

# Science and the Future of Colorado River Policy and Compact Issues

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# Introduction

**The current (recent?) drought on the Colorado River System has opened our eyes and raised new questions concerning the reliability of Colorado River water supplies.**

**Representatives of Interior and the seven Basin States are currently meeting to address river management issues. Should the objective be to “get through” the drought, which assumes conditions will return to “normal” or should it be to address longer term structural problems caused by a demand for water which may exceed the available supply?**

# Introduction (con't)

- If we utilize the 20<sup>th</sup> Century gauge record, Reclamation's modeling tells us risks of continuing drought are low and the system should recover. If we consider the longer term record, we could be in for big trouble.

**WHAT SHOULD THE BASIN WATER OFFICIALS DO?**

# Overview of the 1922 Colorado River Compact

- Compact divides the Colorado River, including all tributaries, into an Upper and Lower Basin.
- The boundary between the two basins is Lee Ferry, Arizona
- The Lower Division states are Nevada, California and Arizona.
- The Upper Division states are Wyoming, Colorado, New Mexico and Utah.
- Arizona, Utah and New Mexico have lands within both basins.



CALIFORNIA

NEVADA

UTAH

ARIZONA

NEW MEXICO

COLORADO

WYOMING

# The Hydrologic Guts of the Compact are in Article III

- III (a). “There is hereby apportioned . . . in perpetuity to the Upper Basin and to the Lower Basin . . . the exclusive beneficial consumptive use of **7,500,000 af** per annum . . . .”
- III (b). “In addition to . . . paragraph (a) the Lower Basin is hereby given the right to increase its beneficial consumptive use . . . by one million af per annum.”

# Article III (con't)

- III (c). Provides that water for Mexico “shall be supplied first from the waters over and above . . . paragraphs (a) and (b); and if such surplus shall prove insufficient . . . the burden . . . shall be equally borne by the Upper Basin and the Lower Basin and the Upper Division states shall deliver at Lee Ferry water to supply (its obligation) . . . in addition to that provided in paragraph (d).
- III (d). The states of the Upper Division will not cause the flow . . . at Lee Ferry to be depleted below an aggregate of **75,000,000 af** for any ten consecutive years . . . ”

# Hydrological Assumptions in 1922

**SOURCE:** Compact Minutes of the Sixth and Eighth Meeting

- Average actual flow at Yuma is **17,300,000 af/yr** (1901-1921 gauge record)

- Commission assumed flow at Lee Ferry is 86% of flow at Yuma

$$17,300,000 \times .86 = 14,964,000$$

- Reclamation Service estimate of depletions in the Upper Basin

$$2,267,000 \text{ af/yr}$$

- **14,964,000 + 2,267,000 = 17,231,00 af/yr**



# The Mexican Treaty of 1944

- Article X. guarantees an annual delivery of **1.5 maf** per annum.
- Provides for an additional **.2 maf** per annum when there is a surplus.
- Allows the United States to reduce deliveries during an “extraordinary drought” by the same proportions. As consumptive uses in the USA are reduced.

# The 1948 Upper Colorado River Basin Compact

- Provides Arizona with **50,000 af** per annum, with the remainder as follows:
  - 51.75 % to Colorado
  - 23.00 % to Utah
  - 14.00 % to Wyoming
  - 11.25 % to New Mexico
- “Consumptive use” is defined as man-made depletions to the native (virgin) flow at Lee Ferry.

NOTE: this definition includes CRSP Reservoir evaporation.

# Two Major Unresolved Compact Issues that Impact Colorado's Available Colorado River Water Supply

- The conflict between Articles III (a) and III (d)
  - which is controlling?

*Stated in other words:*

Must the Upper Basin have to forgo a portion of its **7.5 maf** III(a) supply to deliver the **75 maf**/10 years as required by III(d)?

- Do the Lower Basin tributaries, especially the Gila, have a share in the obligation to meet the Mexican Treaty deliveries?

# Why is this Important?

Because it impacts Colorado's available water supply, and thus, our future.

Depending on the hydrologic Compact assumptions concerning the available water supply:

- Colorado has either a lot of water to develop - upwards of another million acre feet,
- OR -
- Colorado may already be at or above full development of its Colorado River supplies.

# How Much Colorado River Water is Colorado Currently Using?

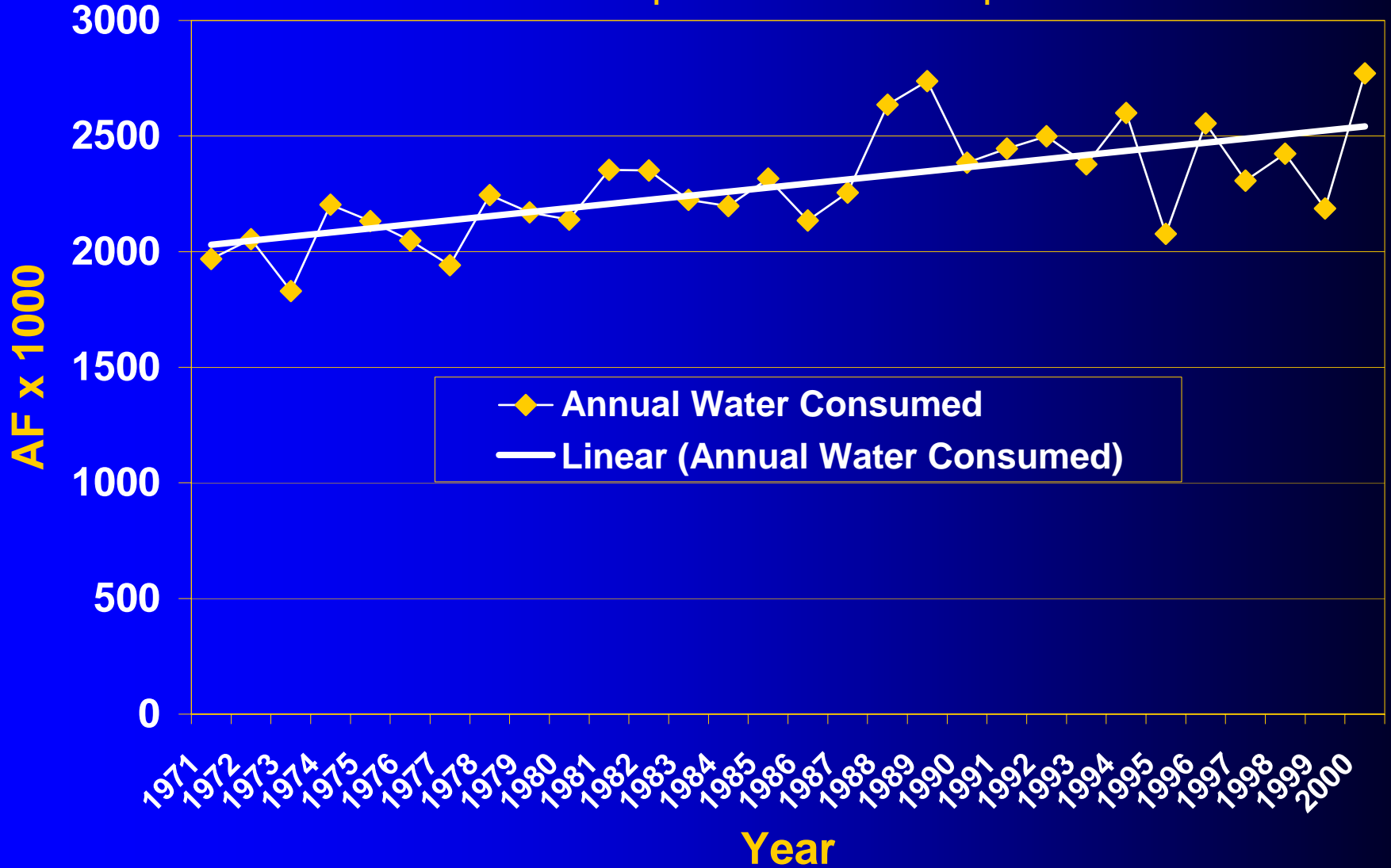
Every five years the Secretary of the Interior publishes the Colorado River System Consumptive Uses and Losses Report. Thirty years of data are available; the latest report covers 1996-2000.

