Current Practices in Aquifer Storage and Recovery

ASR Meeting, Chicago May 2009

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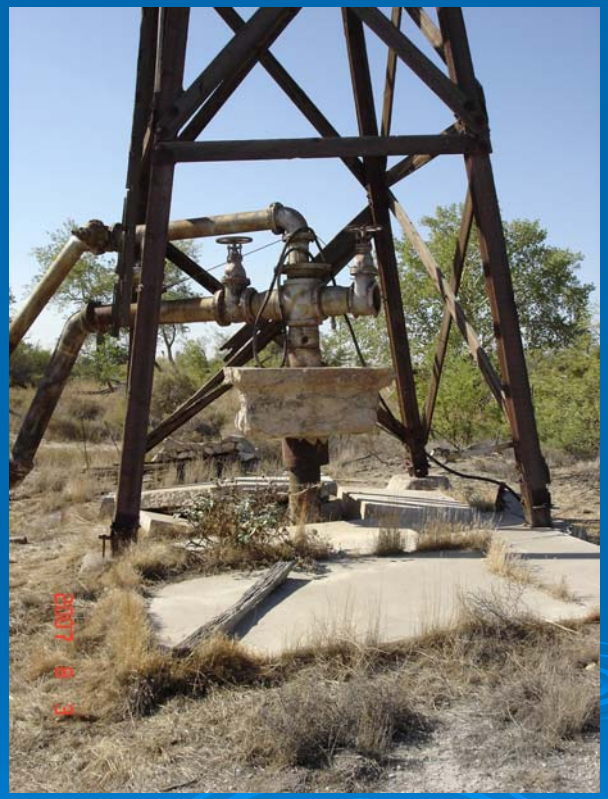
Las Vegas Valley
Water District



LAS VEGAS VALLEY WATER DISTRICT
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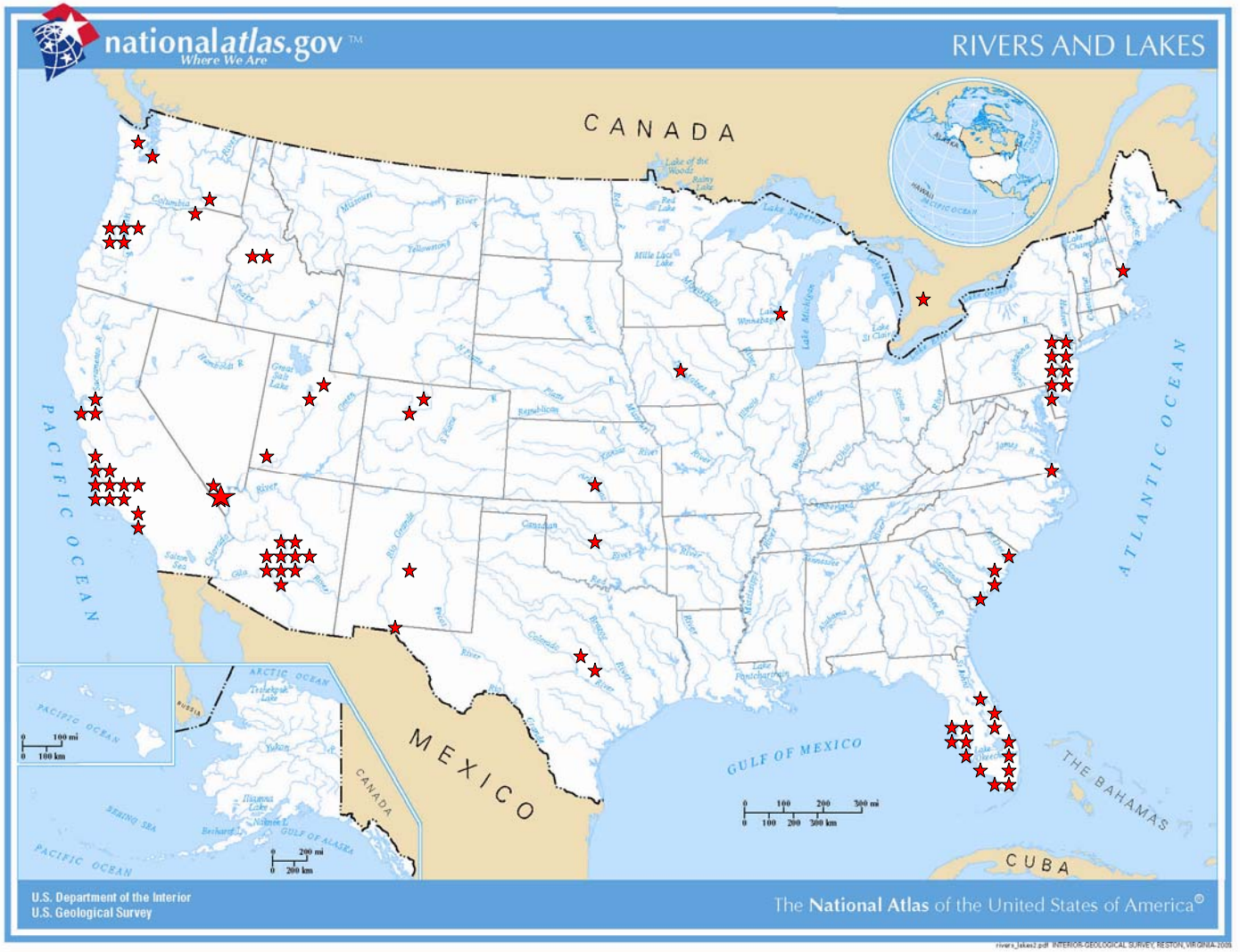
Outline

- Summary of Current Projects - USA
  - Quantity/Location
  - Projects by Source Water
  - Summary of Treatment for Source Water

- Unsuccessful Projects
- Las Vegas Valley Case Study/Lessons Learned

Map of 78 Significant ASR Systems North America

(Pyne, 2005, modified with Pyne and others, 2008)



Projects by Source Water

Source Water	Drinking	Reclaimed	Surface	Combination (surface + reclaimed)
Percent of Projects	82	10	2.5	2.5
Largest Well Capacity facility (MGD) – Theoretical Max	Recharge 120 Recovery 197	Recharge 13 Recovery 15	Recharge >20 Recovery >65	Recharge 8 Recovery 62
Facility	Las Vegas Valley WD, NV	Chandler, Az – Tumbleweed Park Recharge Facility	Blaine AQ, Oklahoma	Scottsdale Water Campus, AZ
End Use	Drinking	Irrigation	Irrigation	Drinking/Irrigation

Ground Water as a Source

Miami-Dade Water and Sewer

Permitted for recharge/recovery = 25 MGD

Max capacity = 50 MGD (recharge & recovery)

Source – Biscayne Aquifer (fresh)

Treatment – disinfection (UV)

Target – Floridian Aquifer (saline)

End Use – to the ground water treatment plant (softening, disinfection) to customers – potable

Treatment of Source

- Drinking Water Sources
  - Multi-stage filtration
  - Disinfection
- Reclaimed/Surface Water
  - Treat for the end use
  - Treat for no negative impacts to ground water
  - Treat for operational reasons

Reclaimed ASR Projects – Major States

- Florida
  - Ground water exchange; no direct injection into potable aquifer
  - Secondary treatment with filtration and disinfection (UV or Ozone)
- Arizona
  - Recharge for recovery by drinking water wells
  - Advanced water treatment and reuse standards
- California
  - Salinity barriers and recharge for recovery by supply wells
  - Full treatment with multiple barrier membrane, UV disinfection and hydrogen peroxide

Surface Water ASR Projects

- **Blaine County, Oklahoma**
  - Untreated runoff
  - Run by local landowners
  - No published data save for demonstration report (1997)
- **Vidler Water, Arizona**
  - Untreated CAP water
  - 0.1 cfs in Vadose Zone Wells

