Climate Change Impacts on Municipal Water Management in El Paso, Texas

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El Paso Water Utilities

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Climate Change and Water Management

- El Paso's water infrastructure and water management approaches have been designed with climate variability in mind

Past EPWU/PSB Investments

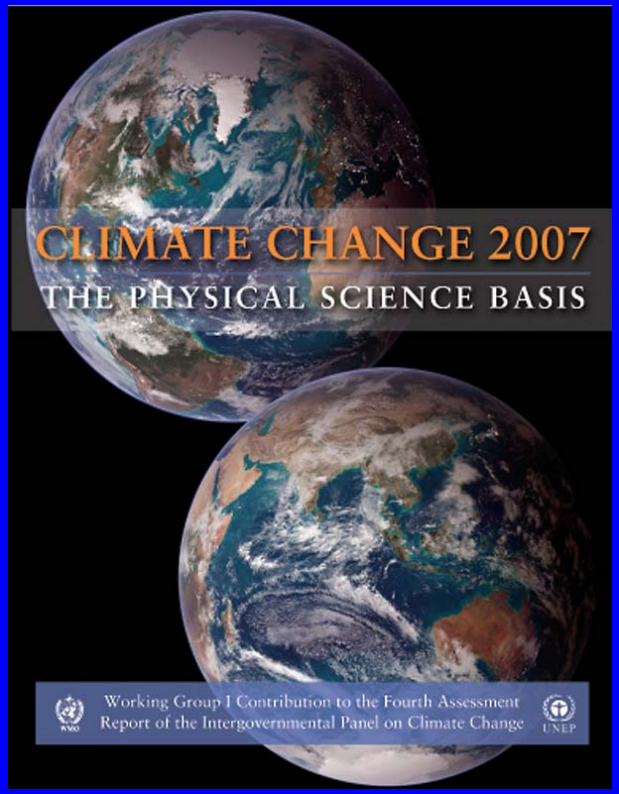
- Conjunctive Use
  - Surface Water Diversion (1940s, 1990s, 2000s and beyond)
  - Groundwater Management (Desalination Projects)
- Reclaimed Water Use
  - Direct (including tertiary treatment)
  - Indirect
- Water Conservation Investments

Objective

- Evaluate vulnerability of EPWU's water infrastructure to natural variation and predicted (IPCC) climate change:
  - Wetter/Drier
  - Hotter/Cooler
  - More Variable/Less Variable

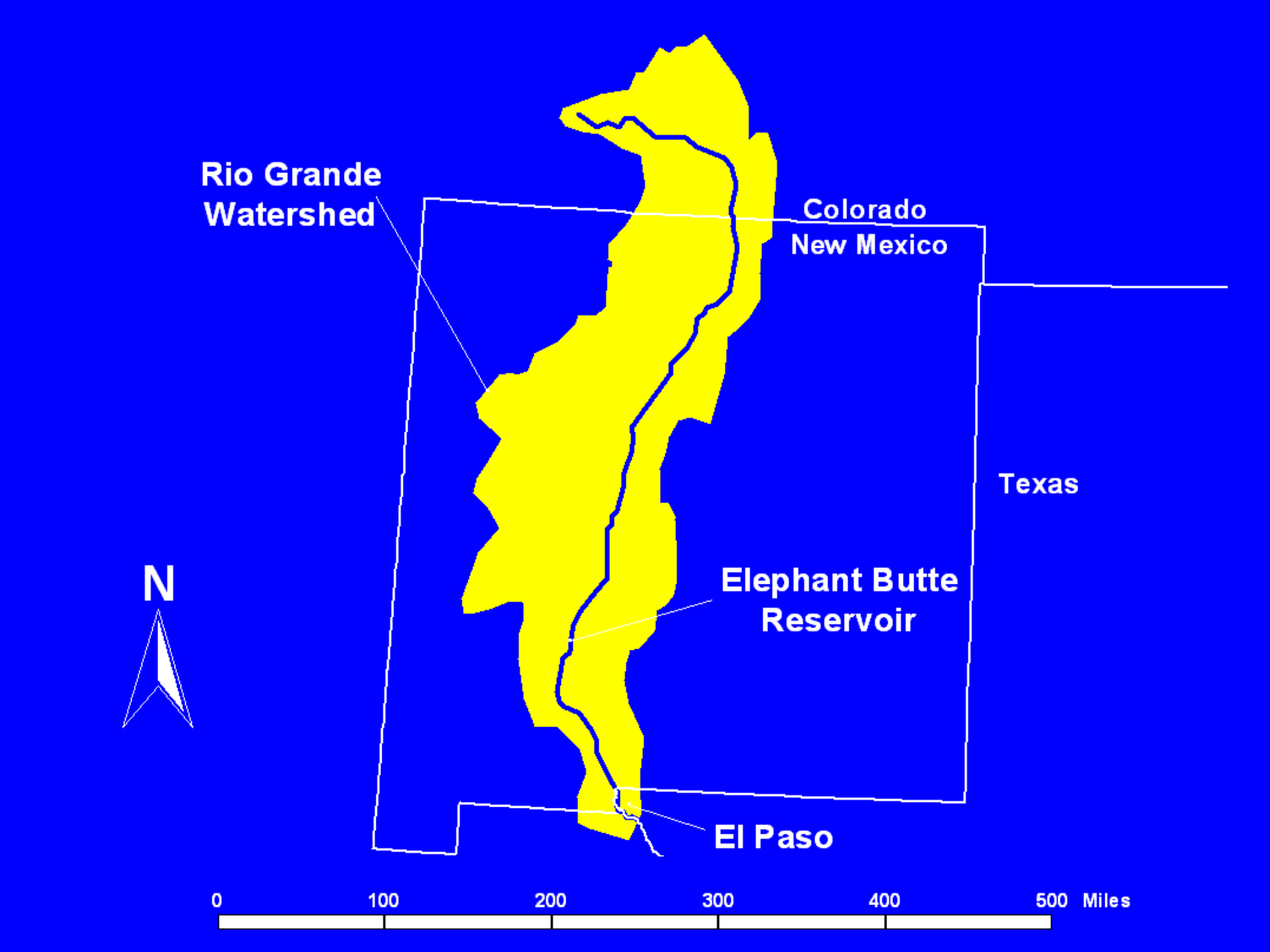
IPCC (2007) Report

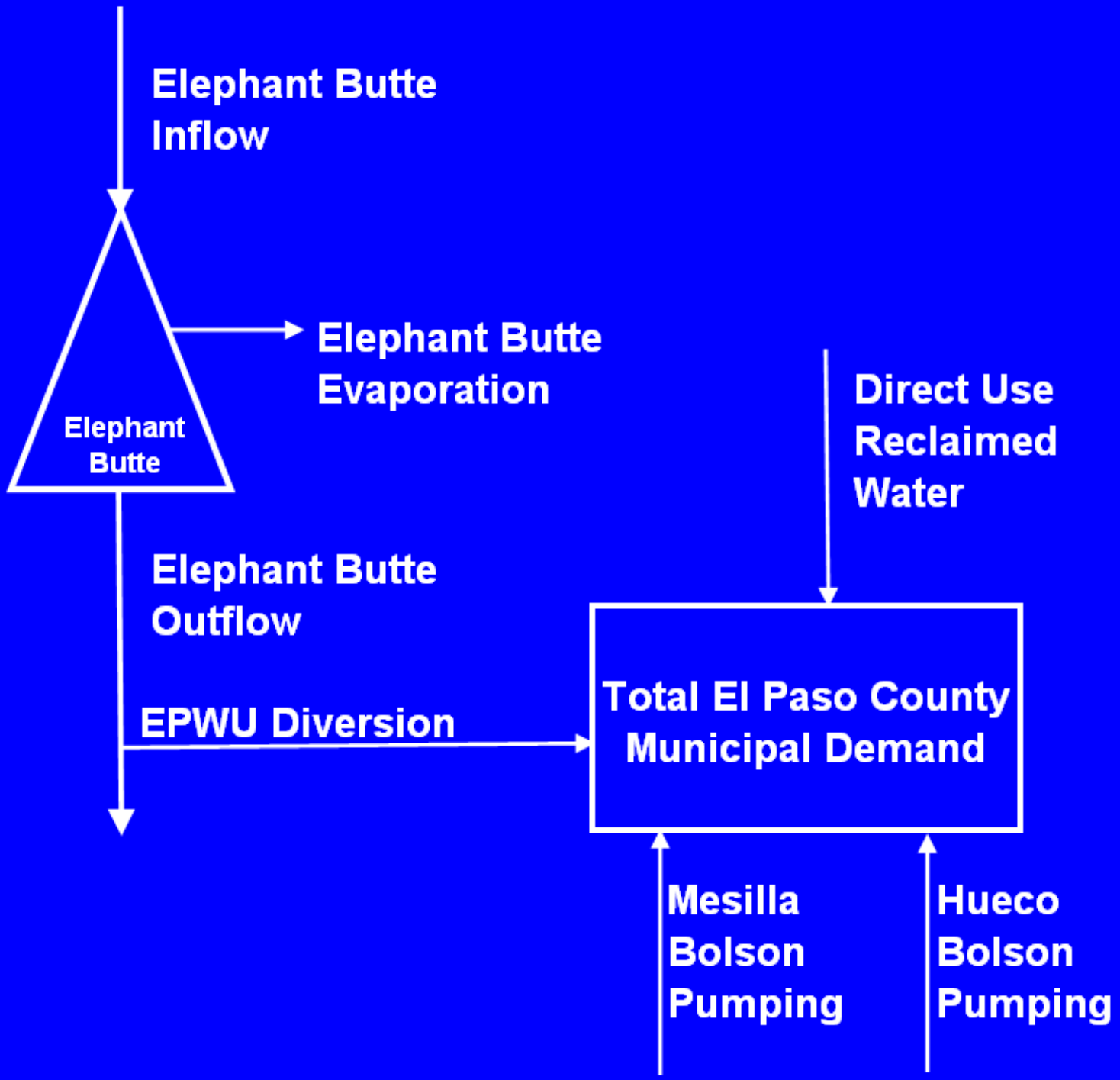
- 21 Global Circulation Models
  - Temperature
  - Precipitation
- Cited literature
- Website to access data used in report

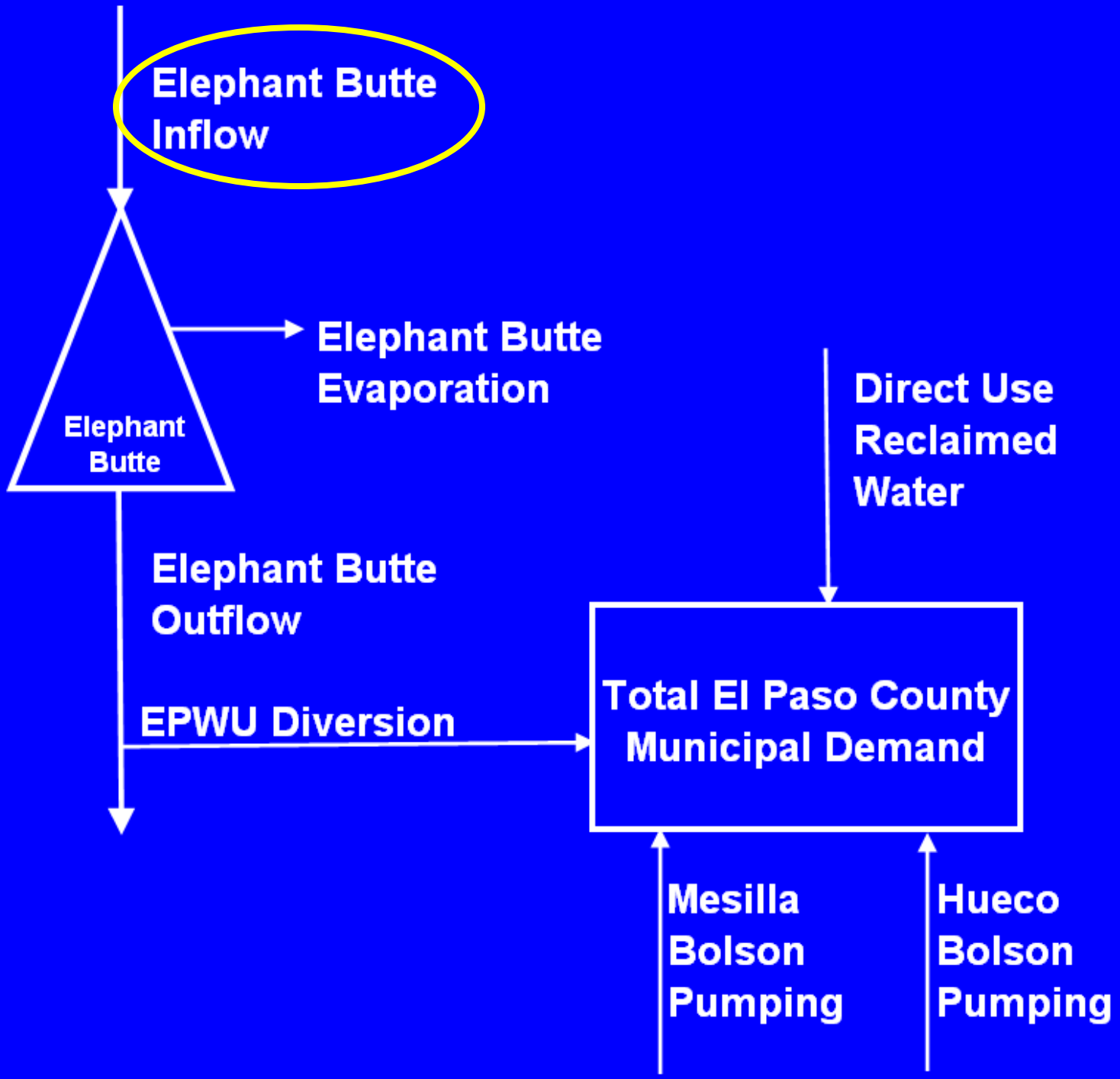


El Paso Total Water Management

- Demand Management
  - Conservation Programs
  - Reclaimed Water Use
- Conjunctive Use
  - Surface Water (Rio Grande)
  - Ground Water


Rio Grande
Watershed
Colorado
New Mexico
Texas
N
Elephant Butte
Reservoir
El Paso
0
100
200
300
400
500 Miles


