Aquifer Storage and Recovery Using Reclaimed Water: Successful Applications and Critical Opportunities

الجمعية العربية السعودية للبيئة المائية
Saudi Arabian Water Environment Association

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Agenda

- Benefits
    - Water Resource
    - Water Quality Improvement
    - Energy Savings
- Existing Applications Around the World
- Future Opportunities – GCC Specific

Reclaimed water as a source is of predictable volume with a fairly uniform rate of flow over time and of constant, but inferior quality (Murray and Tredoux, 1998).

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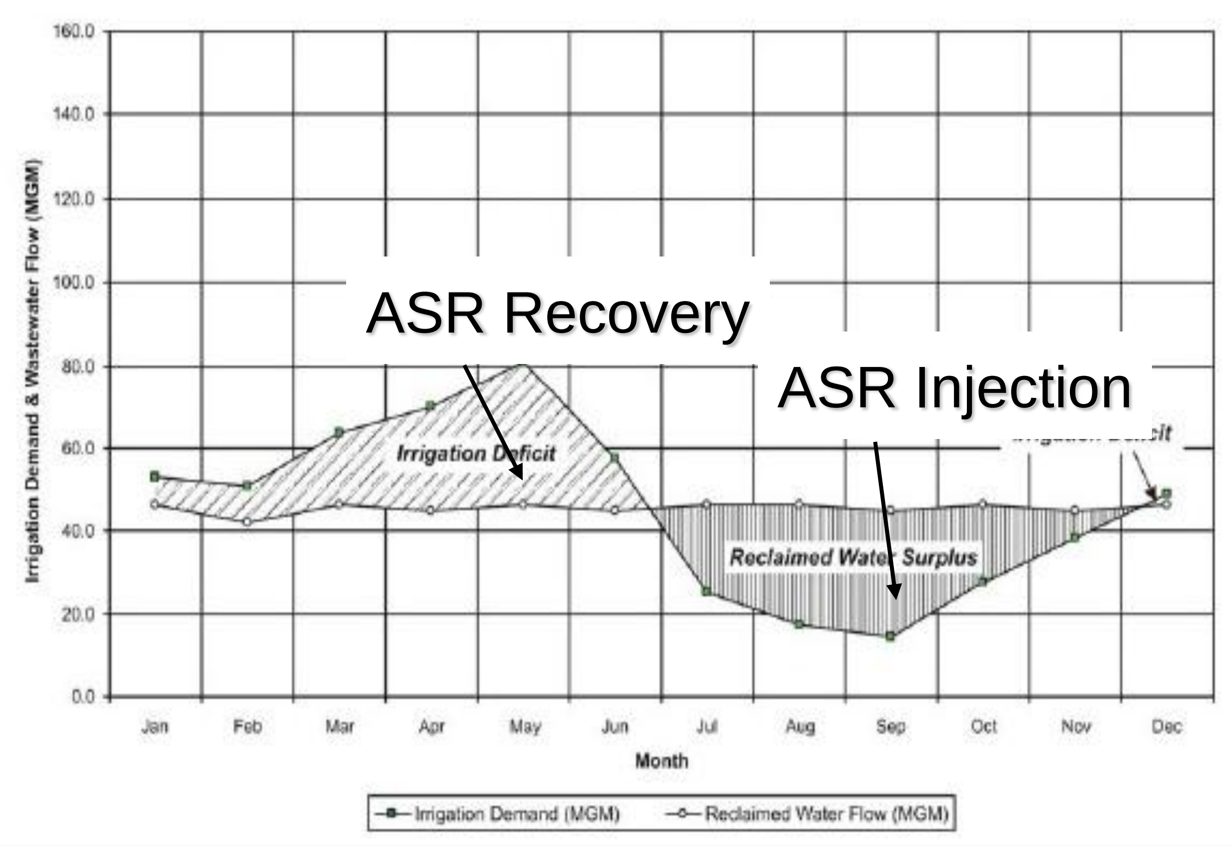
Benefits – Water Resource Management

