WESTCAS

The Western Coalition of Arid States

Report on National WateReuse Symposium: *What I Learned on my Summer Vacation*

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carollo

Engineers...Working Wonders With Water™

2011 Symposium at Sheraton Wildhorse Pass in September

Resources

1. Contact Guy for specific papers
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2. All presentations can be found at:
   https://www.watereuse.org/conferences/symposium/26/presentations

Topics Covered at Symposium

1. Use of Ozone in Water Reclamation
2. Pharmaceuticals, PCPs, and other Unregulated Substances
3. Financing Reuse & Desal Projects
4. Potable Reuse
5. The Energy/Water Nexus
6. Challenges to Long-Term System Operation
7. Alternative Drivers of Reuse
8. Public Education & Outreach
9. Planning for Reuse
10. Environmental Enhancement with Reuse

Topics Covered at Symposium

11. Creative Technology and Procurement Solutions
12. State, National, & Global Reuse Regulatory Issues
13. Advanced Disinfection Technologies
14. Health Effect Studies
15. Groundwater Issues
16. Membrane Bioreactors & Membranes
17. Desalination Case Studies & Future Direction
18. Brine Management
19. Produced Water
20. Membrane Innovation and Troubleshooting

Pharmaceuticals, PCPs, and other Unregulated Substances

1. Utilization of Microconstituents and Stable Isotope Ratios as Markers for Nutrients Originating from Water Reuse Plant Effluents (Joan Oppenheimer, MWH)
2. The List of Lists - Searching for the Best Indicators of Wastewater Impact (Andrew Eaton, MWH Labs)
3. Trace Organic Compound Removal in Biological Wastewater Treatment (Tanja Rauch-Williams, Carollo Engineers)
4. Attenuation of PPCP/EDCs through Golf Courses Using Recycled Water (Mike McCullough, Northern California Golf Association)
5. Considering UV AOP for Direct Potable Reuse: A New Set of Criteria (Erik Rosenfeldt, Hazen and Sawyer)
6. Scale Up of UV AOP Reactors from Bench Tests Using CFD Modeling (Keith Bircher, Calgon Carbon Corporation)

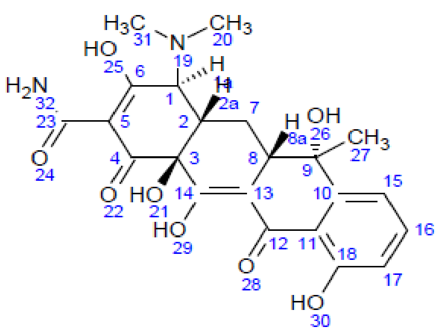
The List of Lists - Searching for the Best Indicators of Wastewater Impact (Andrew Eaton, MWH Labs)

1. Argued that “short lists” that are out there are not sufficient to ID WW influence on receiving water
2. More is better – there are multiple unique tracers of different sources
3. Developed “on-line” LC-MS-MS method to test as many analytes as possible
4. A longer list, with more tracers that show less variation among plants and over time, can be used to better identify both the “presence” of wastewater in a receiving water, and possibly the ultimate source of the impact.

MWH Online Method for Simultaneous Extraction and Analysis of 90+ Analytes

This encompasses lots of categories of compounds (not just drugs) and 3 broad classes (pharma, ww indicators, and pest/herb)

1. Hormones
2. Pharmaceuticals:
   - Antibiotic
   - Anti-inflammatory
   - Lipid regulating agents
   - Triazides
   - Antagonists
3. Personal care products
   - Sunscreen agents
   - Preservatives
4. Pesticide/Herbicides
   - Including EPA 536 compounds -Triazines and their degradates.
5. Flame retardants
6. Stimulants
7. Sugar substitutes (sucralose, acesulfame-k)



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There is Singificant Overlap Amongst The "Lists" for Potential Indicator Compounds

Compound	SAWPA	SWRCB CEC	NWRI	WaterRF 4167	Online Method
Acetaminophen	Yes	No	No	Yes	Yes
BPA	Yes	No/Yes	No	Yes	Yes
Caffeine	Yes	Yes	No	Yes	Yes
Carbamazepine	Yes	No/Yes	No	Yes	Yes
DEET	Yes	Yes	No	No	Yes
Diuron	Yes	No	No	No	Yes
Estradiol	No/Yes	Yes	No	Yes	Yes
Ethinyl Estradiol - 17 alpha	Yes	No	No	Yes	Yes
Gemfibrozil	Yes	Yes	No	Yes	Yes
Ibuprofen	Yes	No	No	Yes	Yes
Iopromide	No	Yes	No	No	Yes
Primidone	No	No	Yes	Yes	Yes
Sucralose	No	Yes	No	No	Yes
Sulfamethoxazole	Yes	No	No	Yes	Yes
TCEP	Yes	No/Yes	No	No	Yes
Triclosan	No/Yes	Yes	No	Yes	Yes

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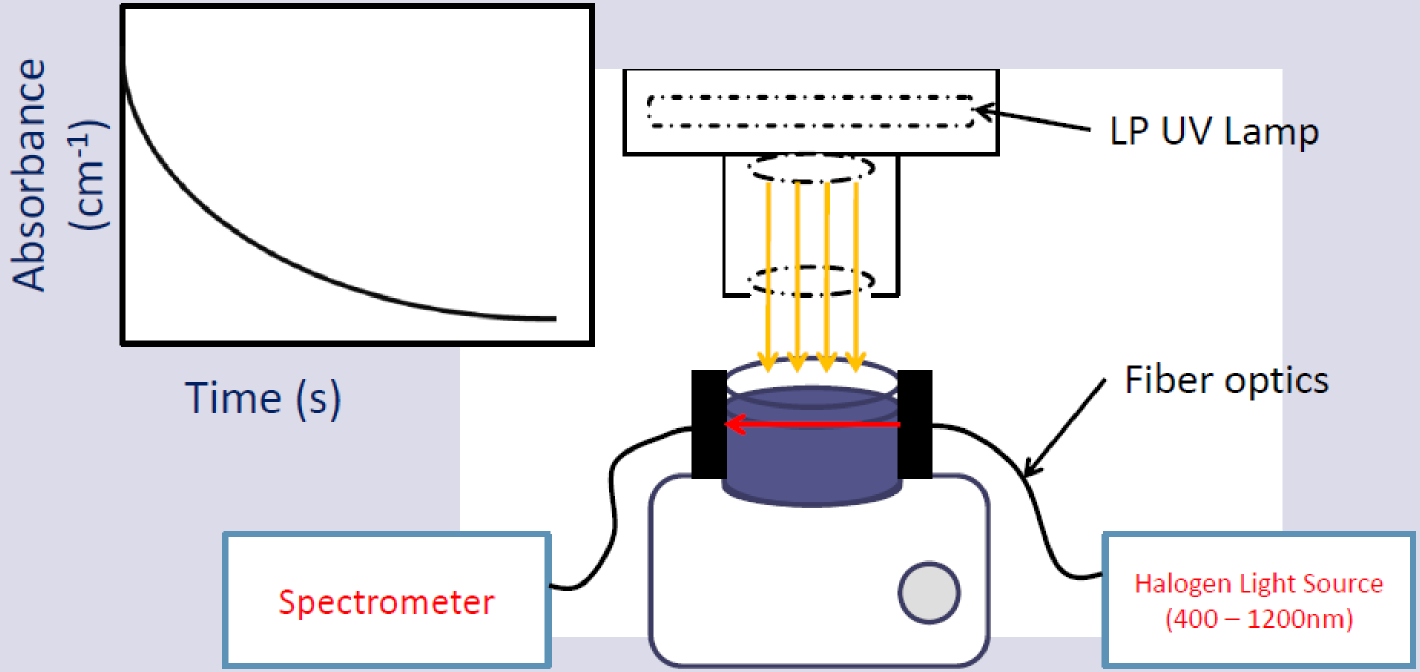
Considering UV AOP for Direct Potable Reuse: A New Set of Criteria

Erik Rosenfeldt, Hazen and Sawyer

1. UV AOP in Direct Potable Reuse is a viable option, particularly when nitrosamines are of concern
2. UV AOP for DPR has unique challenges
   a. Possible to “overdose” H2O2
   b. Nitrogen/Chloramine species scavenging
   c. Defining Scavenging
   d. Determining appropriate challenge compounds
3. Understanding the fundamentals of UV AOP, beyond what we know about UV Disinfection, is key to smart implementation of UV AOP for reuse applications
4. Developed a new on-site scavaging analysis method called Rapid Background Scavaging (RBS)

2.0 Scavenging Factor

- New method: Rapid (portable) measurement of background scavenging



Measure rate of dye oxidation as a function of increased H_2O_2 indicates amount of background scavenging present in the water.

