

A photograph of a wooden flatbed trailer in a grassy field. The trailer has a sign that reads "NO DOCKING THIS SIDE", a metal pot, and a log. The background shows a line of trees.

Groundwater & Lake Interactions: Science, Policy and Tools

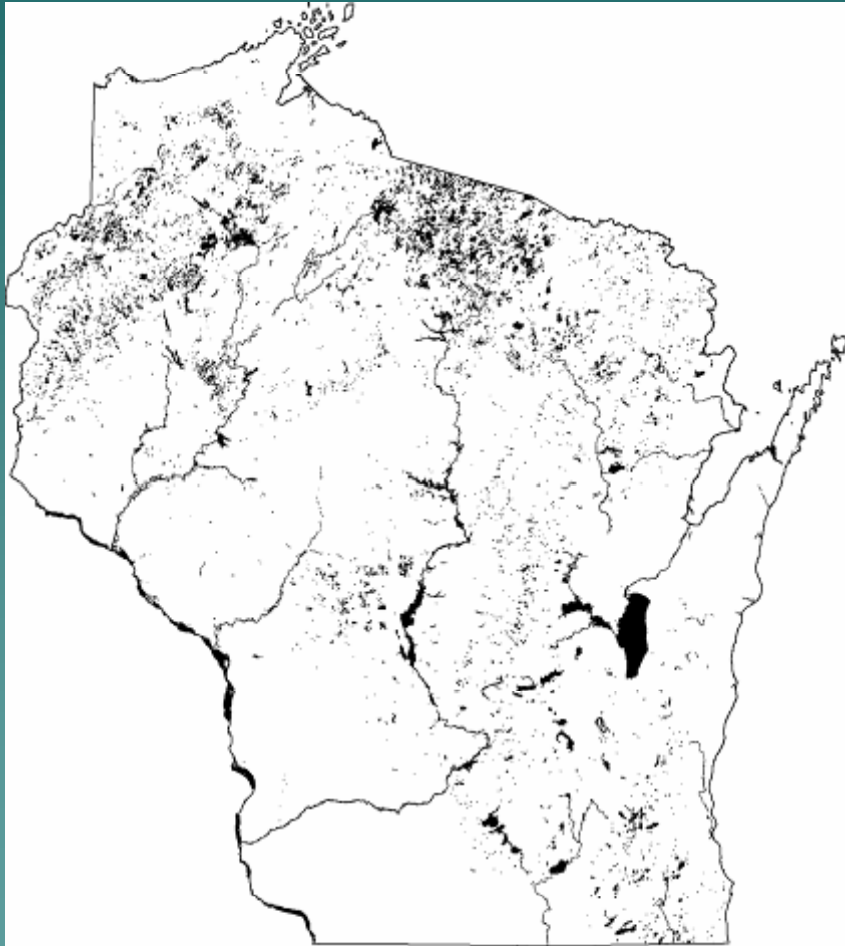
Bob Nauta, RSV Engineering
Chuck Dunning & Herb Garn, USGS
Tim Asplund, WDNR

Wisconsin Lakes Convention
Workshop: April 17, 2008

Introductions




Wisconsin is water rich...



- ◆ 32 inches of rainfall per year
- ◆ 15,000+ lakes
- ◆ 44,000 miles of streams and rivers
- ◆ 1.2 *quadrillion* gallons of ground water
- ◆ 2 Great Lakes and Mississippi River

Why are we here?

- ◆ Low lake levels!
 - ◆ Increased demand for water and uncertain implications of changing climate
 - ◆ Concerns about proposed and existing high capacity wells near lakes, wetlands, and springs
 - ◆ Cumulative impacts of wells on regional water table
 - ◆ Ignorance about how groundwater "works"
 - ◆ Regulatory Limitations
- 



Huron Lake, Waushara County



Twin Lake, Marquette County



Gilbert Lake, Waushara County



Plainfield Lake, Waushara County

R. Lathrop



Fallison Lake, Vilas County

F. Koshere




Tomahawk Lake, Bayfield County



Tomahawk Lake, Bayfield County

Implications of low water levels

- ◆ Navigational issues
 - ◆ Exposure of lake beds to disturbance
 - ◆ Water quality/clarity changes
 - ◆ Shift in aquatic plant community
 - ◆ Reduced fish cover
 - ◆ Potential for spread of invasives (e.g. EWM, *Phragmites*)
 - ◆ Increased likelihood of winterkill
- 

Recent Climate Trends



Projected Climate Changes in the Great Lakes Region by 2100

◆ Temperature

[*http://www.ucsusa.org/greatlakes](http://www.ucsusa.org/greatlakes)

- Winter 5-12 °F (3-7 °C)
- Summer 5-20 °F (3-11 °C)
- Extreme heat more common
- Growing season several weeks longer

◆ Precipitation

- Winter, spring increasing
- Summer, fall decreasing
- Drier soils, more droughts

