project was made in September 2015 to Sharon Waller of **Sustainable Systems, LLC**. Work began in early October. During the first

The objectives of this project are to assess the resiliency of unit treatment processes while mapping the interdependency of these processes to trace failures and impacts. Both potential acute and chronic impacts affecting performance reliability will be identified including water quality and production capacity along with public health

A design guide will be developed incorporating information from the wastewater source, wastewater treatment, and advanced water treatment assessments including the most practical design features, control systems, maintenance programs, and standard operating procedures.

quarterly progress reporting period, work has focused on the literature review and gap analysis to inform the draft utility surveys that will be used for the three DPR stages: wastewater source, wastewater treatment, and advanced water treatment. The literature review is on-going.

WRRF-14-14: White Paper on the Feasibility of Establishing a Framework for Public Health Monitoring

The objectives of this project are to determine the feasibility of acquiring specific kind of health data required to address the health issues adequately with implementation of DPR; to aid in the planning the means and methods used in collecting the required data; and to recommend on necessary action to move the framework towards implementation.

The PAC and other experts gathered for the project workshop on March 25 in Berkeley, CA. The result of the workshop was a draft outline to be used as a starting point for the white paper. The draft white paper will be submitted in June 2016.

WRRF-14-15: Application of Bioanalytical Tools for a Comparative Assessment of Water Sources for DPR

The purpose is to evaluate applicability of current bioanalytical tools for monitoring of source waters for direct potable reuse (DPR) as well as indirect potable reuse (IPR) projects.

The Foundation coordinated a workshop in Huntington Beach in February 2016, with 25 participants who discussed the current state of research on bioassays and research needs. Future directions were drafted, as well as project

descriptions. These project descriptions will be presented to the Research Advisory Committee in May.

WRRF-14-16: Operational, Monitoring, and Response Data from Unit Processes in Full-Scale Water Treatment, IPR, and DPR

An award for this project was made in June 2015 to **Carollo Engineers** with a team lead by Andrew Salvesson. A

The objectives of this project are to assess the failure mechanisms of potential DPR processes that could impact water quality/health risk and the range of times to a failure event associated with specific unit processes. Qualitative operational information will be obtained regarding failure or anomalous events to better understand failures. Recommendations for improving operational and response procedures will be developed along with potential regulations

contract has been signed and work will began in July. Data collection from utility partners has been collected and sorted for a number of treatment processes and monitoring systems and assessment of the initial data is underway. The key process monitoring points are being assessed for probability distribution to enable a better understanding of the range of performance and system monitoring. This assessment is being conducted in parallel with the beginning of the baseline fault tree analysis. The fault tree analysis involves building a fault tree for each unit process of interest with each failure mode its own branch on the fault tree with associated causes and probabilities of occurrence. The fault tree analysis has begun with baseline performance trends being set prior to beginning process upset simulations.

WRRF-14-17: White Paper on the Application of Molecular Methods for Pathogens for Potable Reuse

Develop a white paper assessing the application and need for using molecular methods for detecting pathogens in evaluating water quality in potable reuse facilities. The white paper will assess the potential applications as well as limitations and challenges to implementation in a purified water matrix.

The project Request for Proposals was released July 9, 2015. Contract negotiation is in progress, and is due to be finalized by the end of April.

WRRF-14-18: Ensuring Stable Microbial Water Quality in Direct Potable Reuse Distribution Systems

This workshop took place November 10-11 2015 at West Basin. Participants discussed whether DPR

Determine if DPR presents unique risks to the stability of the DWDS microbiome due to differences in the seed organisms, the type of organic carbon and other nutrients, and the effect of blending different water types.

presents unique risks to the stability of the DWDS microbiome due to differences in the seed organisms, the type of organic carbon and other nutrients, and the effect of blending different water types. Two project descriptions were developed for review by the Research Advisory Committee. The first would involve cross validation of potential methods. The second would aim to identify unintended consequences of introducing DPR water (sloughing, etc) by testing DPR water alongside a conventional water source from the same place in order to determine what the risks of a DPR system are in comparison to the existing potable water system.

WRRF-14-19: Predicting RO Removal of Toxicologically Relevant Unique Organics

The objectives of this project are to predict removal efficiency of compounds identified by state or federal regulatory agencies of potential public health concern by reverse osmosis (RO), and predict removal of compounds that may be precursors of disinfection byproducts (DBPs) of potential health concern.

The project work officially started in January. An extensive literature review on various QSAR modeling techniques, as well as various rejection studies similar to the bench scale

experiments that will take place to gather data for these models has been completed. The experimental apparatus is being assembled and tested, and bench scale experiments have started. Toxicologically relevant organics have been selected, including a wide range of organic and functional groups covered for a robust QSAR model.

