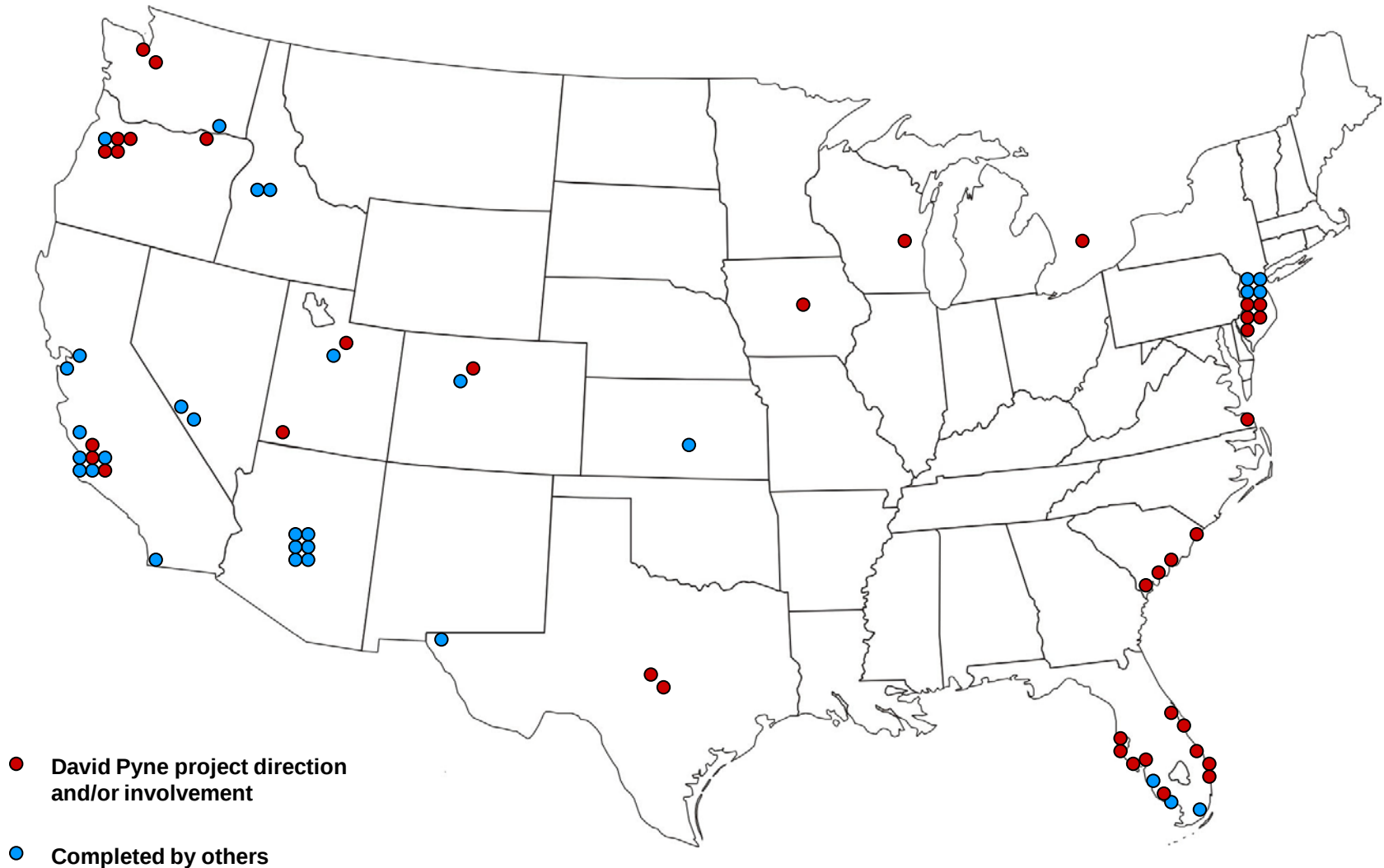


ASR Dynamics, Issues and Solutions

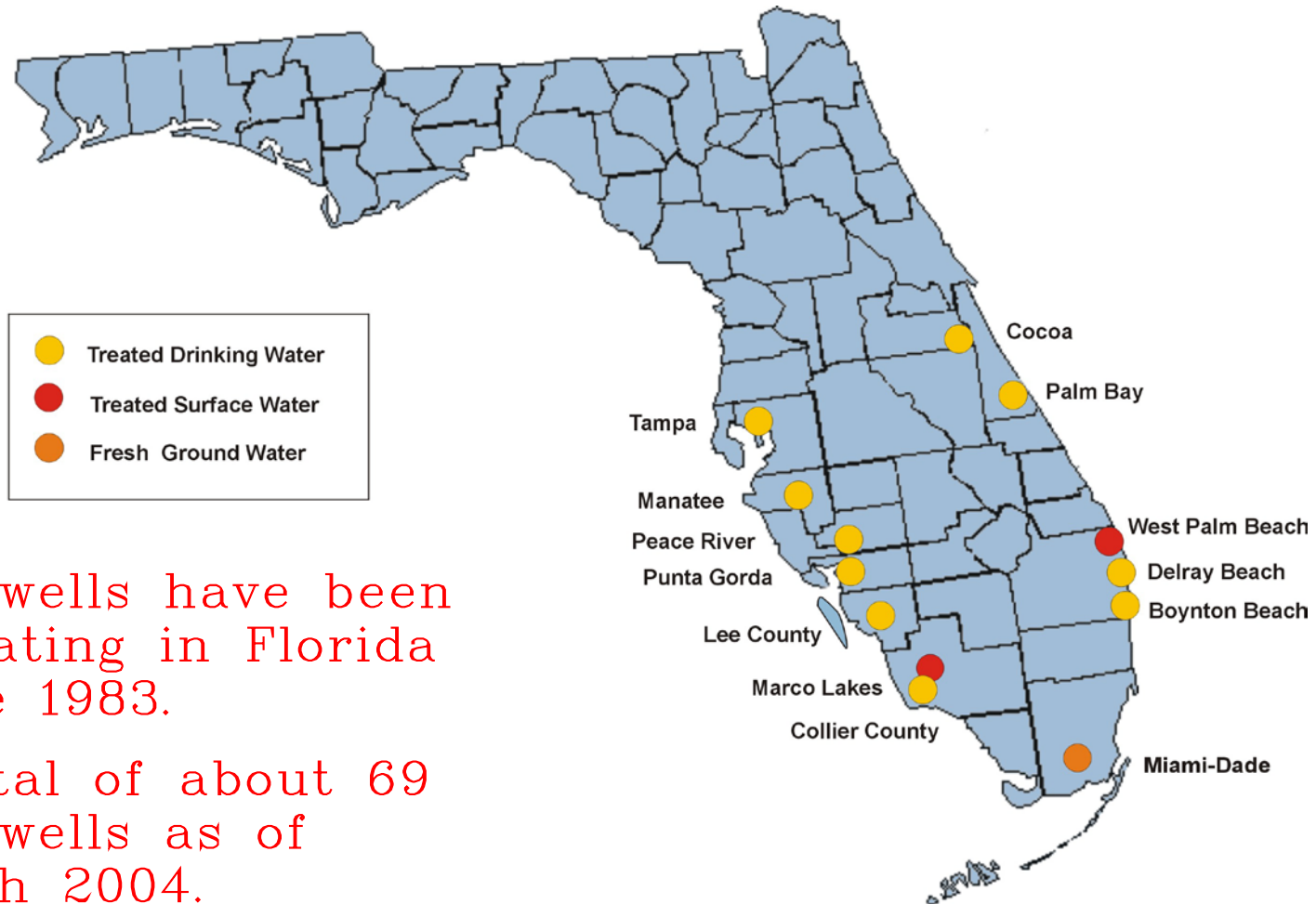
R. David G. Pyne, P.E.
ASR Systems LLC

American Ground Water Trust IV
Tampa, Florida
April 15-16, 2004

69 ASR wellfields are known to be operating in the U.S. as of March 2004.



13 fully permitted ASR wellfields are operating in Florida.



ASR wells have been operating in Florida since 1983.

A total of about 69 ASR wells as of March 2004.

West Palm Beach ASR Well ...equipped for 8 MGD

The largest capacity ASR well in the world



Five Key ASR Issuesand Solutions