Elephant Butte Inflow
Elephant Butte Evaporation
Elephant Butte
Direct Use Reclaimed Water
Elephant Butte Outflow
EPWU Diversion
Total El Paso County Municipal Demand
Mesilla Bolson Pumping
Hueco Bolson Pumping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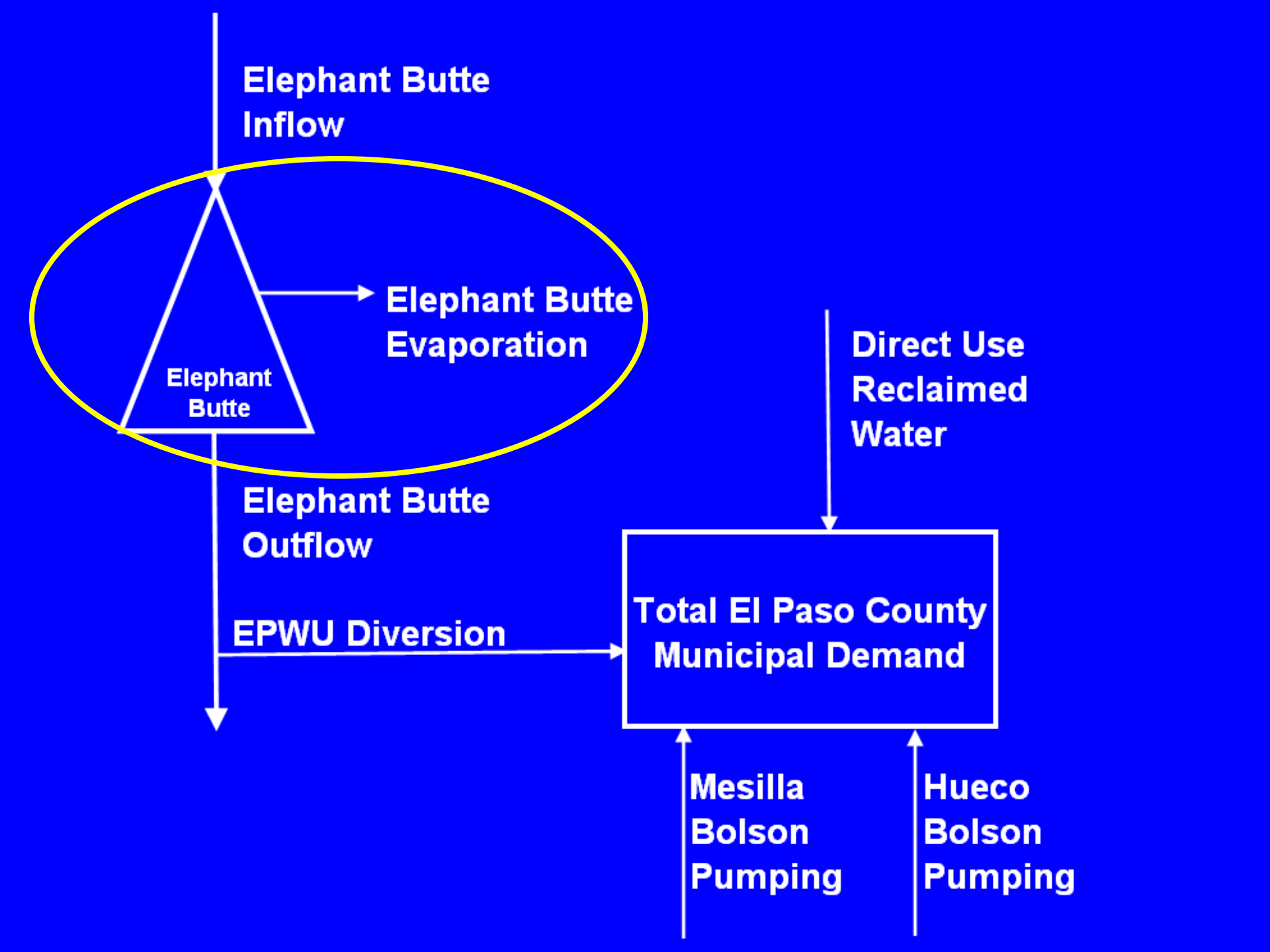
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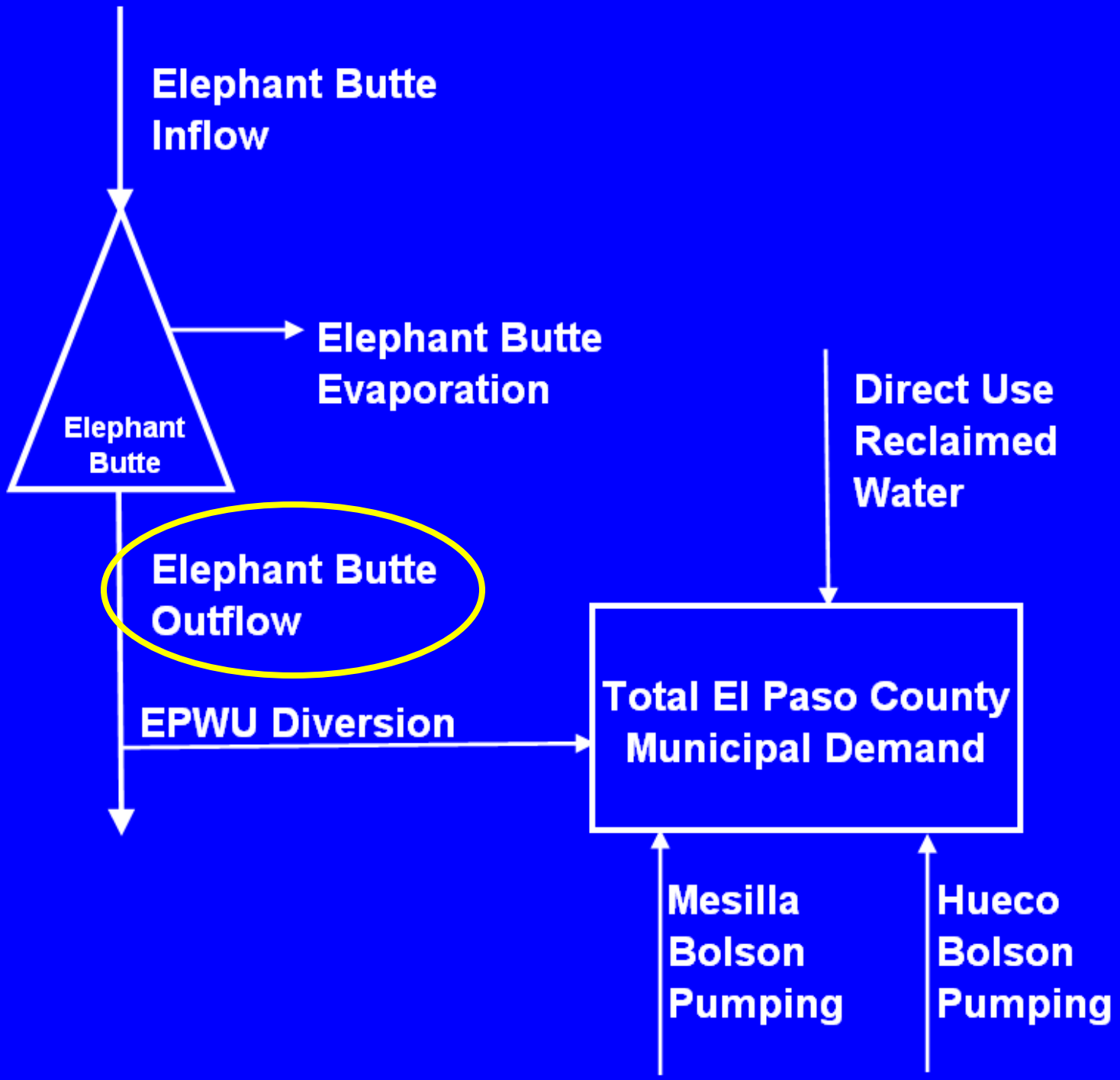
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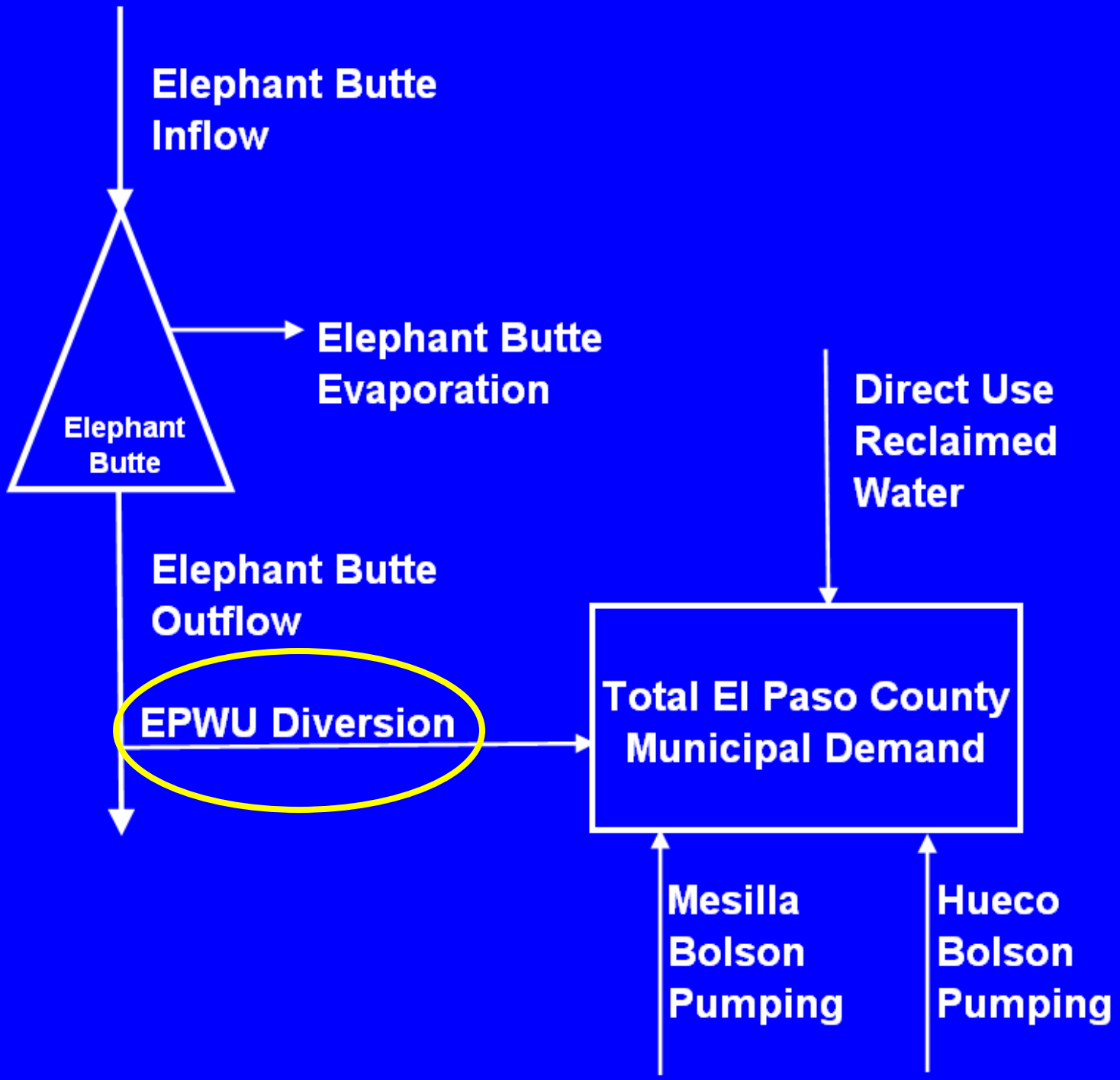
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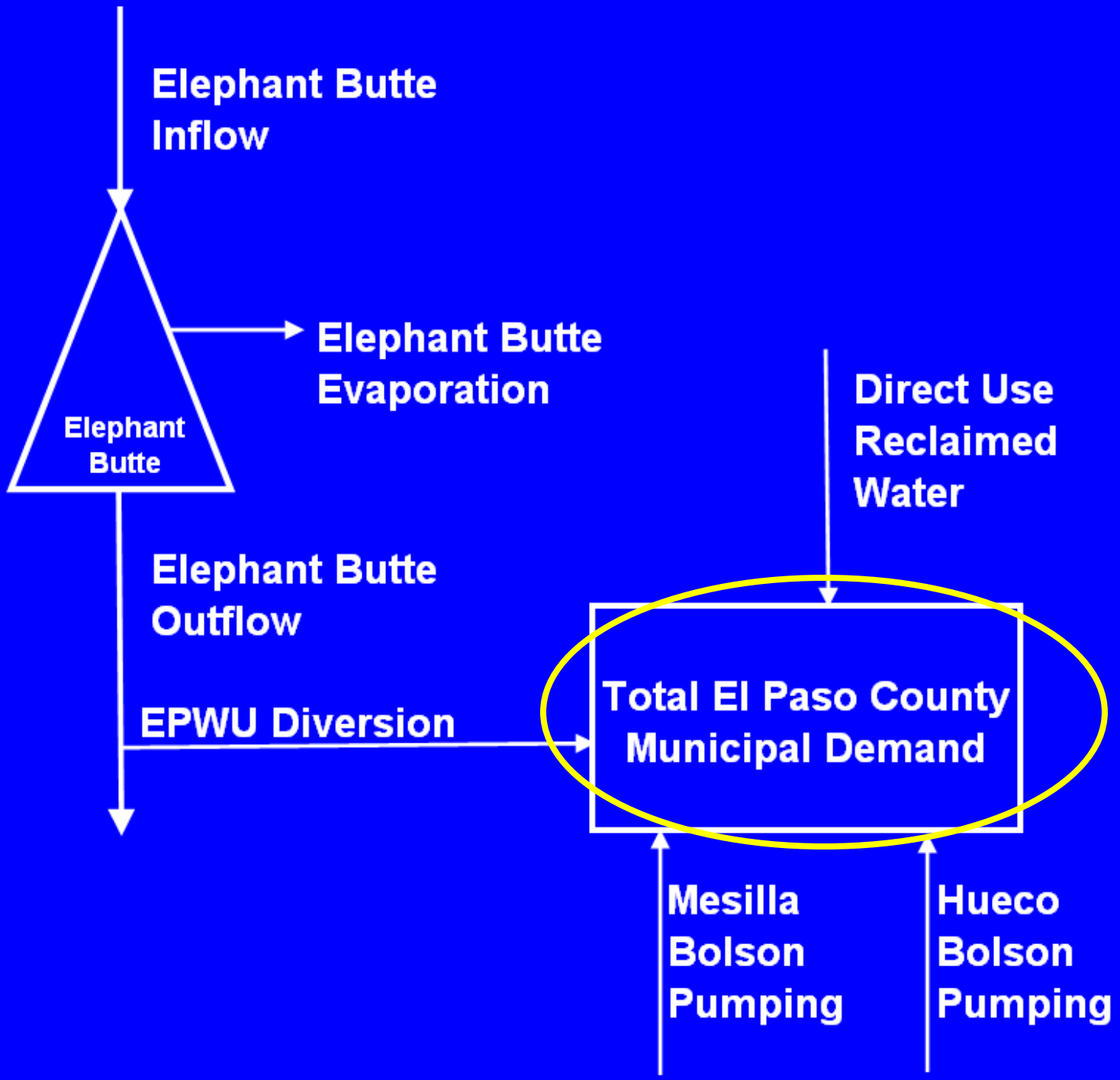
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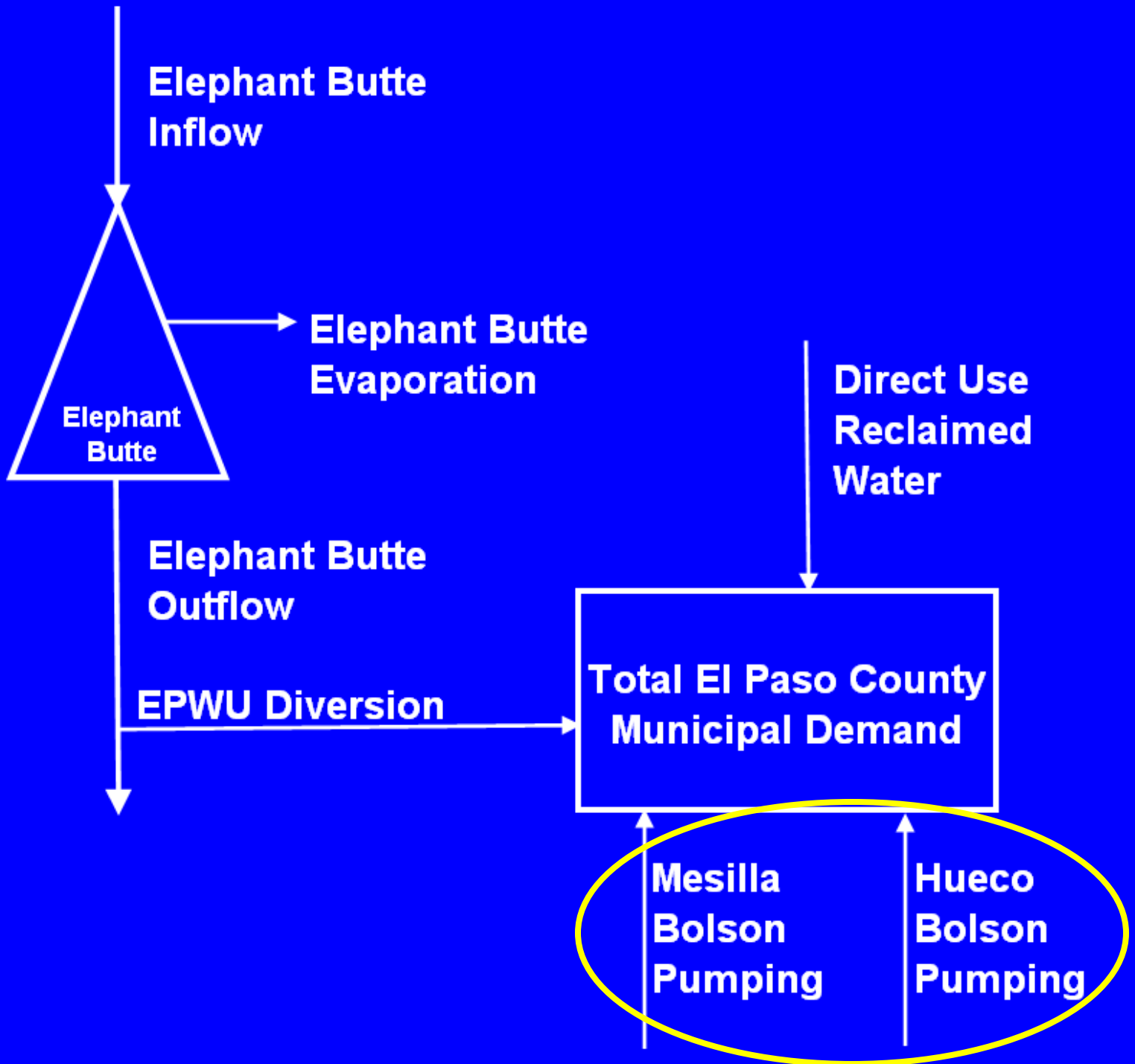
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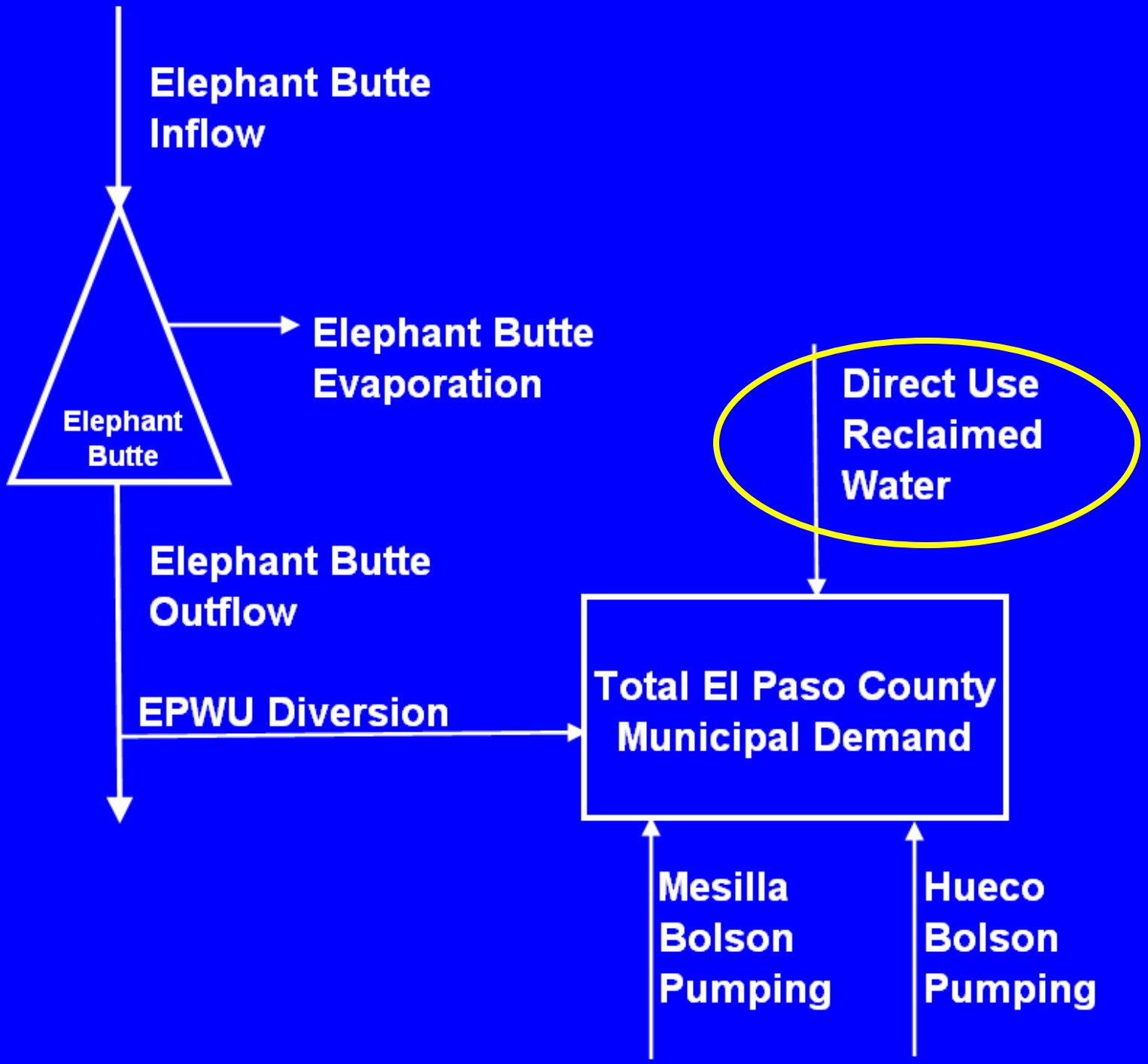
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Elephant Butte Evaporation
Elephant Butte
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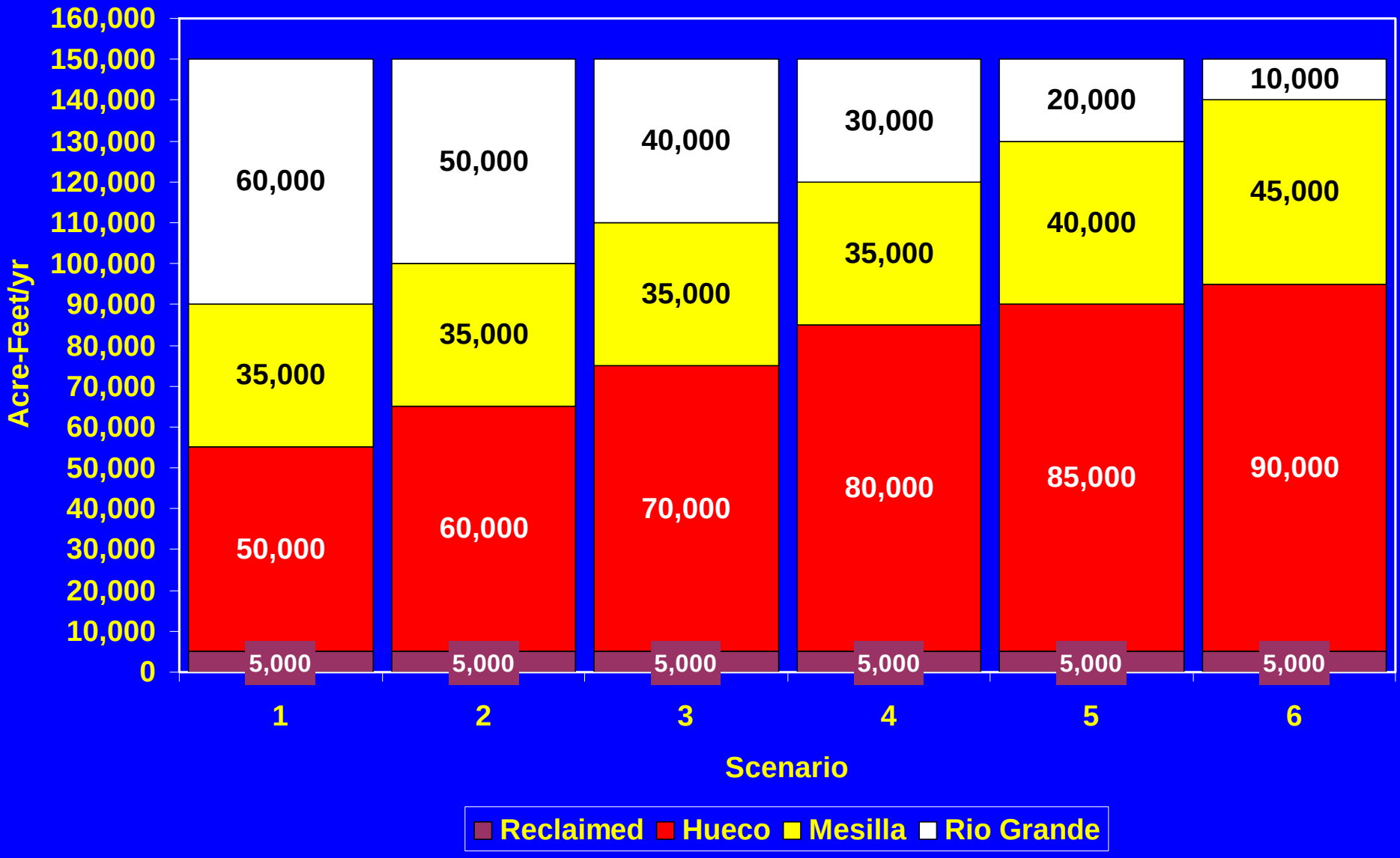
El Paso County Supply



Qualitative Assessment

- Increased Temperatures
  - Increase in EB Evaporation
  - Decrease in EB Storage
  - Decrease in EB Outflow
  - Decrease in EPWU Diversion
  - Increase in EPWU Pumping
  - Decrease in Groundwater Levels

Qualitative Assessment

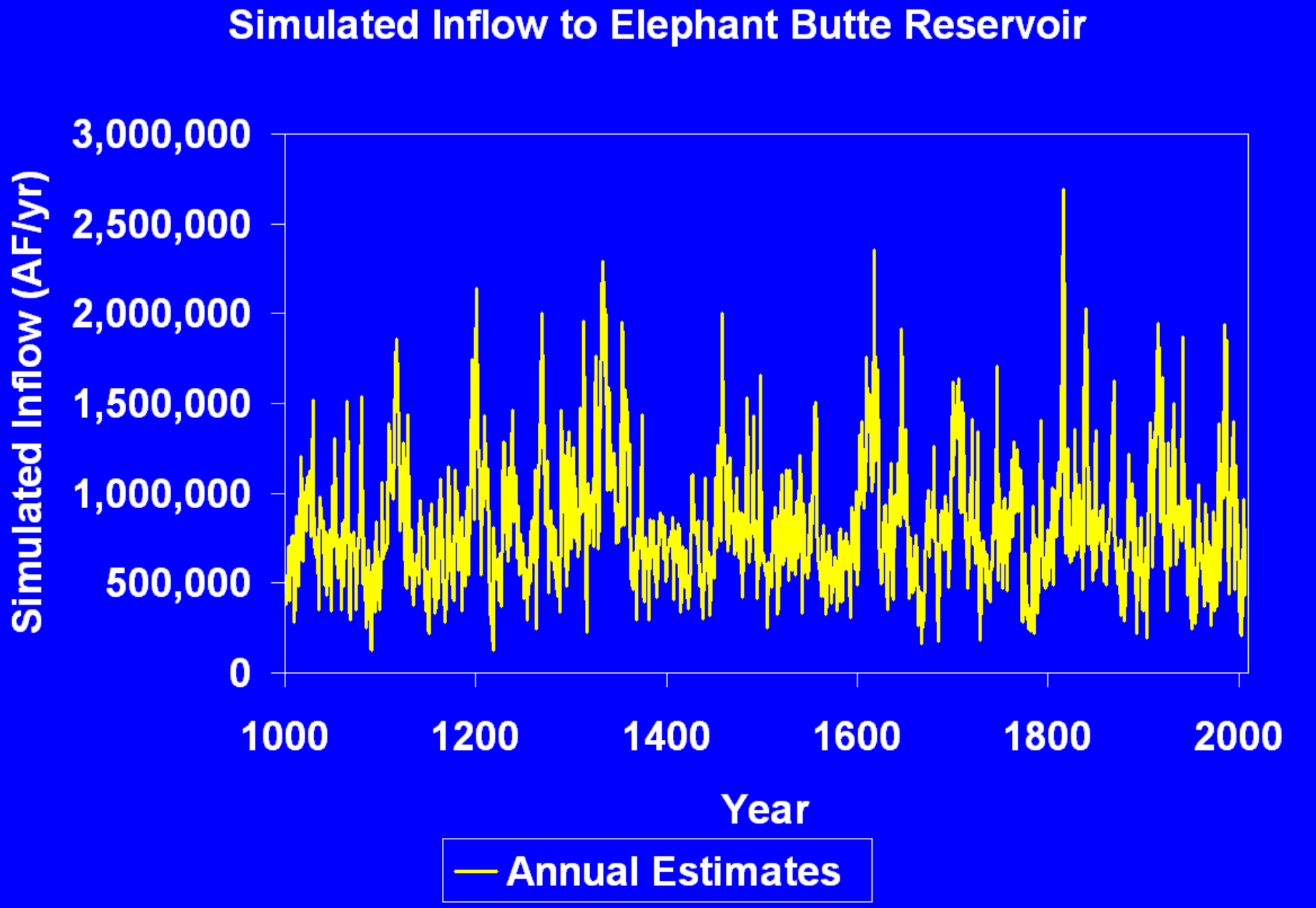
- Decreased Precipitation in Upper Reaches of RG Watershed
  - Decrease in EB Inflow
  - Decrease in EB Outflow
  - Decrease in EPWU Diversion
  - Increase in EPWU Pumping
  - Decrease in Groundwater Levels

Quantitative Assessment

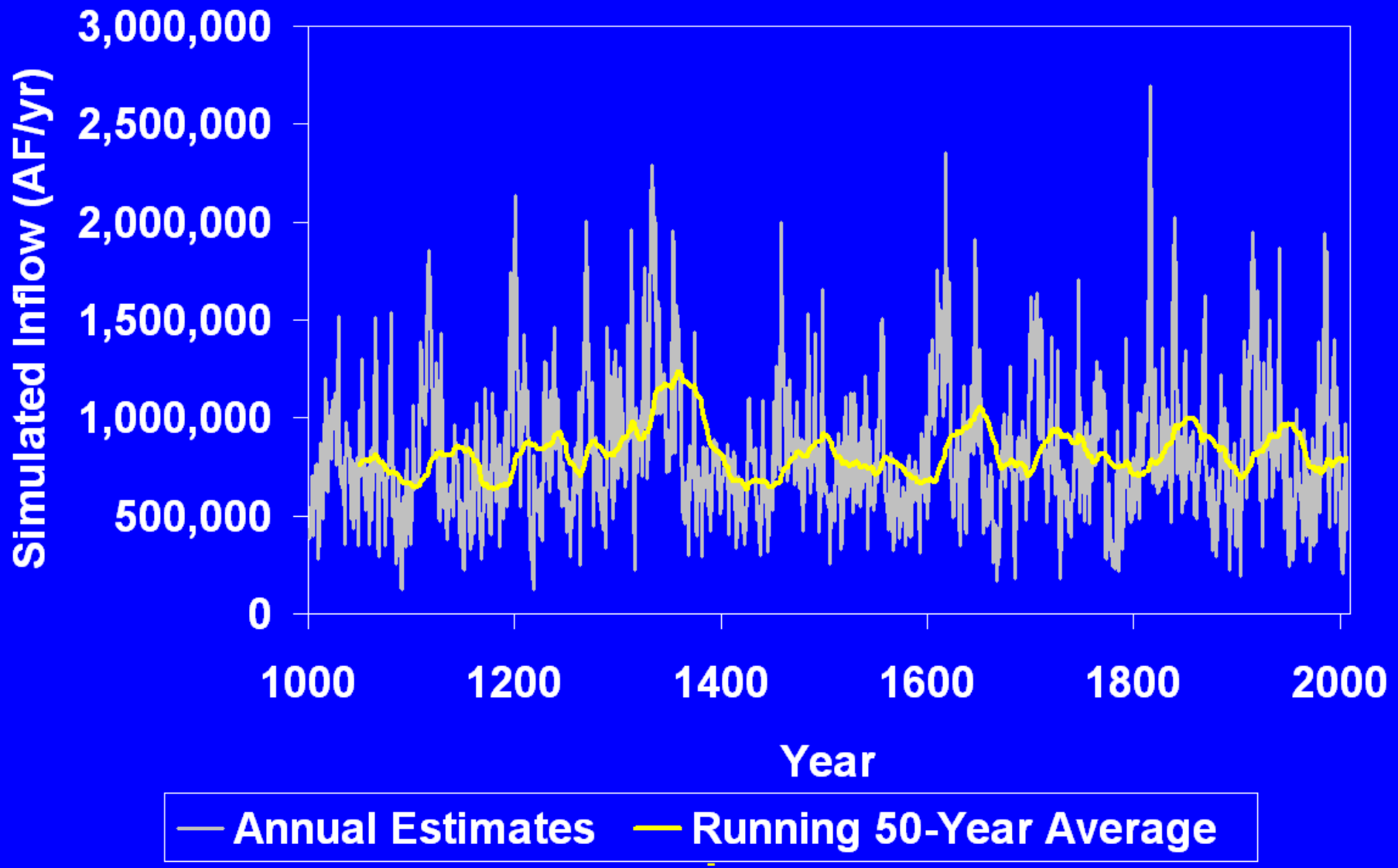
- Use IPCC report and associated data
- Evaluate natural variation and impacts of IPCC predictions on
  - EB Inflow
  - EB Evaporation
  - EB Outflow
  - EPWU Diversions
  - EPWU Pumping
  - Groundwater Levels

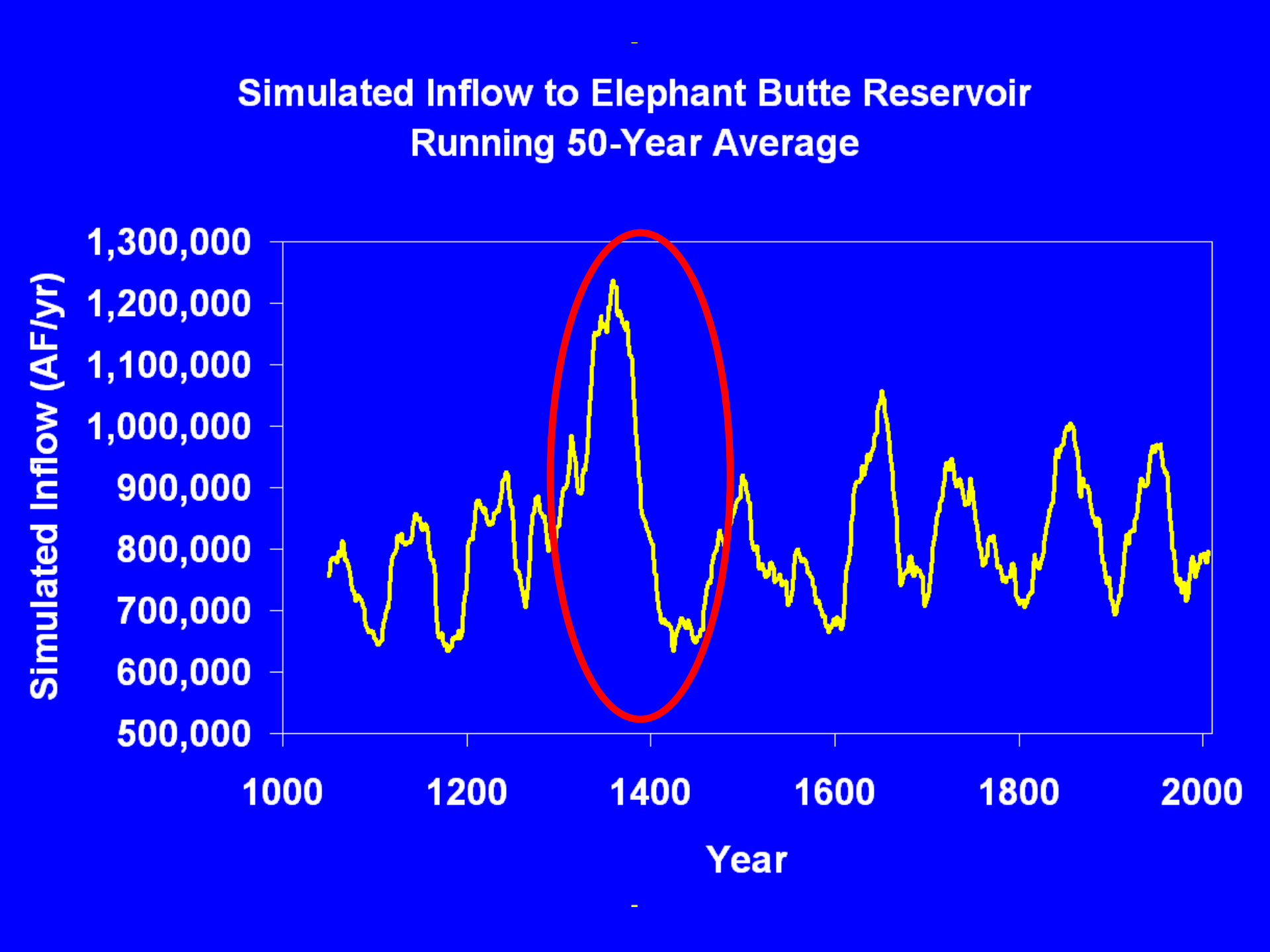
Ni and others (2002)

- Estimated cool-season precipitation from tree rings in NM and AZ
- 1000 to 1988
- Used to reconstruct EB inflow

