

# **HYDROSCIENCE FOR FINDINGS OF FACT**

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**PRESENTATION TO**

**NATIONAL BUSINESS INSTITUTE CONTINUING EDUCATION**

**NOVEMBER 2006**

**BALLEAU GROUNDWATER, INC.**

## **WHAT ARE THE HYDROLOGIC FACTS OF INTEREST TO WATER RIGHTS?**

- Administration--Changes in supply for other purposes due to changes in permitted water-management operations.
- Operation--Effective means to deliver water to authorized uses.
- Adjudication--Amounts and effects to support claims.
- NRD--Damage Assessment

## **Hydrology Toolkit**

- Data – Flow, level, quality, facilities, imagery, reports
- Governing Equations and Water-Accounting Models
- Interpretations and Conclusions on Water Services

# NEW REGULATION ON SURFACE WATER (2005)

Title 19            Natural Resources and Wildlife

Chapter 26        Surface Water

Part 2             Administration

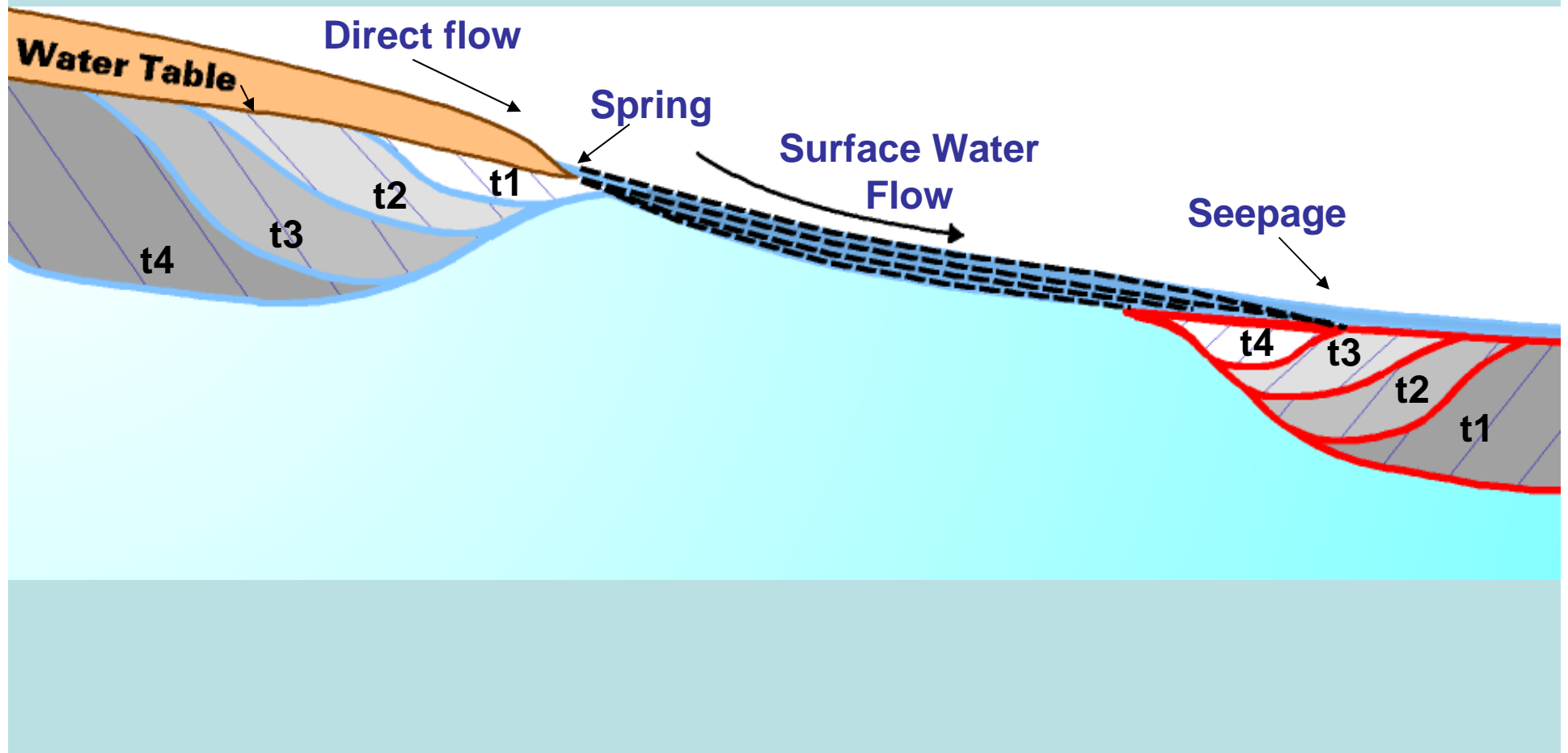
19.26.2.7        Definitions

CC.                **Stream system:** The surface waters of a river or stream and all groundwater hydrologically connected to those surface waters.

DD.                **Surface water:** Water found in any watercourse including impoundments, ponds, lakes, reservoirs, springs, streams and rivers or flows obtained from an infiltration gallery.



# IS GROUNDWATER A SEPARATE SOURCE FROM SURFACE WATER?

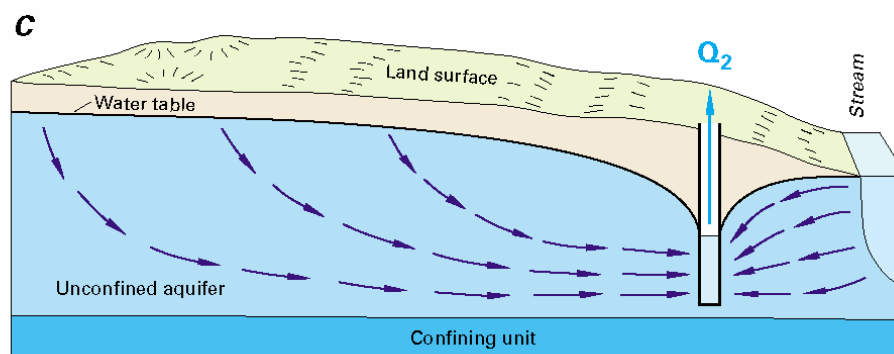
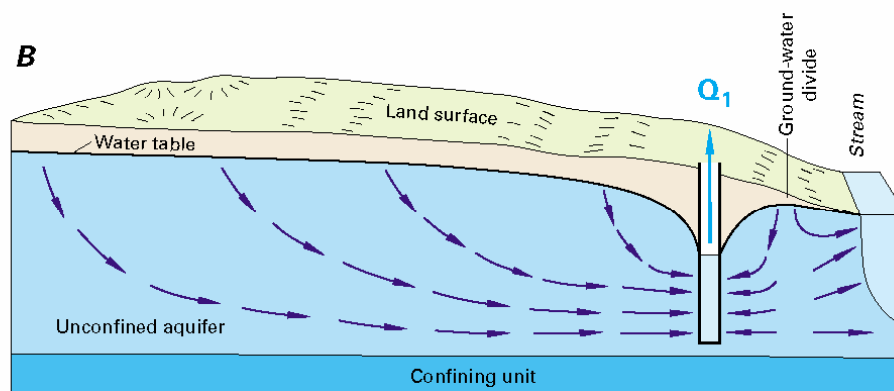
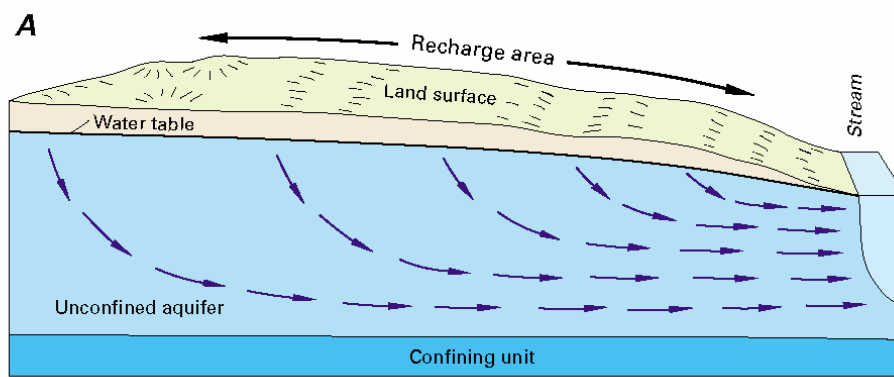


## **WATER ACCOUNTING UNITS**

Water Sources:

- Storage depletion
- Wetlands capture
- Riparian capture
- River flow depletion
- Soil moisture depletion
- Return flow

