MITIGATING DROUGHT CONDITIONS THROUGH OPTIMIZING AQUIFER STORAGE AND RECOVERY (ASR) WELL OPERATION

WESTCAS 2016
Annual Conference

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Carollo Engineers

October 26, 2016

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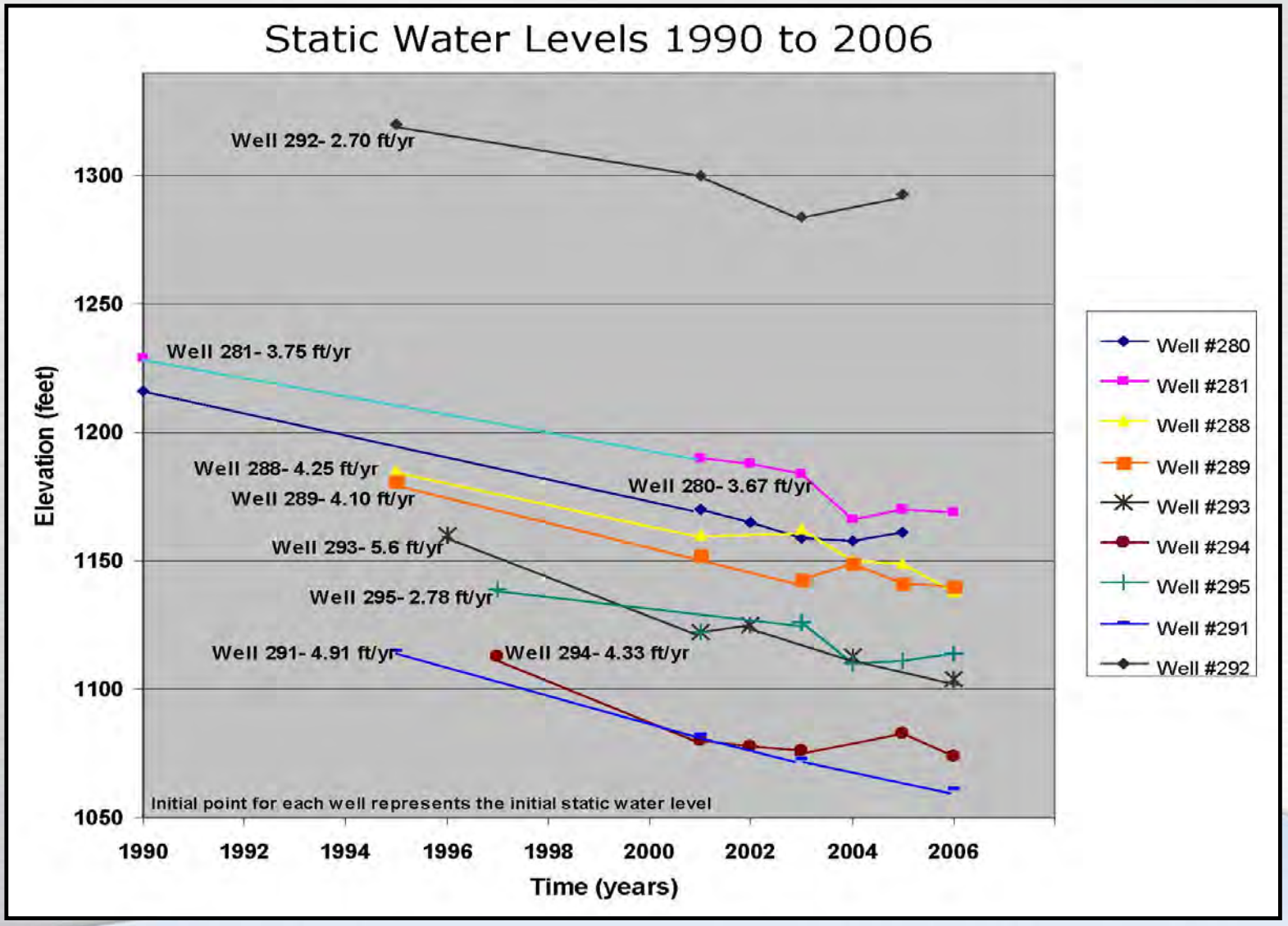
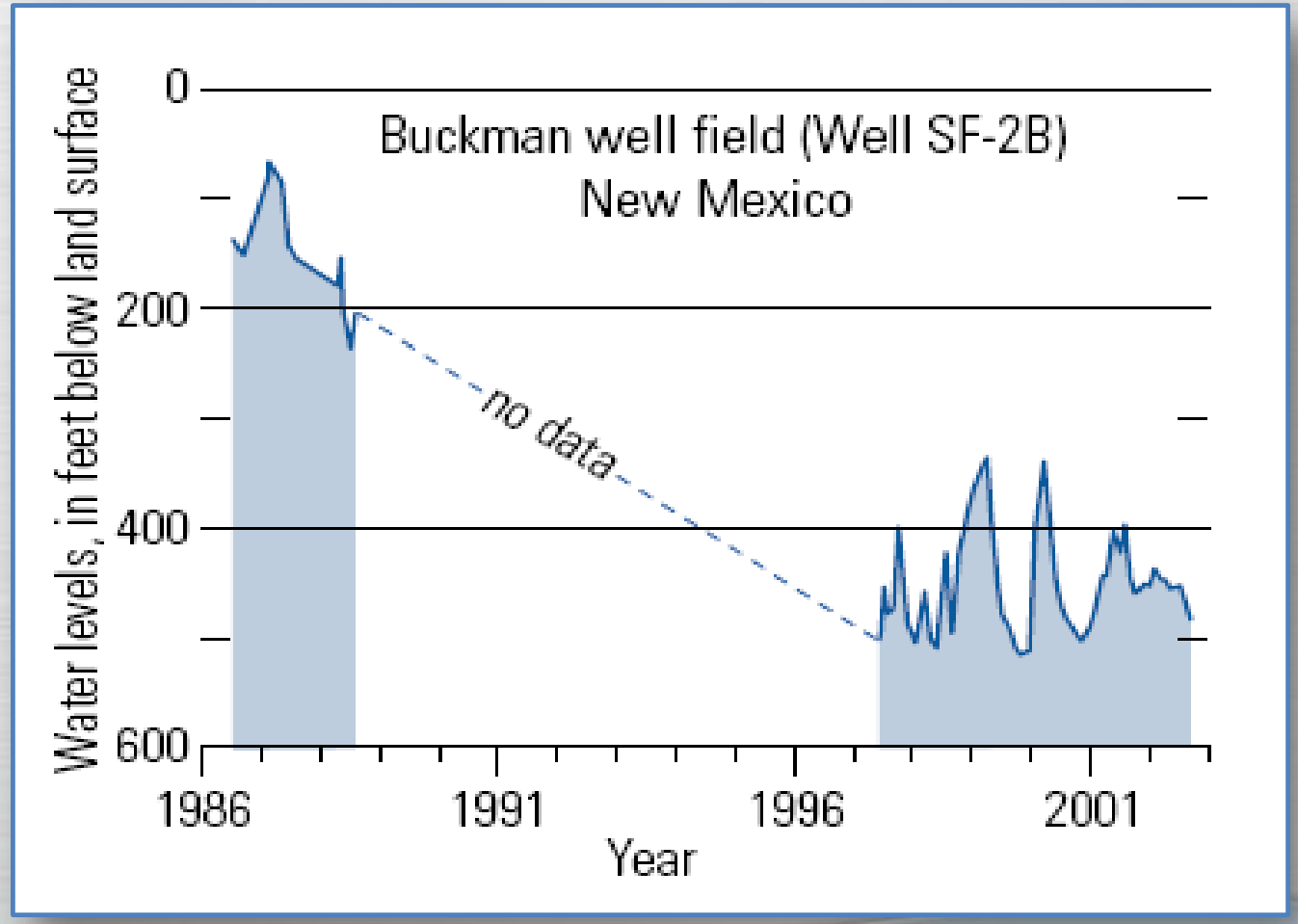
Engineers...Working Wonders With Water®