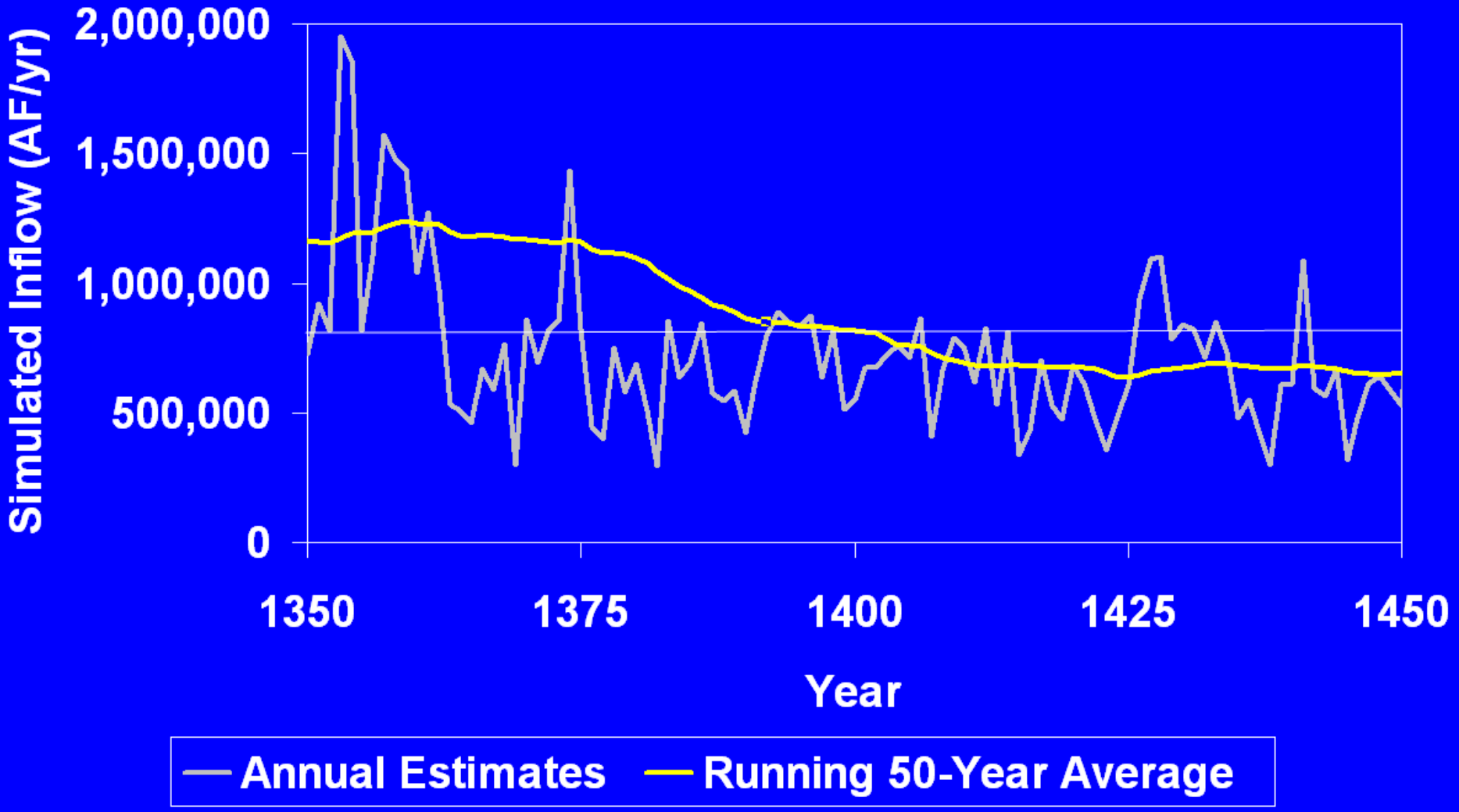

Simulated Inflow to Elephant Butte Reservoir
Simulated Inflow (AF/yr)
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1000
1200
1400
1600
1800
2000
Year
Annual Estimates

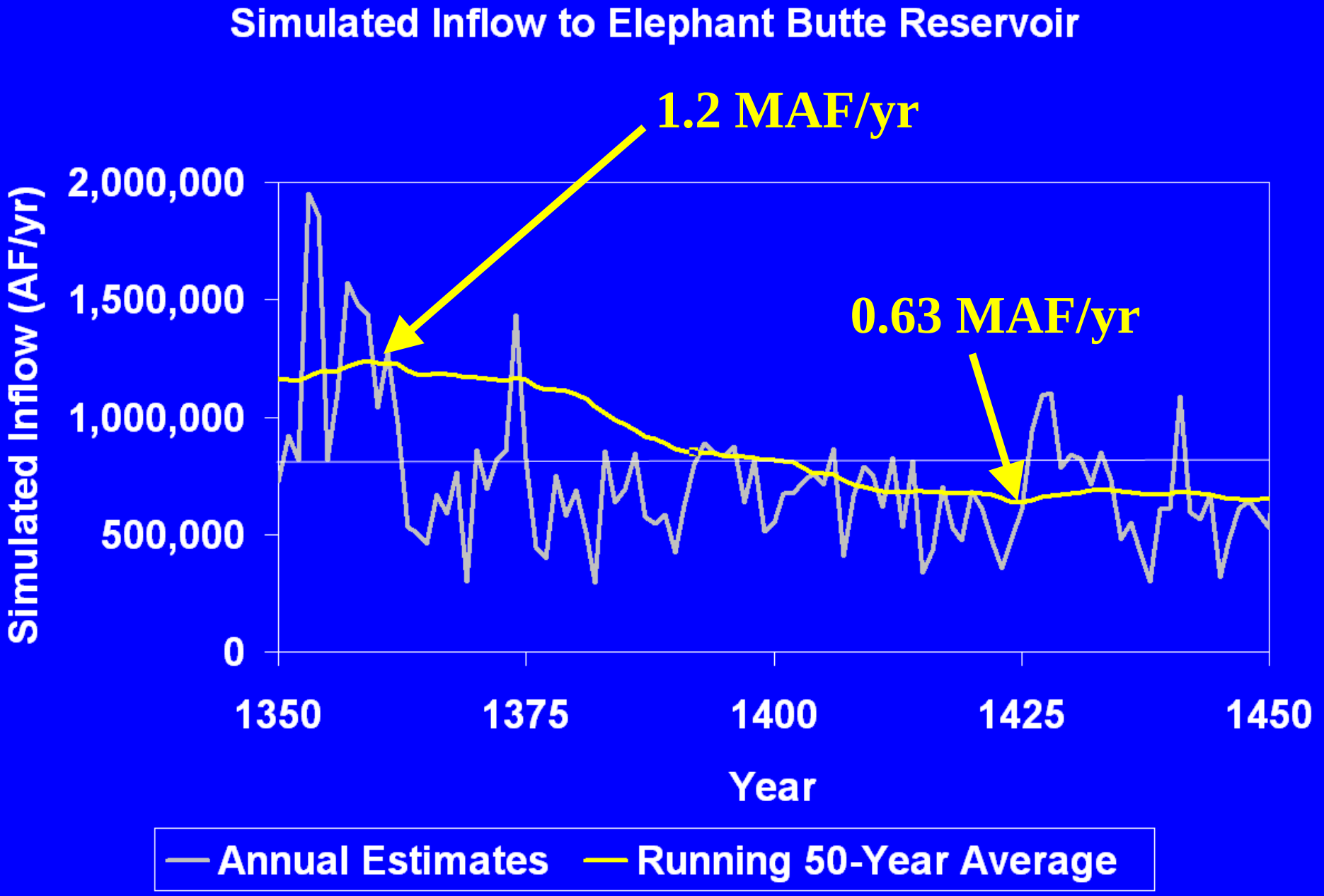
Simulated Inflow to Elephant Butte Reservoir




Simulated Inflow to Elephant Butte Reservoir
Running 50-Year Average
Simulated Inflow (AF/yr)
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
1000
1200
1400
1600
1800
2000
Year

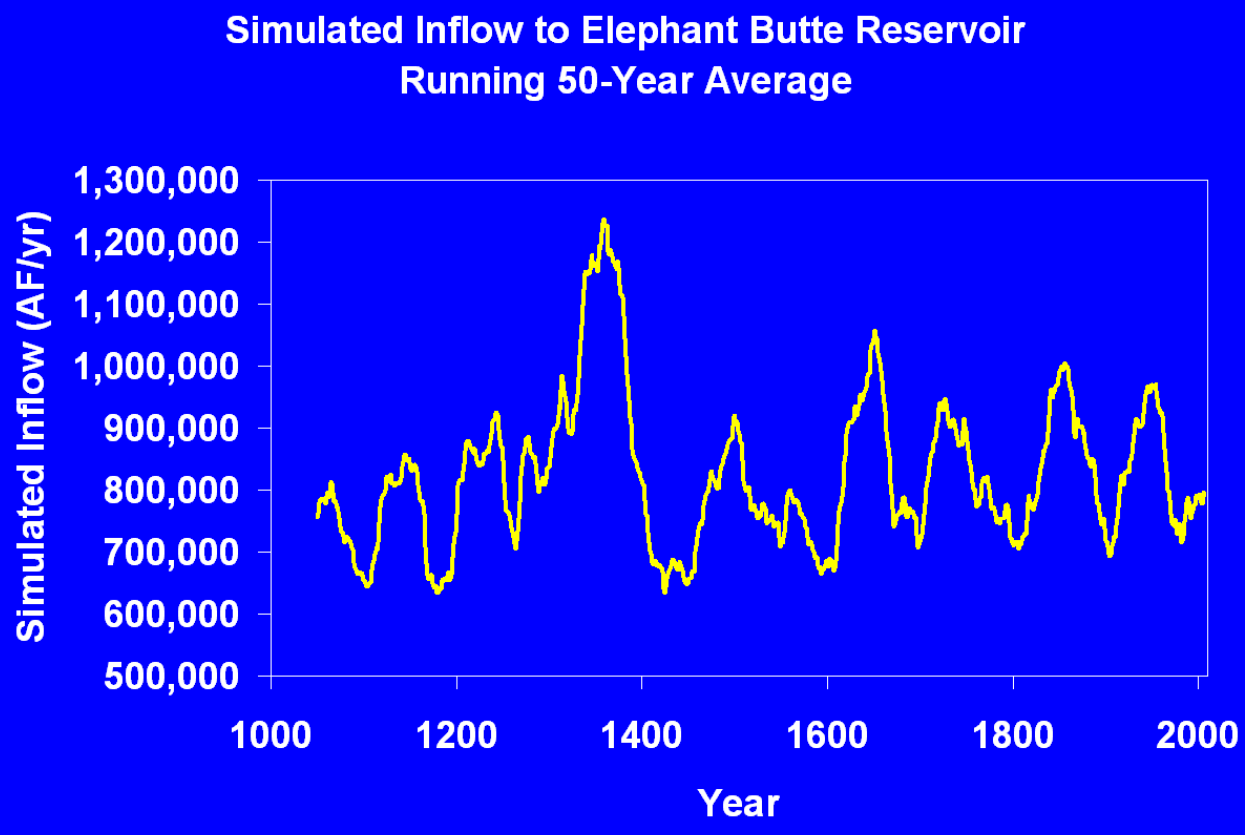
Simulated Inflow to Elephant Butte Reservoir

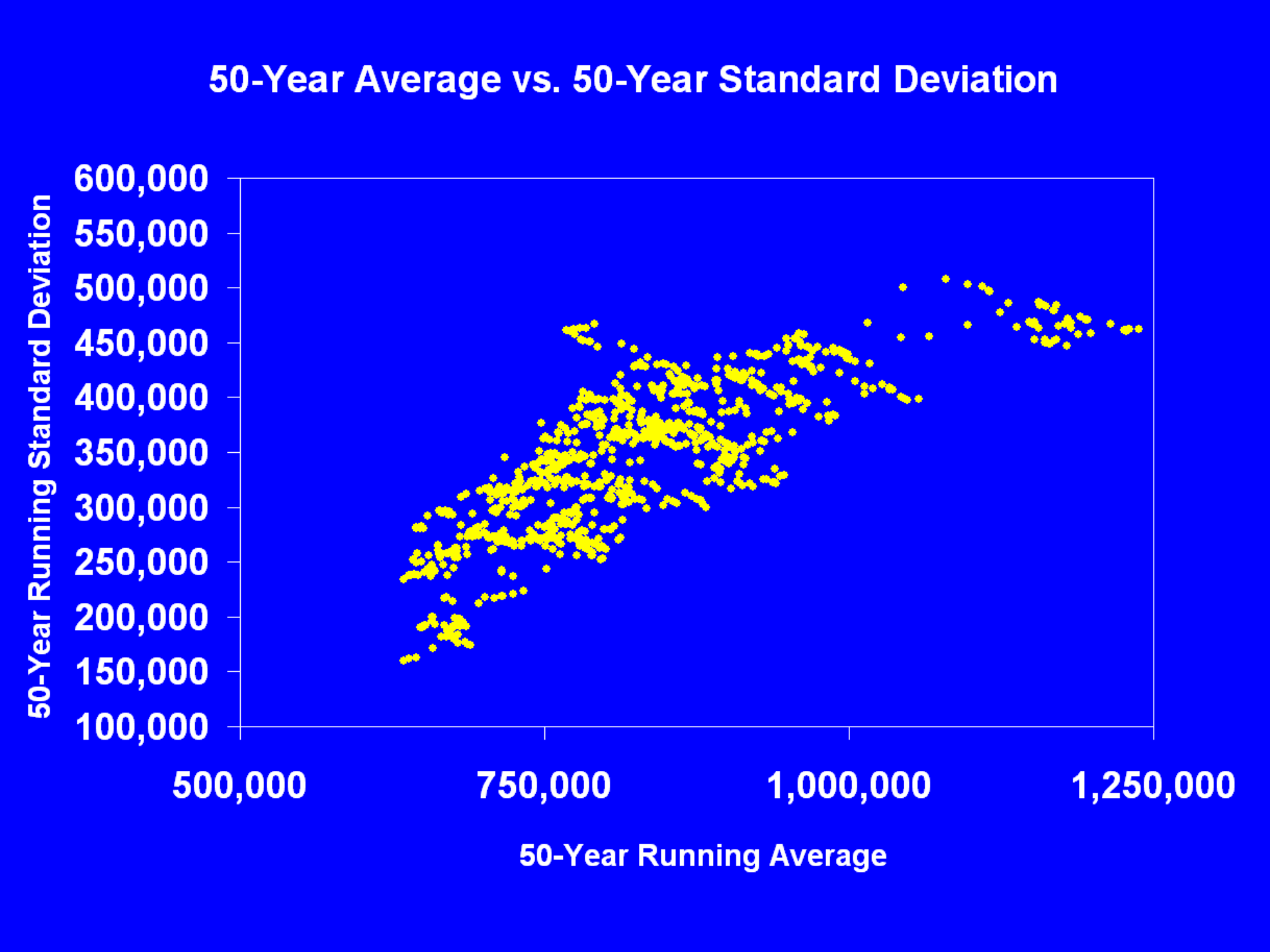


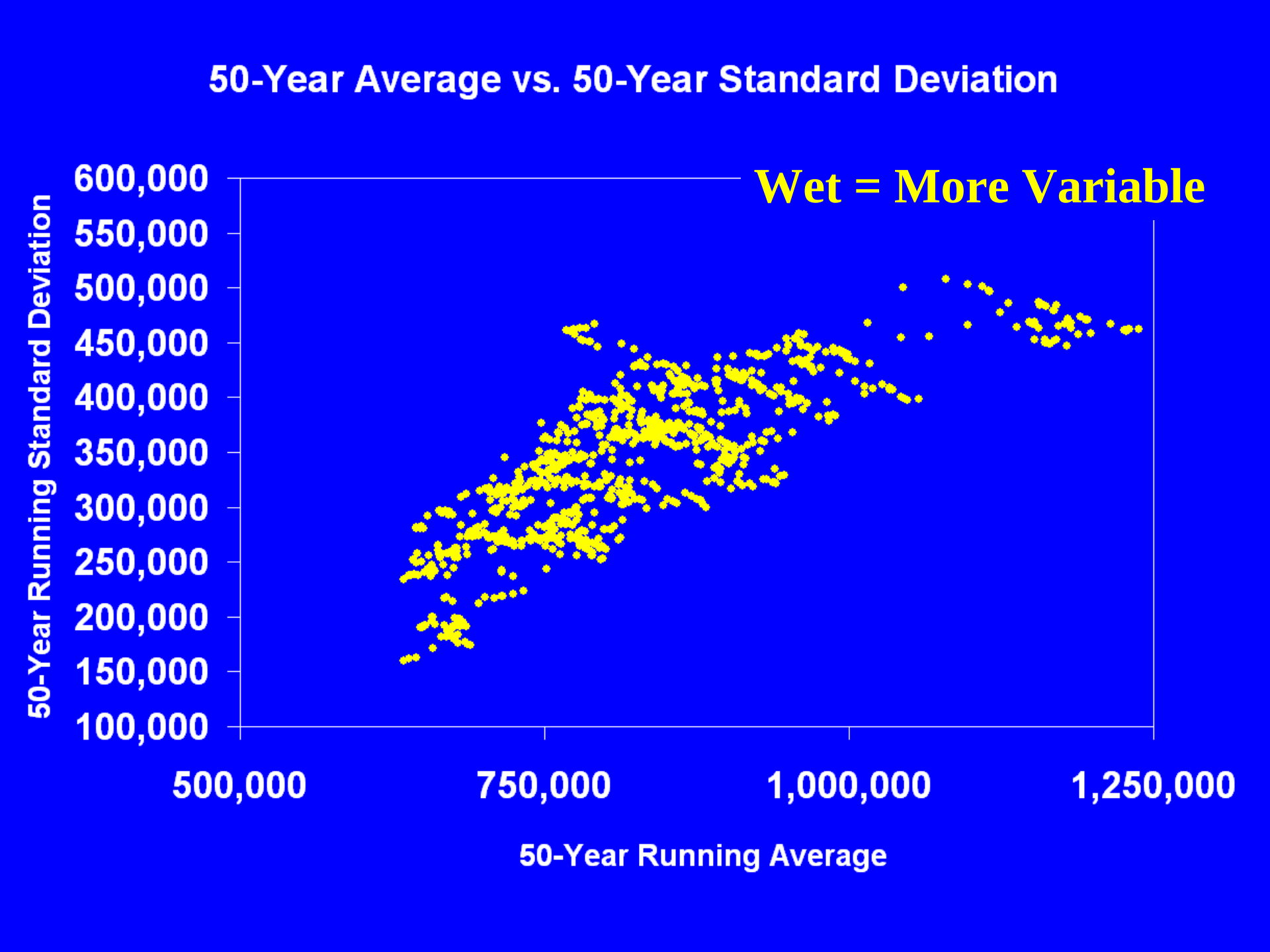

Simulated Inflow to Elephant Butte Reservoir
1.2 MAF/yr
0.63 MAF/yr
Simulated Inflow (AF/yr)
2,000,000
1,500,000
1,000,000
500,000
0
1350
1375
1400
1425
1450
Year
Annual Estimates
Running 50-Year Average

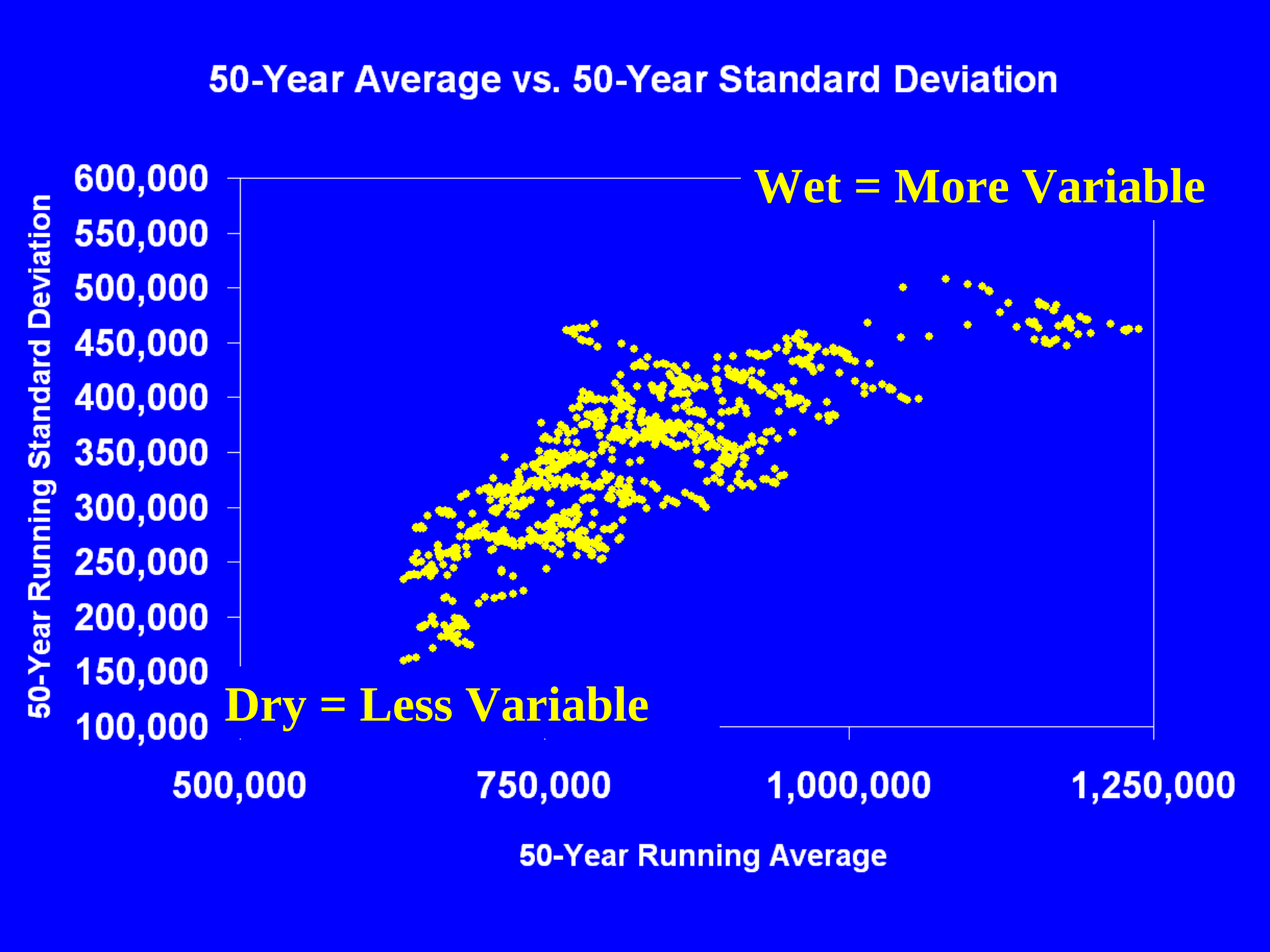
Simulated EB Inflow (1001-2007)

- 958 50-Year Periods
  - 1001 to 1050
  - 1002 to 1051
  - ⋮
  - 1957 to 2006
  - 1958 to 2007




50-Year Average vs. 50-Year Standard Deviation
50-Year Running Standard Deviation
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
500,000
750,000
1,000,000
1,250,000
50-Year Running Average

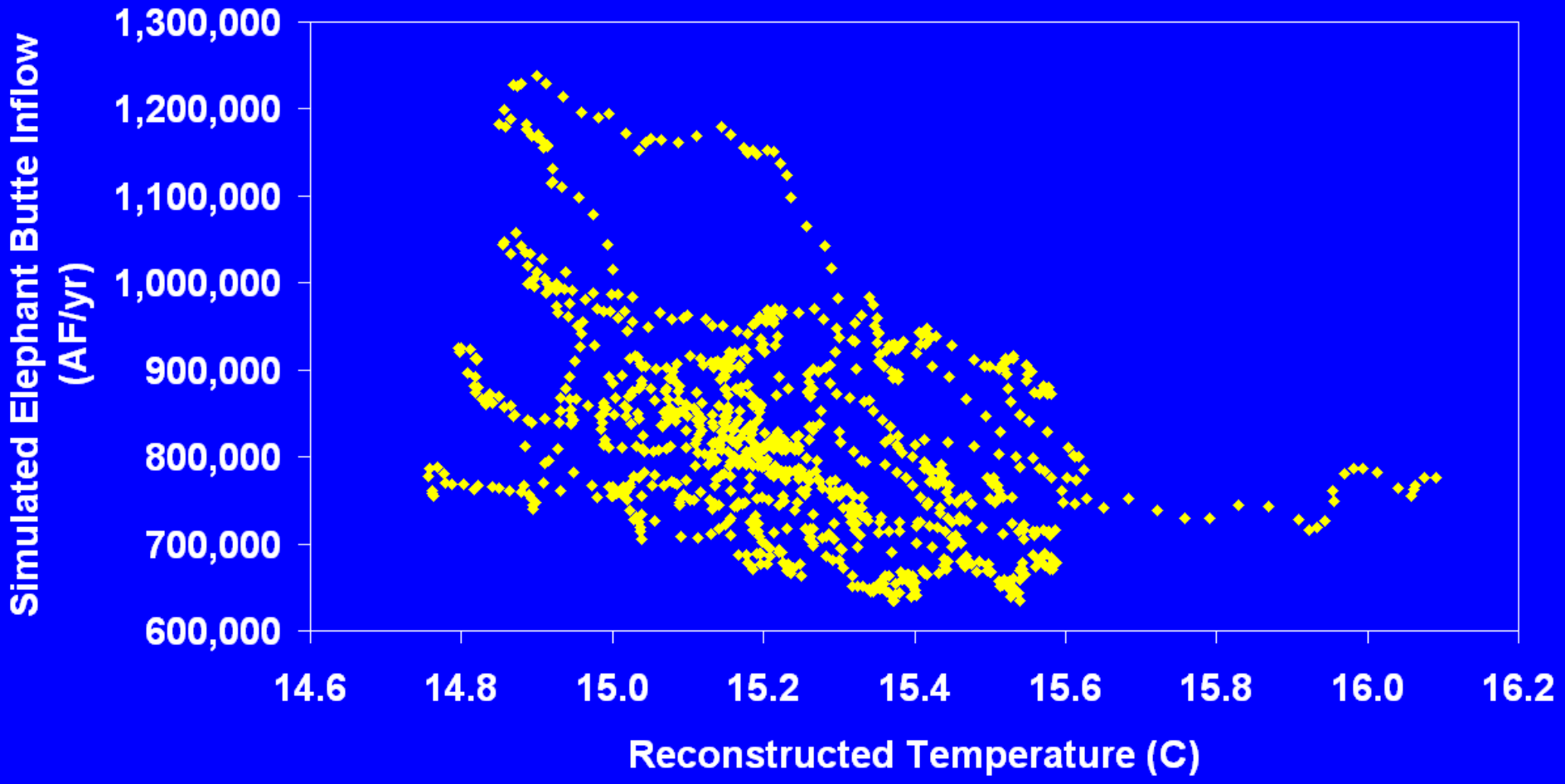

50-Year Average vs. 50-Year Standard Deviation
Wet = More Variable
50-Year Running Standard Deviation
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
500,000
750,000
1,000,000
1,250,000
50-Year Running Average


50-Year Average vs. 50-Year Standard Deviation
50-Year Running Standard Deviation
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
Wet = More Variable
Dry = Less Variable
500,000
750,000
1,000,000
1,250,000
50-Year Running Average

Temperature vs. EB Inflow

- Reconstructed temperature from Southern Colorado Plateau Area
  - 570 to 1987
  - Salzer and Kipfmuller (2005)
- Compare with Simulated Elephant Butte Inflow

Southern Colorado Plateau Temperature (Salzer and Kipfmuller, 2005) vs. Simulated Elephant Butte Inflows