Example of ASR to Meet Supply/Demand



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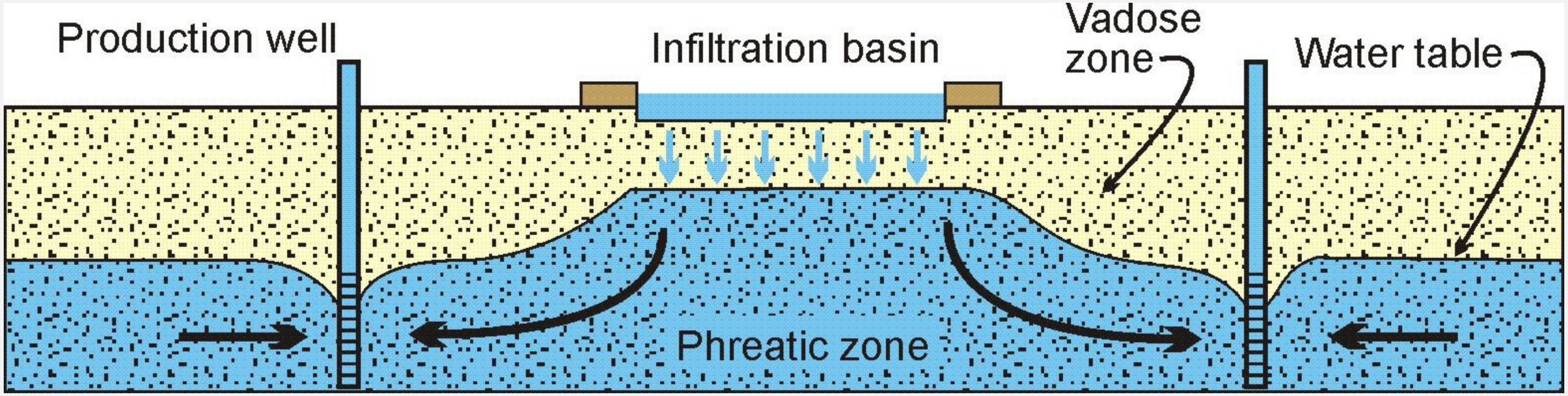
Benefits – Water Quality Improvement



Soil-Aquifer Treatment

Water recovered using production wells.

Production wells control movement of recharged water and can prevent it from reaching more distant potable water wells depending on operational strategy.

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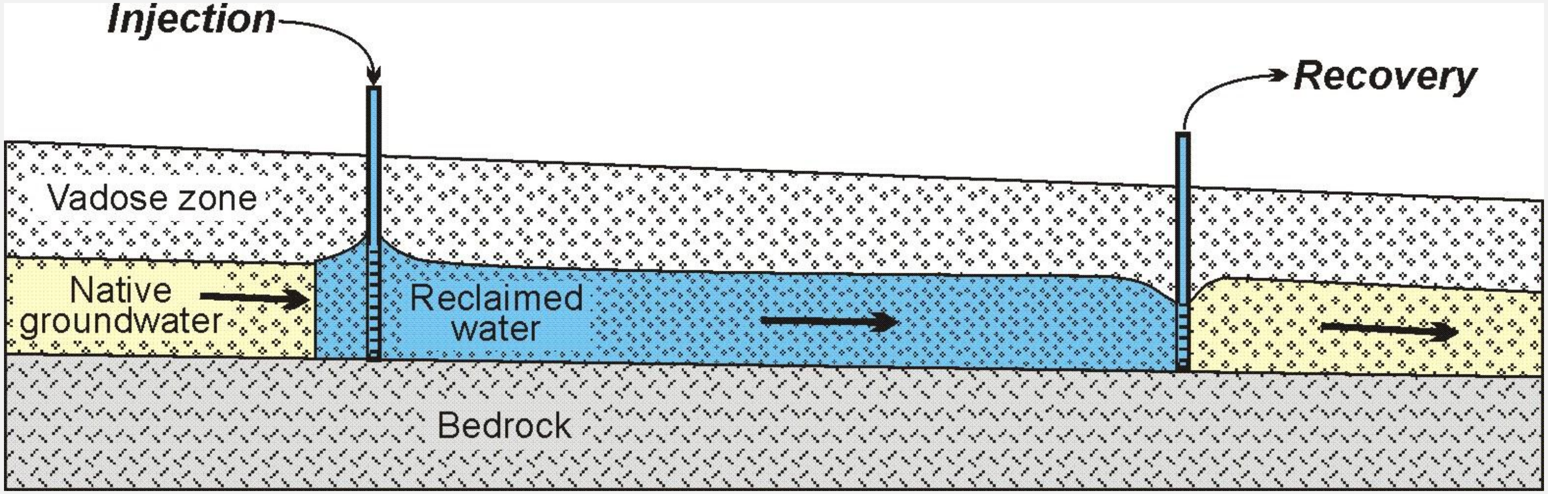
Benefits – Water Quality Improvement



Aquifer Storage Transfer and Recovery

Injection and recovery using separate wells

Flow of recharged water through aquifer provides filtration and time for natural degradation (and other contaminant attenuation) processes to occur.

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Constituents of Concern in TSE

- **Pathogenic microorganism**
  - One time exposure ➔ illness
  - Presence and concentration depends wastewater treatment process and health of population in service area
  - Variety of different pathogens may be present: bacteria, protozoa, viruses, trematodes.