There are a lot of critics of the report. The CWCB and River District staff believe it overstates Colorado irrigation uses in certain years.

Other critics believe it understates Upper Basin irrigation uses. **HOWEVER**, until revised (if ever) it is the official record of the Secretary of the Interior.

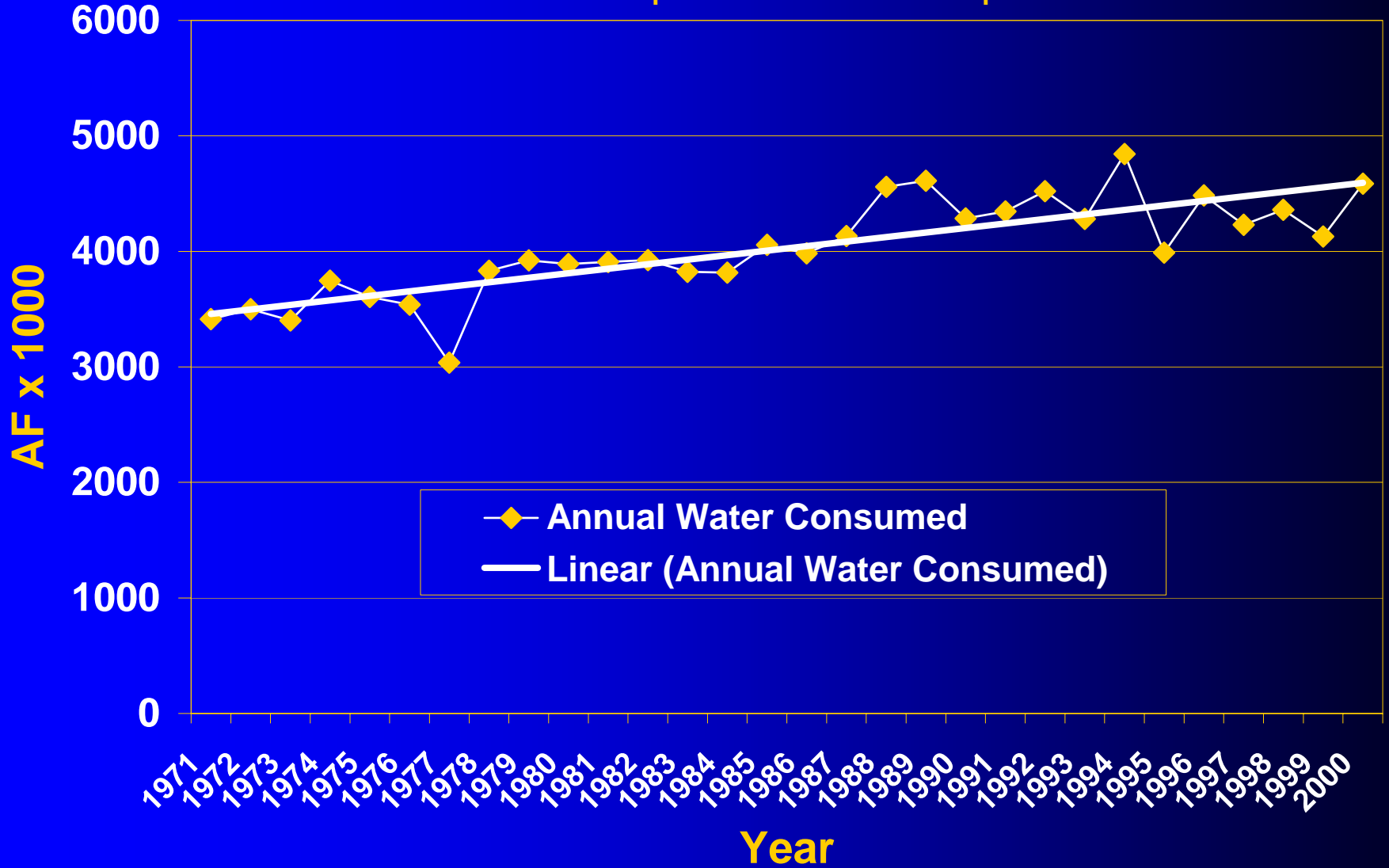
# Total Colorado Consumptive Use

Source: Consumptive Uses and Losses Report - USDOI



# Upper Basin Consumptive Use

Source: Consumptive Uses and Losses Report - USDOI



# Conclusion

Based on the Consumptive Uses and Losses Reports and including Colorado's share of CRSP reservoir evaporation:

COLORADO IS CONSUMING IN THE RANGE OF **2.5** to **2.8 maf** PER ANNUM.