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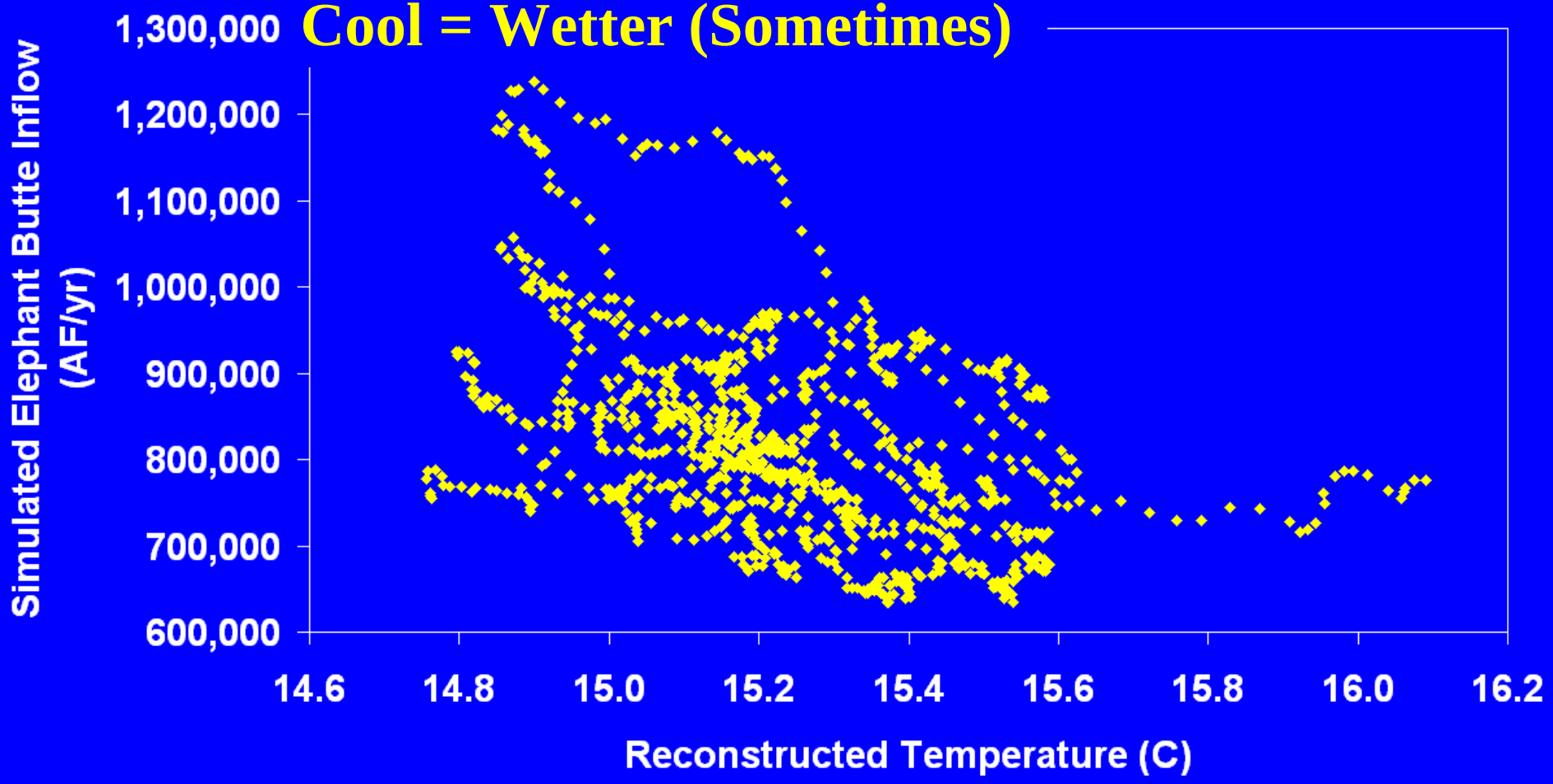
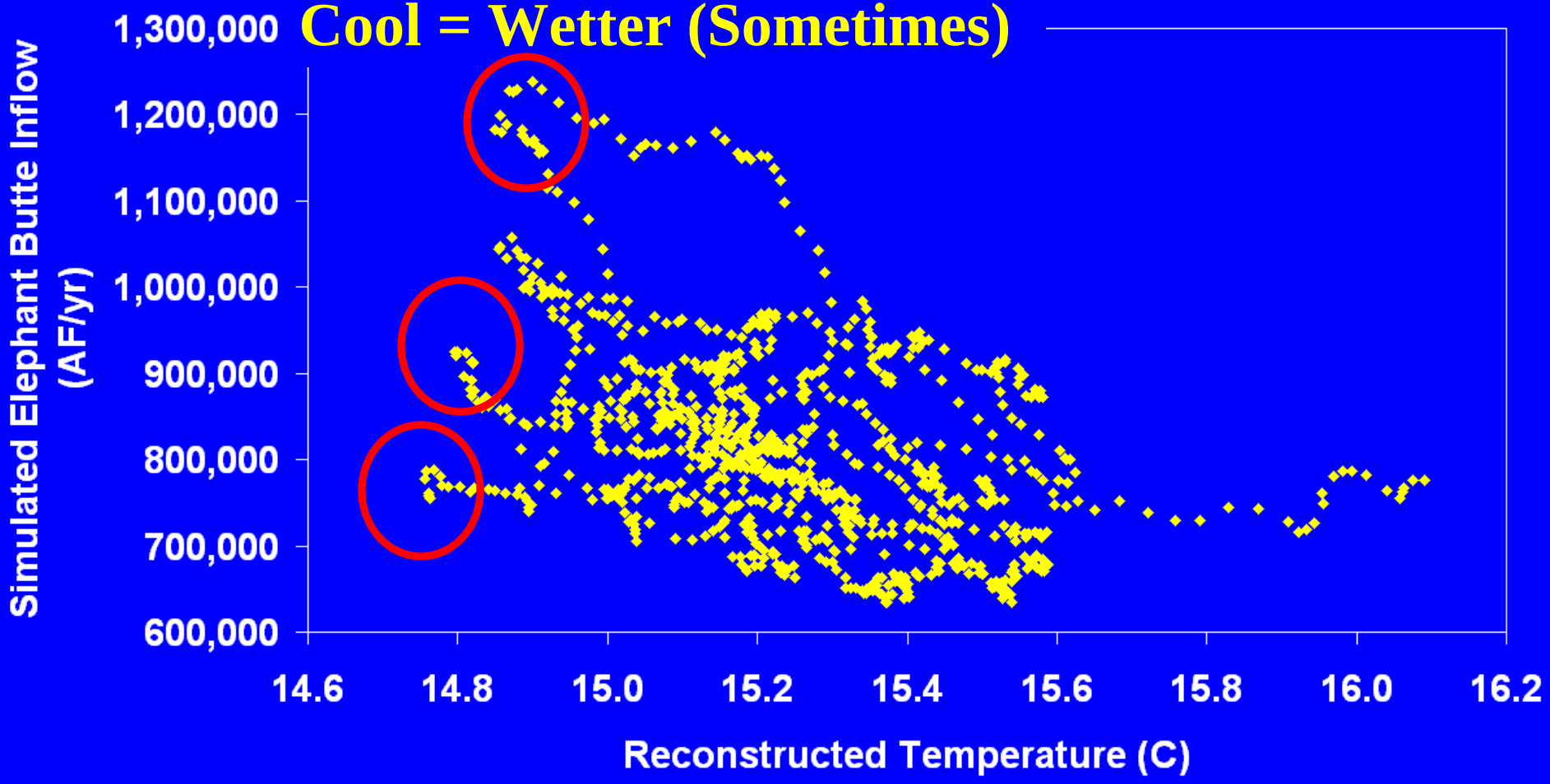


Southern Colorado Plateau Temperature (Salzer and Kipfmuller, 2005) vs. Simulated Elephant Butte Inflows



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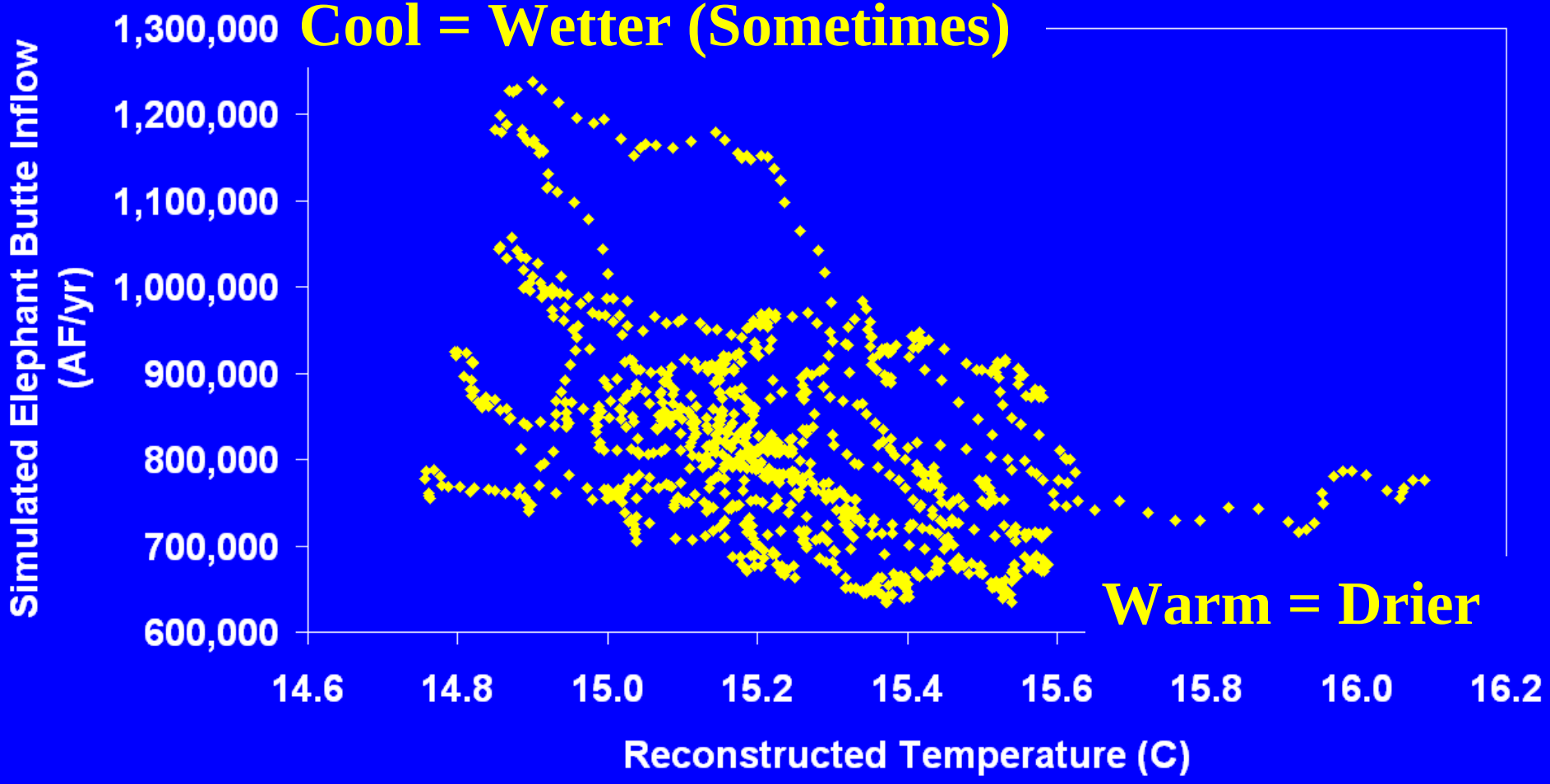
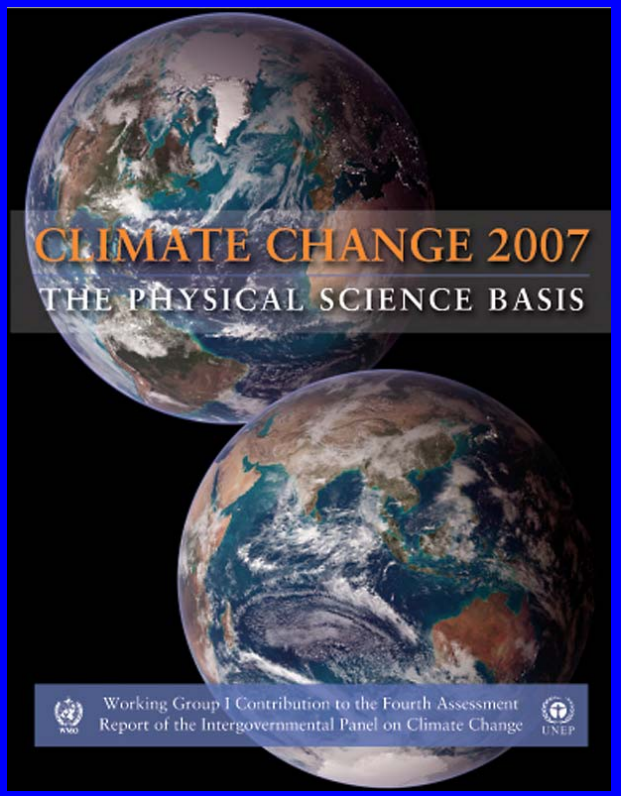
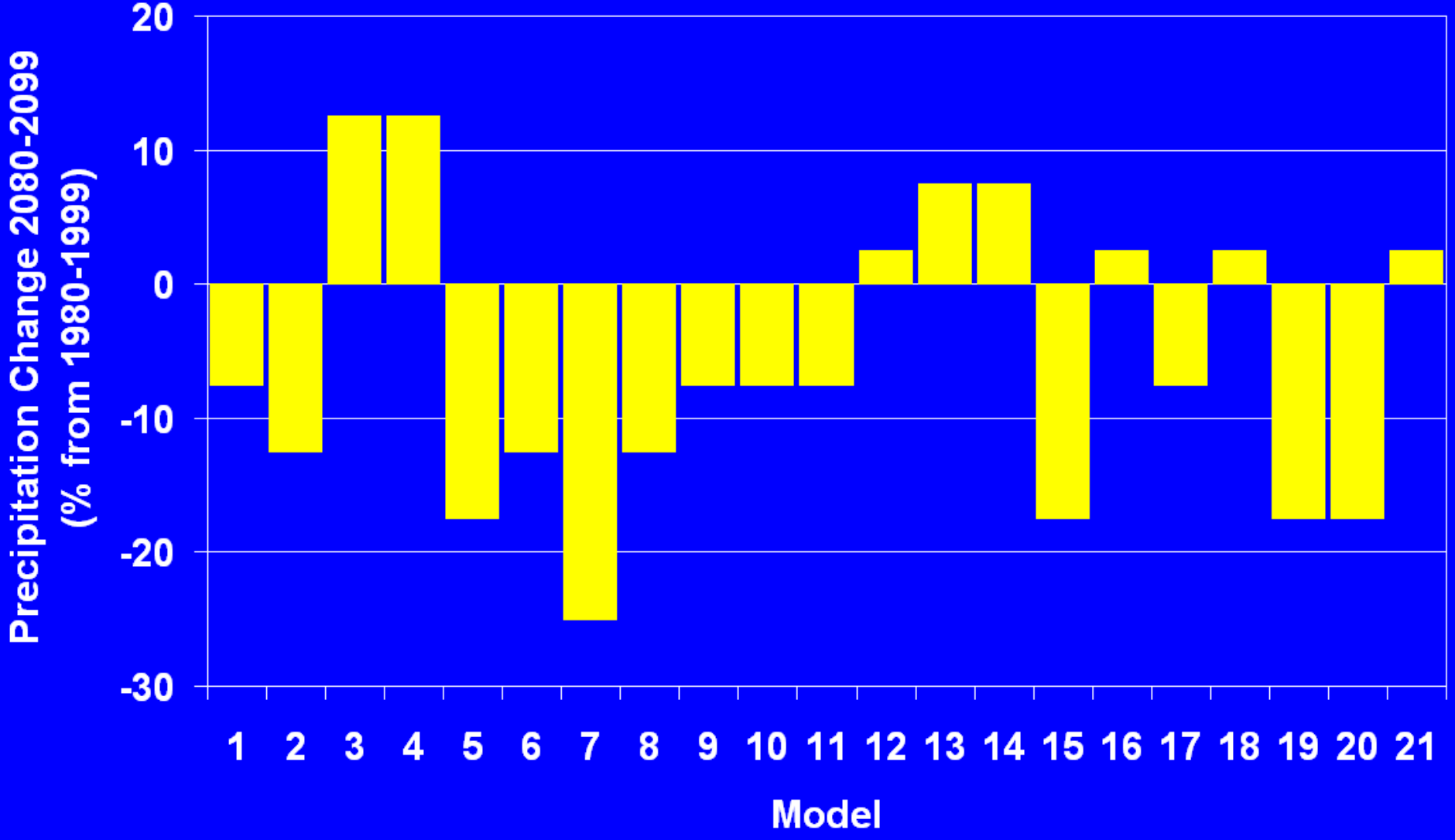


21 IPCC Global Circulation Models

- All 21 predict temperature increase (range = 1 to 5^{o}C)
- Precipitation predictions are mixed
  - GCM limitation associated with rugged topography of Rocky Mountain region



IPCC Predictions on Precipitation in Upper Rio Grande Area



10 Precipitation/Inflow Scenarios (1 to 7 based on IPCC report)

1. Base case (1001 to 2007)
2. 5% Decrease (Avg of all 21 IPCC models)
3. 10% Decrease (8 IPCC models)
4. 20% Decrease (4 IPCC models)
5. 25% Decrease (1 IPCC model)
6. 5% Increase (4 IPCC models)
7. 10% Increase (4 IPCC models)

10 Precipitation/Inflow Scenarios (8 to 10: Assess Increased Variation)

8. Wet+5%, Dry-5%
9. Wet+10%, Dry-10%
10. Wet+20%, Dry-20%

Temperature and Evaporation Elephant Butte Reservoir

- 3% increase in evaporation for every degree (C) in temperature

6 Evaporation Scenarios

- Group 1: Base Evaporation
- Group 2: Base Evap+3% (1^{o}C)
- Group 3: Base Evap+6% (2^{o}C)
- Group 4: Base Evap+9% (3^{o}C)
- Group 5: Base Evap+12% (4^{o}C)
- Group 6: Base Evap+15% (5^{o}C)

Scenario Development Summary

- 60 Scenarios
  - 10 EB Inflow
  - 6 EB Evaporation
- Each scenario: 958 50-year simulations
- Total of 57,480 50-year simulations

Application of 2006 Region E Plan

- EPWU diversion increase over 50-year period
  - 62,000 AF/yr in 2010
  - 82,000 AF/yr in 2060
- EPWU reclaimed use increase over 50-year period
  - 7,600 AF/yr in 2010
  - 23,000 AF/yr in 2060

Approach – Surface Water

- EB outflow based on EB inflow, storage, and evaporation
  - Simple reservoir operations model
  - "Full" Release = 790,000 AF/yr
- EPWU diversion based on EB outflow
  - Percentage of full release

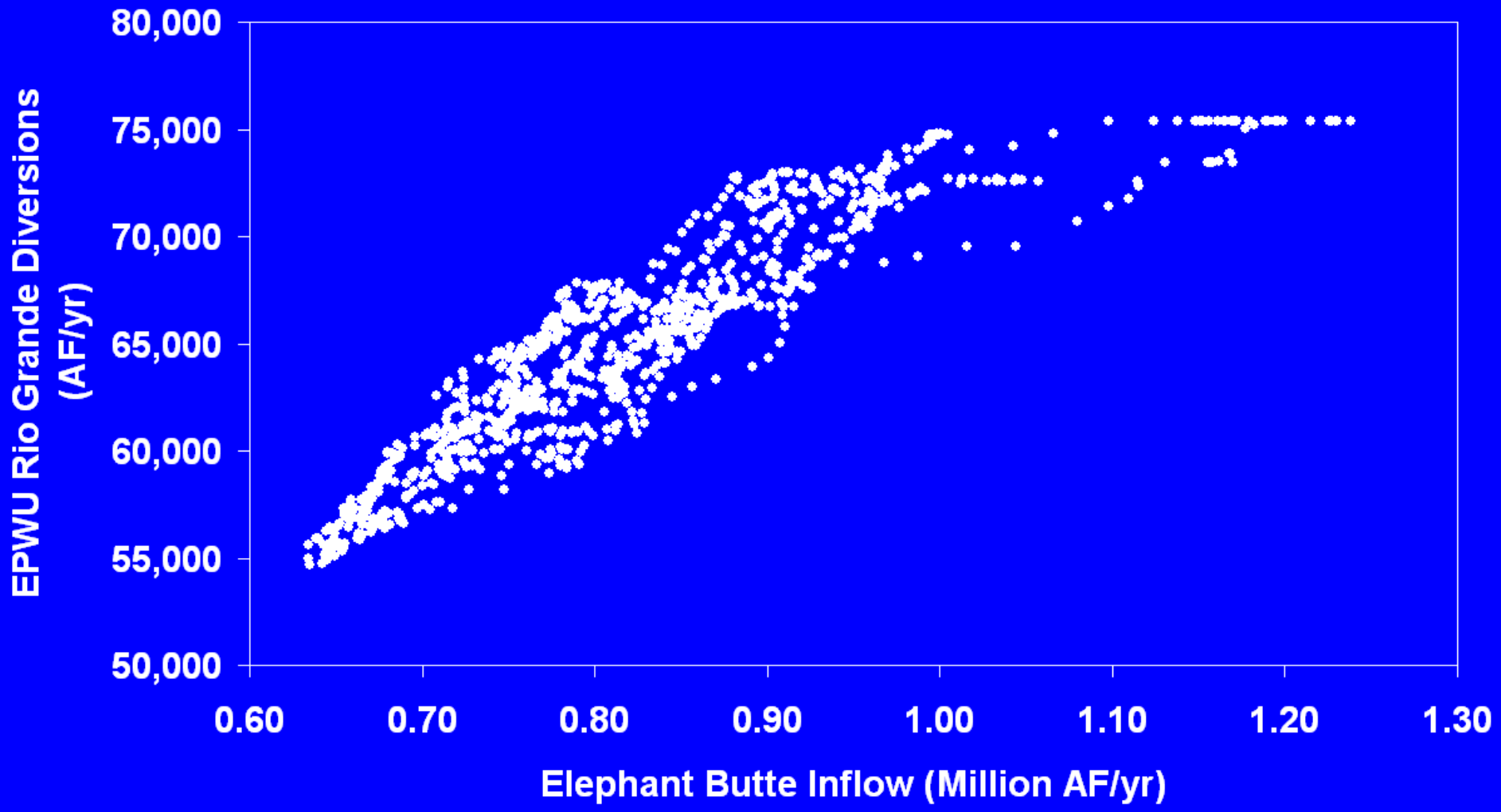
Approach - Groundwater

- EPWU pumping estimated from EPWU diversion
- USGS groundwater model of Hueco Bolson
  - Input: estimated groundwater pumping and Rio Grande flows
  - Groundwater storage affected mostly by surface water flow (recharge) and pumping

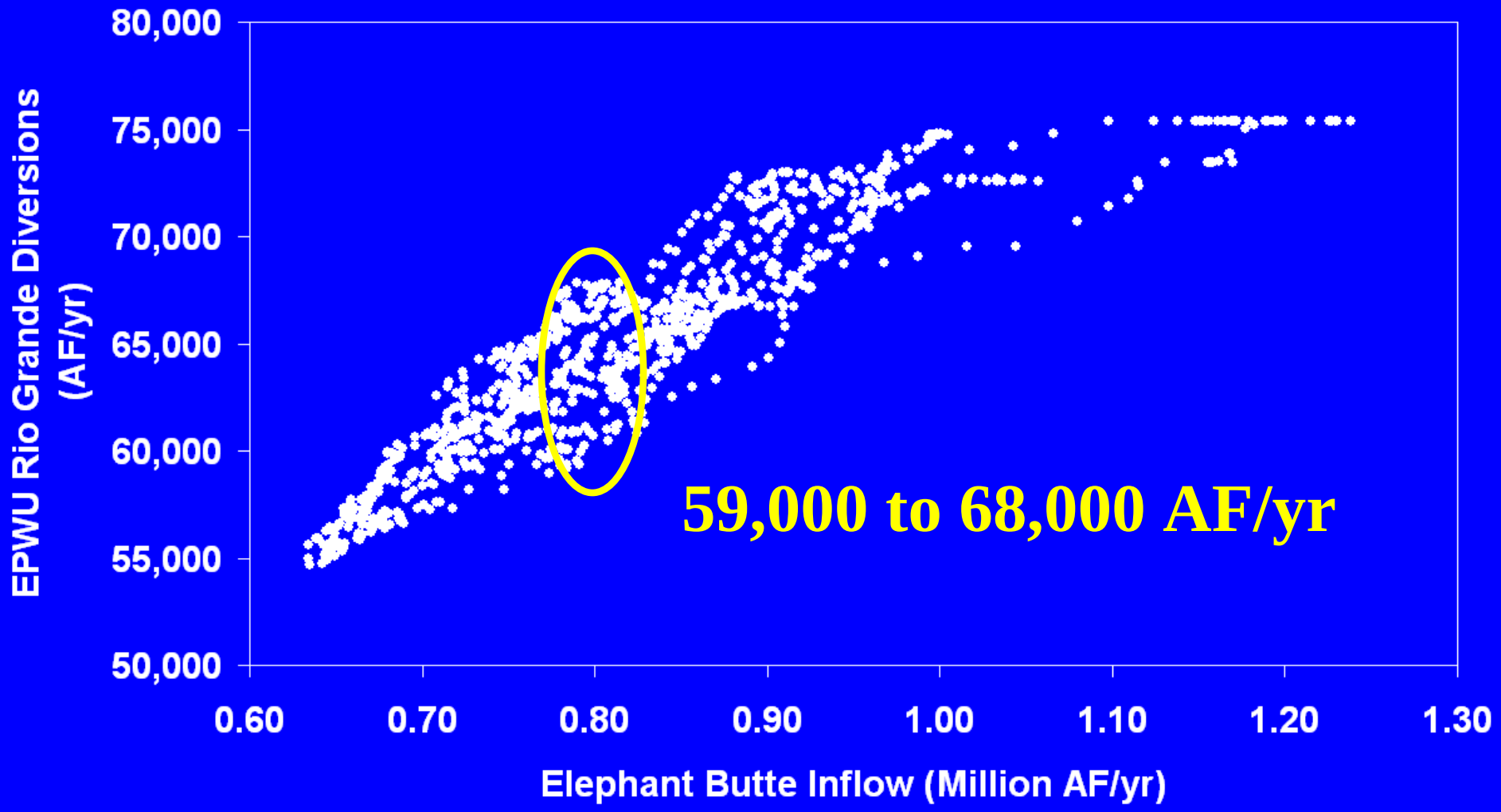
Results

- Base Case (Historic Variability)
  - EB Inflow vs. EPWU Diversions
  - EB Inflow vs. El Paso County Hueco Bolson Pumping
  - EB Inflow vs. Groundwater Storage
- Base Case vs. Decreased Inflow Scenarios
- Base Case vs. Increased Inflow Scenarios
- Higher Evaporation Impacts

