Treatment of Microconstituents for Water Reuse and Drinking Water Applications

Pacific Northwest Section AWWA
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CH2M HILL's Global Technology Leader for Water Reuse

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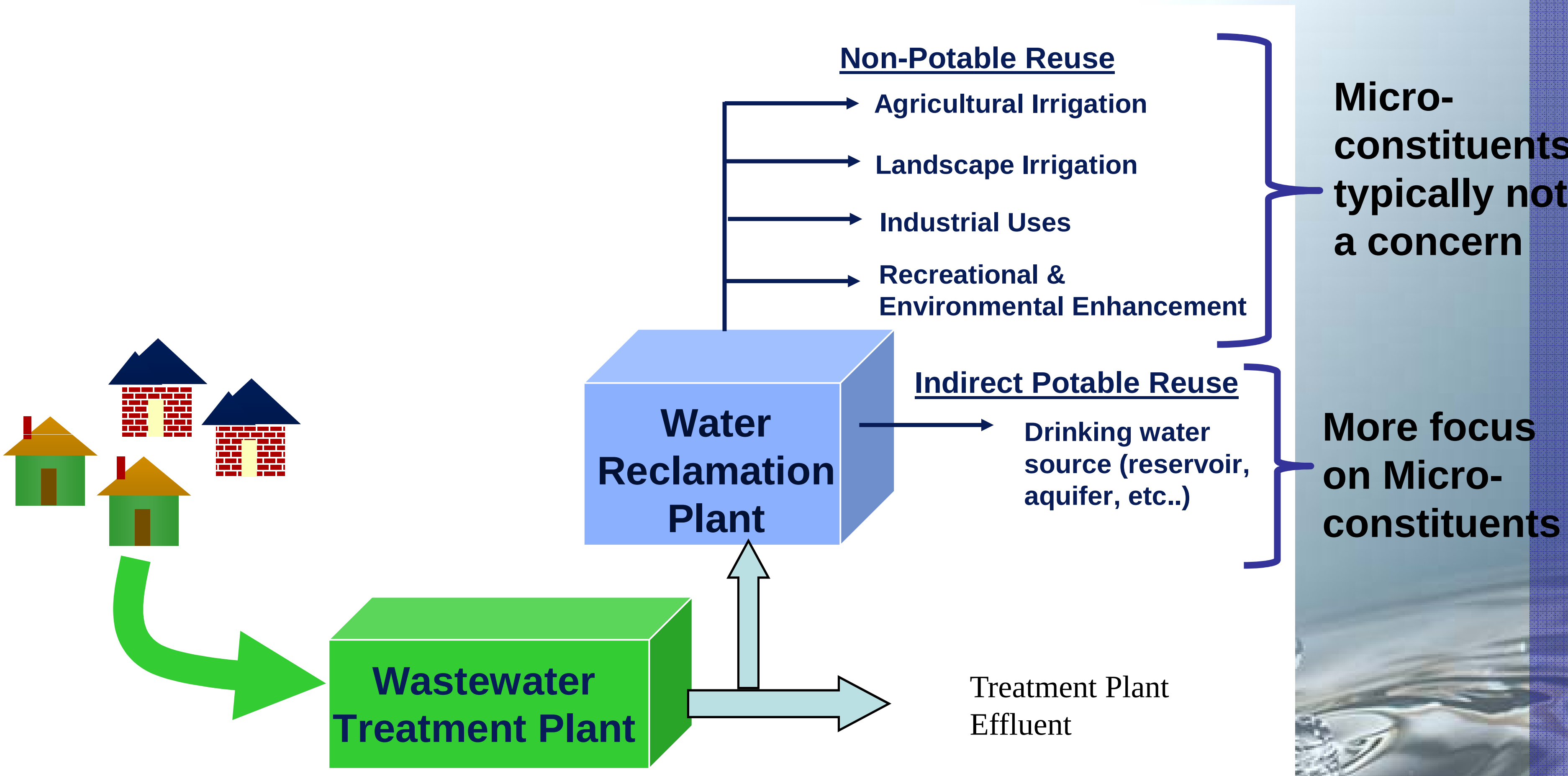
Agenda

- Definition of water reuse
- Treatment Technologies for microconstituents
- Case Studies:
  - Typical urban surface water supply
  - Planned Indirect Potable Reuse
- Sustainability

Water Reuse is the Recycling of Treated Wastewater for Beneficial Use



Impact of Wastewater Discharges to Water Supplies

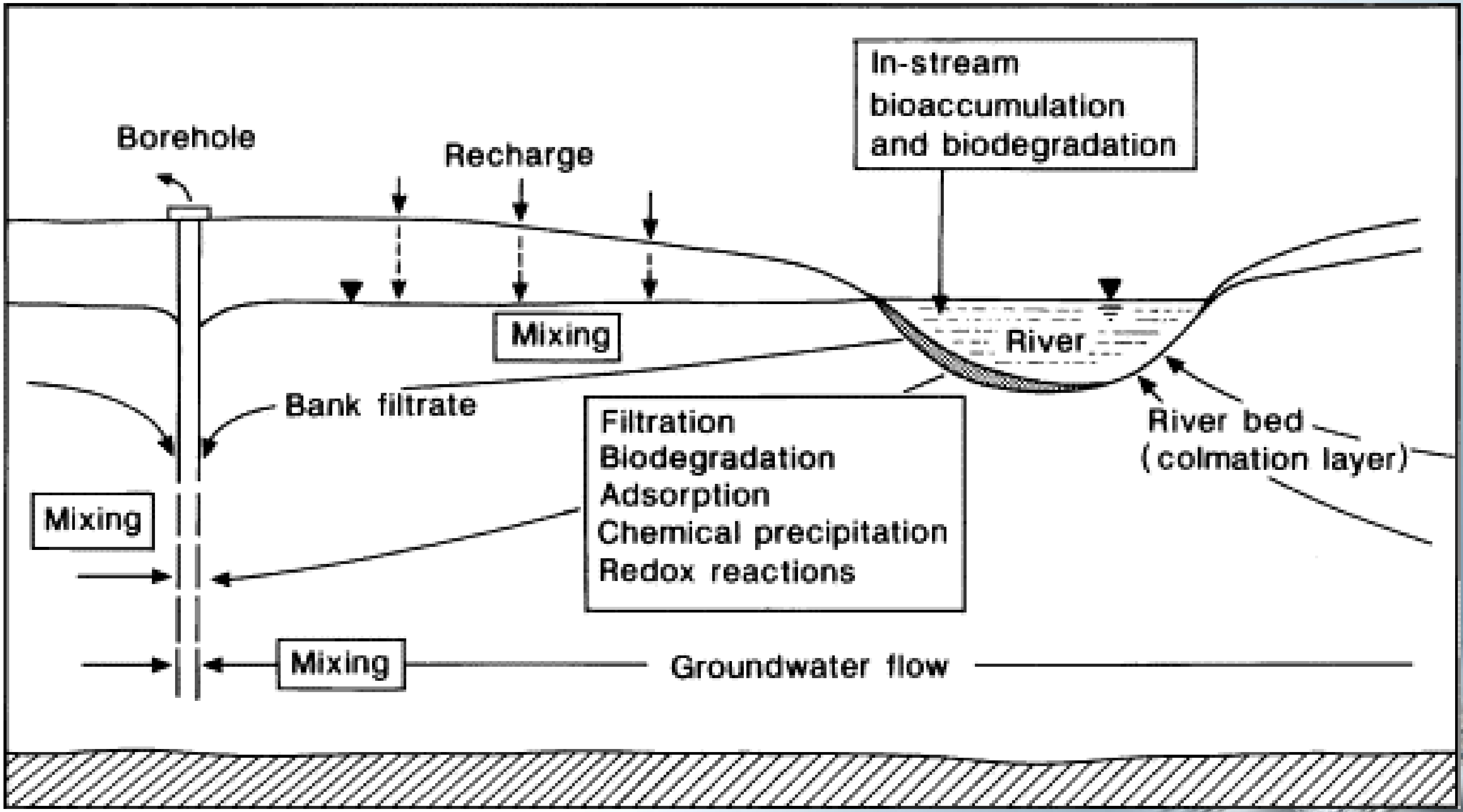
Figure 4. Wastewater discharges above the Colorado River and California State Water Project aqueducts. Source City of San Diego Water Department.

Under low flow conditions, water in Colorado and Sacramento Rivers may be 9%-17% wastewater (Coss, 2007)

Advanced treatment options for Emerging Contaminants

- Soil Aquifer Treatment (SAT)
- Nanofiltration / Reverse osmosis
- Granular activated carbon
- UV - Advanced oxidation (UV-AOP)
- Ozone and Ozone-UV

Soil Aquifer Treatment by Riverbank Filtration



Jörg Drewes (Colorado School of Mines)

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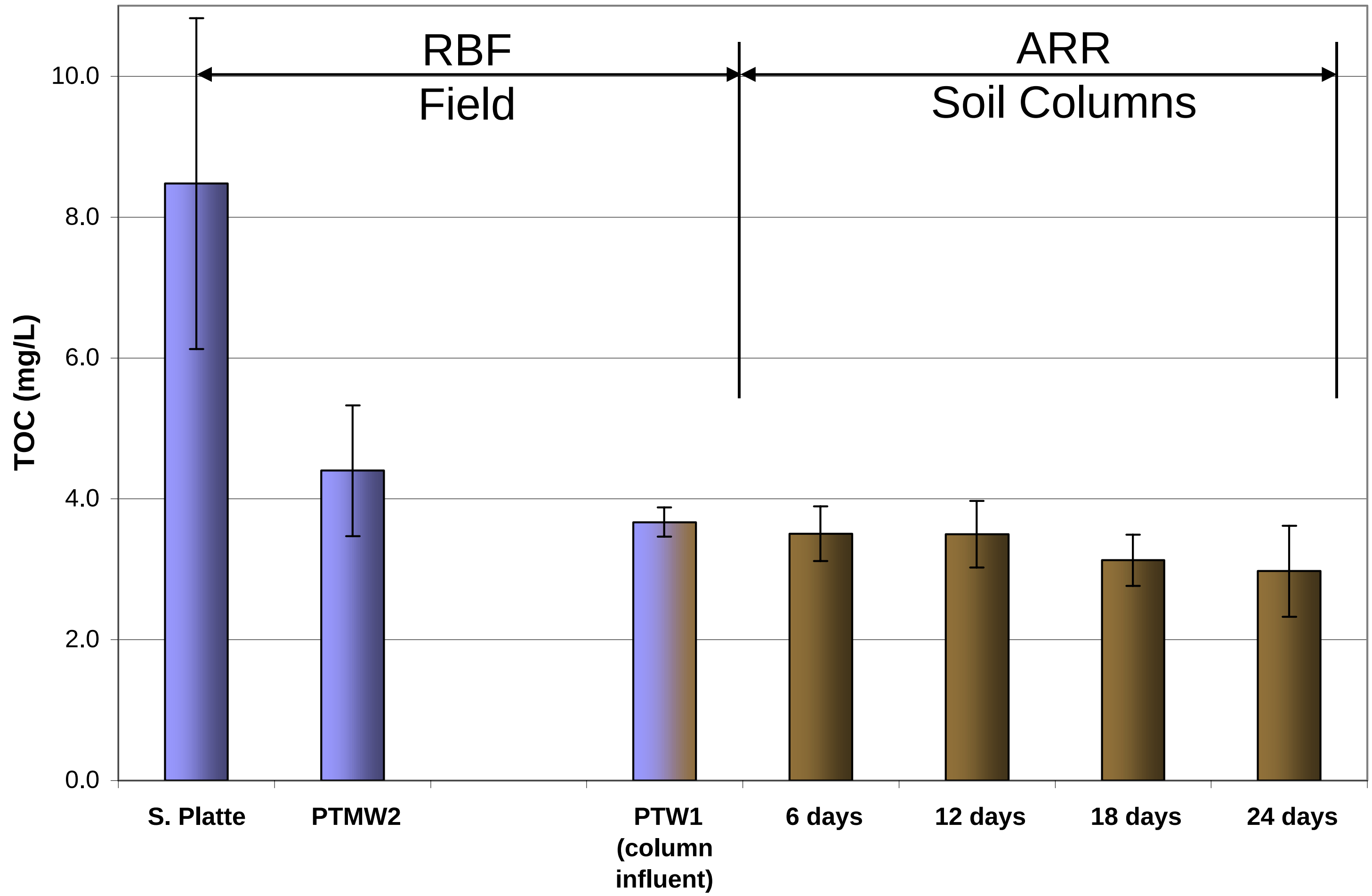
TOC Removal During RBF and ARR