Likewise;

THE UPPER BASIN STATES ARE USING IN THE RANGE OF **4.5** to **5.0 maf** PER ANNUM.



# How Much Water is Available for Colorado to Use?

- This depends ultimately on how the compact issues are resolved, AND
- The assumptions we make on how much water is available, where its diverted in the Upper Basin, AND
- The basic assumptions on inflow to Lake Powell, which is highly variable.

# Different Scenarios

1) Noah's estimate:

$$0.5175 \times (7,500,000 - 50,000) = \mathbf{3,855,000 \text{ af}}$$

2) Reclamation's hydrologic determination:

- Based on the 1954-1965 hydrology (Reclamation assumes a **11.6 maf** ave. undepleted inflow to Lake Powell)
- Assumes a Lee Ferry delivery of **8.25 maf/annum** (**7.5 maf** for the Lower Basin plus **750kaf** for Mexico).

$$0.5175 \times (6,000,000 - 50,000) = \mathbf{3,079,000 \text{ af}}$$

3) The 1965 hydrology with no deliveries from Upper Basin to Mexico – approximately **3,450,000 af**.

# Significant Study 1

In 1965, Tipton and Kalmbach did a study for the UCRC (used 1931 – 1964 hydrology). Tipton was very concerned with a **13.2 maf/year** mean.

This study concluded that if the Lee Ferry annual delivery is **8.25 maf**, the Upper Basin's share (after CRSP evap) could be as low as **4.8 maf**.

With evaporation, this equates to a COLORADO SHARE OF **2.7 maf** per annum.

## **In 1965, Tipton made the following comment:**

“There is evidence to indicate that river flows along with other phenomena associated with and dependent upon climatic and meteorological conditions go through periods of high occurrences followed by periods of low occurrences. However, the occurrences do not follow any regular or cyclic pattern . . . .”

## Significant Study 2

Based on reconstructed flows from tree ring studies, Stockton and Jacoby (1976) suggest there are a number of extended periods when inflow to Lake Powell was less than the 1954 to 1965 period.

Stockton and Jacoby concluded that the mean undepleted flow at Lee Ferry is **13.5  $\times$  5 maf/yr.**

# Significant Study 3

The October 1995 water resources bulletin of AWRA published a series of articles on severe sustained drought in the southwest.

A paper authored by Ben Harding, Taiye Sangoyomi and Elizabeth Payton modelled the Colorado River Basin based on a reconstructed drought from 1579 to 1616 and 1992 depletion levels.

“Lake Powell contents were drawn down to dead storage by the end of year 18. Active storage in Lake Powell was zero for eight years.”

# Sobering Thoughts

Can you imagine the impacts to this region if, for a period of six years, projects such as the CB-T, Dillon Reservoir, Fry-Ark, Moffat Tunnel Collection System, Homestake, Twin Lakes, Wolford, Dallas Creek, Dolores and Central Utah Project, San Juan-Chama, etc., could not legally divert a drop of water?

**What does science tell us about the Colorado River and its future?**

**Can we rely on past hydrology to describe the future with sufficient reliability to make reasonable plans?**

**What are the policy implications of changing conditions on the Colorado River?**



**The Bureau of Reclamation, Denver Water, Aurora, the CWCB, and almost every other major basin water provider uses modeling based on the historical record.**