- **Chemical constituents**
  - **Typically present at low concentrations**
    - **Long-term low-level** (chronic) exposure➔ Adverse health impacts

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Natural Pathogen Attenuation Processes in Groundwater

- Most waterborne pathogenic microorganisms
  - are enteric (intestinal)
  - **do not survive long in groundwater environments**

- Groundwater = **hostile environment** for enteric microorganisms
  - different chemistry
  - already occupied by indigenous microorganisms

- **Log_{10} removal times for most pathogens is several days to weeks, so several months of underground storage can result in high degrees of removal.**

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Energy Savings

- Local Resource reduces transmission cost
  - Pipeline construction, maintenance and lift station pumping costs reduced
- Treatment costs reduced depending on water resources and level of treatment required
  - California recycled water costs 10 – 30% of cost of importing water due to decreased energy and infrastructure
- Increased aquifer levels mean lower pumping costs
  - 10% decrease in pump lift relates to about 10% reduction in energy required

Although it requires additional energy to treat wastewater for recycling, the amount of energy required to treat and/or transport other sources of water is generally much greater. USEPA

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Existing Applications

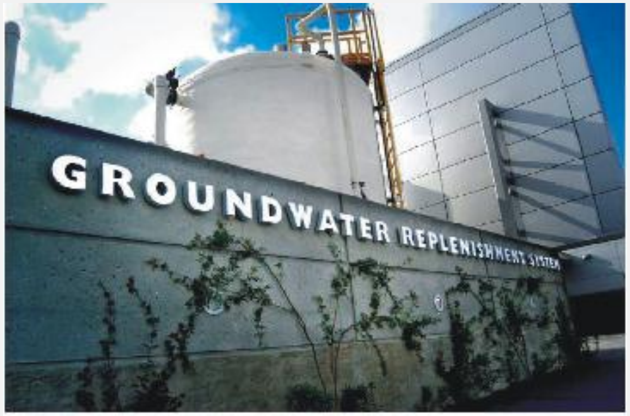
Groundwater Replenishment System Orange County, California

- **Groundwater Replenishment System**
  Following conventional treatment:

-**Microfiltration** (MF), which removes small suspended particles, protozoa, bacteria, and some viruses from the water

-**Reverse osmosis** (RO), which eliminates salts, viruses, pesticides, and most organic compounds, creating near-distilled quality water

-**Ultraviolet** (UV) **light and hydrogen peroxide treatment**, which breaks down remaining organic compounds



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- **Groundwater Replenishment System, California, USA**
  - Capacity of 70 million gallons (264,960 m^3) per day
  - Construction cost of approximately US $485 million
  - Operational cost is US $525 per acre ft => US $1.61 per 1000 gallons or US $426 per 1000 m^3
  - SWRO ~ US $600 per 1000 m^3 (WateReuse.org 2012)

Uses less than one-third the energy that it takes to desalinate ocean water.

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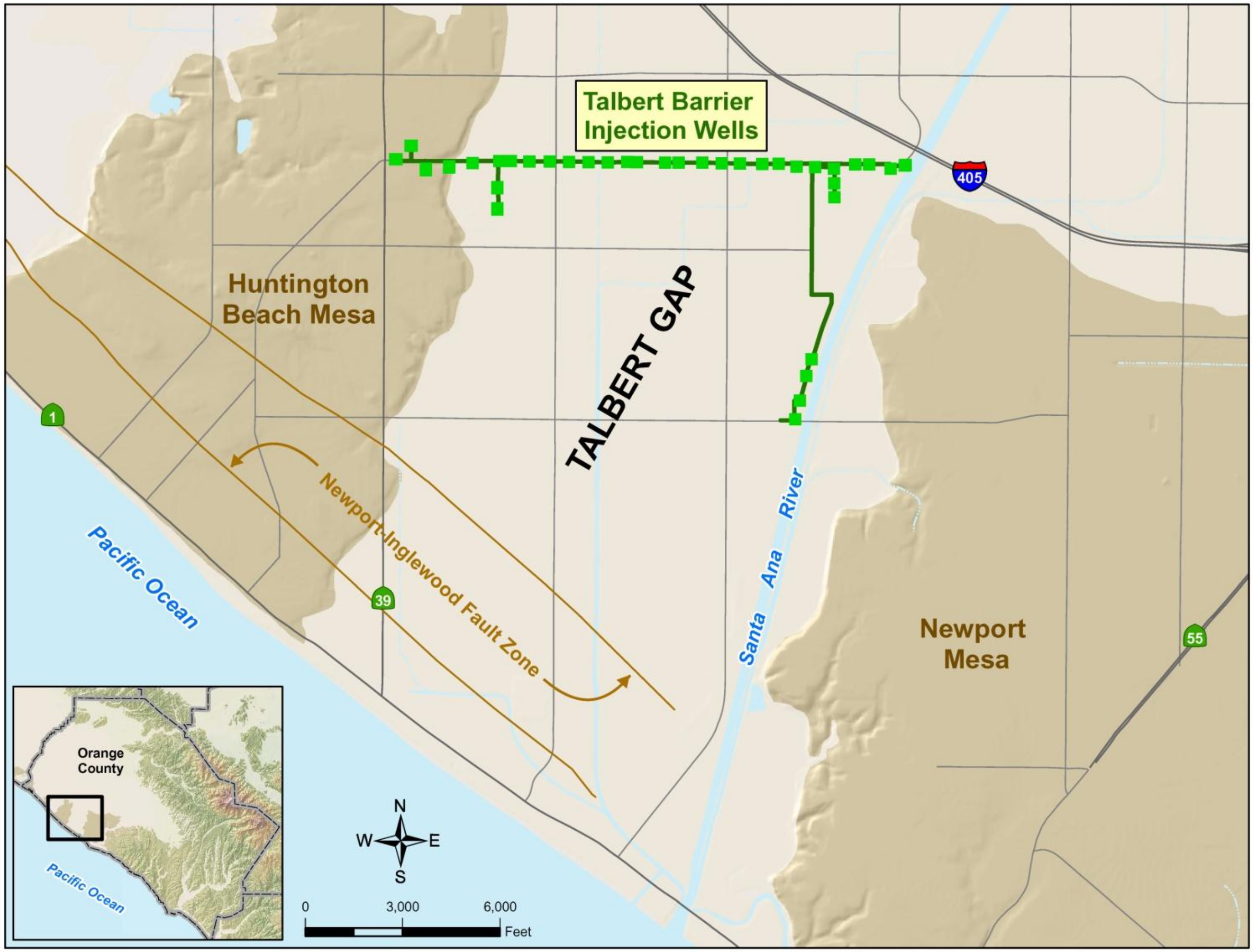
Talbert Gap – Orange County, California