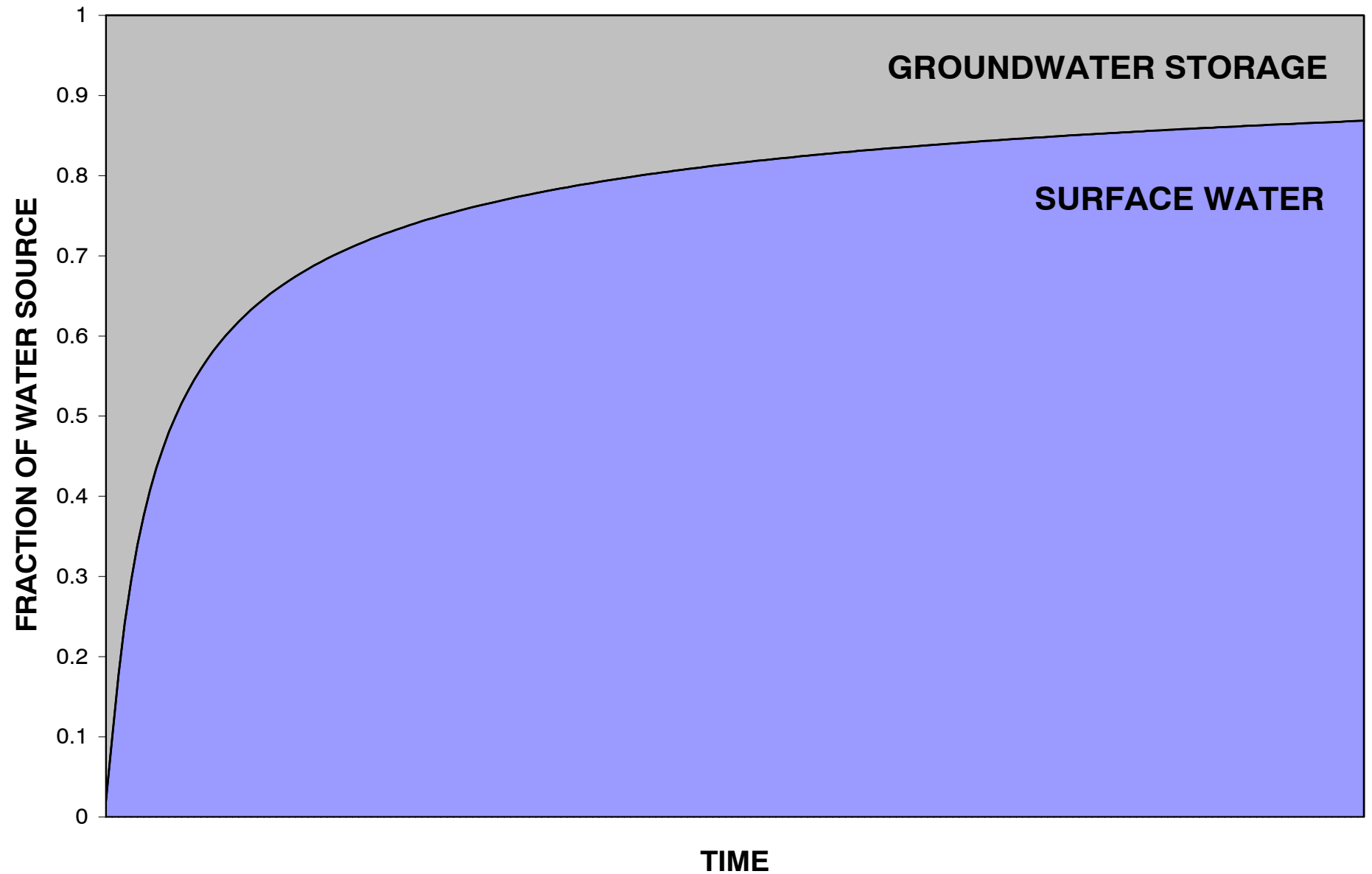
# STREAM CAPTURE



Sustained pumping  
can exceed recharge

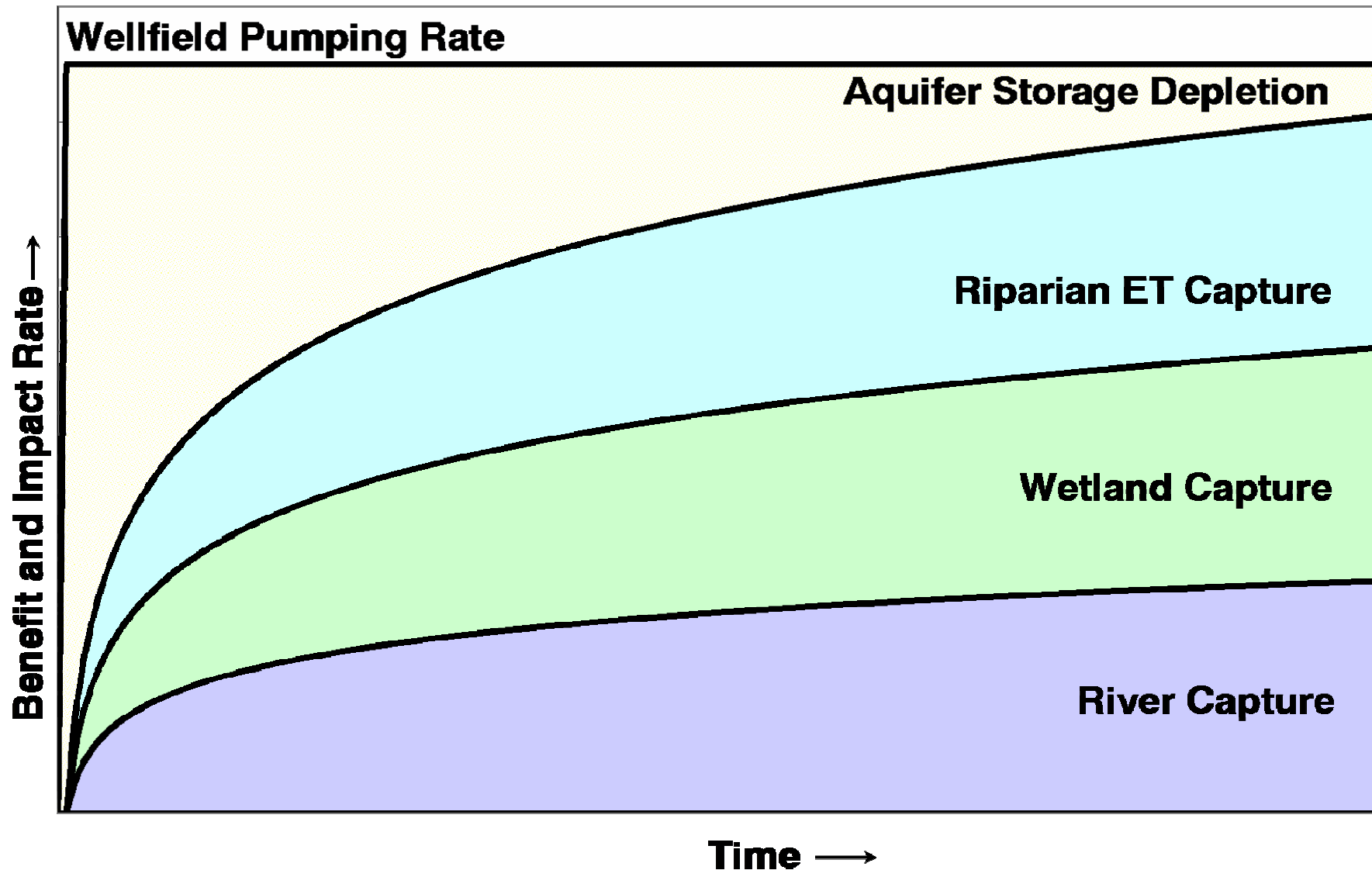
From USGS  
Circular 1186

# GROUNDWATER/SURFACE WATER TRANSITION CURVE - OLD STYLE -

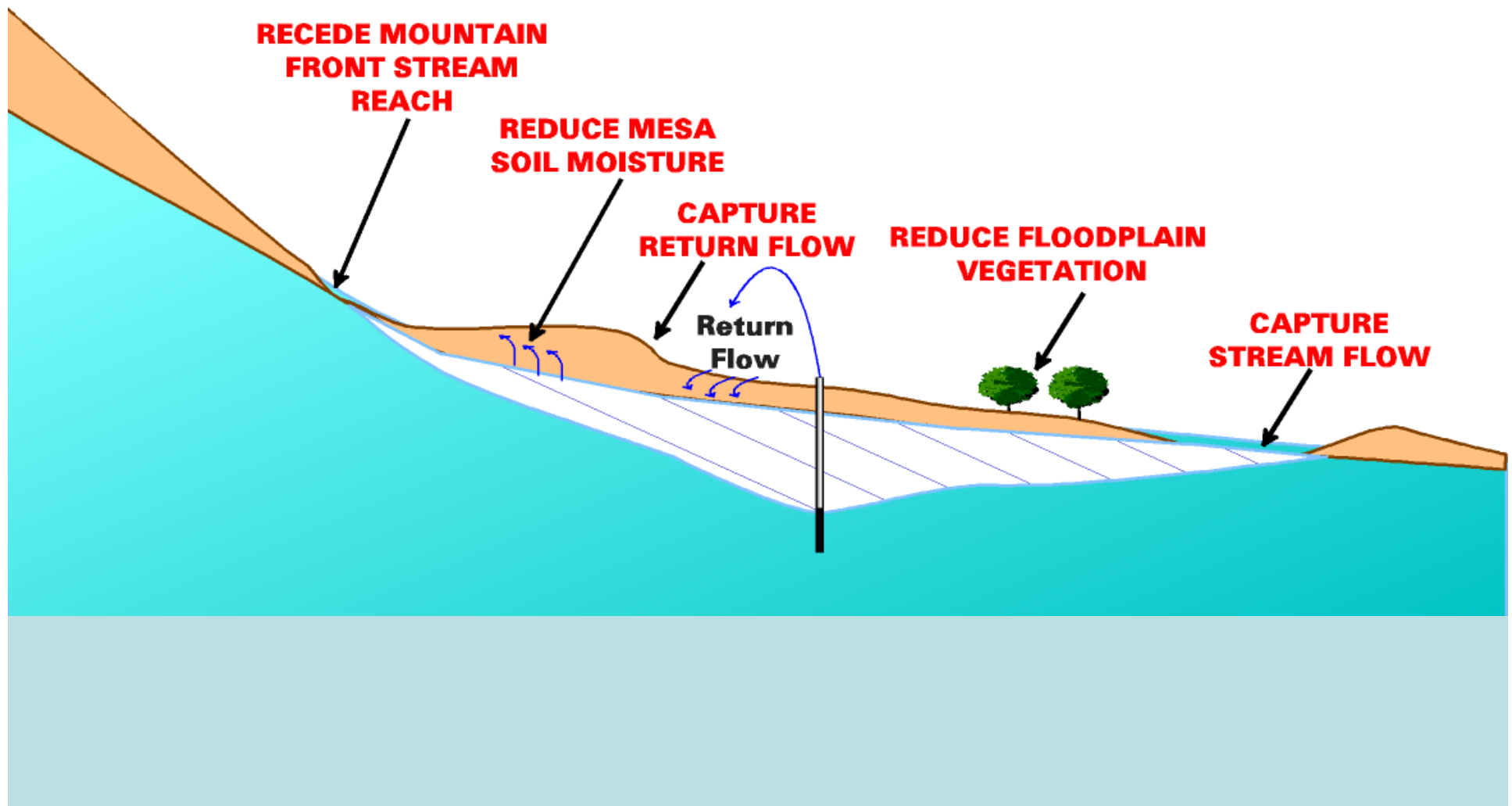




# GROUNDWATER/SURFACE WATER TRANSITION CURVE - NEW STYLE -



# COMPONENTS OF SOURCES IN AREA OF INFLUENCE



## **WESTERN WATER RIGHTS ACCOUNTING**

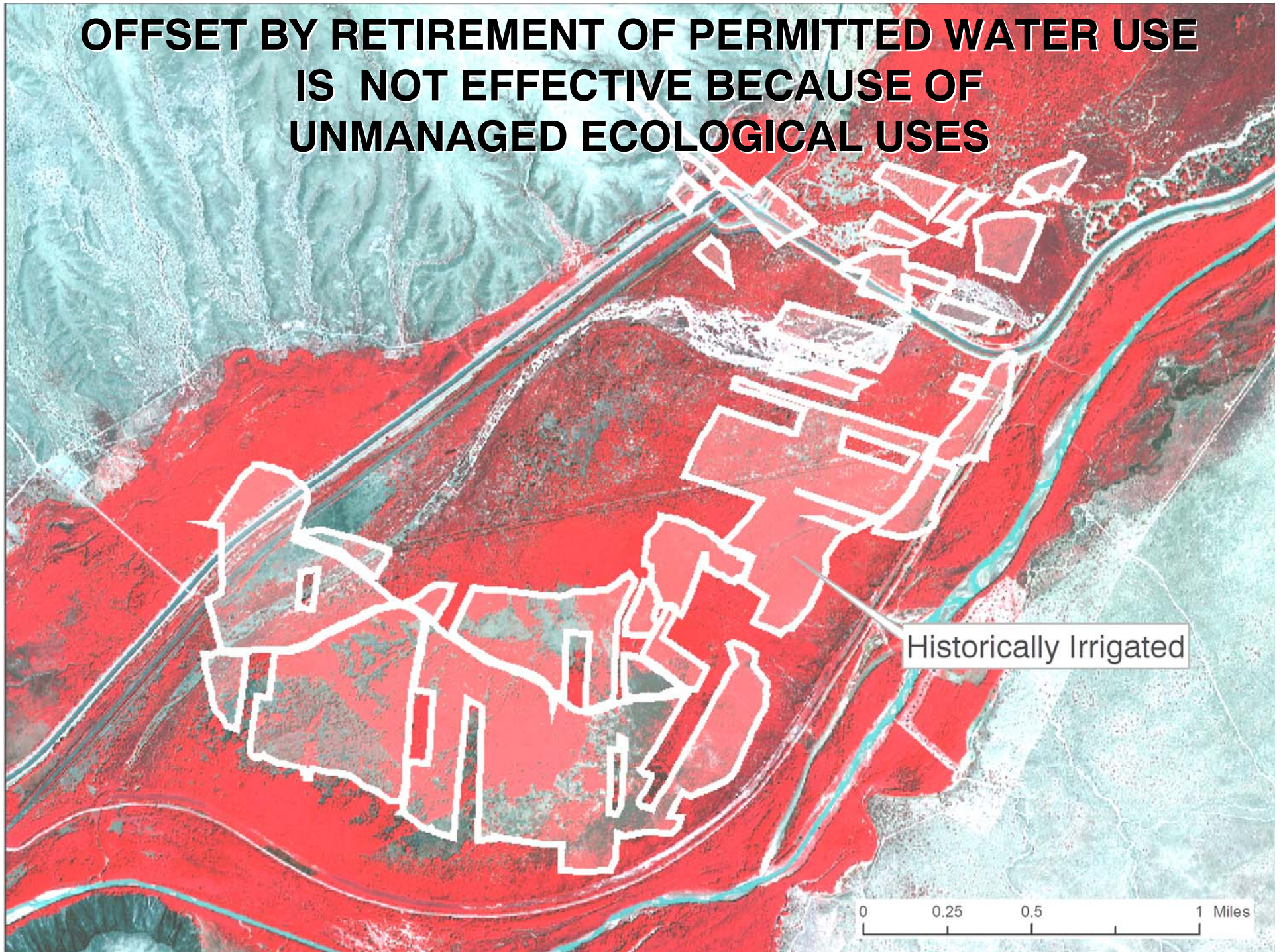
- Requires offset of river capture:

“Since the declaration of the Rio Grande Underground Water Basin, groundwater permittees have been required to obtain valid water rights in an amount sufficient to offset the effects of their diversions on the surface flows of the Rio Grande stream system. This requirement protects the surface flows of the Rio Grande stream system from being depleted or reduced by groundwater diversions.”

-Middle Rio Grande Administrative Guidelines (September 13, 2000)



**OFFSET BY RETIREMENT OF PERMITTED WATER USE  
IS NOT EFFECTIVE BECAUSE OF  