Unsuccessful ASR Projects

- Well Clogging
  - Urrbrae Wetland ASR Project-Australia
  - ASR portion of the successful East Meadow Reclaimed Water Recharge Project – New York
  - Bay Park, New York, AR of Drinking Water and Treated Wastewater
- Deteriorated Water Quality
  - Northwest Hillsborough County Reclaimed Water ASR Project – Florida

Well Clogging impacts all ASR operators

- Suspended solids in source water for AR
- Biofilm production on well screens
- Chemical precipitation
- Remobilization of drilling mud or fines
- Air entrainment/gas binding

Combat Well Clogging

Tumbleweed – Az

- Source water – highly treated reclaimed water
- Maintain Chlorine residual in recharge water
- Capacity – 7 ASR wells @ 1,500 gpm ~ 15 MGD
- End use – Irrigation

Backflush ASR wells 3 times per day to combat biofouling

Vadose zone wells – no longer operational due to clogging

Backflush and/or Purge

- Highlands Ranch, Denver Colorado
  - Before recharging, pump well to waste (purge)
  - During recharge operation, back flush once per month
- Las Vegas Valley WD, Las Vegas NV
  - No purging of dual-use (ASR) or AR wells
  - Dual-use wells are pumped in the summer – lag time before AR may be from weeks to months
- City of Beaverton, Oregon
  - Backflush every 3 to 4 weeks for each ASR well
- San Antonio Water System, Texas
  - Backflush twice per month

Combat Well Clogging

- **Peace River, Desoto County, Florida**
  - Use CO_2 gas, bubbled into recharge water
  - Use well development treatments using acid
- **Las Vegas Valley Water District**
  - Use super-chlorination (pH controlled) followed by well development with surge/pumping

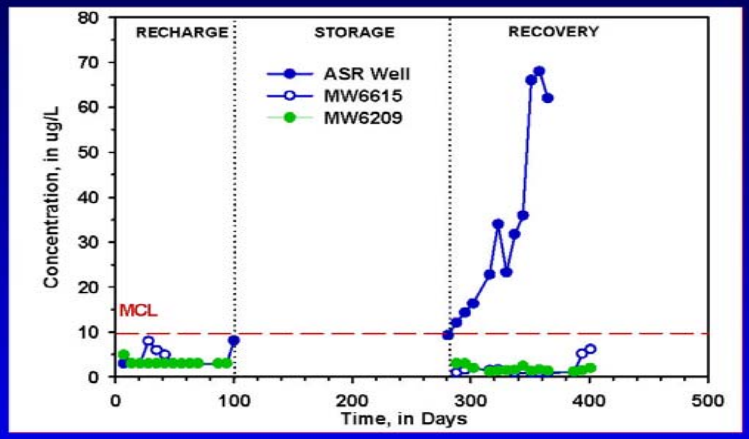
Northwest Hillsborough County Reclaimed Water ASR Project – Florida - unsuccessful due to water quality

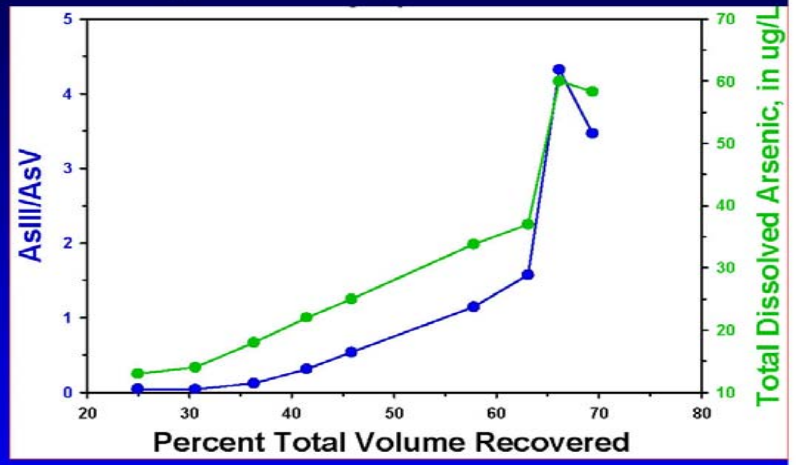
- Recharge tertiary treated reclaimed water
  - 60% of source used for irrigation
  - 40% of source remains for AR
- Deep carbonate aquifer, brackish
- Invasion of poor water in aquifer reduced recovery to ~25% - inadequate confinement of deeper, more brackish ground water
- Chemical reactions increase metals and arsenic

Water Quality Issues at Successful Sites
Olga WTP, Lee County Florida

Arsenic Mobility During ASR Cycle Tests

Olga – Lee County ASR System Cycle 3





Arsenic exceeds MCL in ASR Well, not monitor wells during recovery

Arsenic occurs primarily as arsenite ($H_2AsO_3^-$) as recovery proceeds

US Army Corps of Engineers

LVVWD Artificial Recharge of Ground Water

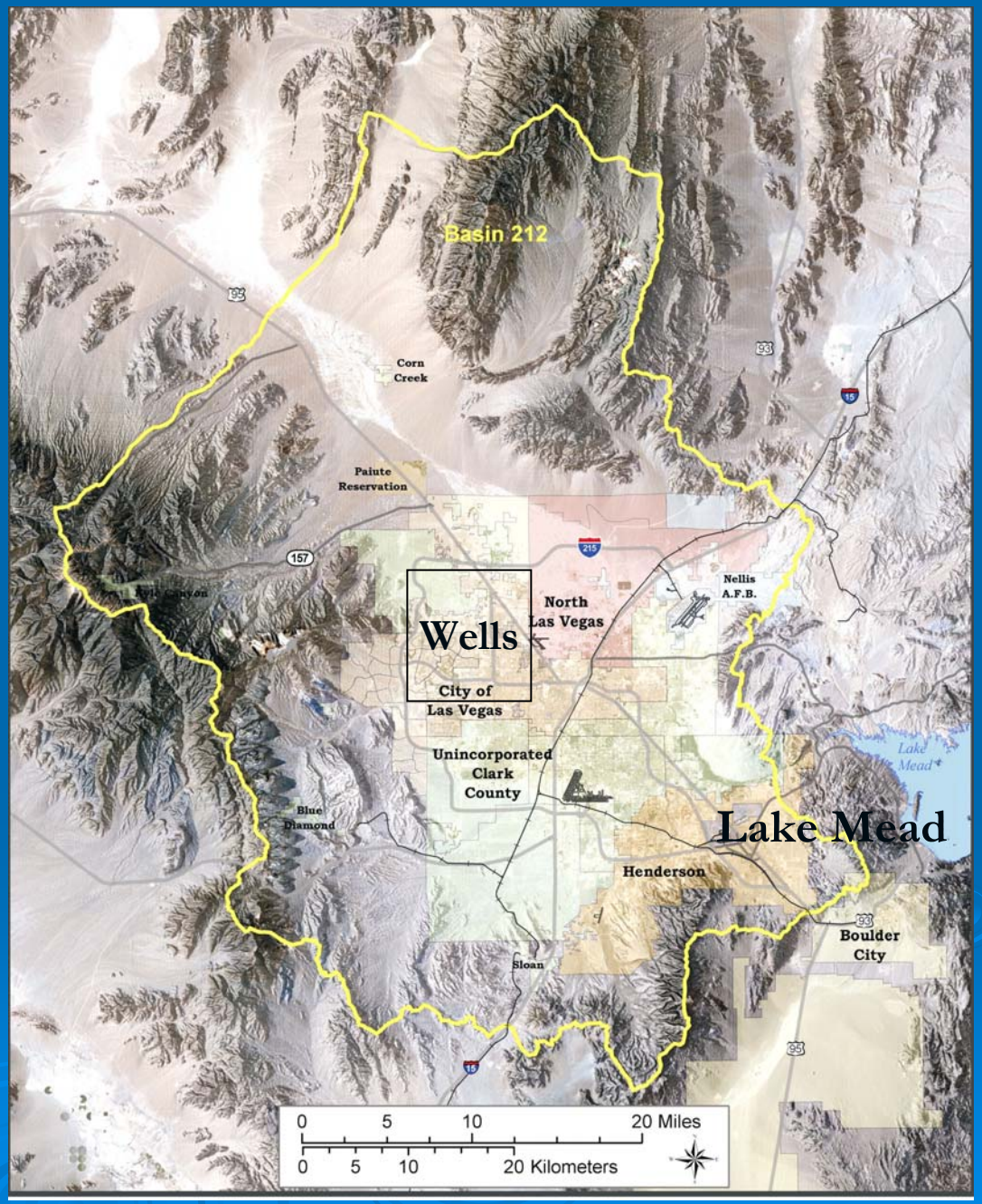
- **Full Consumptive Use of Colorado River allocation**
  - Moving target depends upon customer demands & return flows
- **Combat aquifer depletion with Artificial Recharge**
  - Maintain beneficial use of GW rights – use it or loose it! (prior to Nov. 2004)
  - Arrest falling water levels and associated land subsidence
- **Well water ~$90/AF, SNWS water ~$250/AF**
  - Use as much well water as possible
  - Use well water in the SUMMER
  - Feed highest elevations in the north and west