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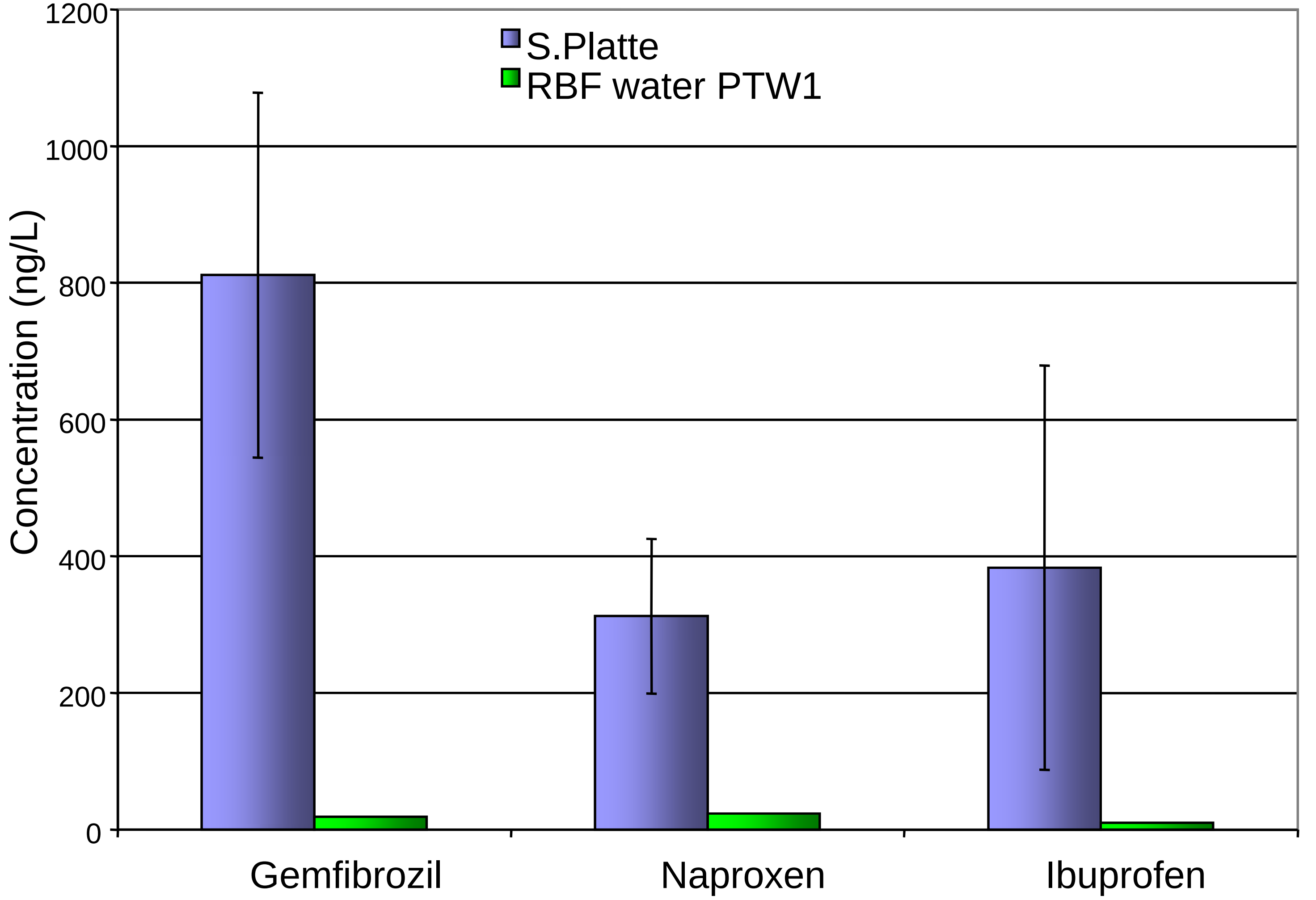
RBF Field Monitoring
Pharmaceutical Compounds Removal



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RBF - Field Monitoring
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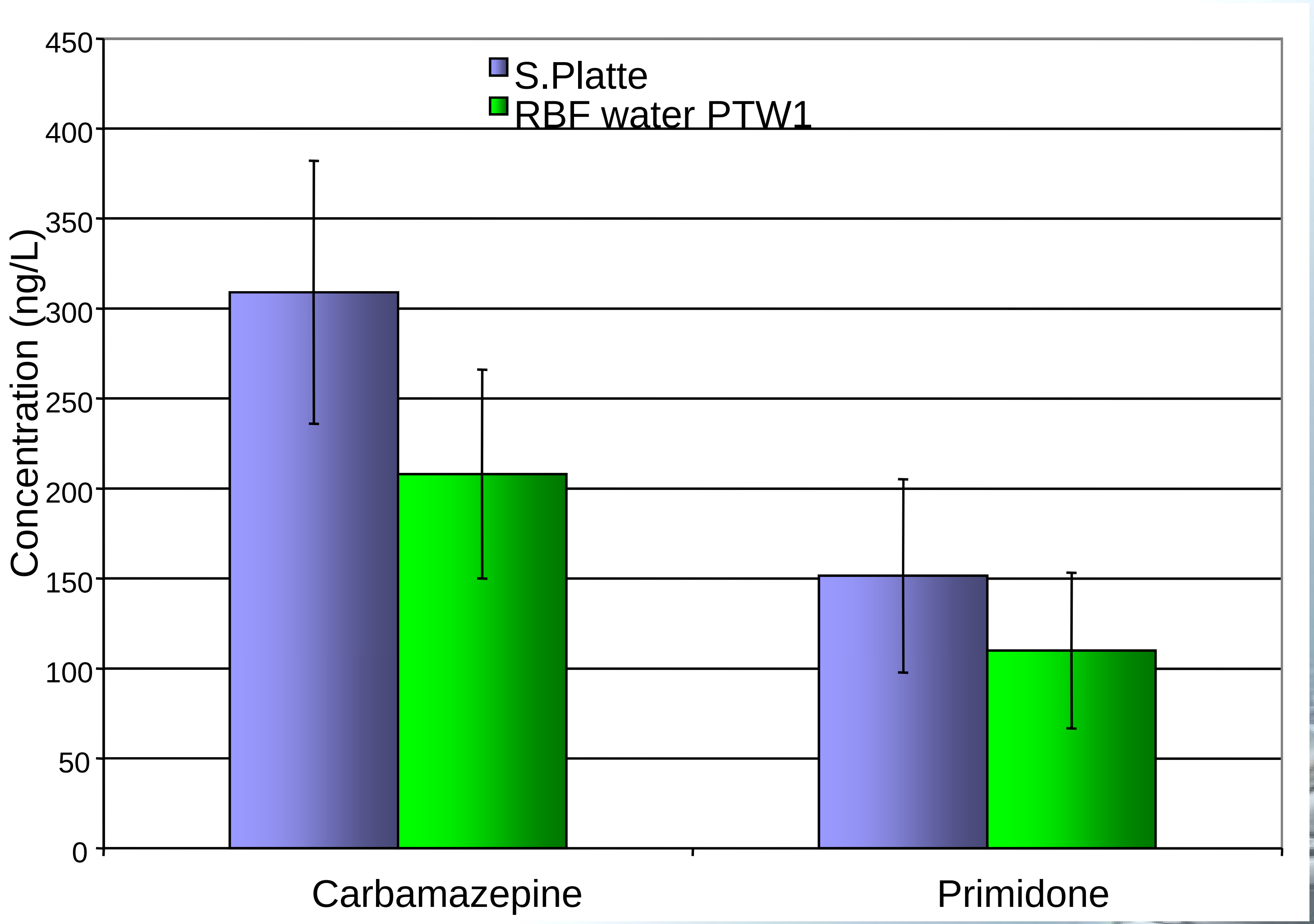