UNMANAGED ECOLOGICAL USES**





# CAUSAL MODEL VS. BLACK BOX

- A causal model aims at representing the underlying physical mechanisms that explain observed or projected conditions.

For drawdown:

$$S = \frac{QW\left(\frac{r^2 S}{4Tt}\right)}{4\pi T}$$

Physical properties that explain the result = causal.

- One can reason about managing and controlling the results of a causal model, for example by conditioning a rate or time or distance in an application for water rights.

**Why do good models disagree on results?**  
**Confusion prevails over what is a valid water right for examination of the baseline for a new proposal**

- Declared
- Permitted
- Decreed
- Historical
- Projected Future



# **HYDROLOGIC EFFECT**

## **Terms:**

**“But for...”**

**“With and without...”**

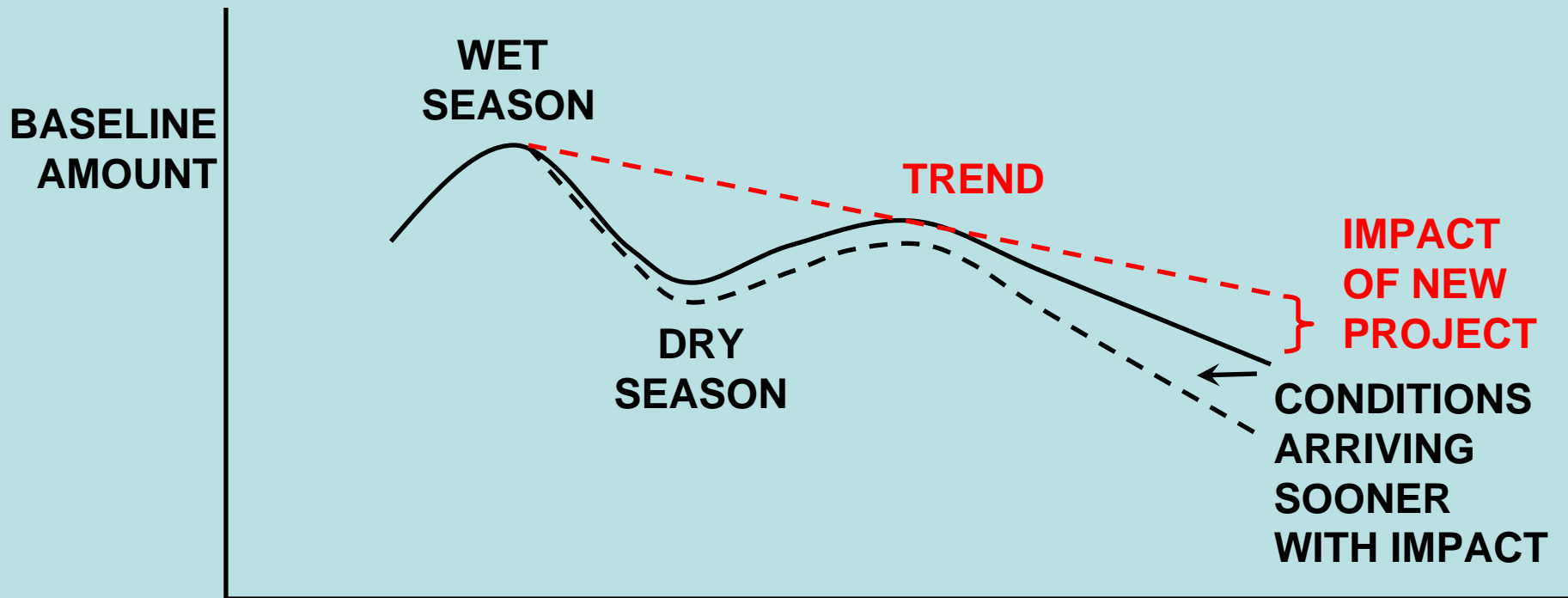
**“Isolated...”**

**“Counterfactual...”**

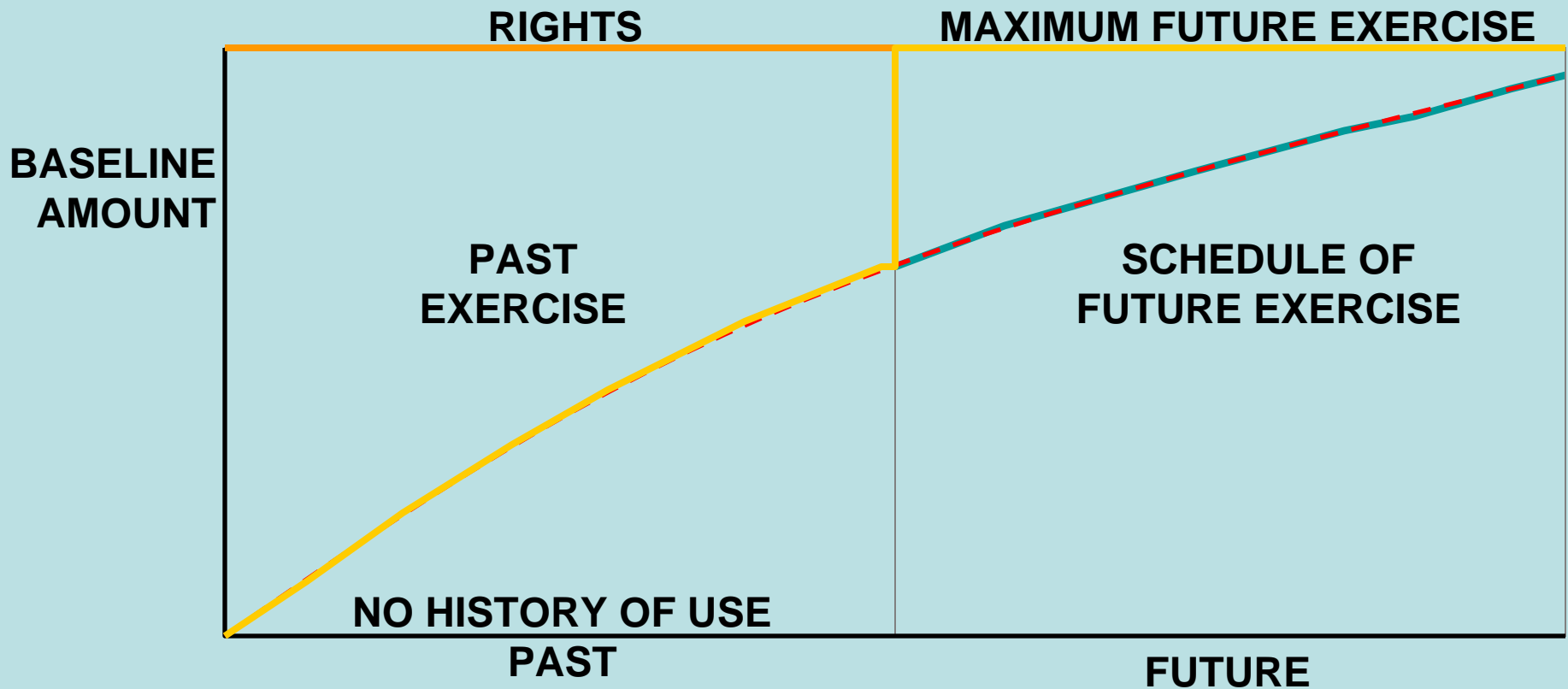
**All imply Hydrologic Condition 1 versus Condition 2 and the difference in the two hydrologic conditions.**