◆ More extreme events – storms, floods

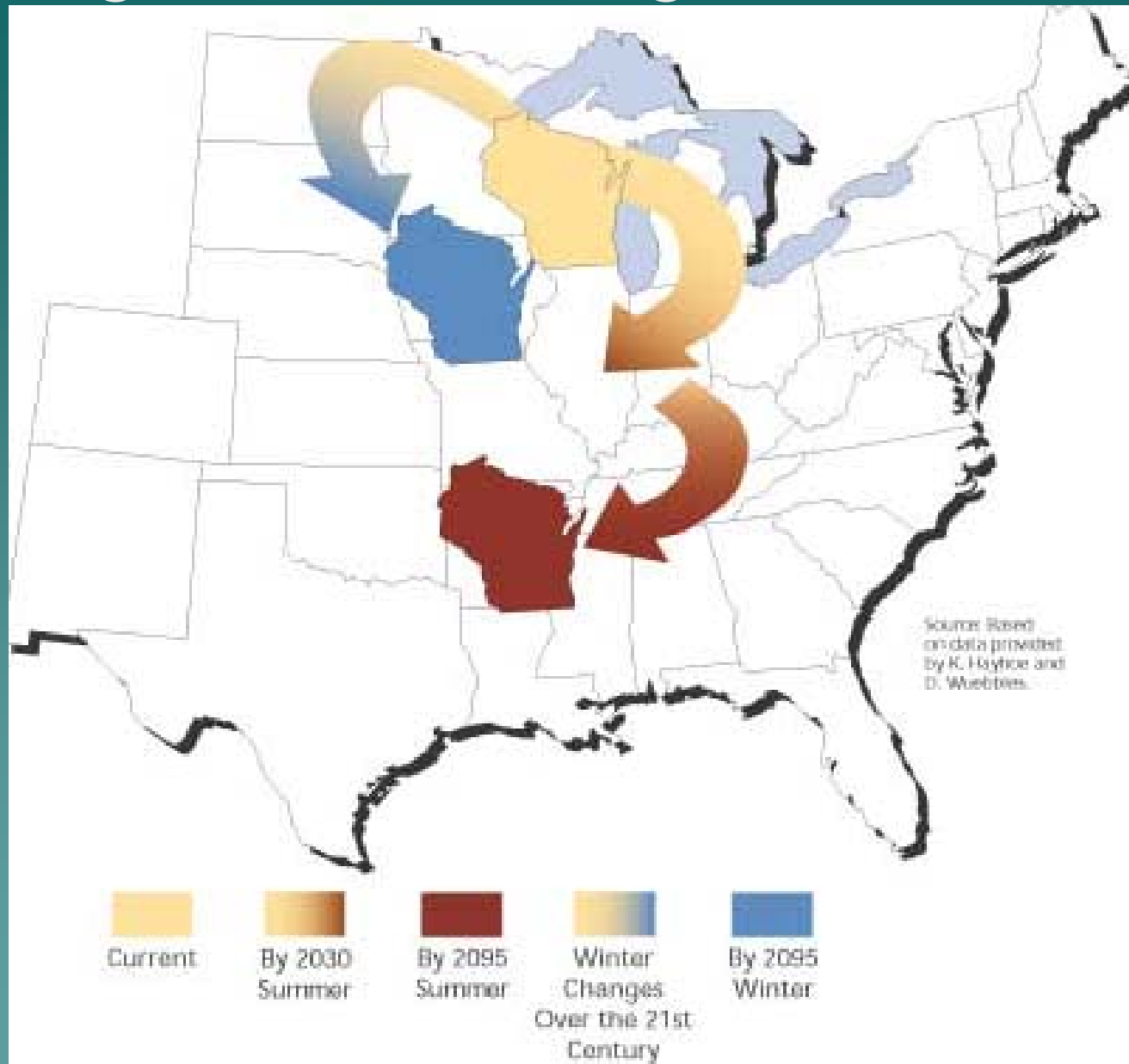
- Could be 50-100% more frequent than now

◆ Ice cover decline will continue



Source: Bob Allan, NREL

Moving States - Going to Arkansas?



Water Levels – Scenario #1

- ◆ Warmer, wetter winters increases recharge
- ◆ More recharge increases baseflow and groundwater levels
- ◆ More storms increases summer runoff and flooding
- ◆ More CO₂ in atmosphere makes plants more water efficient, decreasing ET
- ◆ Lakes may go up