The Next Gold Rush

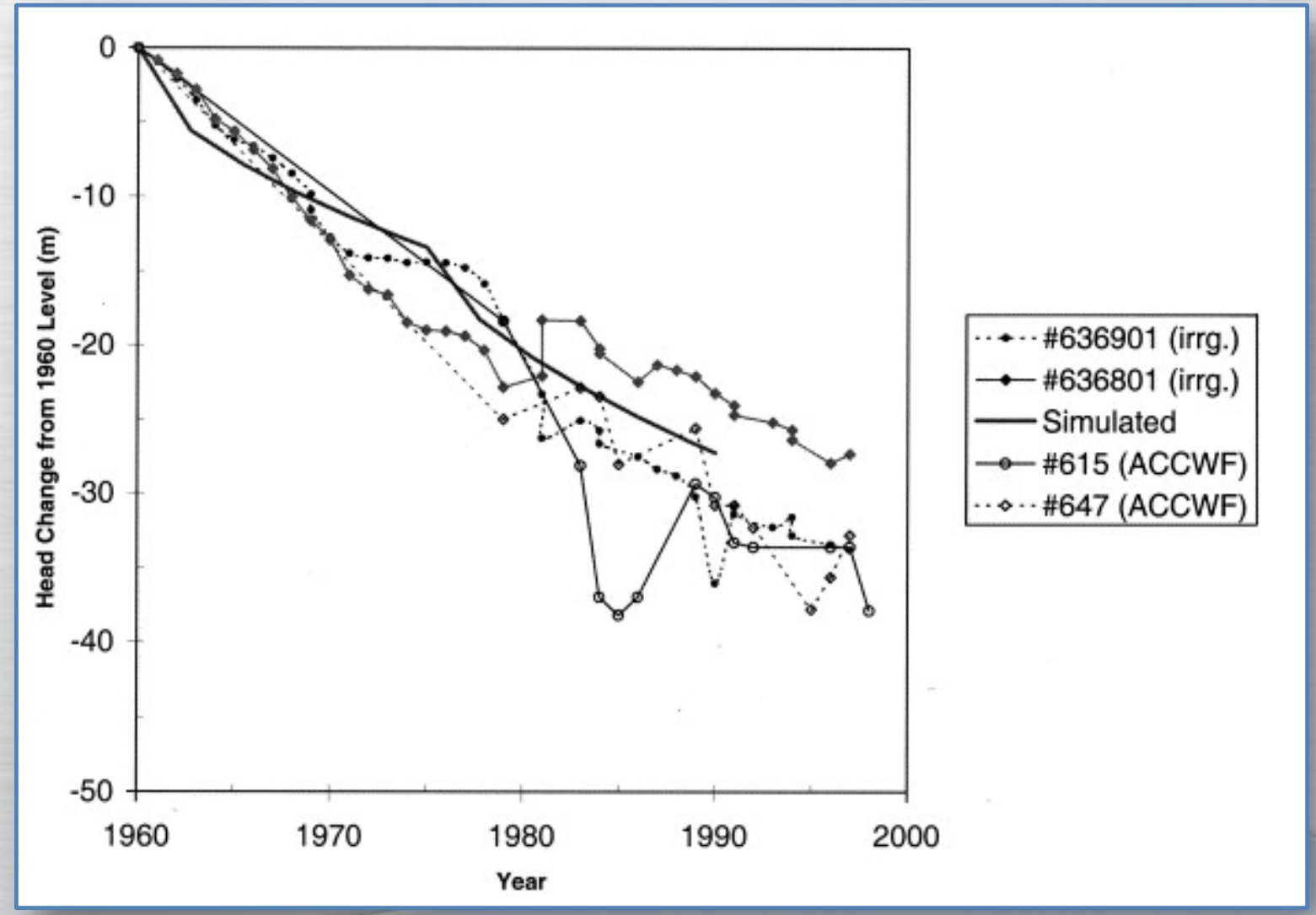
Arizona


Static Water Levels 1990 to 2006
Well 292- 2.70 ft/yr
Well 281- 3.75 ft/yr
Well 288- 4.25 ft/yr
Well 289- 4.10 ft/yr
Well 280- 3.67 ft/yr
Well 293- 5.6 ft/yr
Well 295- 2.78 ft/yr
Well 291- 4.91 ft/yr
Well 294- 4.33 ft/yr
Initial point for each well represents the initial static water level
Elevation (feet)
1300
1250
1200
1150
1100
1050
1990
1992
1994
1996
1998
2000
2002
2004
2006
Time (years)
Well #280
Well #281
Well #288
Well #289
Well #293
Well #294
Well #295
Well #291
Well #292

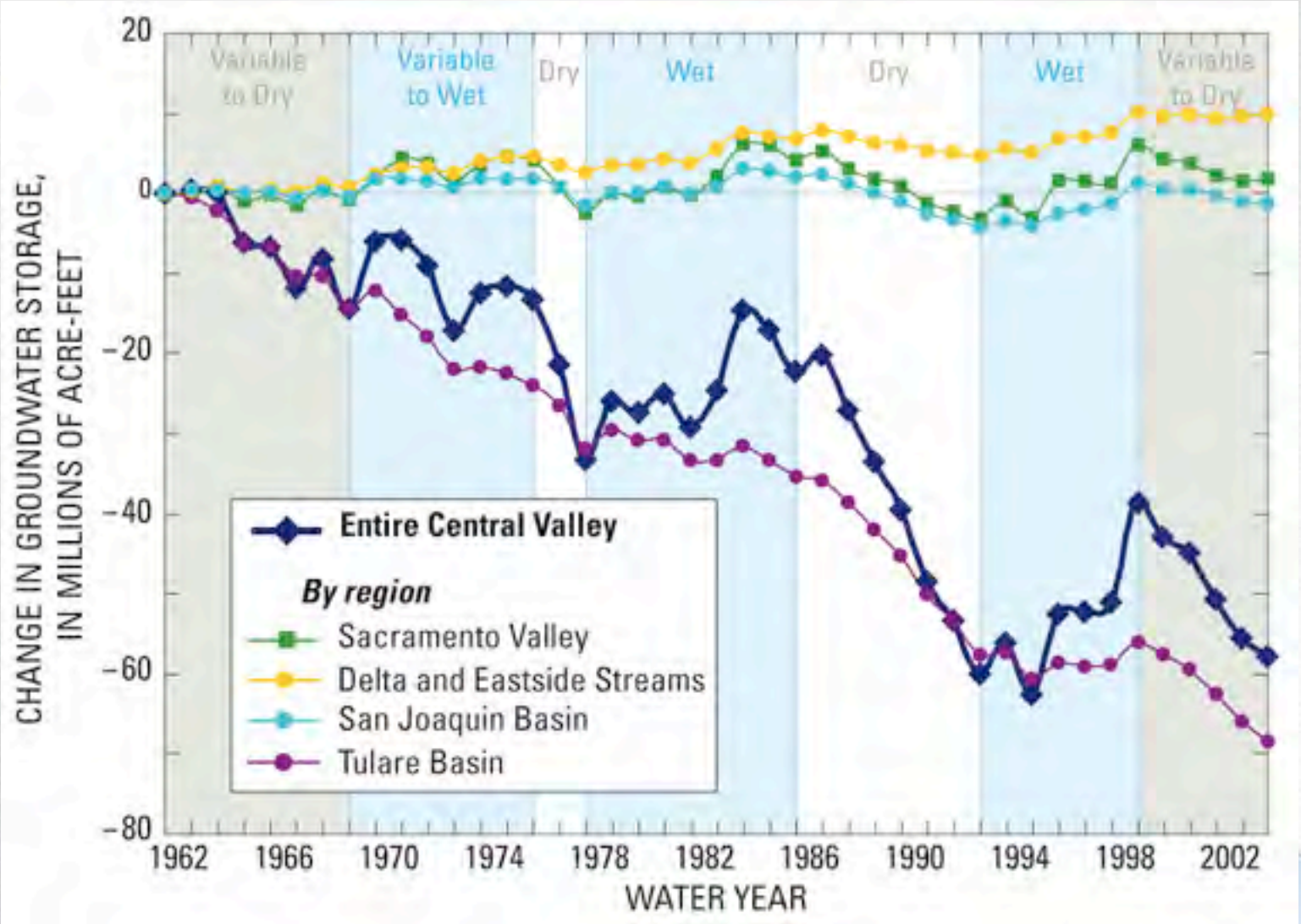
New Mexico


Buckman well field (Well SF-2B)
New Mexico
Water levels, in feet below land surface
0
200
400
600
no data
1986
1991
1996
2001
Year

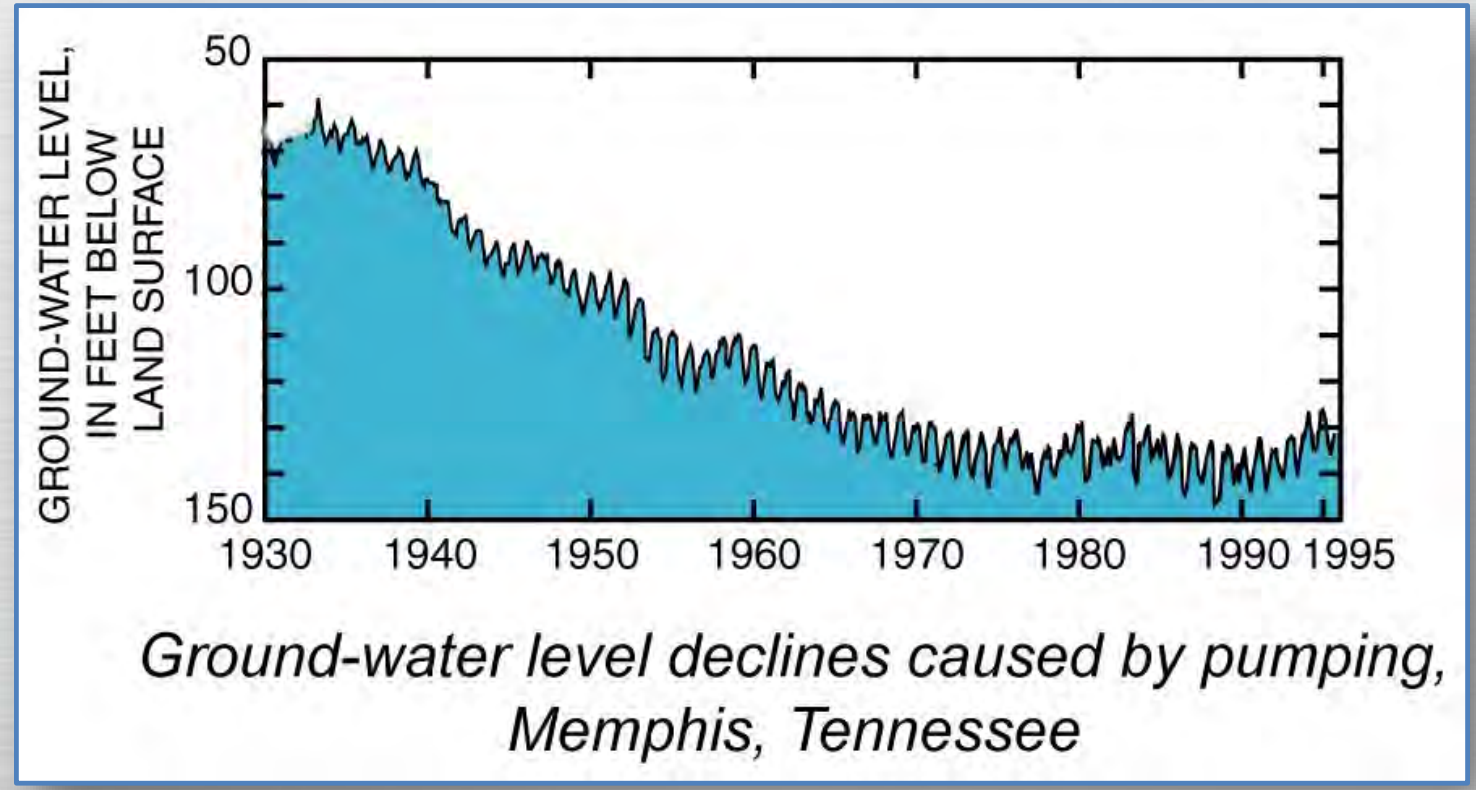
South (Texas)


0
-10
-20
-30
-40
-50
Head Change from 1960 Level (m)
1960
1970
1980
1990
2000
Year
#636901 (irrg.)
#636801 (irrg.)
Simulated
#615 (ACCWF)
#647 (ACCWF)