- Models superimpose side-by-side comparisons.**
- Real water operations are sequential. Actual differences cannot be observed or calculated.**
- Problem arises in specifying baseline Condition 1. Are the baseline rights, permits, declarations, exercise valid?**

# BASELINE VS. IMPACT

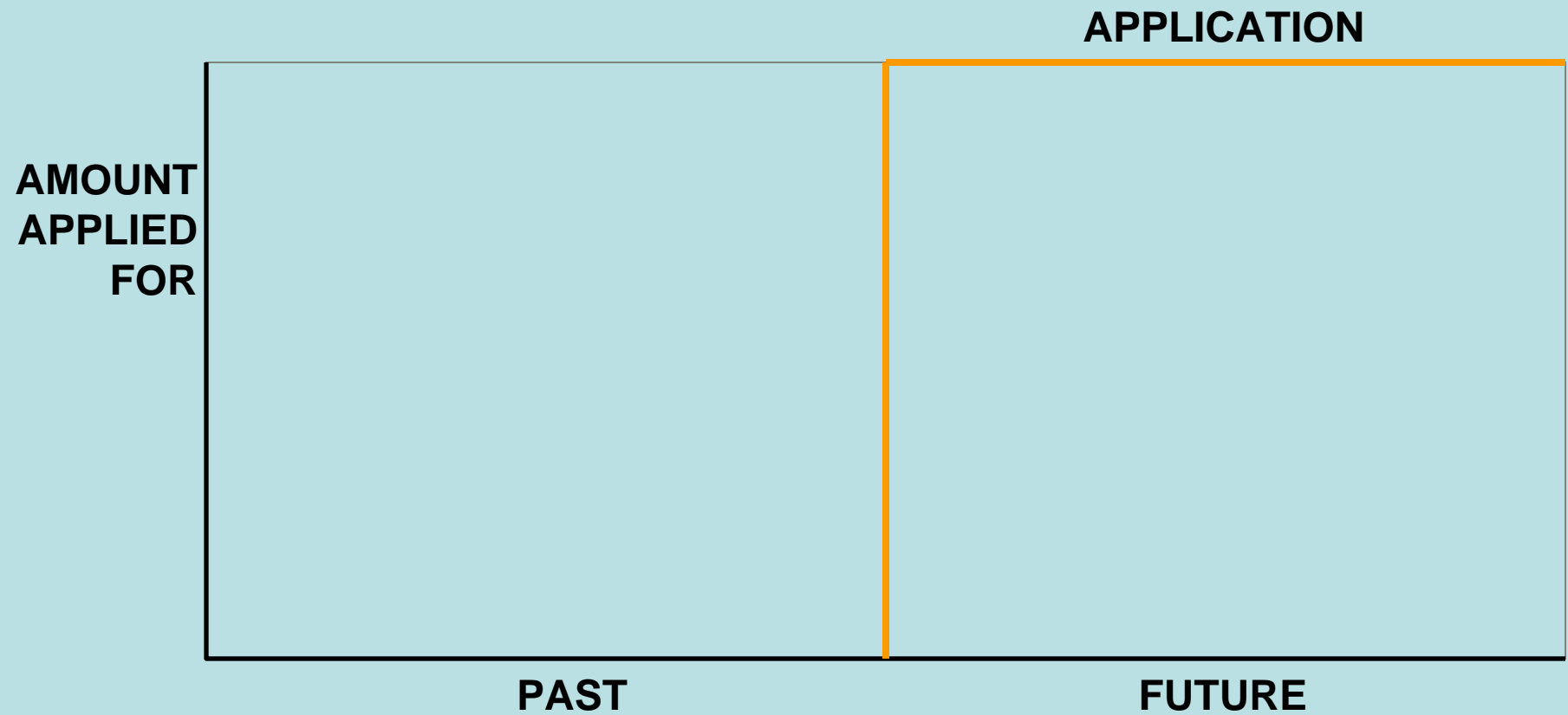


# WHAT BASELINE SHOULD AN APPLICATION BE COMPARED TO?



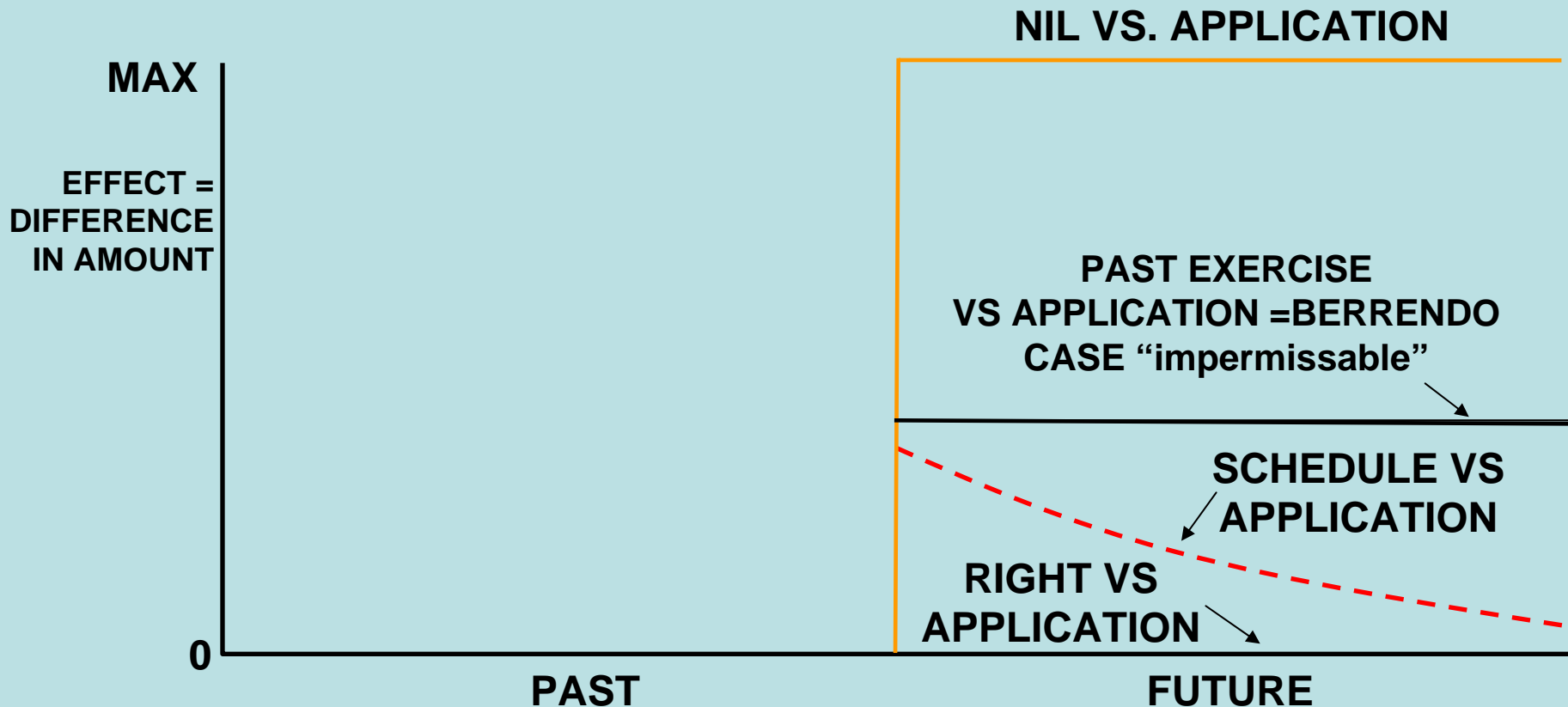
**BASELINE = MAXIMUM OF RIGHT OR SCHEDULE OF GROWTH OR NIL?**

# WHAT FUTURE SHOULD AN APPLICATION RUN?



APPLICATION = AS APPLICATION

# ? HELP YOUR HYDROLOGIST, WHAT IS A VALID RIGHT FOR BASELINE ?



**DIFFERENCE DEPENDS ON SCENARIO,  
NO EFFECT BY COMPARING RIGHTS,  
OR MAJOR EFFECT BY COMPARING HISTORY OF EXERCISE, OR NIL.**

**How can a senior right be moved in a stream system without making junior rights worse off?**

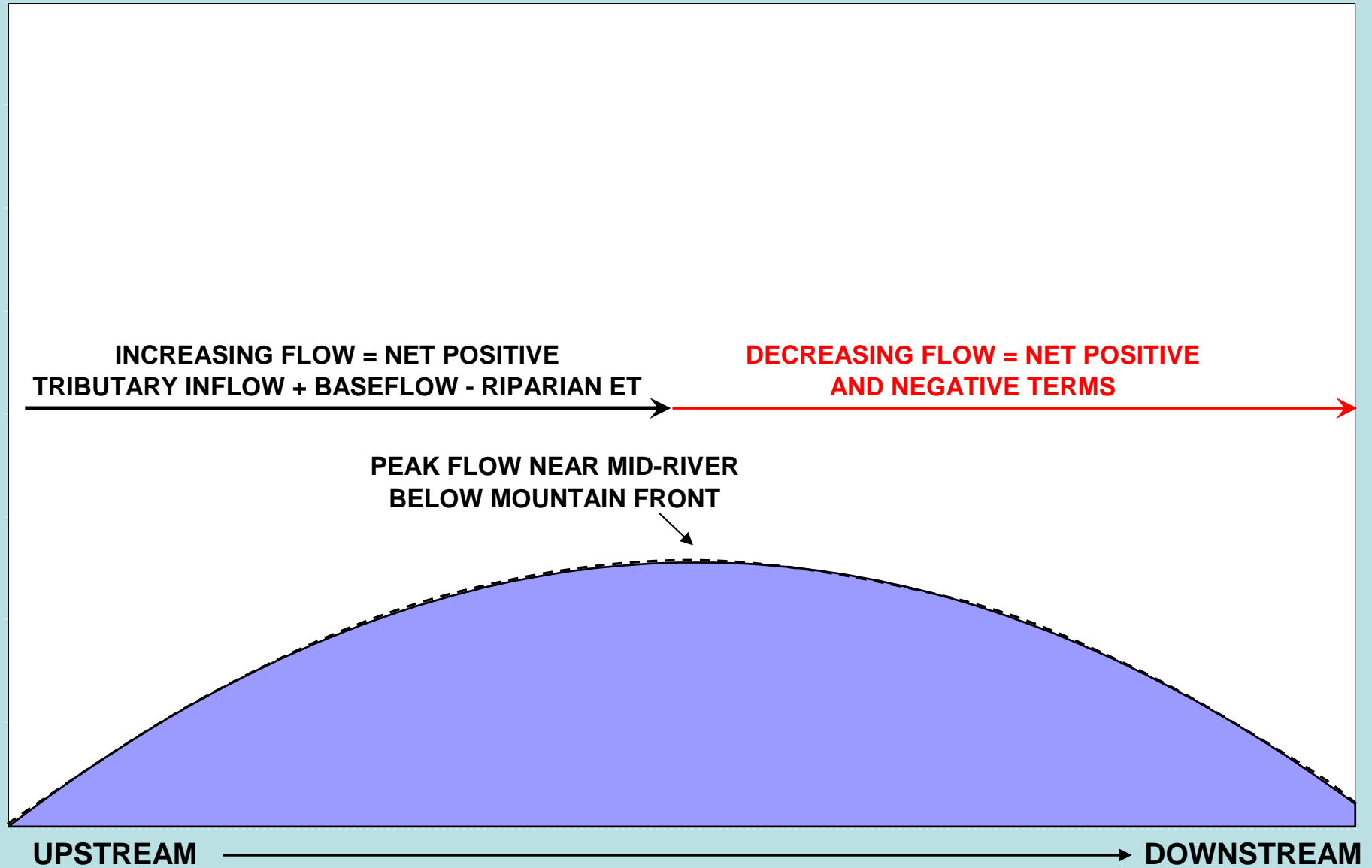
**Answer: Tie priority enforcement to flow at the original POD.**