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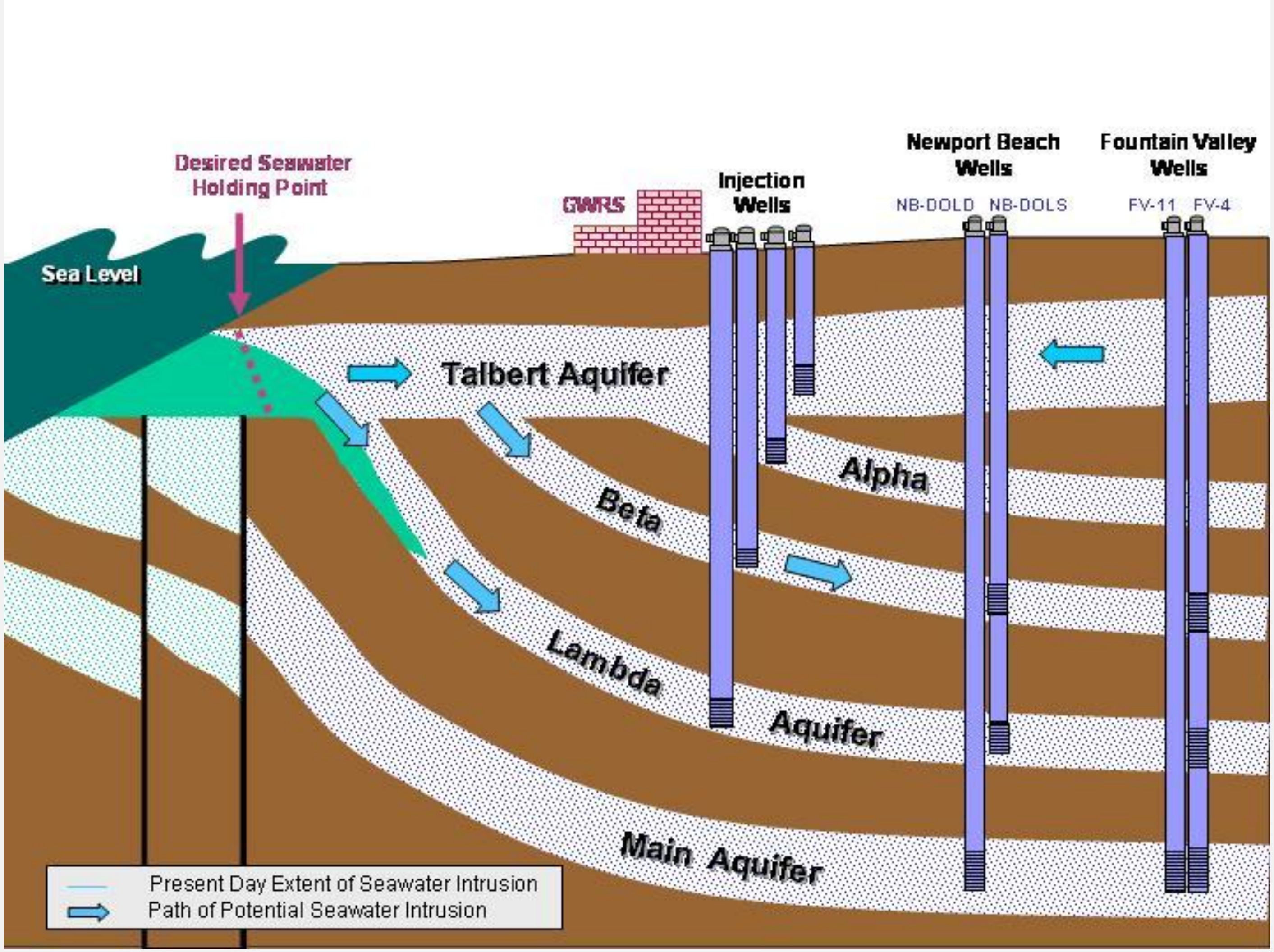
Talbert Gap Salinity Barrier Cross Section



