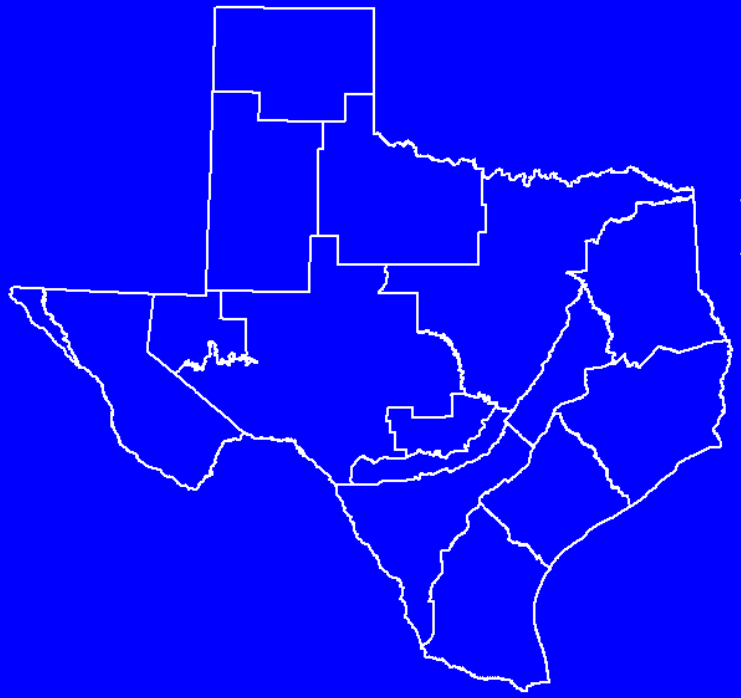
Comparing Groundwater Elevation Data and Groundwater Model Results in the Context of Desired Future Conditions



Bill Hutchison, Ph.D., P.E., P.G.

GSA Meeting

April 5, 2013

Topics

- Joint Planning
  - GCD, GMA, DFC, GAM and MAG
- Model Runs in the Development of DFCs
- Example of Comparing DFCs (Model Results) with Actual Data

Joint Planning

- Desired Future Condition (DFC)
  - Adopted by Groundwater Conservation Districts (GCD) within a Groundwater Management Area (GMA)
- Modeled Available Groundwater (MAG)
  - Calculated by Texas Water Development Board
  - Pumping that will achieve a DFC
  - Often accomplished with Groundwater Availability Models (GAM)

Desired Future Condition (DFC)

- Quantified conditions of groundwater resources
- Specified time or times in the future
- Broad Policy Goal
  - Drawdown
  - Spring flow
  - Storage volumes
- Updated at least every 5 years

Modeled Available Groundwater (MAG)

- TWDB calculates based on DFC
  - Models
  - Water budget calculations
  - District provided data and information
- Included in GCD Management Plans
- One factor in permitting decisions
- Replaces “Groundwater Availability” in Regional Water Plans

Model Runs (“Predictions”)

- Simulations of changes in:
  - Groundwater pumping and/or
  - Drought conditions
- Output examples:
  - Drawdown
  - Spring Flows
  - Storage Volumes

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DFC

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MAG

Role of Models

- Models are constrained by
  - Computational limitations
  - Assumptions
  - Knowledge gaps
- Tools to help inform decisions
- Models do not generate truth or make decisions

Important to Remember

- Groundwater management is more than just science
- Model results are not data
- Model results should be used by decision-makers to understand range of conditions

Objective

- Compare model results from DFC simulations with actual data
- Identify trends in “compliance”
- Identify areas with “deviations” and assess
  - Pumping assumptions (historic and projected)
  - Aquifer parameters
  - Boundary condition influence
- Use findings in next round of Joint Planning

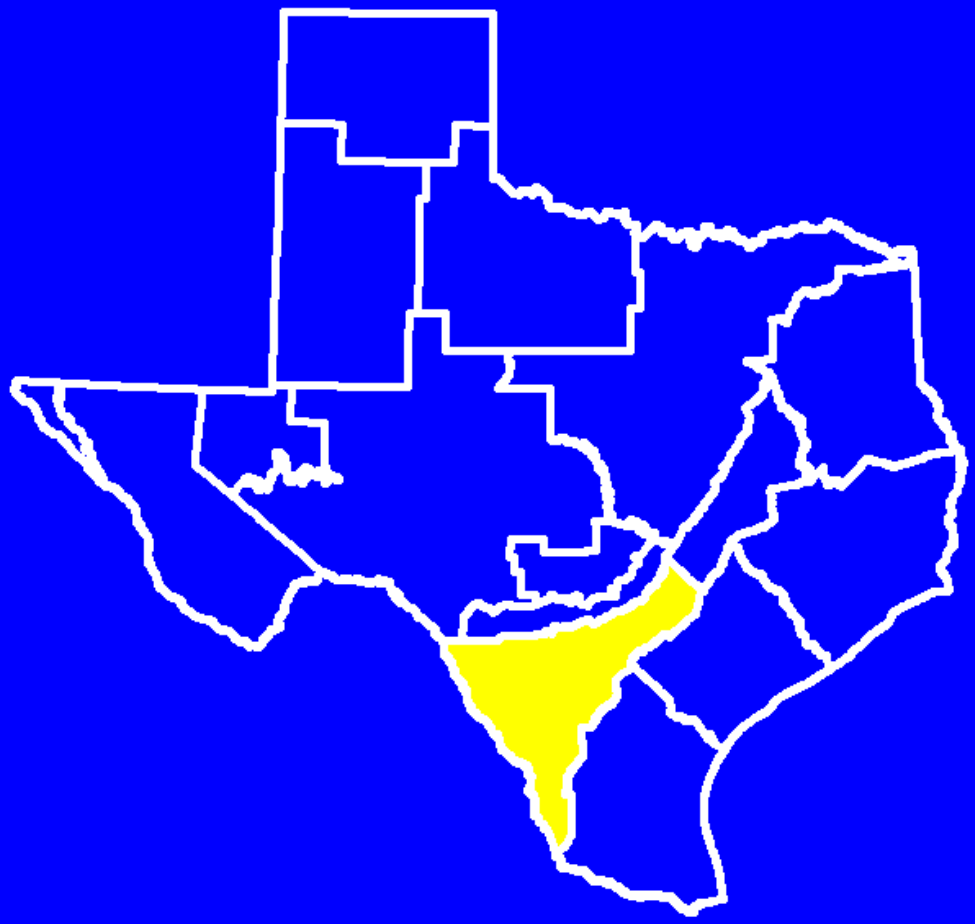
“Compliance” and “Deviation”

- No formal requirement to report on DFC “compliance” or “deviation”
  - Local management vs. state oversight
  - Statute provides for petition process with TCEQ if DFC is not being met or district is not managing to DFC
- Good practice to evaluate in the context of next round of Joint Planning

Applications

- Completed work in GMA 13
  - Shown today as an example
- Similar work completed in part of GMA 11
- Similar work near completion in
  - GMA 9 (excluding Kerr County)
  - Kinney County (parts of GMA 7 and GMA 10)
- Similar work about to start in Val Verde County (part of GMA 7)