# CHANGE IN POD IN A PRIORITY SYSTEM

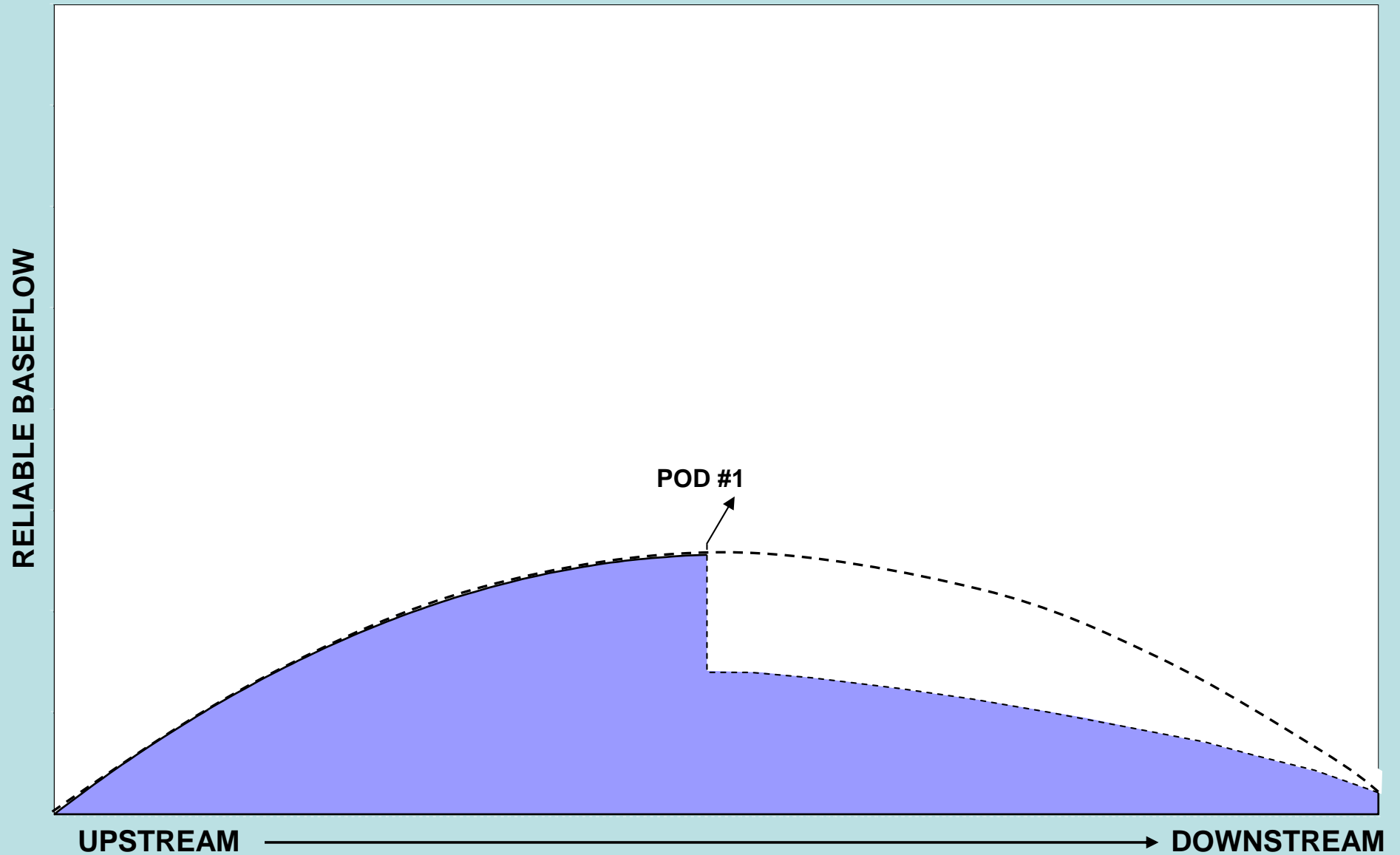
## NATURAL

RELIABLE BASEFLOW



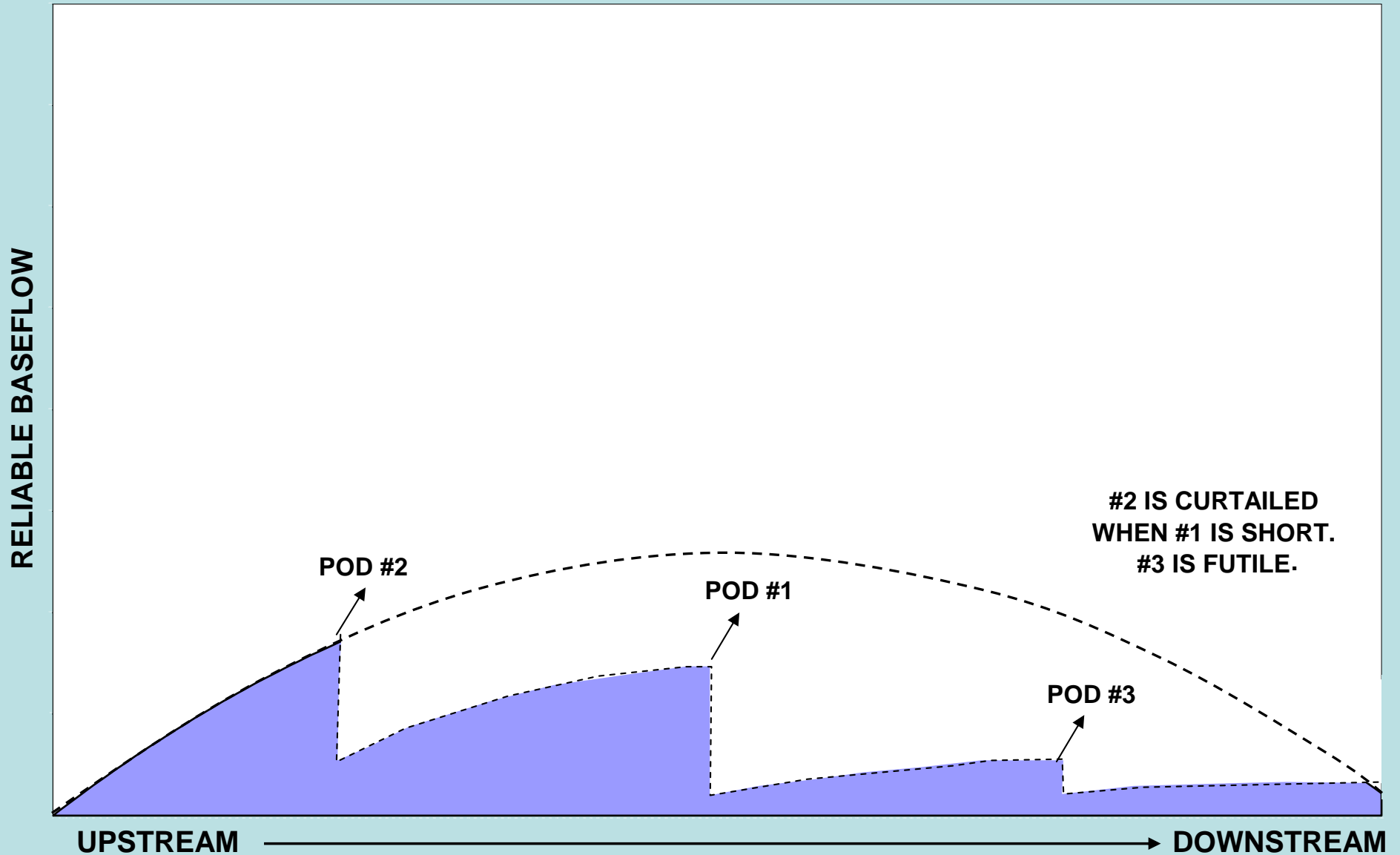
# CHANGE IN POD IN A PRIORITY SYSTEM

EARLY



# CHANGE IN POD IN A PRIORITY SYSTEM

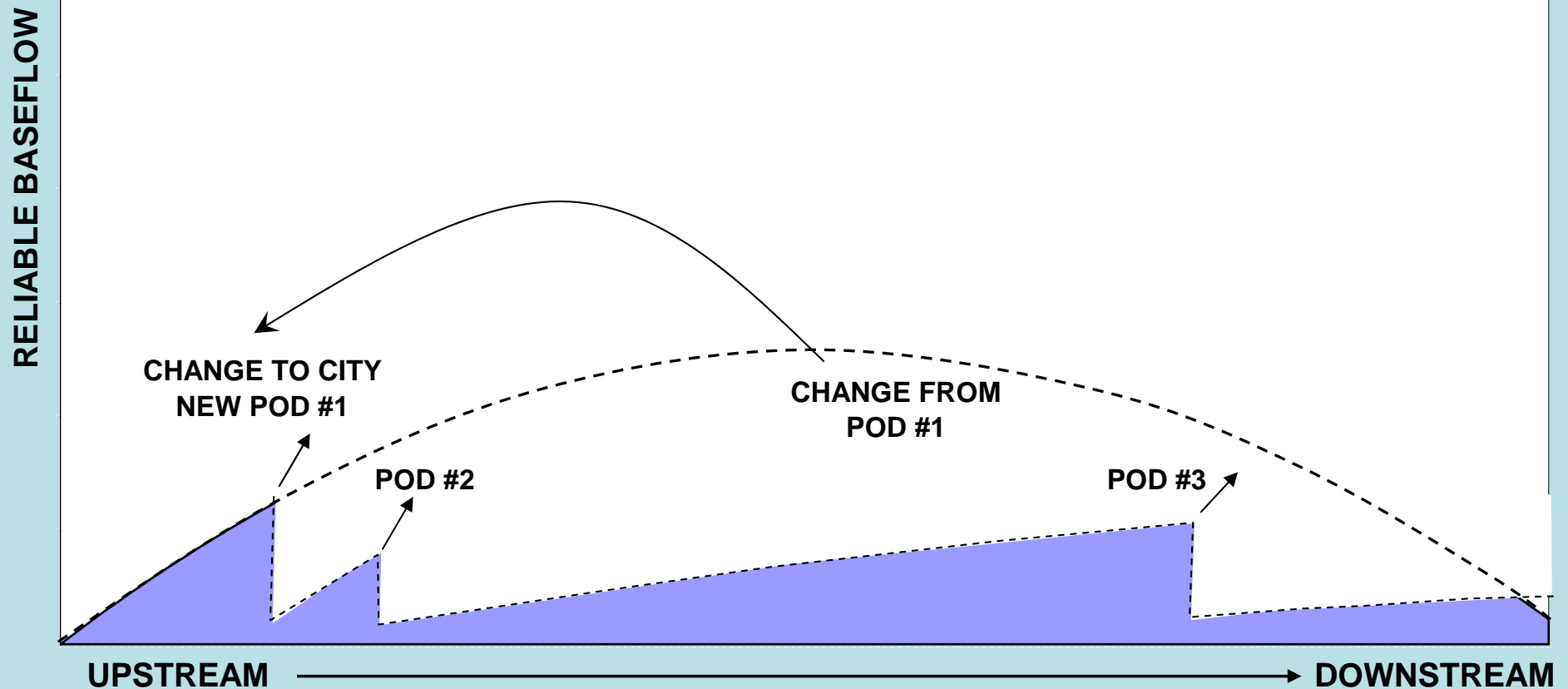
CHANGE FROM



# CHANGE IN POD IN A PRIORITY SYSTEM

## CHANGE TO

CONCLUDE: #2 IS WORSE OFF WITH SENIOR POD MOVED UPSTREAM,  
BECAUSE LESS FLOW UP STREAM FOR THE SENIOR RIGHT MEANS THAT  
JUNIOR #2 MUST GIVE UP MORE WATER MORE OFTEN THAN BEFORE THE CHANGE.  
DOWNSTREAM JUNIOR #3 BENEFITS BY THE CHANGE IN #1 POD.



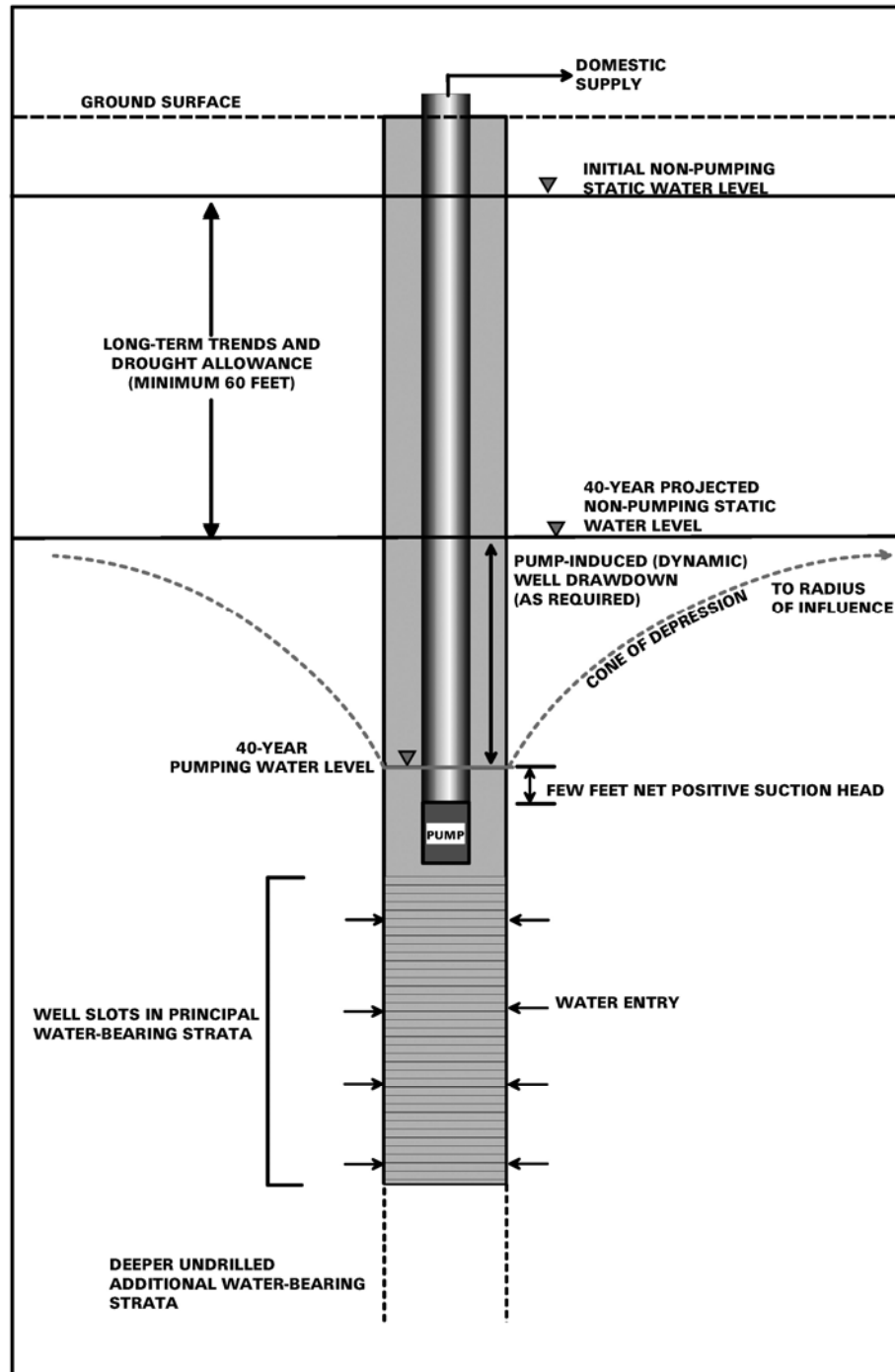
# **New Tool For Projecting Well Impairment**

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Where Pumping Water Level Causes Yield Decline