Potable Reuse

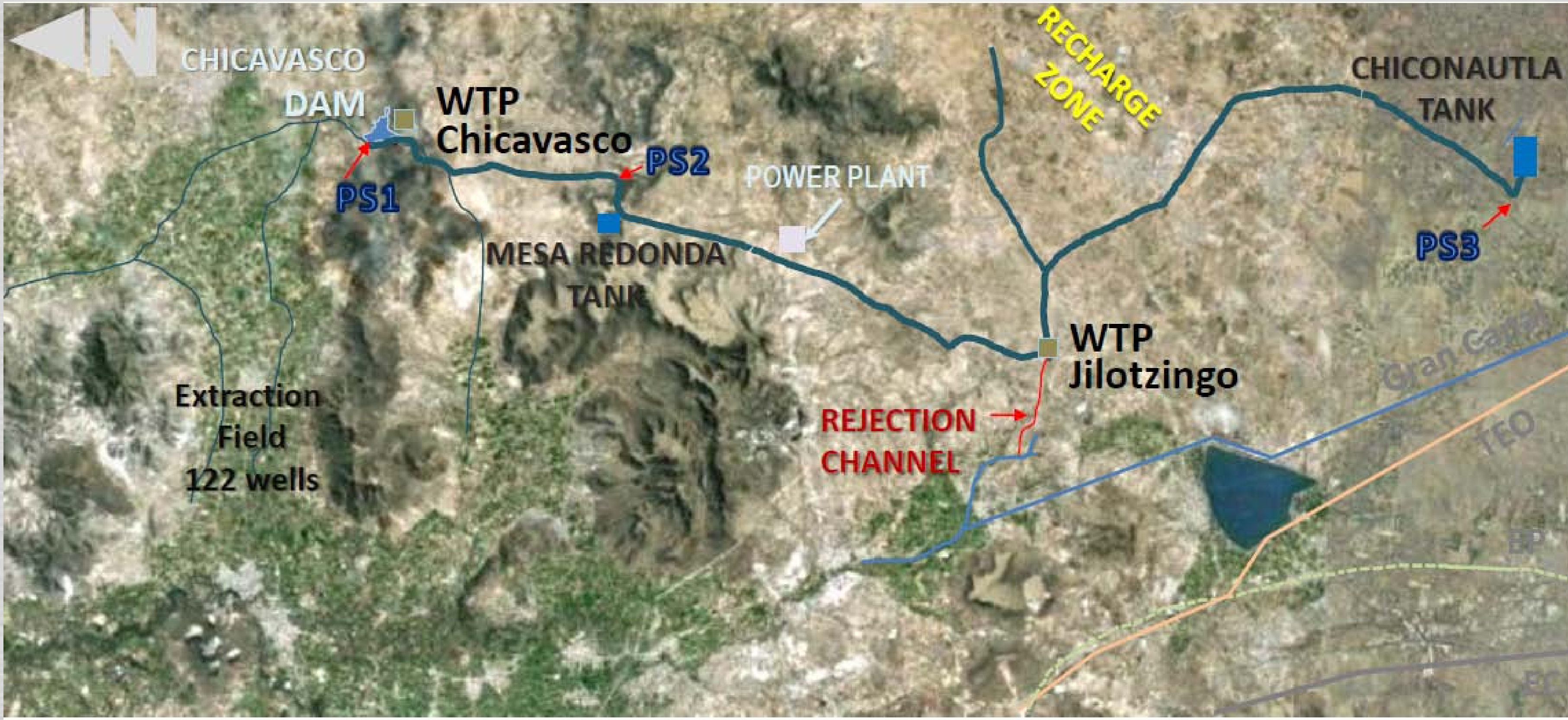
1. A Framework to Design Monitoring Programs for Compounds of Emerging Concern in Recycled Water (Jorg Drewes, Colorado School of Mines)
2. Mezquital Valley Aqueduct: Intensive Water Reuse in Mexico (Fernando Gonzalez-Villarreal, FG & Associates)
3. Indirect Potable Reuse Versus Potable Reuse – What’s the Difference? (Bruce Chalmers, CDM)

A Framework to Design Monitoring Programs for Compounds of Emerging Concern in Recycled Water (Jorg Drewes, Colorado School of Mines)

1. Done from California (Title 22) perspective
2. Decision making framework to prioritize CECs now and in the future
3. Application of framework to CA projects (what to monitor, where)
4. Monitoring recommendations and interpretation

ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/CECpanel/CECMonitoringInCARecycledWater_FinalReport.pdf

Mezquital Valley Aqueduct: Intensive Water Reuse in Mexico (Fernando Gonzalez-Villarreal, FG & Associates)



Mexico City →

PS – PUMPING STATION
WTP – WATER TREATMENT PLANT

Indirect Potable Reuse Versus Potable Reuse – What's the Difference? (Bruce Chalmers, CDM)

1. What is Direct Potable Reuse
2. Regulatory Requirements for Direct Potable Reuse
3. Required Treatment Processes
4. Risk versus Costs
5. Public Acceptance
6. Available Resources

Summary

- The definitions if IPR and DPR are still developing
- The environmental barrier is what separates DPR from IPR
- There are a small number of DPR facilities in the world
- Regulatory requirements are not developed but would probably be the same or stricter than IPR
- Treatment schemes vary, but will require multiple barriers
- Increased risks due to elimination of environmental barrier
- Costs will probably be less since no 2nd WTP is required
- Public acceptance will depend on the need for the project
- Start small and prove the technology and health safety
- “Make IPR commonplace and DPR will come”

What is Direct Potable Reuse
Goreangab WTP, Windhoek, Namibia

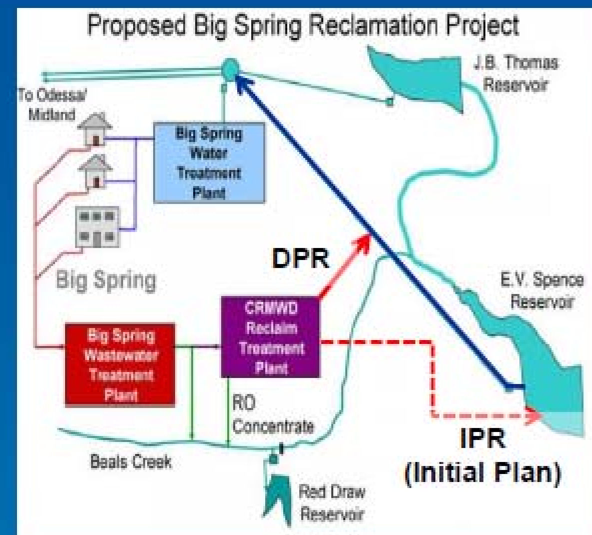
- Type: Direct potable reuse
- Capacity: 5.6 mgd
- WRP: PAC/pre-ozonation/coag-floc/DAF/filtration/ozone/BAC/GAC/UF/disinfection
- WTP: coag-floc/DAF/filtration/GAC/disinfection
- Discharge Facilities: lake/pot. distrib.
- Status: Operational in 1969/2002
- Up to 50% of potable water demand
- No industrial discharges

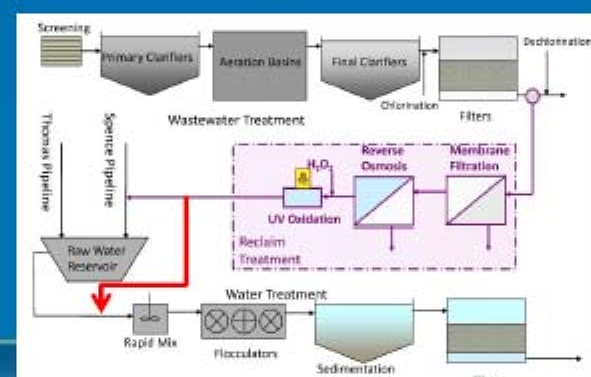
What is Direct Potable Reuse
PUReWater Project, Village of Cloudcroft, New Mexico

- Type: Direct potable reuse
- Capacity: 0.1 mgd
- WRP: MBR/RO/UV-A
- WTP: UF/UV disinfection/GAC
- Recharge Facilities: lake
- Cost: $3.5M ($9/1000 gal)
- Status: Operational in 2011
- Up to 50% of potable water demand
- 1st DPR in the US

What is Direct Potable Reuse
CRMWD, Big Springs, Texas

- Type: Direct potable reuse
- Capacity: 2 mgd
- WRP: MF/RO/UV-A
- WTP: rapid mix/floc/sed/ filtration/disinfection
- Recharge Facilities: pipeline
- Cost: $9.5 Million ($2.59/1000 gal)
- Status: Operational in 2012
- 10%-30% blend with lake water
- 100% reuse 100% of the time