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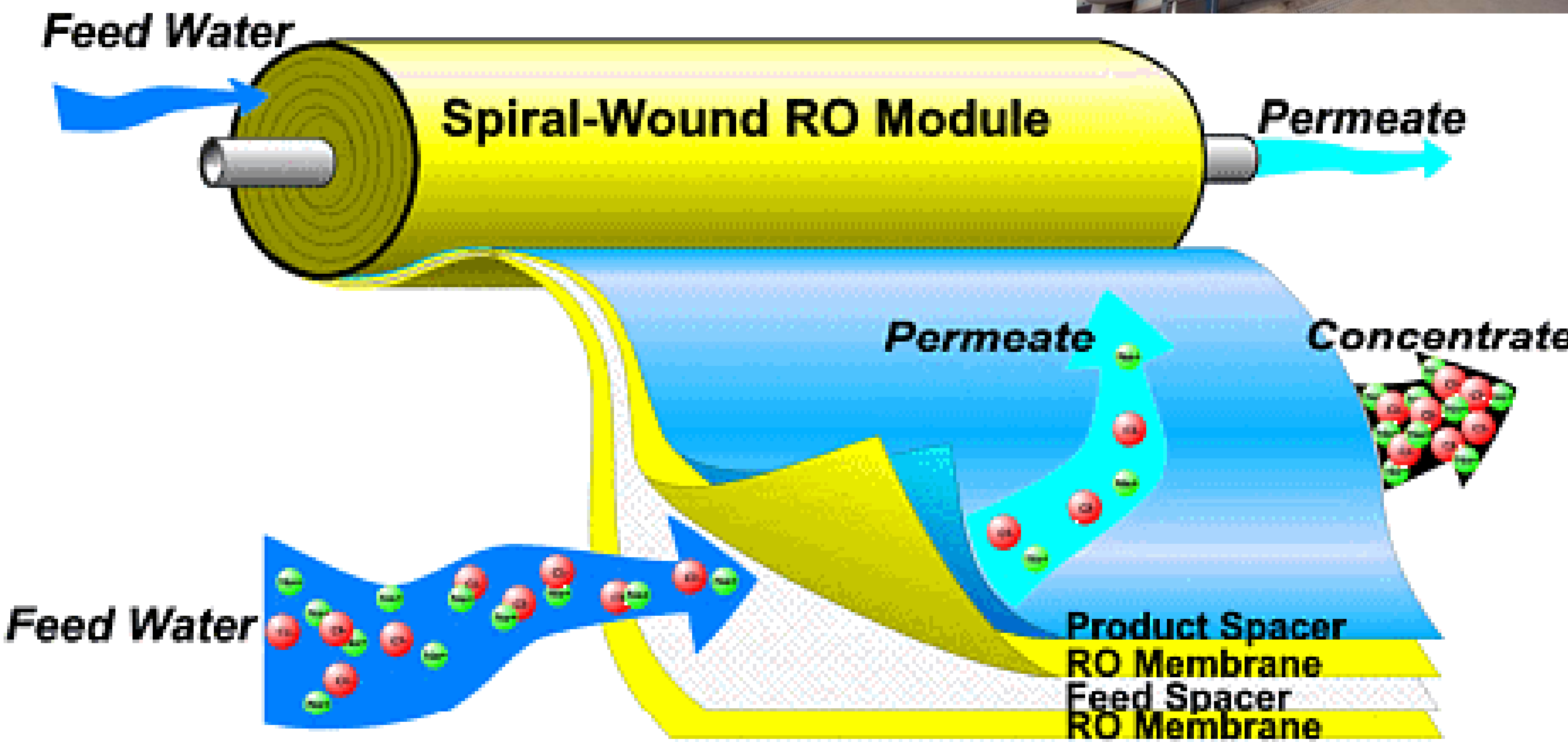
Reverse Osmosis Membranes



Rejection of Microconstituents by RO is Excellent

- Generally greater than 99% for most compounds
- Some compounds not well removed (e.g., NDMA)

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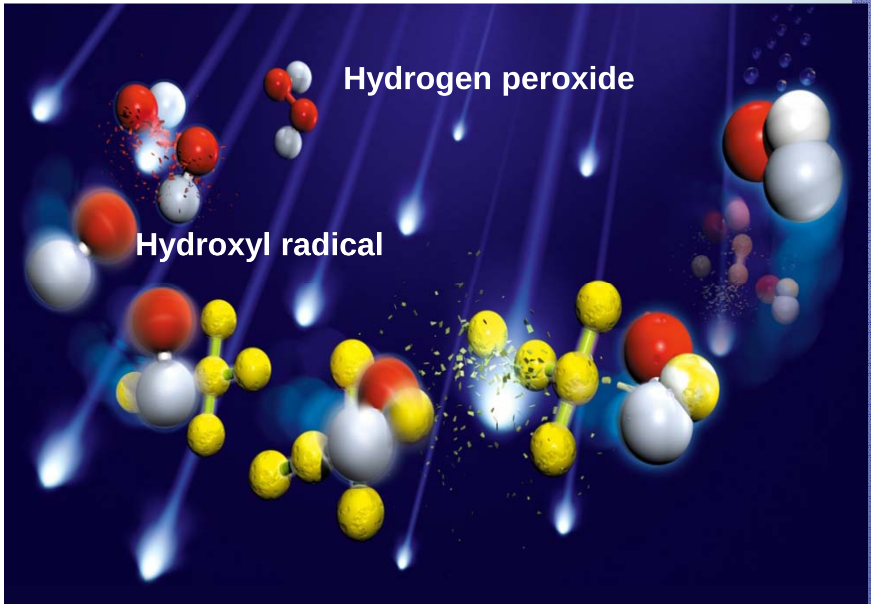
What is UV Advanced Oxidation?

- Definition: water treatment with the use of UV light (photolysis) in combination with hydroxyl radical (advanced oxidation)
- UV light destroys photo-sensitive compounds
- Hydrogen peroxide fed upstream
- UV light converts H_2O_2 to OH· radical:
  - hydroxyl radical = very powerful oxidant
  - effective at oxidizing emerging contaminants, like ozone, but no bromate is formed



Courtesy of Trojan

Oxidant	Half-Cell Potential, E^o_{red}
Chlorine Dioxide	0.95V
Hypochlorite	1.64V
Permanganate	1.68V
Hydrogen Peroxide	1.78V
Ozone	2.08V
Hydroxyl Radical	2.85V

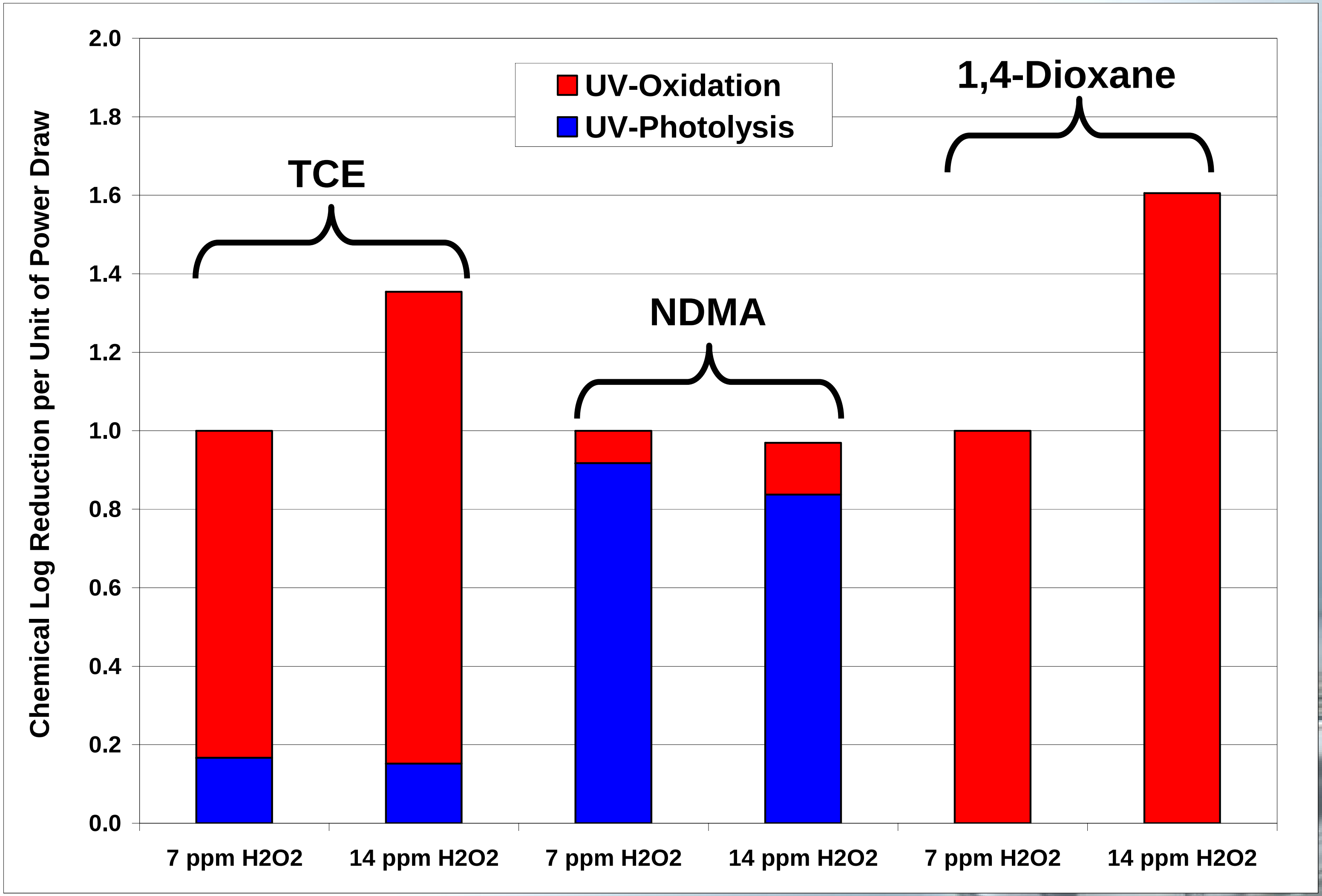
Source: Water Quality and Treatment, 5th Ed. p.12.3

How is UV-AOP Different from UV Disinfection?

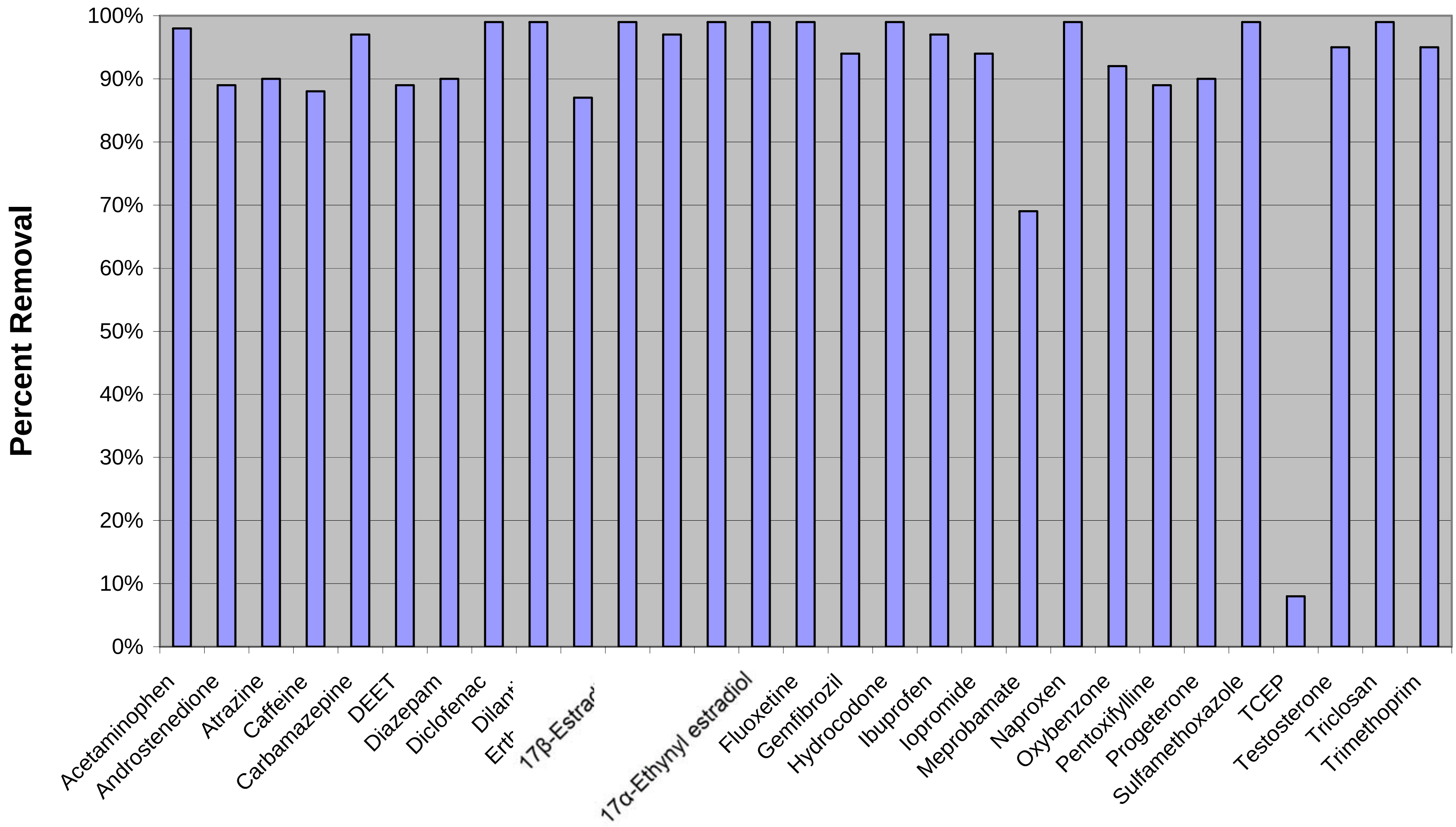
- UV-AOP typically uses a dose in excess of 500 mJ/cm2 to destroy emerging contaminants (more than 10 times greater than typical UV disinfection dose)