and

Water Column (60-foot buffer) is exceeded.





# MODFLOW MULTI-NODE WELL (MNW) PACKAGE WELL HYDRAULICS CALCULATION COMPONENTS

$$h_{WELL} - h_n = A Q_n + B Q_n + C Q_n^P$$

where,

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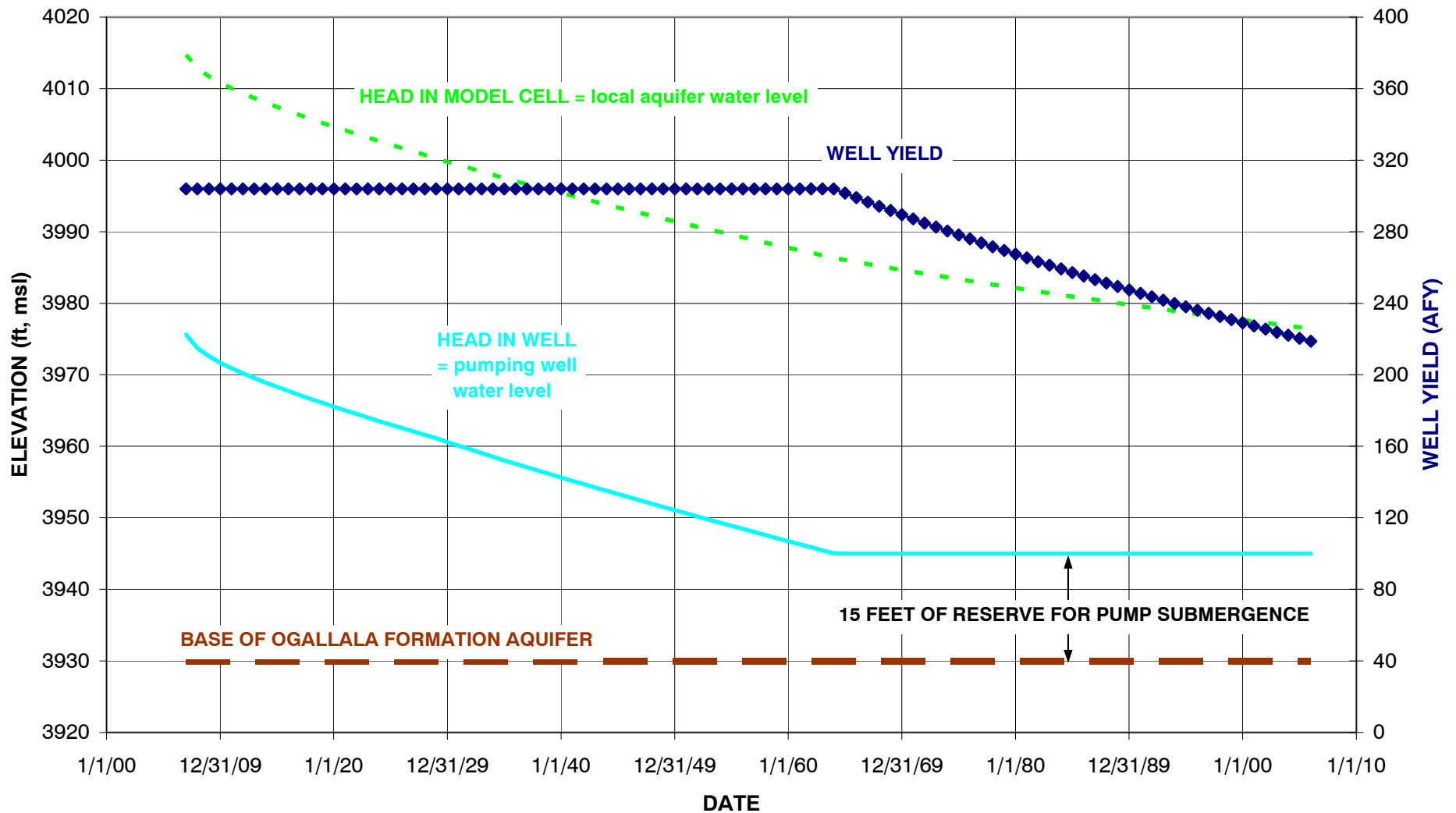
$h_{WELL}$	is the head in the well (L),
$h_n$	is the head in the $n^{th}$ cell (L),
$Q_n$	is flow between the $n^{th}$ cell and the well ( $L^3 / T$ ),
$A$	is linear aquifer-loss coefficient ( $T / L^2$ ),
$B$	is linear well-loss coefficient ( $T / L^2$ ),
$C$	is nonlinear well-loss coefficient ( $T^P / L^{(3P-1)}$ ), and
$P$	is power of the nonlinear discharge component of well loss that usually varies between 1.5 and 3.5 (Rorabaugh, 1953)

