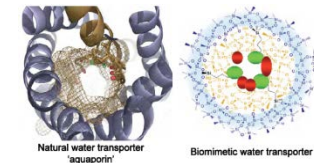
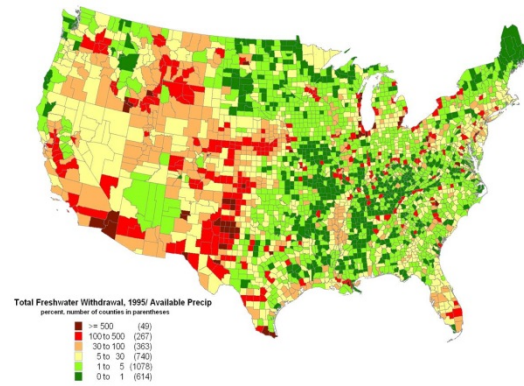


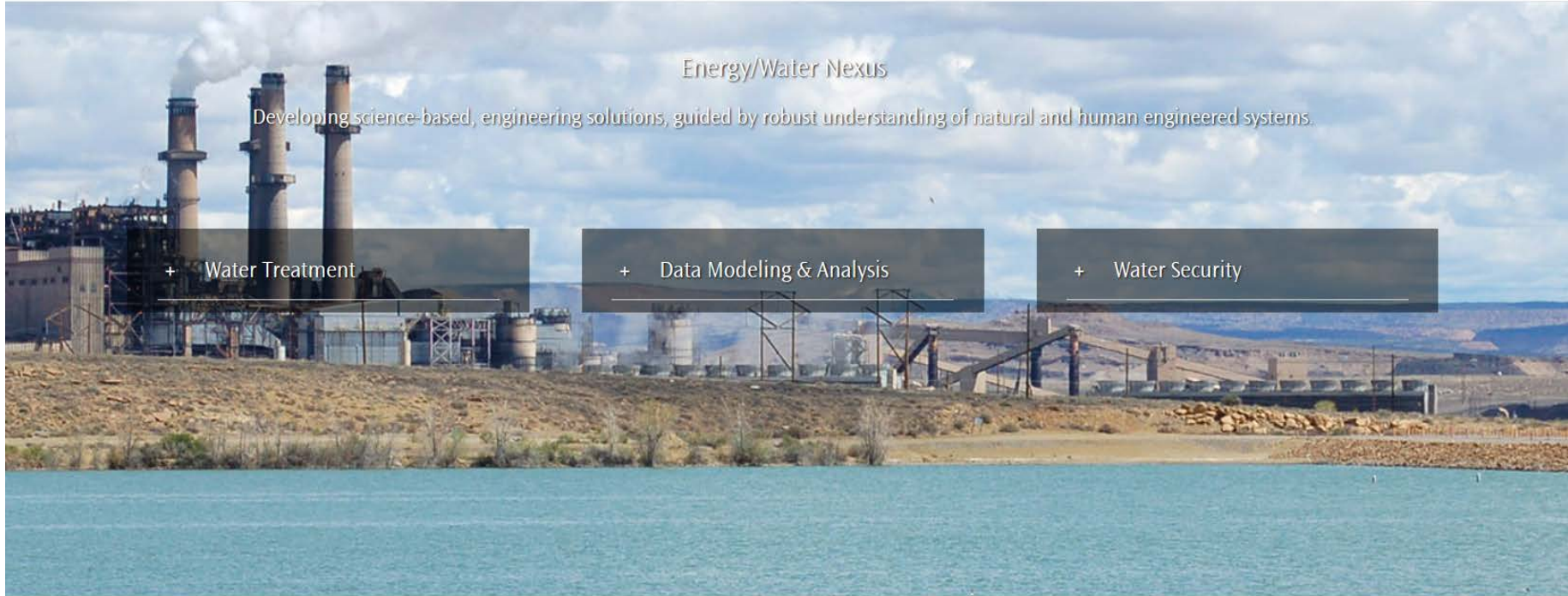
*Exceptional service in the national interest*



# Sandia Water Treatment & Desalination Research, Development & Demonstration

Susan J. Altman, Ph. D.  
Manager, Geochemistry Department

April 18, 2017



### Energy/Water Nexus

Developing science-based, engineering solutions, guided by robust understanding of natural and human engineered systems.