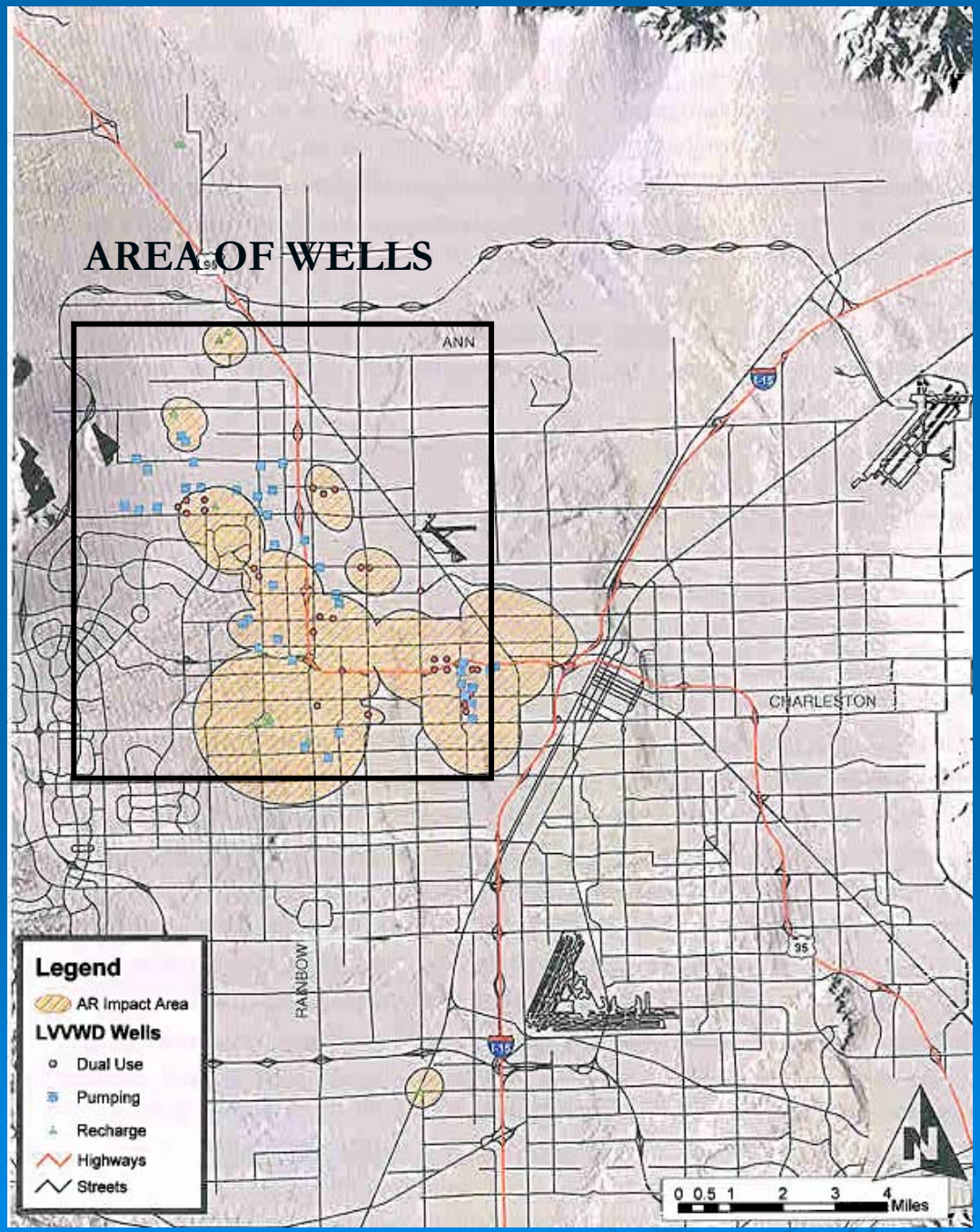
LAS VEGAS HYDROGRAPHIC BASIN

Las Vegas
Water Supply

90% Surface Water
10% Ground Water

MAX Day – 2008:
450 MG (1.7 M m3)
120 MGD from Wells
(summer only)