Diagrams courtesy of CRMWD

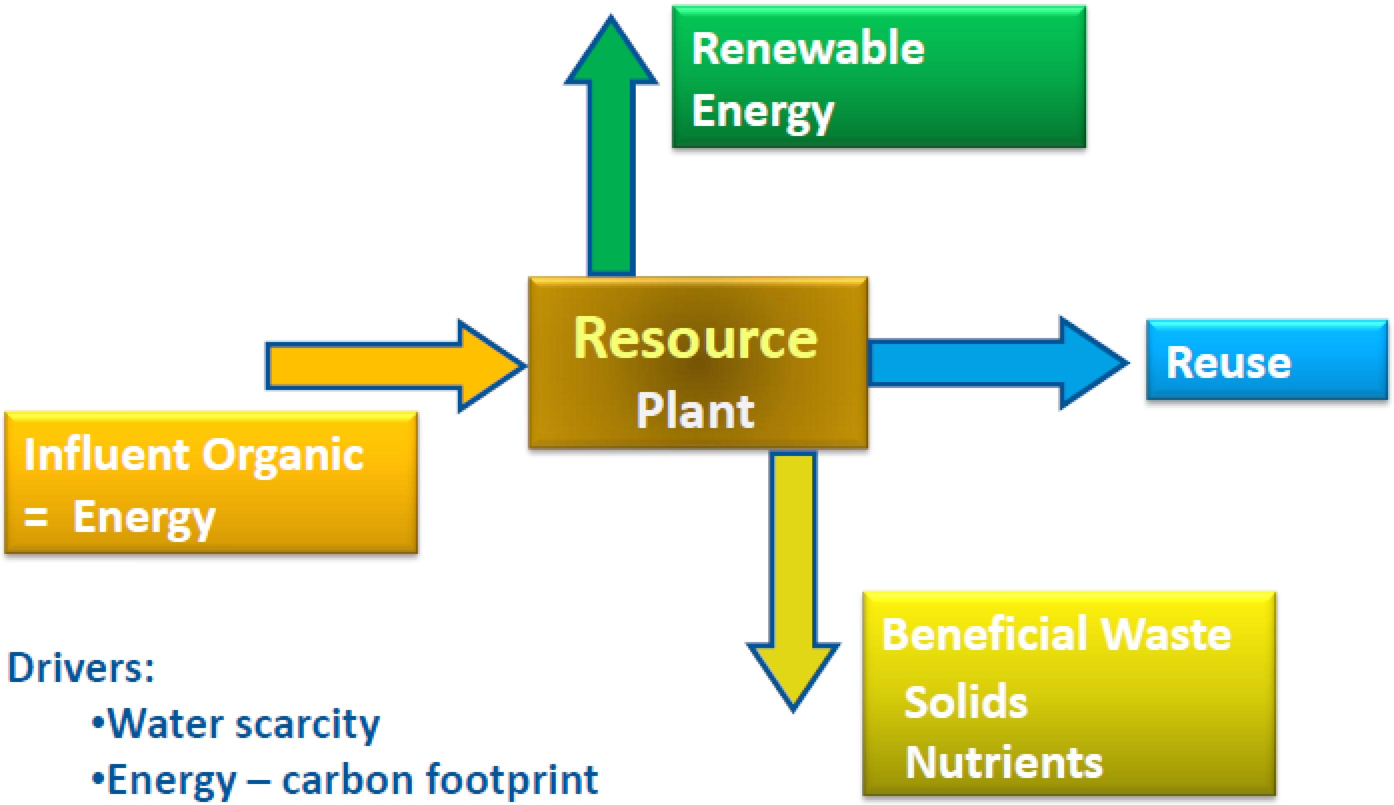
Energy/Water Nexus

1. Providing Low Phosphorus Reclaimed Water to Power Plants: Operational and Design Considerations from Two Full-Scale Reuse Plants (Larry Schimmoller, CH2M HILL)
2. The Paradigm Shift: Wastewater Plants to Resource Plants! (Cindy Wallis-Lage, Black & Veatch)
3. Indirect Potable Reuse: City of Phoenix's Cave Creek Water Reclamation Aquifer Storage and Recovery Well Program - From Conceptual Plan and Beyond (Gary Gin, City of Phoenix)
4. The Importance of a Distributed Wastewater Management Architecture in Comprehensive Energy Analyses and Planning (Victor D'Amato, Tetra Tech)
5. Sustainable Return on Investment Tool Provides Early Stakeholder Buy-In (Matt Gough, HDR Engineering)

The Paradigm Shift: Wastewater Plants to Resource Plants! (Cindy Wallis-Lage, Black & Veatch)

1. Inspiration to recover water, energy, nutrients, and assets
2. Case study examples
3. Discussion on Ostara process (phosphorus recovery)

PARADIGM CHANGE:
RAW WASTEWATER IS A VALUABLE RESOURCE!



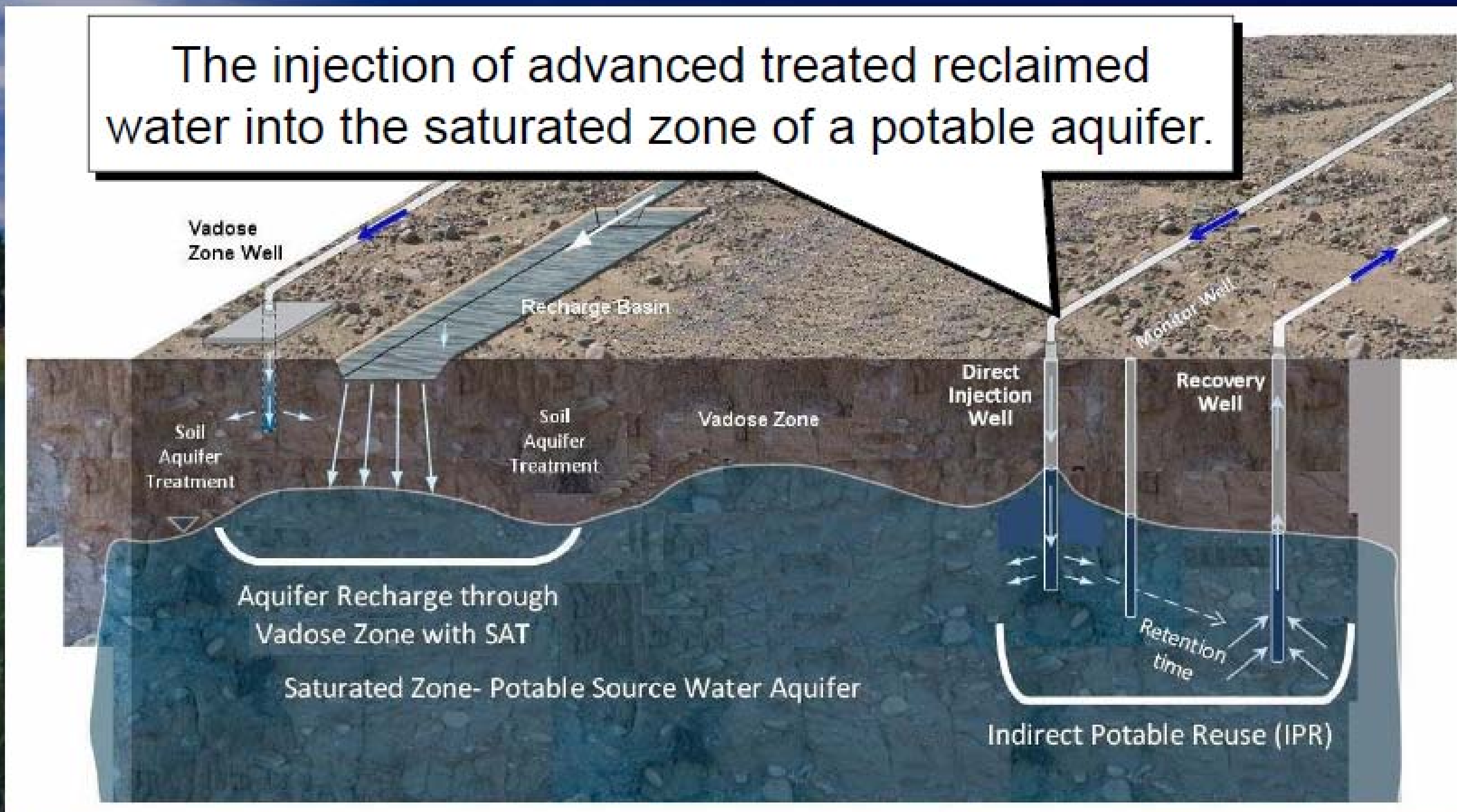
Drivers:

- Water scarcity
- Energy – carbon footprint
- Nutrient recovery
- Asset recovery

Indirect Potable Reuse: City of Phoenix's Cave Creek Water Reclamation Aquifer Storage and Recovery Well Program - From Conceptual Plan and Beyond

(Gary Gin, City of Phoenix)

What is IPR ?


The injection of advanced treated reclaimed water into the saturated zone of a potable aquifer.
Vadose Zone Well
Recharge Basin
Monitor Well
Direct Injection Well
Recovery Well
Soil Aquifer Treatment
Soil Aquifer Treatment
Vadose Zone
Aquifer Recharge through Vadose Zone with SAT
Saturated Zone- Potable Source Water Aquifer
Retention time
Indirect Potable Reuse (IPR)

Regulatory Impediments

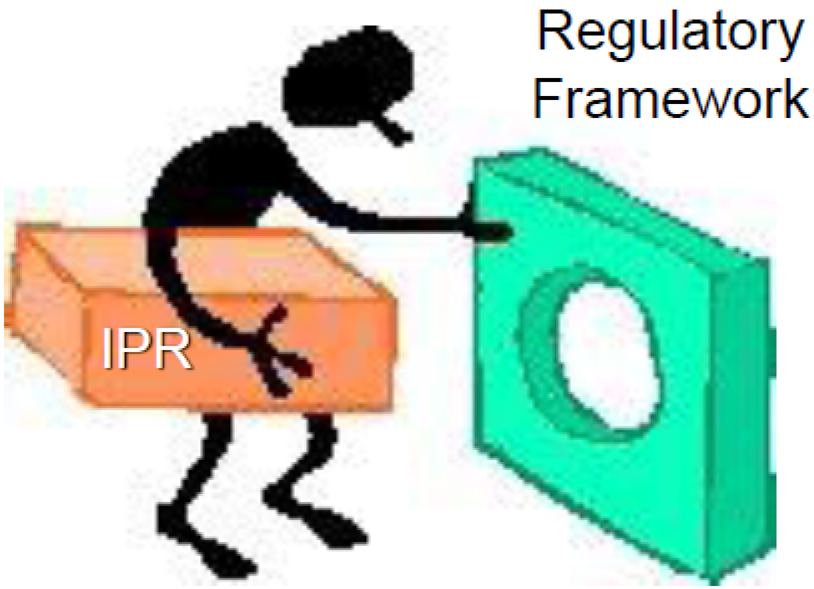
Multi-Agency Permitting Requirements

Agency	Permit / Approval
Arizona Dept. of Environmental Quality	• Aquifer Protection Permit
Arizona Dept. of Water Resources	• Underground Storage Facility Permit • Water Storage Permit • Recovery Well Permit • Service Area Permit
Maricopa County Environmental Services Department	• Approval to Construct • Approval of Construction • Source Water Approval