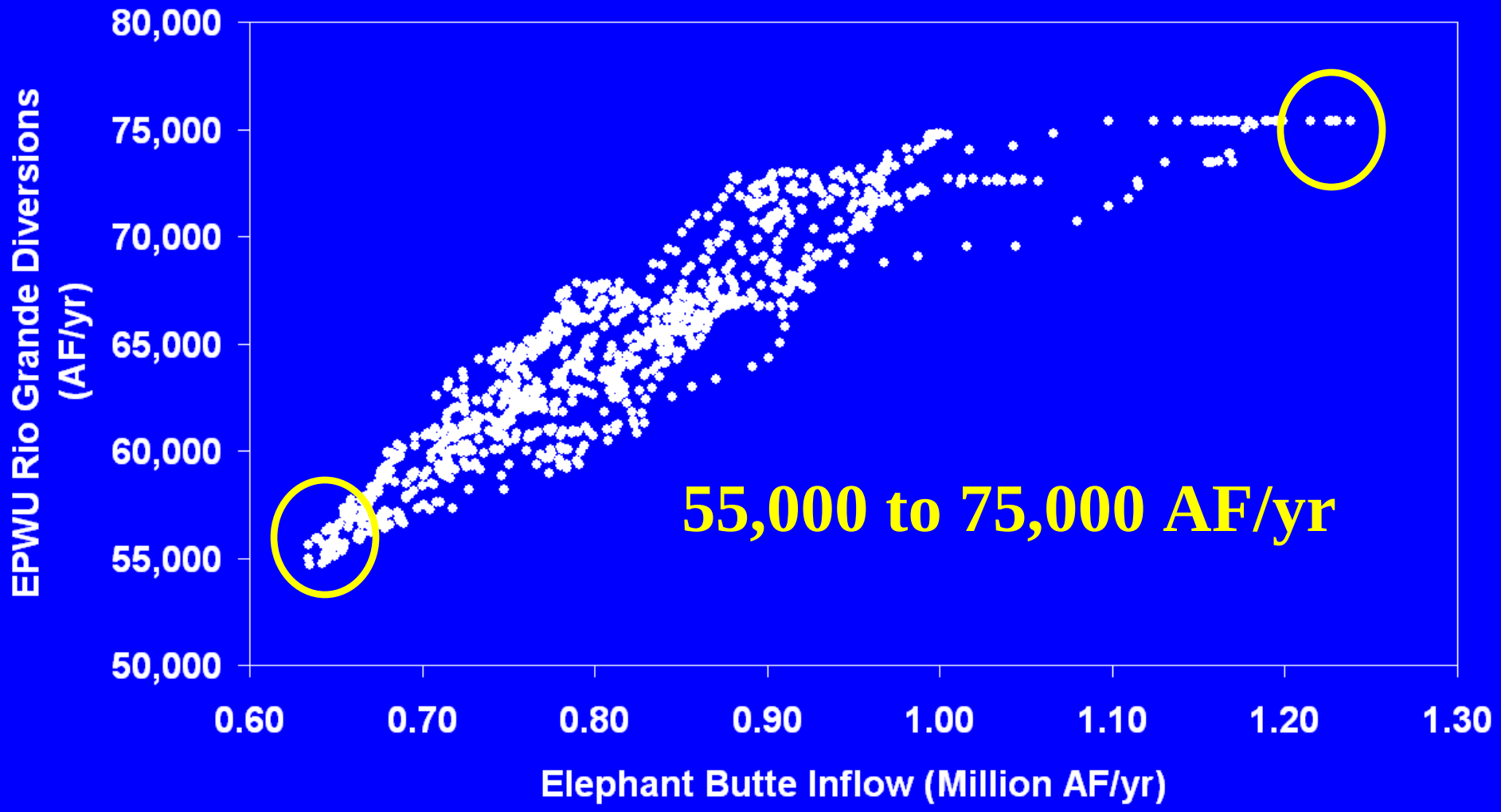
Elephant Butte Inflow vs. EPWU Diversions
Base Case - 50 Year Averages



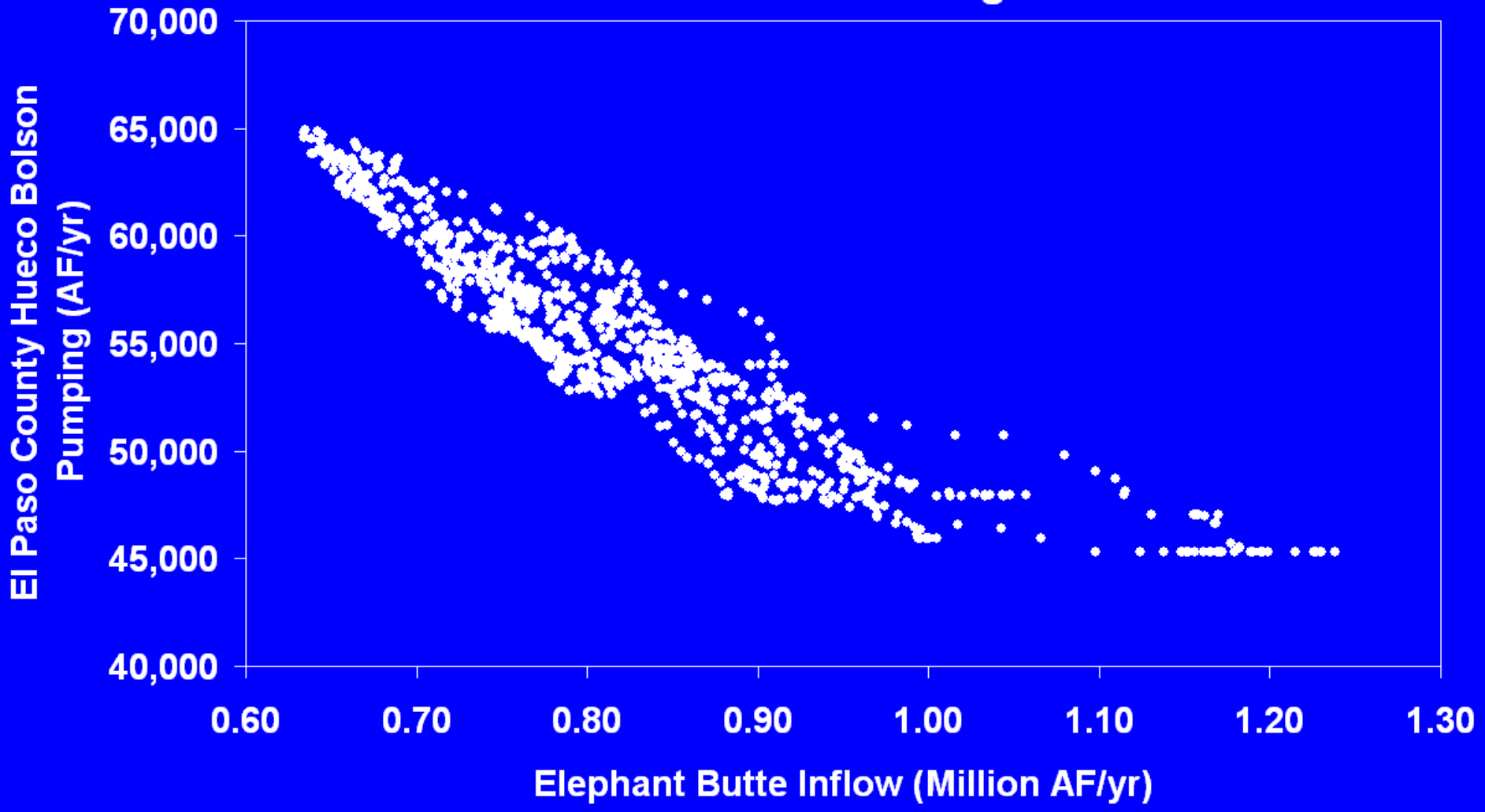
Elephant Butte Inflow vs. EPWU Diversions
Base Case - 50 Year Averages

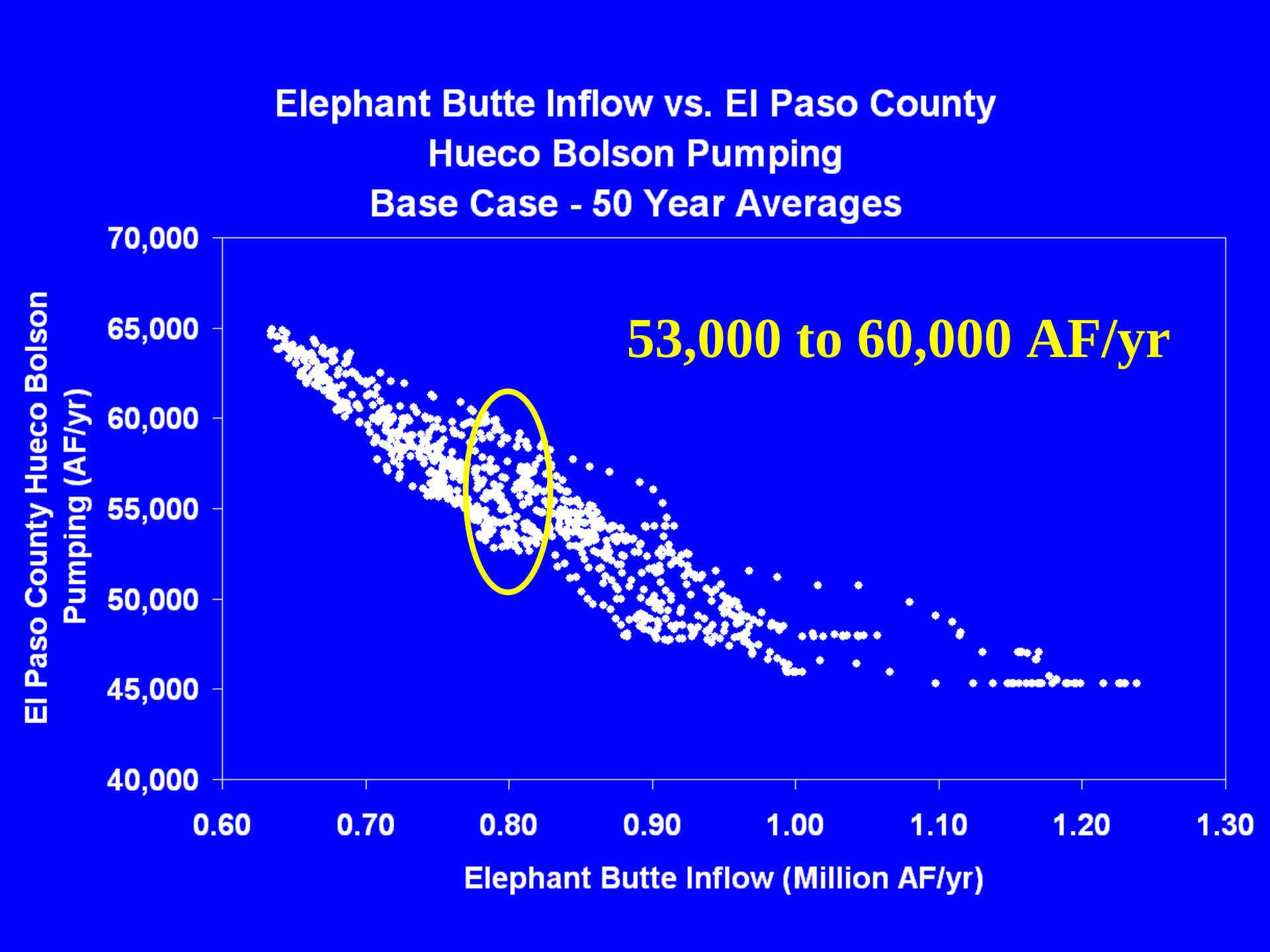


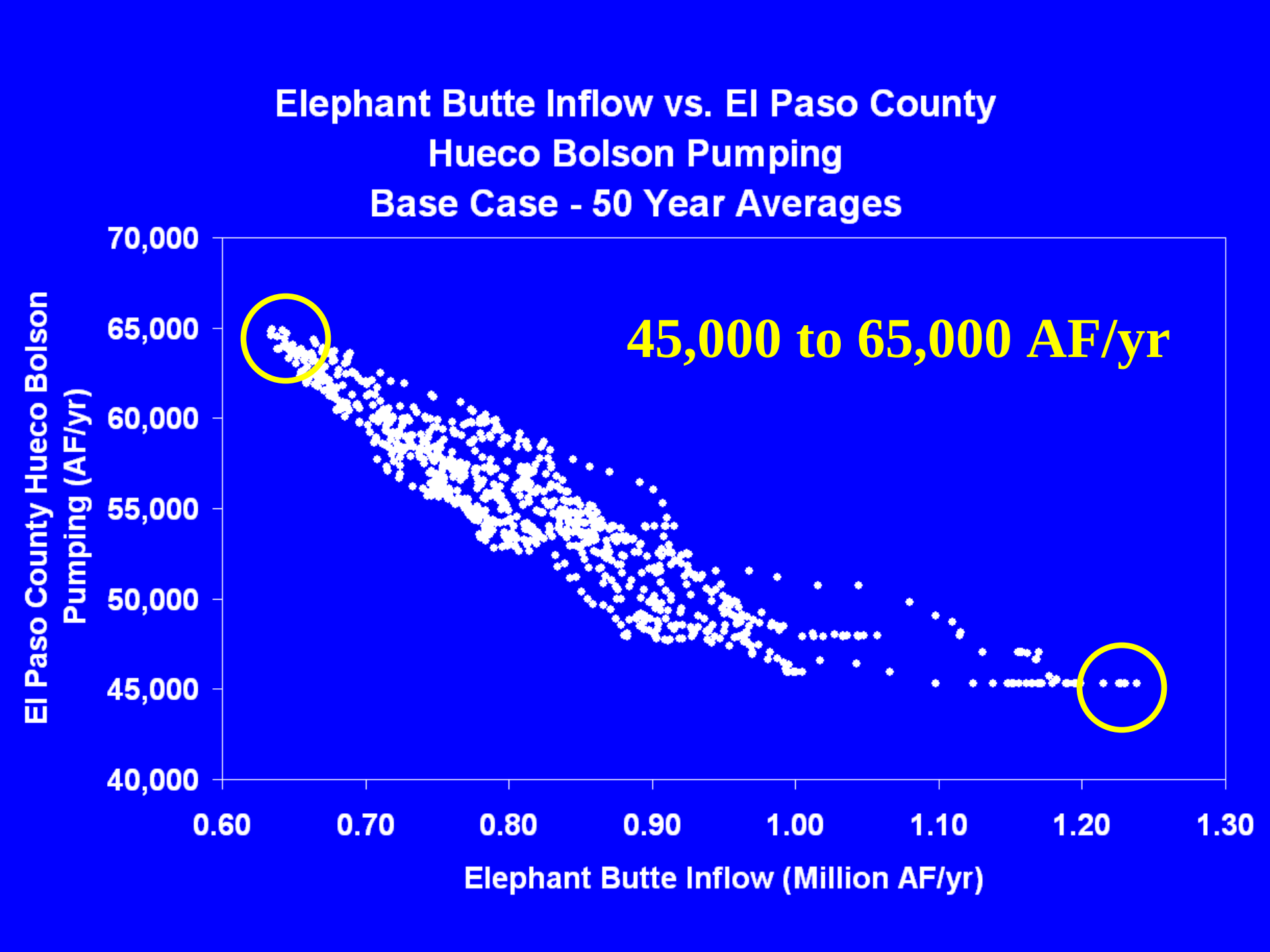
Elephant Butte Inflow vs. EPWU Diversions
Base Case - 50 Year Averages



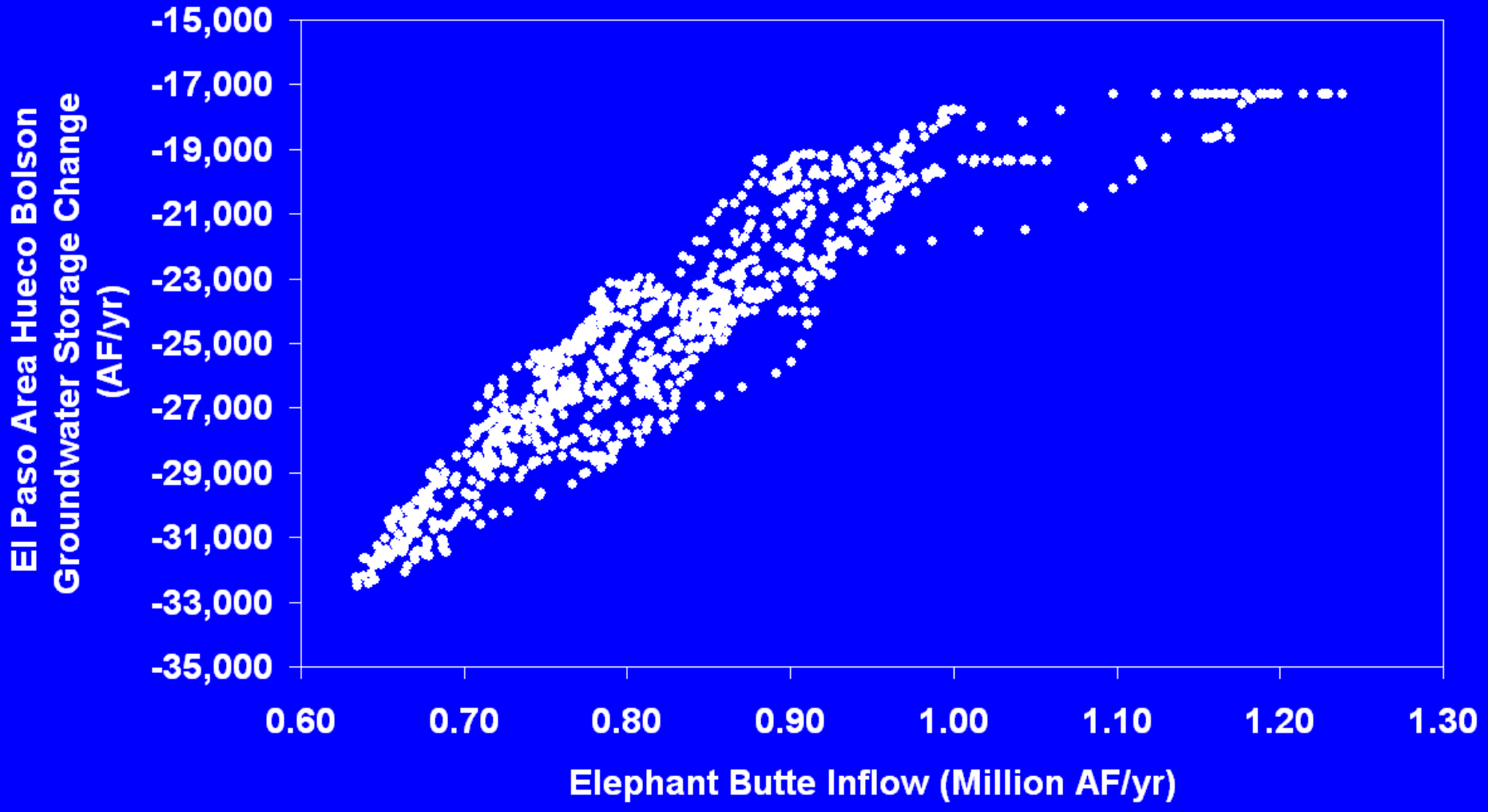
Elephant Butte Inflow vs. El Paso County Hueco Bolson Pumping
Base Case - 50 Year Averages



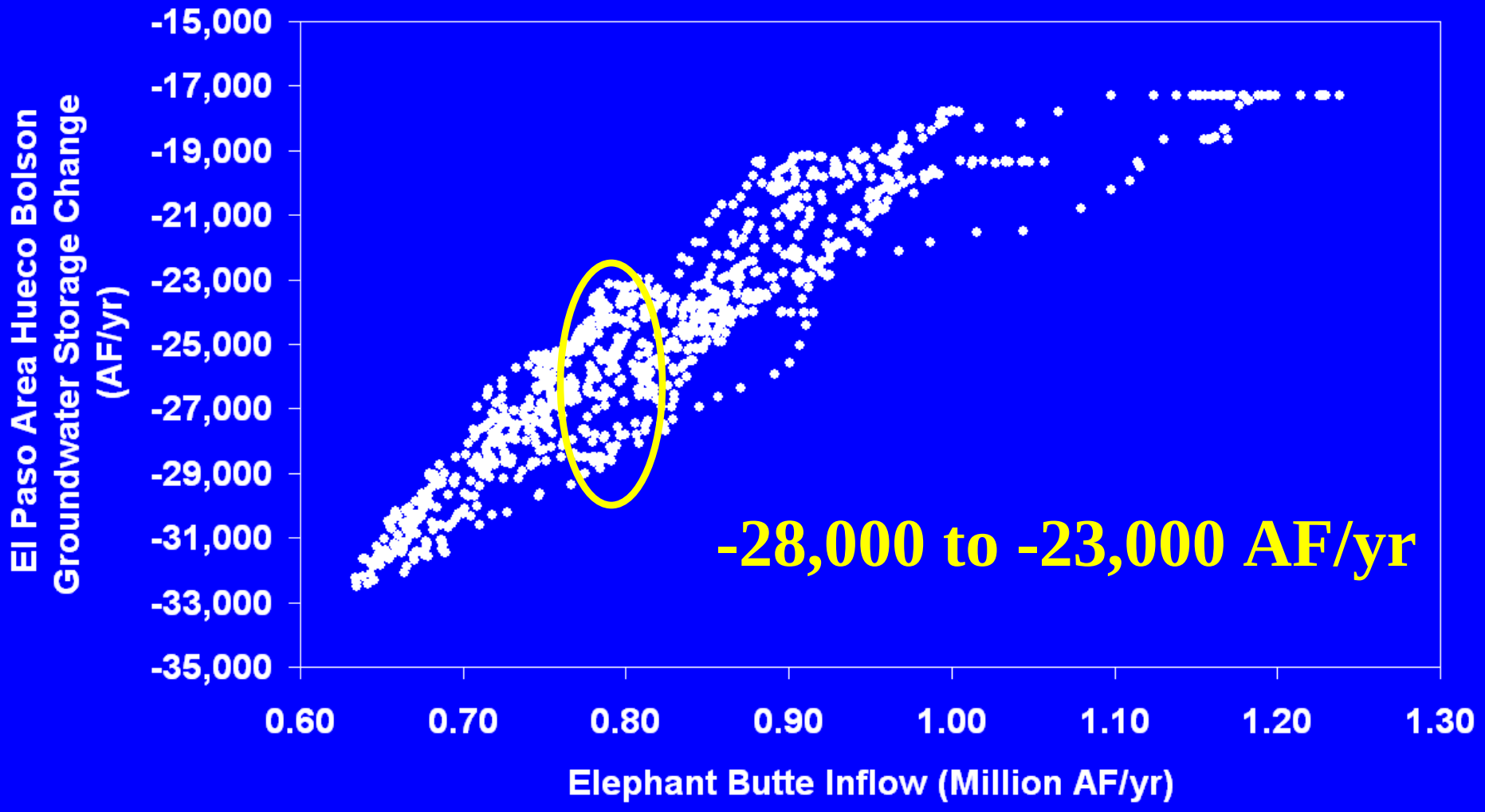

Elephant Butte Inflow vs. El Paso County
Hueco Bolson Pumping
Base Case - 50 Year Averages
53,000 to 60,000 AF/yr
El Paso County Hueco Bolson Pumping (AF/yr)
70,000
65,000
60,000
55,000
50,000
45,000
40,000
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
Elephant Butte Inflow (Million AF/yr)


Elephant Butte Inflow vs. El Paso County
Hueco Bolson Pumping
Base Case - 50 Year Averages
45,000 to 65,000 AF/yr
El Paso County Hueco Bolson Pumping (AF/yr)
70,000
65,000
60,000
55,000
50,000
45,000
40,000
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
Elephant Butte Inflow (Million AF/yr)

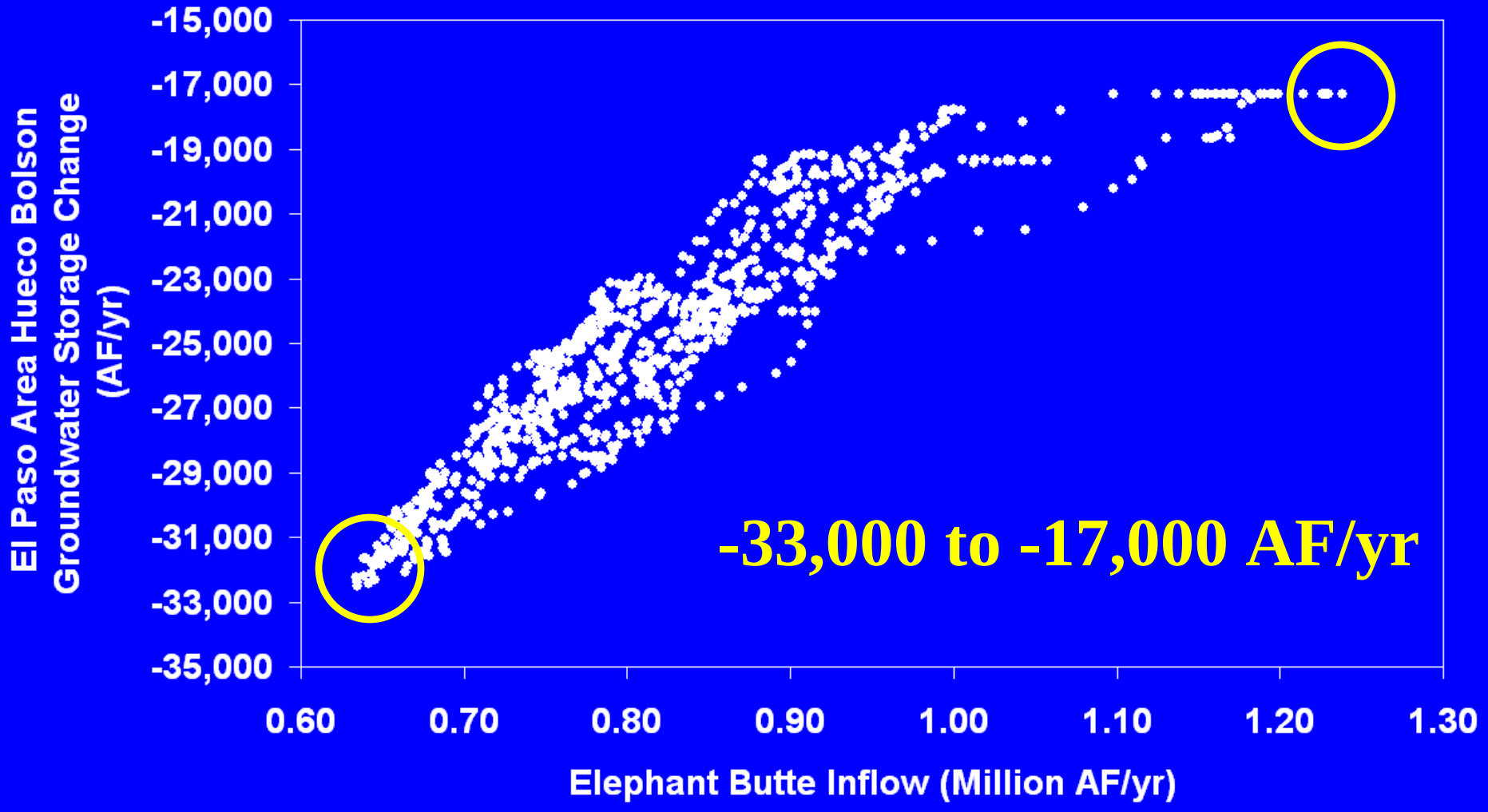
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Groundwater Storage Change
Base Case - 50 Year Averages



Elephant Butte Inflow vs. El Paso Area Hueco Bolson Groundwater Storage Change
Base Case - 50 Year Averages