- **Dispelling misinformation**
- Arsenic solutions
- Recovery efficiency
- Point of compliance
- Integrating new technologies with ASR
 - Bank filtration
 - Horizontal directional drilling



Kiawah Island, SC, Well ASR-2

An ASR Position Paper and other information are available at www.asrforum.com.



The 12-page paper is peer reviewed and addresses...

- ASR Fundamentals
- Disinfection byproducts
- Arsenic
- Recovery efficiency
- References

PLUS, other website information is available:

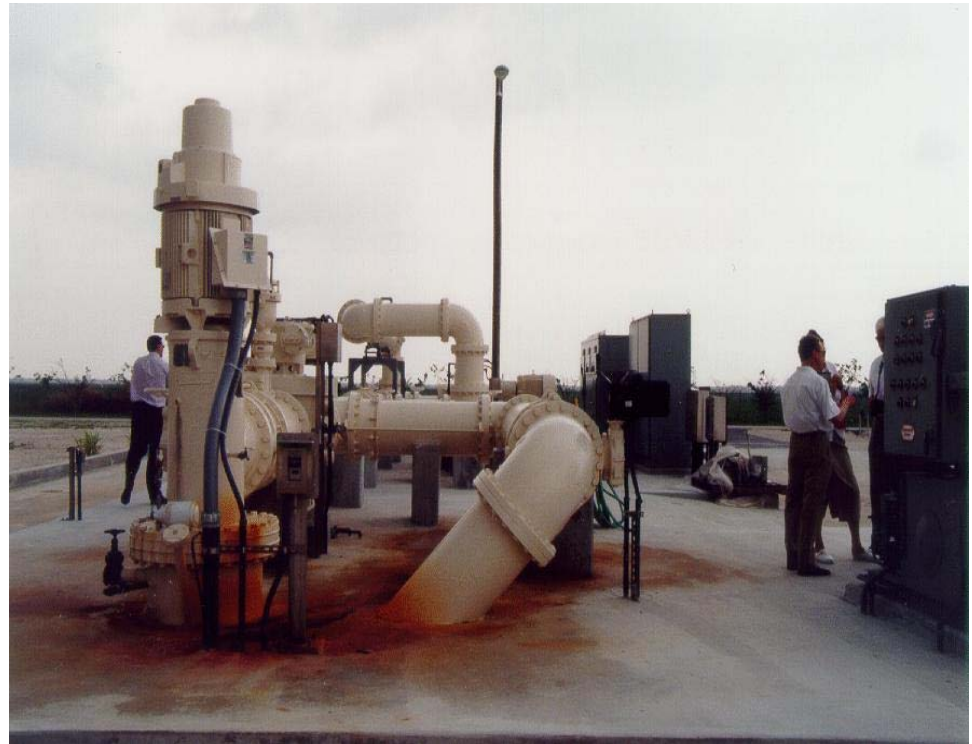
- Bulletin board/forum
- Video
- List of ASR sites
- Contact information
- Much more