Regulatory Impediments

Reclaimed Water IPR not defined under SDWA

- Surface Water
- Groundwater
- Surface Water Under the Influence



City of Phoenix Next Steps

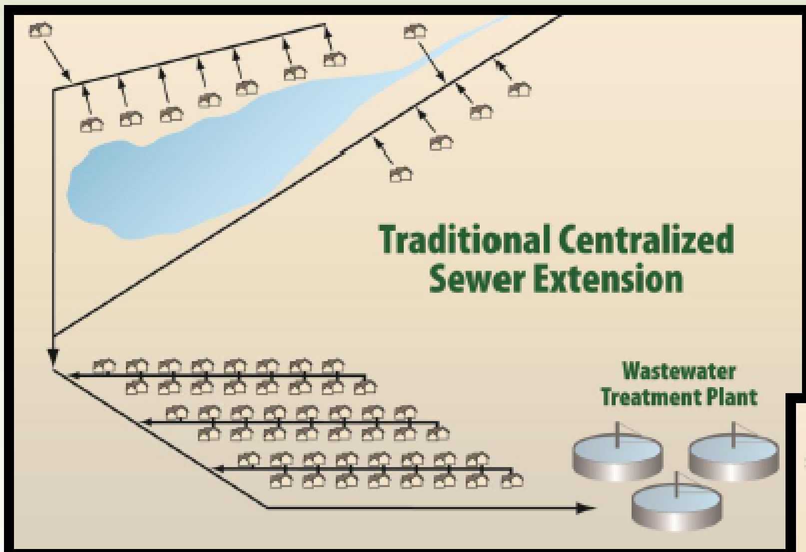
- Pilot ASR well (potable supply) at CCWRP with monitoring well network
  - Sustain water-levels in Northeast Aquifer
- Tracer Analysis
  - Determine aquifer characteristics
  - Travel time and distance
- Refine Groundwater Model
  - Recalibrate model
  - Further recharge and recovery operations
- Use Pilot ASR Study data to support the scientific basis for IPR permitting requirements (long-term process).

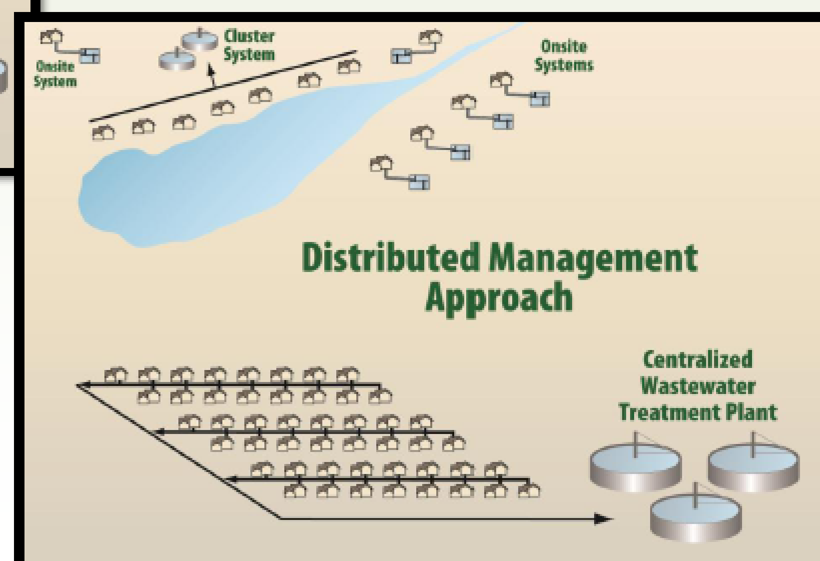
The Importance of a Distributed Wastewater Management Architecture in Comprehensive Energy Analyses and Planning

(Victor D'Amato, Tetra Tech)

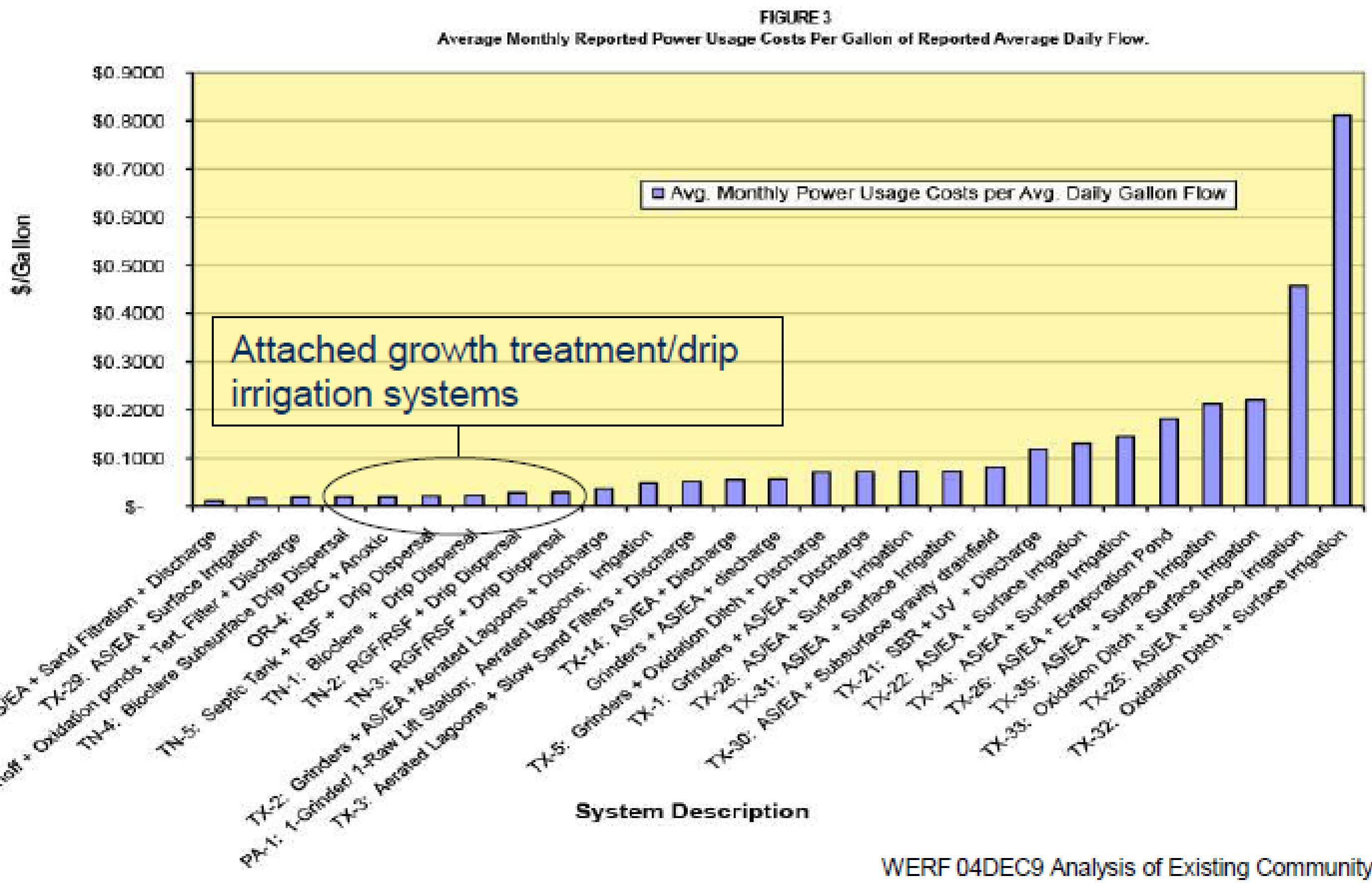
System architecture

- Treatment proximate to source/use
  - Less conveyance energy
  - Add'l reuse opportunities
  - Lower energy processes



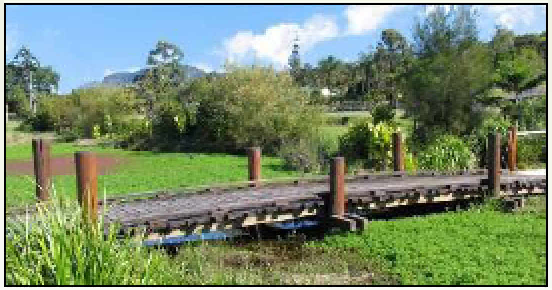


Power demands of decentralized systems



WERF 04DEC9 Analysis of Existing Community-Sized Decentralized Wastewater Treatment Systems
Decentralized Systems

Currumbin Ecovillage, Queensland, Australia



- 144 home sites ~7 km from Currumbin Beach on Queensland's Gold Coast, Australia
- ***Closed-loop*** water supply system – disconnected from public water system
- Food producing streetscaping and landscaping
- Intelligent monitoring system (water, gas, electricity) installed at each home
- Each house equipped with rainwater tank(s) that supply all potable water used inside the house
- Wastewater centrally treated to Class A+ reuse standards
  - Textile filters, membrane filtration, UV treatment and chlorine disinfection
- Reclaimed water pumped back to the houses for non-potable uses (> 80 percent recycled water use)
  - Toilet-flushing, Garden watering, Car washing, Laundering, Fire fighting