+ Water Treatment

+ Data Modeling & Analysis

+ Water Security

The continued security and economic health of the United States depends on a sustainable supply of both energy and water. The availability of adequate water supplies has a profound impact on the availability of energy, while energy production and power generation activities affect the availability and quality of water. While our supply of water today is largely safe and adequate, we as a nation face increasing water supply challenges in the form of extended droughts, demand growth due to population increase, more stringent health-based regulations, and competing demands from a variety of users.

Sandia's Energy-Water program strives to:

- Increase the safety, security, and sustainability of water infrastructure through the development of advanced technologies that create new water supplies,
- Decrease demand through efficient water use, and
- Provide decision-making tools to the institutions responsible for balancing supply and demand.

Contact: Stephanie Kuzio  
 Energy & Water Program Manager  
 spkuzio@sandia.gov

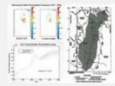
Middle Rio Grande Regional Water Planning Model



2001-2003

Middle Rio Grande EIS Support  
 2002

2004-2006



Water Management Toolbox

2005



Borders as Membranes

2005-2007



Modeling the Gila-San Francisco Basin

2006-present



Upper Rio Grande Simulation Model

2005-2006



Water Quality Monitoring in the Jordan River Valley

2007  
 Libyan Workshop

2007  
 Water Resources Decision Making

2007  
 Algae Testbed Project

2007



New Mexico Dairy Project

2009



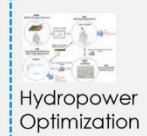
Study of the Willamette Basin, Oregon

2010



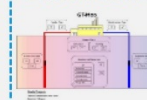
State-wide Climate Study through 2050

2011-2014



Hydropower Optimization

2011-2014



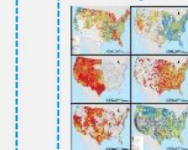
Model for Geothermal Energy Development

2013



Spatially Variant Process Models

2014-present



Energy Water in the Eastern Interconnect

2015



Climate Change Impacts in the Southeast US

2015-2016



Water Atlas

2000 2005 2010 2015 Present

2001-2010



NMSBA Projects Providing Technical Support to New Mexico Small Businesses

2001-2008

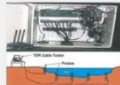


Water Quality Monitoring in Central Asia



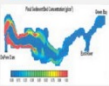
Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL-8500 SAND2017-2218 M

2003-2005



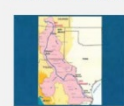
Tool to Evaluate Sediment Transport in Western Streams and Rivers

2002



Evaluation of Contaminants in Rivers

2005-2006



Water Resource Management for the Rio Grande

2005



Global Water Futures

2006



Rainey River Basin Project

2007



Water Leasing Market Design for Mimbres River

2007



Nambe Pueblo Project

2008



Algae Biofuels Project

2008



Sandia-GM Biofuel Deployment Model

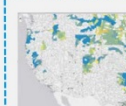
2007-2008



Model for Iraqi Water Planners

2010

2010-2014



Energy-Water Planning in the Western and Texas Interconnections

2010

Algae Biofuels Technology Roadmap

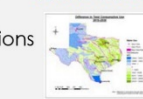


2011-2013



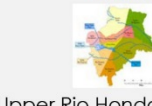
WECSim Model

2012-2013



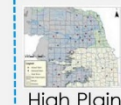
ERCOT Climate Study

2012



Upper Rio Hondo Water Availability Model

2014-2016



High Plains Aquifer Analysis

2014-present

SWaRMS Regional Partnership

2014



National Climate Assessment Energy-Water-Land Chapter

2015



Water Consumption for Energy Production Around the Pacific Rim

2016-2017



Water Sustainability in the Permian Basin Region of New Mexico

# Sandia Water Security Software

Sandia has developed a wide range of simulation and optimization software tools to improve security and resilience of water distribution networks. These tools include:

## **SPOT – Sensor placement optimization tool**

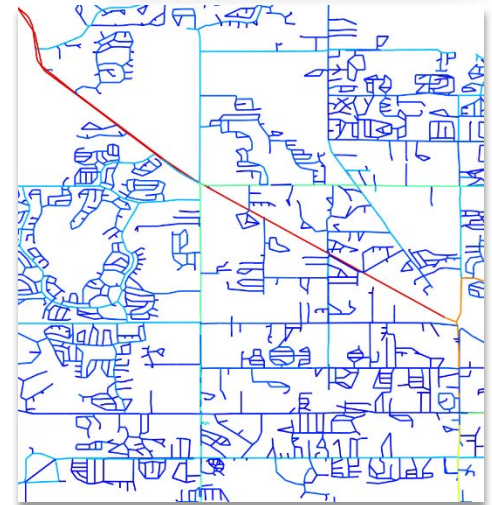
Optimize sensor placement locations in the network to minimize impact. (2008 Edelman Prize, 2008 COIN-OR Cup, used to place sensor in 4 US cities)

## **CANARY – Real time event detection**









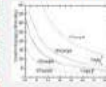

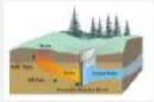
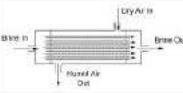

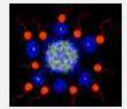


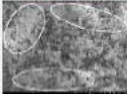


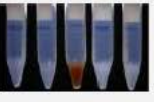



Event detection algorithms for online sensors, alerts water utilities if water quality becomes anomalous. (2010 R&D100 Award, running at Metropolitan Water District of Southern California, and on the Singapore national system)

## **WNTR – Water Network Tool for Resilience**

Simulate and analyze water distribution networks under disaster scenarios. (Release October 2016 on the USEPA GitHub site)



Sandia has been actively working in a broad range of water treatment technical challenges for over a decade