- Consequently, UV-AOP requires more energy than UV disinfection and good water quality (low TSS and organics) is very important.

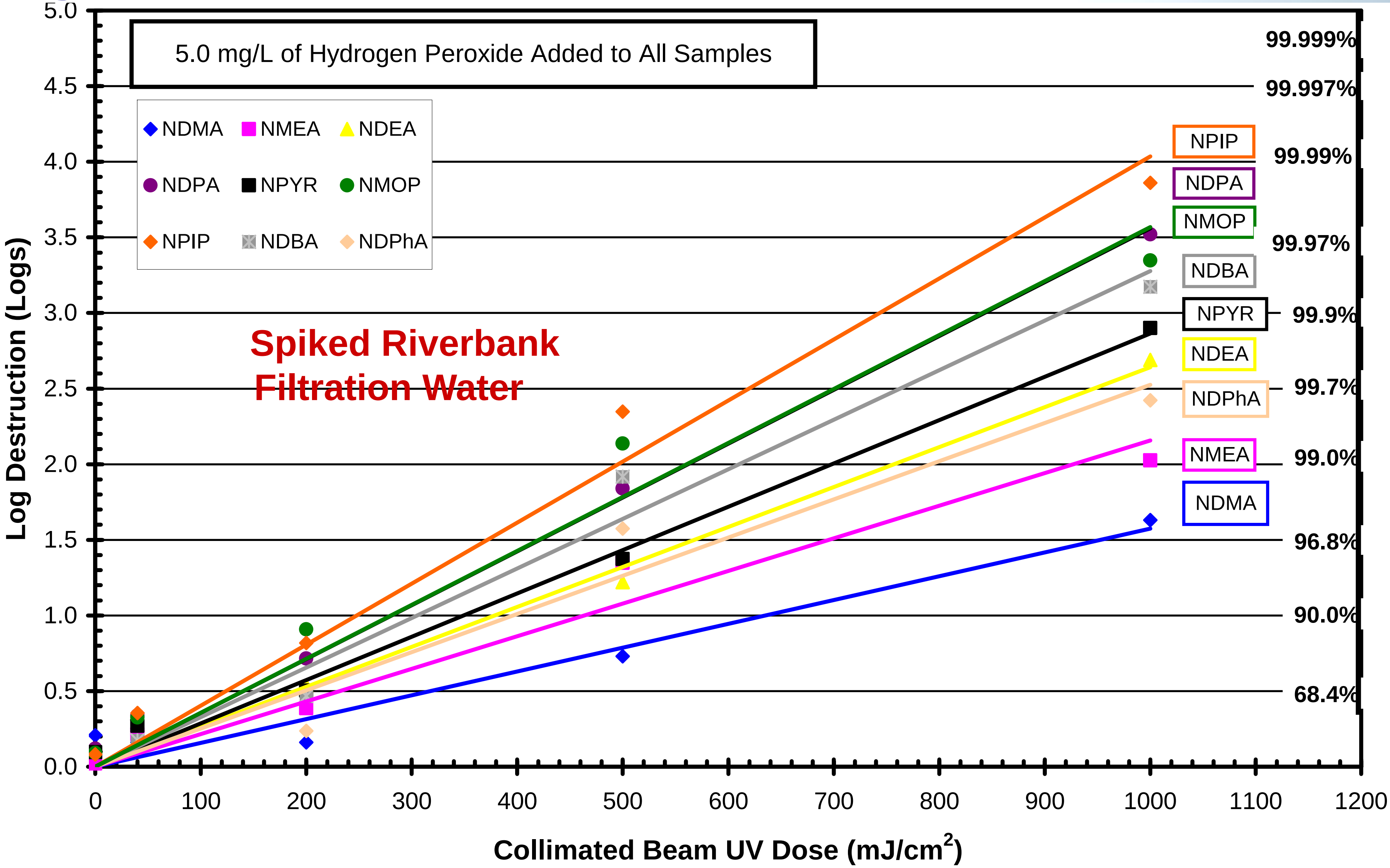
UV-Photolysis / UV-Oxidation Balance



Removal of Emerging Contaminants by UV-AOP (Snyder et. al 2007)
UV Dose: 671 mJ/cm2 H2O2 Dose: 5 mg/L



Destruction of Nine Nitrosamines by UV AOP



Case Studies

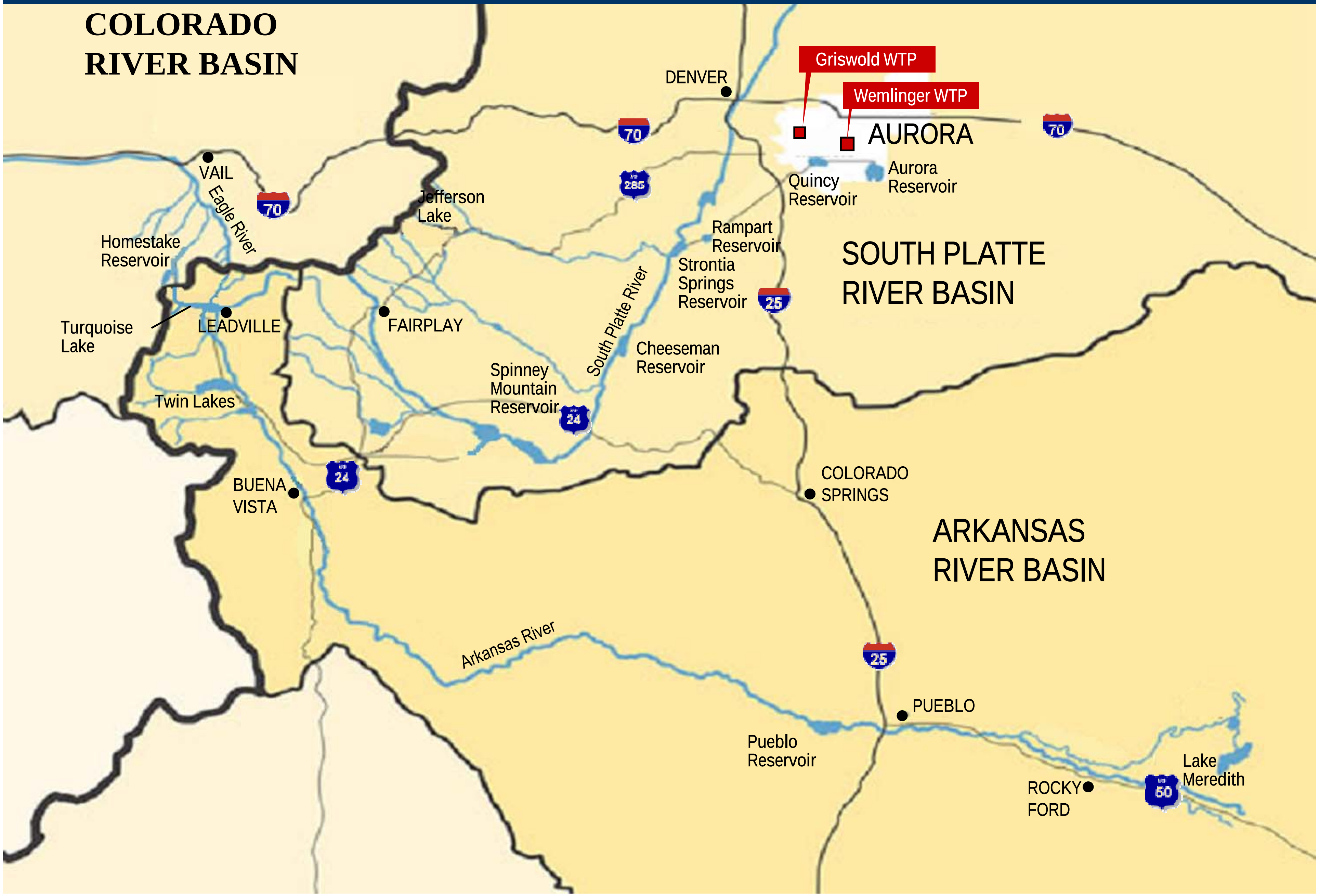
- Prairie Waters Project (Aurora, Colorado)
  - Drinking water project treating a typical urban surface water
- Western Corridor Recycled Water Project (Southeast Queensland, Australia)
  - Planned Indirect Potable Reuse Project

Prairie Waters Project

- Add sustainable water yield to Aurora's water system
  - "Drought Harden" Aurora's existing system
  - Develop new supplies for new development