Loudoun Water, Loudoun County, VA

- **Loudoun Water Service Area**
  - Water and wastewater utility for Loudoun County, VA (DC suburb/exurb)
  - Growth pays for growth: developers design and construct facilities to Loudoun Water standards and at no cost to Loudoun Water
- **Shared review and approval responsibilities**
  - Indiv. systems – Local Health review
  - Discharging systems – Loudoun Water & DEQ
  - Cluster systems – Local Health, Loudoun Water, & State Health review
- **Management highlights**
  - RME Level IV (operation) when operating treatment plants for commercial facilities
  - RME Level V (ownership and operation) operating treatment plants for communities
  - Financially self-sustaining via rates and developer paid revenues

Environmental Enhancement with Reuse

1. The 91st Avenue Unified WWTP Targets 100 Percent Reuse on a Large Scale in Phoenix, AZ Area (Steve Rohrer, Malcolm Pirnie, the Water Division of ARCADIS)
2. The Tres Rios Constructed Wetlands Phoenix, AZ Water Quality Performance; Year-1 (Roland Wass, Wass Gerke + Associates)
3. Assessing Risk from an Environmental Application of Reclaimed Water (Kara Warner, Golder Associates)
4. Miami-Dade's Biscayne Bay Coastal Wetlands Rehydration Pilot Project (Harold Schmidt, MWH)

The Tres Rios Constructed Wetlands Phoenix, AZ Water Quality Performance; Year-1

(Roland Wass, Wass Gerke + Associates)

1. Demonstration Project 1995 – 2008
2. Design 2004 - 2008
3. Construction October 2009 – January 2011
4. Permits
   a. APP December 2010
   b. NPDES July 2010
5. Operations
   a. Flows delivered to site January 2010
   b. Surface discharge begins August 3, 2010

Facility Layout

- 50% - Emergent Marsh
- 45% - Deepwater
- 5% - Islands

- FRW1 = 98 Acres
- FRW2 = 43 Acres
- FRW3 = 34 Acres

Tres Rios Year 1 Water Quality Results

1. Temperature decreases Sept – June; increases slightly in July & August
2. cBOD5 & TSS increase variably over months
3. DO increases significantly in all months
4. pH increases from ~7.3 to ~8.5. pH expected to drop again as macrophytes mature/senesce, etc.
5. Ammonia nitrogen nitrified in first wetland cell; nitrite & nitrate reduced, but expected to reduce more as system matures.
6. Phosphorus initially increased, but then decreased beginning in mid-May
7. Total Residual Chlorine reduced from 2.53 to 0.01 mg/L

State, National, & Global Reuse Regulatory Issues

1. EPA Guidelines for Water Reuse Progress Update (Robert Bastian, U.S. Environmental Protection Agency)
2. Washington State's "Purple Book" Guidance Manual for the New Reclaimed Water Rule (Chad Newton, Gray & Osborne)
3. A Ride on a Regulatory Roller Coaster- Reclaimed Water Permitting for the Las Colinas Development in Irving, TX (Ellen McDonald, Alan Plummer Associates)
4. Study and Discussion on Reclaimed Water Quality Guidelines (Shuang Liu, Lund University, Sweden)

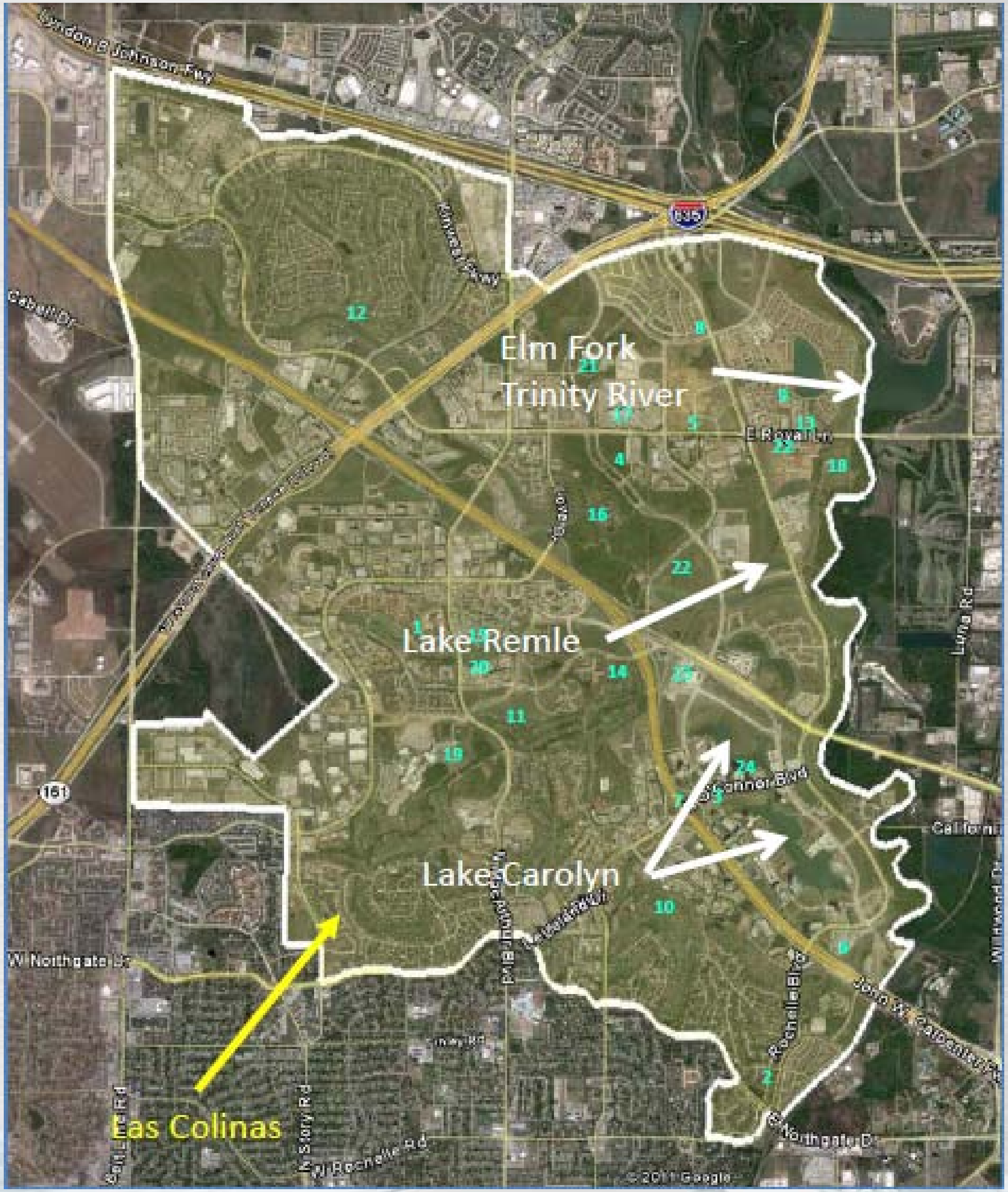
Update to EPA Guidelines for Water Reuse, Bob Bastion - USEPA, and Don Vandertulip - CDM

1. Original in 1980 was R&D Technology Review document
2. Updated in 1992 with USAID with recommended minimum requirements
3. 2004 update by CDM/EPA aimed at technical standards, case study examples worldwide, and treatment recommendations for end uses

1. Current update began in 2009; complete in 2012
   a. Total water management approach
   b. Reflect integrated water resources management
   c. Recognize technology and regulations for higher quality
   d. Utilize current knowledge base – supplement with recent experience
   e. Increased focus on international project economics
   f. International development standards and guidelines (WHO, EU, IWA)

Reuse Project in Irving TX has Nationwide Implications,

Ellen McDonald, Alan Plummer Associates



Health Effect Studies

1. Risk of *Cryptosporidium* Infections Associated with Wastewater Reuse (Zia Bukhari, American Water)
2. Modeling Microbial Risk and Irrigation Drift of Wastewaters of Varying Microbial Qualities for Determination of Buffer Zones (Michael Cook, Idaho Department of Environmental Quality)
3. Optimization of Recycled Water Supply to the West Werribee Dual Supply Scheme (Muthu Muthukaruppan, City West Water)

American Water

Risk Estimates

- **Based on human infectivity studies, probability of infection from a single oocyst of an unknown strain estimated to be 0.028**
- **This probability used to calculate risk estimates with:**
  - Different analytical methods (Method 1623 to CC-PCR; LeChevallier et al, 2003), following UV treatment (LeChevallier and Hubel, 2004) & consumption of contaminated drinking water systems (Aboytes et al., 2004).
- **Equations for calculating the daily risk of protozoan infection from drinking water are:**
  - Daily Risk (DR) = (1.232 L per day) (oocysts/L) (infection probability for unknown strain).
  - Annual Risk (AR) = $1-(1-DR)^{350*}$
    - * based on assumption that exposure occurs for 350 days per year

Exposure

- Daily water ingestion by US population estimated at 1.232 L per day (U.S. EPA, 2000).
  - Adults consume approx 75 mL water during swimming, children consume twice this volume (Dufour et al., 2006).
- Exposure to reuse water varies depending on the type of activities.
  - Consumption from park irrigation estimated at 0.01 to 1% of daily intake (i.e. 0.12 mL to 12 mL).
    - Median value by this exposure route around 6 mL