Cocoa ASR Well, Florida

Five Key ASR Issuesand Solutions

- Dispelling misinformation
- **Arsenic solutions**
- Recovery efficiency
- Point of compliance
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 - Horizontal directional drilling



Miami-Dade WSD, Well ASR-1
(designed for 10-MGD recovery capacity, equipped for 5 MGD)

We need to focus more on arsenic solutions, not arsenic problems.

- Arsenic concentrations in the recovered water attenuate with time, distance and repeated cycling at the same volume.
- Pretreat recharge water to control As mobilization, or
- Post-treat recovered water to reduce initially high As concentrations.
- Reprecipitate As in the buffer zone.
- Do not overpump the well during recovery.
- Improved well design.
- Appropriate number and location of monitor well(s) to evaluate compliance.



Marathon ASR, Florida
(Not in current operation. First ASR well to successfully store drinking water in a seawater aquifer.)

Arsenic in the recovered water is a transitional, short-term issue.

- Typically not detected in recovered water from long-term operating ASR sites in Florida.
- We need to demonstrate Arsenic attenuation by collecting data from long-term operating ASR sites this Spring (As, Eh, pH, Fe, DO, Temperature, etc.).
- Dutch research shows As attenuation during aquifer storage.
- Florida As standard drops from 50 • g/l to 10 • g/l in January 2005. Federal standard drops in January 2006.