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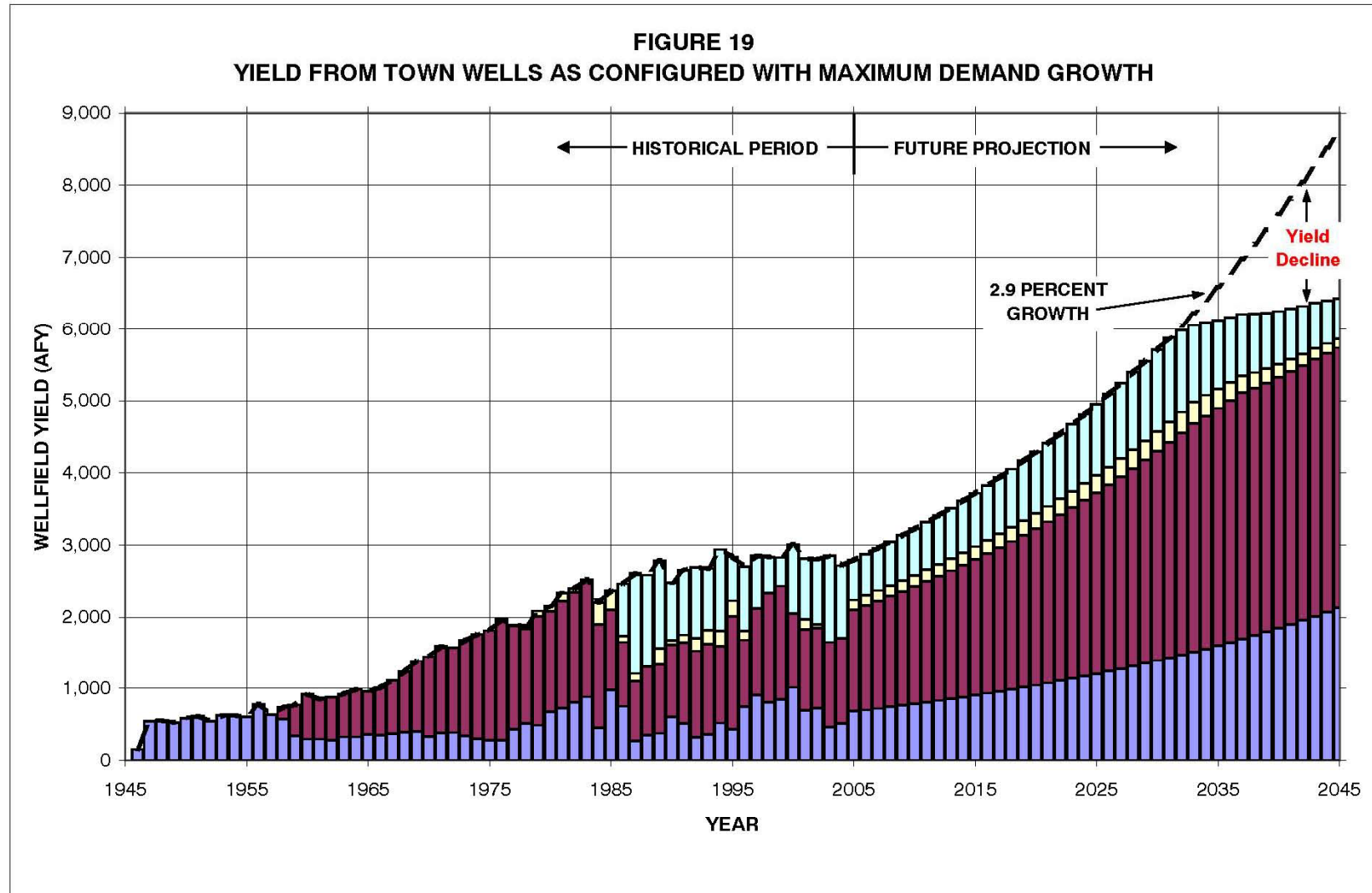
**Adapted From: User Guide for the Drawdown-Limited, Multi-Node Well (MNW) Package for the U.S. Geological Survey's Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, Versions MODFLOW-96 and MODFLOW-2000**