***Is this a wise process?***

***If not, what are the alternatives?***

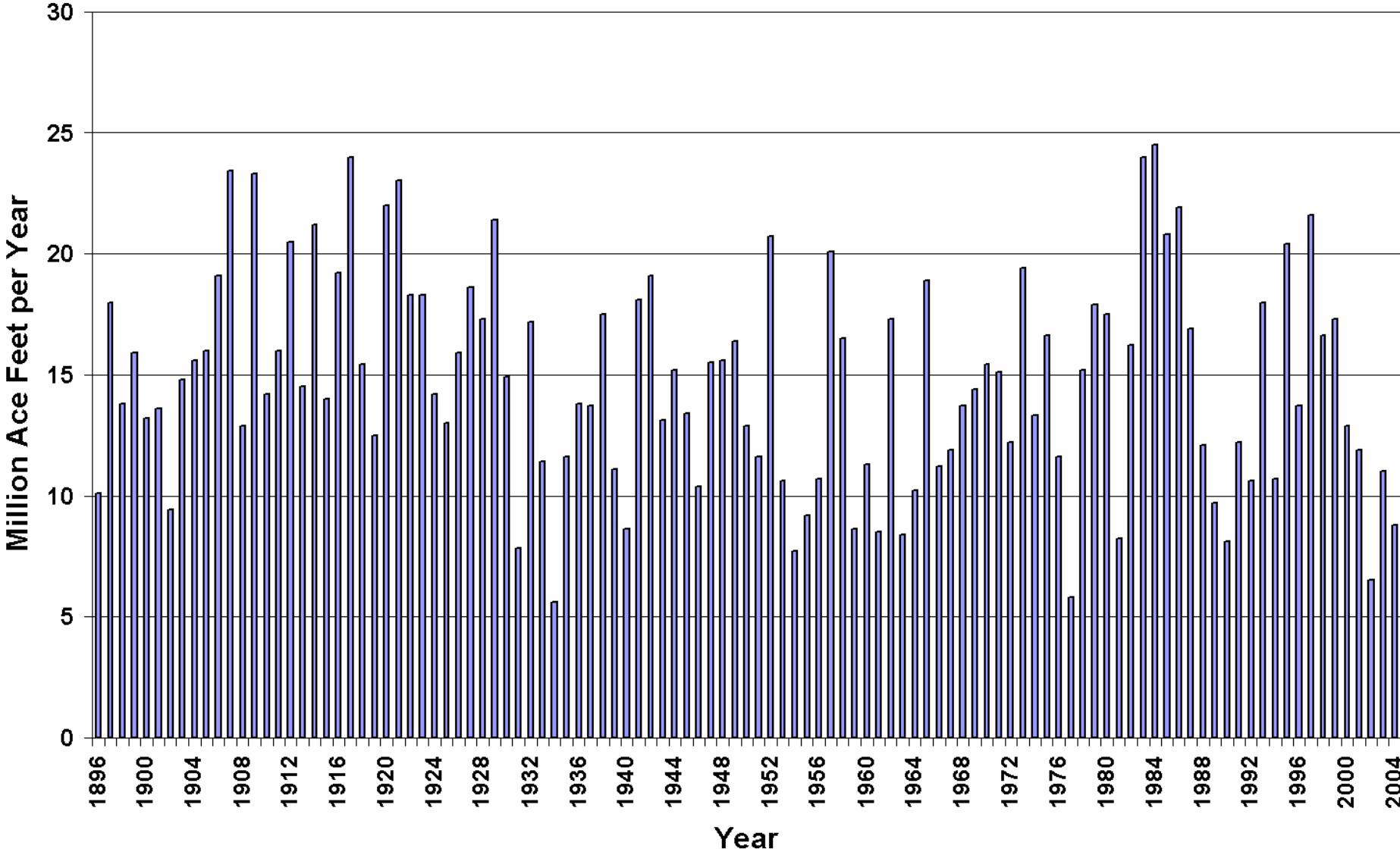
# Sources

“Virgin Flow at Lee’s Ferry.” – Annual Reports of the Upper Colorado River Commission (I estimated 2004)

“Atlantic Multidecadal Oscillation Index – Pacific and Atlantic Ocean Influences on Multidecadal Drought Frequency in the United States.” McCabe, Palecki & Betancourt

“Mean Annual Northern Hemisphere Temperature Data.” Climate Research Unit, East Anglia U.K.