<p>ADVANCED CONCEPTS WATER-TREATMENT PROGRAM BEGINS</p> 	<p>DESALINATION TECHNOLOGY ROADMAPS</p> 	<p>ARSENIC WATER TECHNOLOGY PARTNERSHIPS FORMS</p>  <p>DEVELOPMENT OF NOVEL ARSENIC TREATMENT APPROACHES</p> 	<p>JOINT WATER REUSE &amp; DESALINATION TASK FORCE</p>  <p>METHOD FOR SYNTHESIZING LAYERED DOUBLE HYDROXIDE CAPABLE OF SORBING ANIONIC AND IONIC CONTAMINANTS FROM FLUID</p>	<p>COMMERCIALIZATION OF ZERO LIQUID DISCHARGE PROCESS FOR BRACKISH WATER DESALINATION</p>  <p>BRACKISH GROUNDWATER NATIONAL DESALINATION RESEARCH FACILITY</p> 	<p>MEMBRANES &amp; SURFACES NANO-ENGINEERED FOR PATHOGEN CAPTURE &amp; DESTRUCTION</p>  <p>LOW COST ARSENIC TREATMENT SYSTEM FOR SMALL COMMUNITIES</p> 	<p>MICRO-MIXERS FOR MITIGATING MEMBRANE FOULING</p> <p>NOVEL SILICA REMOVAL STRATEGIES BY WARM LIME SOFTENING</p> <p>BIO-FOULING RESISTANT CERAGENIN-MODIFIED WATER TREATMENT MEMBRANES</p> <p>MEMBRANE TREATMENT OF SIDE-STREAM COOLING TOWER FOR REDUCTION OF WATER REUSAGE</p>	<p>PATENT ON METHOD FOR RECOVERING ALKALI METALS</p>  <p>APATITE PERMEABLE REACTIVE BARRIERS FOR IN SITU REMEDIATION OF URANIUM IN SUBSURFACE OF UMTRA SITE</p> 									
<p>2000</p>	<p>2001</p>	<p>2002</p>	<p>2003</p>	<p>2004</p>	<p>2005</p>	<p>2006</p>	<p>2007</p>	<p>2008</p>	<p>2009</p>	<p>2010</p>	<p>2011</p>	<p>2012</p>	<p>2013</p>	<p>2014</p>	<p>2015</p>	<p>2016</p>
<p>DEVELOPMENT OF SWEEPING GAS MEMBRANE DESALINATION USING COMMERCIAL HYDROPHOBIC HOLLOW FIBER MEMBRANES</p> 	<p>FRONTIERS OF INTERFACIAL WATER RESEARCH WORKSHOP</p> 	<p>PRODUCED WATER PILOT SAN JUAN BASIN</p> <p>CAPACITIVE IONIZATION FOR COAL-BED NATURAL GAS PRODUCED WATER</p> 	<p>IMPLEMENTATION OF THE NATIONAL DESALINATION AND WATER PURIFICATION TECHNOLOGY ROADMAP</p> 	<p>EXPLOITING INTERFACIAL WATER PROPERTIES FOR DESALINATION &amp; WATER PURIFICATION APPLICATIONS</p> 	<p>SELF-SEALING EVAPORATIVE POND LINER</p>  <p>BIOMIMETIC MEMBRANE R&amp;D 100 AWARD</p> 	<p>CRYSTALLINE SILICOTITANATES FOR RADIOACTIVE CESIUM REMEDIATION</p>  <p>COAGULATION CHEMISTRIES FOR SILICA REMOVAL FROM COOLING TOWER WATER</p> 	<p>WASTE WATER FOR POWER GENERATION VIA ENERGY EFFICIENT SELECTIVE SILICA SEPARATIONS</p>  <p>GRAPHENE OXIDE/POLYMER MEMBRANES</p>  <p>MEMBRANE DISTILLATION PROJECT FOR SMALL NEW MEXICO BUSINESS</p> 									
<p>For more information contact: Susan J. Altman, Ph.D. Geochemistry Department sjaltma@sandia.gov</p>		<p>ARSENIC PILOT DEMONSTRATION PROJECTS</p> <p>UV ULTRAVIOLET WATER PURIFICATION SYSTEMS FOR RURAL ENVIRONMENTS AND MOBILE APPLICATIONS</p>	<p>PATENT FOR NEXT-GEN COAGULENT FOR THE REMOVAL OF BACTERIA AND VIRUSES</p>	<p>MEMBRANE DISTILLATION WATER TREATMENT USING POWER PLANT WASTE HEAT</p>												

Sandia has been active

ADVANCED  
CONCEPTS WATER-  
TREATMENT  
PROGRAM BEGINS



DESALINATION  
TECHNOLOGY  
ROADMAPS



## DESALINATION AND WATER PURIFICATION TECHNOLOGY ROADMAP

A REPORT OF THE EXECUTIVE COMMITTEE



Discussion Facilitated by Sandia National Laboratories  
and the U.S. Department of Interior, Bureau of Reclamation

Desalination and Water Purification Research & Development Program Report #95



2000 2001 2002 2003

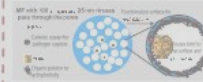
water treatment technical challenges for over a decade