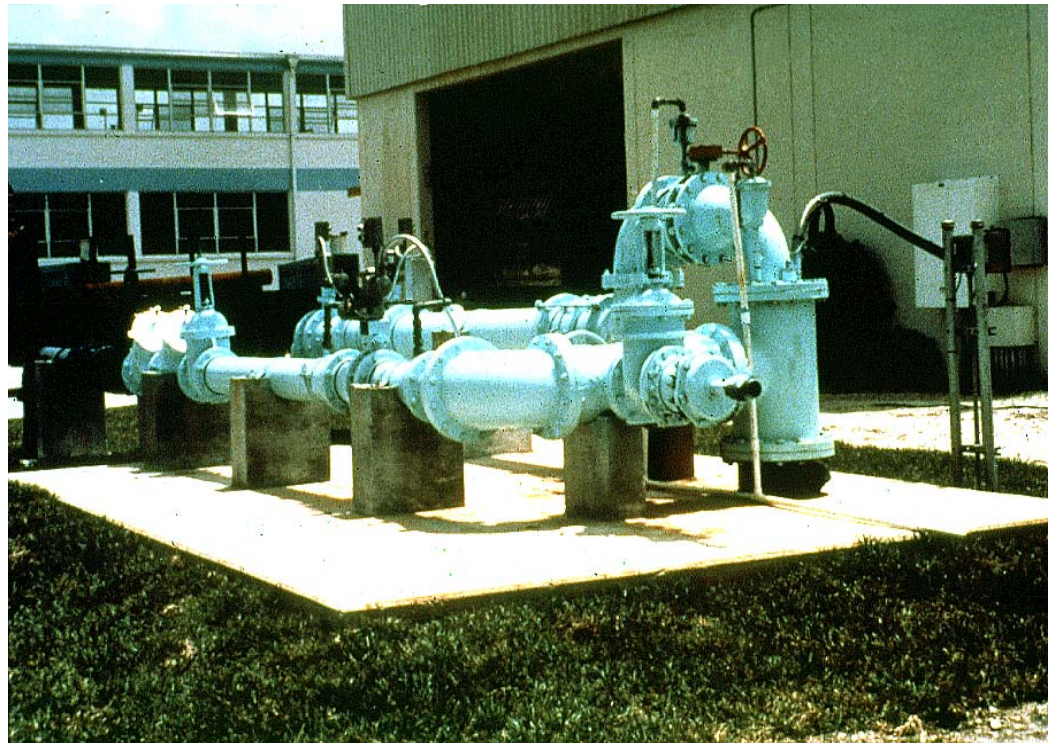
Arsenic Geochemical Reactions



Plus Dissolved H_2AsO_4^-

Five Key ASR Issuesand Solutions

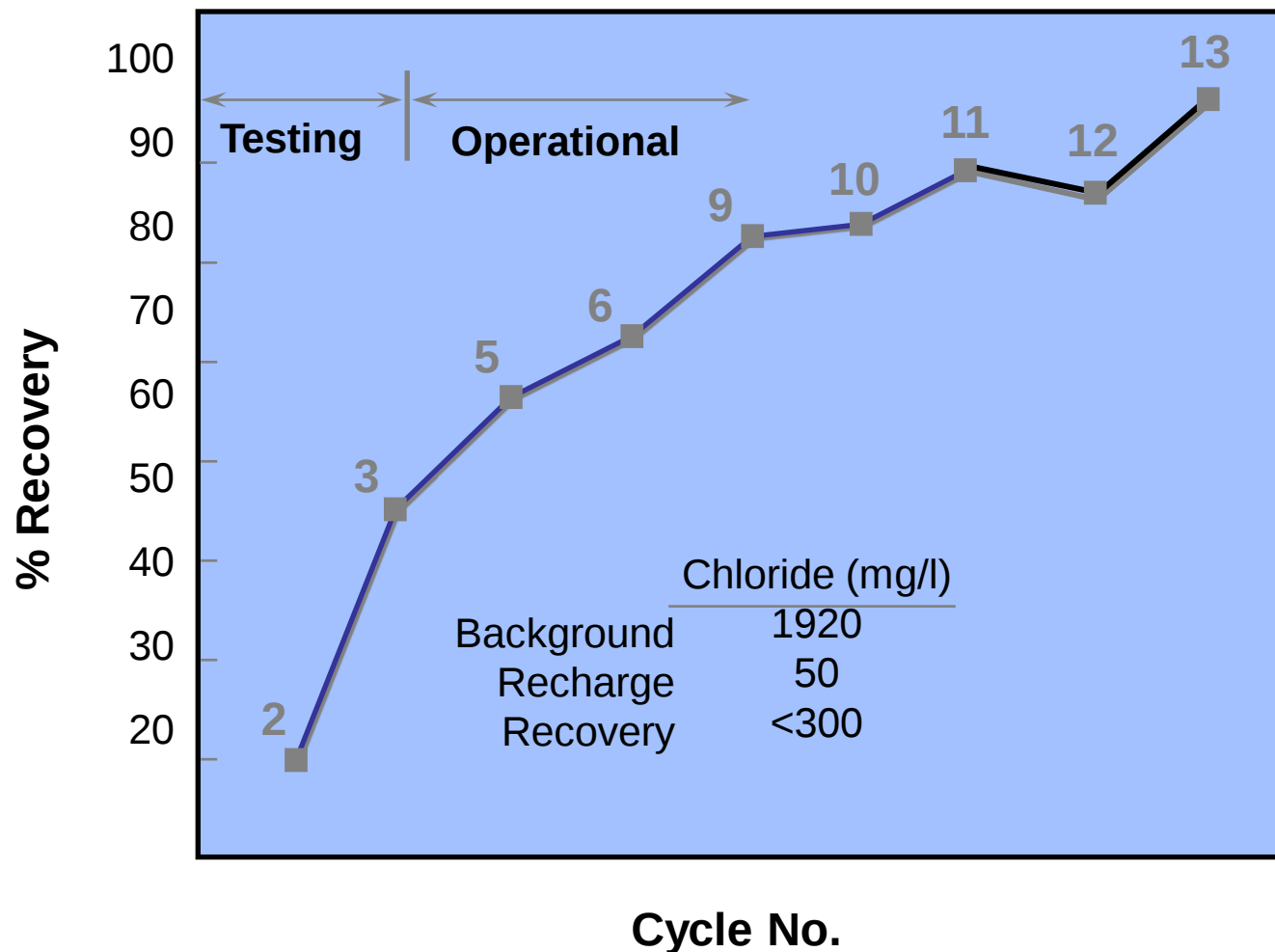
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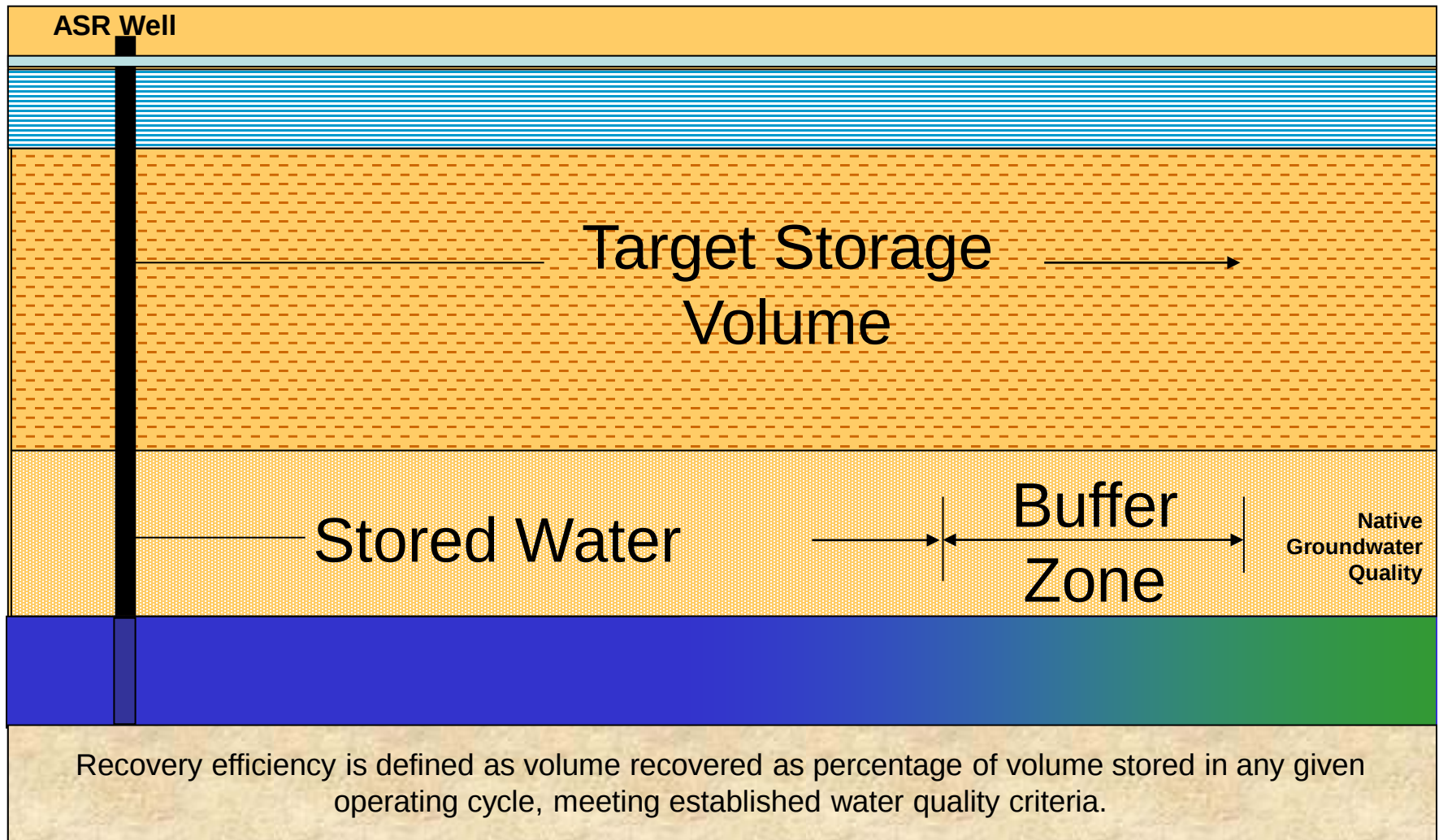
Boynton Beach ASR Well, Florida