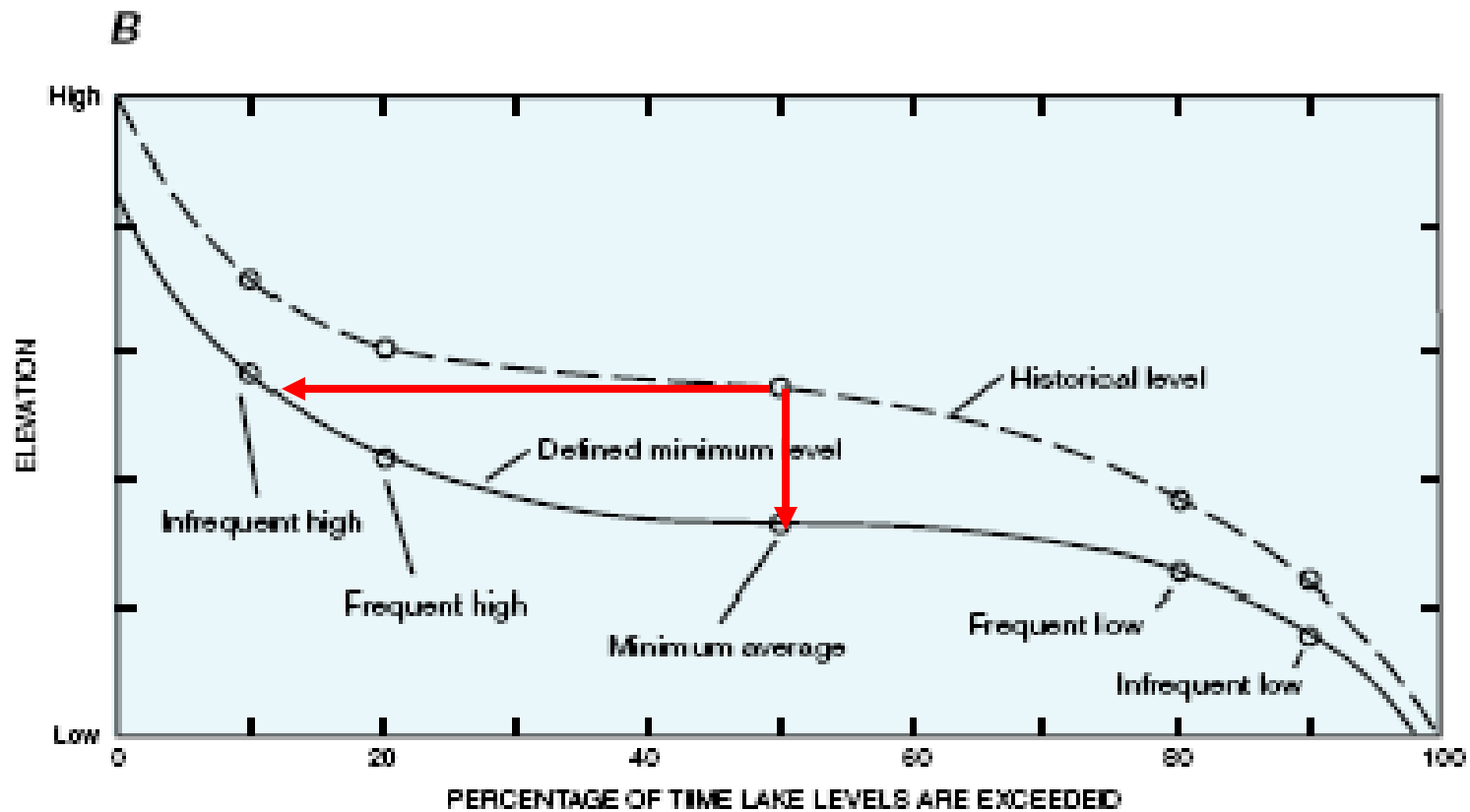
Source: John Magnuson, 2007

Water Levels – Scenario #2

- ◆ Shorter duration of ice cover increases time for evaporation
- ◆ Warmer air temperatures increase evapo-transpiration rates
- ◆ Lower precipitation in summer decreases soil moisture
- ◆ Extended dry periods between storm events
- ◆ Lakes may go down