AMERICAN WATER

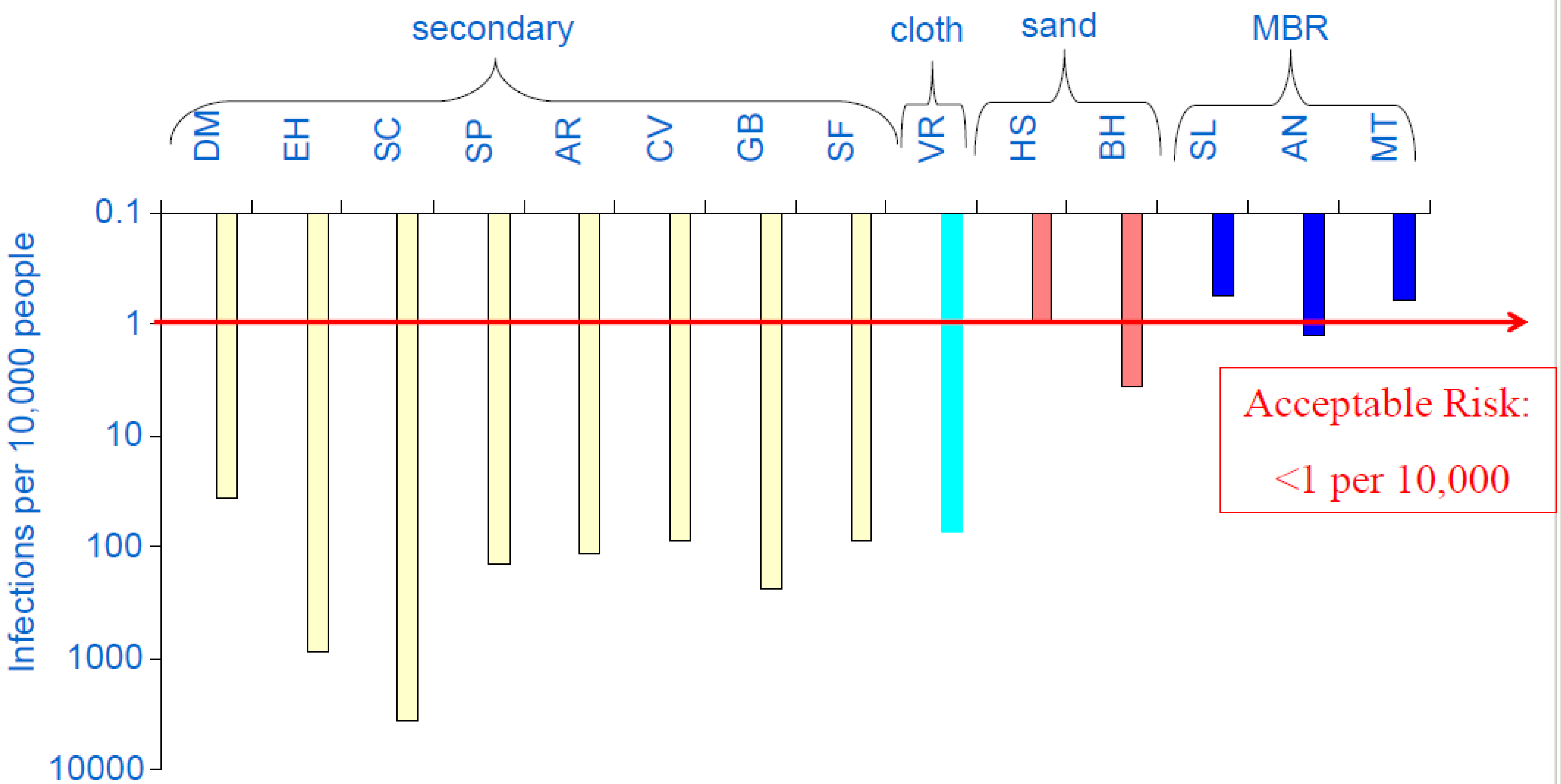
Exposure

- **This study assumed that susceptible human individuals exposed to a conservative 1 mL of reuse water**

- **Daily Risk (DR) = 0.001 L x N x 0.028**
  - Where 0.001 L is the volume ingested per day, N is the adjusted oocyst concentration (i.e. concentration, method recovery, infectivity, genotype etc) per L and 0.028 is the probability of oocysts causing an infection.

- **The duration of exposure can be expressed as a daily exposure (for infrequent events – such as exposure to golf course irrigation), or be annualized for frequent exposures**

Annual Risk of Infection



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Conclusions

- **Samples from secondary clarification plants (n=8) were 94.7% *Giardia* positive. *Cryptosporidium* detected in 36.5% of these samples**
  - No apparent association between *Giardia* and *Cryptosporidium*
  - No association between protozoa and various physicochemical parameters (i.e. turbidity, ammonia, TSS etc)

- **Cloth, and MBRs were 42-46% *Giardia* positive. Sand 25% *Giardia* positive**
  - Speciation showed almost exclusively assemblages A&B

- **Cloth 25% *Cryptosporidium* positive. Sand 4.2% *Cryptosporidium* positive. MBRs were 1.4% *Cryptosporidium* positive**
  - MBRs 4.2% *Cryptosporidium* positive by PCR
  - Speciation showed *C. parvum* and *C. hominis*

AMERICAN WATER

Conclusions

- **Risk of human cryptosporidiosis**
  - High risk from secondary clarification or cloth filtration. Substantial risk reduction with sand filtration
  - MBR most effective
- ***Cryptosporidium* and *Giardia* can pass through MBR**
  - Future control strategies should utilize combination of disinfectants (i.e. chlorine/UV)
  - Determine risks of human giardiasis

Groundwater Issues

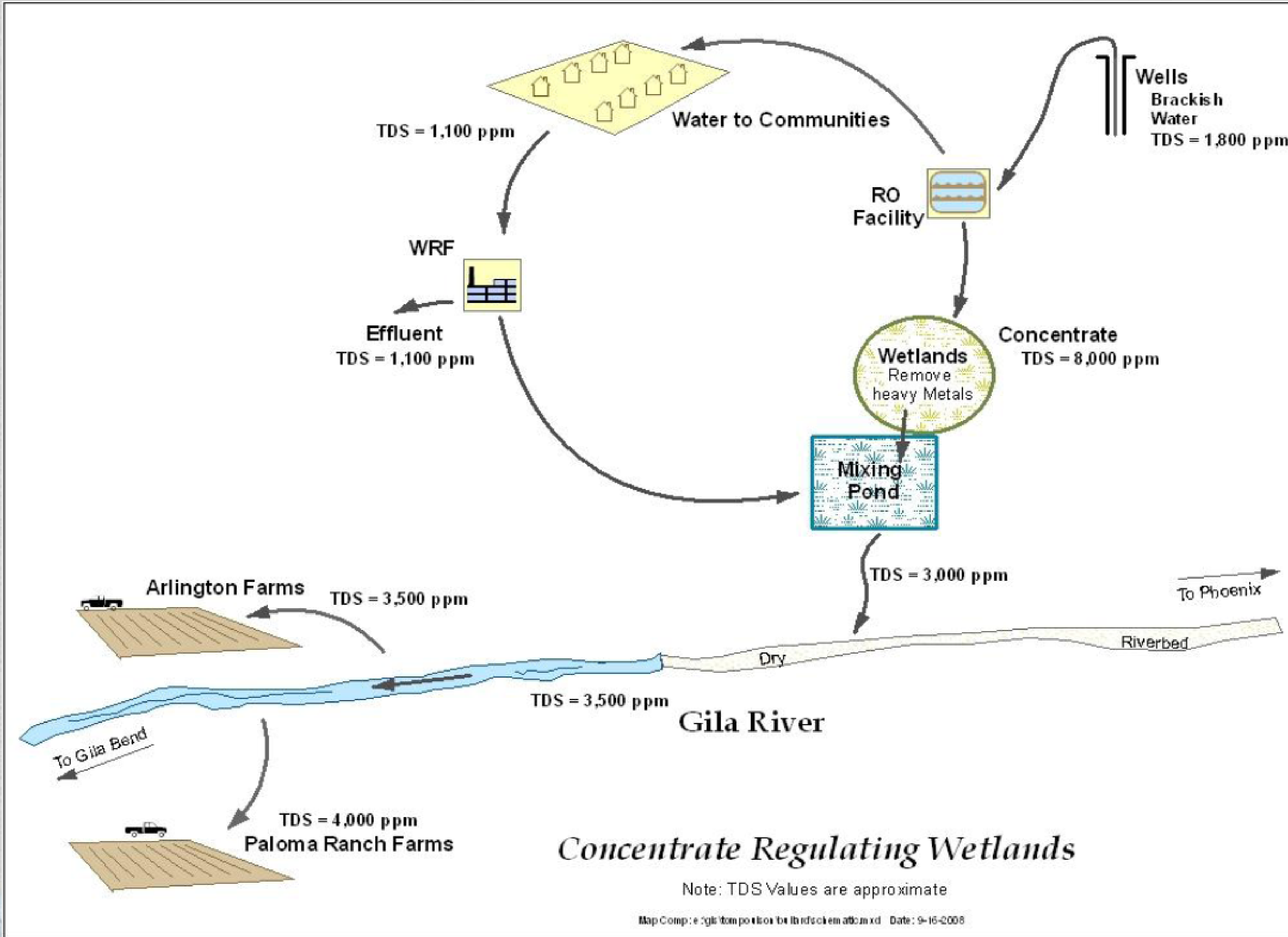
1. National Review of Water Quality Issues, Practices and Policies for Potable Reuse Aquifer Storage Recovery (Cat Shrier, The National Water Education Center)
2. Challenges of Indirect Potable Reuse in Florida: Clearwater's Groundwater Replenishment Program (James Christopher, Tetra Tech)
3. Indirect Reuse - Aquifer Recharge Methods to Optimize Capacity in Urban and Non-Urban Areas (Arne Sandvik, Padre Dam Municipal Water District & Tim Smith, Helix Water District)
4. Using Soil Aquifer Treatment to Meet Filtration and Disinfection Treatment Goals (John Rehring, Carollo Engineers)
5. The Role of Travel Time on the Removal of Emerging Trace Organic Compounds during Surface Spreading Aquifer Recharge (Eric Dickenson, Southern Nevada Water Authority)
6. Evaluation of Water Stabilization Options at Leo Van Lander Lans Advanced Water Treatment Facility (Ufuk Erdal, CH2M HILL)
7. Fountain Hills Sanitary District: 40 Years of Zero-Discharge Through Innovation and Persistence (Doug Kobrick, Kobrick PLC)