California


Variable to Dry
Variable to Wet
Dry
Wet
Dry
Wet
Variable to Dry
20
0
-20
-40
-60
-80
CHANGE IN GROUNDWATER STORAGE, IN MILLIONS OF ACRE-FEET
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
WATER YEAR
Entire Central Valley
By region
Sacramento Valley
Delta and Eastside Streams
San Joaquin Basin
Tulare Basin

East



Ground-water level declines caused by pumping, Memphis, Tennessee

Northeast

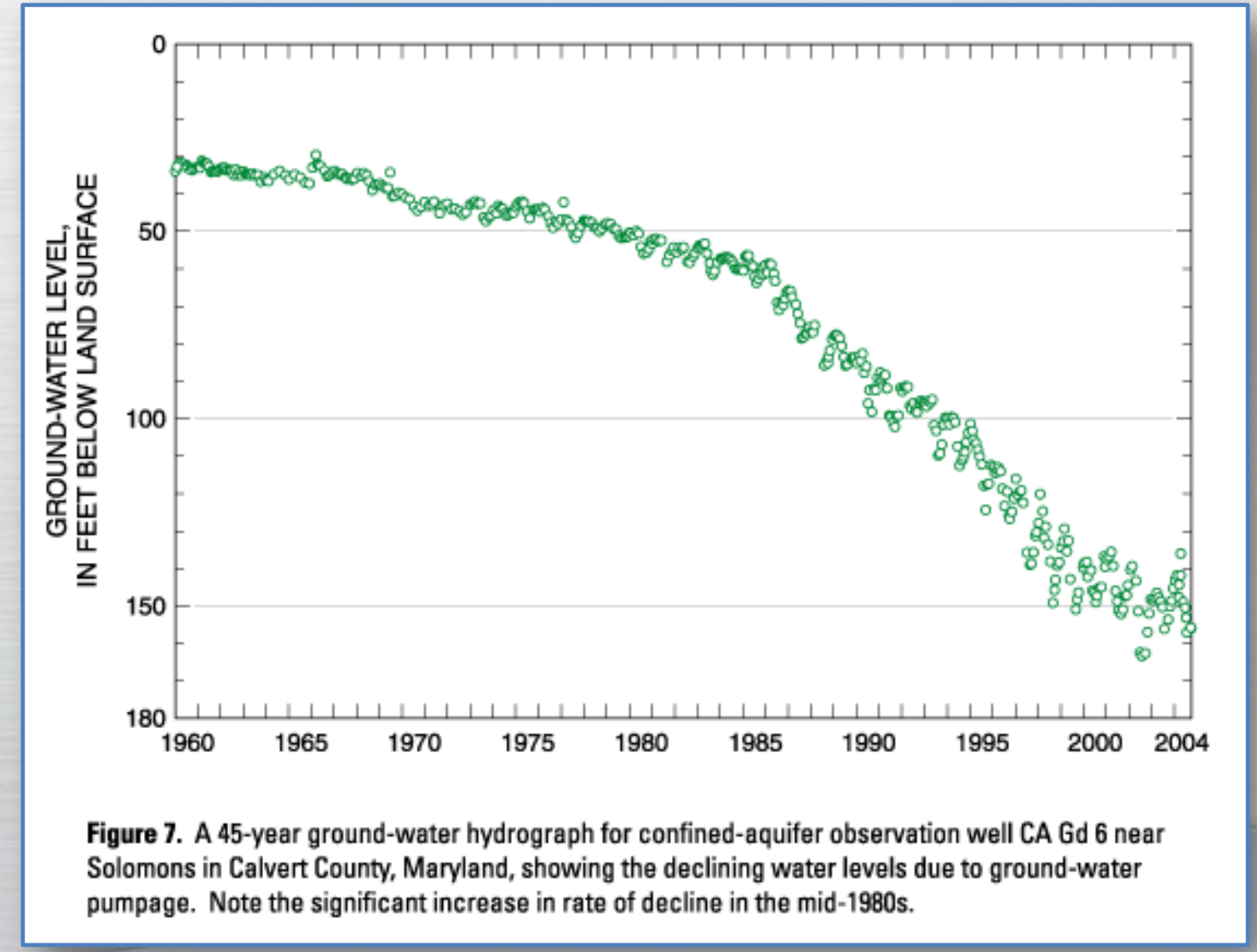
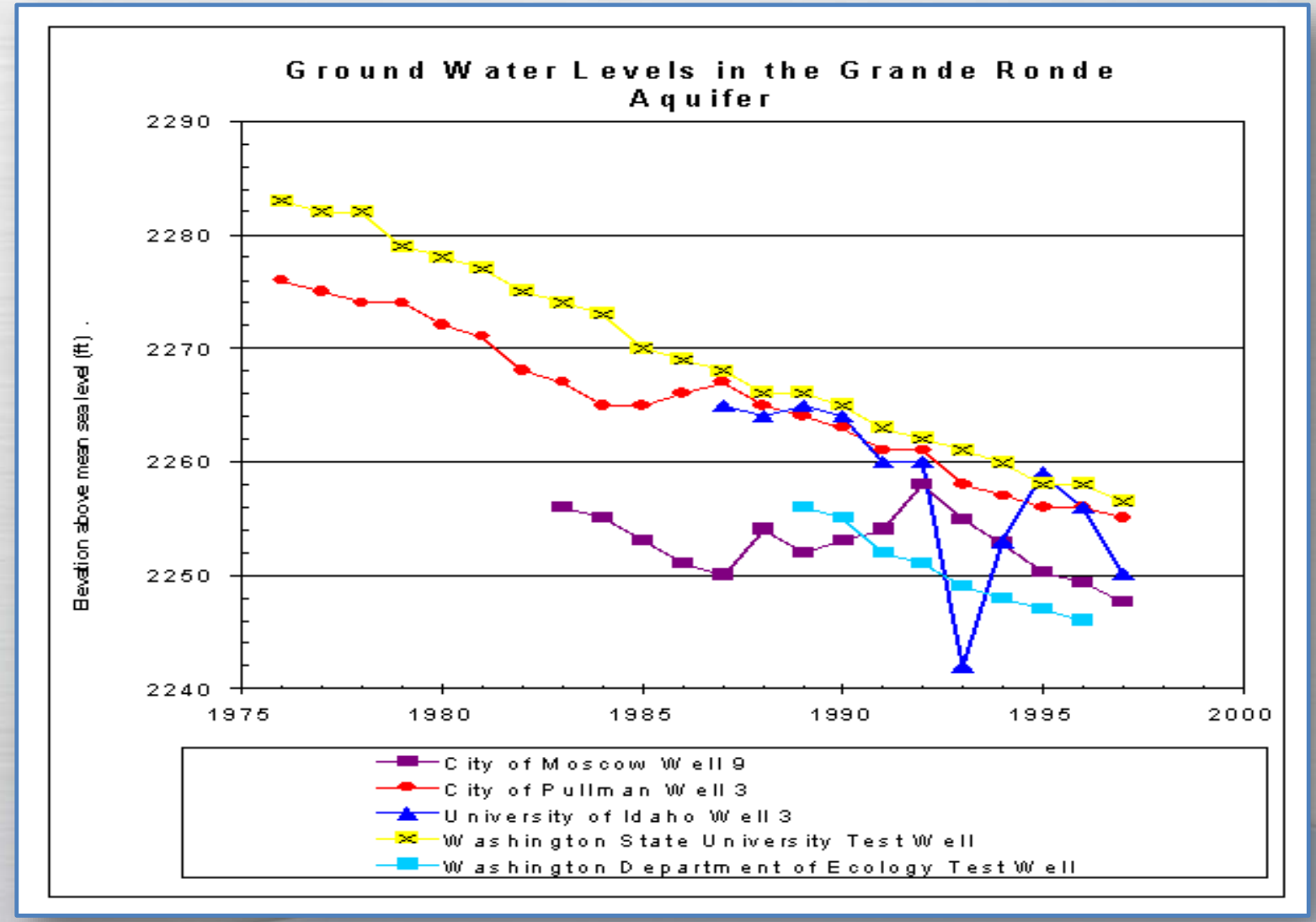
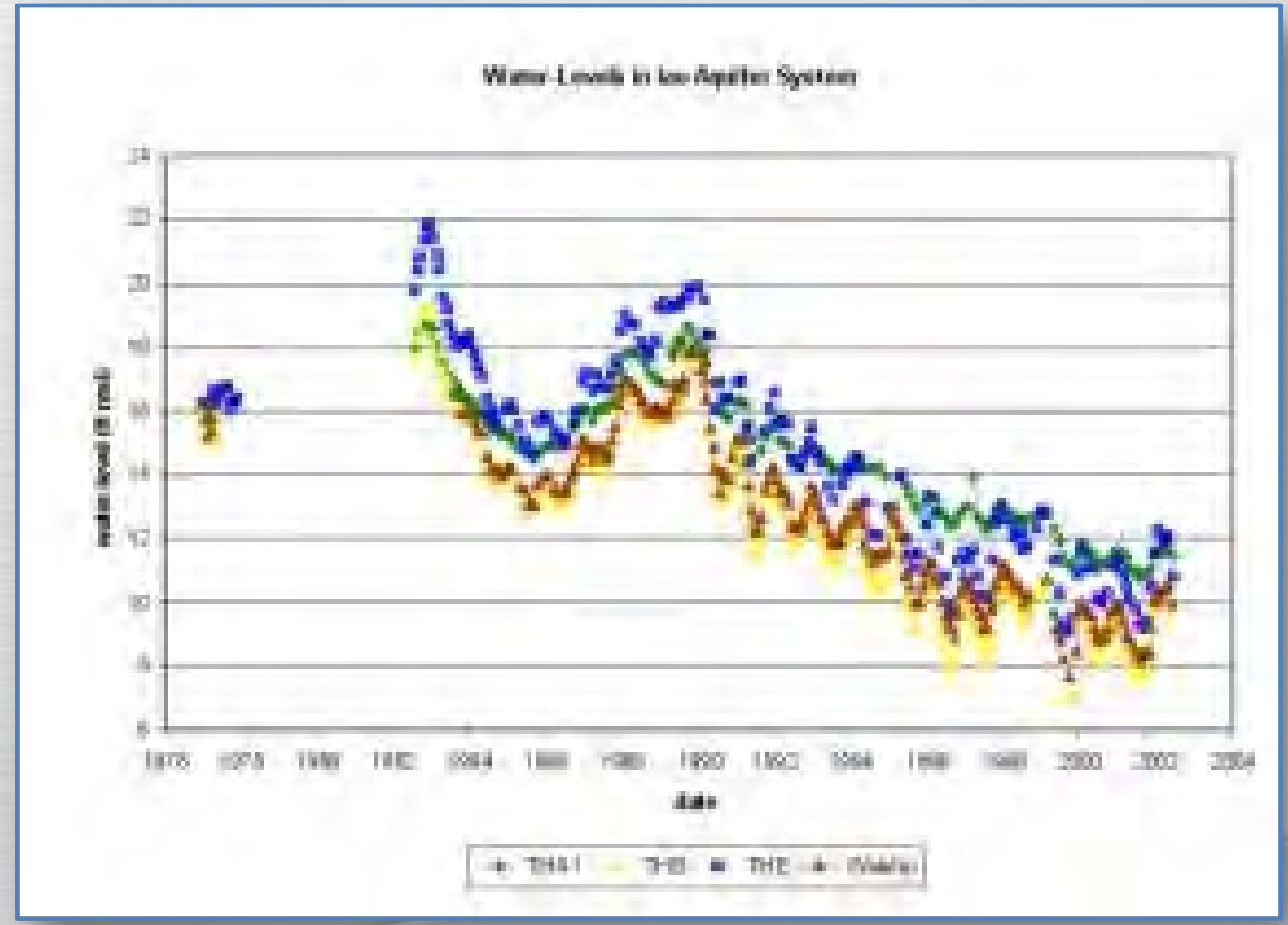