GMA 13
Southern Carrizo-Wilcox Aquifer



GMA 13

- GMA 13 adopted a Desired Future Condition (DFC) for the Carrizo-Wilcox, Queen City and Sparta aquifers on April 9, 2010
- DFC establishment relied on results from several model simulations
  - DFC = GMA-wide average drawdown (23 ft)
    - Measured from end of 1999
  - Based on Scenario 4 of GAM Run 09-034
    - 61 year simulation (2000 to 2060)
    - Assumed a starting point: end of 1999

DFC and GAM Run

- Scenario 4 of GAM Run 09-034
  - Assumed average recharge each year for 61 years
  - Distribution and timing of pumping
    - Increase from 1999 amounts in some areas/layers
    - About the same as 1999 amounts in some areas/layers
    - Decrease from 1999 amounts in some areas/layers

Evaluate “DFC Assumptions” from 2000 to 2011

- Pumping locations
- Timing and amount of pumping increases
- Timing and amount of pumping decreases
- Adequacy of GAM to predict drawdown
- Appropriateness of average recharge assumption

DFC and GAM Run

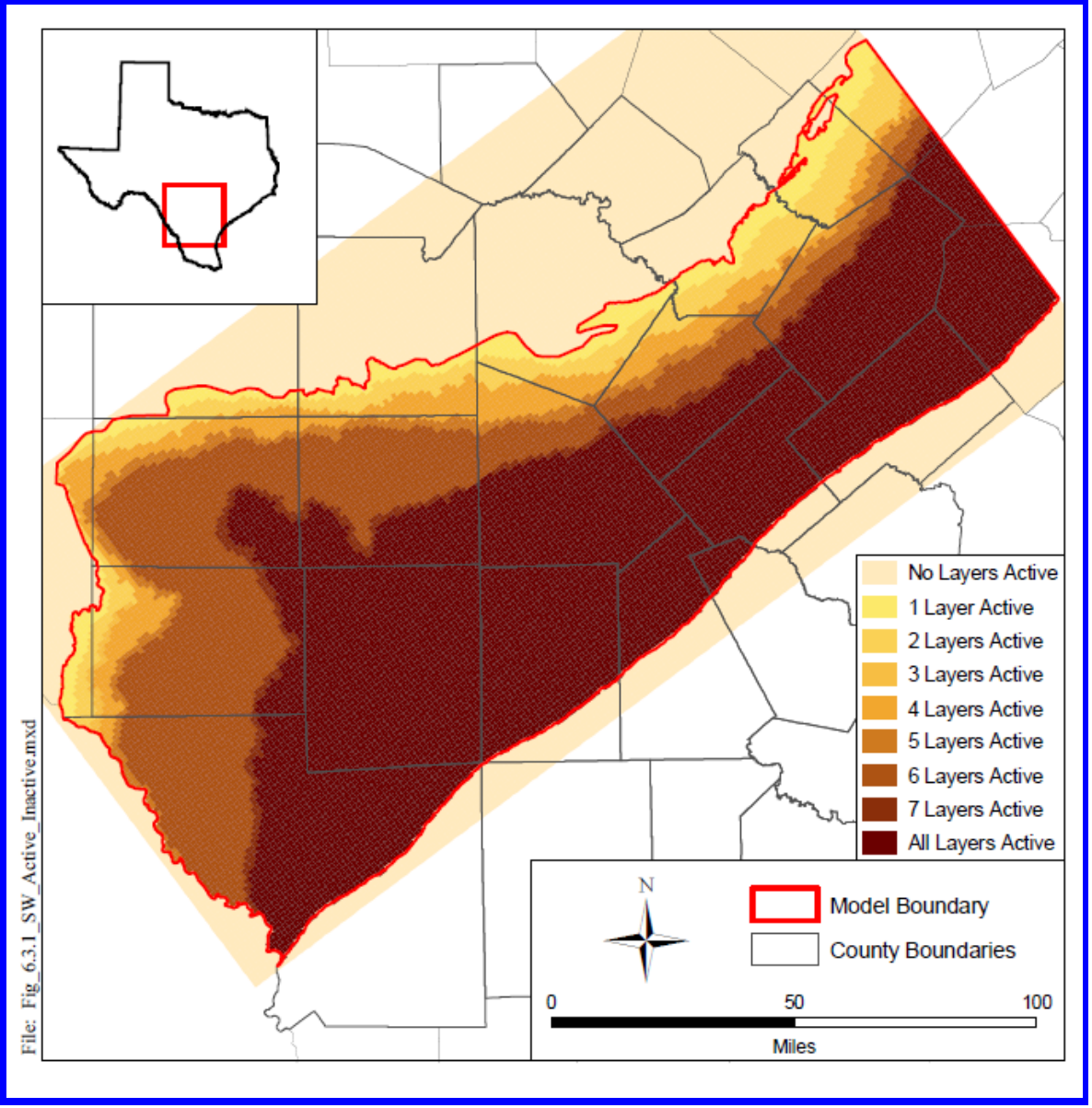
- How to measure DFC “compliance” with “idealized” model run?
- How to compare “average” drawdown over entire GMA (23 ft) with individual well measurements?

Point-by-Point Comparison

- Extract predicted groundwater levels/ drawdown from model files
- Compare to actual monitoring data
- Comparisons at discrete locations
- Limited use of averages

GAM for GMA 13

- Southern Carrizo-Wilcox, Queen City, Sparta



GAM for GMA 13

- One square mile grid cells
  - 112 Rows
  - 217 Columns
  - 8 Layers
  - 194,432 cells
  - 93,549 no-flow cells
  - 100,883 active cells
- GMA 13 = 82,029 active cells (~81% of model)

Calculation of "Average" Drawdown

- Each active cell (one square mile) groundwater elevation calculated at end of each "stress period" (one year)
  - Drawdown in each cell = groundwater elevation at the end of the year of interest minus the groundwater elevation at the initial time (end of 1999)
  - Sum the drawdowns for an area of interest (e.g. county, layer, county-layer, entire GMA)
  - Divide sum of drawdowns by the number of cells

For GMA 13

- DFC = 23 feet of drawdown in 2060
  - Average of 82,029 individual drawdown estimates
- Note that there are drawdown estimates each year (61 years)
  - Over 5 million individual drawdown estimates in GMA 13

Hypothetical Example of Average Drawdown

2	4	6	4	2
4	6	8	6	4
6	8	10	8	6
4	6	8	6	4
2	4	6	4	2

Avg = 5.2 ft

Hypothetical Example of Average Drawdown

	4			
4			6	
	8	10	8	6

Avg = 6.6 ft

Point-by-Point Comparison

- GAM Data
  - Top and bottom elevations of 8 layers for each cell (one square mile)
- Useful to identify layer completion of wells in TWDB database

TWDB Database

- Well location (latitude and longitude)
- Well depth
- Completion data (screen top and bottom)
- Groundwater elevation data
  - GMA 13 statistics
    - 1906 to 2012
    - 31,247 groundwater level measurements
    - 6,956 wells