What to do with the Brine

1. Emerging Desalination Technologies-An Overview (Srinivas Veerapaneni, Black & Veatch)
2. Concentrate and Brine Management Through Deep Well Injection (Jeff Couture, GeoEnvironment Technologies)
3. Concentrate Management Wetlands Pilot Project (Thomas Poulson, Bureau of Reclamation)
4. Demonstrating Innovative Inland Concentrate Management Solutions (Brandy Kelso, City of Phoenix)
5. An Innovative Approach to Minimizing Membrane Residuals Associated with Advanced Water Reclamation and Indirect Potable Reuse (James Lozier, CH2M HILL)
6. ZDD - Achieving Maximum Water Recovery (Malynda Cappelle, University of Texas, at El Paso)

Concentrate Management Wetlands Pilot Project (Thomas Poulson, Bureau of Reclamation)

1. Output of CASS related work
2. Can 8,070 ppm TDS brine (including heavy metals) from Bullard Water Campus be treated with wetlands prior to discharge to Gila River?
    a. Do the vertical flow wetlands actually remove/reduce regulated ions?
    b. What size of vertical flow wetlands would be needed to treat all the concentrate?
    c. Will the blend of “treated” concentrate and 157th Ave WRF effluent match or be better then the Gila River?
    d. How long will wetland last before it is full of contaminants?

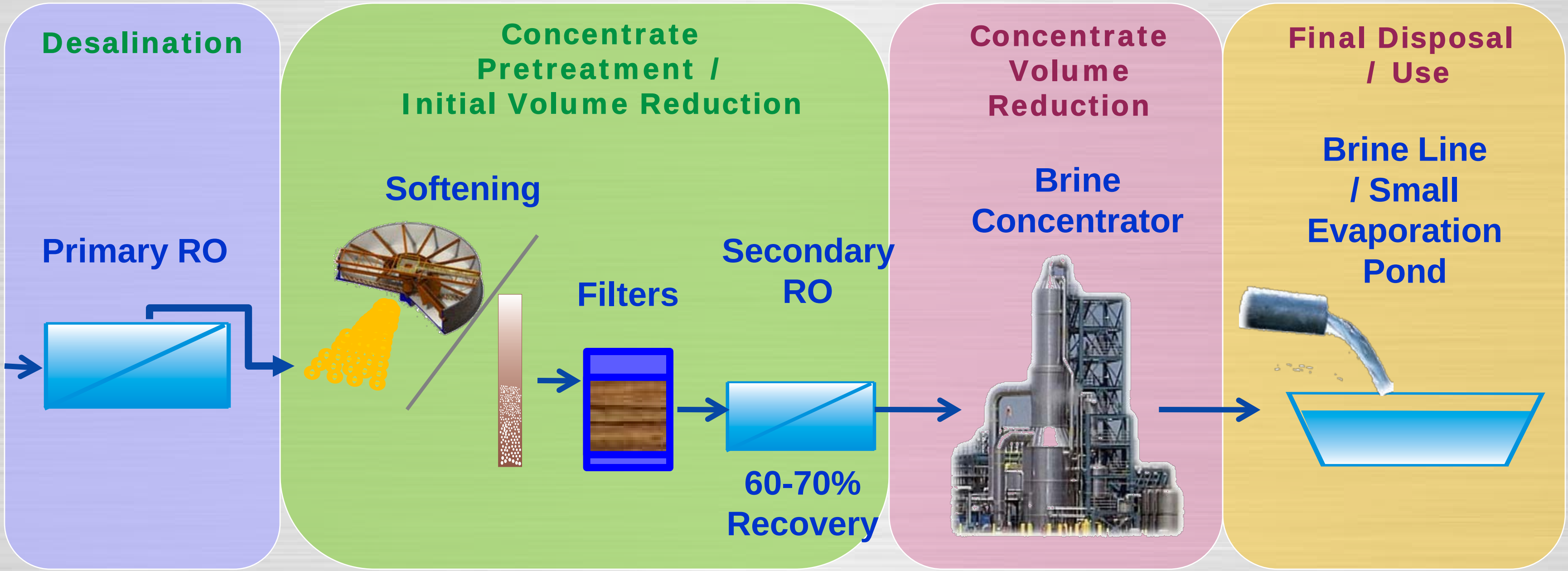

Water to Communities
Wells
Brackish
Water
TDS = 1,800 ppm
TDS = 1,100 ppm
RO
Facility
WRF
Effluent
TDS = 1,100 ppm
Concentrate
TDS = 8,000 ppm
Wetlands
Remove
heavy Metals
Mixing
Pond
TDS = 3,000 ppm
To Phoenix
Arlington Farms
TDS = 3,500 ppm
Dry
Riverbed
TDS = 3,500 ppm
Gila River
To Gila Bend
TDS = 4,000 ppm
Paloma Ranch Farms
Concentrate Regulating Wetlands
Note: TDS Values are approximate

Concentrate Management Wetlands Pilot Project (Thomas Poulson, Bureau of Reclamation)

1. From November – June, 2011
   a. Good reductions in As, Se, Cr, NO_3
   b. WET Problem:
      - Chlorides are predicted to be approximately 1220 mg/L
      - Most likely not able to pass WET test
      - Net Ecological Benefits R18-11-106
      - Work with ADEQ to implement the Rule
      - Work with Environmental community

View of Bin #6

Demonstrating Innovative Inland Concentrate Management Solutions (Brandy Kelso, City of Phoenix)