Boynton Beach ASR Well

Percent Recovery by Cycle

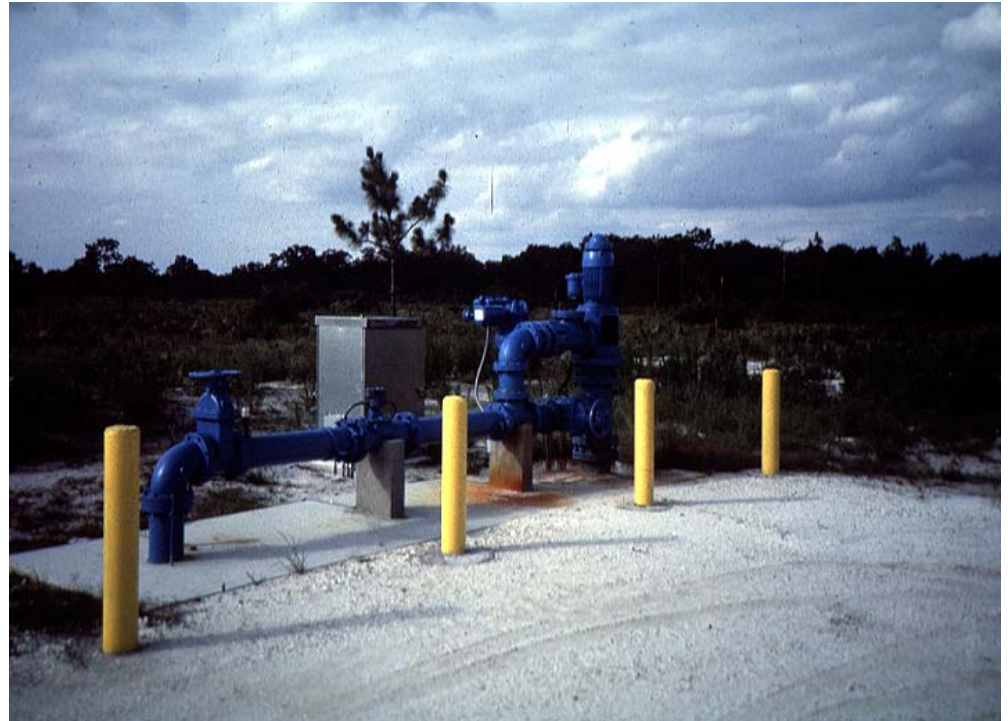


Target Storage Volume



Recovery Index andRecovery Efficiency

- **Recovery Efficiency** is volume recovered meeting local target water quality criteria, as a percentage of volume stored during each cycle. It should reach close to 100% for most ASR sites after the TSV is reached.
- **Recovery Index** is an indirect measure of the aquifer dispersion characteristics at each ASR site, facilitating comparison between different sites.
- Chris Brown/USACOE & UF (dissertation in process)