COMMERCIALIZATION  
OF ZERO LIQUID  
DISCHARGE PROCESS  
FOR BRACKISH  
WATER  
DESALINATION

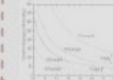
BRACKISH  
GROUNDWATER  
NATIONAL  
DESALINATION  
RESEARCH FACILITY



MEMBRANES &  
SURFACES NANO-  
ENGINEERED FOR  
PATHOGEN CAPTURE &  
DESTRUCTION



LOW COST ARSENIC  
TREATMENT SYSTEM FOR  
SMALL COMMUNITIES



MICRO-MIXERS FOR  
MITIGATING  
MEMBRANE FOULING

NOVEL SILICA REMOVAL  
STRATEGIES BY WARM  
LIME SOFTENING

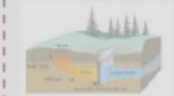
BIO-FOULING RESISTANT  
CERAMENIN-MODIFIED  
WATER TREATMENT  
MEMBRANES

MEMBRANE TREATMENT  
OF SIDE-STREAM  
COOLING TOWER FOR  
REDUCTION OF WATER  
REUSAGE

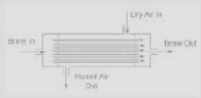
PATENT ON METHOD FOR  
RECOVERING ALKALI METALS



APATITE PERMEABLE  
REACTIVE BARRIERS FOR  
IN SITU REMEDIATION OF  
URANIUM IN SUBSURFACE  
OF UMTRA SITE



2008 2009 2010 2011 2012 2013 2014 2015 2016



DEVELOPMENT OF  
SWEEPING GAS MEMBRANE  
DESALINATION USING  
COMMERCIAL HYDROPHOBIC  
HOLLOW FIBER MEMBRANES



FRONTIERS OF  
INTERFACIAL WATER  
RESEARCH WORKSHOP

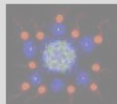


ARSENIC PILOT  
DEMONSTRATION  
PROJECTS

UV ULTRAVIOLET WATER  
PURIFICATION SYSTEMS FOR RURAL  
ENVIRONMENTS AND MOBILE  
APPLICATIONS

PRODUCED  
WATER PILOT  
SAN JUAN BASIN

CAPACITIVE  
IONIZATION FOR  
COAL-BED  
NATURAL GAS  
PRODUCED  
WATER



PATENT FOR  
NEXT-GEN  
COAGULENT FOR  
THE REMOVAL OF  
BACTERIA AND  
VIRUSES

IMPLEMENTATION  
OF THE NATIONAL  
DESALINATION  
AND WATER  
PURIFICATION  
TECHNOLOGY  
ROADMAP



EXPLOITING  
INTERFACIAL  
WATER  
PROPERTIES FOR  
DESALINATION &  
WATER  
PURIFICATION  
APPLICATIONS



MEMBRANE  
WATER TREA  
POWER PLAN

Implementation of the National Desalination and Water Purification Technology Roadmap:  
*Structuring and Directing the Development of Water Supply Solutions*

WATER RESEARCH FOUNDATION WATER REUSE Sandia National Laboratories

WASTE WATER FOR  
POWER GENERATION  
ENERGY EFFICIENT  
SELECTIVE SILICA  
SEPARATIONS



GRAPHENE  
OXIDE/POLYMER  
MEMBRANES



PROJECT  
NEW MEXICO

For more information contact:

Susan J. Altman, Ph.D.  
Geochemistry Department  
sjaltma@sandia.gov



wholly owned subsidiary of Lockheed Martin  
DE-AC04-94AL-8500 SAND2016-12525 M

# Roadmapping

# Efforts to Accelerate Brackish Water Desalination Technology Development

## Brackish Groundwater National Desalination Research Facility (BGNDRF) Alamogordo, NM



- Led effort with Bureau of Reclamation on a Report to Congress for the conceptual design of a national brackish water desalination research facility - 2003
- Supported BOR on final design, construction, and operation - 2004 - 2009

### Clients:



# Fundamental Research



## Broad range of water treatment technical challenges for over a decade

- JOINT WATER REUSE & DESALINATION TASK FORCE
- COMMERCIALIZATION OF ZERO LIQUID DISCHARGE PROCESS FOR BRACKISH WATER DESALINATION
- MEMBRANES & SURFACES NANO-ENGINEERED FOR PATHOGEN CAPTURE & DESTRUCTION
- MICRO-MIXERS FOR MITIGATING MEMBRANE FOULING
- PATENT ON METHOD FOR RECOVERING ALKALI METALS
- WATER REUSE
- METHOD FOR SYNTHESIZING LAYERED DOUBLE HYDROXIDE CAPABLE OF SORBING ANIONIC AND IONIC CONTAMINANTS FROM FLUID
- BRACKISH GROUNDWATER NATIONAL DESALINATION RESEARCH FACILITY
- LOW COST ARSENIC TREATMENT SYSTEM FOR SMALL COMMUNITIES
- NOVEL SILICA REMOVAL STRATEGIES BY WARM LIME SOFTENING
- BIO-FOULING RESISTANT CERAMENIN-MODIFIED WATER TREATMENT MEMBRANES
- APATITE PERMEABLE REACTIVE BARRIERS FOR IN SITU REMEDIATION OF URANIUM IN SUBSURFACE OF UMTRA SITE