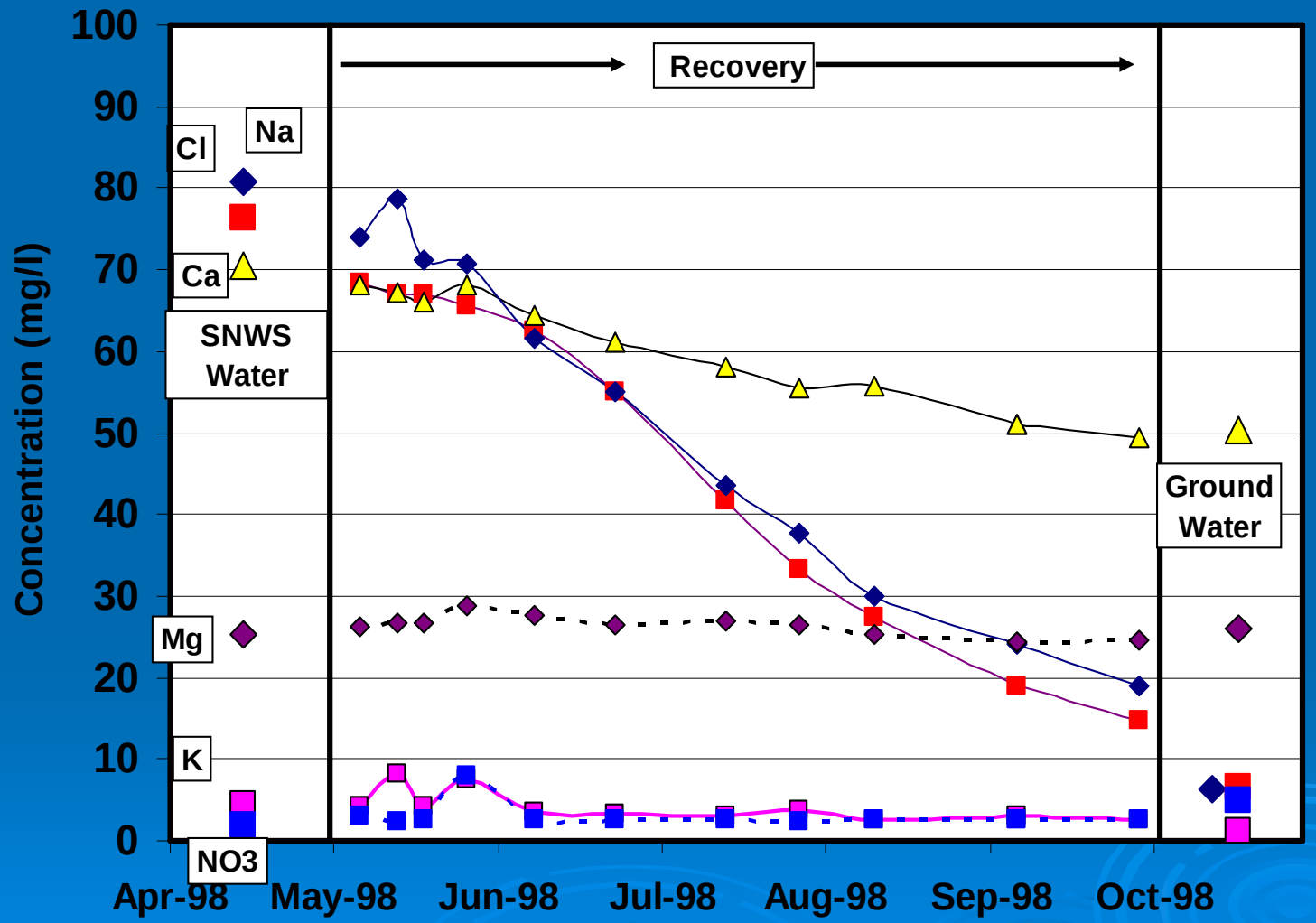




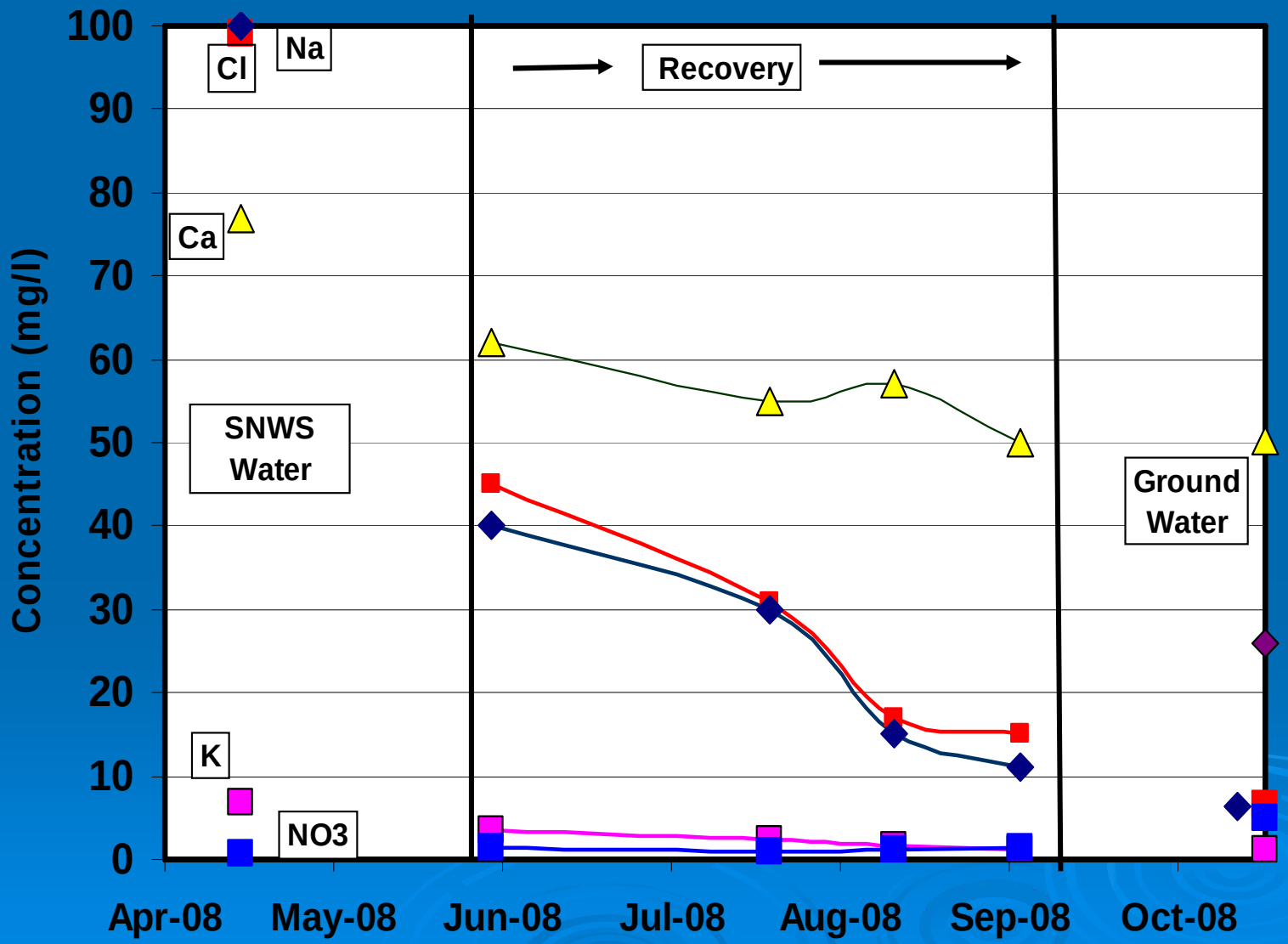
Las Vegas Springs Aquifer Groundwater with >10% AR water

(Leising, 2004)

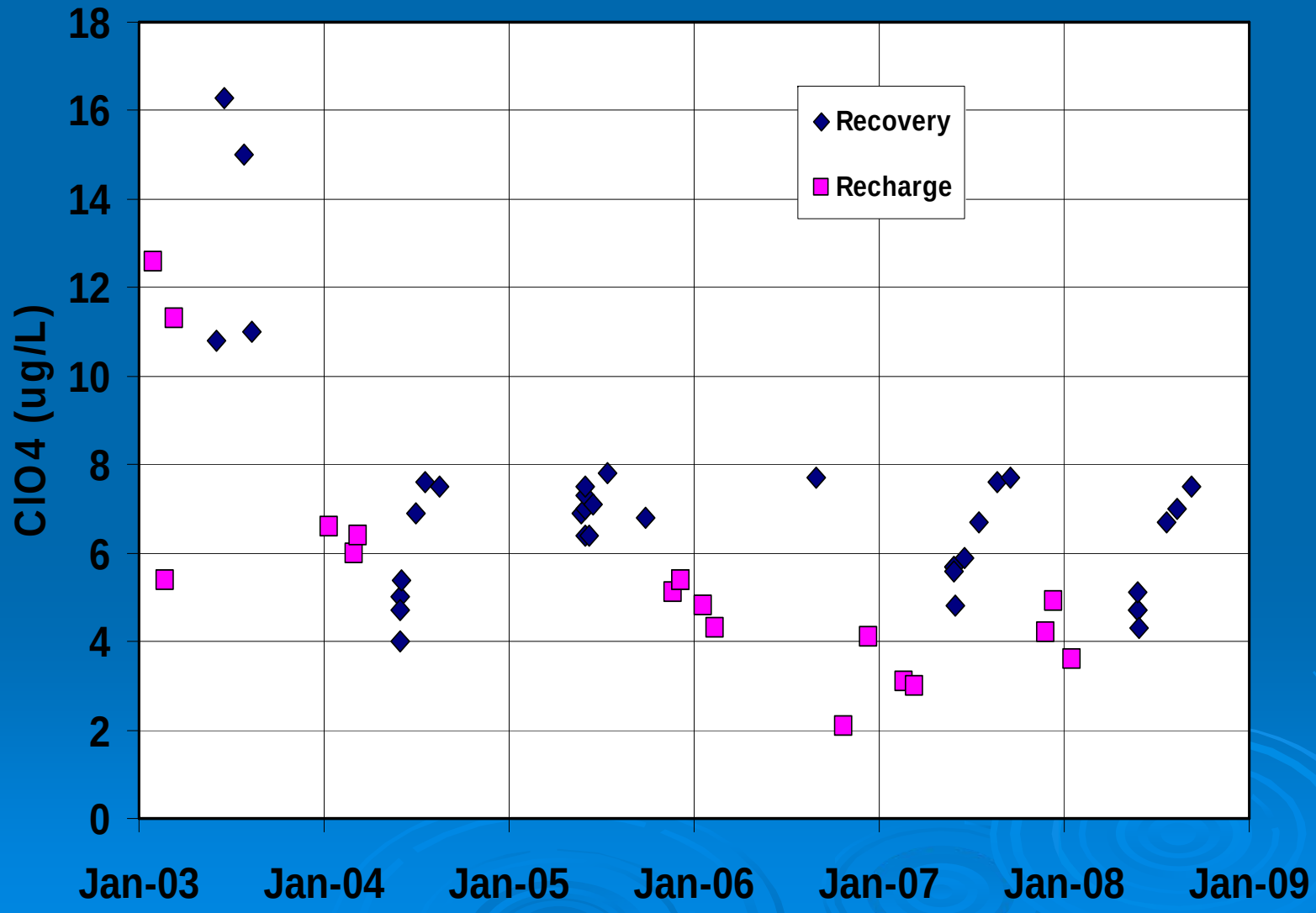
Recovery Water Quality: Well 33, 1998 Pumping Season