GMA 13 Wells in TWDB Database

- 6,956 wells
  - 5,112 have no details of screened interval
    - Most of these have an aquifer designation
  - 1,844 have screen top and bottom

Integrate TWDB Database Wells with GAM

- 1,844 Wells with completion data
  - Locate each well in model grid (row and column)
- Identify appropriate layer(s) for the well
- Extract model data for each cell with a well
  - Aquifer parameters
  - Pumping
  - Groundwater elevations

Wells in a Single Model Layer

- 748 Wells in GMA 13
  - 92 with 10 or more groundwater level measurements with at least one past 2000 (hydrographs in the report)
  - 70 wells with late 1999/early 2000 measurement and at least one measurement at the end of year/beginning of year from late 2000/early 2001 to late 2011/early 2012 (drawdown comparison)

Compare Drawdowns in 70 Wells with DFC Drawdowns

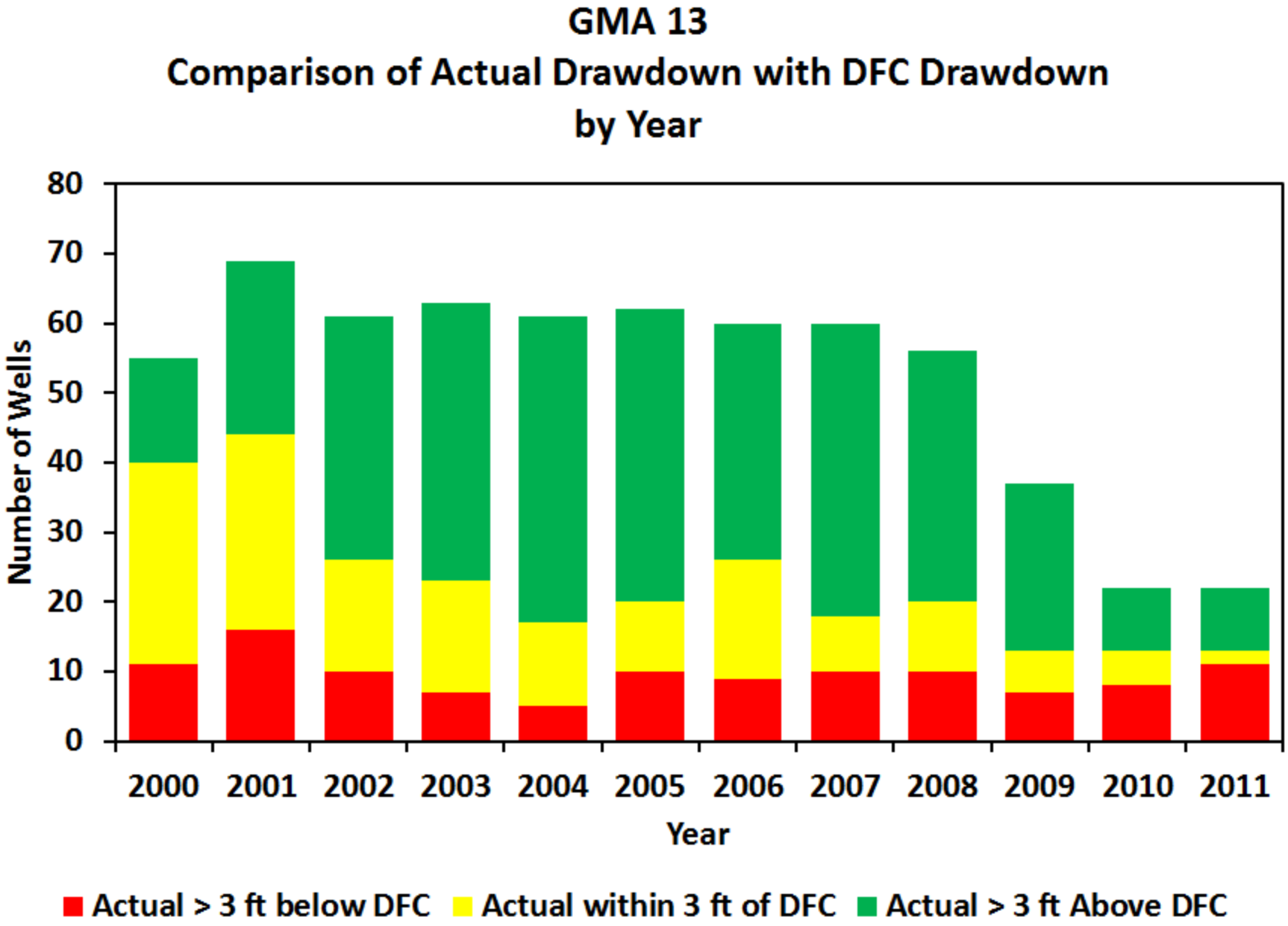
- Calculate drawdown from late 1999/early 2000 measurement
- 628 measurements
- Compare drawdown with DFC drawdown

Method

- DFC Drawdown minus Actual Drawdown for any given year
  - Positive number means that actual groundwater level is higher than DFC groundwater level
    - DFC drawdown = 10 ft
    - Actual drawdown = 8 ft
    - Difference = 2 ft
  - Negative number means that actual groundwater level is lower than DFC groundwater level