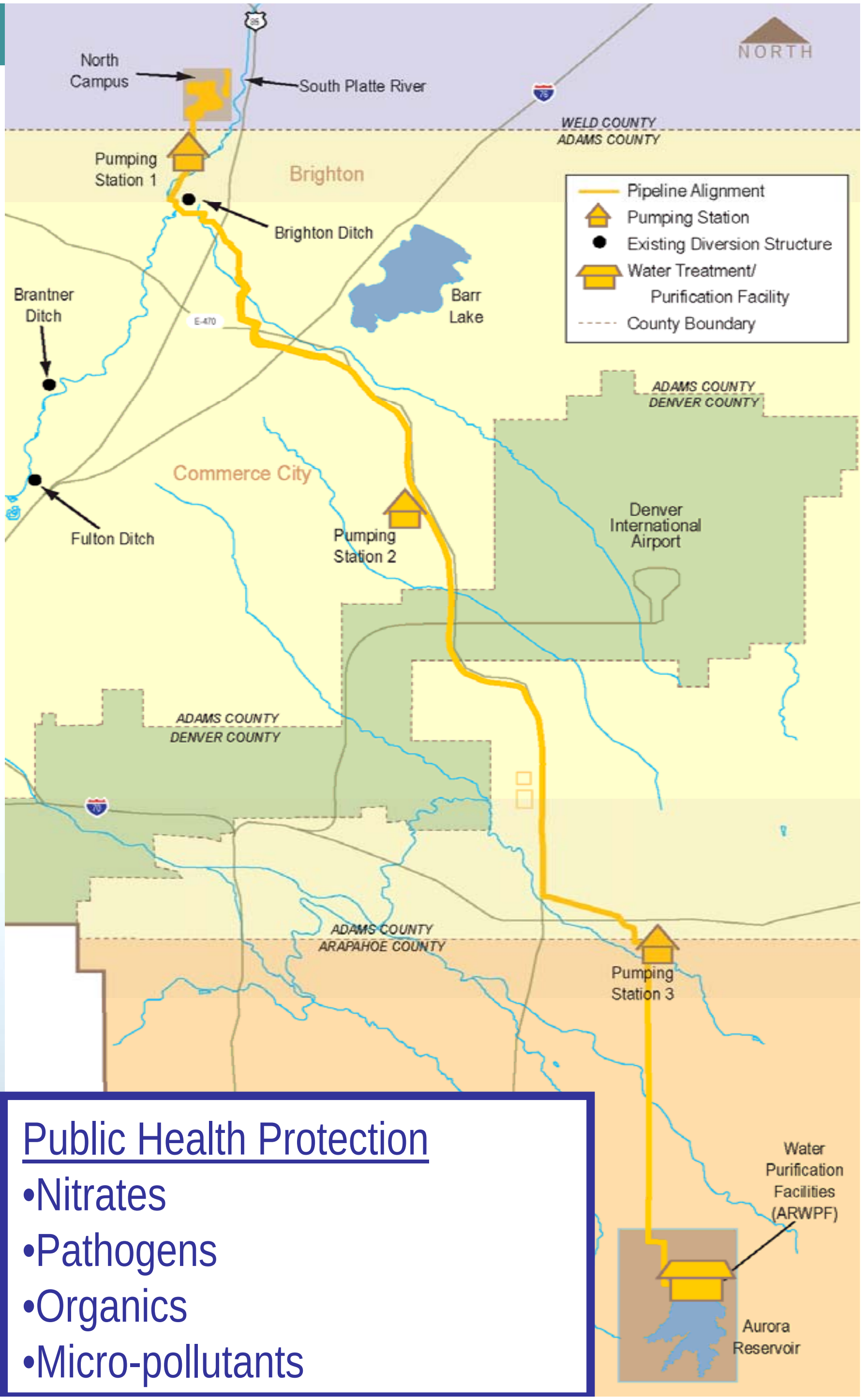
- Use existing available water rights to deliver no less than 10,000 af/yr of additional supply by 2010

Aurora's Water Supply System



Prairie Waters Project

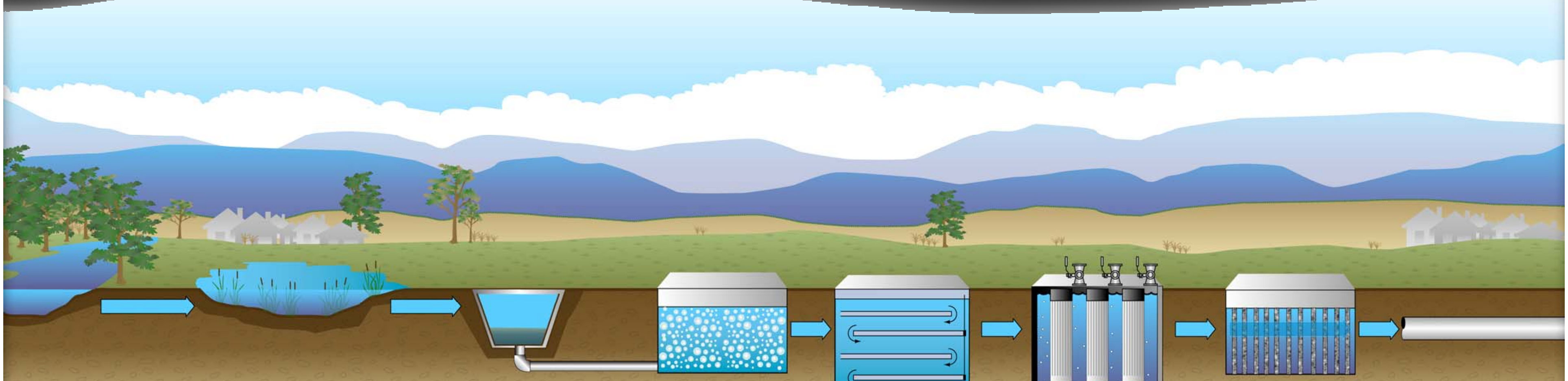
- 34 miles of 60-inch pipeline
- 3 pumping stations
- North Campus
  - Bank filtration
  - Aquifer Recharge and Recovery
- ARWPF
  - 50 mgd water purification facility



Public Health Protection

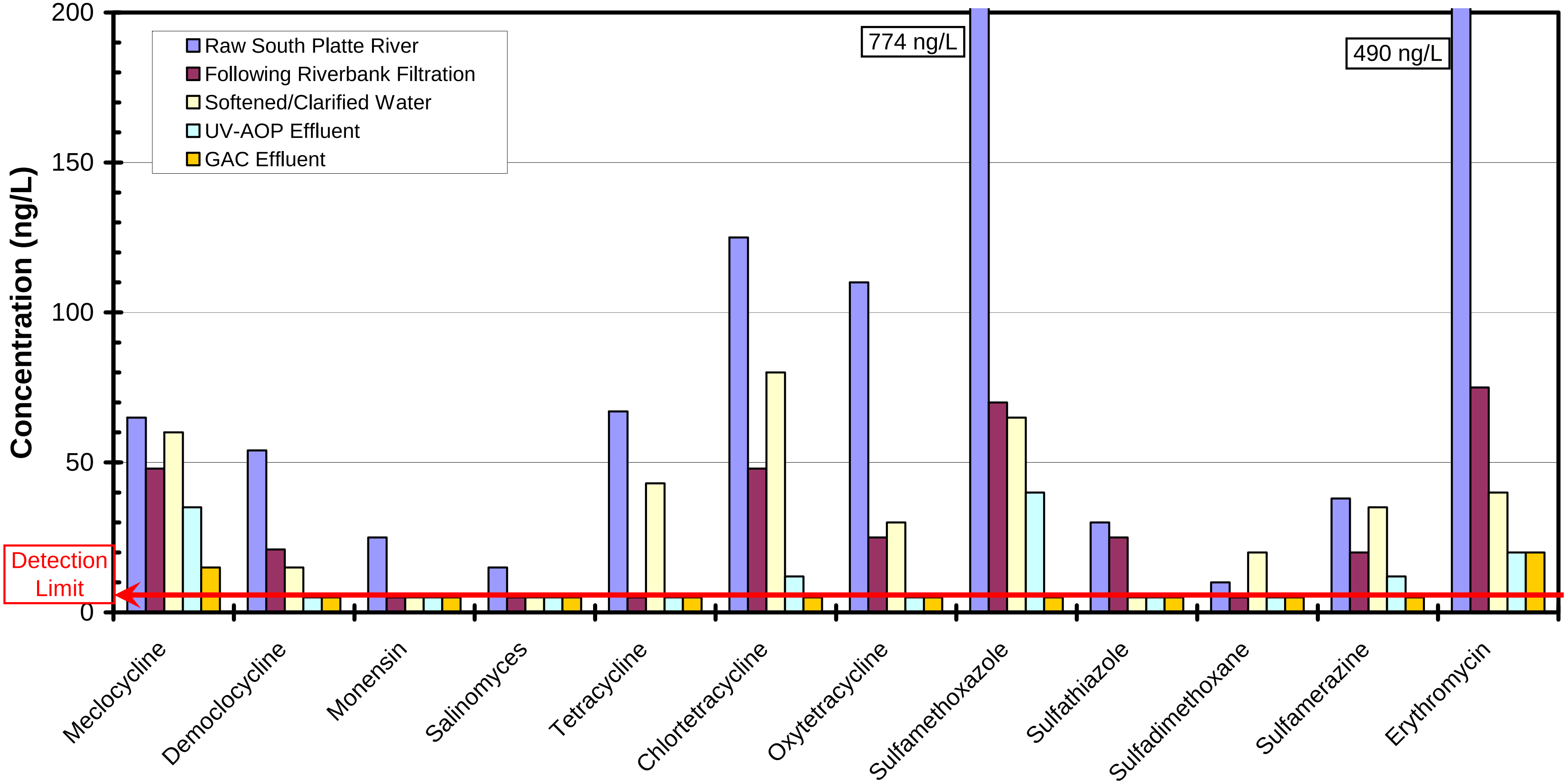
- Nitrates
- Pathogens
- Organics
- Micro-pollutants

Combining the Best of Natural and Engineered Purification Steps



	Natural Treatment	Softening	UV-AOP	Filters	GAC	Blending
Taste and Odor	✓	✓	✓		✓	
Color	✓	✓	✓			
TDS						✓
Nitrate	✓					
Pathogens	✓		✓	✓		
Organics	✓	✓			✓	
Micro-Pollutants	✓		✓		✓	