Water Quality and Water Levels Monitored with Westbay Multi-zone Monitoring Systems

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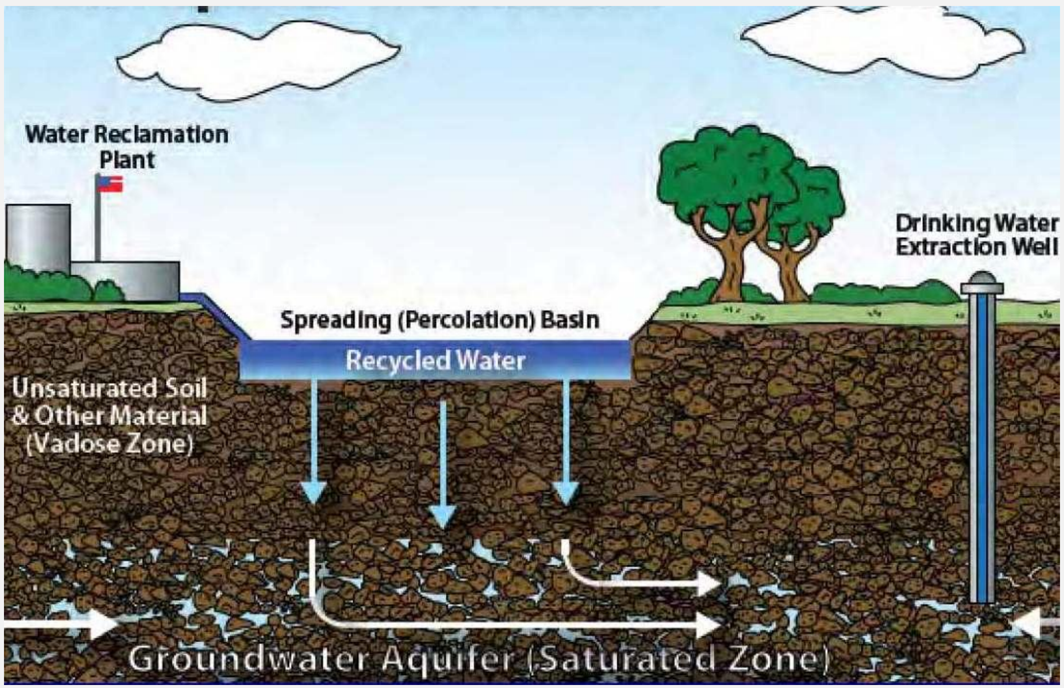
Montebello Forebay Ground Water Recharge Project

For over 35 years, in the Montebello Forebay Ground Water Recharge Project, tertiary treated recycled water has been applied to the Rio Hondo spreading grounds to recharge a potable ground water aquifer in south-central Los Angeles County.

> 1.5MAcre Feet Since 1962 = 1.85M Megaliters



Source: Los Angeles County Sanitation District

Other Projects of Note:
Nardò, Italy
Bolivar, Australia
Perth, Australia
Adelaide, Australia
Sabadell, Spain
Torreele, Belgium
Atlantis, South Africa
Florida, USA
California, USA
Texas, USA