Recovery Water Quality: Well 33, 2008 Pumping Season



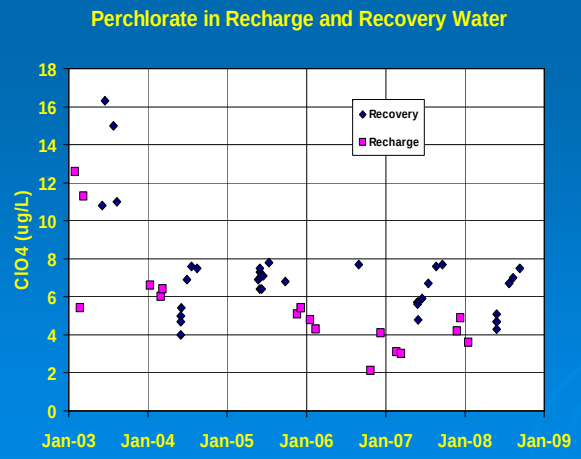
Perchlorate in Recharge and Recovery Water

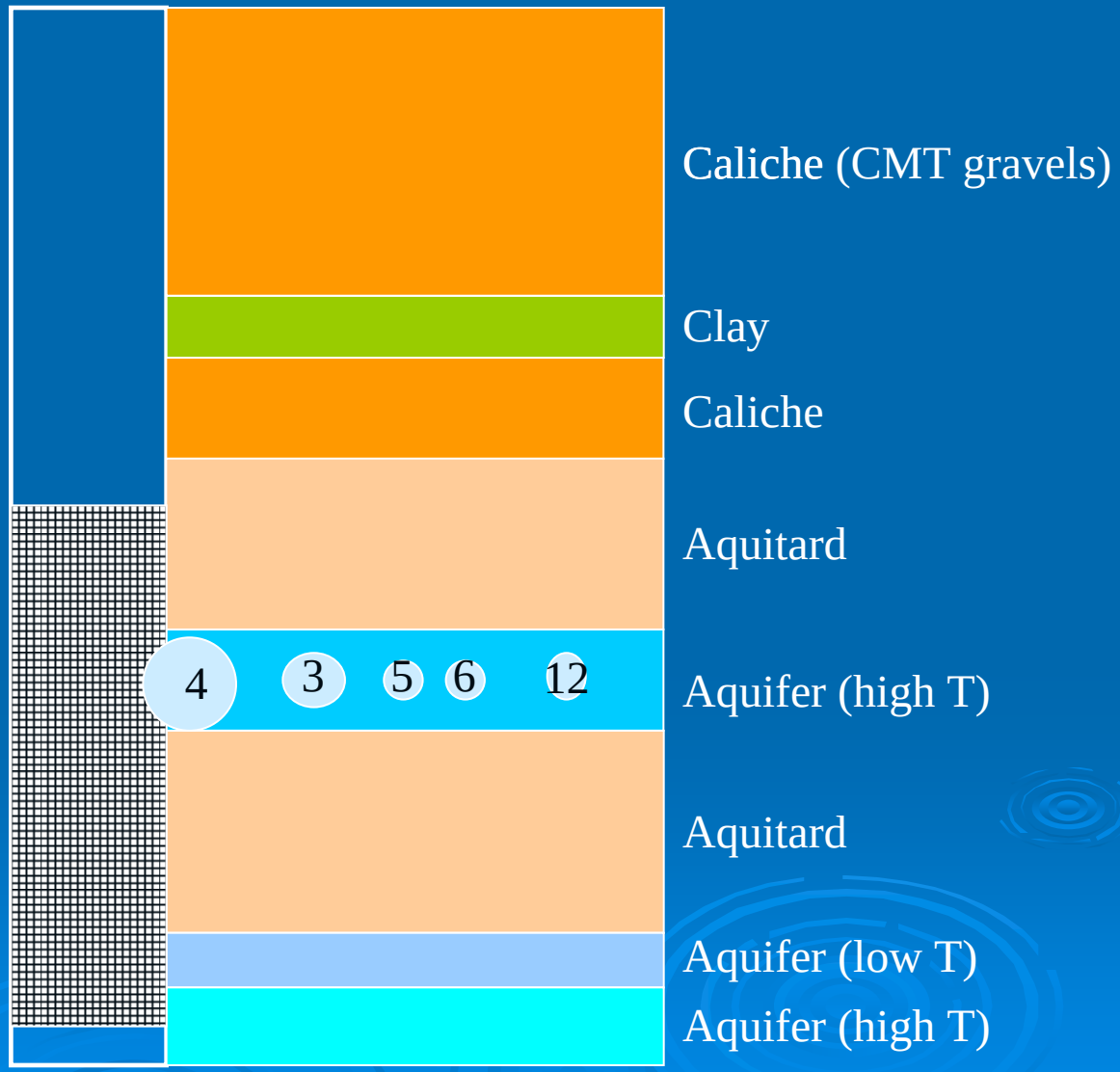


ASR "Bubble"