Results Demonstrate Effectiveness of Multiple Barrier Approach



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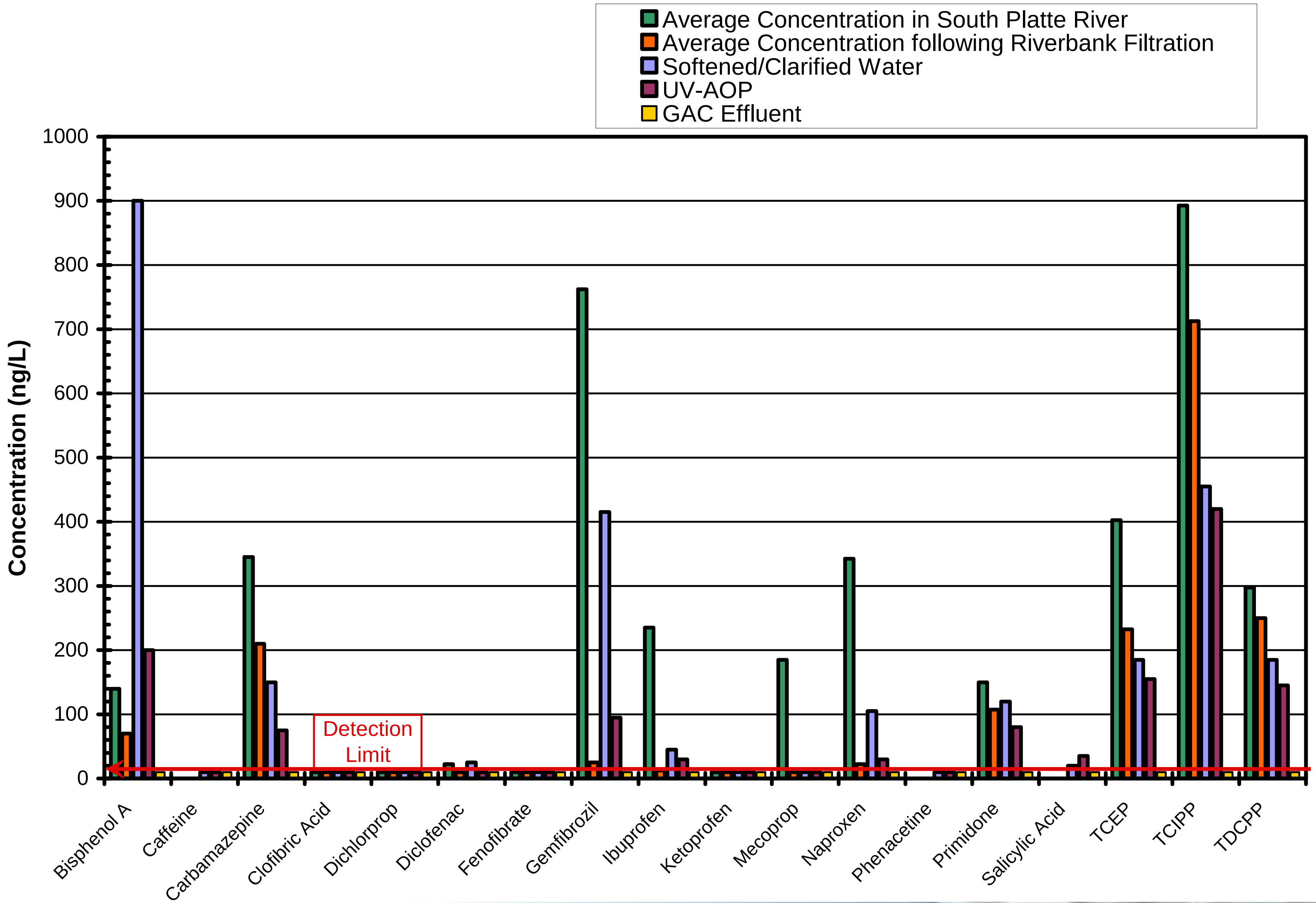

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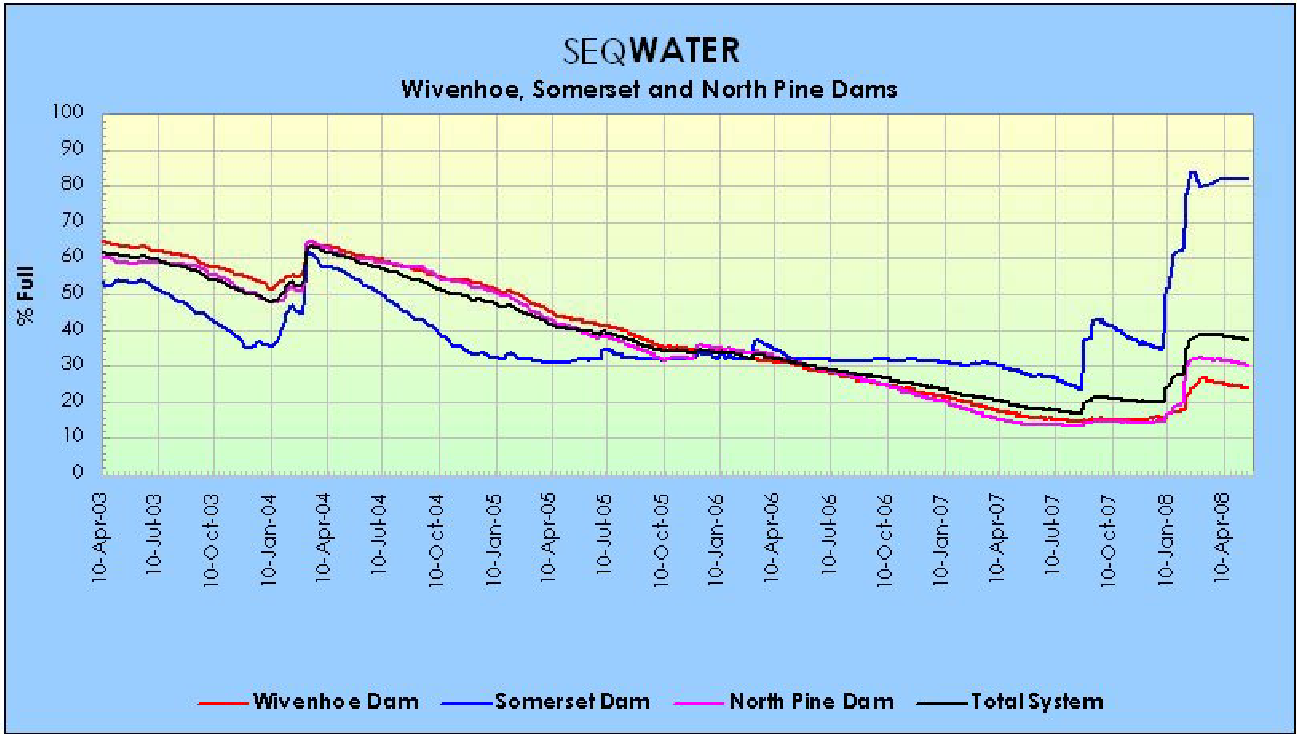
Western Corridor Recycled Water Project - Background

- Southeast Queensland has had the worst drought on record from 2001 – 2008



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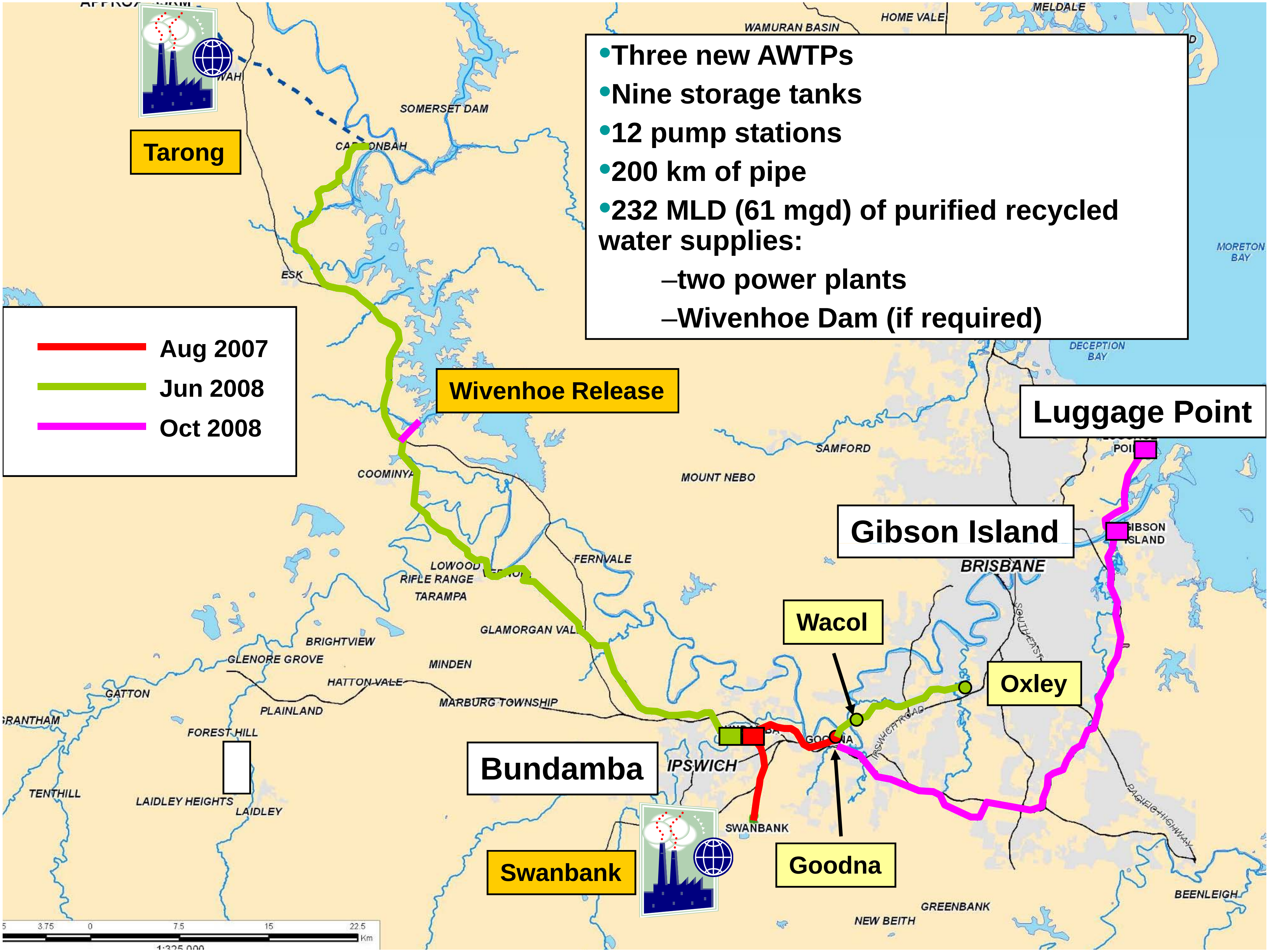
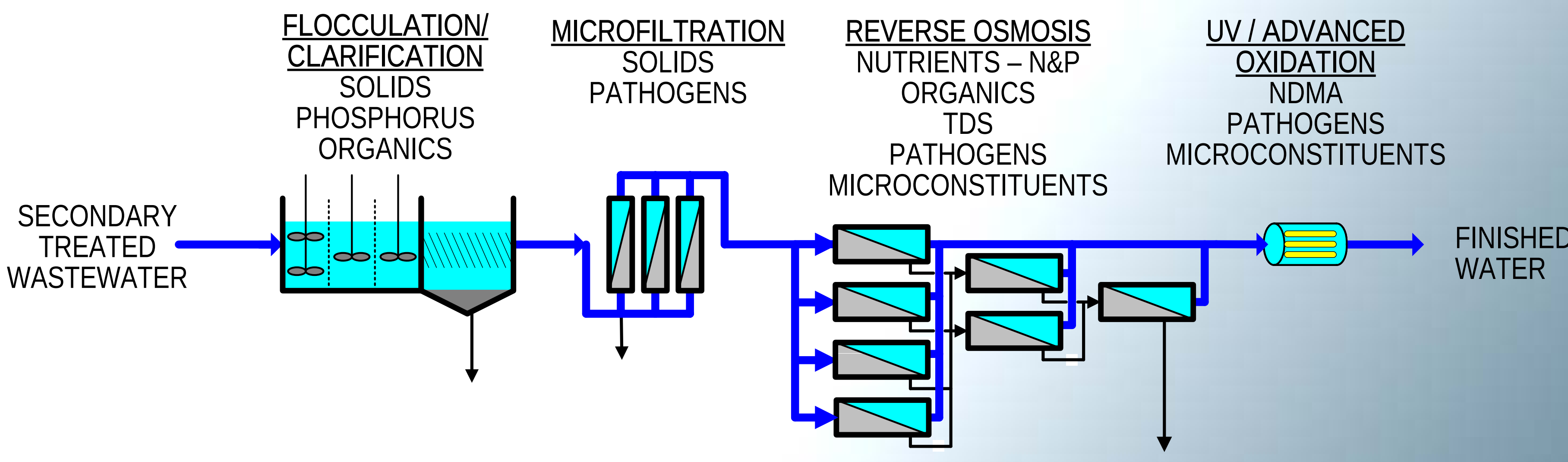