Figure 7. A 45-year ground-water hydrograph for confined-aquifer observation well CA Gd 6 near Solomons in Calvert County, Maryland, showing the declining water levels due to ground-water pumpage. Note the significant increase in rate of decline in the mid-1980s.

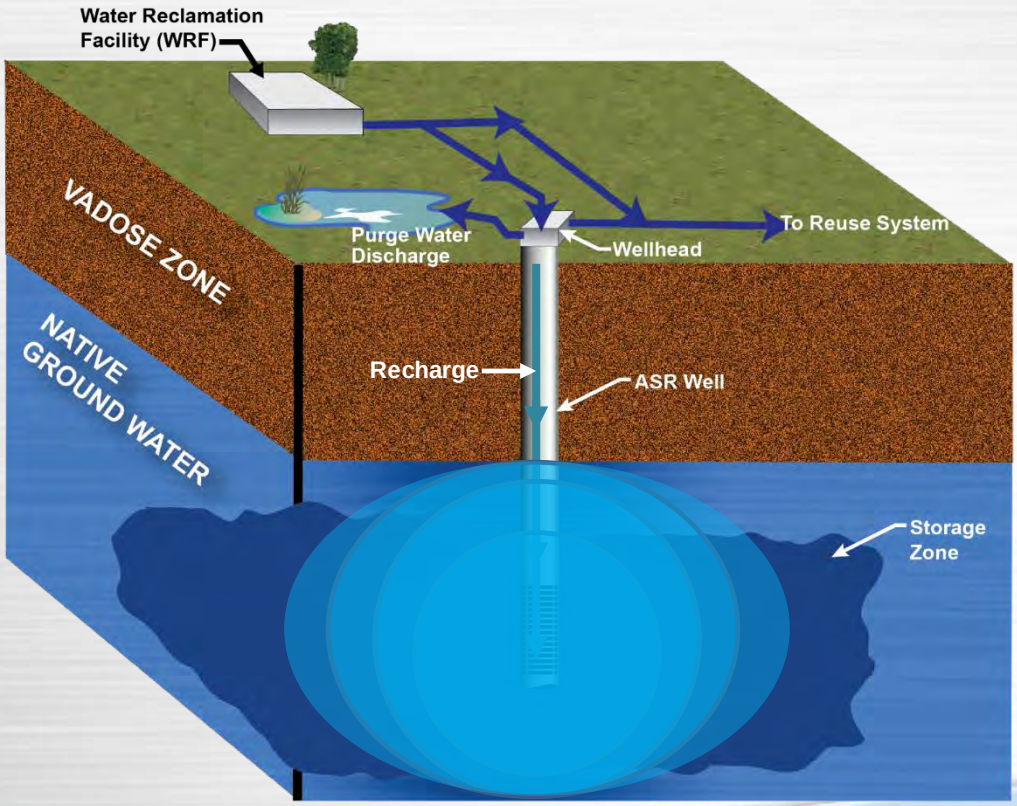
Northwest


Ground Water Levels in the Grande Ronde Aquifer
Elevation above mean sea level (ft) .
2290
2280
2270
2260
2250
2240
1975
1980
1985
1990
1995
2000
City of Moscow Well 9
City of Pullman Well 3
University of Idaho Well 3
Washington State University Test Well
Washington Department of Ecology Test Well