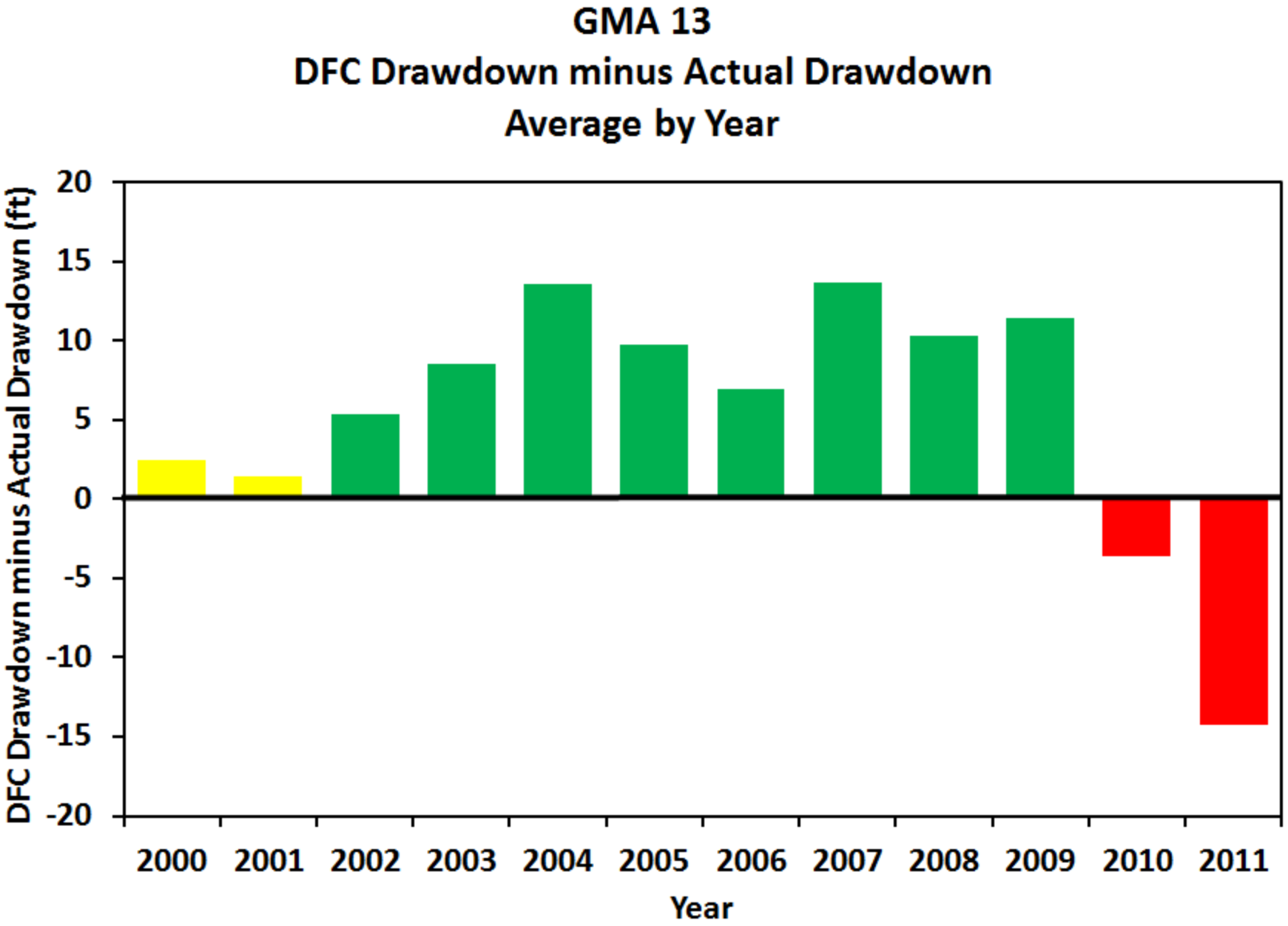
Summary of Year-by-Year

- 2000 to 2011
- Three groups to summarize by year
  - Green = > 3 ft difference
  - Yellow = difference is within +/- 3 ft
  - Red = < -3 ft difference


GMA 13
Comparison of Actual Drawdown with DFC Drawdown by Year
Number of Wells
0
10
20
30
40
50
60
70
80
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Actual > 3 ft below DFC
Actual within 3 ft of DFC
Actual > 3 ft Above DFC