•Three new AWTPs
•Nine storage tanks
•12 pump stations
•200 km of pipe
•232 MLD (61 mgd) of purified recycled water supplies:
–two power plants
–Wivenhoe Dam (if required)
Aug 2007
Jun 2008
Oct 2008
Tarong
Wivenhoe Release
Luggage Point
Gibson Island
Wacol
Oxley
Bundamba
Goodna
Swanbank
WAMURAN BASIN
HOME VALE
MELDALE
SOMERSET DAM
ESK
MORETON BAY
DECEPTION BAY
SAMFORD
MOUNT NEBO
COOMINYA
LOWOOD
RIFLE RANGE
TARAMPA
FERNVALE
BRISBANE
GLAMORGAN VALE
BRIGHTVIEW
GLENORE GROVE
MINDEN
HATTON VALE
GATTON
MARBURG TOWNSHIP
PLAINLAND
FOREST HILL
IPSWICH
TENTHILL
LAIDLEY HEIGHTS
LAIDLEY
SWANBANK
IPSWICH ROAD
PACIFIC HIGHWAY
GREENBANK
NEW BEITH
BEENLEIGH
3.75
0
7.5
15
22.5
Km

Key Design Criteria of Full-Scale Plant

- Production capacity of 70 ML/d (18.5 mgd)
- Provide multi-barrier treatment process
- Meet all water quality requirements
  - Meet all Australian drinking water guidelines
  - Total Nitrogen < 1.2 mg/L as N
  - Total Phosphorus < 0.13 mg/L
  - NDMA < 10 ng/L

Major Treatment Processes



Example Constituent Removal (based on pilot results)

- Total nitrogen
  - Influent average 10 mg/L
  - Permeate average 1.2 mg/L
  - 88% removal

Ammonia Nitrogen	TKN	Nitrate Nitrogen	Nitrite Nitrogen	Total organic nitrogen	Total Nitrogen
83%	88%	87%	94%	92%	88%

- Total phosphorus removal
  - Influent average 7.5 mg/L
  - Permeate average <0.01 mg/L
  - 99.9% removal

- NDMA Removal
  - Below detection limit

Luggage Point AWTP Site

Luggage Point AWTP

Flocculation / Clarification

Reverse Osmosis

Microfiltration

UV / Advanced Oxidation

Excerpts From:

Indirect Potable Reuse:
BALANCING COSTS AND BENEFITS

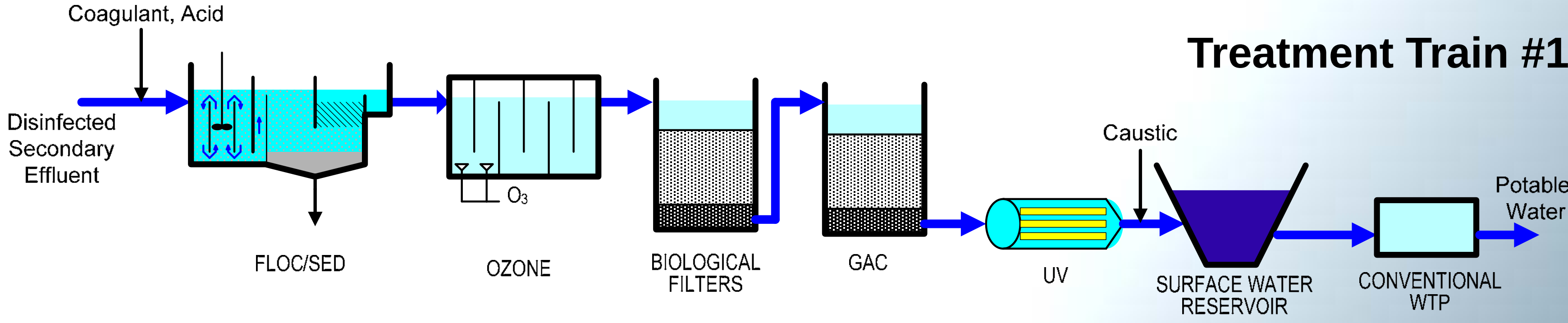
IWA World Water Congress
September 2008
Vienna

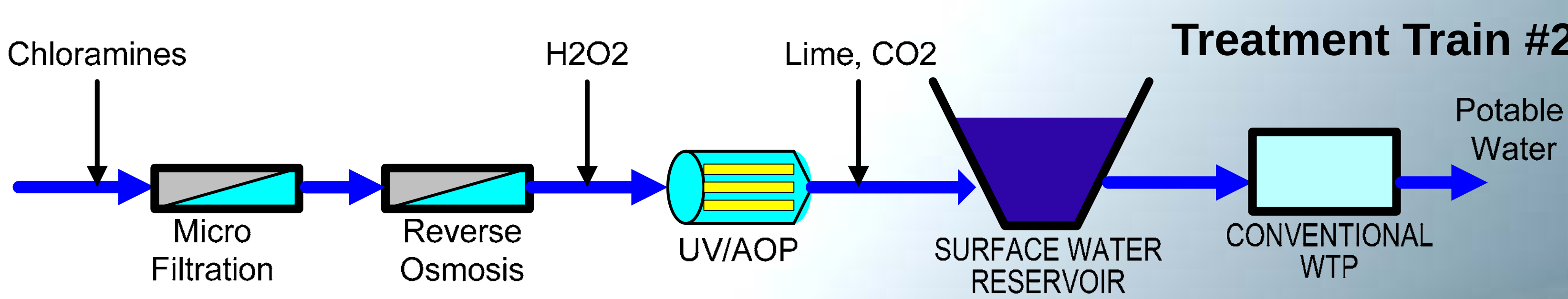
Larry Schimmoller – CH2M HILL
Bill Bellamy – CH2M HILL
Jason Curl – CH2M HILL

Background

- Greater focus on sustainability throughout society
- Intent of this paper is to compare two indirect potable reuse (IPR) treatment trains with respect to cost, health, and environmental impact

Treatment Trains Evaluated



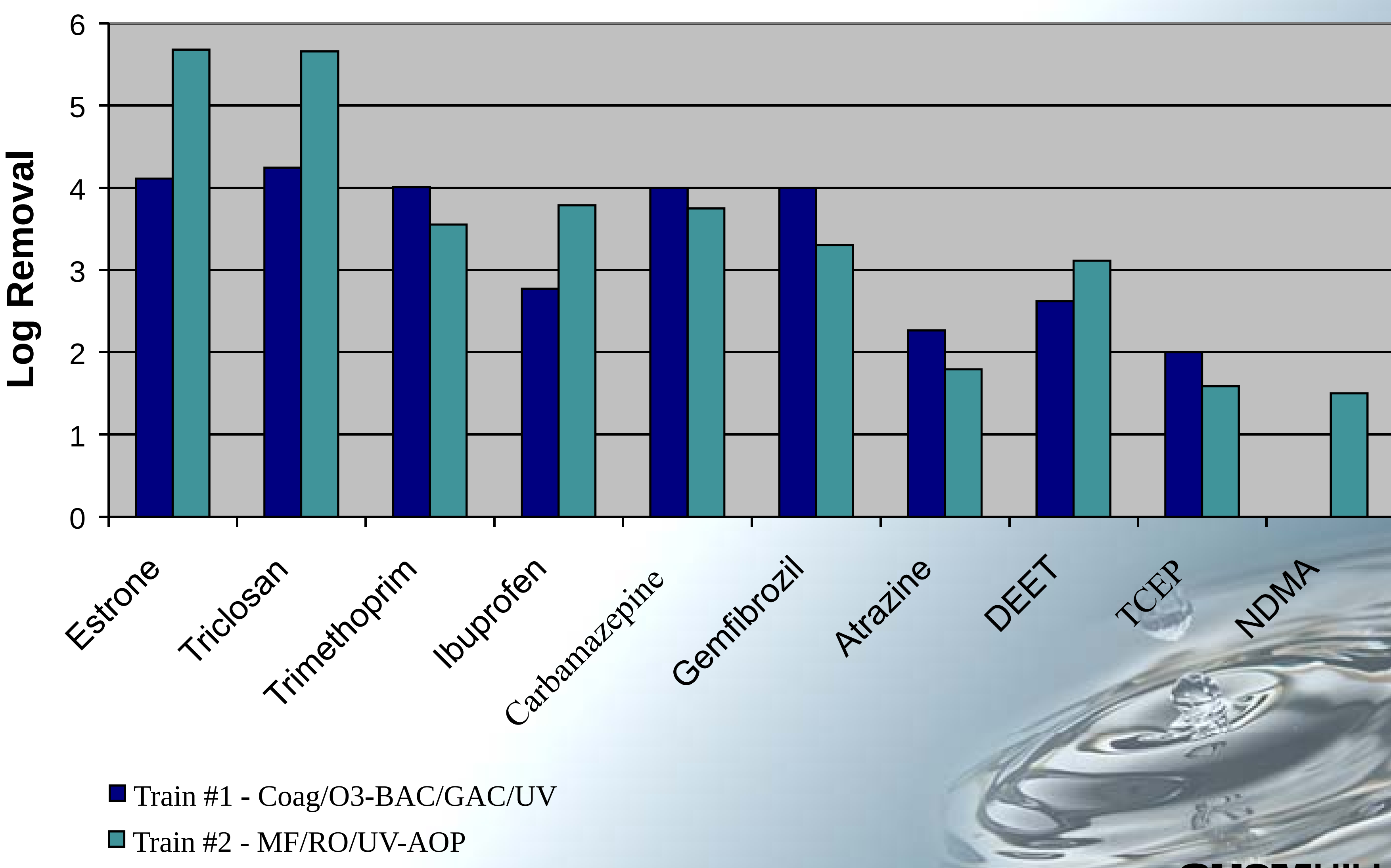


- Multiple barriers provided by each treatment train for removal of bulk organic matter, trace organics, and pathogens
- Disposal of RO concentrate required for Train #2