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2016



DEVELOPMENT OF SWEEPING GAS MEMBRANE DESALINATION USING COMMERCIAL HYDROPHOBIC HOLLOW FIBER MEMBRANES

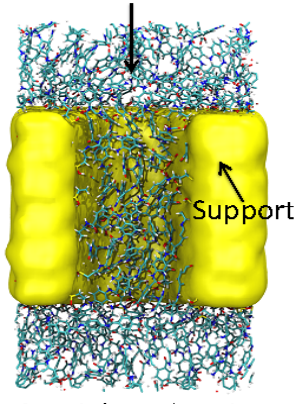
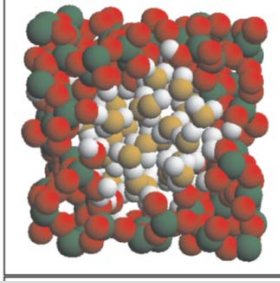
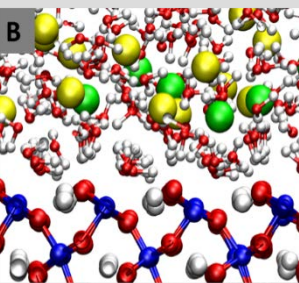
FRONTIERS OF INTERFACIAL WATER RESEARCH WORKSHOP

PRODUCED WATER PILOT SAN JUAN BASIN  
CAPACITIVE IONIZATION FOR COAL-BED

EXPLOITING INTERFACIAL WATER PROPERTIES FOR DESALINATION & WATER PURIFICATION APPLICATIONS

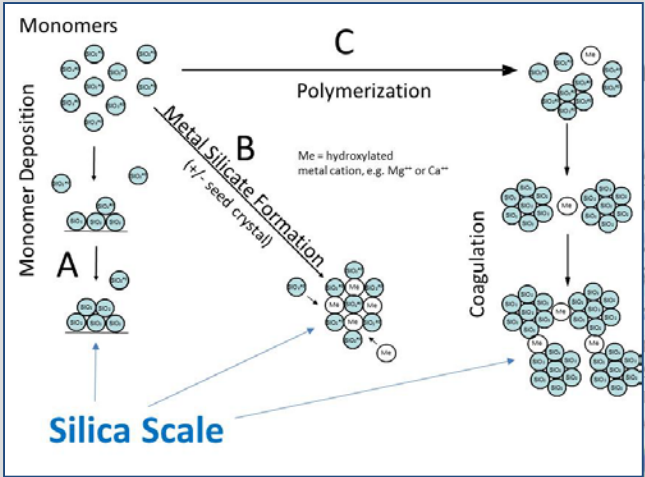
SELF-SEALING EVAPORATION POND

MEMBRANE DISTILLATION WATER TREATMENT POWER PLANT WASTE



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# Silica Removal

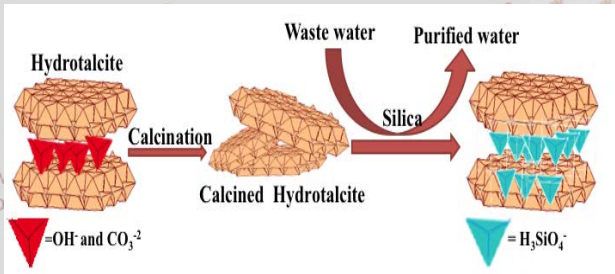


Technical challenges for over a decade

- MICRO-MIXERS FOR MITIGATING MEMBRANE FOULING
- PATENT ON METHOD FOR RECOVERING ALKALI METALS
- NOVEL SILICA REMOVAL STRATEGIES BY WARM LIME SOFTENING
- BIO-FOULING RESISTANT CERAMENIN-MODIFIED WATER TREATMENT MEMBRANES
- APATITE PERMEABLE REACTIVE BARRIERS FOR IN SITU REMEDIATION OF URANIUM IN SUBSURFACE OF UMTRA SITE
- MEMBRANE TREATMENT OF SIDE-STREAM COOLING TOWER FOR REDUCTION OF WATER REUSAGE