Peace River ASR, Florida
(largest ASR wellfield in eastern US)

Five Key ASR Issuesand Solutions

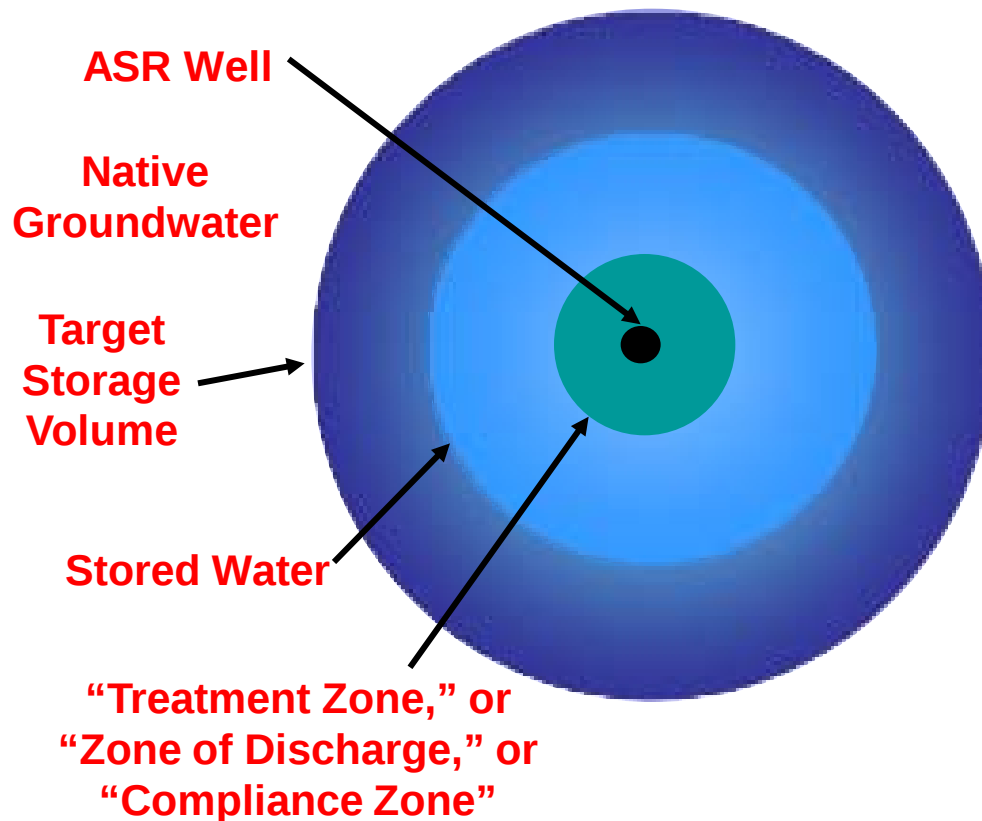
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Bradenton ASR Well, Florida
(beginning cycle testing)

Treatment occurs in an aquifer due to natural processes.

ASR Bubble (Top View)



- $\text{NO}_3, \text{NH}_3, \text{P}$
- THMs
- HAAs
- H_2S
- Fe, Mn, As
- Ra
- Gross Alpha Rad.
- Bacteria
- Protozoa
- Viruses

Where to measure compliance with drinking water standards?

- Wellhead prior to recharge?
 - Florida (brackish aquifers)
- Observation well inside buffer zone?
- Observation well outside buffer zone?
 - Arizona, Wisconsin, N. Carolina (freshwater aquifers)
 - Suggested Florida solution
- A disconnect exists between federal law (1974 SDWA) and federal regulations.
- This is getting to be a very expensive issue in FL.