Triple Bottom Line Analysis

- **Social**
  - Health impacts: evaluated effectiveness of each treatment train for removal of emerging contaminants, bulk organic matter, and pathogens
- **Financial**
  - Evaluated the capital cost, annual operating cost, and net present value of each treatment train
- **Environmental**
  - Evaluated greenhouse gas emissions produced by each plant

Pharmaceutical and EDC Removal



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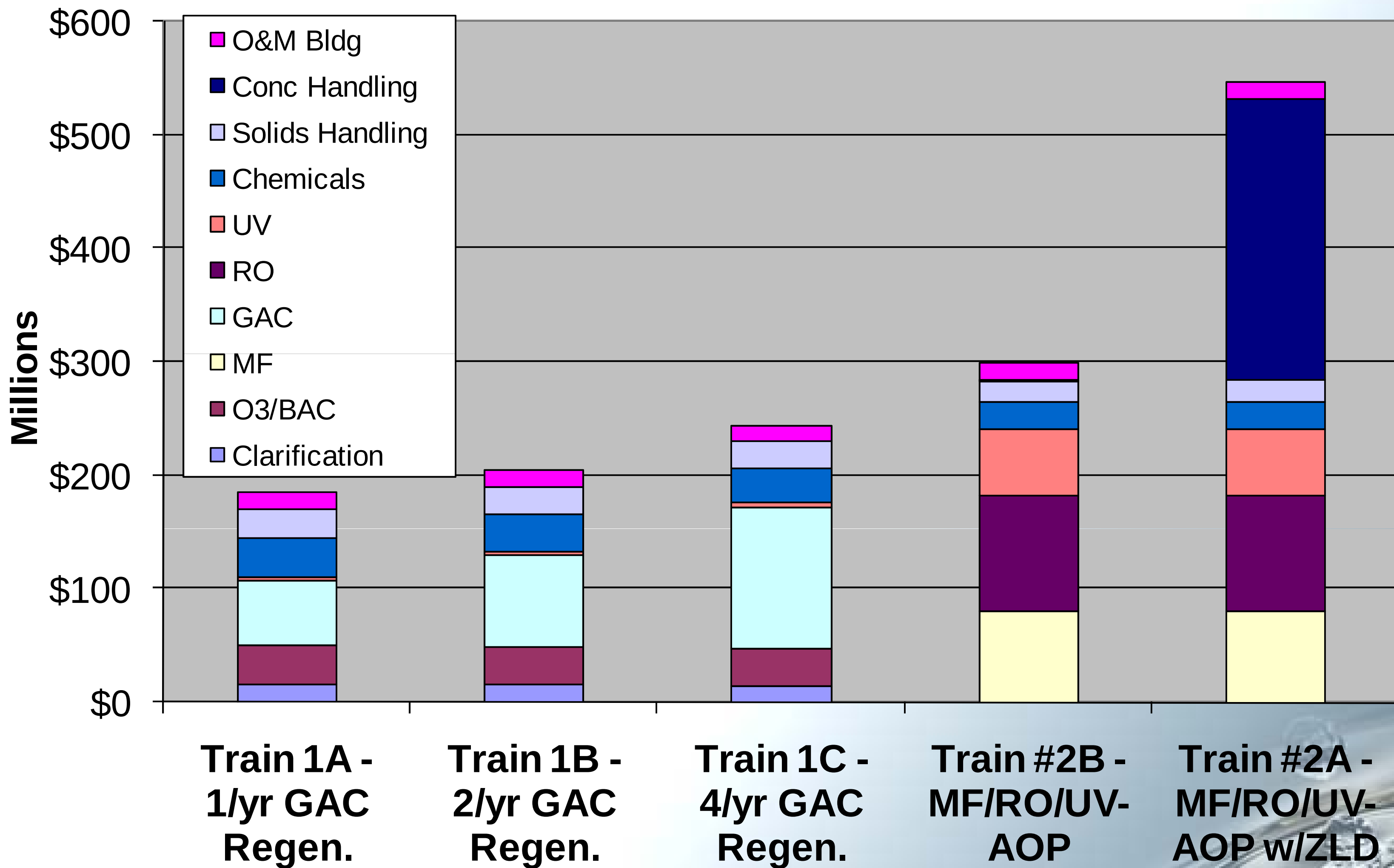
Net Present Worth (US Dollars)



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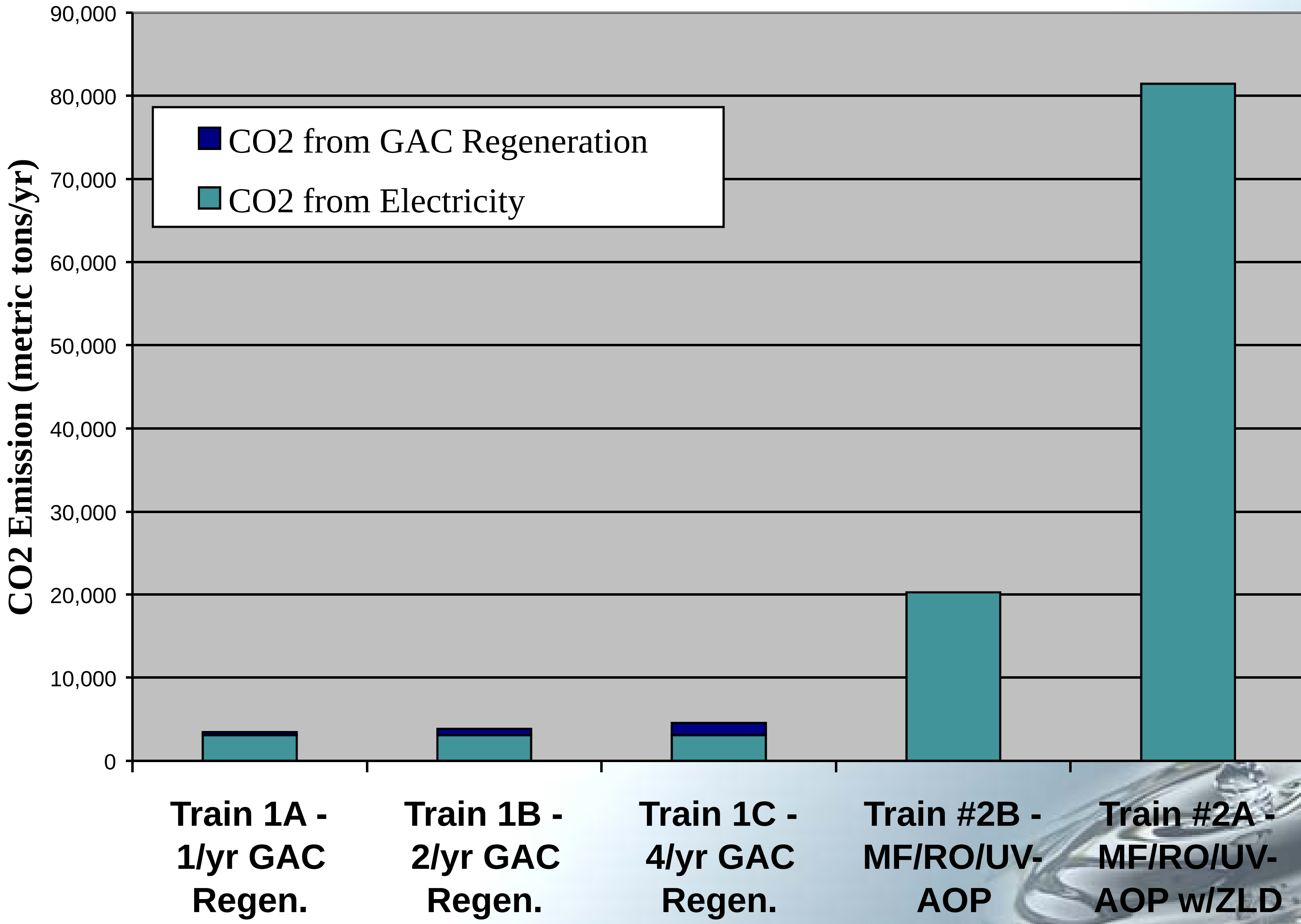
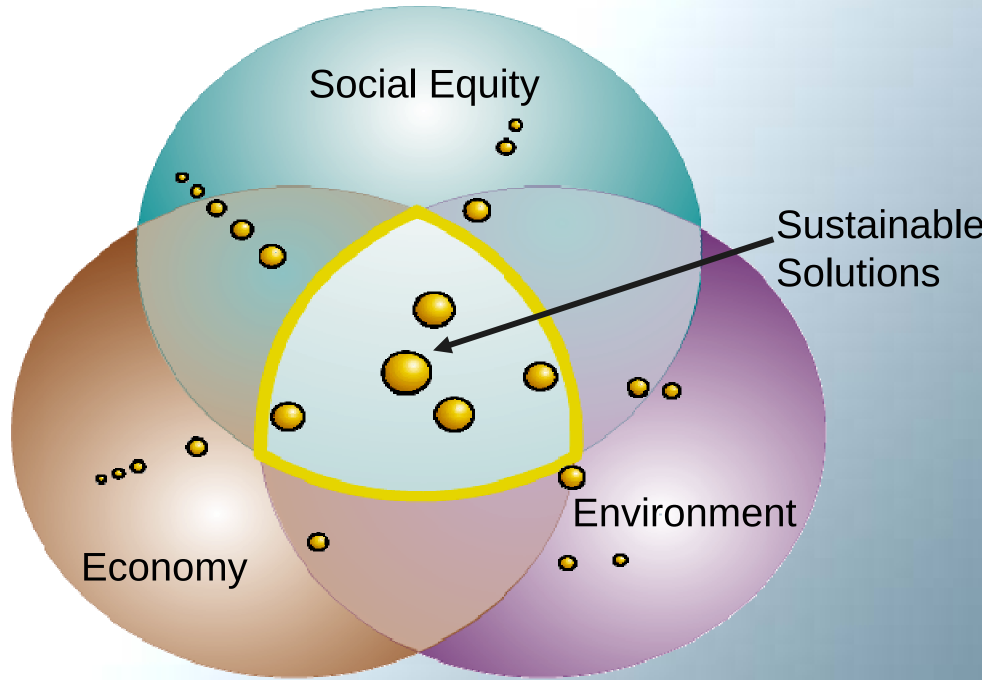
CO2 Emissions



Major Conclusions

- Alternative treatment trains should be considered for IPR applications (especially for inland locations)
  - cost can be significantly less
  - environmental impact can be substantially less
  - treated water is of similar quality
- Alternative selected for implementation should support the most sustainable approach
- Where TDS removal is required, RO treatment is necessary



Thank you

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