AVG Year

- 4 – 2008
- 3 – 2007
- 5 – 2006
- 6 – 2004
- 12 - 2003

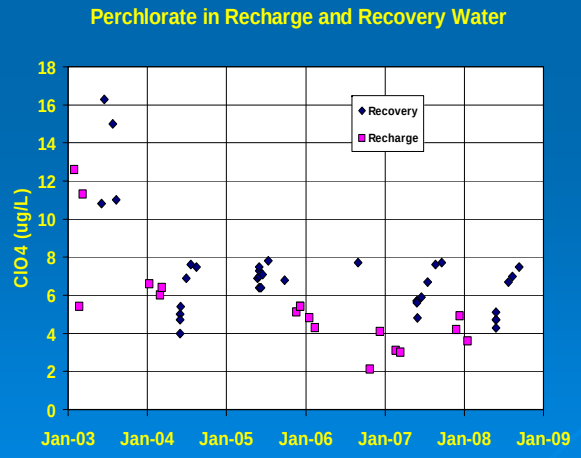


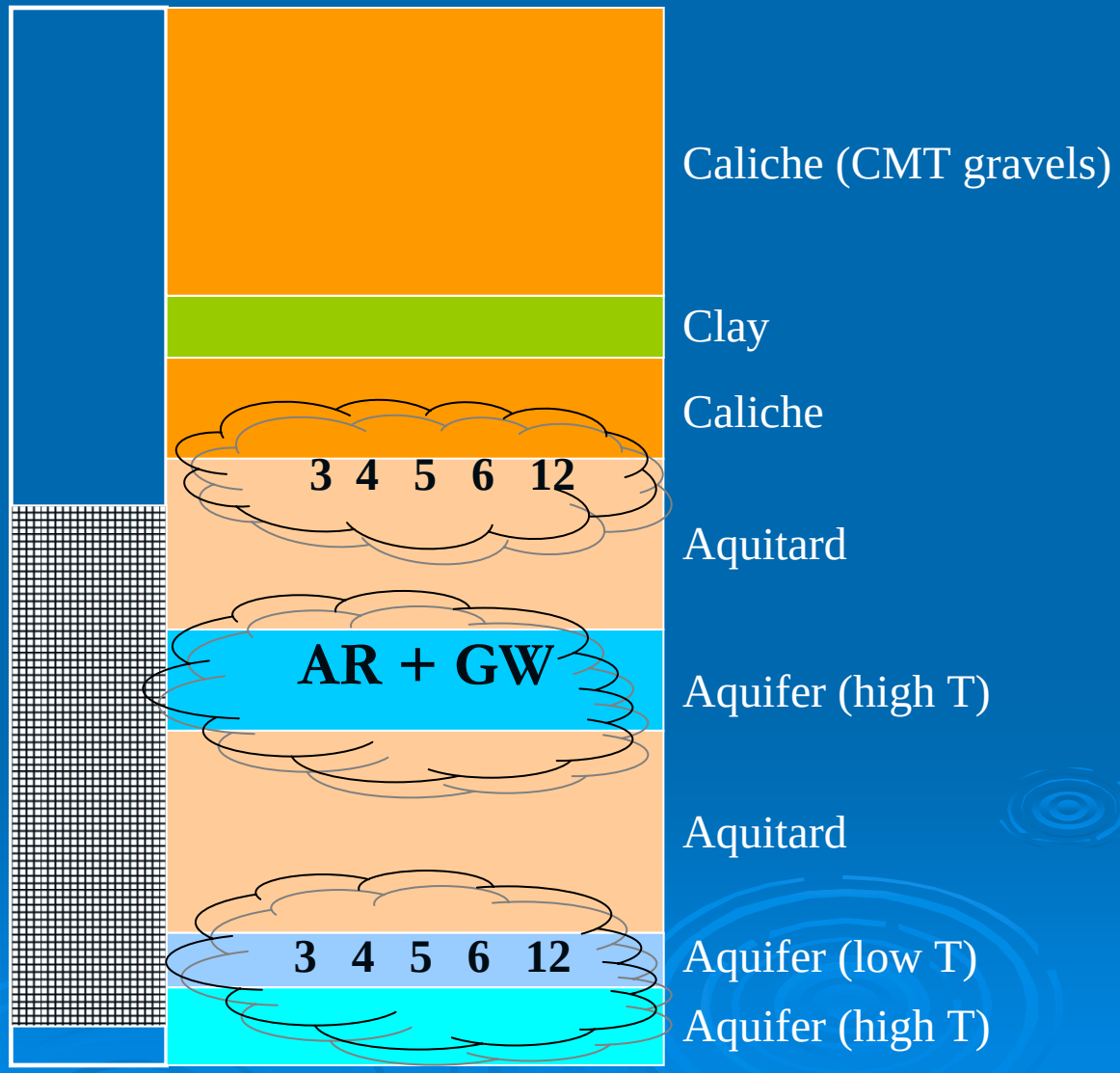


Is the Bubble not really just a Bubble?

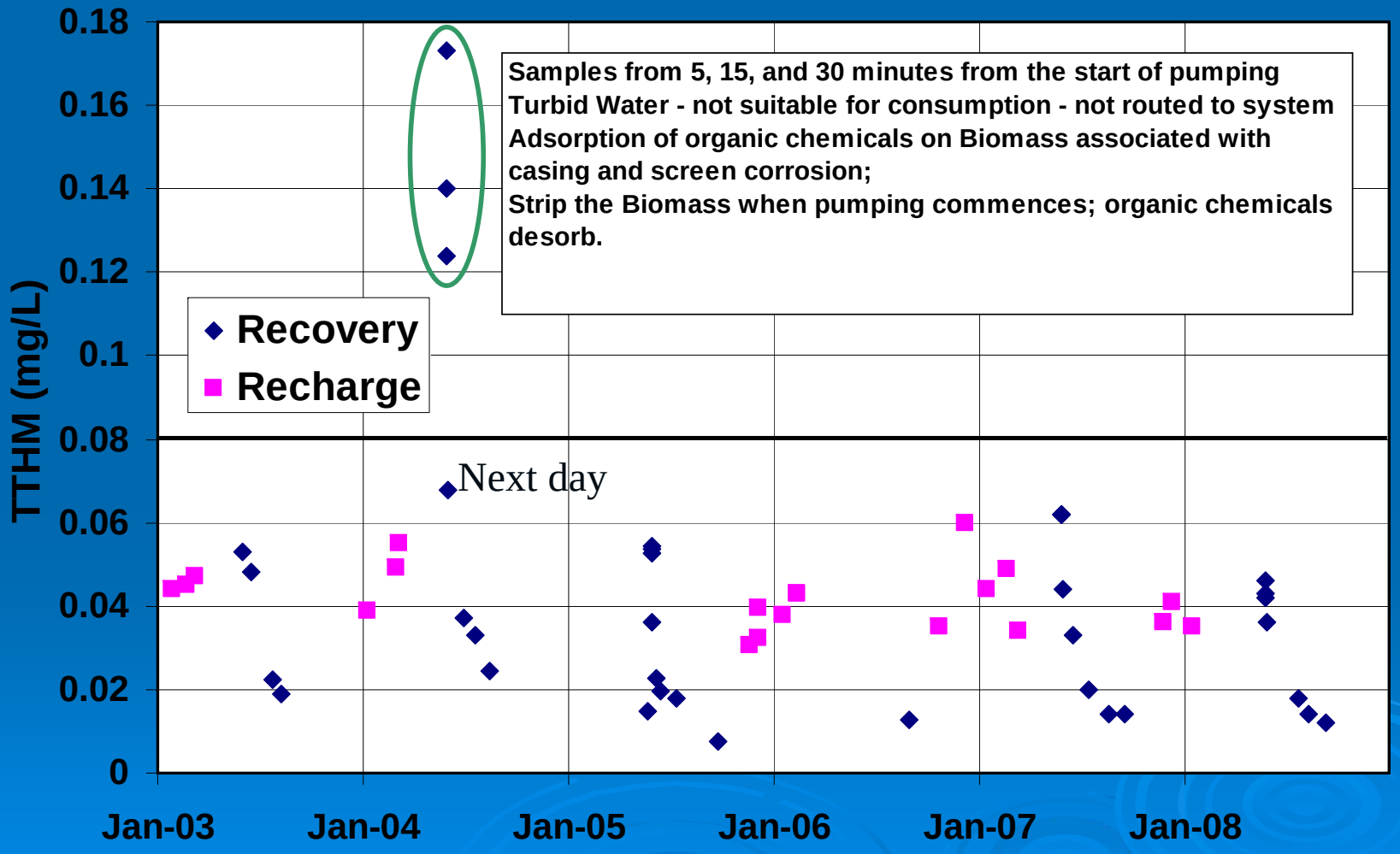
-slow bleeding of AR water from low permeability aquifers/aquitards