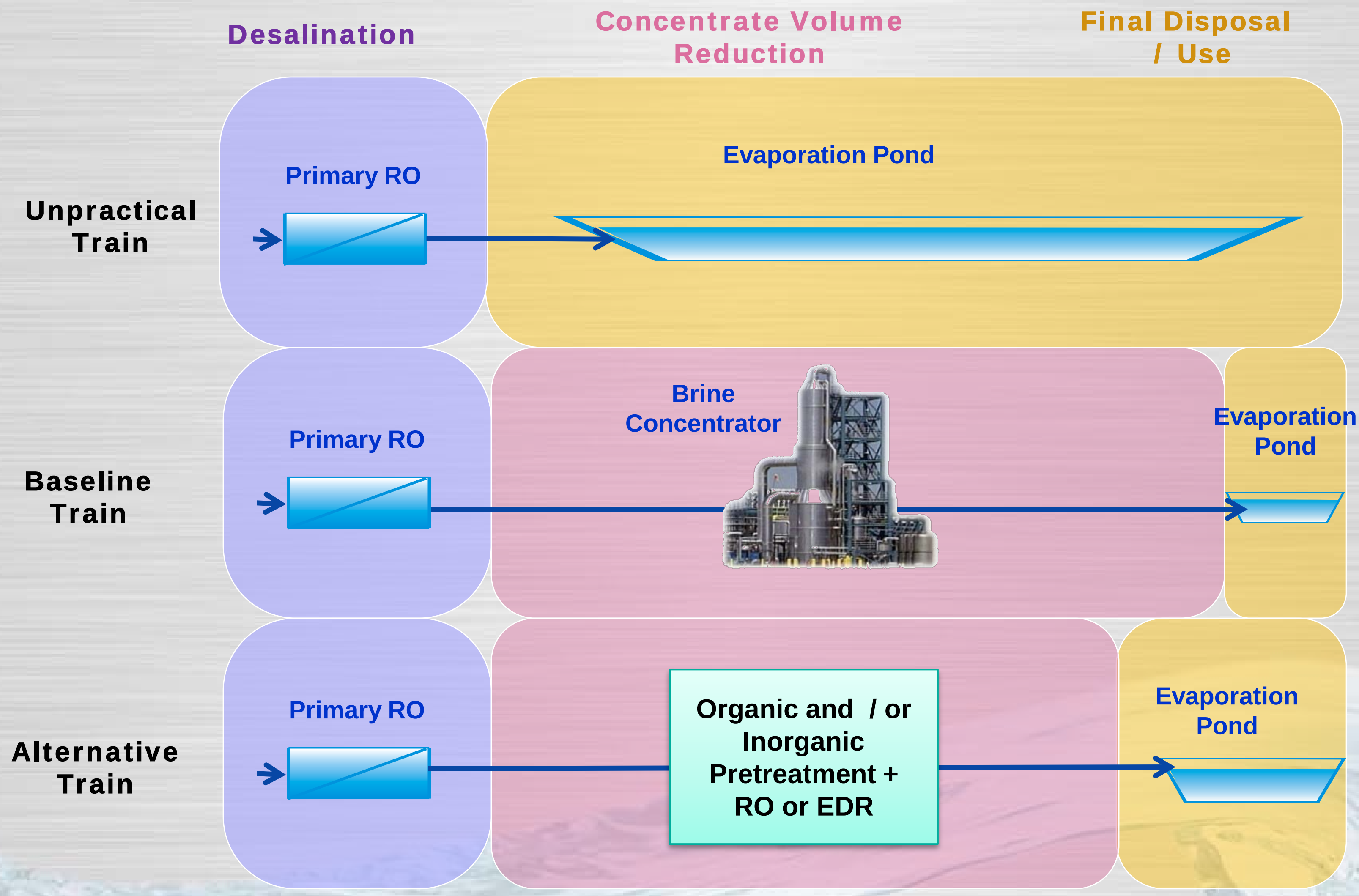


85% 95% ~99.5% **Recovery (%)**

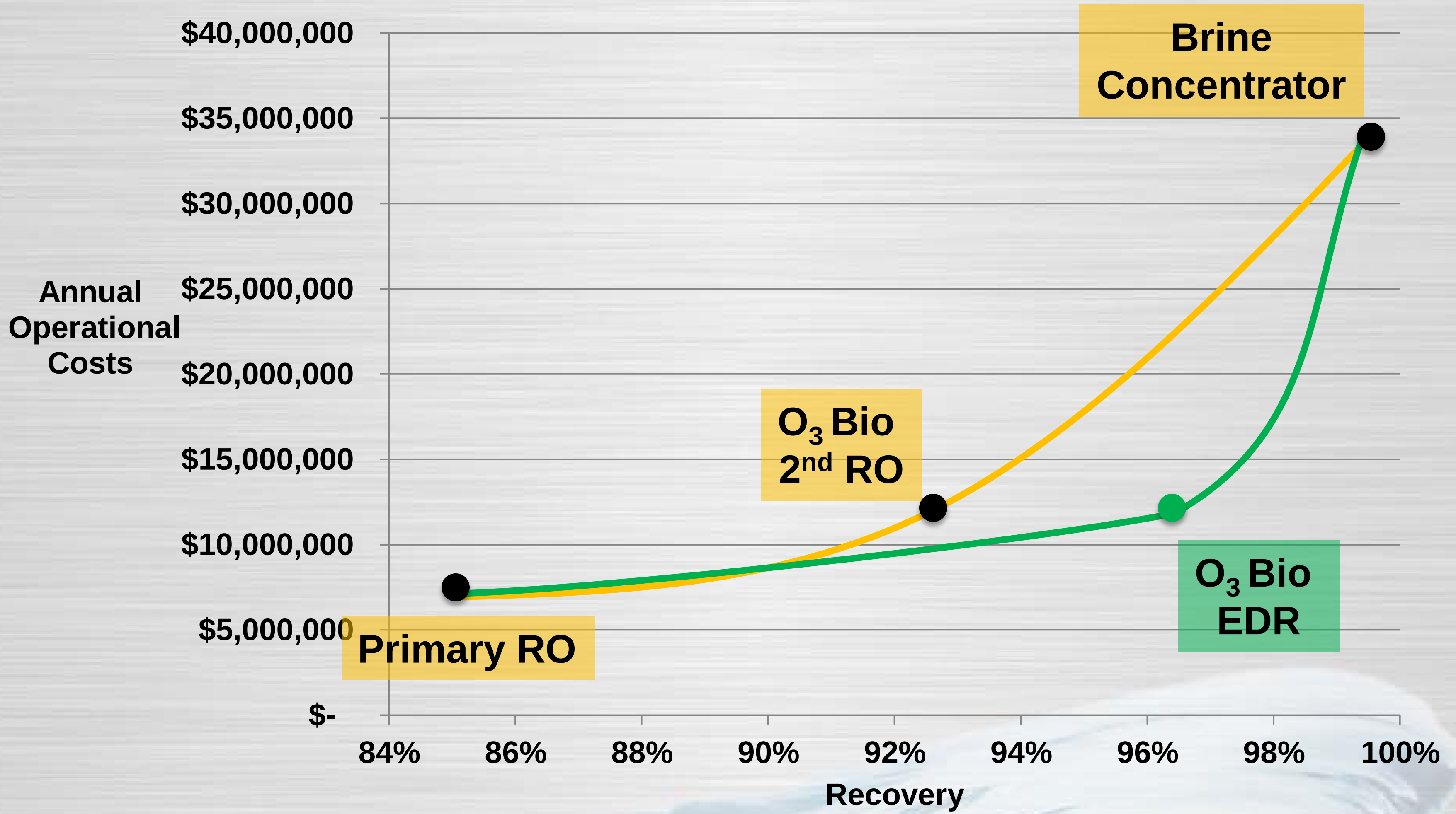
1K 6-7K 17-20K ~100-200K **TDS (mg/L)**

1 mgd 53 acres 18 acres ~2 acres **Pond Size**

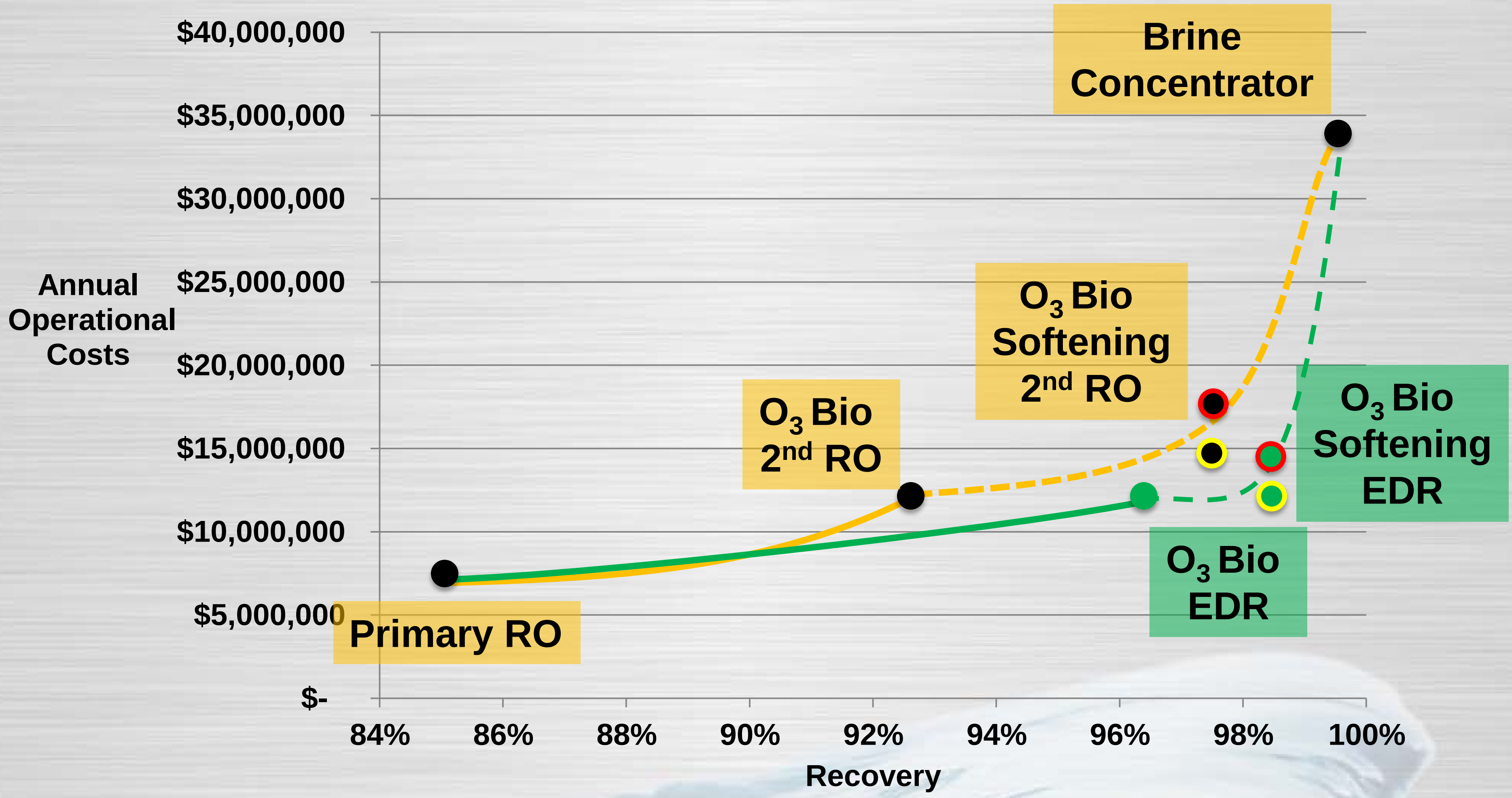
The Objective of the Project is to Develop Alternatives to Brine Concentrators



Recommended Trains Improve the Recovery-to-Cost Ratios



Recommended Trains Improve the Recovery-to-Cost Ratios



Resources

1. Contact Guy for specific papers
   gcarpenter@carollo.com

2. All presentations can be found at:
   https://www.watereuse.org/conferences/symposium/26/presentations

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The Western Coalition of Arid States

Thank you for your attention.

Questions?

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