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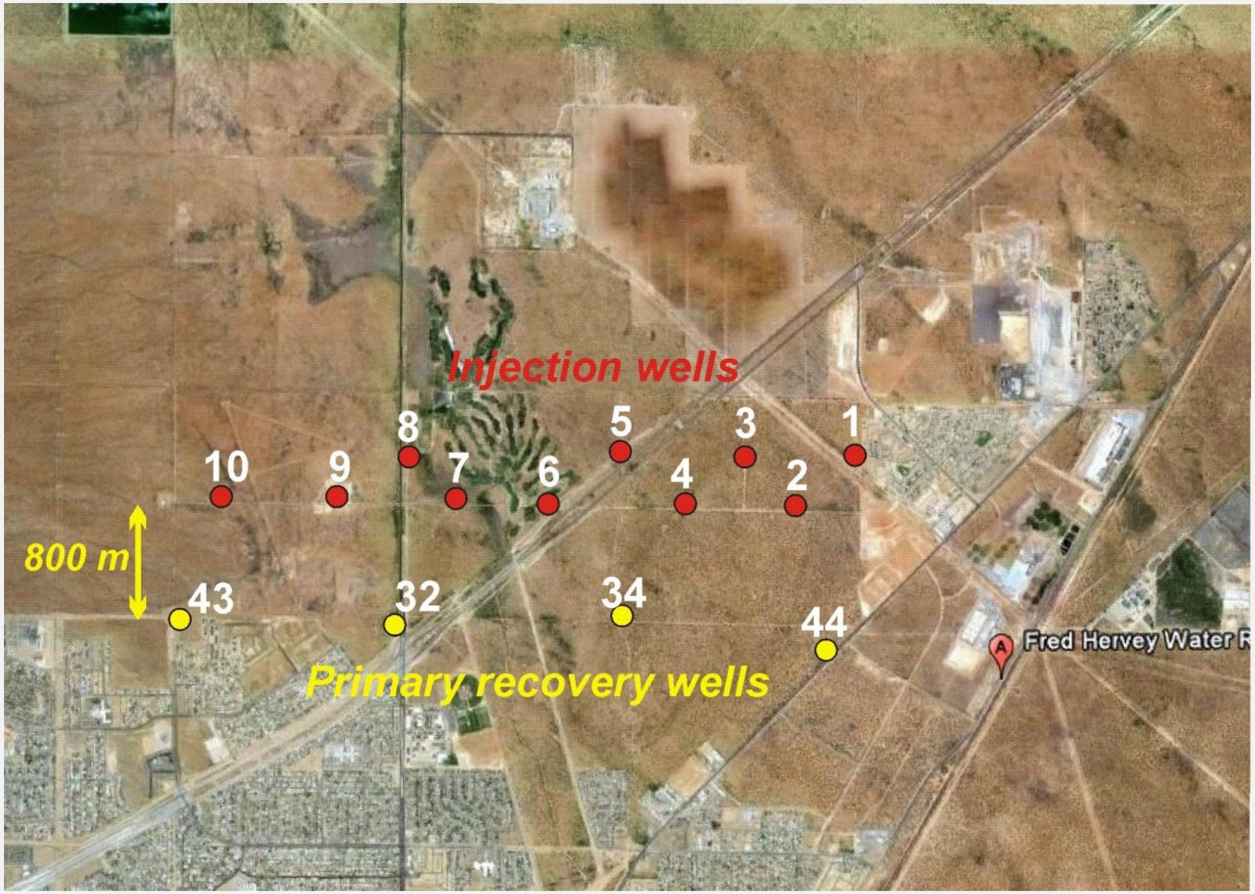
Aquifer Storage Transfer and Recovery
Fred Hervey WTP – El Paso, Texas

- Minimum two-year travel time from injection wells to recovery wells

- Added infiltration basins for wastewater recharge



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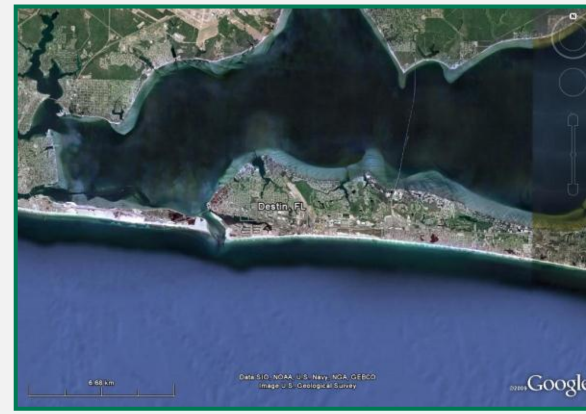
Reclaimed Water ASR in Destin, Florida

- TSE ASR needed for additional wet season reclaimed water disposal capacity (operational and regulatory requirement).
- Environmental issues are very sensitive because of tourism. Area is known for its beautiful beaches and sport fishing.