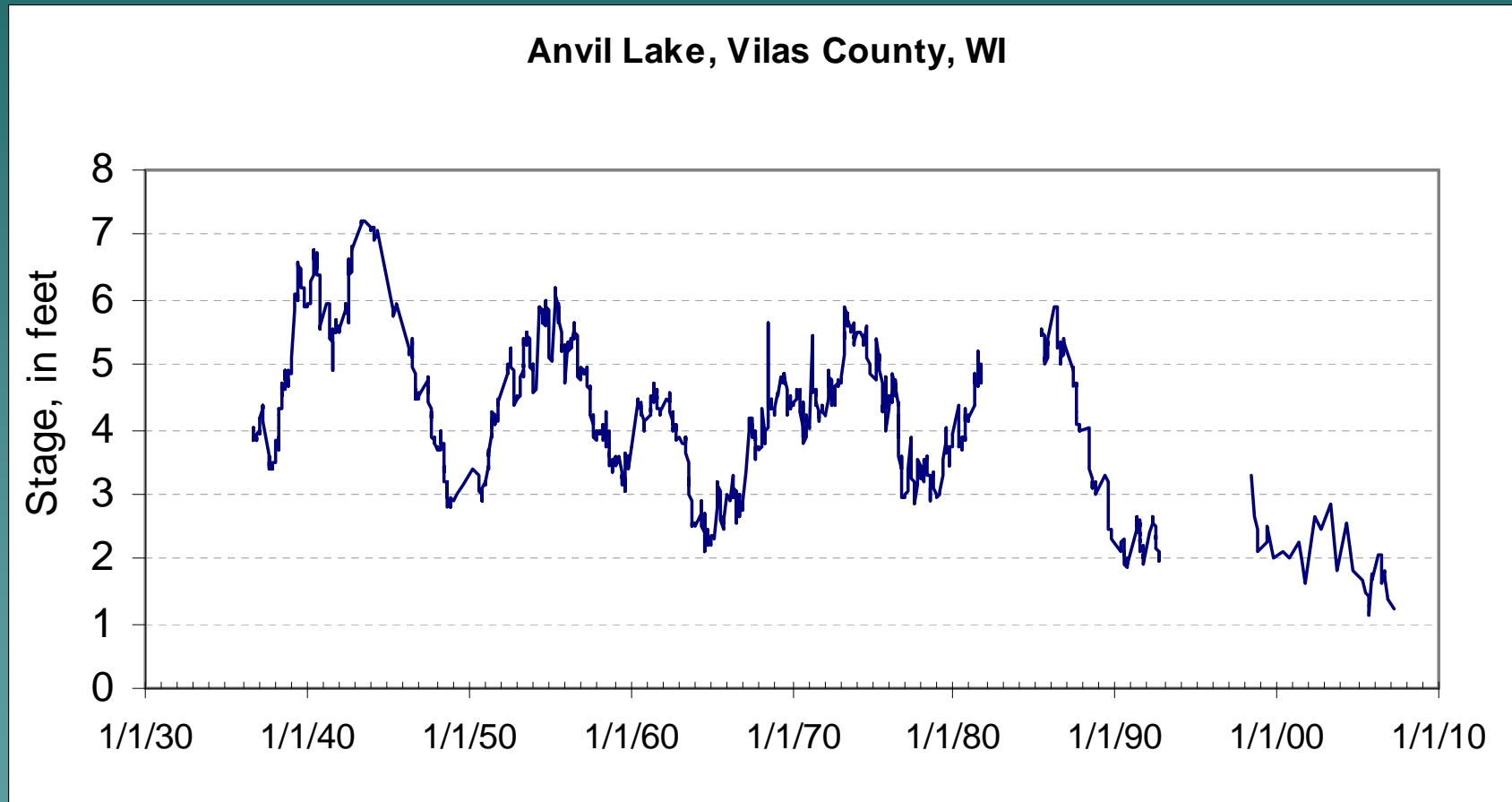


Changing water level regime



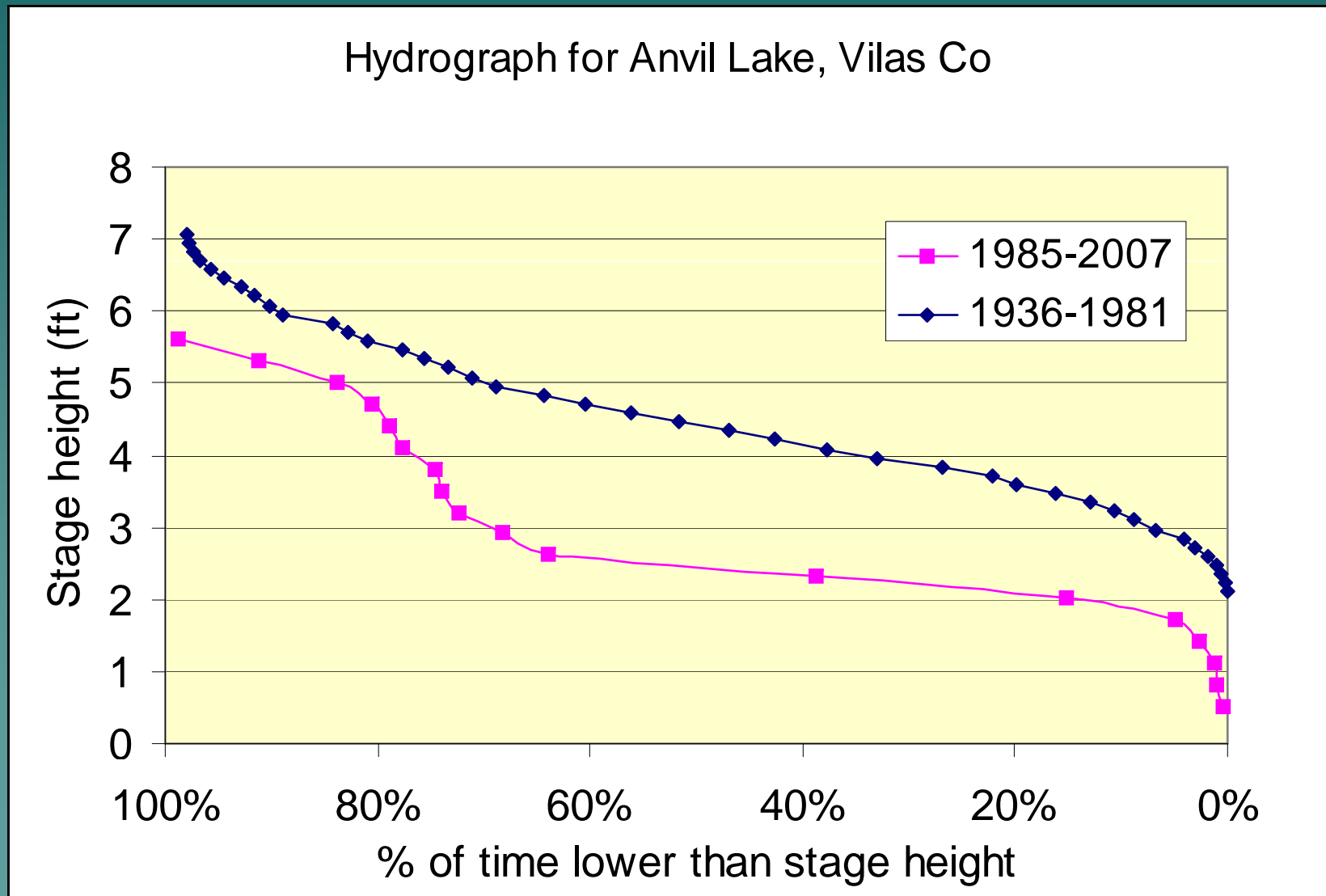
Source: USGS Circular 1186