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

Silica: Chloride Ratio	% Silica Removed	Silica: Sulfate Ratio	% Silica Removed
1:1	99.0	1:1	99.0
1:5	98.8	1:5	97.0
1:10	98.5	1:10	95.8
1:15	97.9	1:15	95.2
1:20	97.6	1:20	94.8



- WASTE WATER FOR POWER GENERATION VIA ENERGY EFFICIENT SELECTIVE SILICA SEPARATIONS
- USE OF FLUE GAS TO CONTROL SILICA AND CALCITE SCALE IN COOLING TOWERS
- GRAPHENE OXIDE/POLYMER MEMBRANES
- MEMBRANE DISTILLATION PROJECT FOR SMALL NEW MEXICO BUSINESS





# Pilot Testing

Sandia has been actively working in a broad range of water technologies

Sandia National Laboratories  
Challenges for over a decade

ADVANCED CONCEPTS WATER-TREATMENT PROGRAM BEGINS

ARSENIC WATER TECHNOLOGY PARTNERSHIPS FORMS

JOINT WATER REUSE & DESALINATION TASK FORCE

COMBINATION OF ZEPHYRUS DISCOVERY FOR WATER DESALINATION



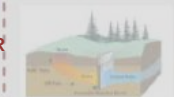
MEMBRANE MIXERS FOR MITIGATING MEMBRANE FOULING

PATENT ON METHOD FOR RECOVERING ALKALI METALS



NEW SILICA REMOVAL STRATEGIES BY WARM SOFTENING

APATITE PERMEABLE REACTIVE BARRIERS FOR IN SITU REMEDIATION OF URANIUM IN SUBSURFACE OF UMTRA SITE



METHOD FOR SYNTHESIZING LAYERED DOUBLE HYDROXIDE CAPABLE OF ADSORBING ANIONIC AND IONIC CONTAMINANTS FROM FLUID

BRACKISH GROUNDWATER NATIONAL DESALINATION RESEARCH FACILITY



LOW COST ARSENIC TREATMENT FOR SMALL COMMUNITIES

FOULING RESISTANT CERAMIC-MODIFIED WATER TREATMENT MEMBRANES

MEMBRANE TREATMENT OF SIDE-STREAM COOLING TOWER WATER FOR REDUCTION OF WATER USAGE

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016



DEVELOPMENT OF SWEEPING GAS MEMBRANE DESALINATION USING COMMERCIAL HYDROPHOBIC HOLLOW FIBER MEMBRANES



FRONTIERS OF INTERFACIAL WATER RESEARCH WORKSHOP

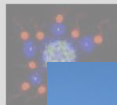


ARSENIC PILOT DEMONSTRATION PROJECTS

ULTRAVIOLET WATER TREATMENT SYSTEMS FOR RURAL COMMUNITIES AND MOBILE APPLICATIONS

PRODUCED WATER PILOT SAN JUAN BASIN

CAPACITIVE IONIZATION FOR COAL-BED NATURAL GAS PRODUCED WATER



PATENT ON COAGULATION SYSTEMS FOR REMOVING BACTERIA



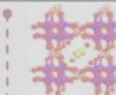
EXPLOITING

ROADMAP

SELF-SEALING EVAPORATIVE LINER



BIMIMETIC LINE R&D AWARD



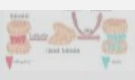
CRYSTALLINE SILICOTITANATES FOR RADIOACTIVE CESIUM REMEDIATION



COAGULATION

USE OF FLUORIDE GAS TO CONTROL SILICA AND CALCITE SCALE IN COOLING TOWERS

WASTE WATER FOR POWER GENERATION VIA ENERGY EFFICIENT SELECTIVE SILICA SEPARATIONS



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# Sandia Water Treatment Partnerships: Past and Present



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