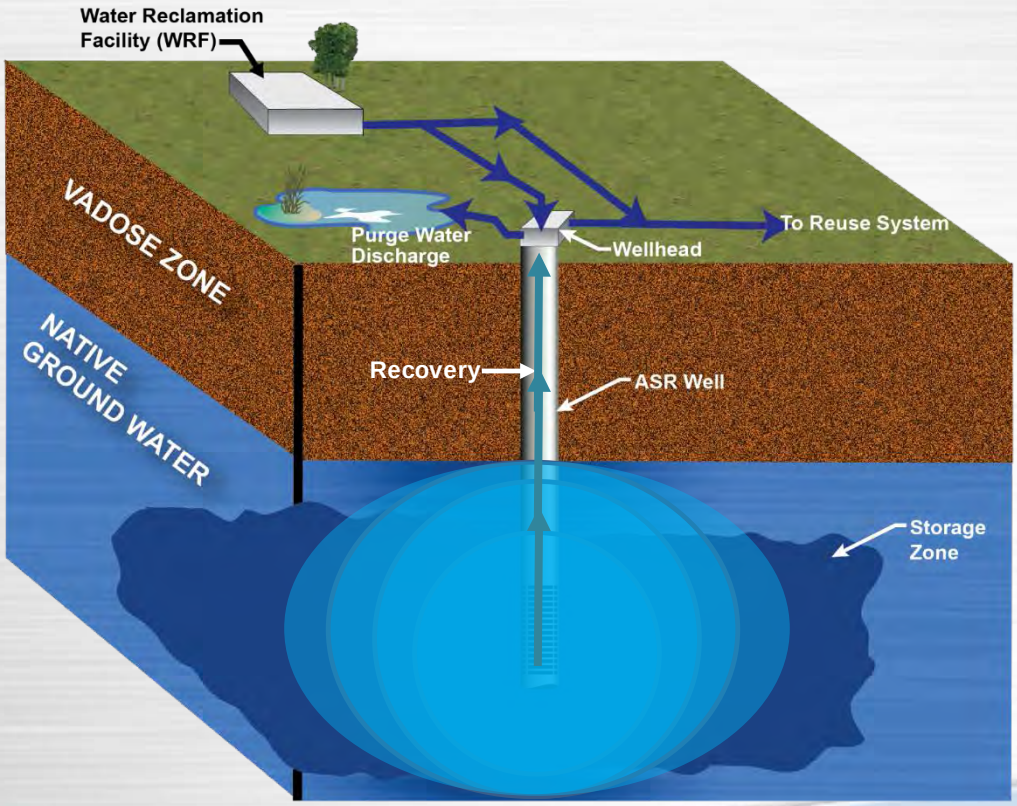
Hawaii



ASR Operational Concept

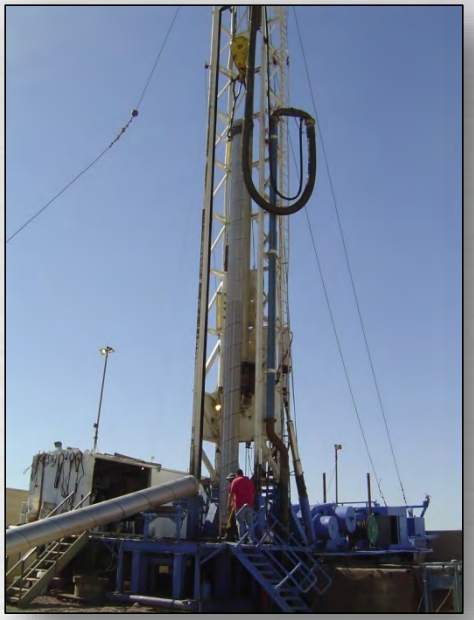


ASR Operational Concept

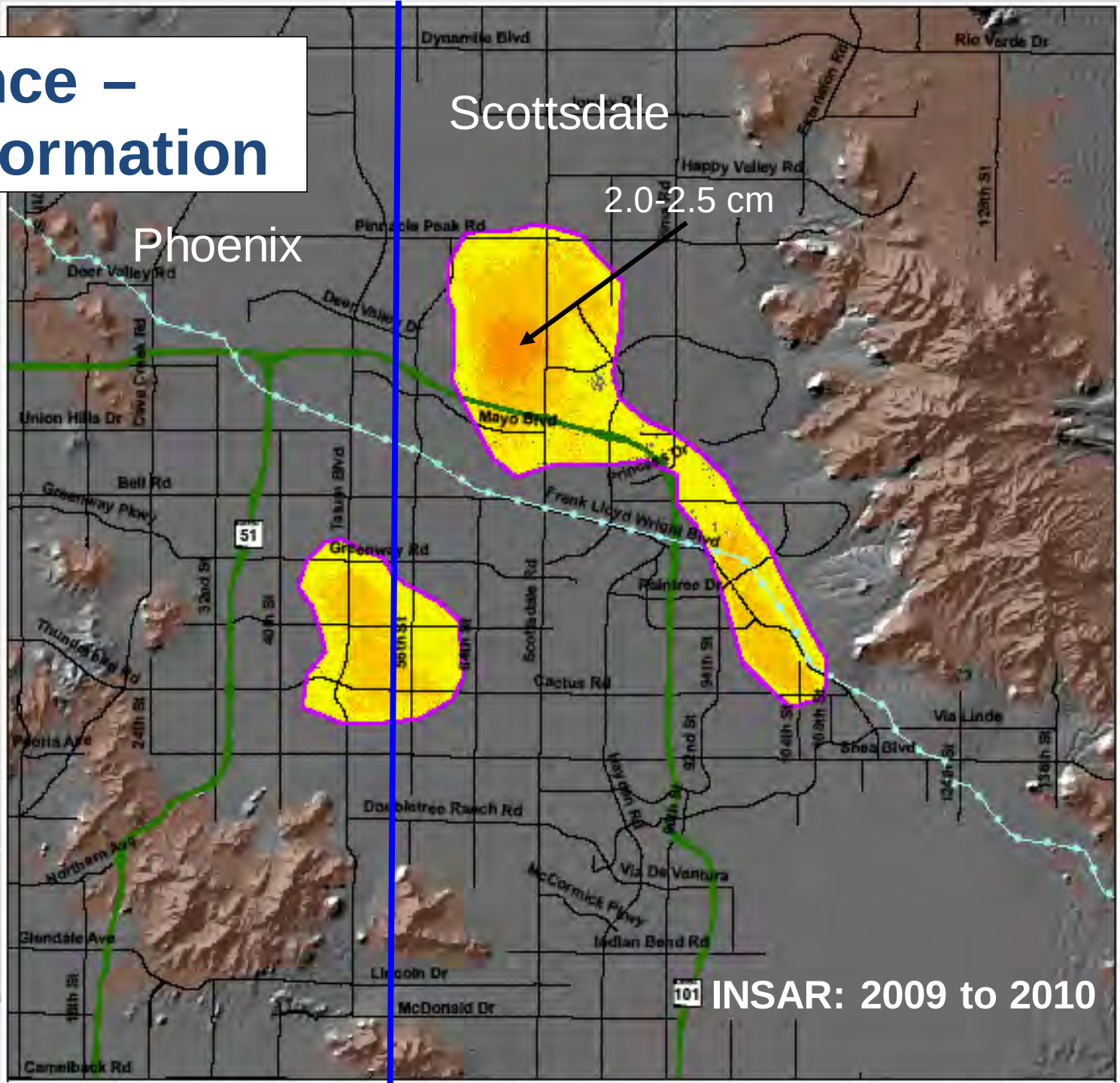


ASR Strategies

- Mitigate/Sustain Declining Water Levels



Subsidence – Land Deformation



ASR Strategies

- Mitigate/Sustain Declining Water Levels
- Increase Well Capacity
- System Redundancy and Flexibility - Potable Delivery
- Long-Term Storage for Drought
- Potential for Base Loading Water Treatment Plant Flows

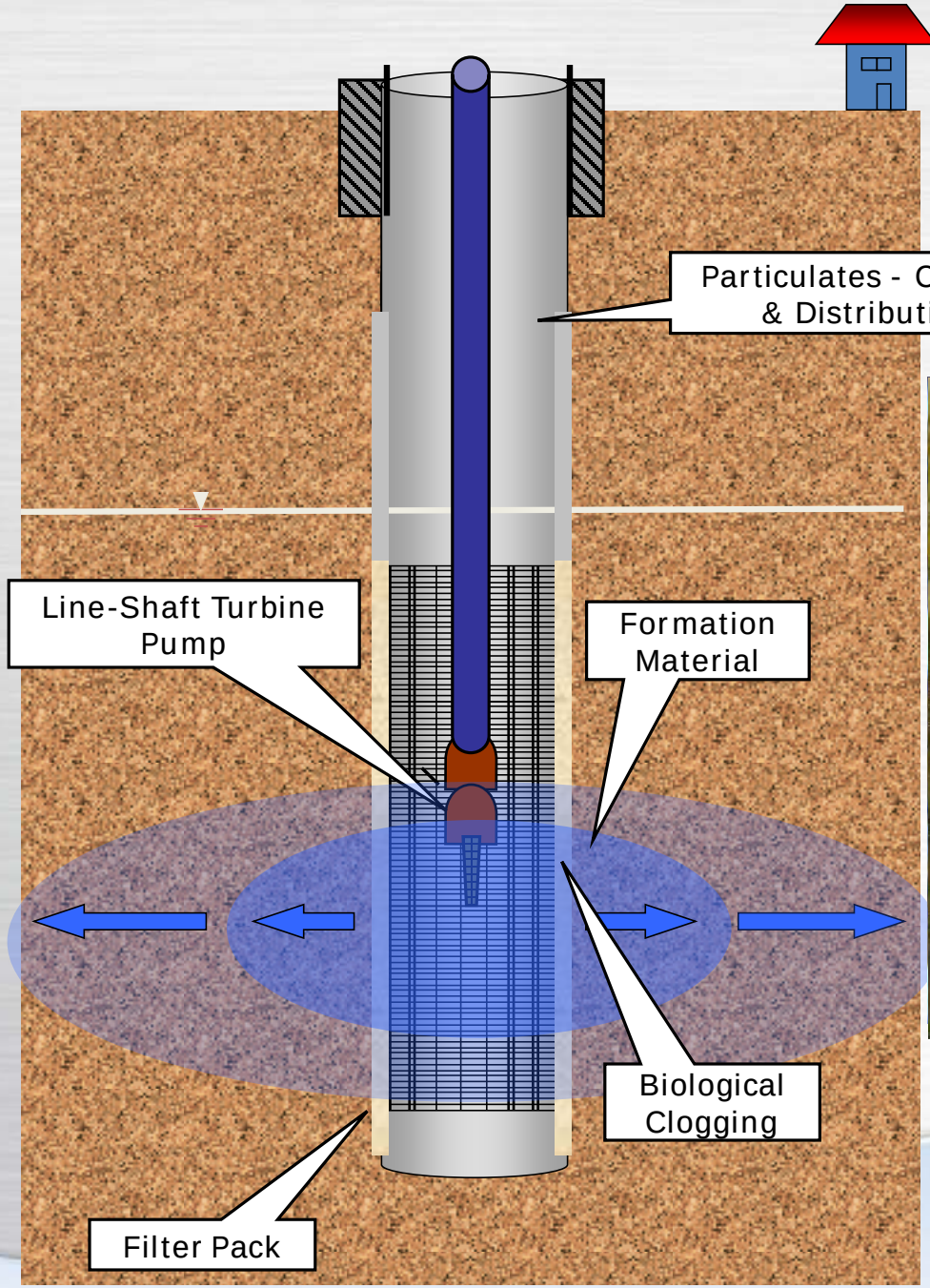
ASR Preliminary Steps

- Identify the funding source.
  - Drilling - $1,000,000
  - Equipping Construction - $2,250,000
  - Engineering and Construction Management - $750,000
  - Total Cost - $4,000,000
- Conduct geochemical analysis between groundwater and source water (core sample needed).
  - Is additional treatment required at the plant?
  - Are the pH differences small enough to mitigate mobilization of adverse constituents and/or mineral deposition?
  - (In some states) Is the recharged water of a lesser quality than the groundwater?
  - Will TTHM's be an issue? Is a dechlorination system required?
- Verify whether lateral velocity is an issue
- Identify potential ASR well sites

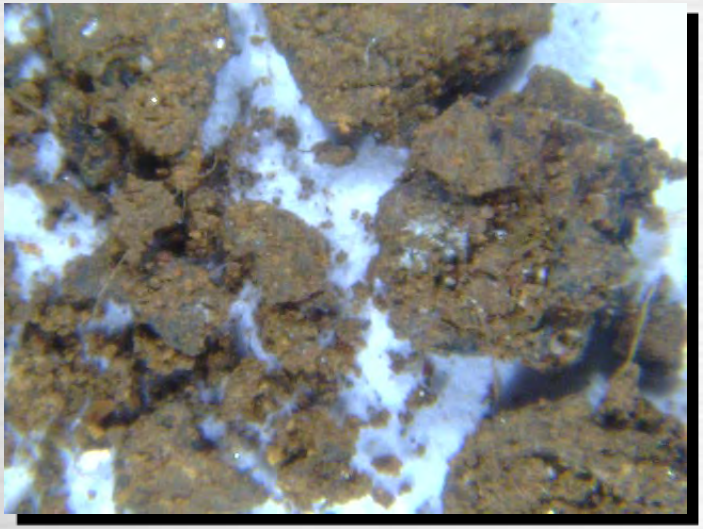
Goals for Optimizing an ASR System:

- Minimize clogging within the well
  - Particulate clogging
  - Air entrainment
  - Biofouling

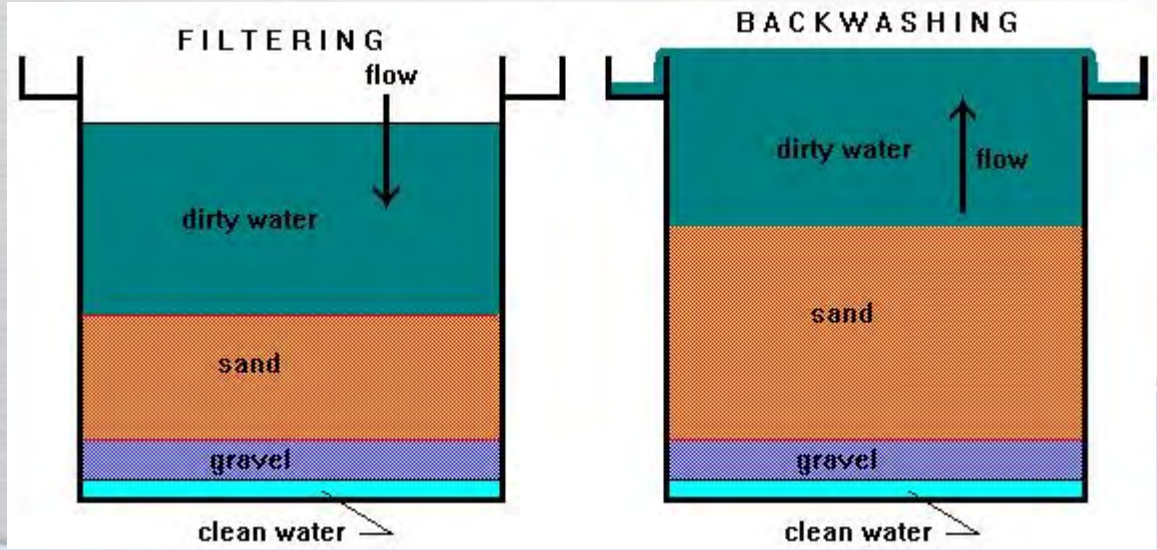
Agents of Clogging = Reduced Injection Rates