# Estimated Virgin Flow at Lee Ferry

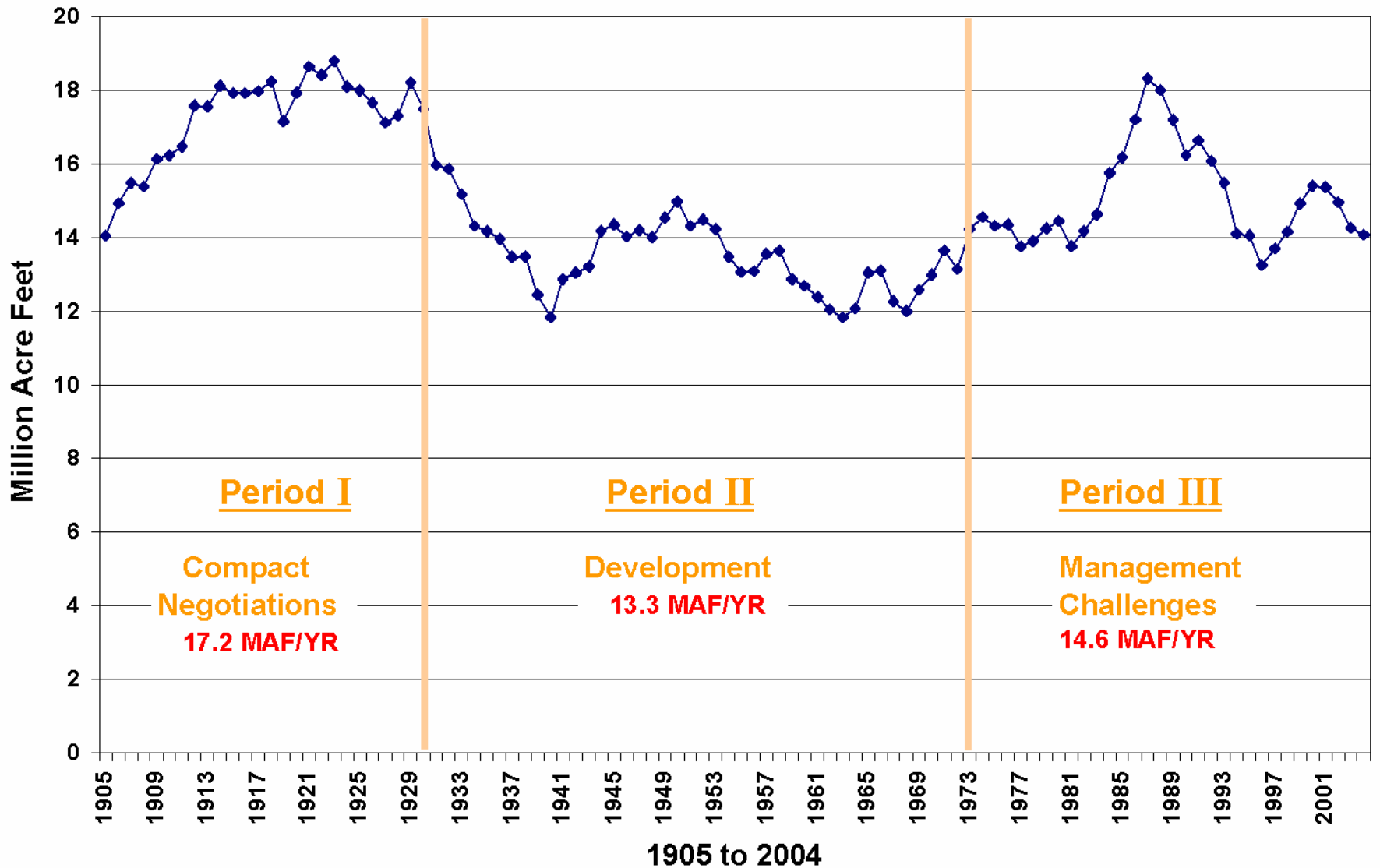


# **The Colorado River Gage History Can be Divided into 3 Distinct Periods**

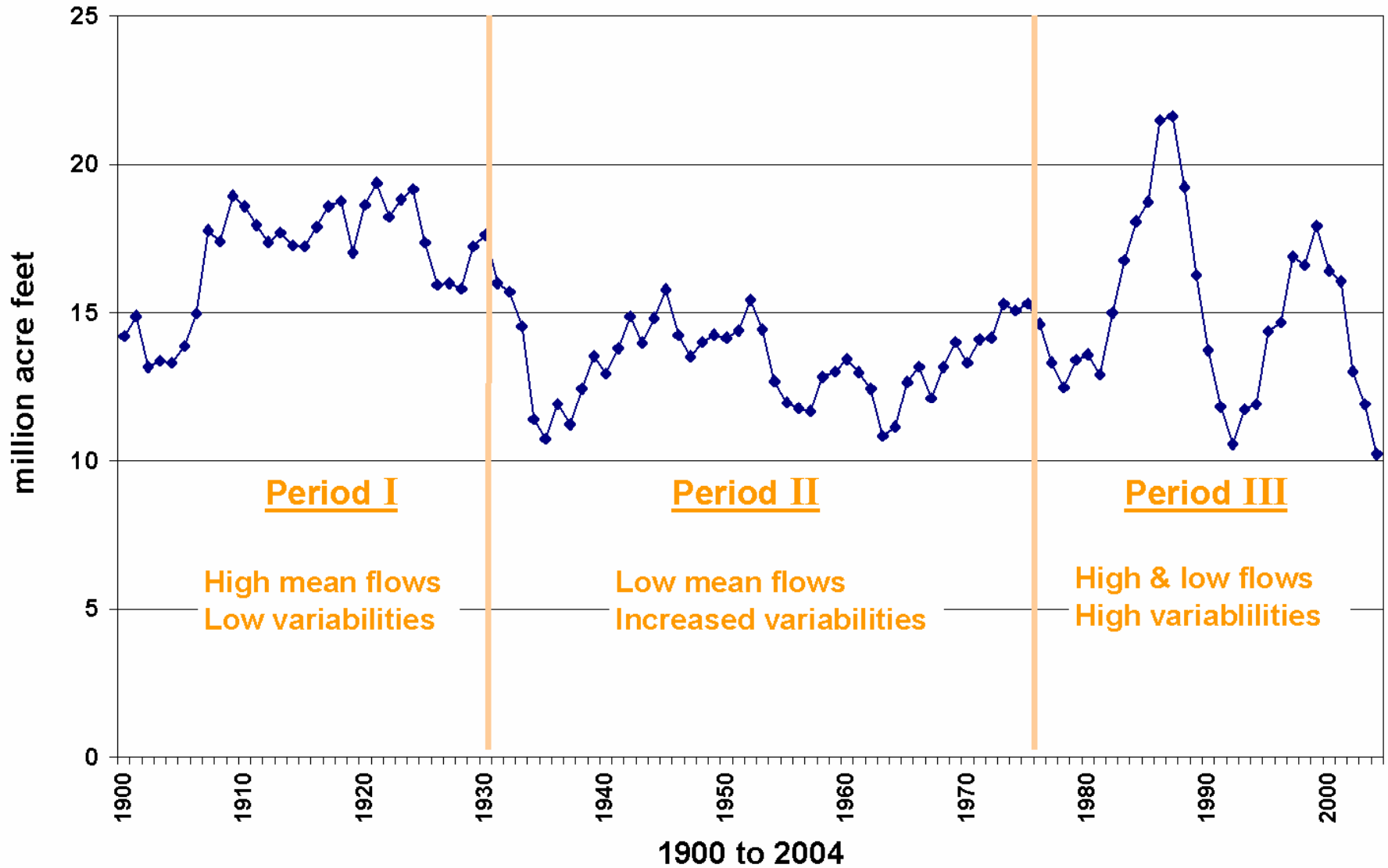
- **Period I Early 1900s to about 1930**
- **Period II 1931 to the early 1970's**
- **Period III Early 1970's to Present**

**The undepleted flows, climate conditions, challenges and river politics during each of these periods were all very different.**

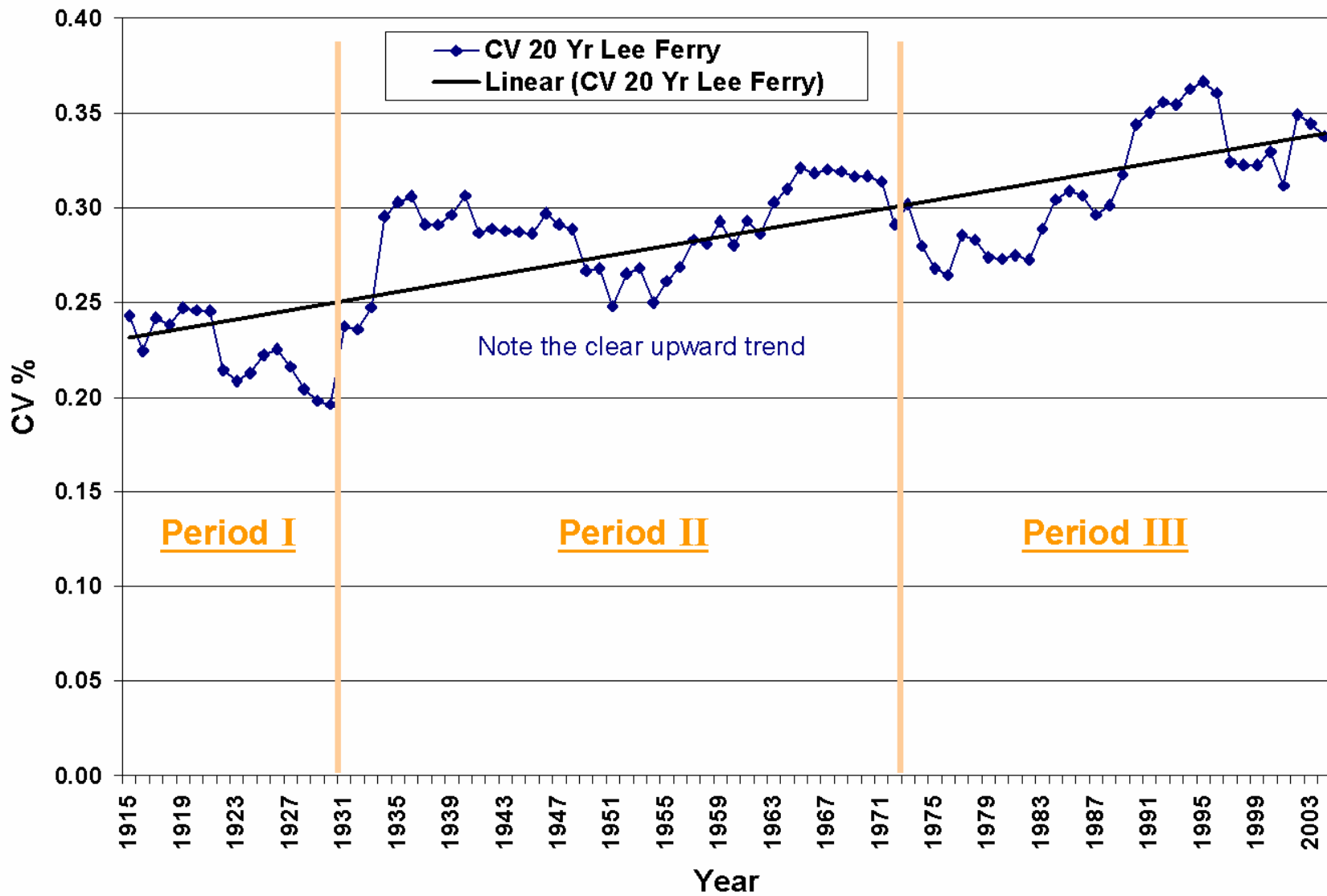
# Lee Ferry Virgin Flow 10 Year Running Average