AVG	Year
4 –	2008
3 –	2007
5 –	2006
6 –	2004
12 -	2003



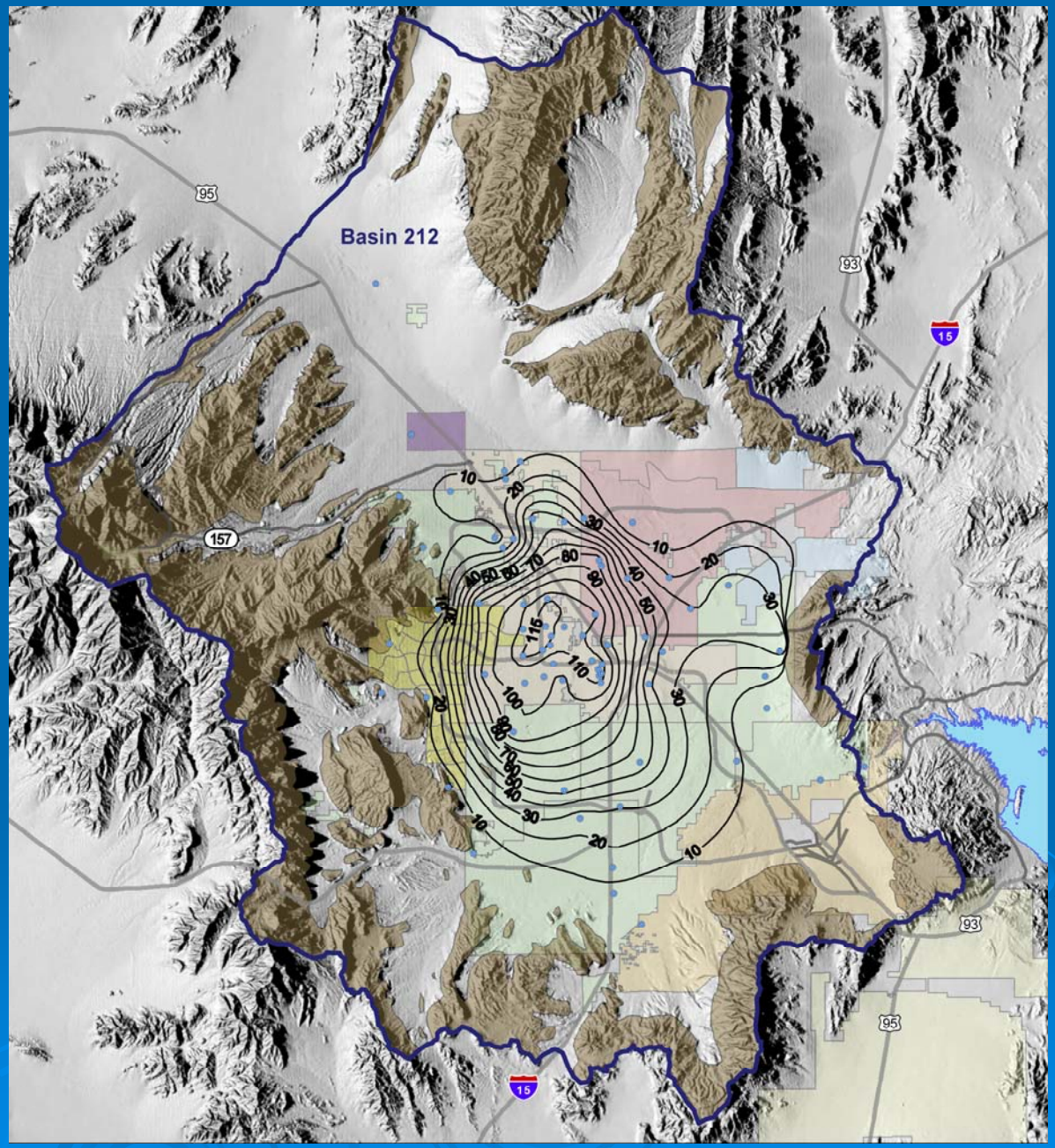


TTHM in Recharge and Recovery Water



Las Vegas Springs Aquifer

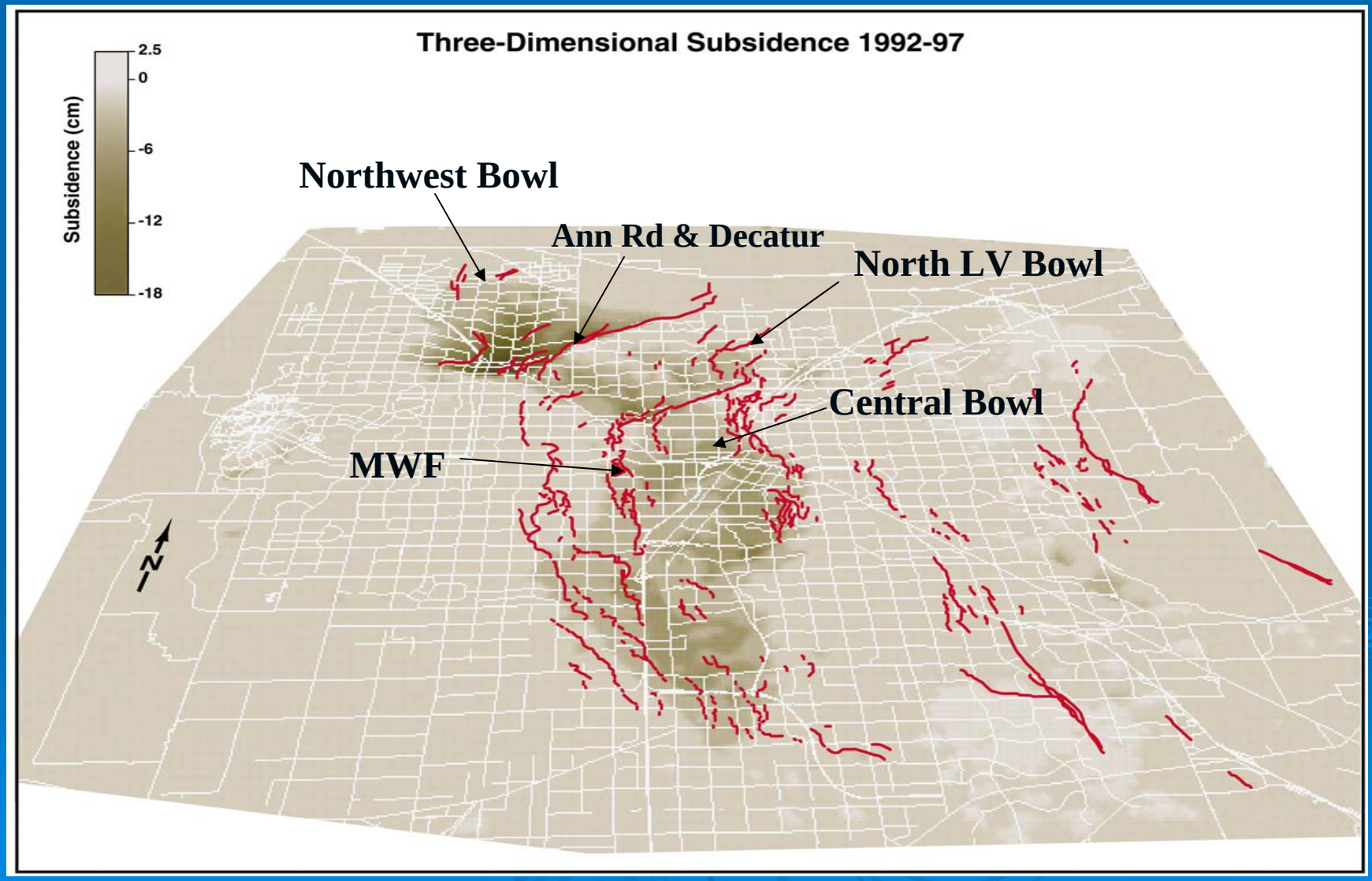
Change in Potentiometric Surface 1990 – Fall 2008