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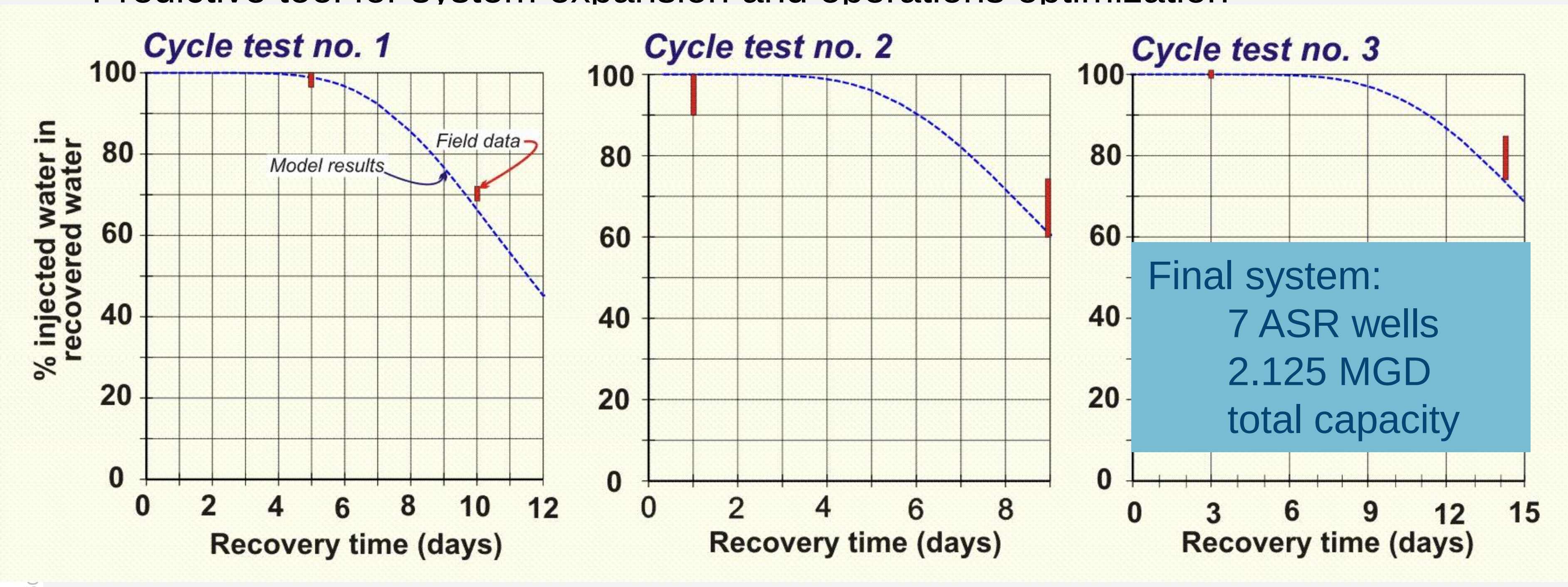
Pilot Testing Results

- Solute-transport modeling

  - Modeling was used to analyze system performance and hydrogeology through calibration process

  - Predictive tool for system expansion and operations optimization



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Australia

Adelaide

~22 ASR schemes using ponds, galleries & injection bores

•recharge treated stormwater and wastewater

• mostly confined limestone aquifers

Perth – sand aquifers

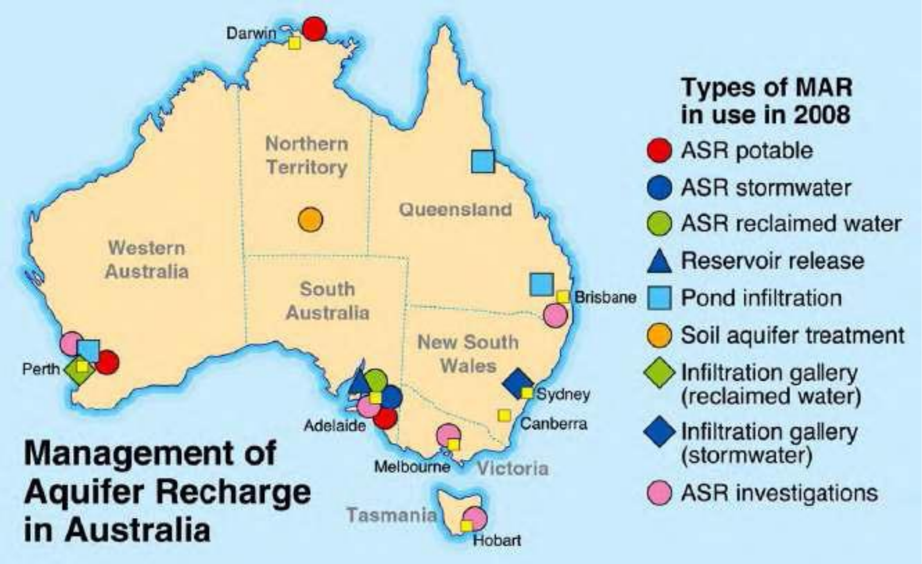
• gw supplies 70% of water use

• gw supplies 30% of potable water

• practice MAR with stormwater

• successful trials of infiltration galleries with treated wastewater

Source: UNSW Water Research Laboratory



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TSE MAR Opportunities in GCC

1) ASR in reaches of aquifers downstream from cities (TSE typically available at downstream side of city).

2) ASR or salinity barrier systems in coastal areas. TSE used for increasing hydraulic head and holding back saline water migration.

3) Recovery of water levels in aquifers.