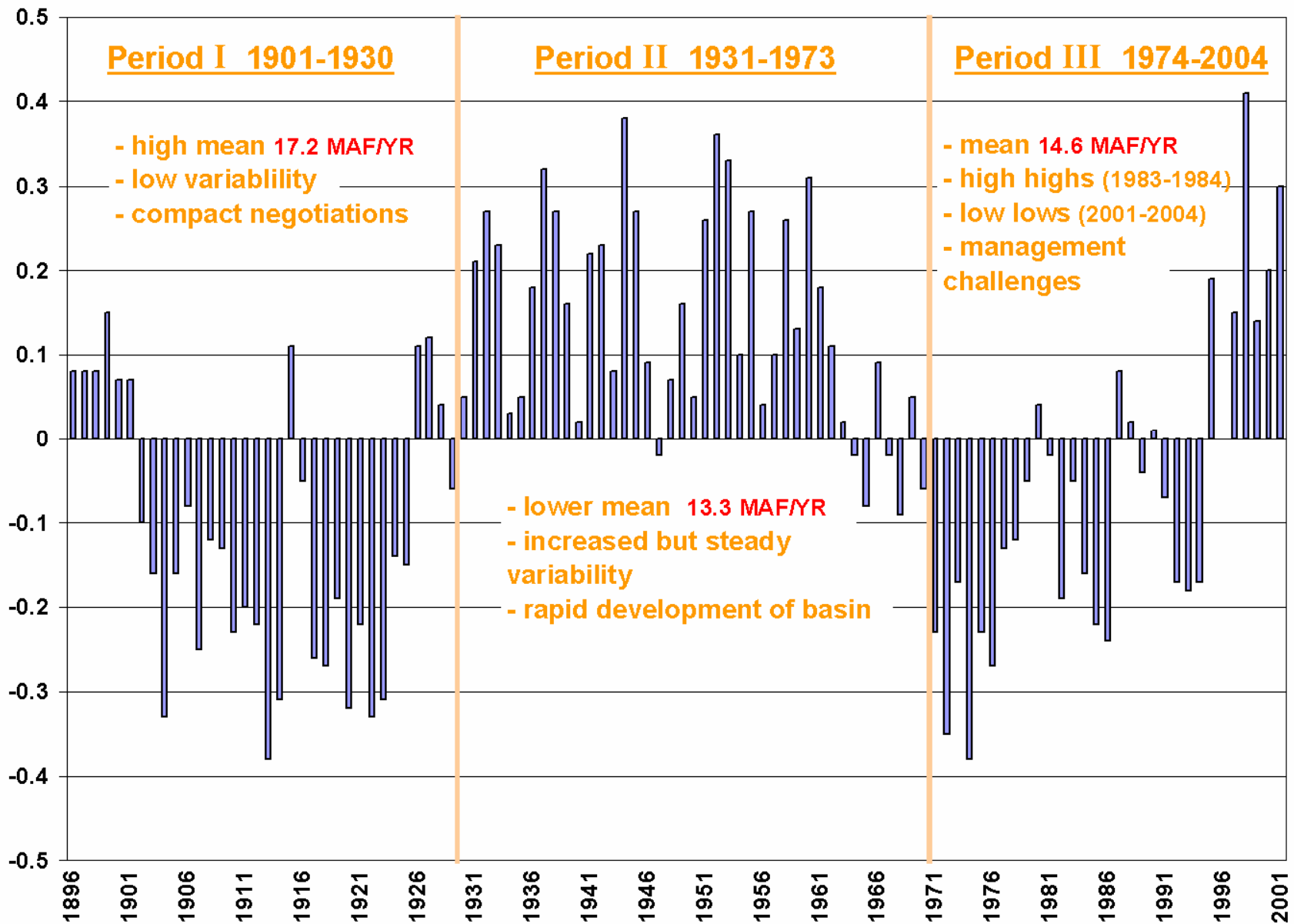
# Lee Ferry Virgin Flow 5 Year Running Average