Anvil Lake (Vilas Co) Stage (1936 – 2006)

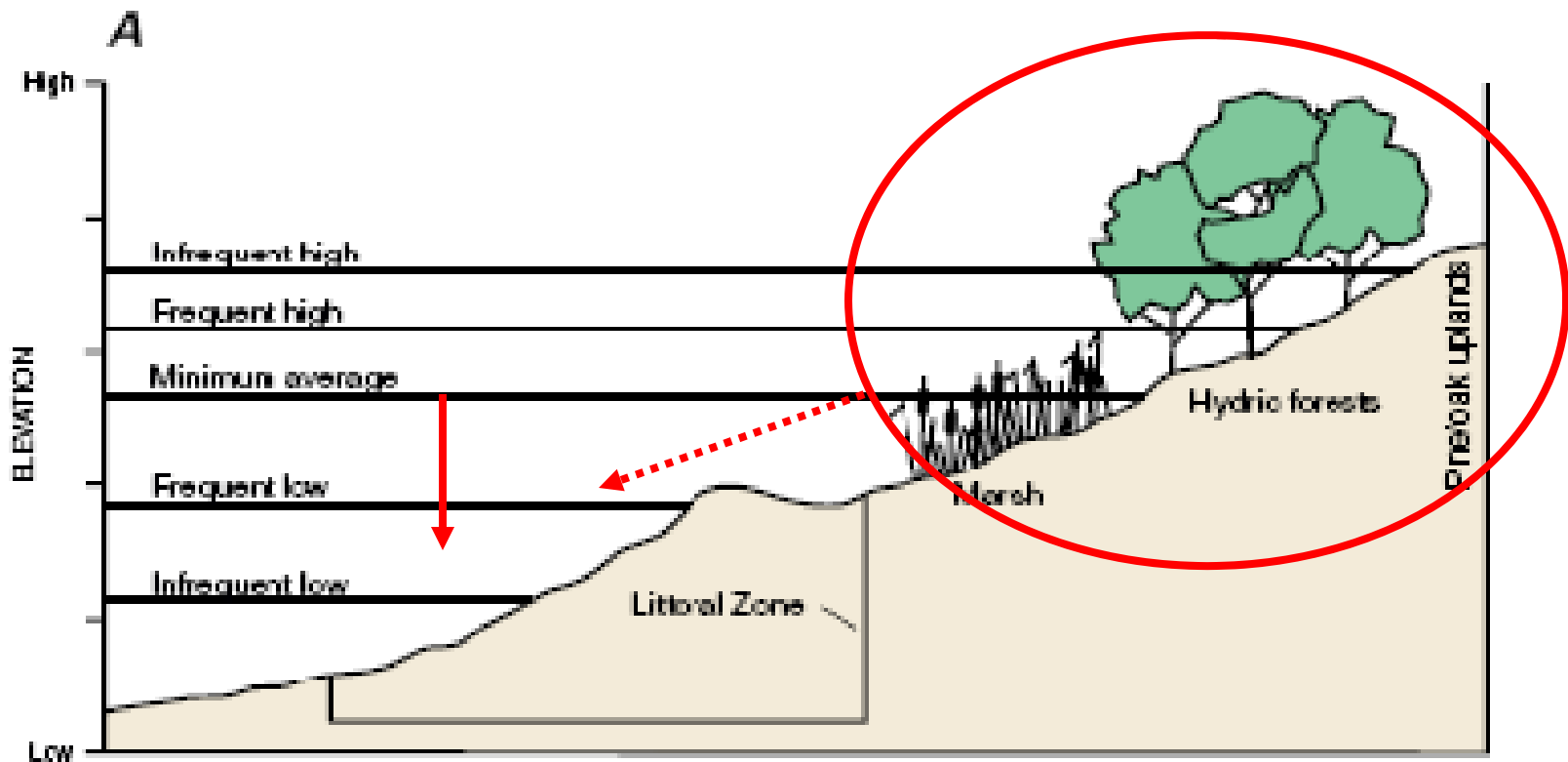


Source: USGS

Anvil Lake – Regime shift?