# PROJECTED WELL YIELD AND WATER LEVEL CALCULATED USING MNW

FIGURE 13B  
SIMULATED YIELD IN ILLUSTRATIVE WELL  
OPERATING AT REDUCED EFFICIENCY



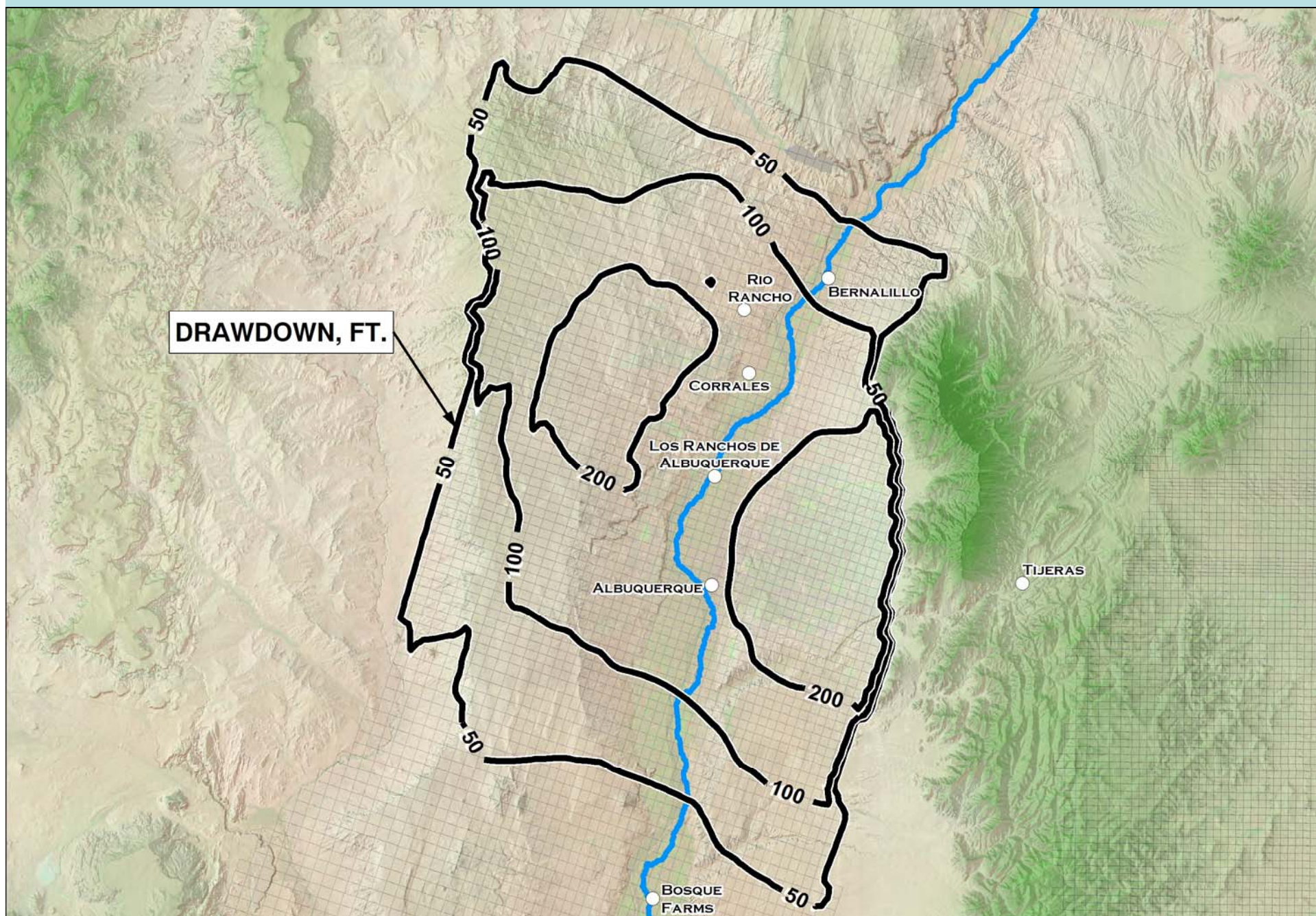
# PROJECTED WELLFIELD YIELD CALCULATED USING MNW



**Resource Conservation  
Issues Can Be  
Addressed By  
Water Accounting Models**

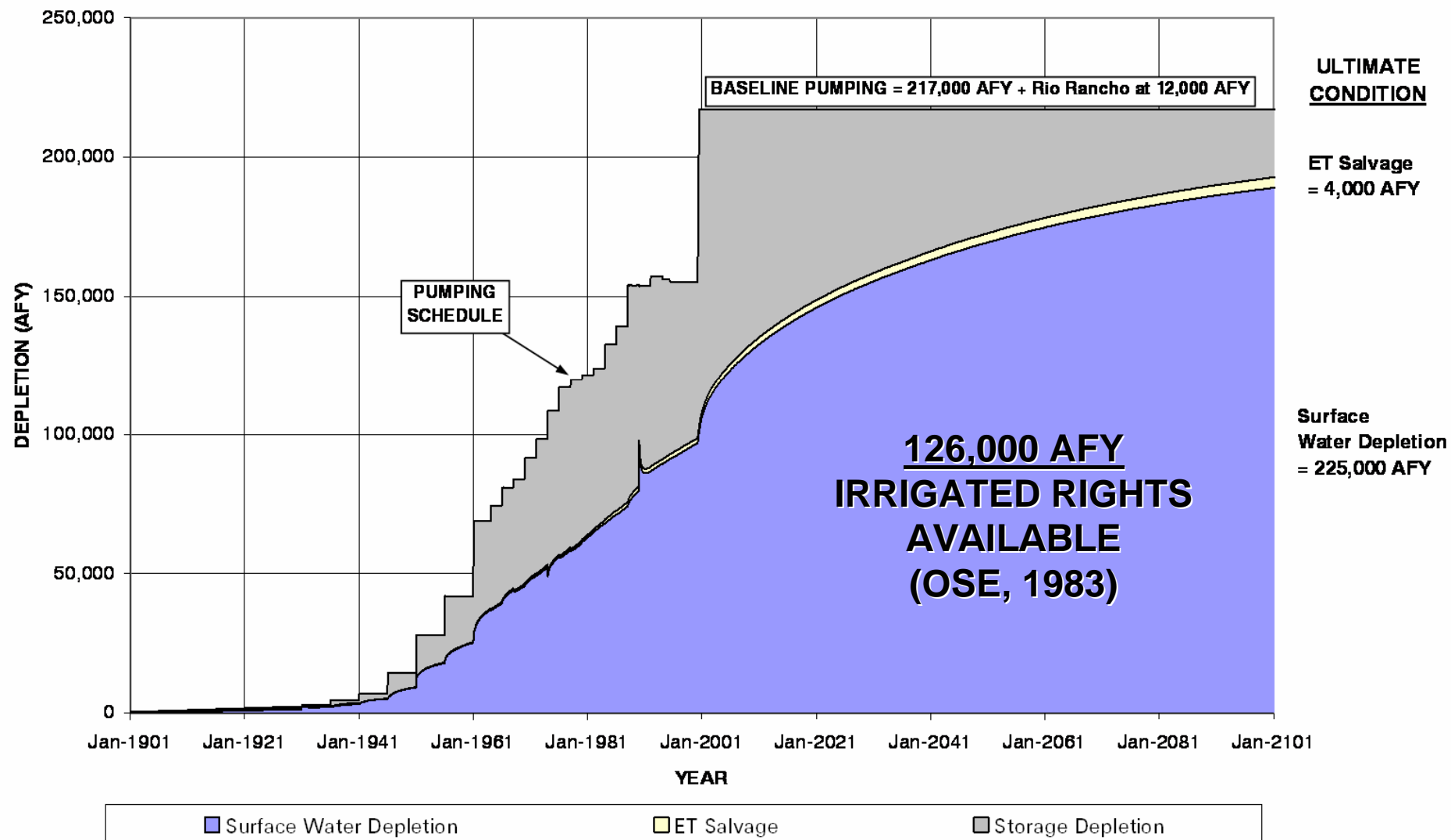


# ULTIMATE DRAWDOWN IN ALBUQUERQUE BASIN



# SOURCES OF WATER (YEAR 1900 PROJECTED TO YEAR 2101, ULTIMATE CONDITION INDICATED)

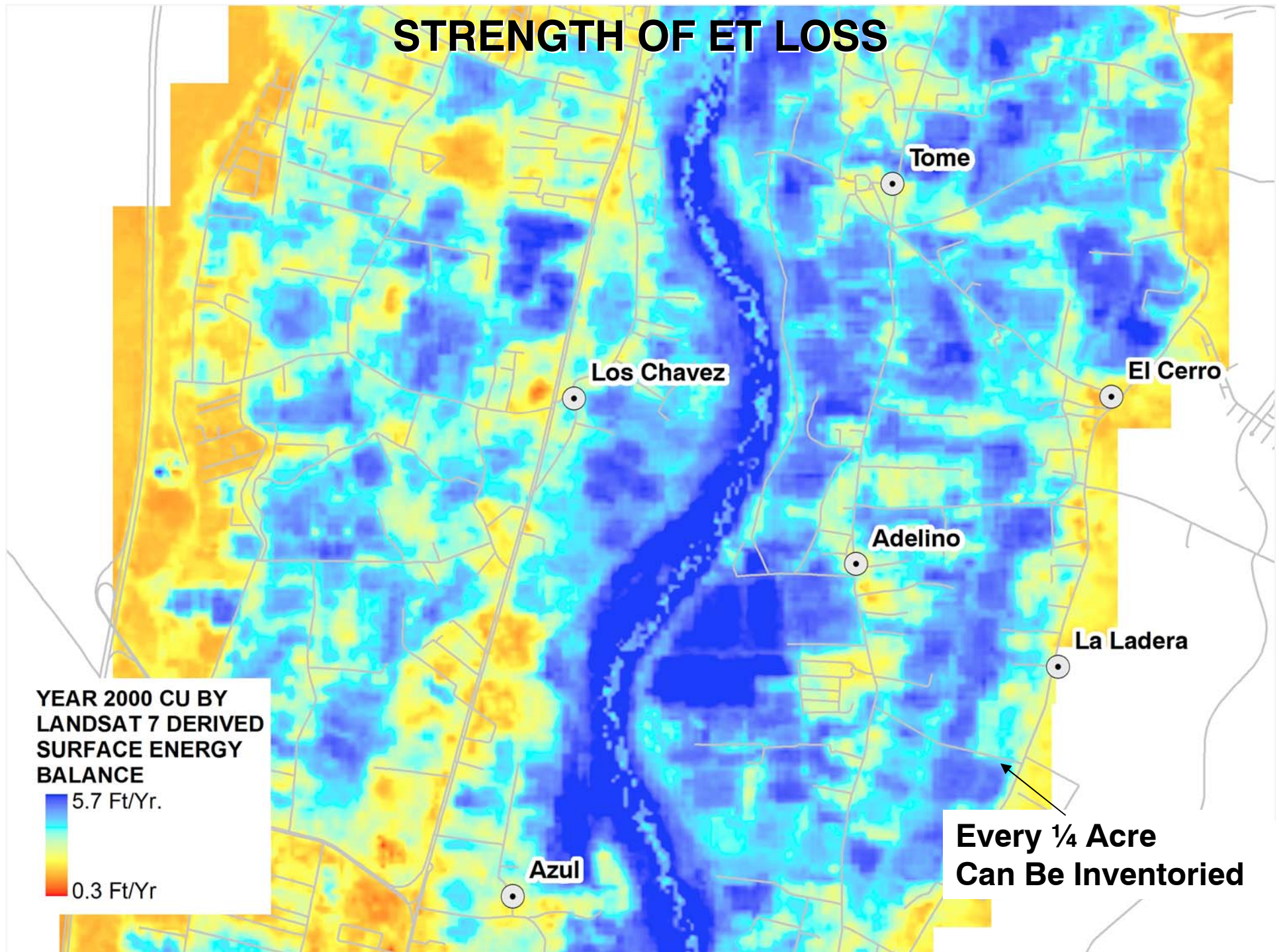
STATE ENGINEER MIDDLE RIO GRANDE ADMINISTRATIVE AREA MODEL



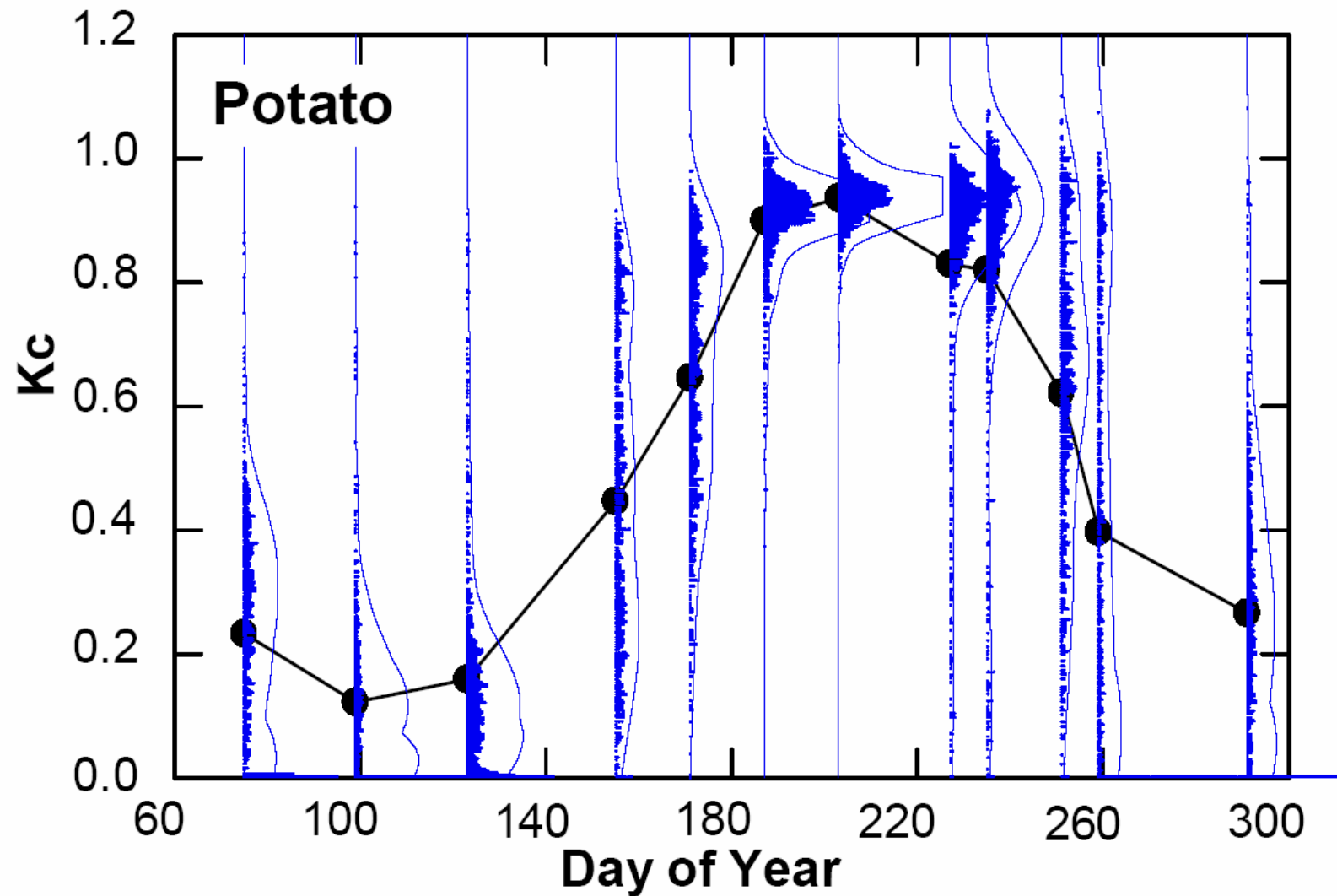


**Remote Sensing**  
**provides new picture**  
**of location and strength of**  
**water losses**

# STRENGTH OF ET LOSS



# VARIATION OF STRENGTH PER LU CATEGORY



Adapted from: Allen, R.G., Morse, A., Tasumi, M., 2003, Application of SEBAL  
for Regulation of Western US Water Rights and Planning: ICID Workshop on Remote Sensing of ET for Large Regions.

# CONCLUSIONS

- 1. Causal Models are Needed to Illustrate How to Manage Impacts and to Condition Permits**
- 2. New Capabilities are Continually Available**
- 3. Wide Acceptance = Evidentiary Value**

*This presentation is available electronically  
under “papers & talks” at:  
[www.balleau.com](http://www.balleau.com)*