Summary of Year-by-Year

- Take average difference for each year
- Compare to precipitation


GMA 13
DFC Drawdown minus Actual Drawdown
Average by Year
DFC Drawdown minus Actual Drawdown (ft)
20
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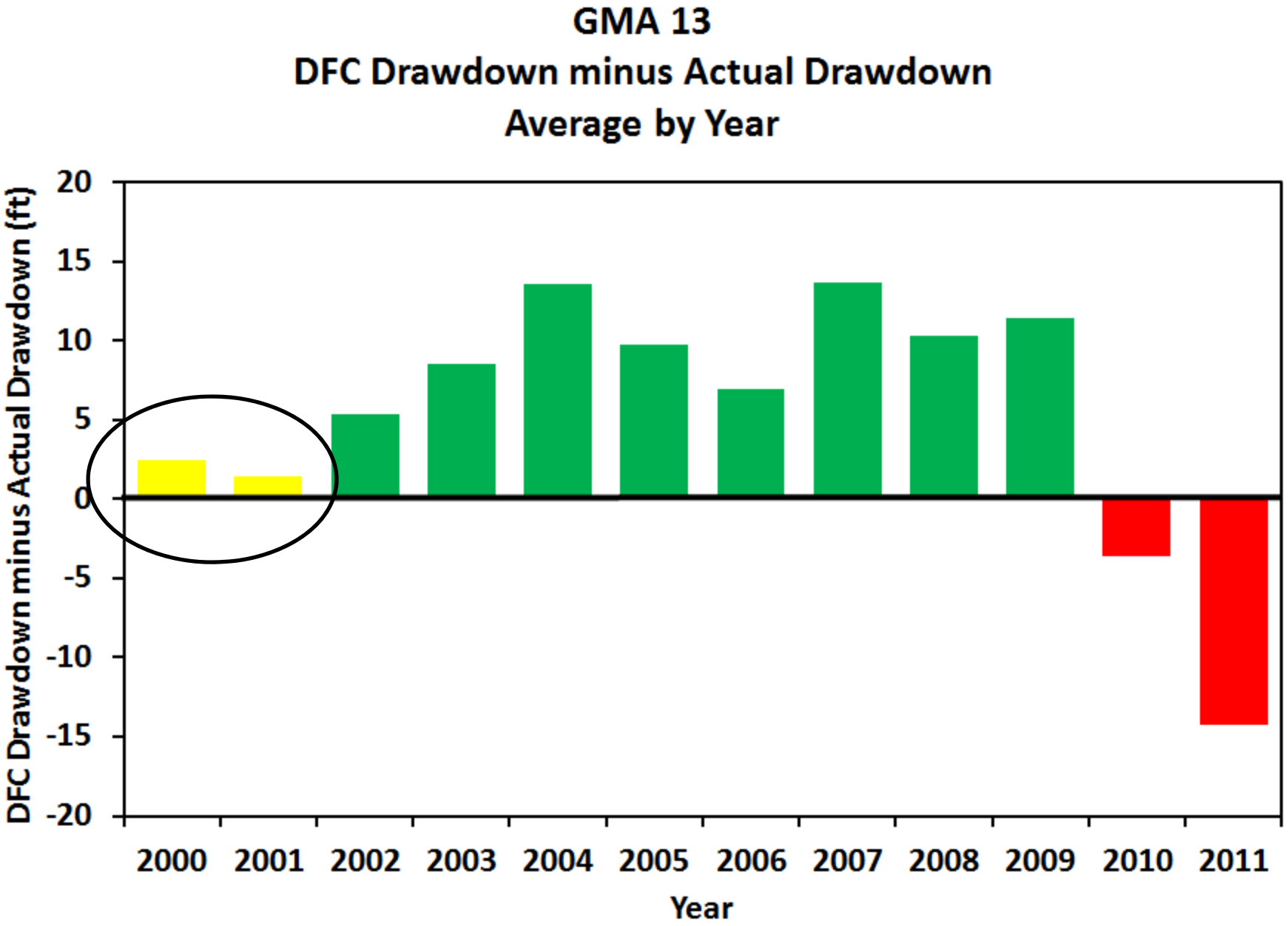
Year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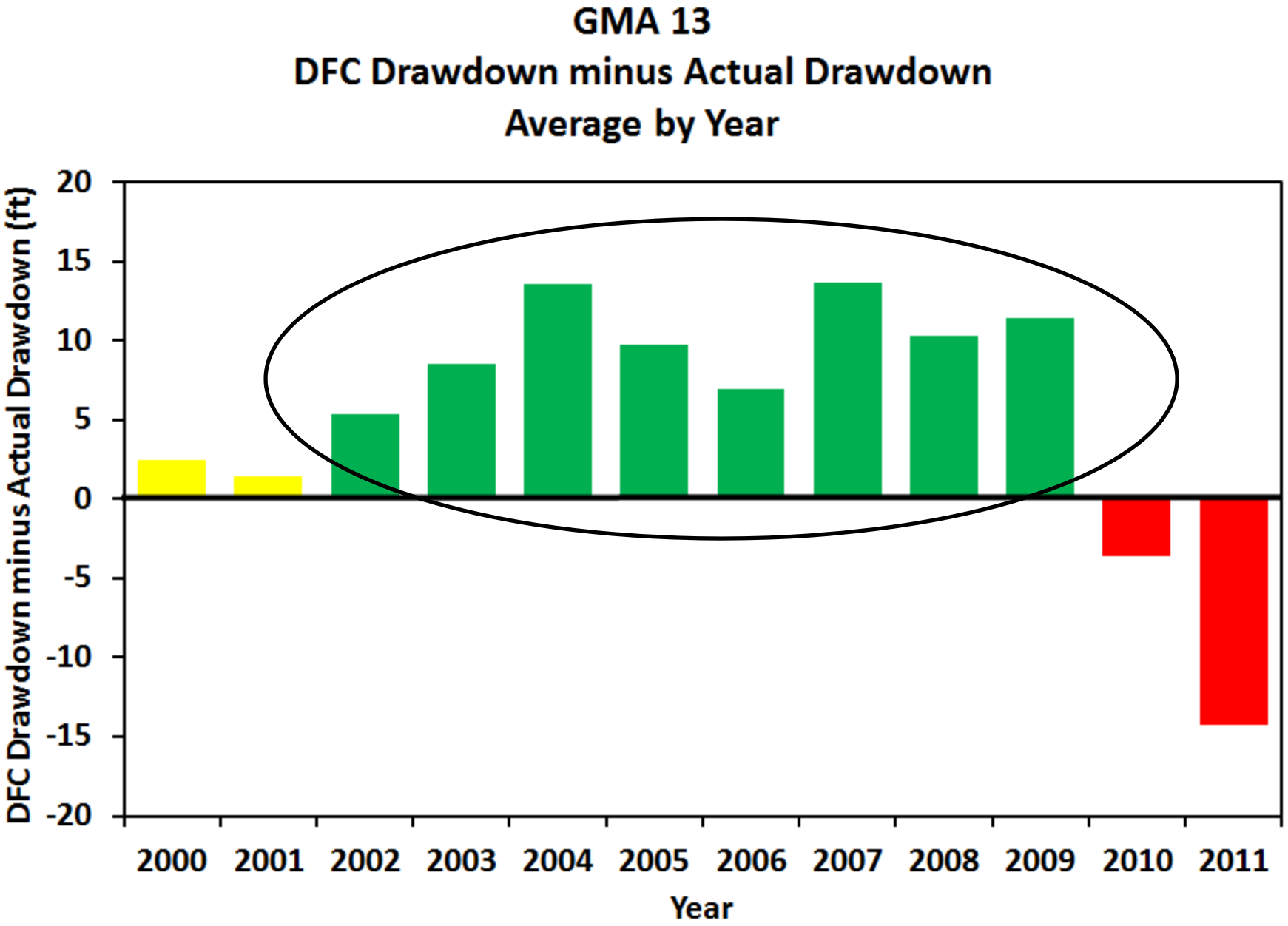