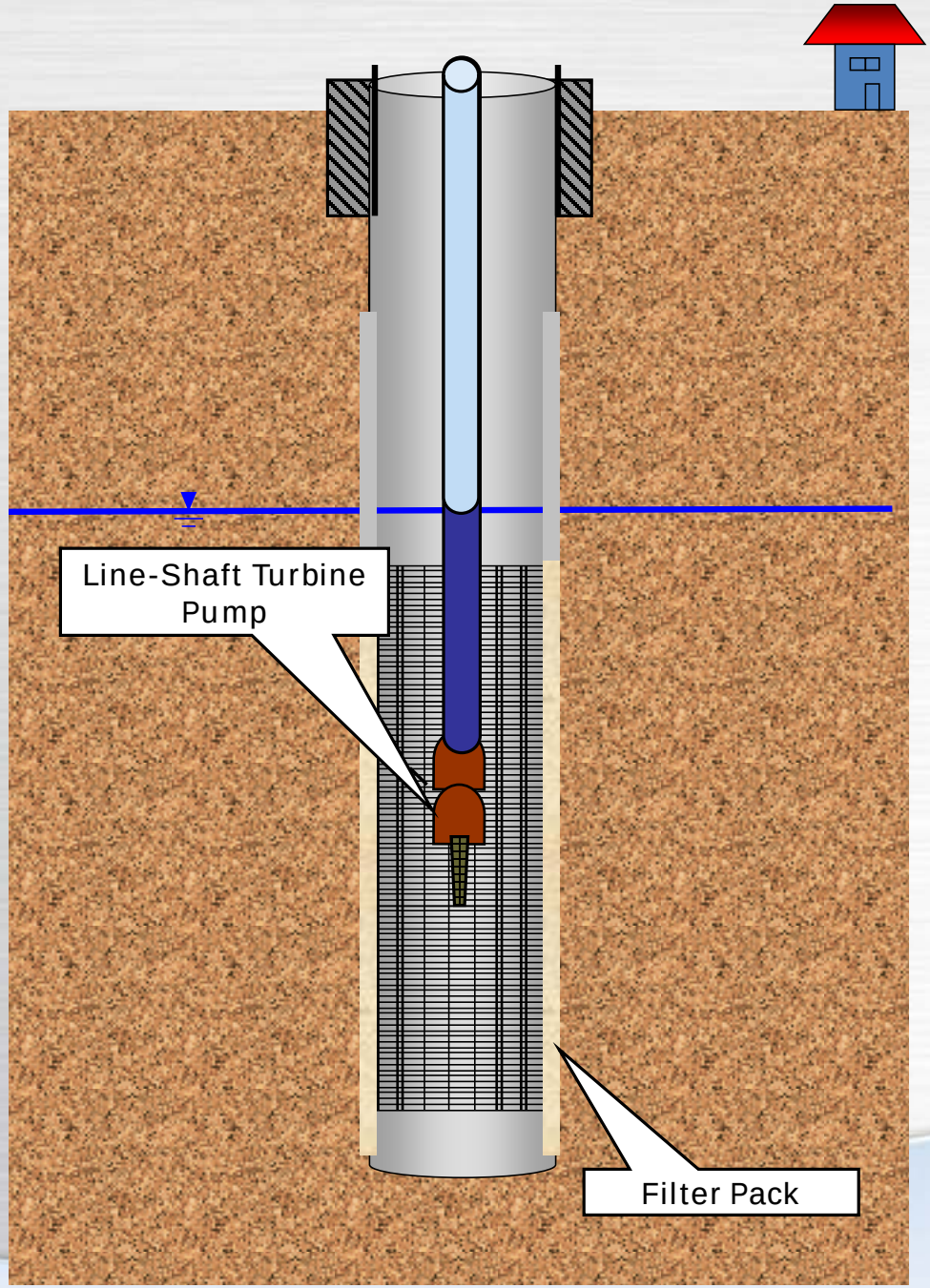
Effects of Clogging



- Reduced injection/recovery rates
- Increased O&M Cost
  - Capital costs
  - Energy costs
  - Labor costs