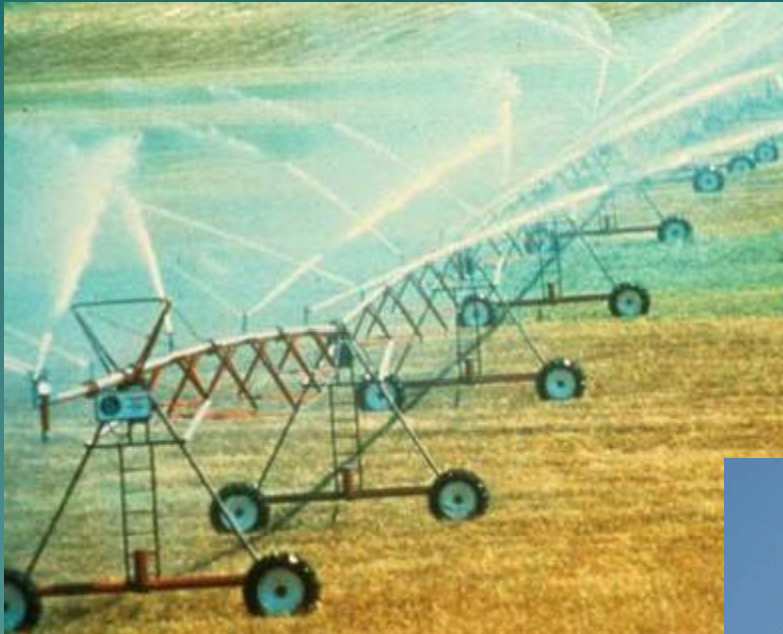


Implications of low water levels



Source: USGS Circular 1186

Human water use

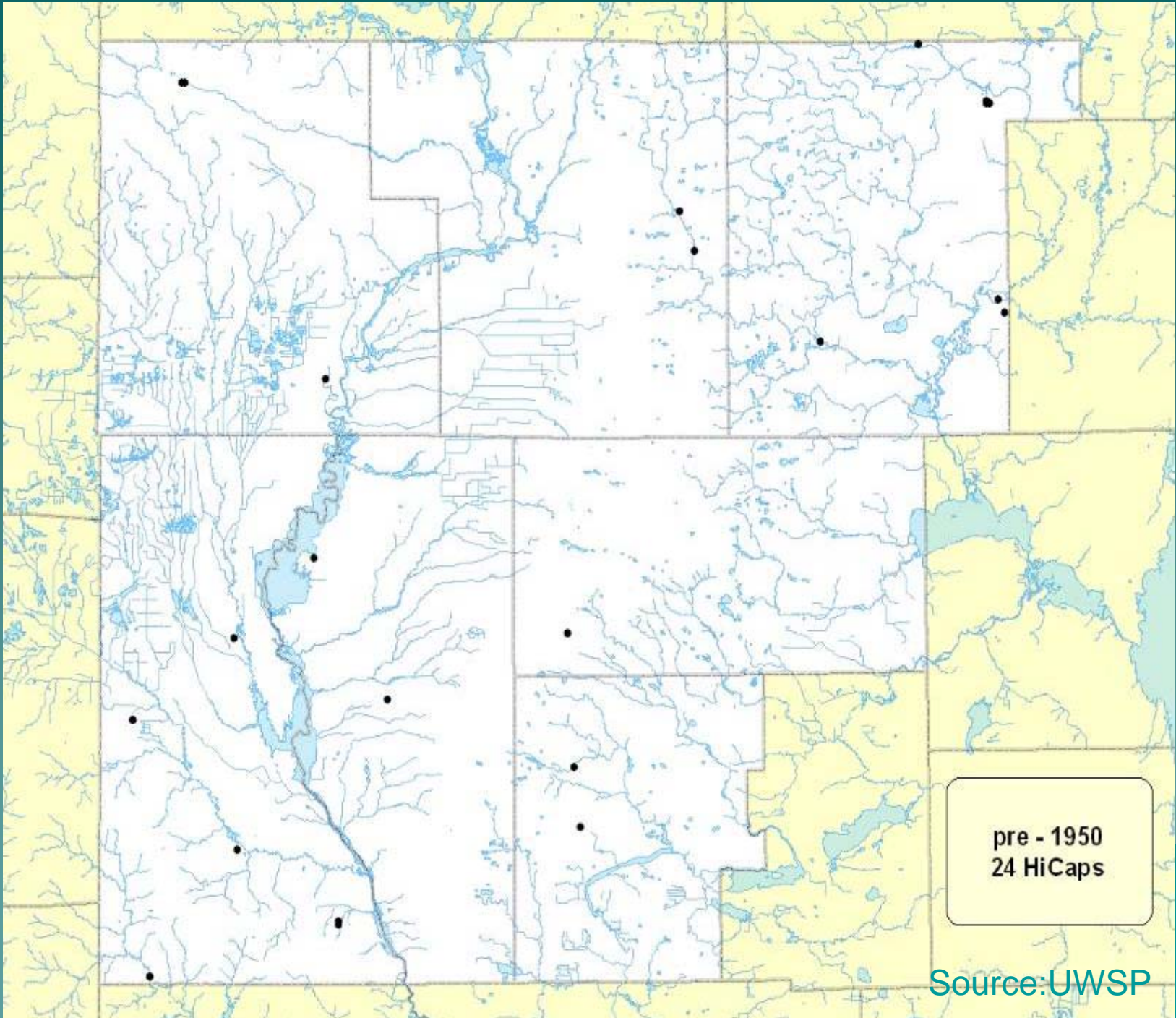