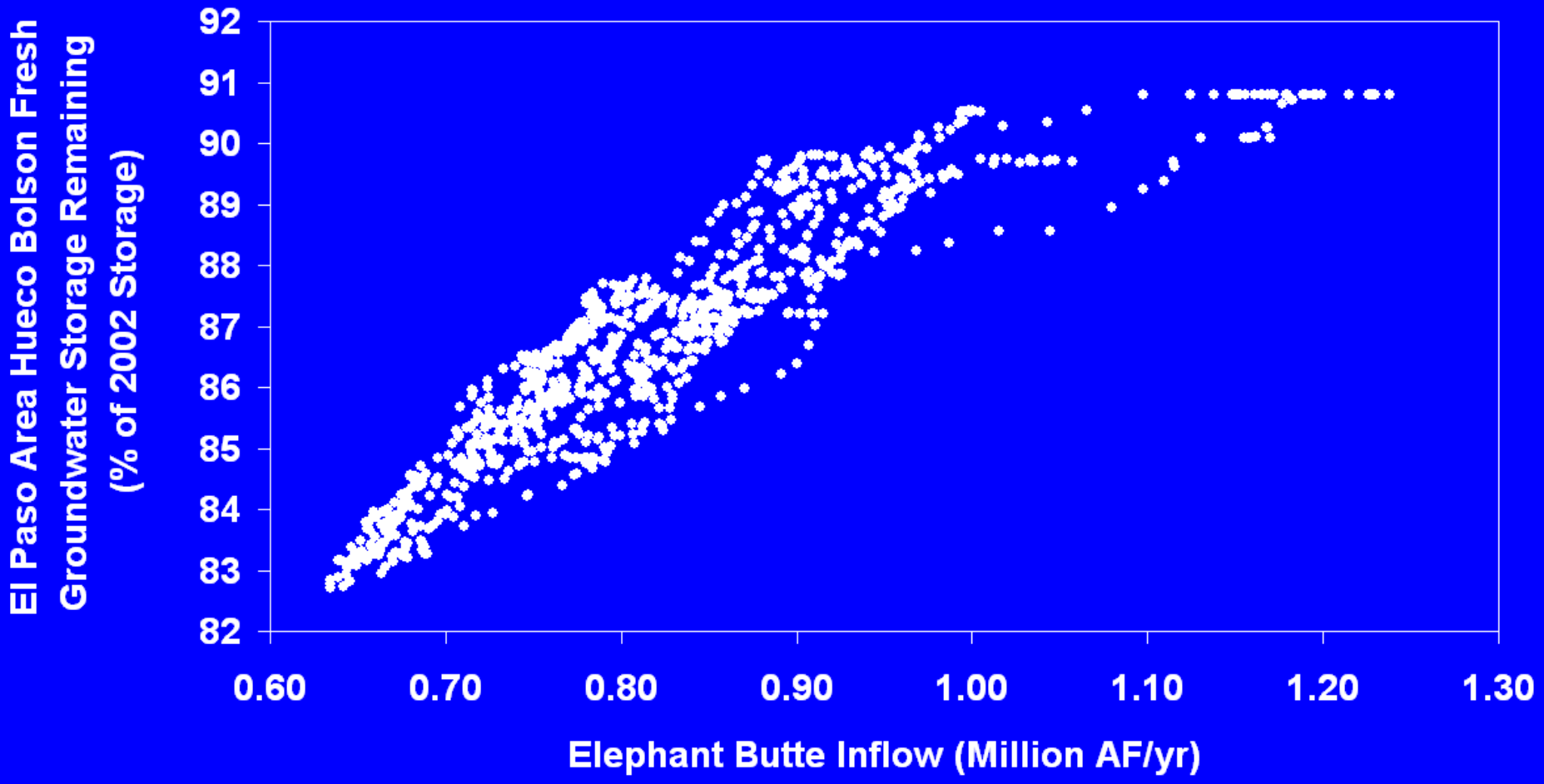
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Groundwater Storage Change
Base Case - 50 Year Averages



Storage Change Impact on Estimated 2002 Fresh Groundwater Storage

- 2002 Fresh Groundwater Storage in El Paso Area = 9.4 Million AF
- Attribute all storage change to fresh groundwater (conservative)
- Estimate percentage of fresh groundwater remaining after 50 years

Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
Base Case - 50 Year Averages



Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
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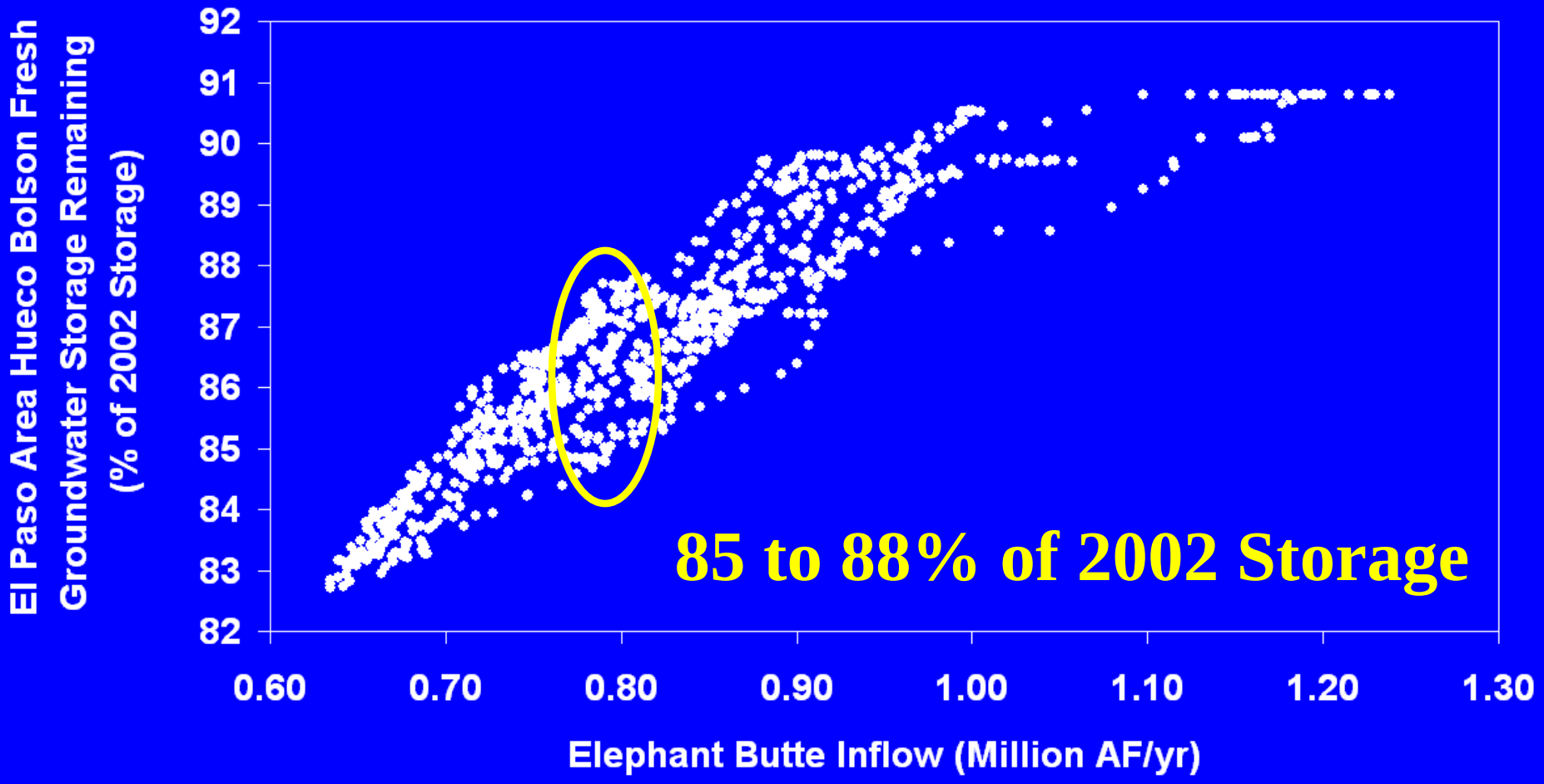
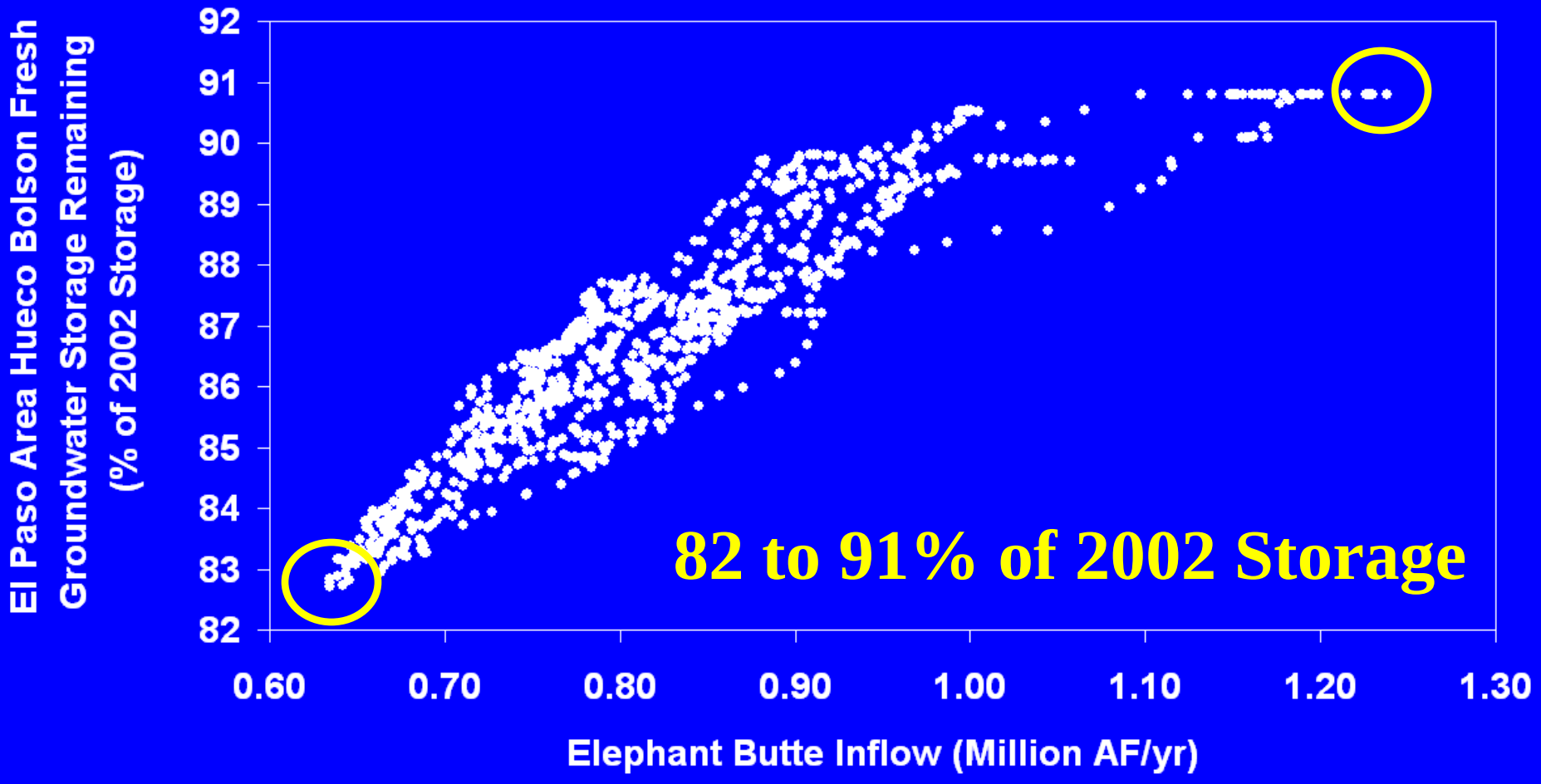


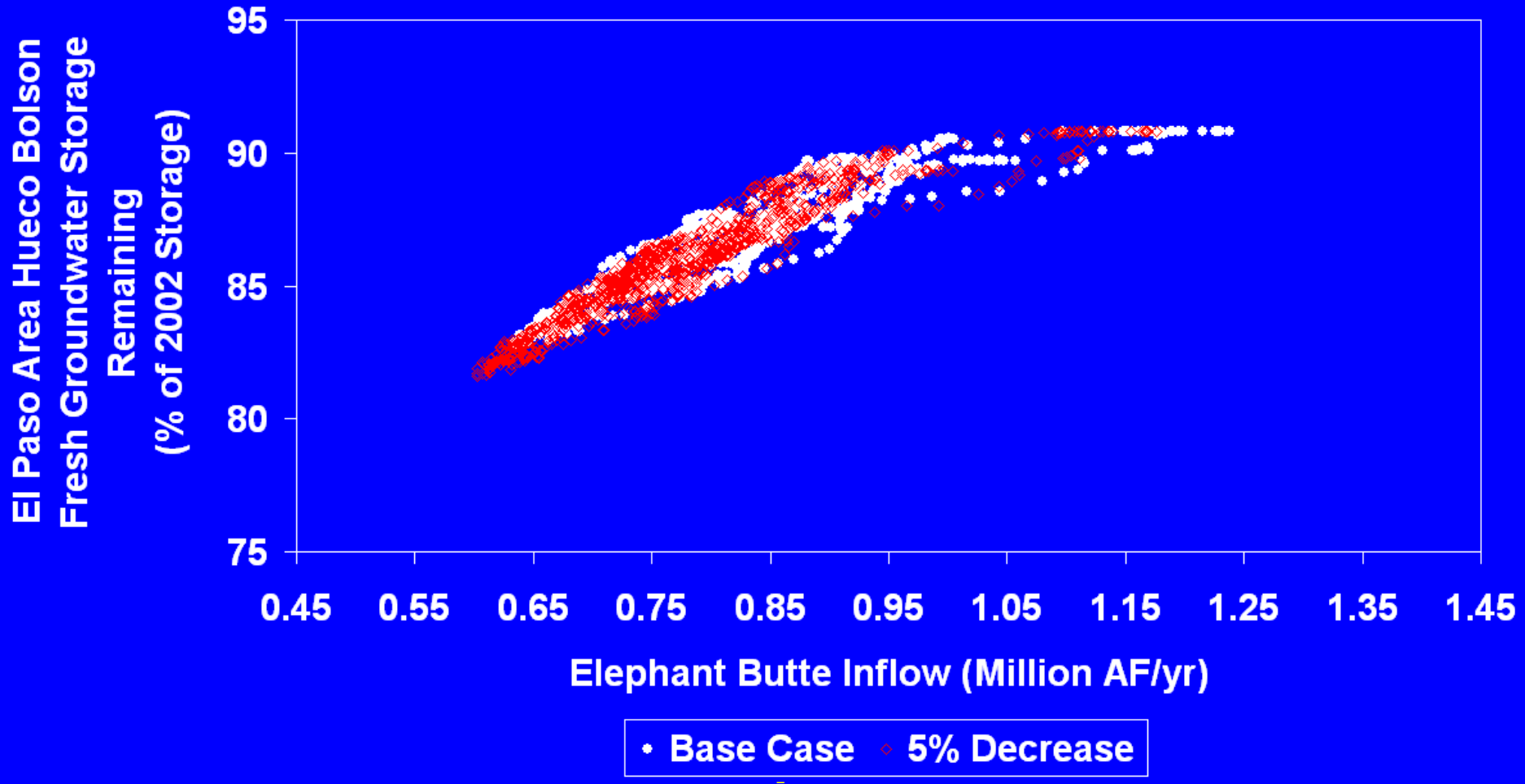
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
Base Case - 50 Year Averages



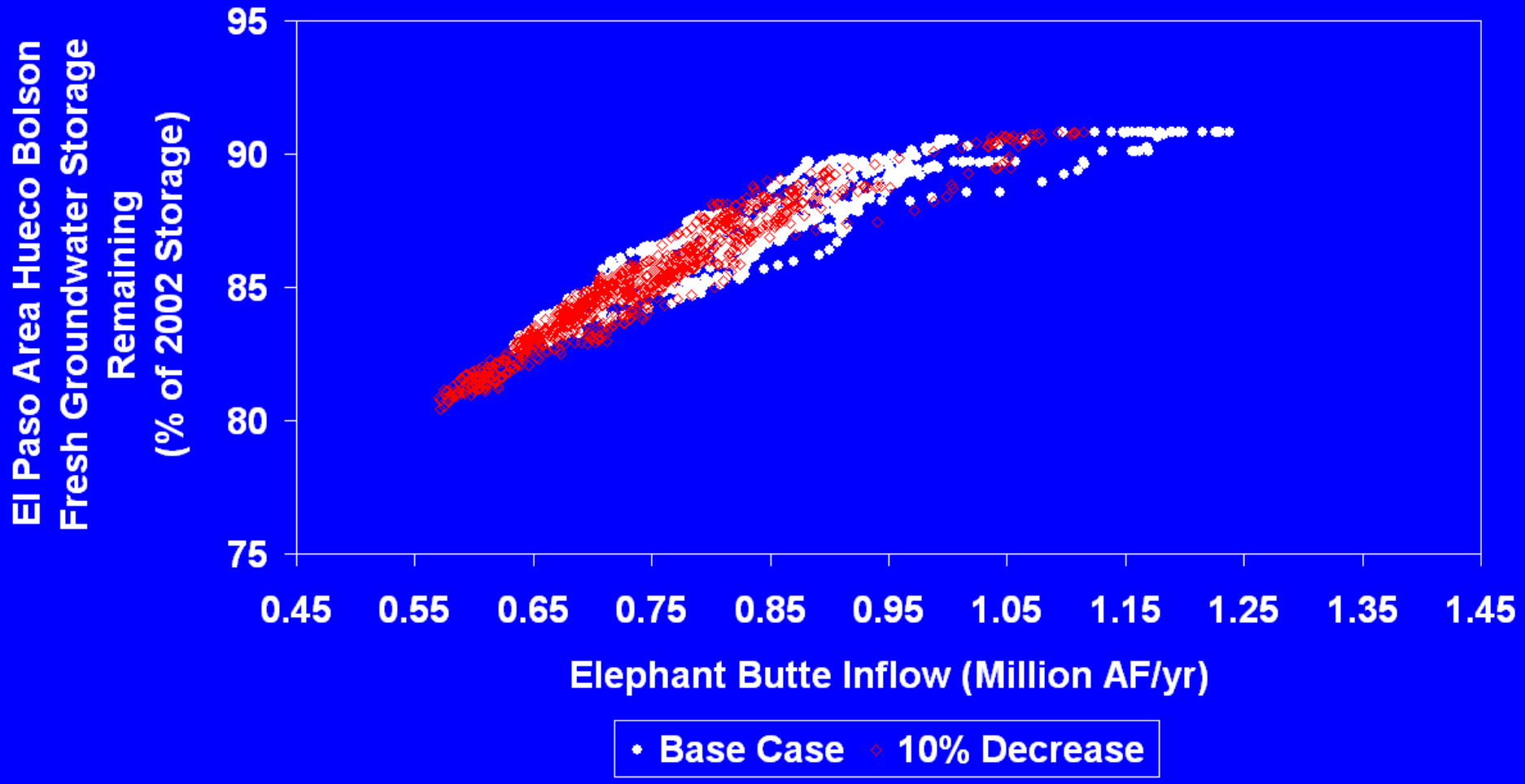
Changes in Precipitation/Inflow (IPCC Predictions)

- 5% Decrease (Avg of all 21 IPCC models)
- 10% Decrease (8 IPCC models)
- 20% Decrease (4 IPCC models)
- 25% Decrease (1 IPCC model)
- 5% Increase (4 IPCC models)
- 10% Increase (4 IPCC models)

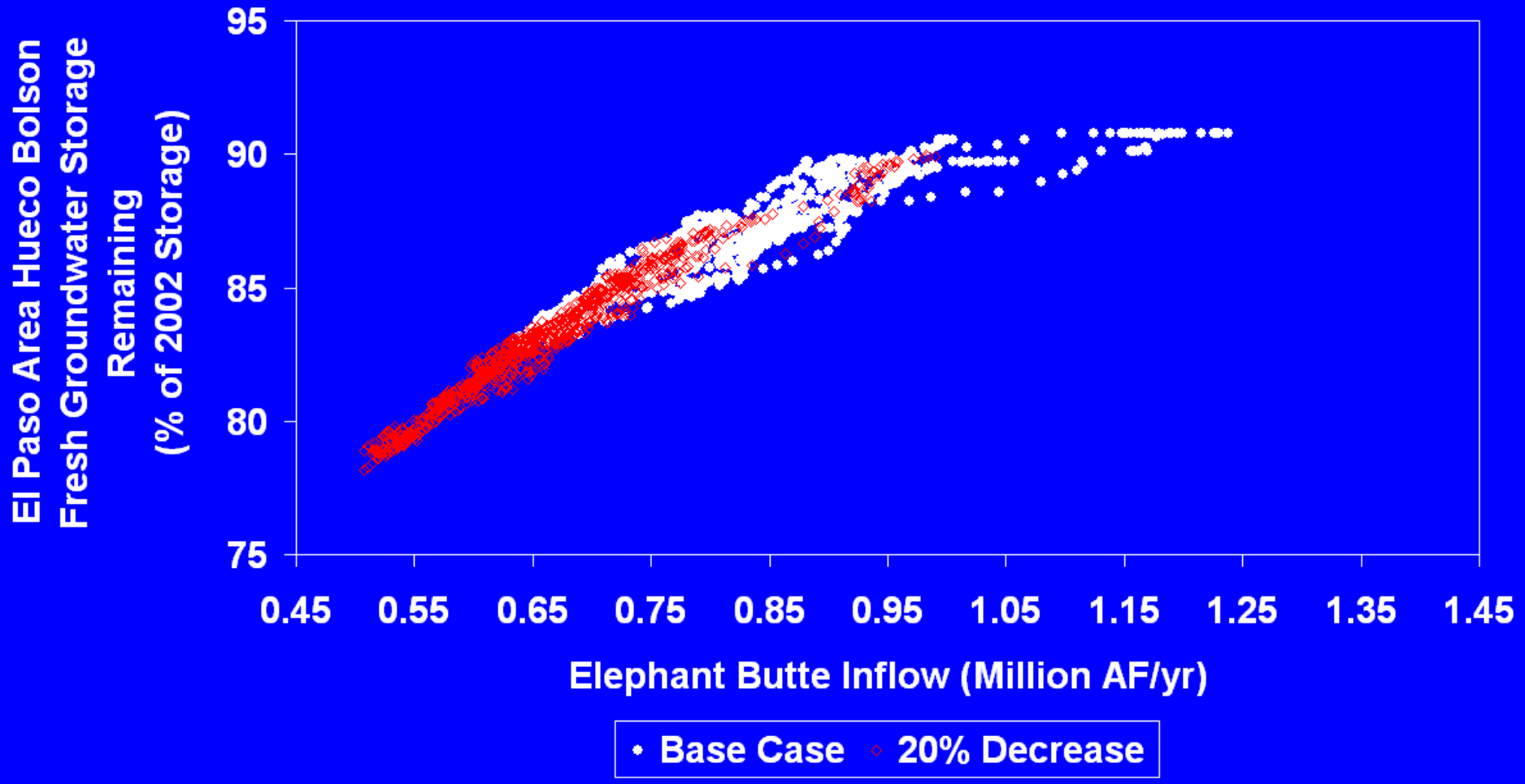
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining 5% Decrease (average of all IPCC models)



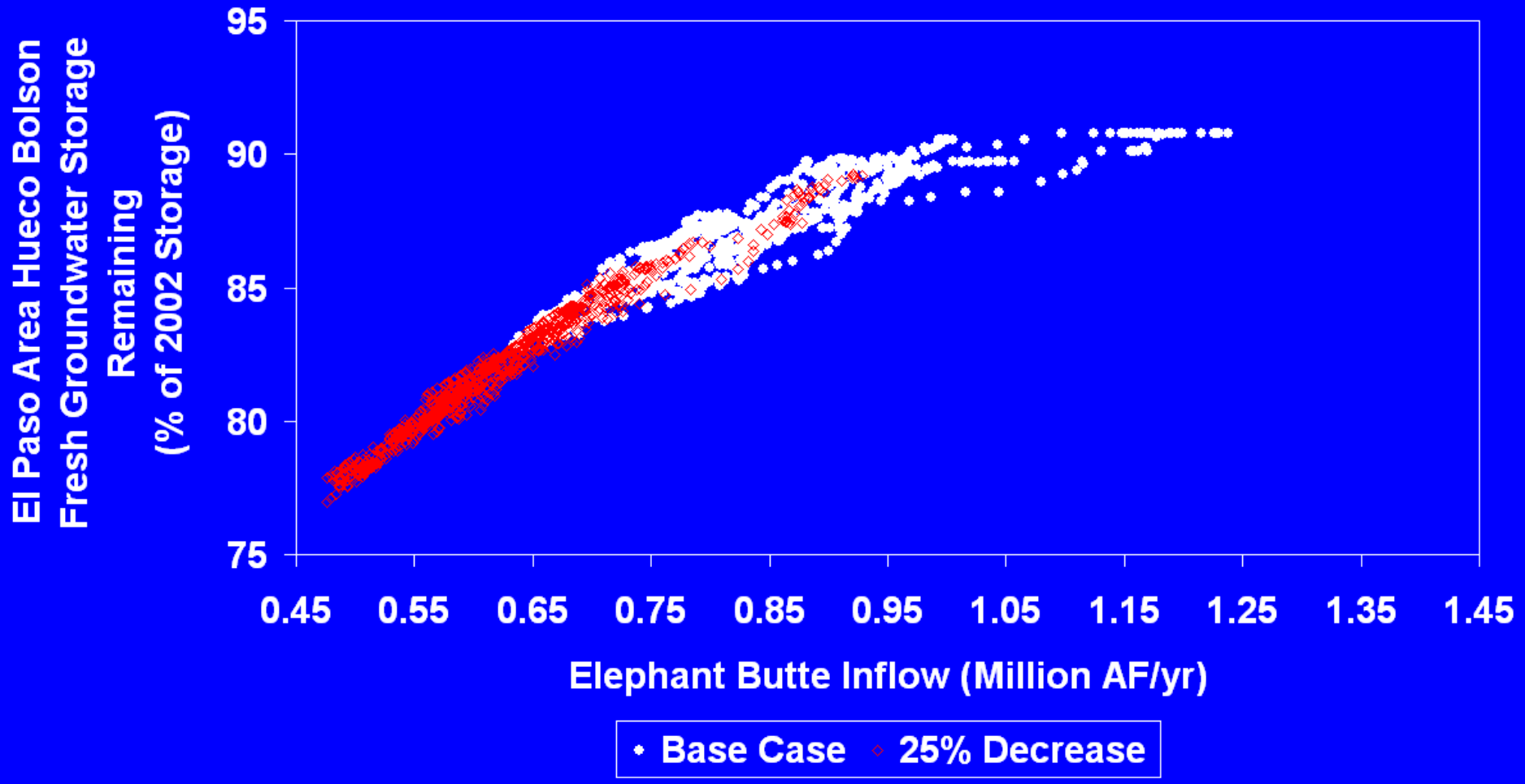
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining 10% Decrease (8 IPCC models)