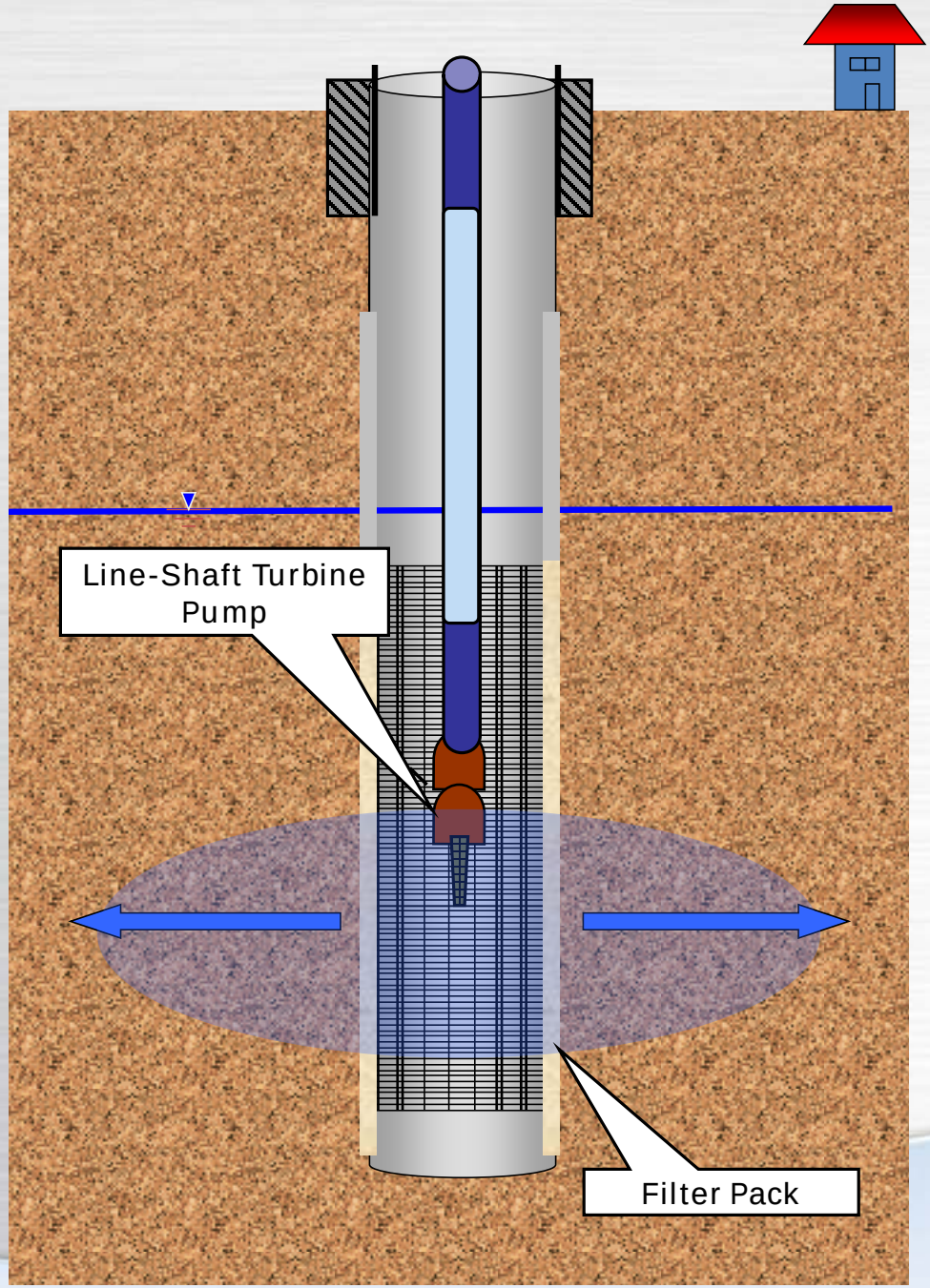


“Big” Air Entrainment = Reduced Injection Rates



-650’- Static Water Level
-838’- Top of Screen

“Big” Air Entrainment = Reduced Injection Rates



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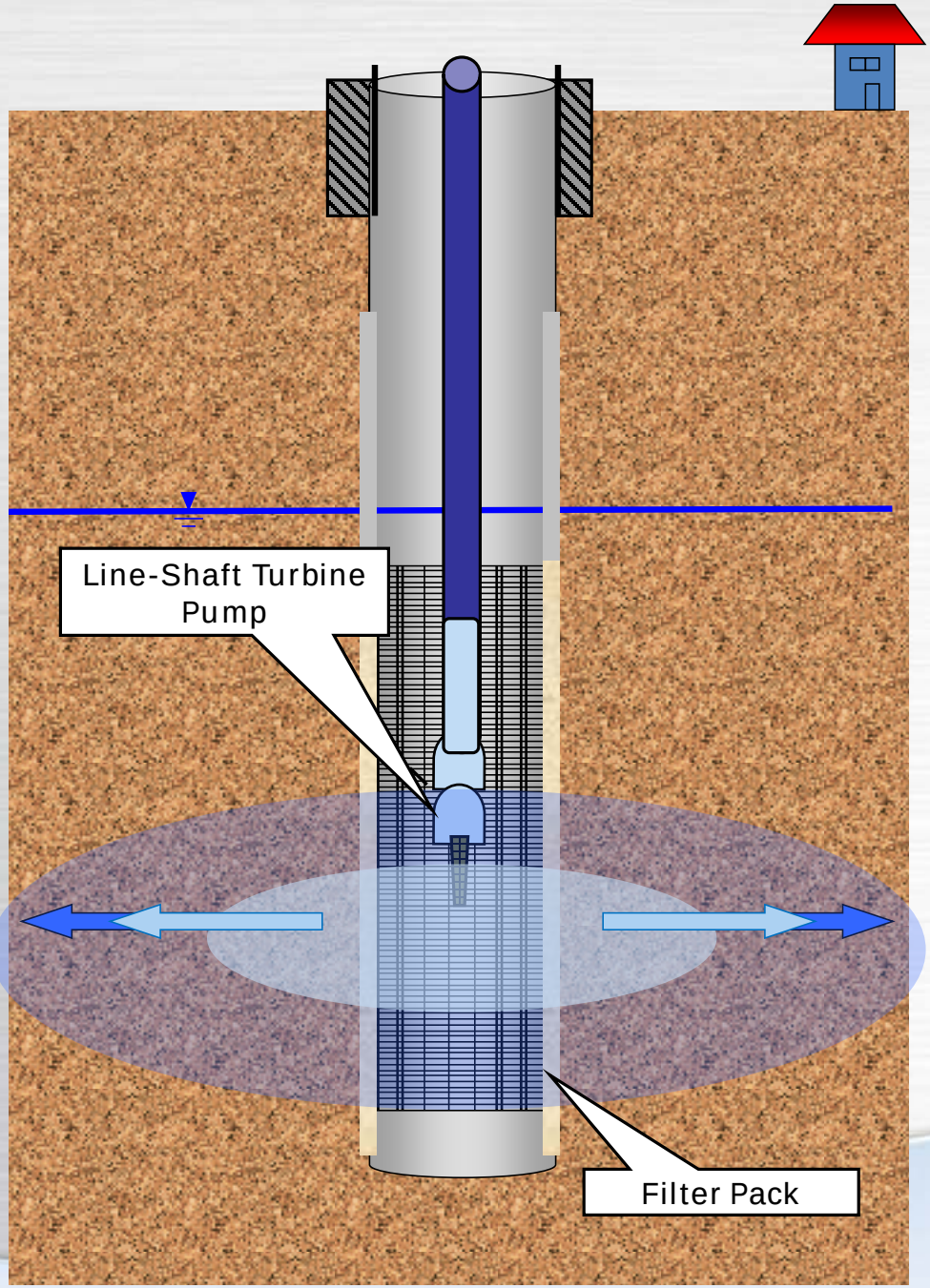

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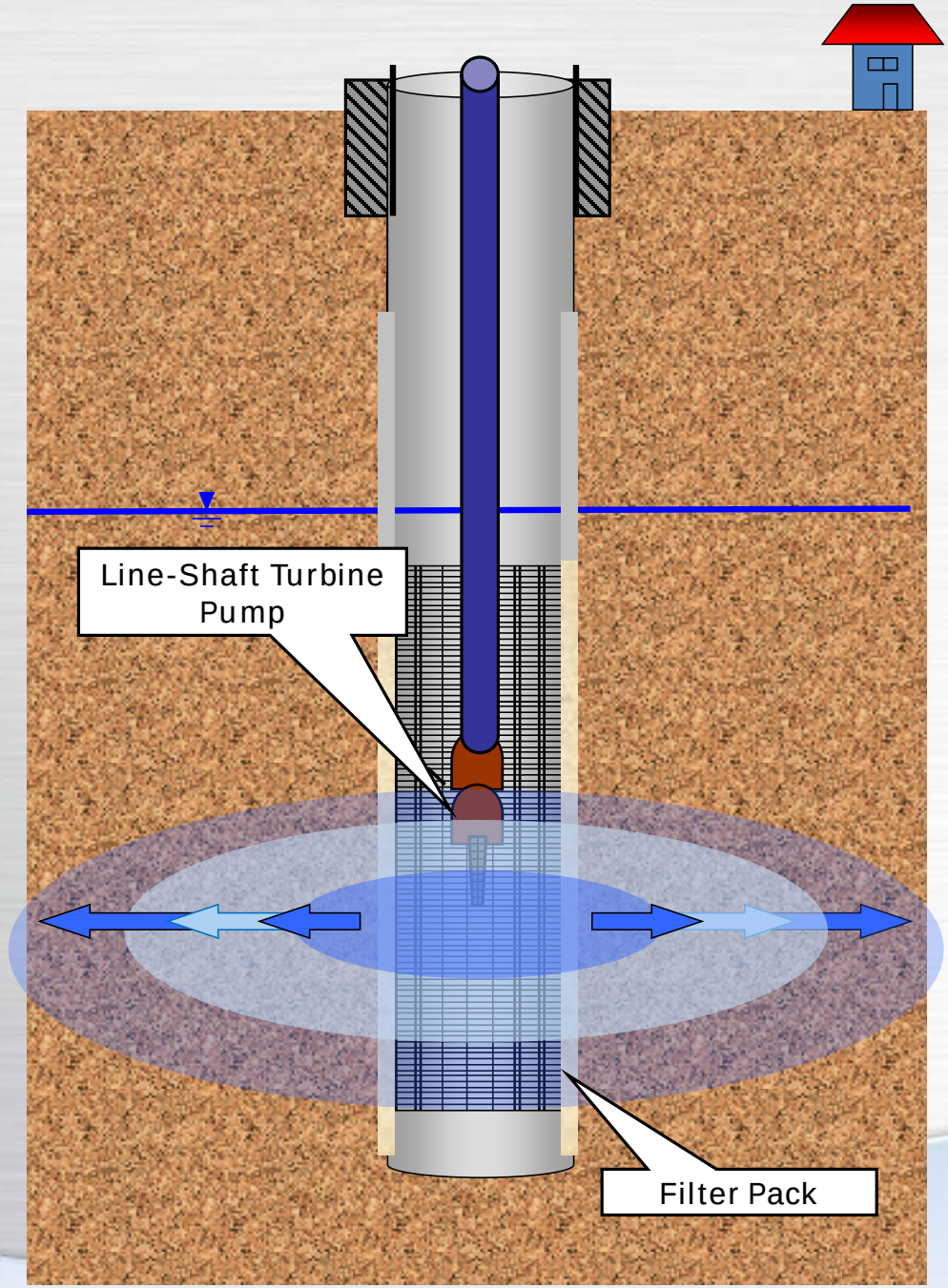

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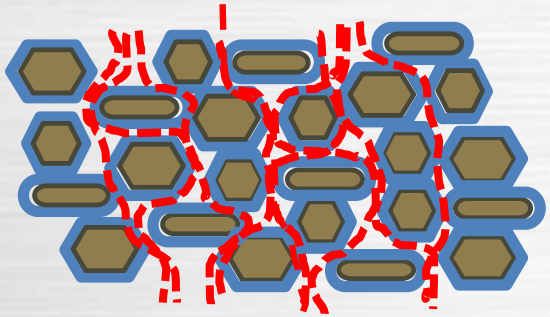
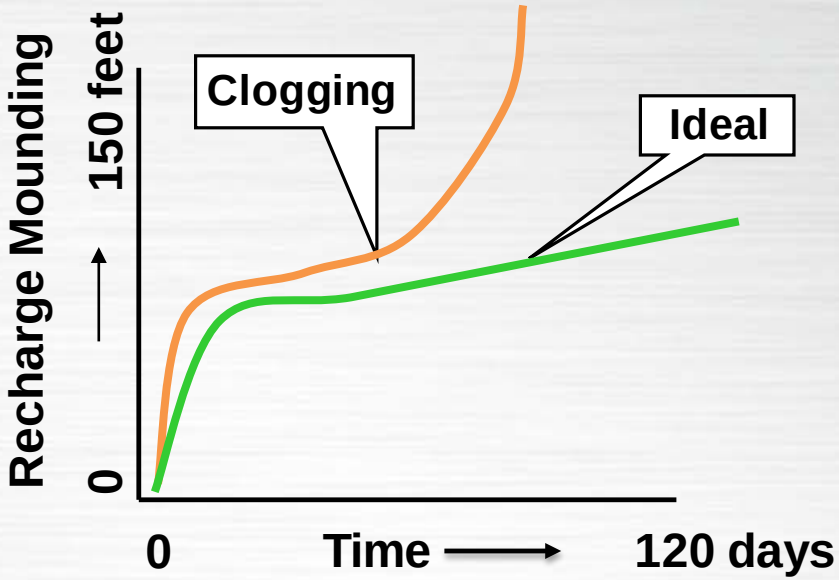
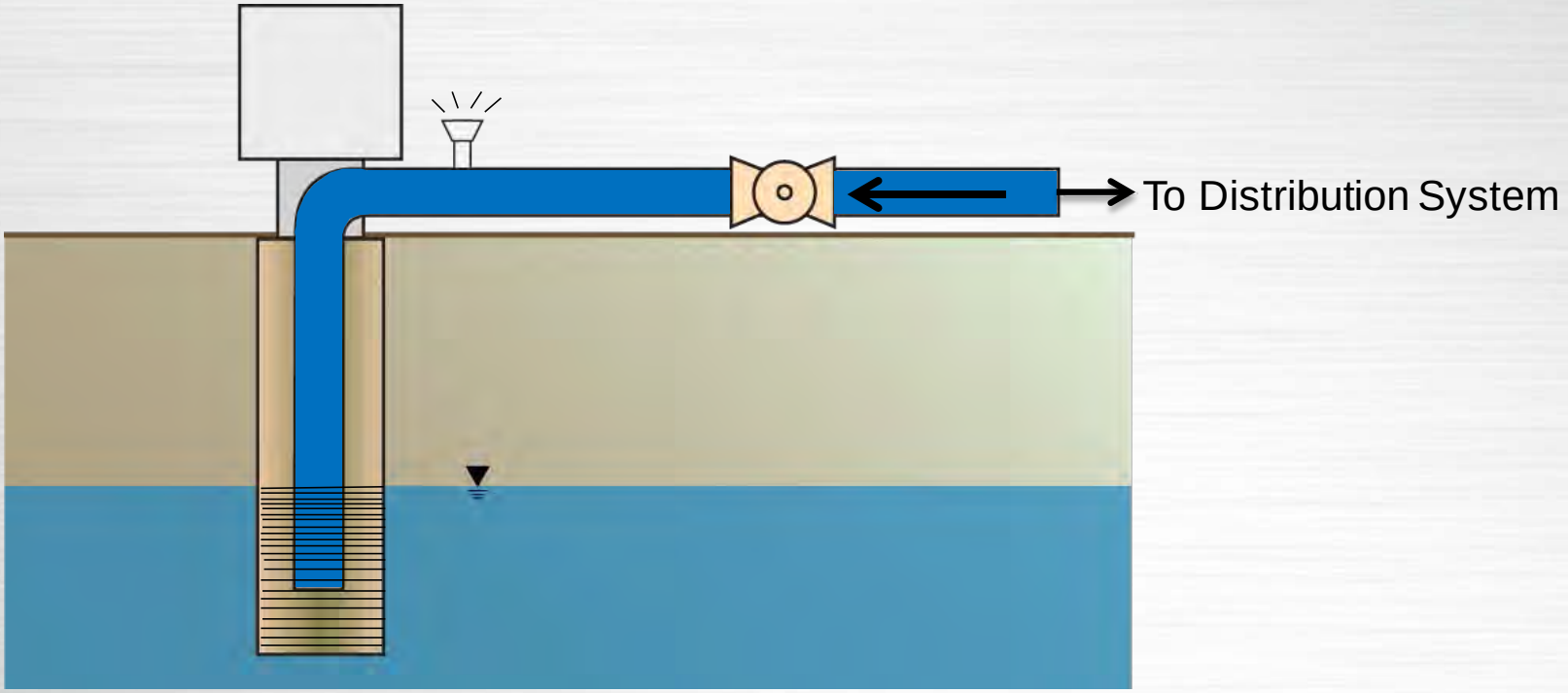
Injection Issues:

– Air entrainment





Reverse Siphon Concept and Bowl Assembly Hydraulics



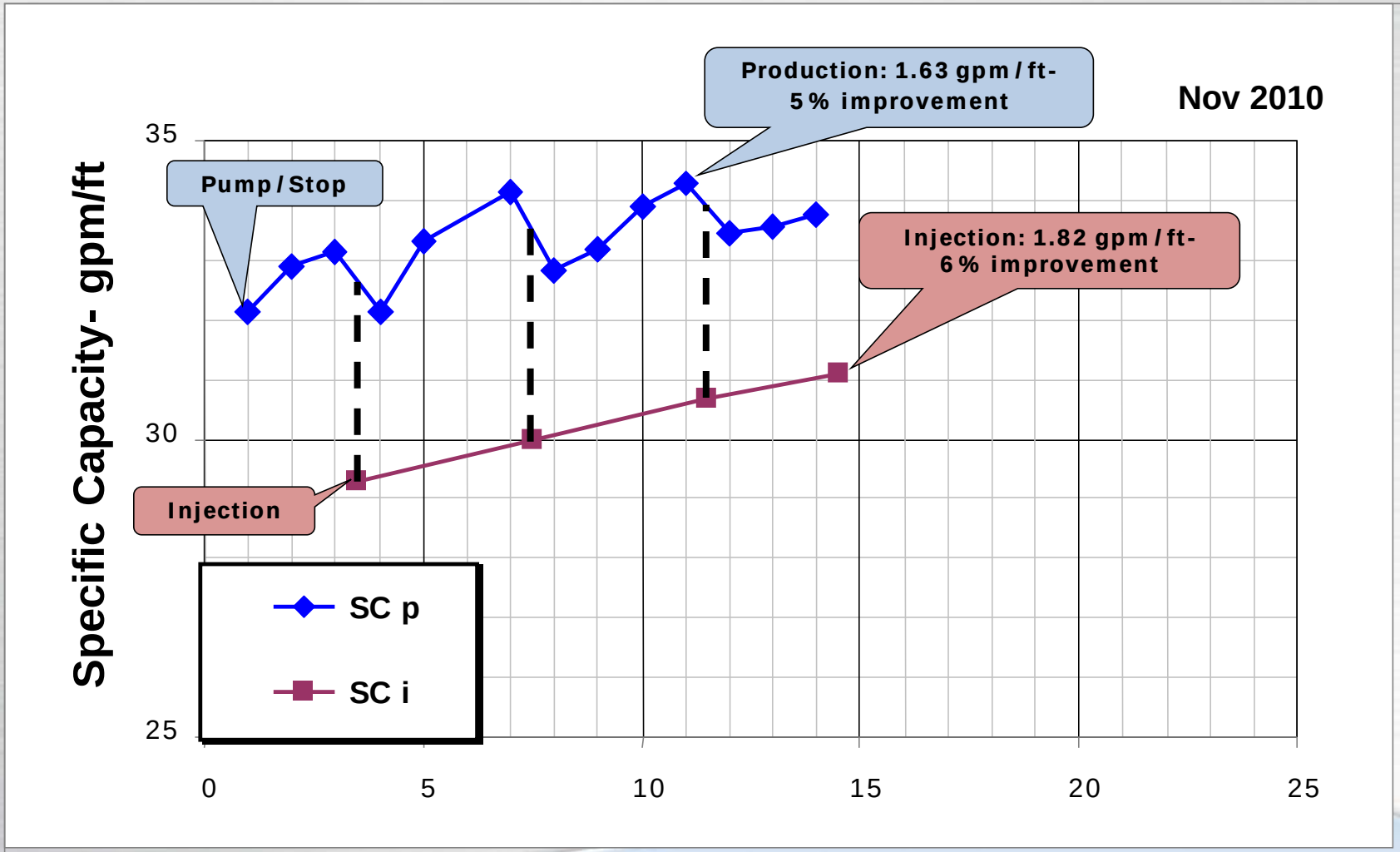
Goals for Optimizing an ASR System:

- Minimize clogging within the well
  - Particulates
  - Air entrainment
  - Biofouling
- Identify ratio of recharge/recovery that is acceptable
  - Well redevelopment
  - Data acquisition

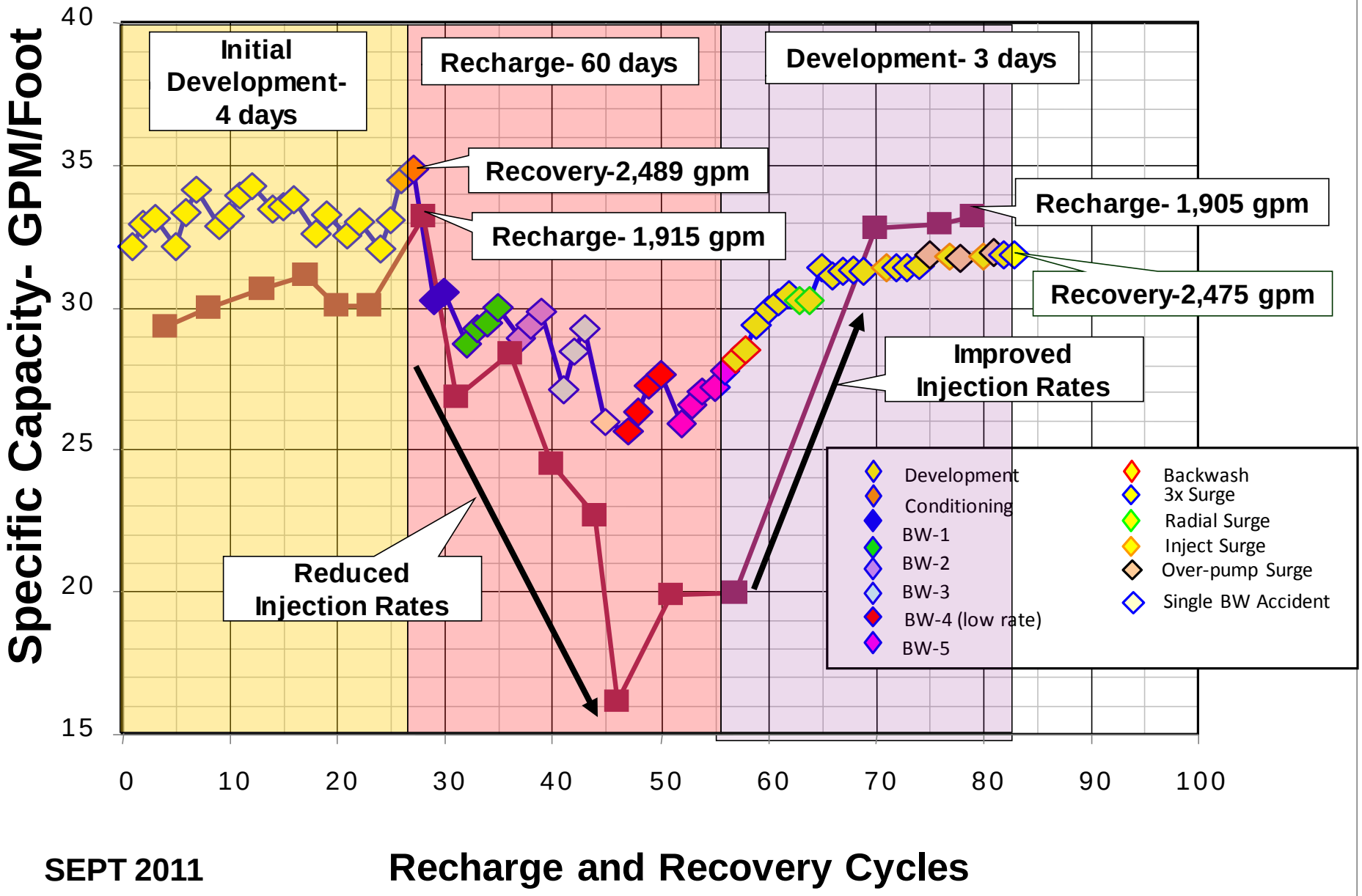
ASR Redevelopment Benefits:

- Condition aquifer for injection operations
  - Reduce clogging potential
- Improve injection and recovery rates
  - Extend life-cycle of the well
- Use permanent pump equipment
  - Eliminate pulling the pump assembly
  - Reduce maintenance costs and time

Data Acquisition for Determining Efficiency



Data Acquisition for Determining Efficiency



SEPT 2011

Recharge and Recovery Cycles

Summary of Redevelopment

- Operator friendly
- Efficient cleaning method (in-situ equipment)
- Removal of “big” air and fine grained particulates
- Verify recharge/recovery ratio
- Maximize recharge efficiency through backwash program

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- Minimize clogging within the well
  - Particulates
  - Air entrainment
  - Biofouling
- Identify ratio of recharge/recovery that is acceptable
  - Well redevelopment
  - Data acquisition
- Multi-level institutional involvement
  - Operators
  - Engineers
  - Management

Q&A and Discussion

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