# Running 20 Year Coefficient of Variation at Lee Ferry

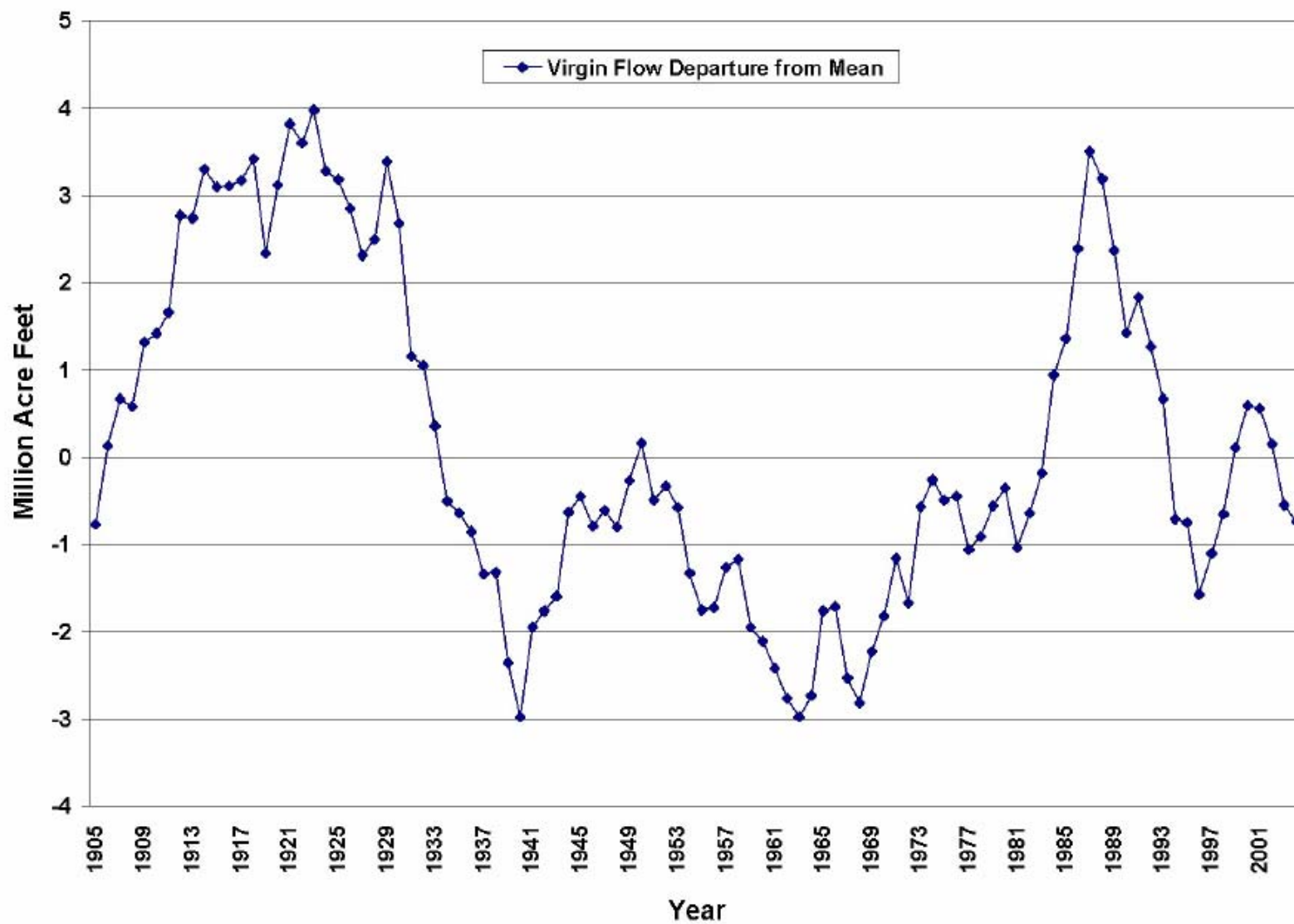


# Atlantic Multidecadal Oscillation Annual Departures

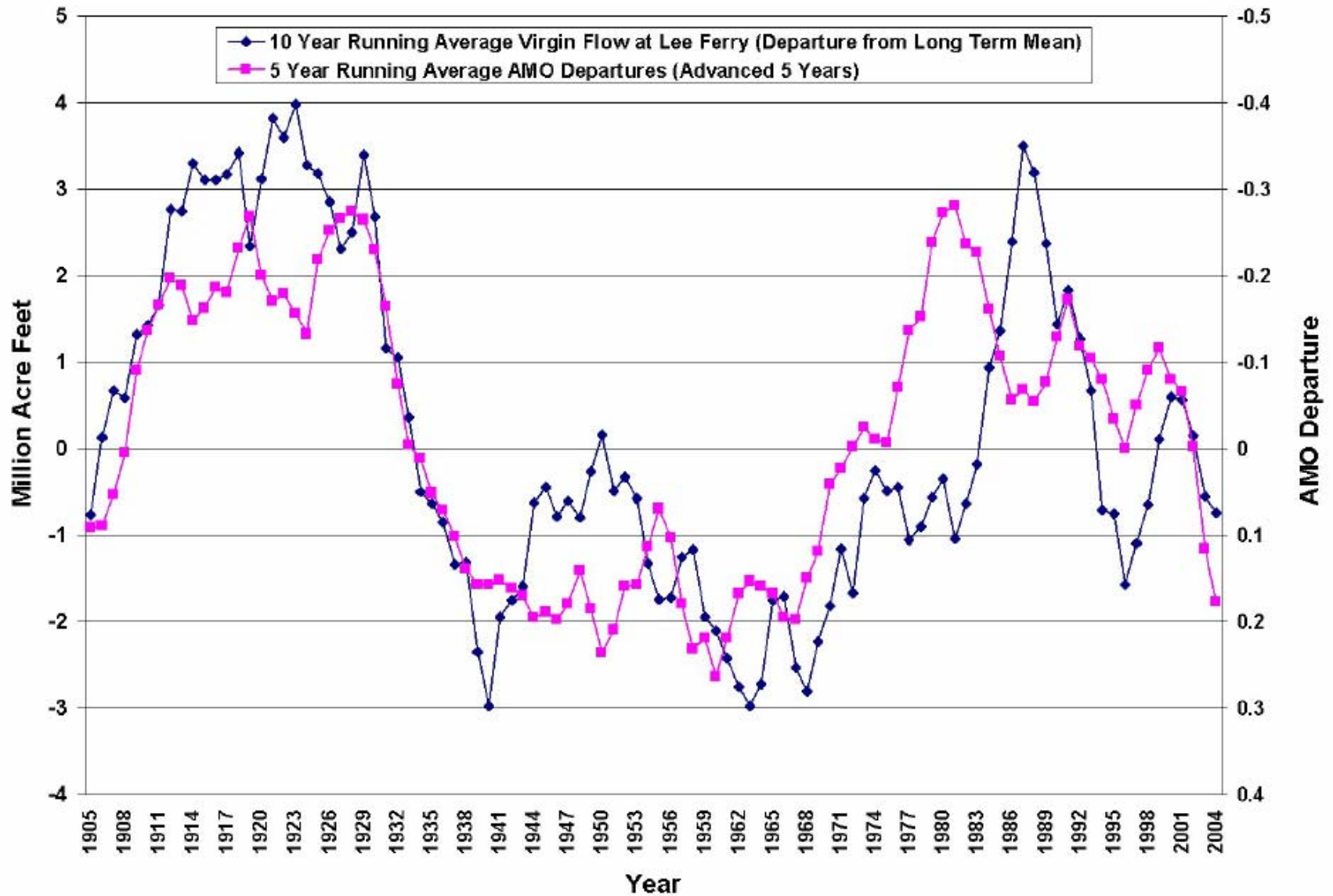


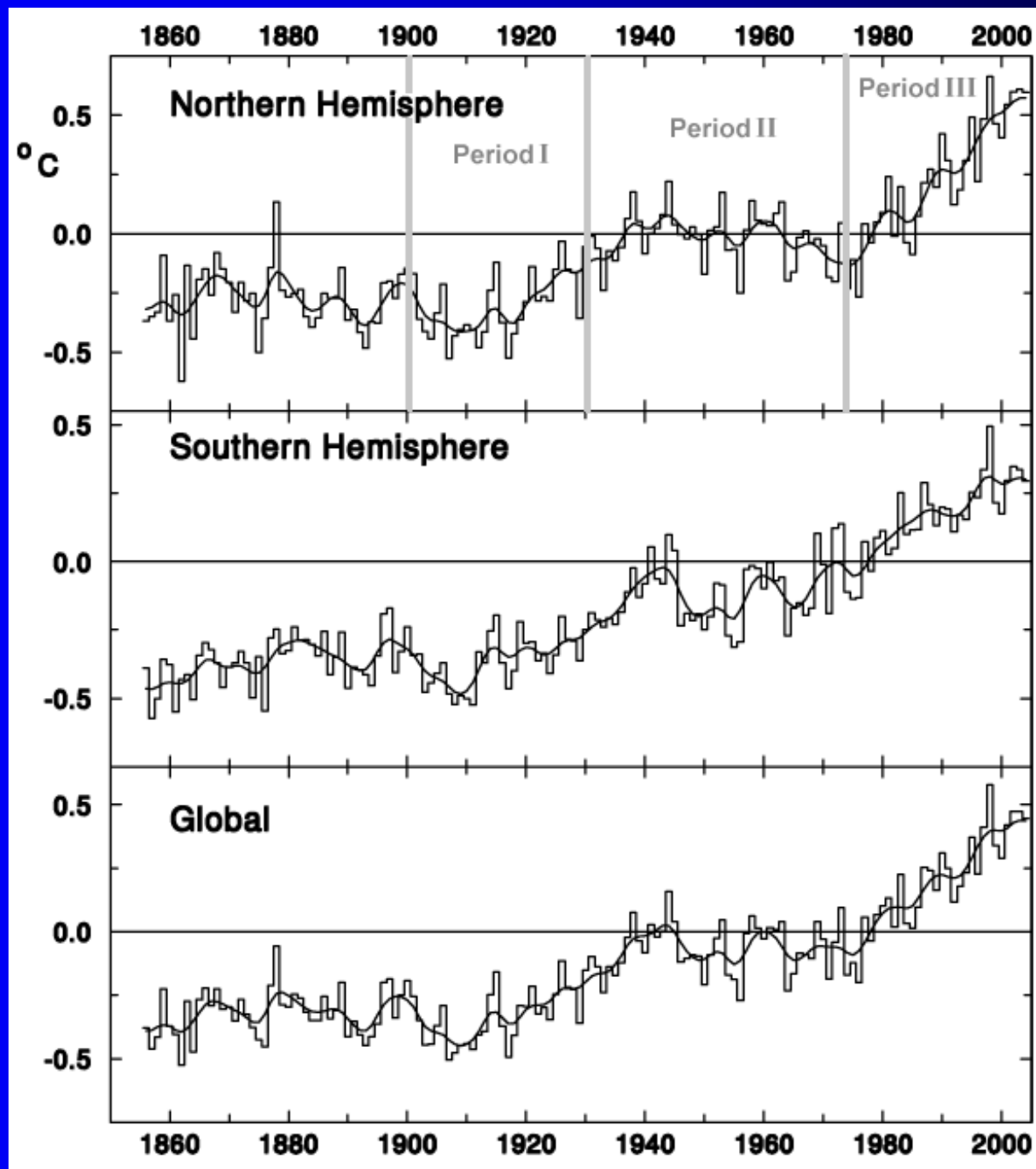


## Virgin Flow 10 Year Running Average at Lee Ferry



# Atlantic Ocean Impact on Colorado River Flows





from Climate Research Unit, Norwich, UK (Modified)

# Concerns / Questions

- The model results Reclamation has provided the Basin States uses the 1906-1995 period. Is this period representative of the long term hydrology?
- When merged with the Stockton data, this period looks very wet.
- Are hydrologic and climatic conditions changing faster than our ability to recognize these changes and develop near modeling and planning tools?
- What are the alternatives to using the gauge record?

Tree Ring Inflow (with UCRC data 1962-2004) Hydrology at Lee Ferry AZ  
90 Year Running Average



# Bottom Line

If flow at Lee Ferry (undepleted) for the next 10-30 yrs. averages about 15 maf/yr – we're probably ok.

## Simple Mass Balance

	15.0	maf	- available above Lee Ferry
less	4.5		- Upper Basin depletions