WRA-14-20: Developing a Direct Potable Reuse Framework

Duration: April 2014 – July 2015

The DPR Framework document was officially released at our Symposium and was developed through a collaborative effort between WaterReuse, the American Water Works Association, and the Water Environment Federation through an independent advisory panel administered by the **National Water Research Institute**. The panel, chaired by Dr. George Tchobanoglous, convened over a period of almost two years to identify the subject areas and topics that future DPR guidelines will need to address.

The objective of this project is to develop a framework focusing on issues such as public health protection, sufficient multiple barriers, risk assessment, water quality monitoring, and operation management that states can use to develop guidelines for Direct Potable Reuse.

Projects Initiated in 2015 – funded by DPR Initiative

The 2015 DPR program includes 8 DPR projects, half of which are underway.

WRRF-15-02: Creating a Roadmap for Bioassay Implementation in Reuse Waters: A cross disciplinary workshop

WaterReuse is working with experts in bioanalytical tools for water in Australia and Singapore to properly scope this project to build off of former and ongoing work. This workshop, mentioned above, was the second, and next steps will result from the next international workshop to be held in June 2016 in Singapore.

This project will engage experts that have focused on bioassays in a variety of applications and matrixes (cosmetic, pharmaceutical, oil/gas industry). Federal government regulators that have integrated bioassays into risk assessment will also be examined to identify lessons learned and best practices from previous studies.

WRRF-15-04: Characterization and Treatability of TOC from DPR Processes Compared to Surface Water Supplies

To develop framework for determination of site-specific TOC guidelines for utilities considering alternative treatment for potable reuse and determine the range of acceptable TOC concentrations and characteristics from alternative advanced water treatment approaches on potable water reuse projects.

Proposals are currently under view by the Project Advisory Committee with an award expected to be finalized in early May.

WRRF-15-05: Developing Curriculum and Content for DPR Operator Training

The award has been finalized by the PAC and will be announced this spring.

This project will build on the framework being developed in WRRF-13-13 to create curriculum and content for operator training program in DPR. Curriculum will be developed that can be used by universities and colleges to become a part of their undergraduate training programs.

WRRF-15-07: Molecular Methods for Measuring Pathogen Viability/Infectivity

The aim of this project is to improve sensitivity, reduce analysis turnaround time and reduce cost of measuring pathogens in sewage, treated wastewater and reuse water including IPR and DPR produce water. Ultimately use methods developed in project to replace measurement using viability/infectivity assays, with a specific focus on validating treatment performance and providing starting microbial concentrations for QMRA.

The RFP is currently under development and is expected to be released at the end of April 2016.

WRRF-15-10: Optimization of ozone-BAC treatment processes for potable reuse applications

This tailored collaboration project is led by American Water by Principal Investigator Zia Bukhari. Two rounds of monitoring have been completed to establish a baseline relationship between effluent quality and disinfection by-products formation in systems

This project will establish baseline relationships between ozone-BAC effluent TOC levels and disinfection byproducts (DBPs) and/or their formation potential; To conduct pilot scale testing to optimize BAC design variables to maximize nitrosamines (e.g., NDMA) and emerging contaminants (especially flame retardant) removal; To Develop a comprehensive guidance manual for BAC system operators and regulators.

using RO membranes and ozone-BAC. Analyses were also performed for microbial activity in the biofilters. A tailored questionnaire was sent to all the facilities to capture the operational conditions at the time of sampling. Currently, the project team is working to collect responses to this questionnaire as well as to design and implement the pilot testing system.

WRRF-15-11: Demonstration of High Quality Drinking Water Production Using Multi-Stage Ozone-Biological Filtration (BAF): A Comparison of DPR with Existing IPR Practice

The objectives of this project are to develop a process control strategy for biologically active filtration that can be applied to DPR. This project will integrate the monitoring framework being developed in WRF 4508 and provide an in-depth validation of these tools to provide data allowing rigorous analysis of the practicality and functionality of these monitoring parameters.

This tailored collaboration project is being conducted by a team lead by Denise Funk of the Gwinnett County Department of Water Resources. Since beginning work in August, the HACCP evaluation was completed to inform the development of the research test plan. The research team also designed and procured the pilot equipment

necessary to conduct the study. The research team has developed the draft pilot test work plan along with the literature review, which was reviewed by the PAC. They also collaborated with the pilot equipment vendor to finalize details and review submittals. Site preparations have also been finished to be ready for pilot equipment installation in March.

WRRF-15-13: NDMA Precursor Control Strategies for DPR

This tailored collaboration project is led by Roshanak Aflaki at LASAN. The contract was just executed and the project is expected to start in May.

This project will investigate the fate and transport of *N-nitrosodimethylamine* (NDMA) precursors (e.g. organic nitrogen compounds) through secondary treatment and potential direct potable reuse (DPR) treatment trains and to develop control strategies to optimize removal of NDMA precursors and minimize NDMA formation.