4) Water resource management tool for cities, power plants, industrial cities, etc. Large storage capacity depending on hydrogeologic conditions.

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GCC Characteristics with Respect to Water Resources

- Rapid urban population growth.
- Diminishing groundwater supplies.
- Increasing TSE resource.
- Increasing reliance on seawater desalination.
- Best to diversify resources
- Energy resources of increasing concern

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Conclusions

- TSE MAR projects demonstrate that the technology is viable and can provide significant water resources benefits.
- Significant energy savings can be realized over development of other water resources dependent on situation.
- The multiple barrier approach is typically employed to ensure that public health is protected, although the barrier elements used vary between systems.
- TSE MAR systems tend, if anything, to be over-designed in order to provide public with greater confidence in projects.
- Modern planned TSE MAR systems have a excellent safety record. No documented adverse health impacts.
- The GCC has many opportunities to employ this valuable water resource tool

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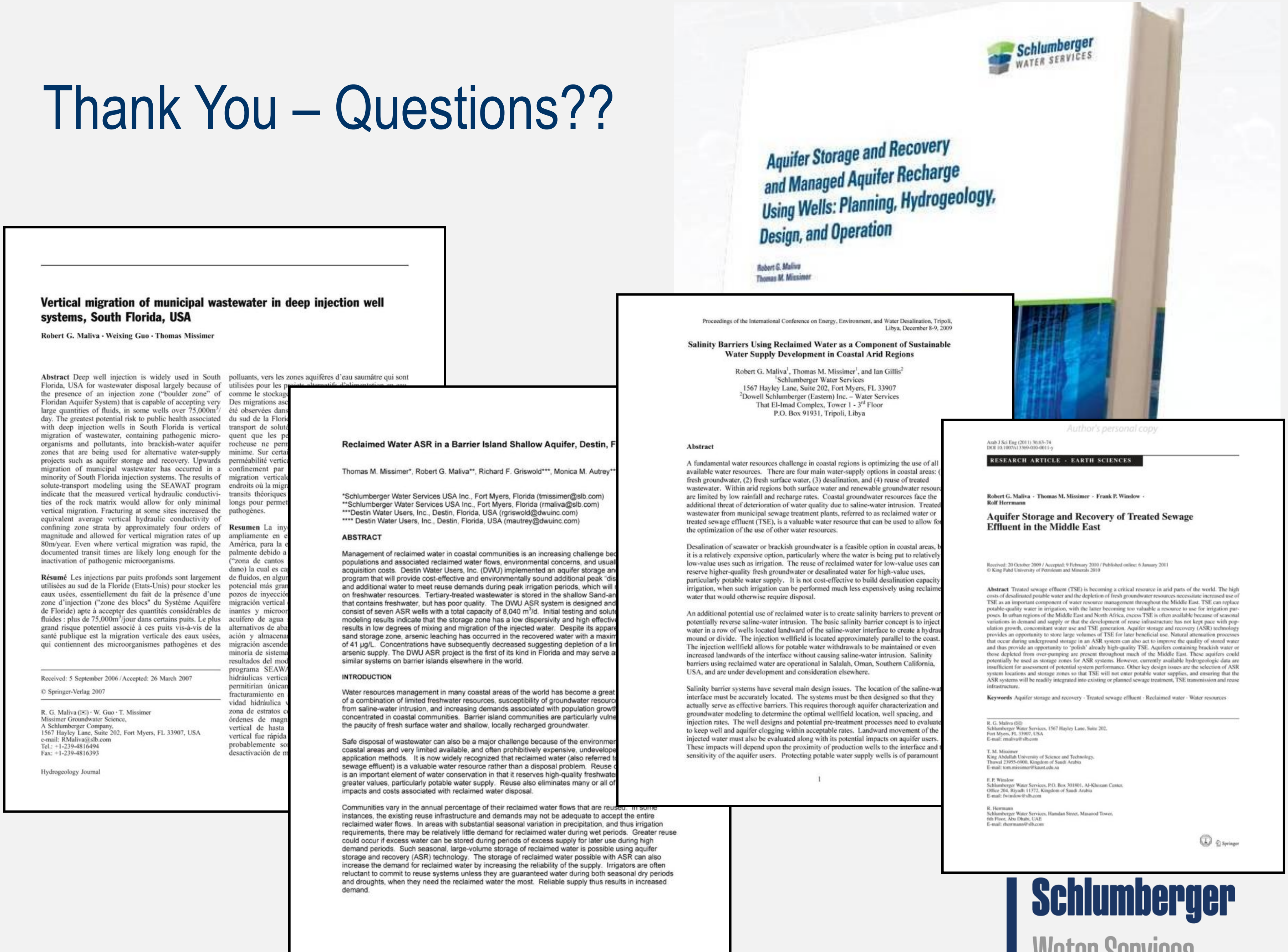
Thank You – Questions??



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Thank You