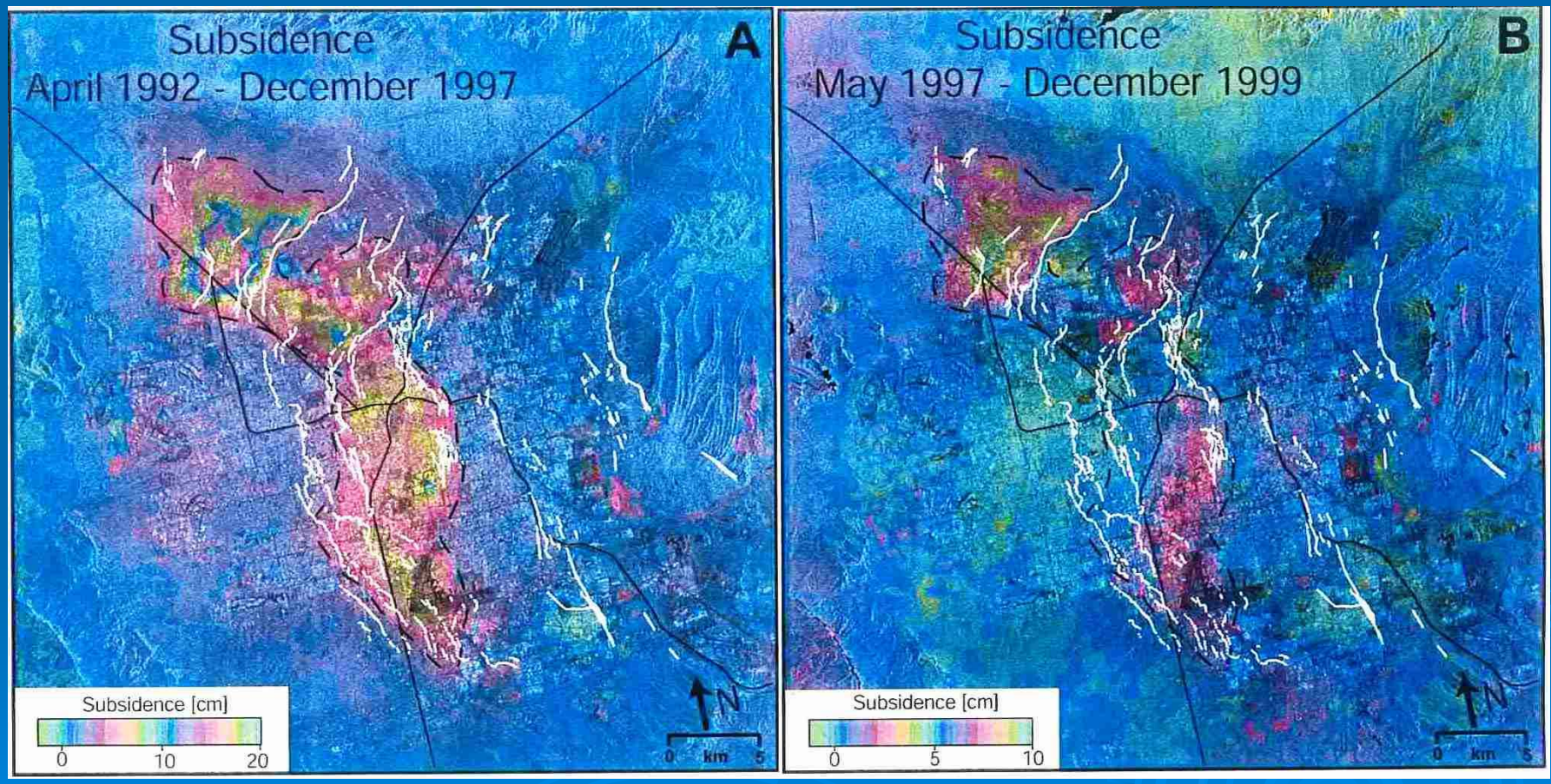
(SNWA, 2009)

Land Subsidence 1992-97

Bell, et. al., 2002

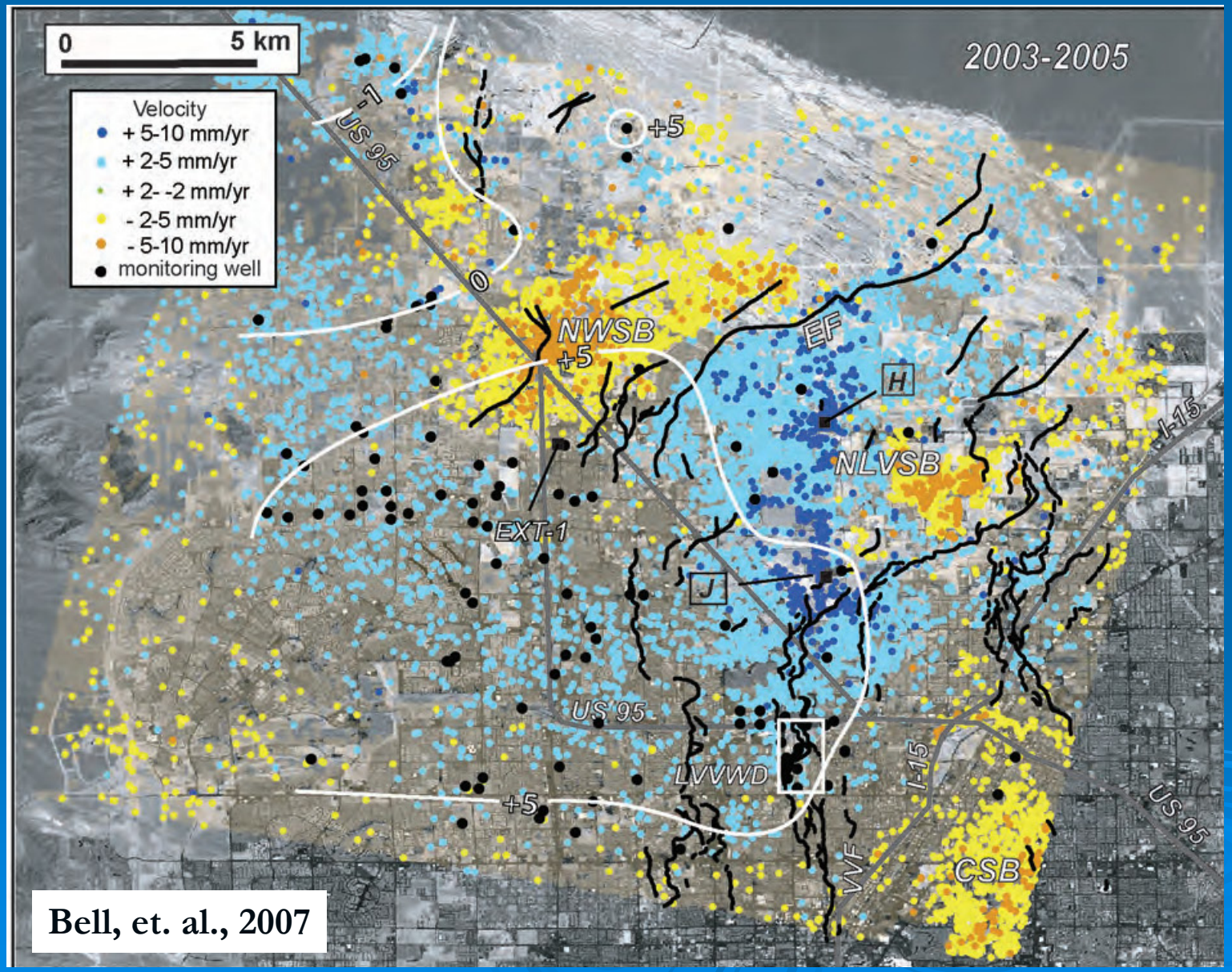


Change in land subsidence since AR



Bell, et. al., 2002

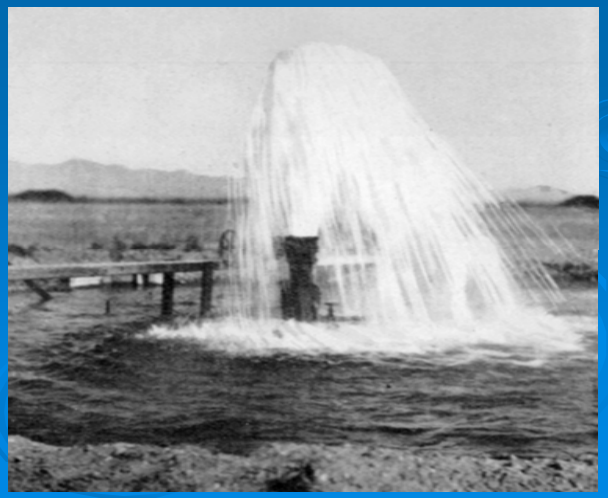
Subsidence Rates - Spring 2003 to Spring 2005



Bell, et. al., 2007

ASR success depends upon:

- Suspended solids in injectate
- Microorganisms and biofouling
- Ion exchange and adsorption – clay mineralogy
- Reduction/oxidation processes
- Carbonate precipitation/dissolution
- Disinfection by-products
- Unknown future contaminants
- Aquifer response to added water
- Ability to recover



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Thank you