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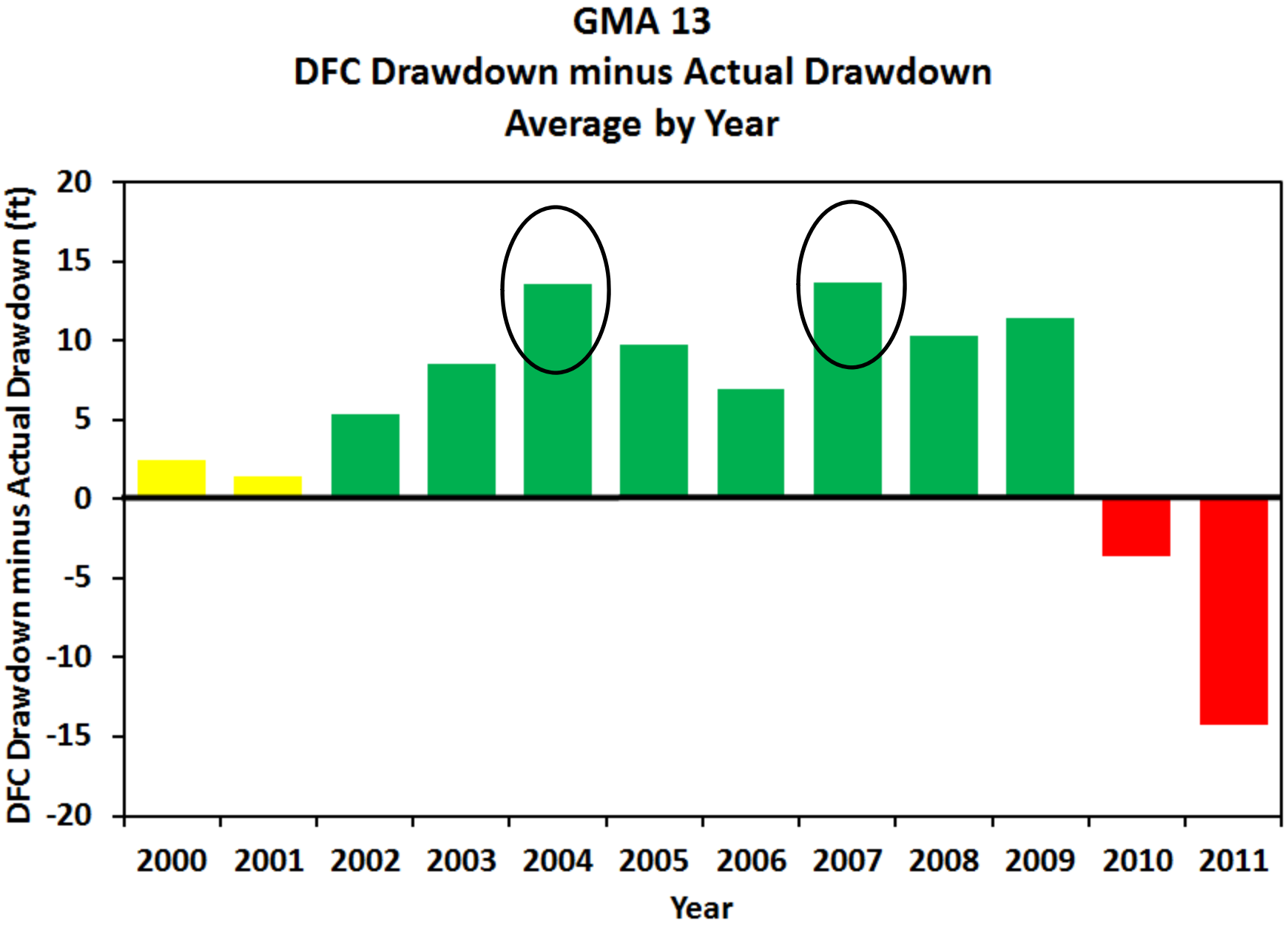
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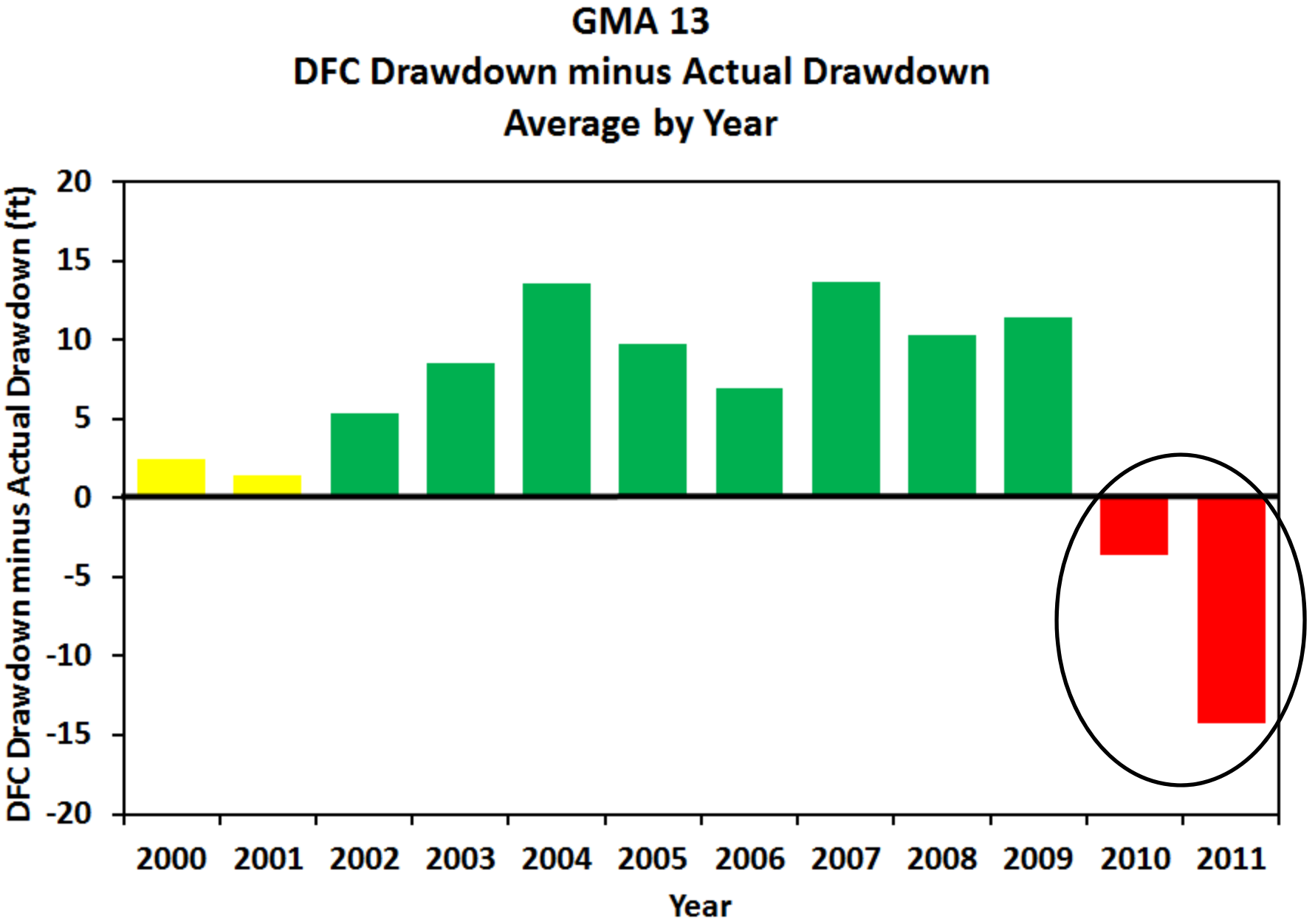
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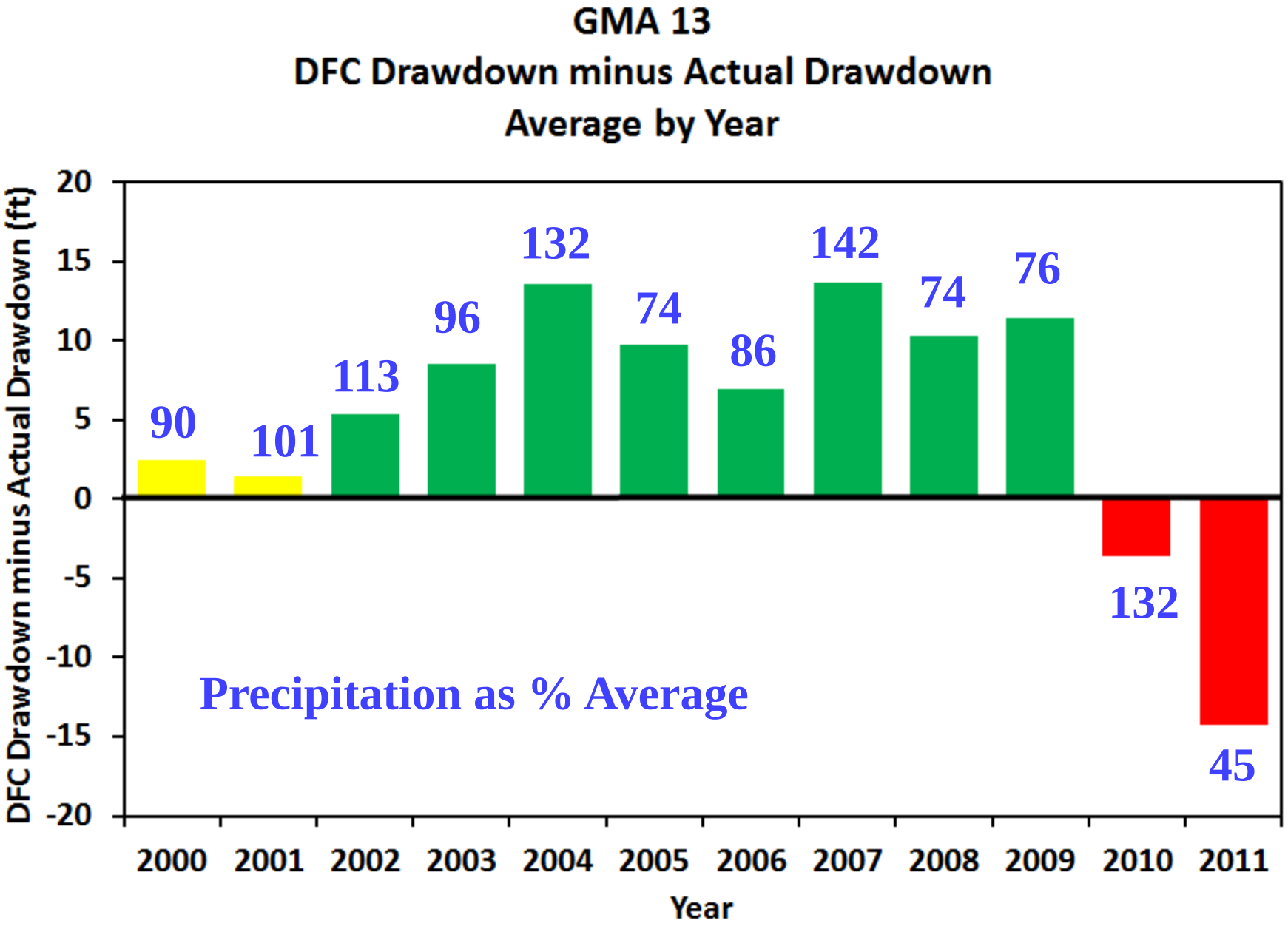
Precipitation