less	0.5		- evap. on Lake Powell & CRSP res.
	<hr/>		
	10.0		- available for Lower Basin
plus	0.7		- inflow Lee Ferry to Lake Mead
less	1.2		- LB evaporation & system losses
	<hr/>		
	9.5		- available for LB & Mexico
less	1.5		- Mexico delivery
	<hr/>		
<b>Equals</b>	<b>8.0 maf</b>		- Available for CA, NV & AZ

- Upper Basin's Mexican Treaty obligation may not matter.
- **8.0 maf > 7.5 maf** normal year apportionment

# However

If flow at Lee Ferry (undepleted) for the next 10-30 yrs. averages about 13 maf/yr – could be big trouble

## Simple Mass Balance

13.0 maf	-	available above Lee Ferry
less 4.5	-	Upper Basin depletions
<u>less 0.5</u>	-	evap. on Lake Powell & CRSP res.
8.0	-	available for LB, but min. release now at 8.25 maf
plus 0.7	-	inflow Lee Ferry to Lake Mead
<u>less 1.2</u>	-	Lower B. evaporation & system losses
7.5	-	available for LB & Mexico
<u>less 1.2</u>	-	Mexico delivery
<b>Equals 6.3 maf</b>	-	Available for CA, NV & AZ

- Upper Basin's Mexican Treaty obligation critical.
- Arizona & Nevada must take a > 1.0 maf/yr shortage.
- Would USA really short Mexico?
- Interstate litigation would be very likely.
- Lakes Powell & Mead would operate at very low levels.