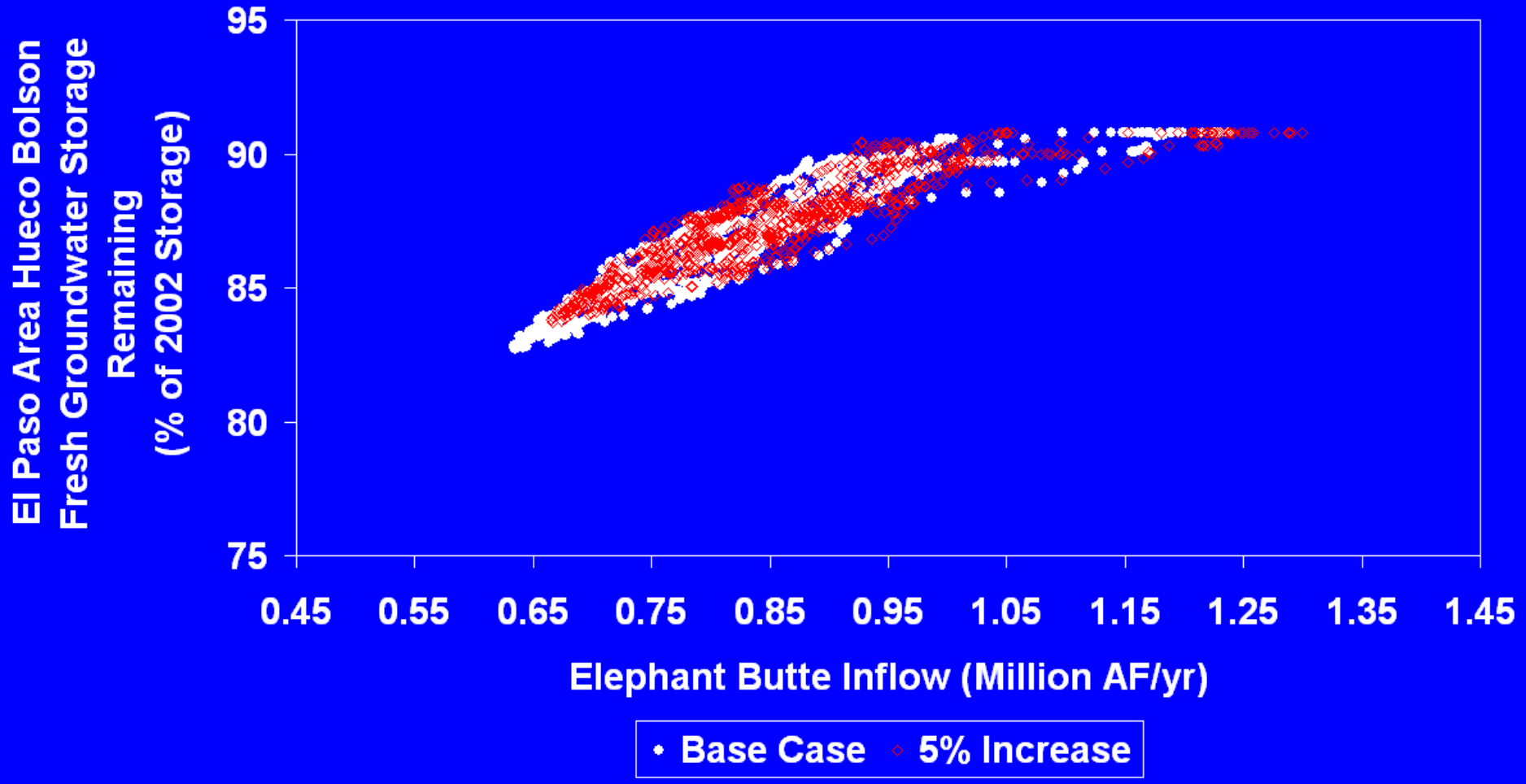
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining 20% Decrease (4 IPCC models)



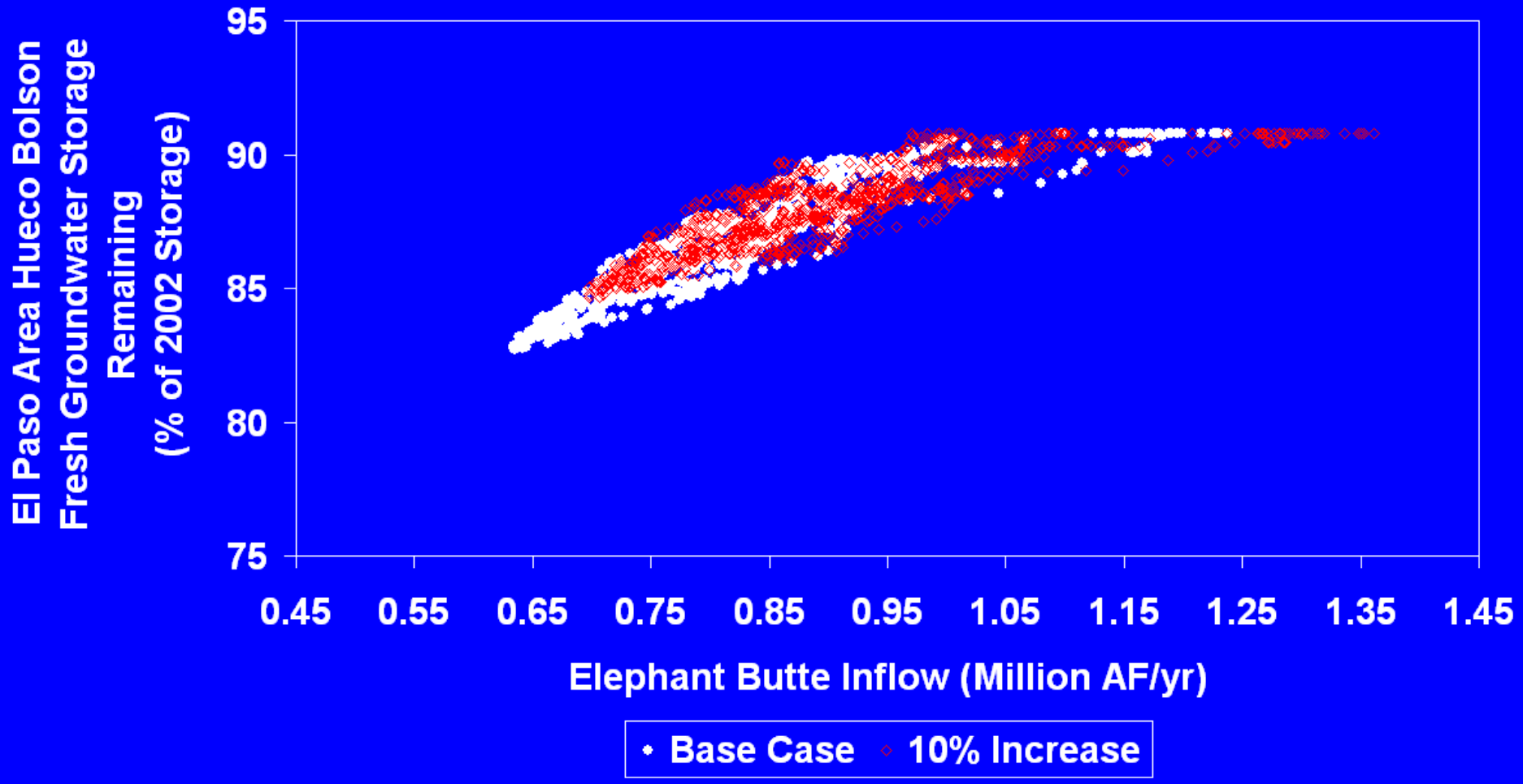
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining 25% Decrease (1 IPCC model)



Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining 5% Increase (4 IPCC models)



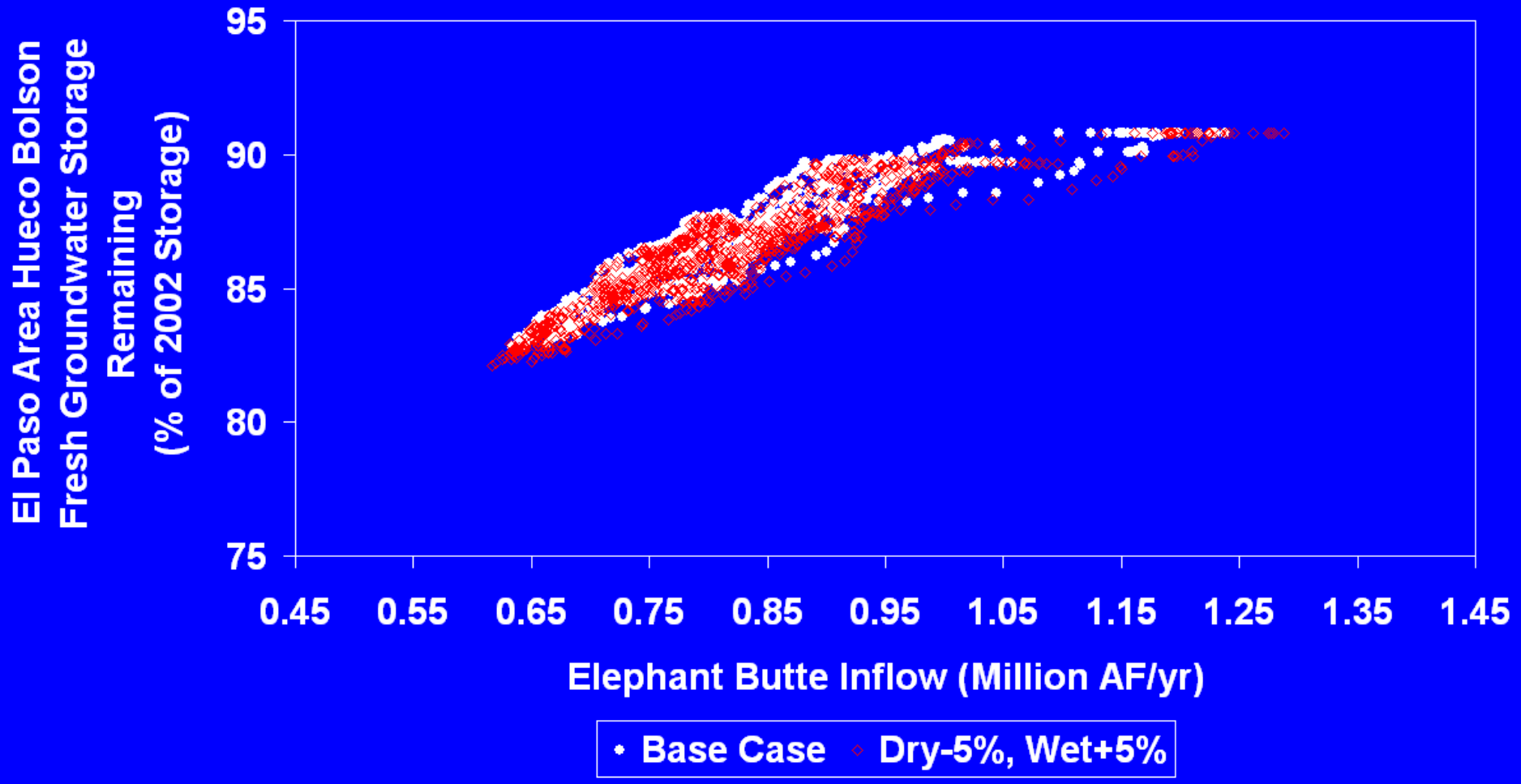
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining 10% Increase (4 IPCC models)



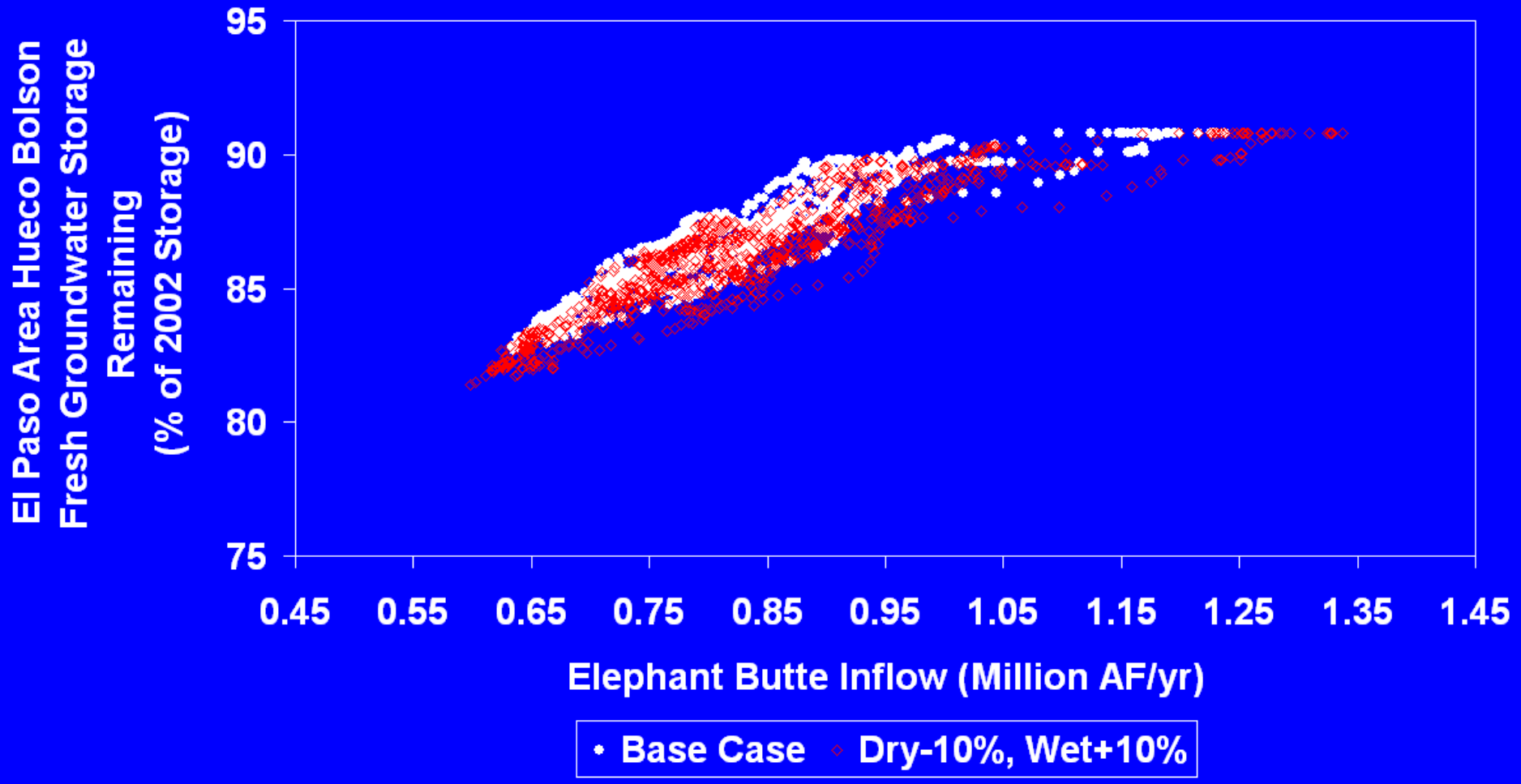
Increased Variability

- Dry -5%, Wet +5%
- Dry -10%, Wet +10%
- Dry -20%, Wet +20%

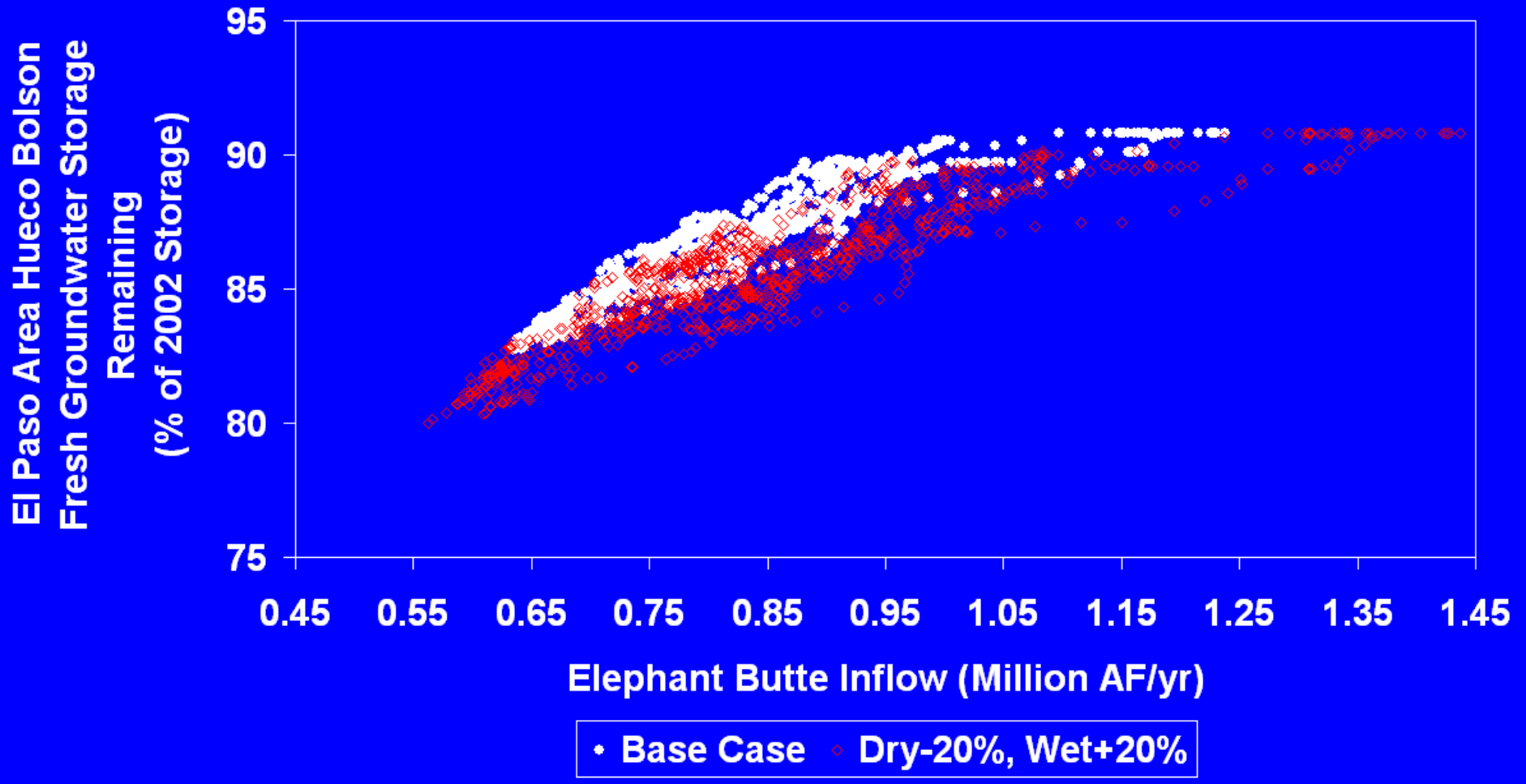
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
Dry 5% Decrease, Wet 5% Increase



Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
Dry 10% Decrease, Wet 10% Increase



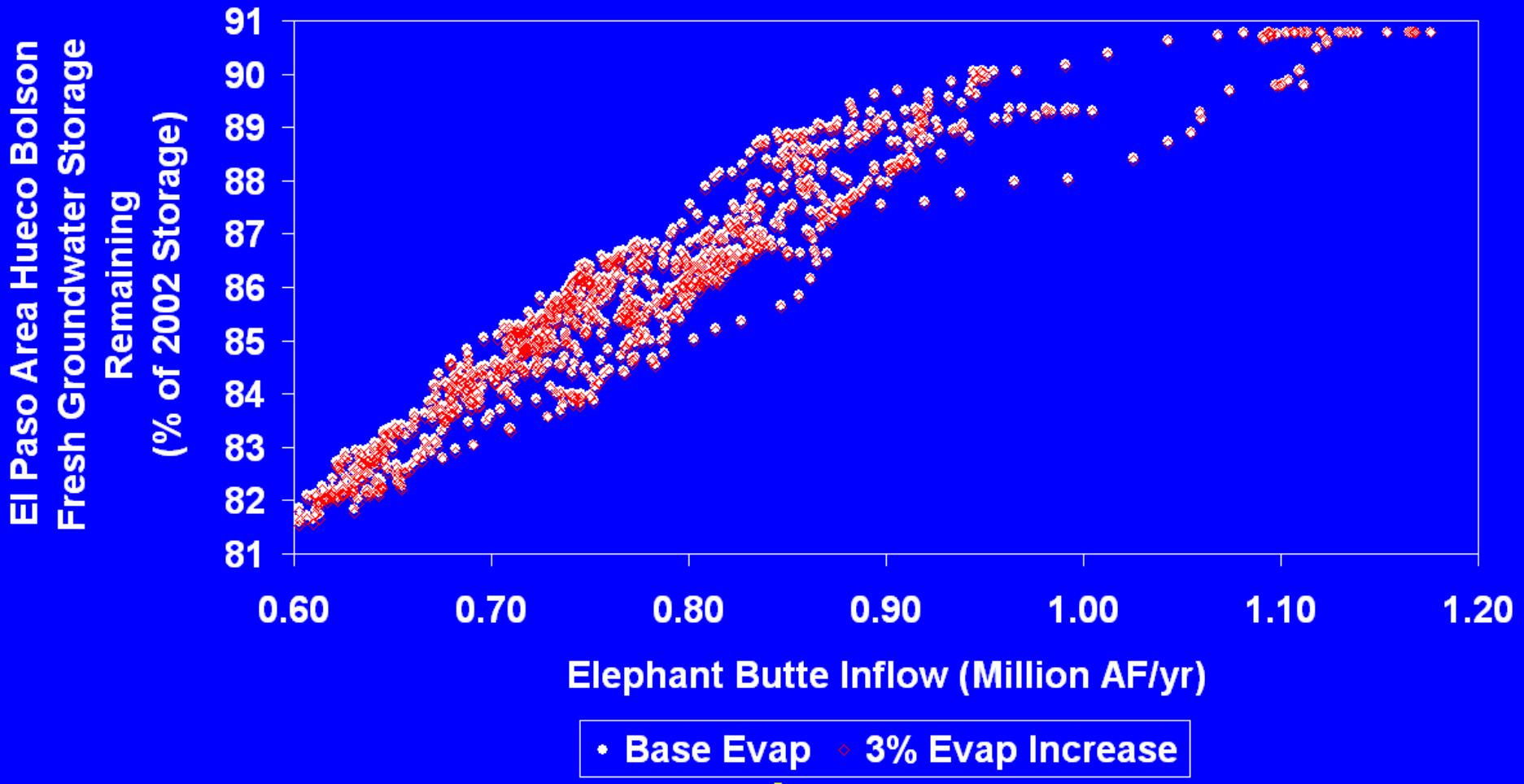
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
Dry 20% Decrease, Wet 20% Increase



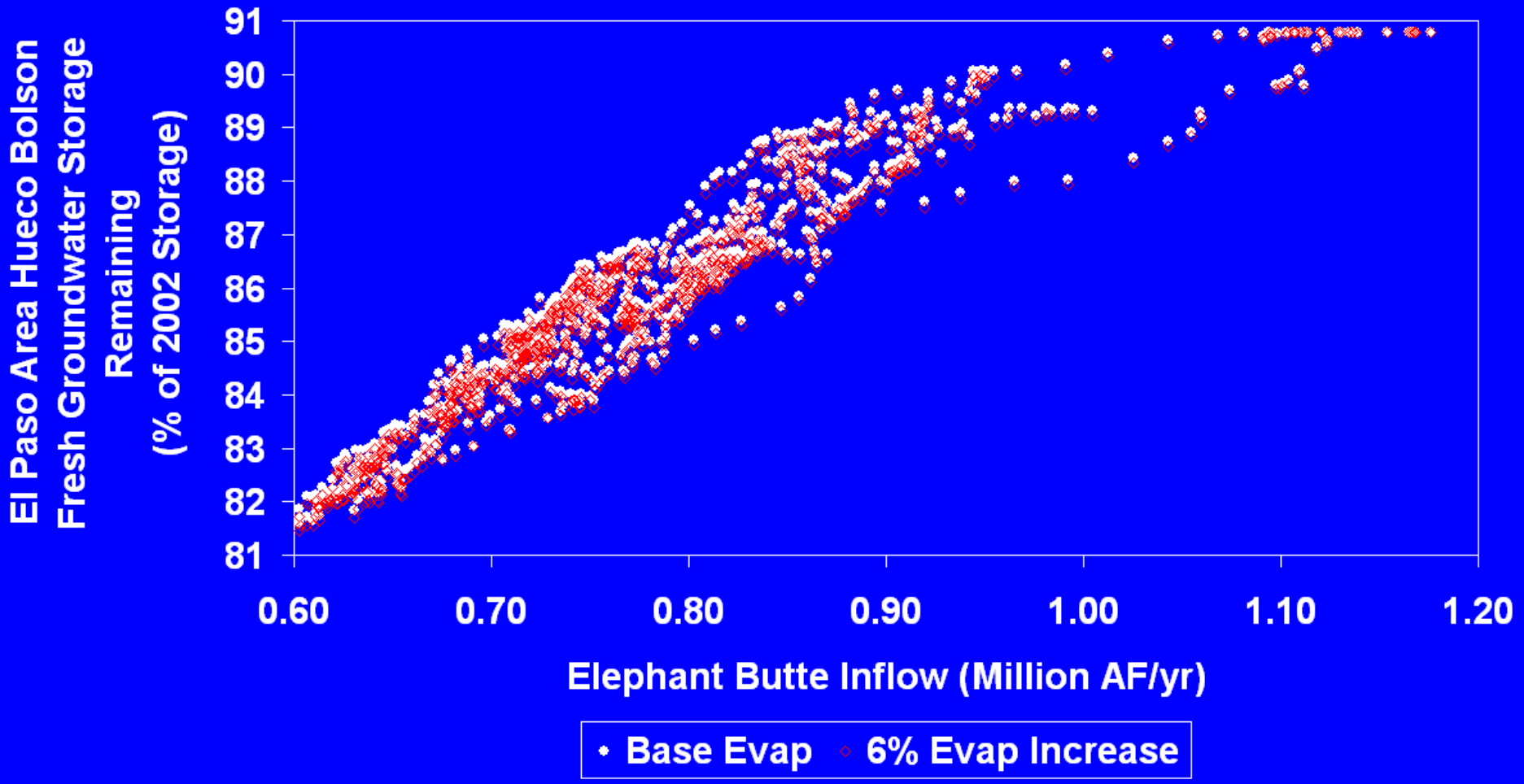
Impacts of Increased Evaporation

- 3 % (1°C)
- 6 % (2°C)
- 9 % (3°C)
- 12 % (4°C)
- 15 % (5°C)