- Annual Precipitation from State Climatologist Website
  - Corpus Christi
  - Del Rio
  - San Antonio
- Sum of three stations
- Express as percent average of sum of average precipitation of three stations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-20
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132
74
86
142
74
76
132
45
Precipitation as % Average
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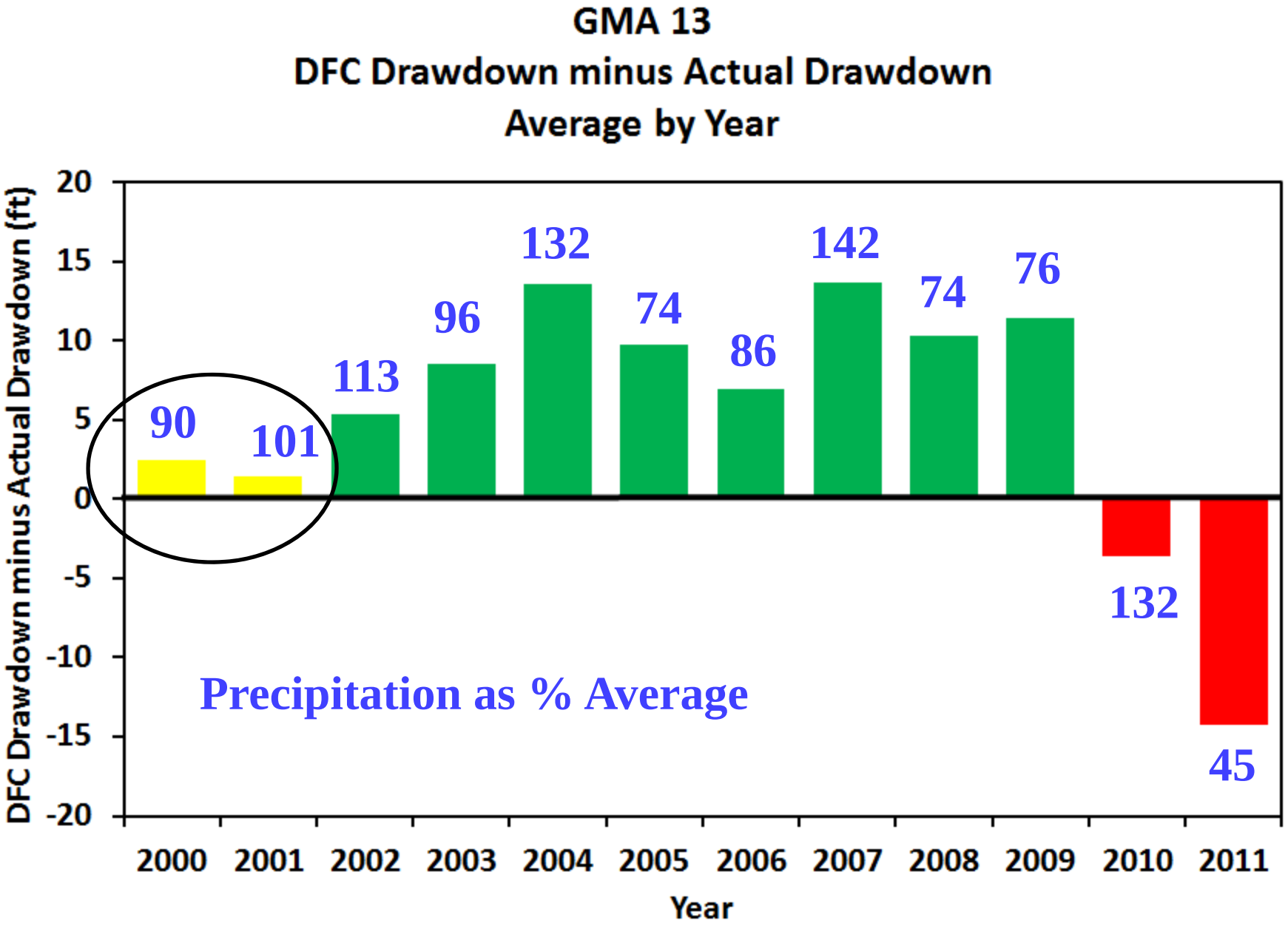
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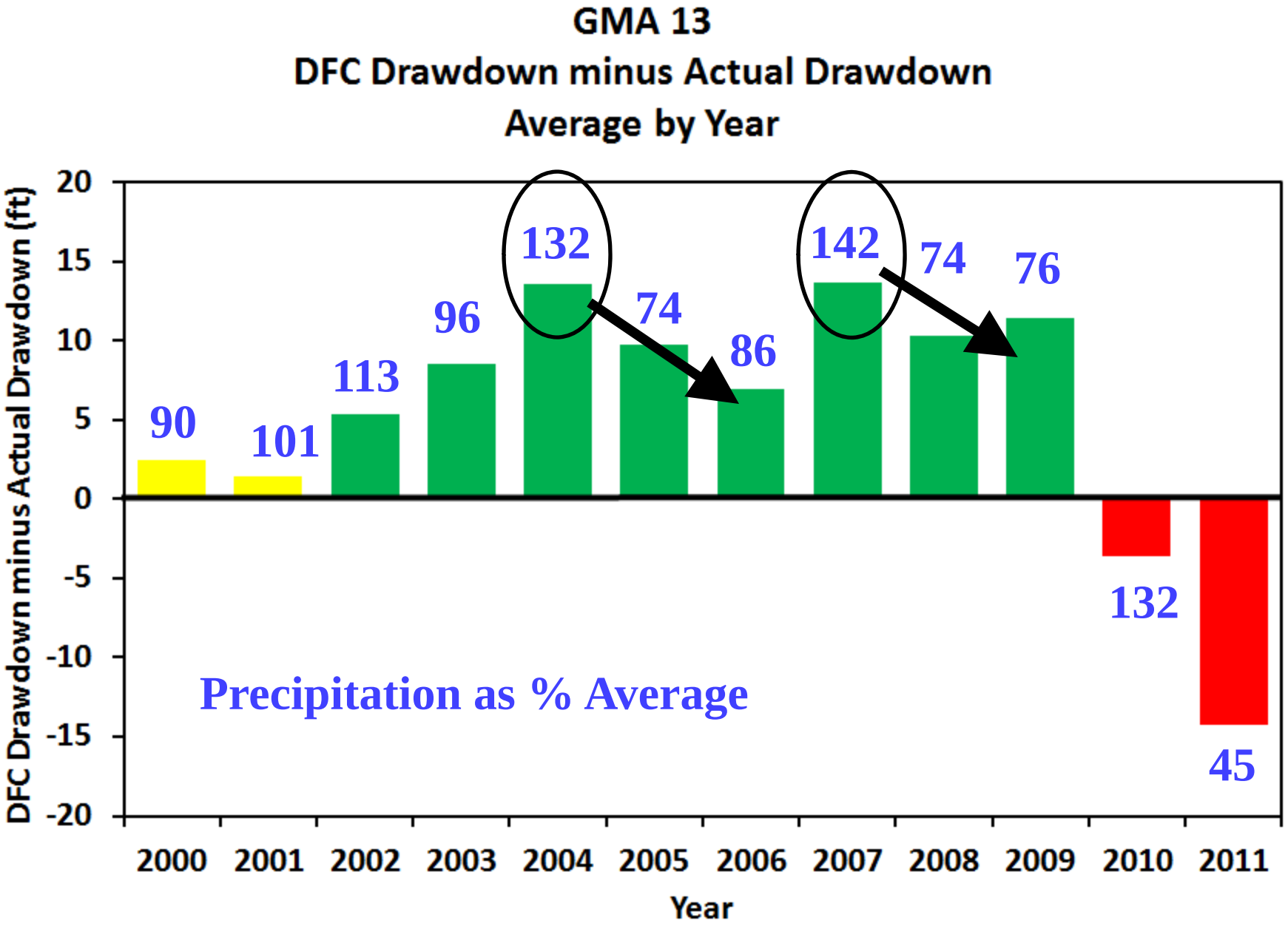
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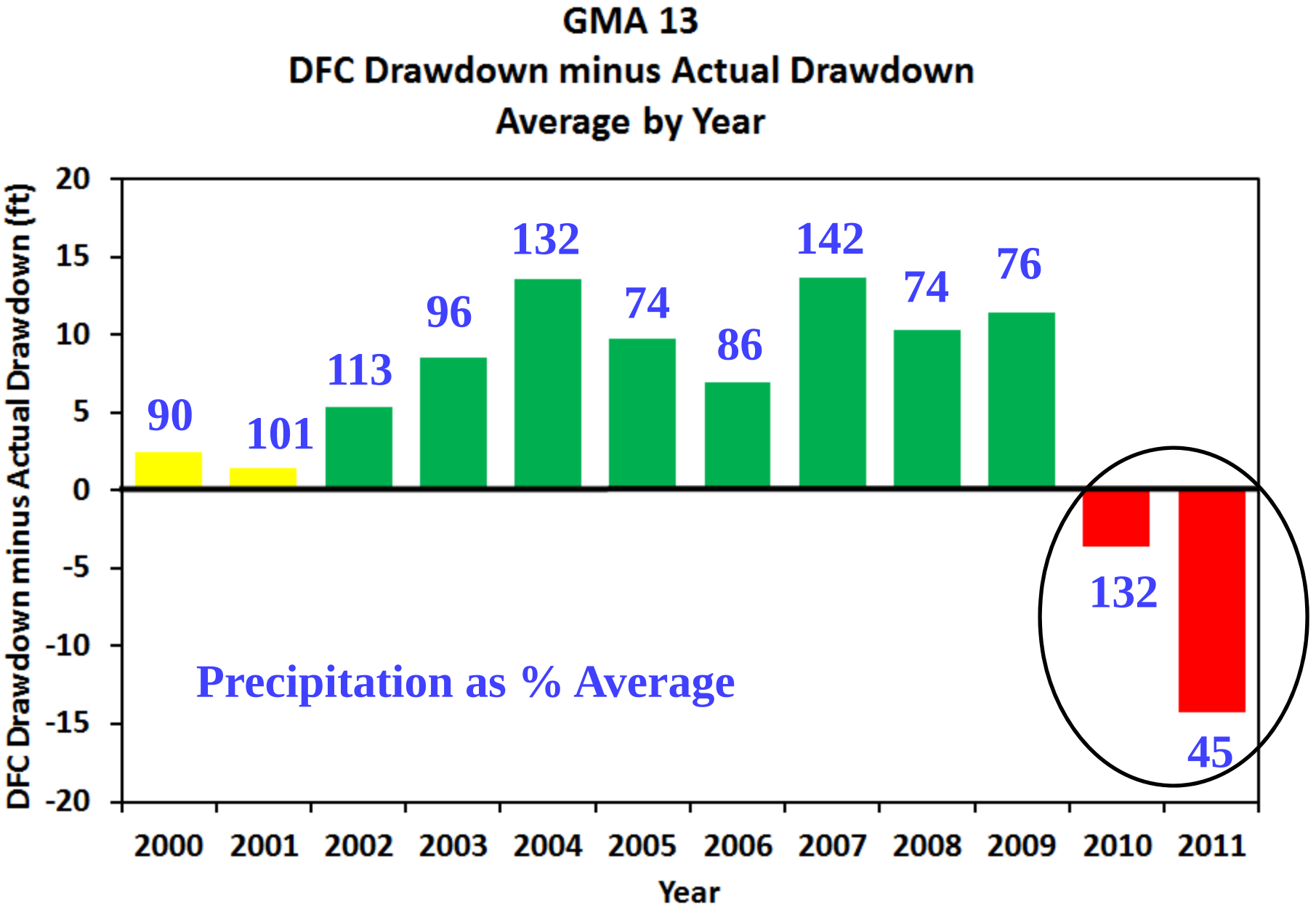
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Observations

- Actual drawdown less than DFC drawdown
- Exception in 2010 and 2011
  - Increased use due to drought and increased pumping from hydraulic fracturing?
  - Decreased recharge due to drought?
  - Skewed by wells with data?
- Suggests that simulations of something other than “average” recharge for 61 years would be appropriate

Current Round of Joint Planning

- Completed this analysis in late 2012
- Draft report/final report in early 2013
- Results useful for guiding current joint planning effort

Issues for Current Round of Joint Planning

- Improvements in pumping from 2000 to present
  - Model calibration ended in 1999
  - Change in starting point to DFC drawdown?
  - Work in progress
- Pumping from present to 2060 (2070?)
  - Hydraulic fracturing estimates
  - Groundwater export estimates

Issues for Current Round of Joint Planning

- How to better incorporate actual well data in DFC statement
  - Specific indicator wells (unconfined, confined) to supplement and complement averages derived from model simulations
  - Recognize that the GAM will be used by TWDB to develop MAG
  - Ongoing discussion in GMA 13

Questions?

Bill Hutchison
512-745-0599
billhutch@texasgw.com