The present position
of the theory of
the origin of the
universe

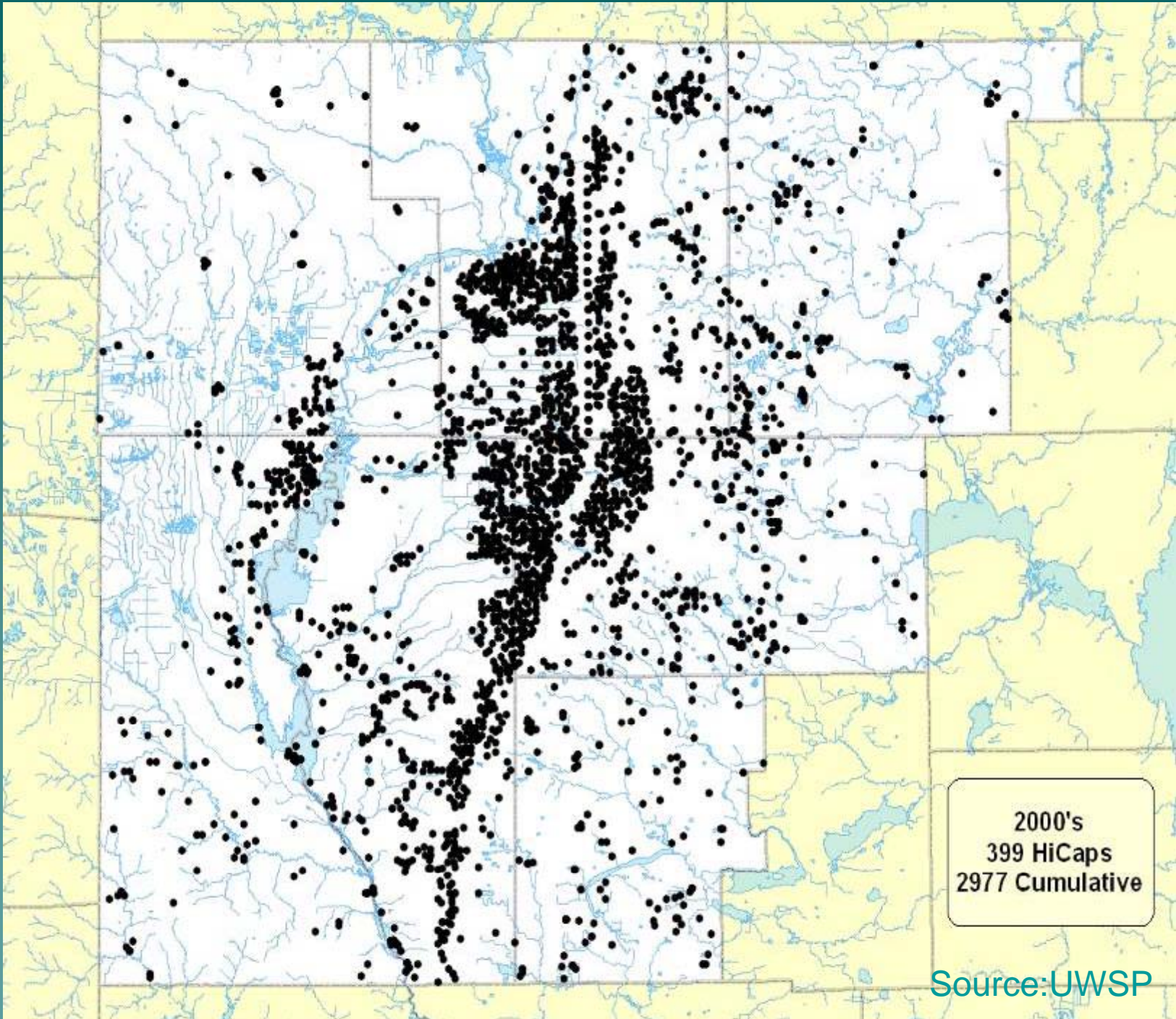
THE UNIVERSITY OF
WISCONSIN
LIBRARY
EQUIPMENT