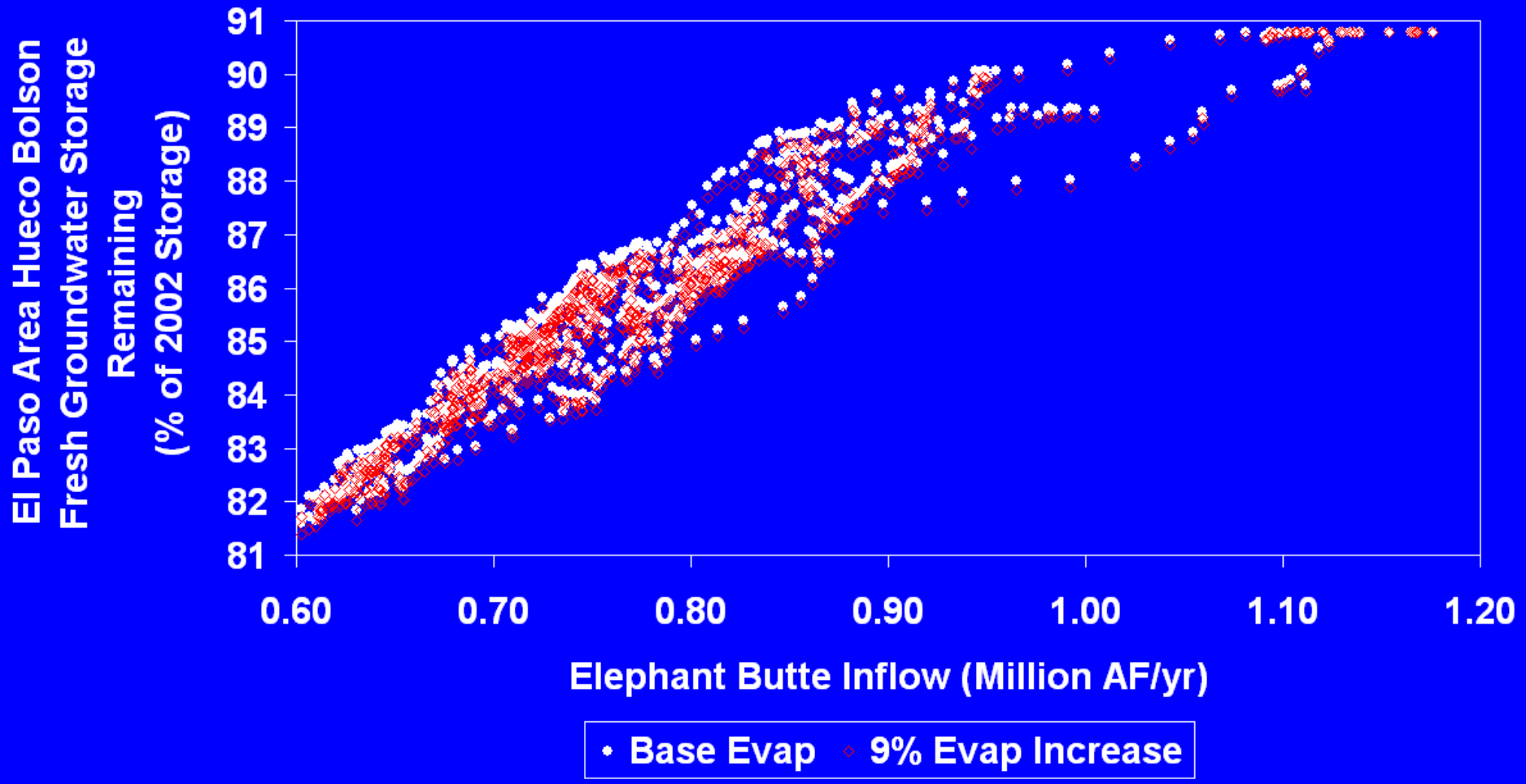
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
5% Inflow Decrease, 0 to 3% Evaporation Increase



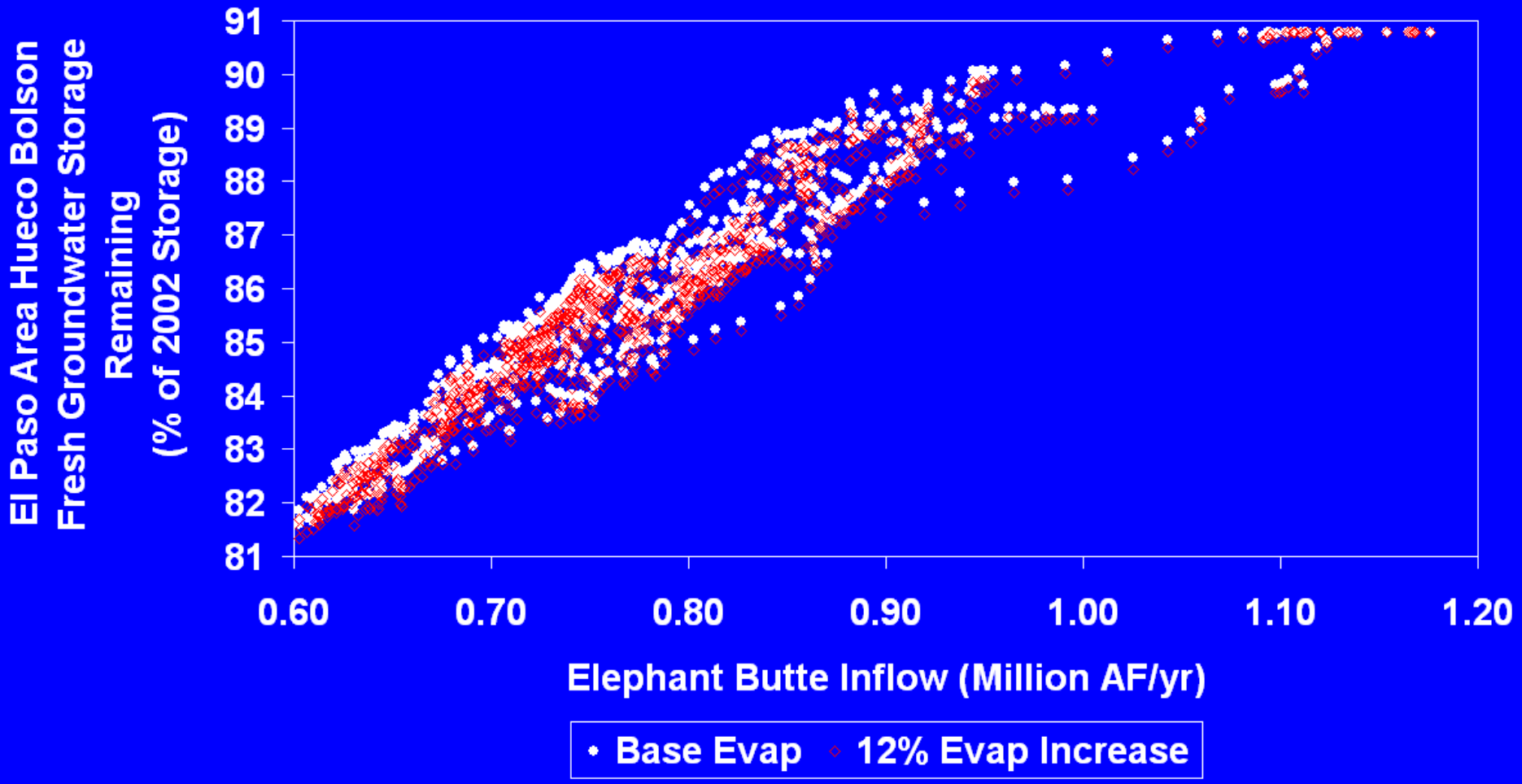
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
5% Inflow Decrease, 0 to 6% Evaporation Increase



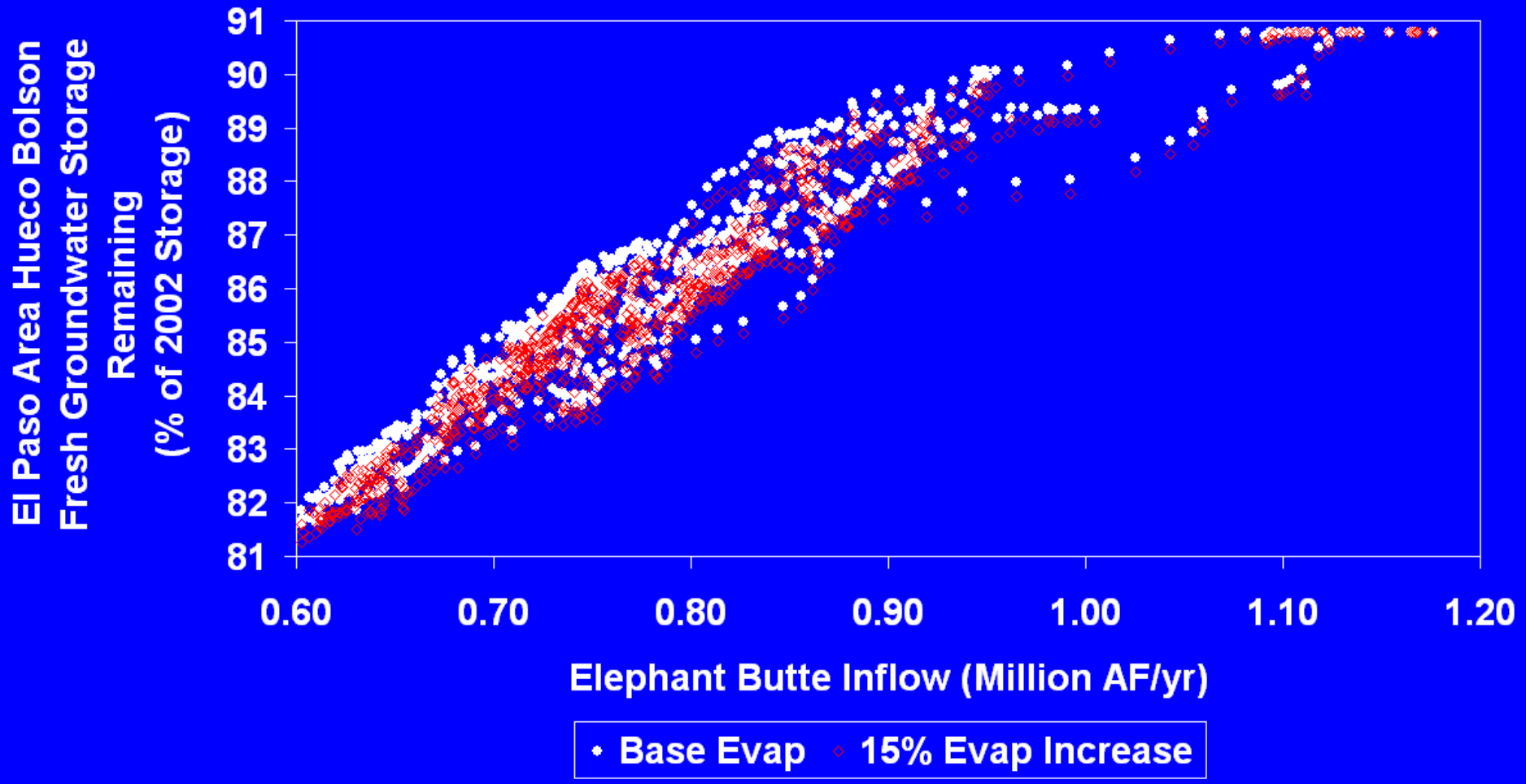
Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
5% Inflow Decrease, 0 to 9% Evaporation Increase



Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
5% Inflow Decrease, 0 to 12% Evaporation Increase



Elephant Butte Inflow vs. El Paso Area Hueco Bolson Fresh Groundwater Storage Remaining
5% Inflow Decrease, 0 to 15% Evaporation Increase



Findings (Surface Water)

- Increased Temperature (up to 5°C) will have no impact on El Paso Municipal Supplies
  - Did not consider impacts on demand
- IPCC predictions on precipitation are mixed
  - Past 1,000 years suggest that future changes in EB inflow are likely (historic variability)

Findings (Surface Water)

- It will be difficult to attribute cause of future EB inflow changes:
  - Natural variability
  - Impacts from upstream land use changes
  - Changes in upstream diversion patterns
  - Increased CO_2 impacts (IPCC)

Findings (Groundwater Resources)

- Fresh groundwater storage will be > 75% of 2002 condition in 2060 under current management approach
  - > 82% under historic variation
- Conservative Analysis:
  - RG Flow varies only with EB outflow
  - Recharge from summer monsoons ignored

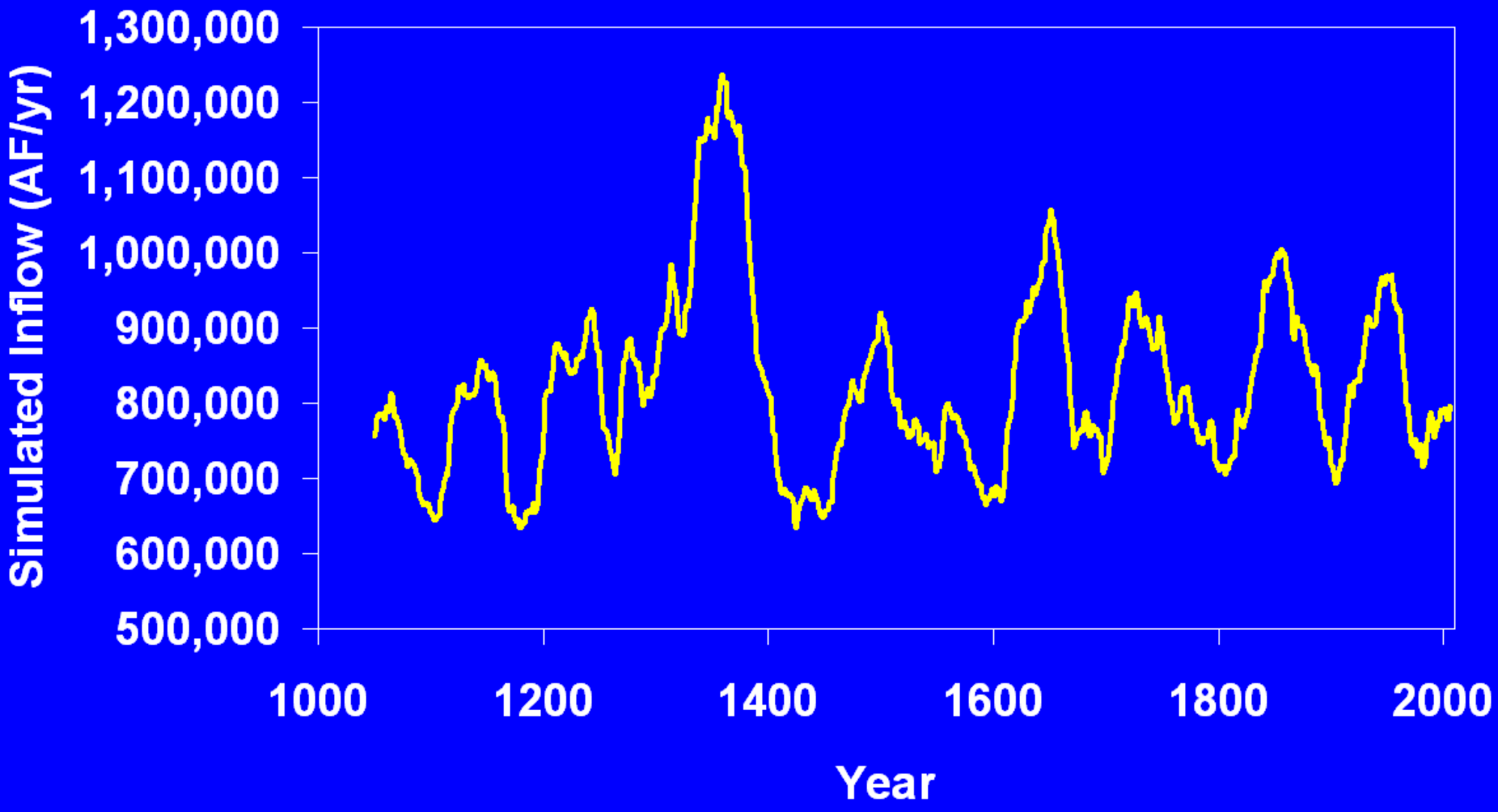
Findings (Groundwater Infrastructure)

- Even under the most extreme surface flow reductions:
  - Groundwater infrastructure will be adequate for the next 50 years
  - Meeting conjunctive use objectives in 2006 Region E plan is feasible

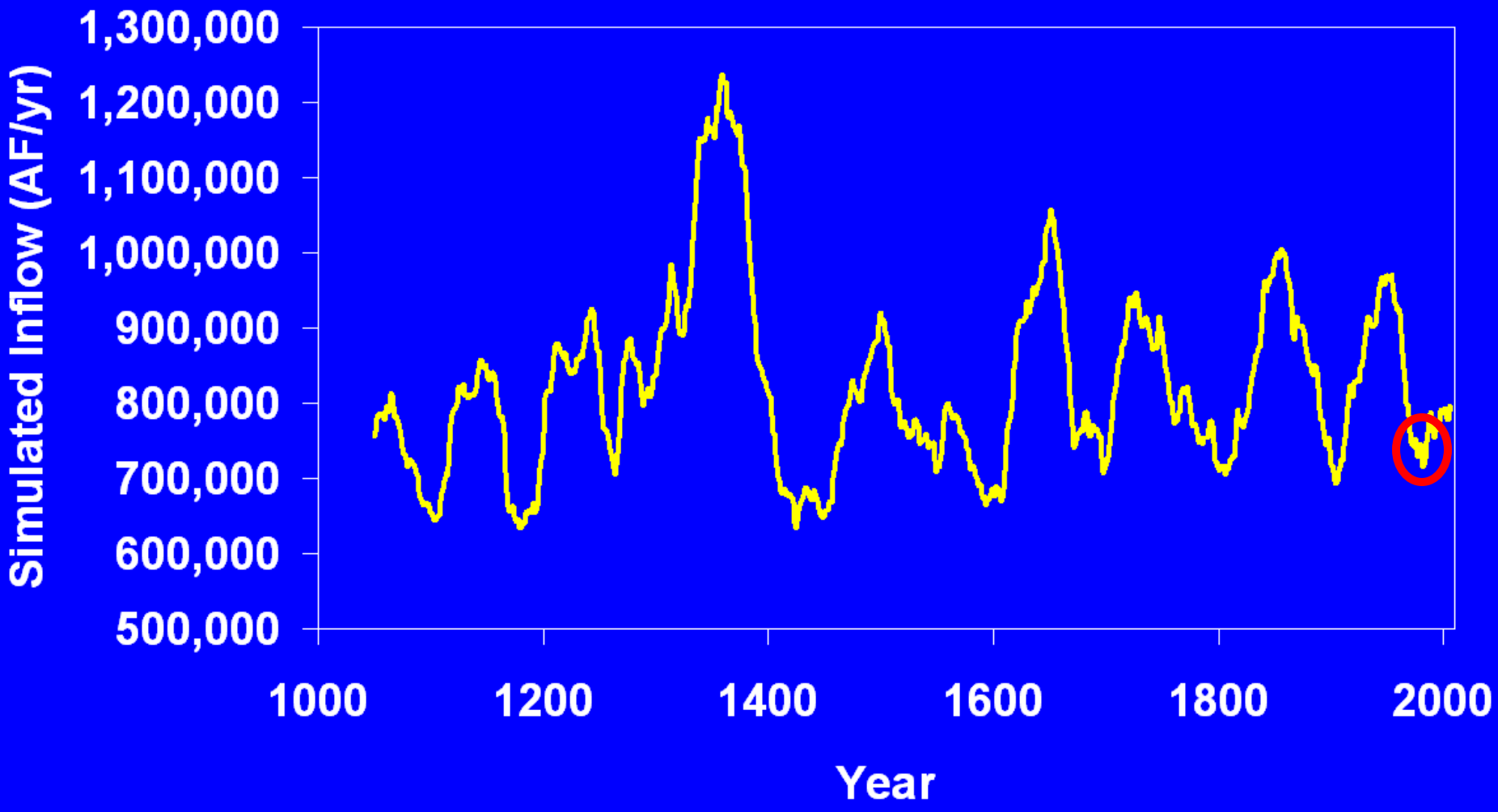
Regional Planning Recommendations

- "Drought of Record"
  - Current Requirement
  - Not well suited to Region E
  - Does not allow for context of drought in light of conjunctive use
- Management Strategies need to be viewed in context of more complete history

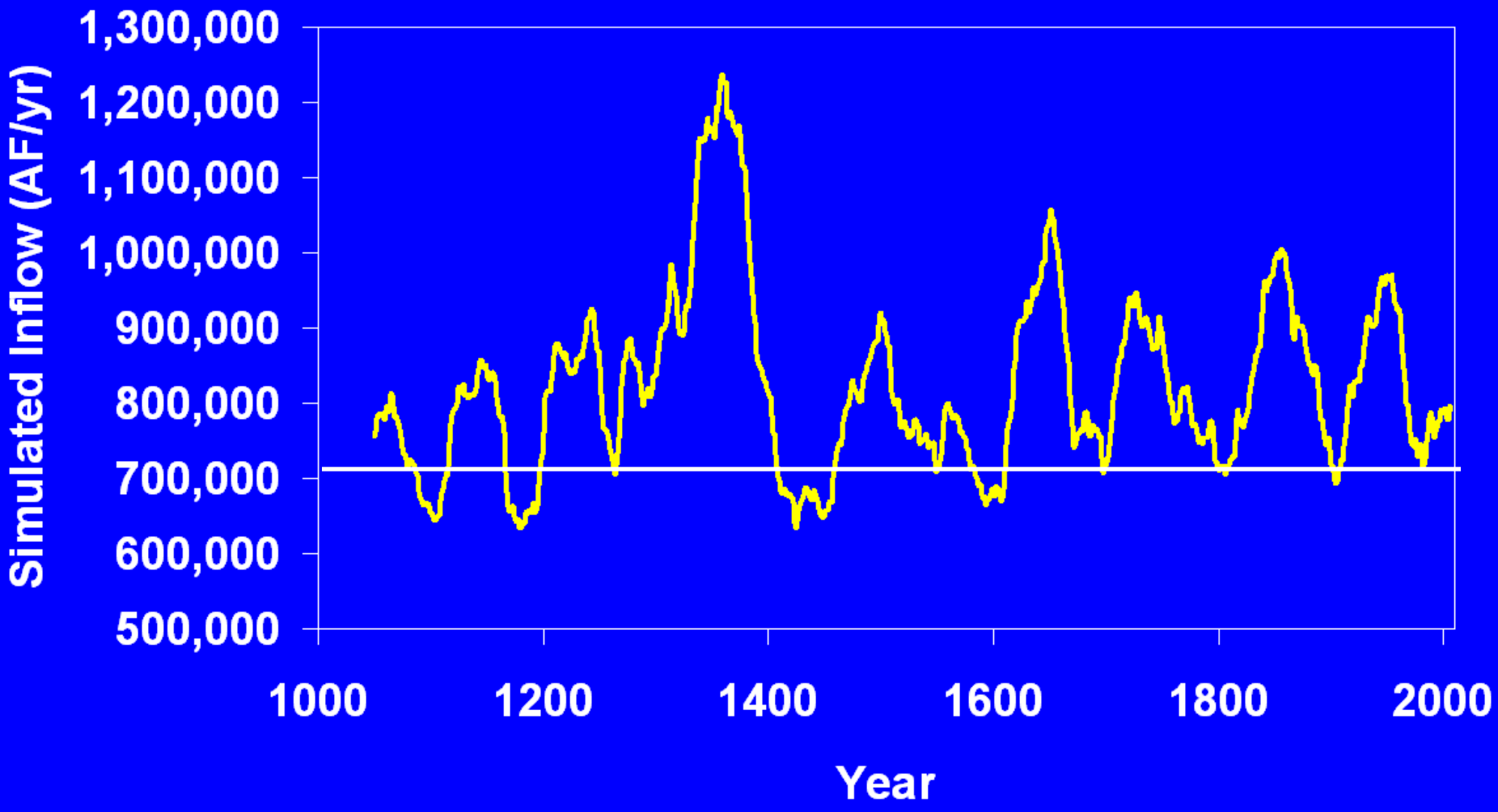
Simulated Inflow to Elephant Butte Reservoir
Running 50-Year Average



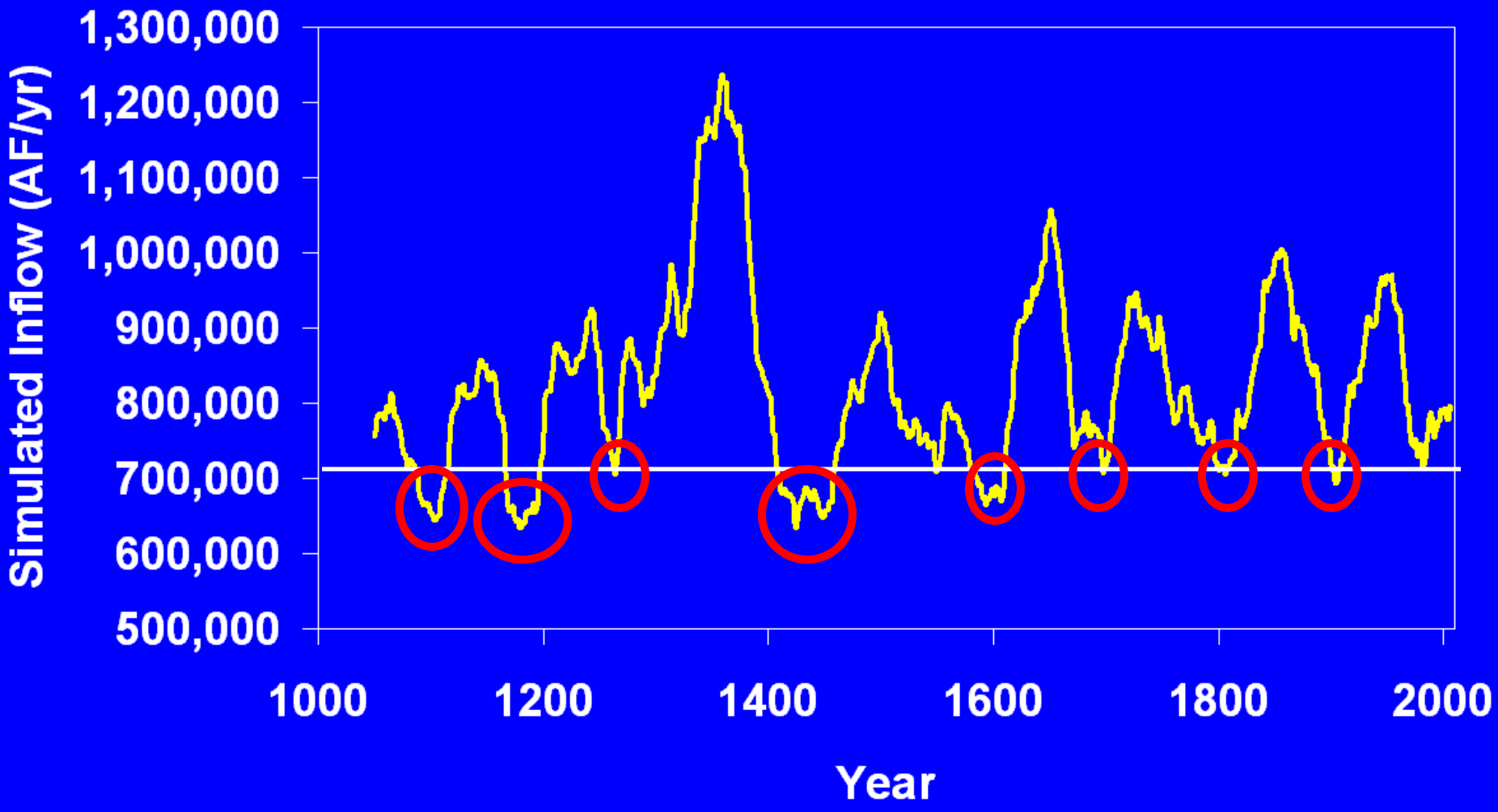
Simulated Inflow to Elephant Butte Reservoir
Running 50-Year Average



Simulated Inflow to Elephant Butte Reservoir
Running 50-Year Average



Simulated Inflow to Elephant Butte Reservoir
Running 50-Year Average



Regional Planning Recommendations

- IPCC predicts 5% decrease in EB inflow
  - Average of 21 GCMs
  - Range is 25% decrease to 10% increase
  - Natural variability has similar impacts
  - Recommend limited discussion in Regional Plan

Regional Planning Recommendations

- Recognize that Regional Planning Process is a form of “Adaptive Management”
- Total Water Management
  - Diverse portfolio of supply sources and demand management to meet future challenges
- Plan is updated every 5 years
  - Can “adapt” to changing circumstances

Potential Adaptive Strategies: EB Inflow Decrease

- Accept reduced groundwater levels
- Reduce per capita demand goal
- Increase reclaimed use
- Develop a more aggressive artificial recharge program
- Modify importation schedule

Is El Paso Vulnerable?

- Past EPWU/PSB investments were designed to deal with climatic variability
- Infrastructure and management approaches are adequate to meet goals of 2006 Region E Plan
  - Historic (1000 yr) conditions
  - IPCC Predictions


Questions?