Five Key ASR Issuesand Solutions

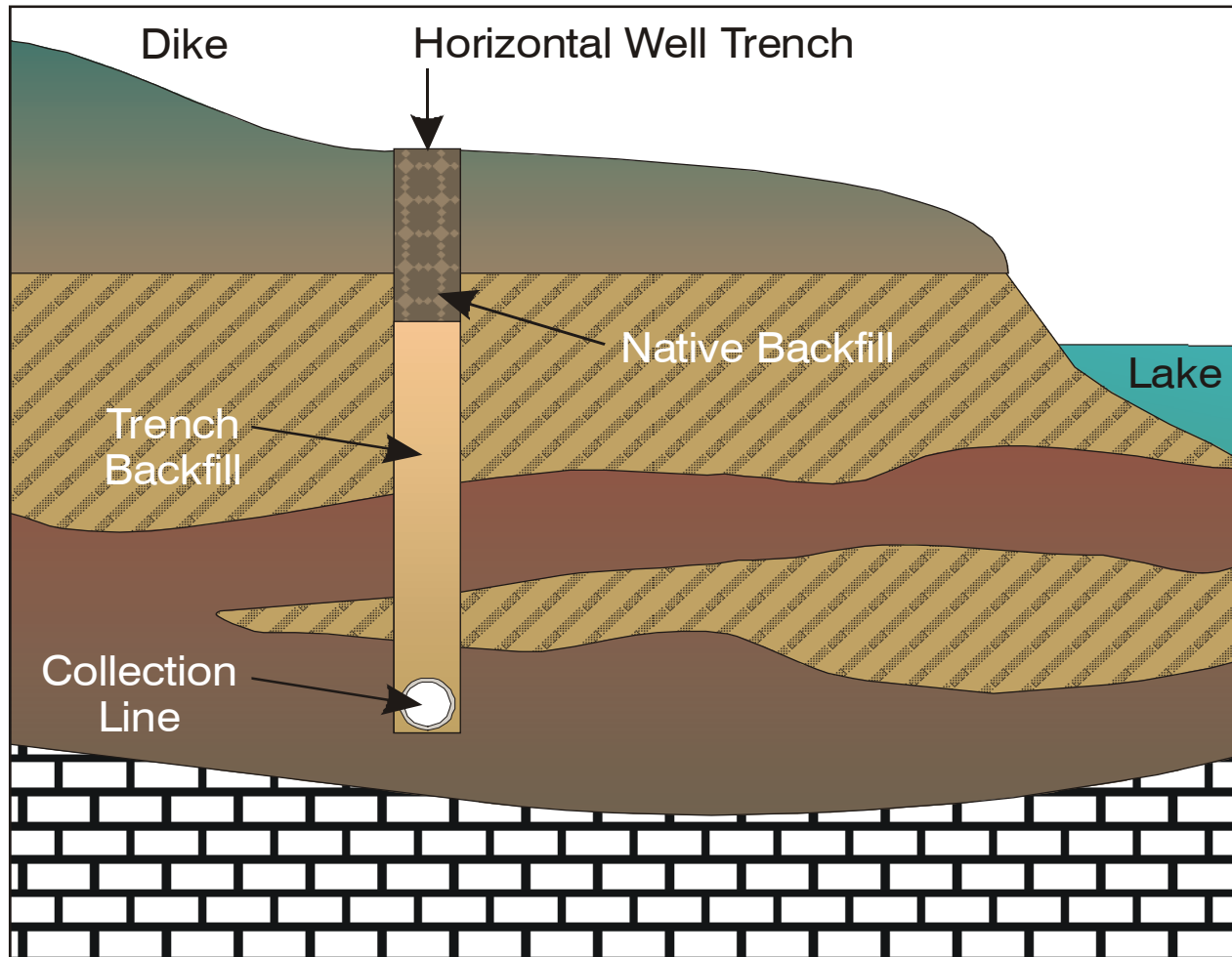
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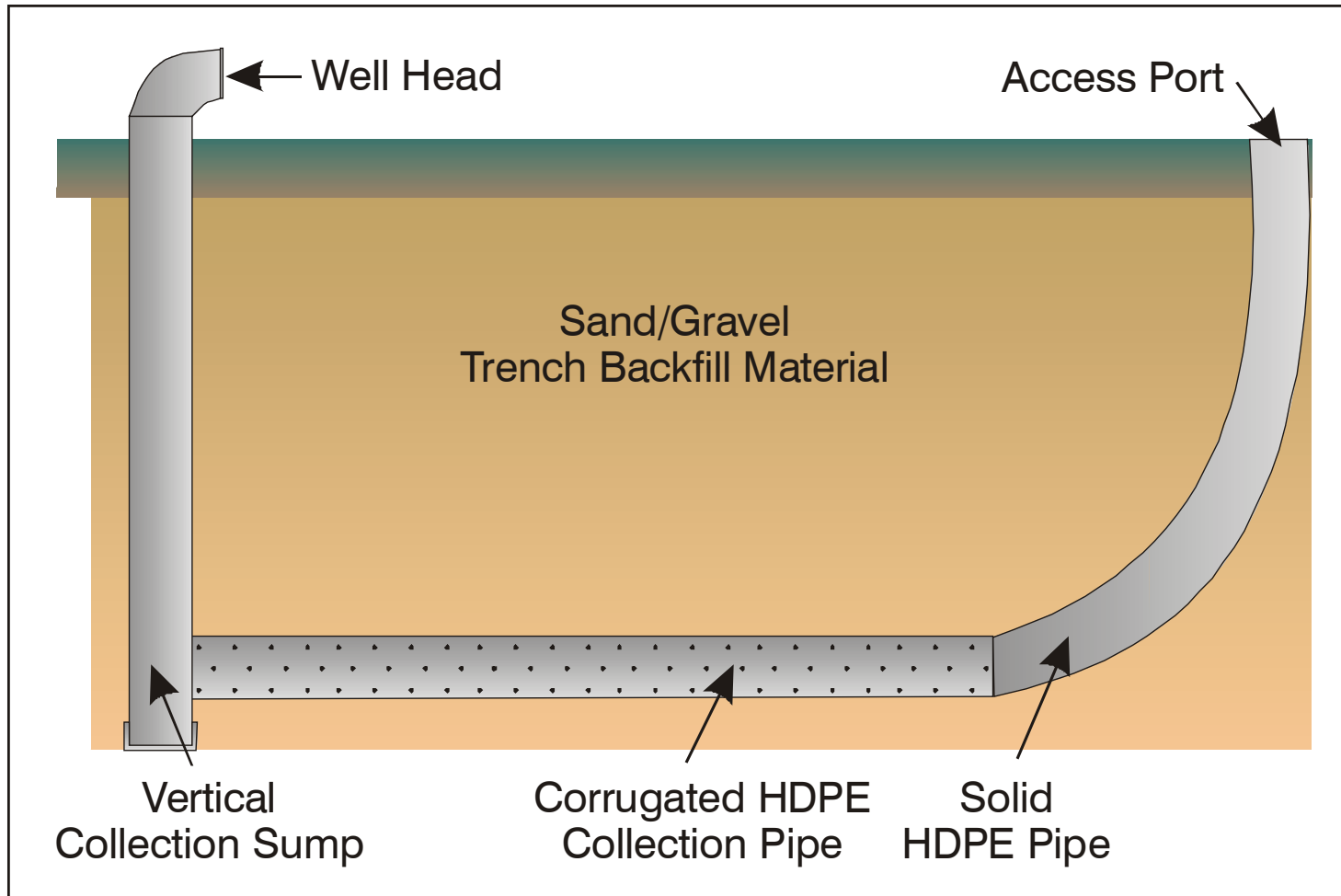
Bank Filtration

A picture is worth 1,000 words.

Typical Horizontal Well Bank Filtration Cross-Section

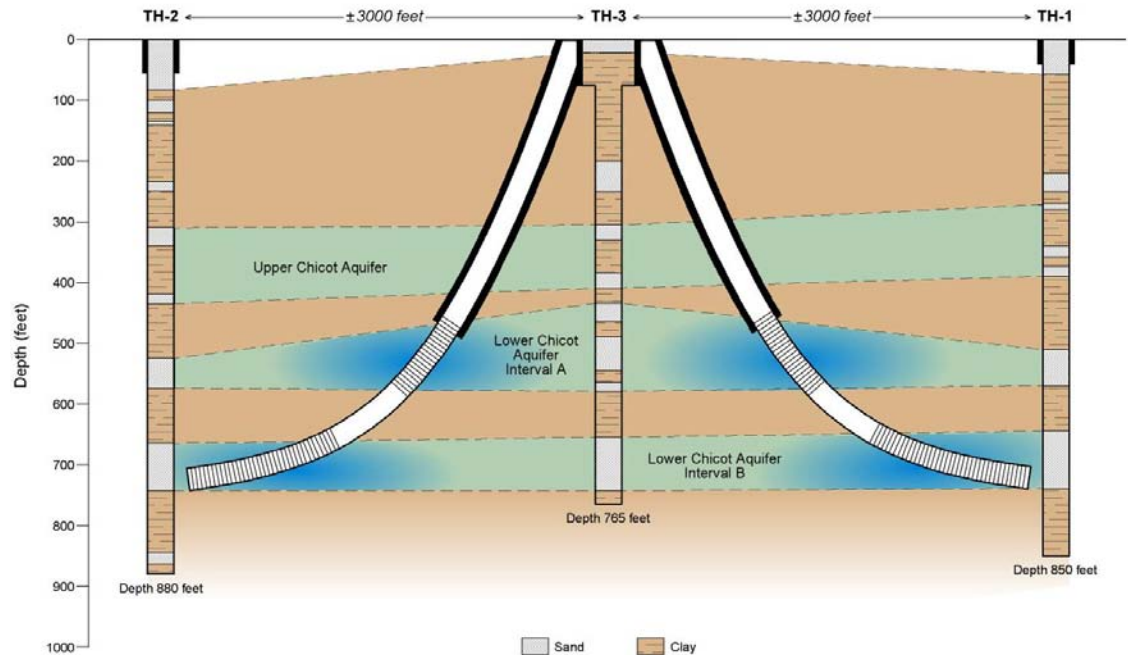


Horizontal Collector Well Trench



Five Key ASR Issuesand Solutions

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**Horizontal Directional-Drilled
(HDD) ASR Wells**

Santa Barbara Well Island... an ASR model for Everglades Restoration



Santa Barbara Well Island

....an inside view



Manatee County, FL Reclaimed Water ASR Well



Upcoming ASR Events

- International Symposium on Managed Aquifer Recharge (ISMAR5), June 12-17, 2005, Berlin, Germany (www.ismar2005.org)
- Second edition of 1995 ASR book coming out real soon

www.asrforum.com