WISCONSIN



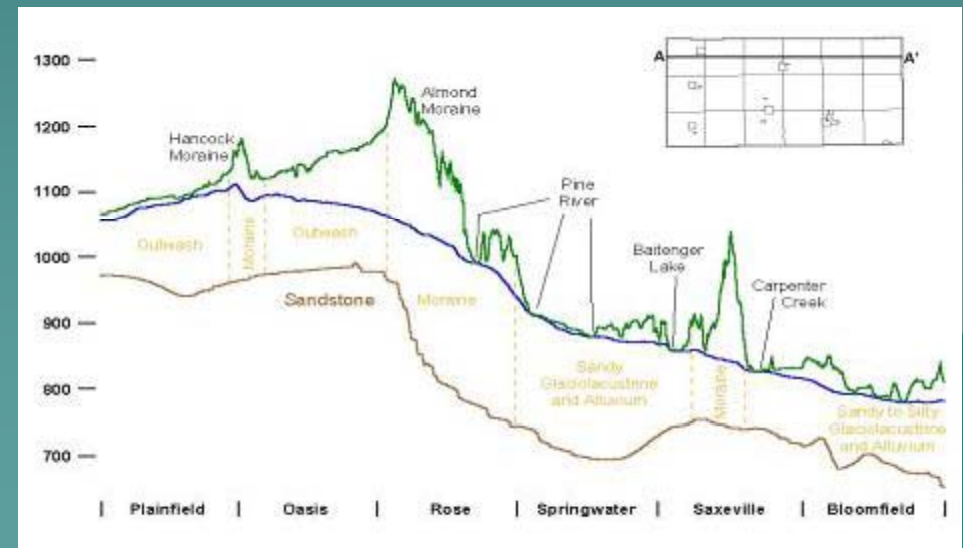
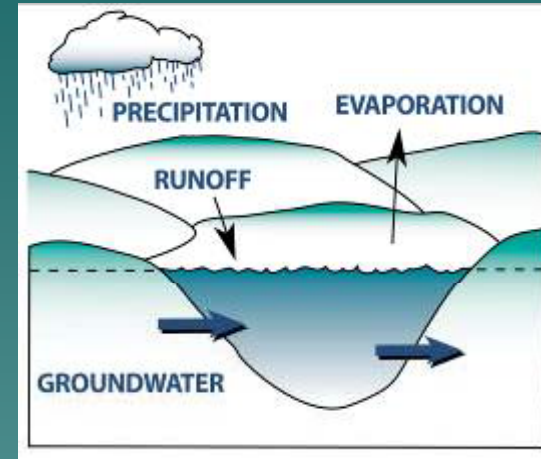
pre - 1950
24 HiCaps

Source: UWSP

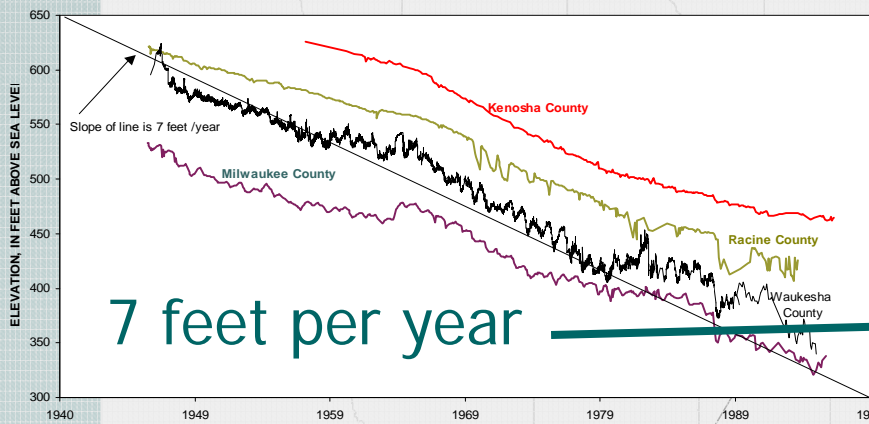
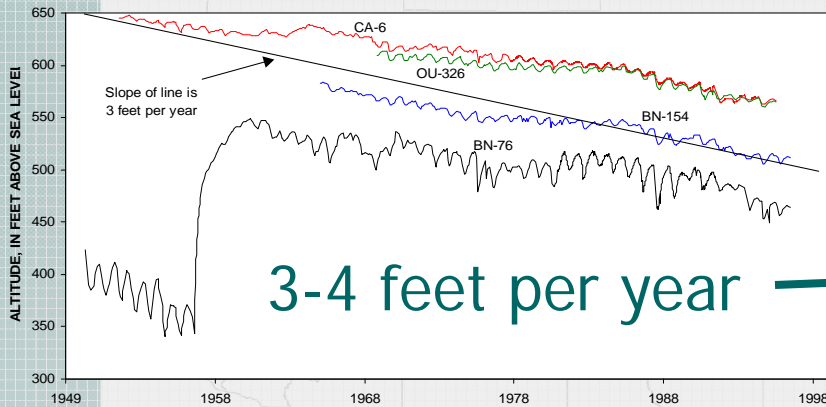


NW Waushara County Lakes

- ◆ Landlocked lakes, no outlet
- ◆ Sandy soils
- ◆ Lakes near major regional groundwater divide
- ◆ Recent declines after unusually high period in the 1990s
- ◆ Short-term drought in Central WI
- ◆ Major pumping center



Overpumping of the deep sandstone aquifer:



50 feet

50 feet

10 feet

Max
drawdown
> 300 feet

and, adding
Chicago...

Source: US Geological Survey and
Wisconsin Geological and Natural History Survey

Increased pressure on shallow sand and gravel aquifer

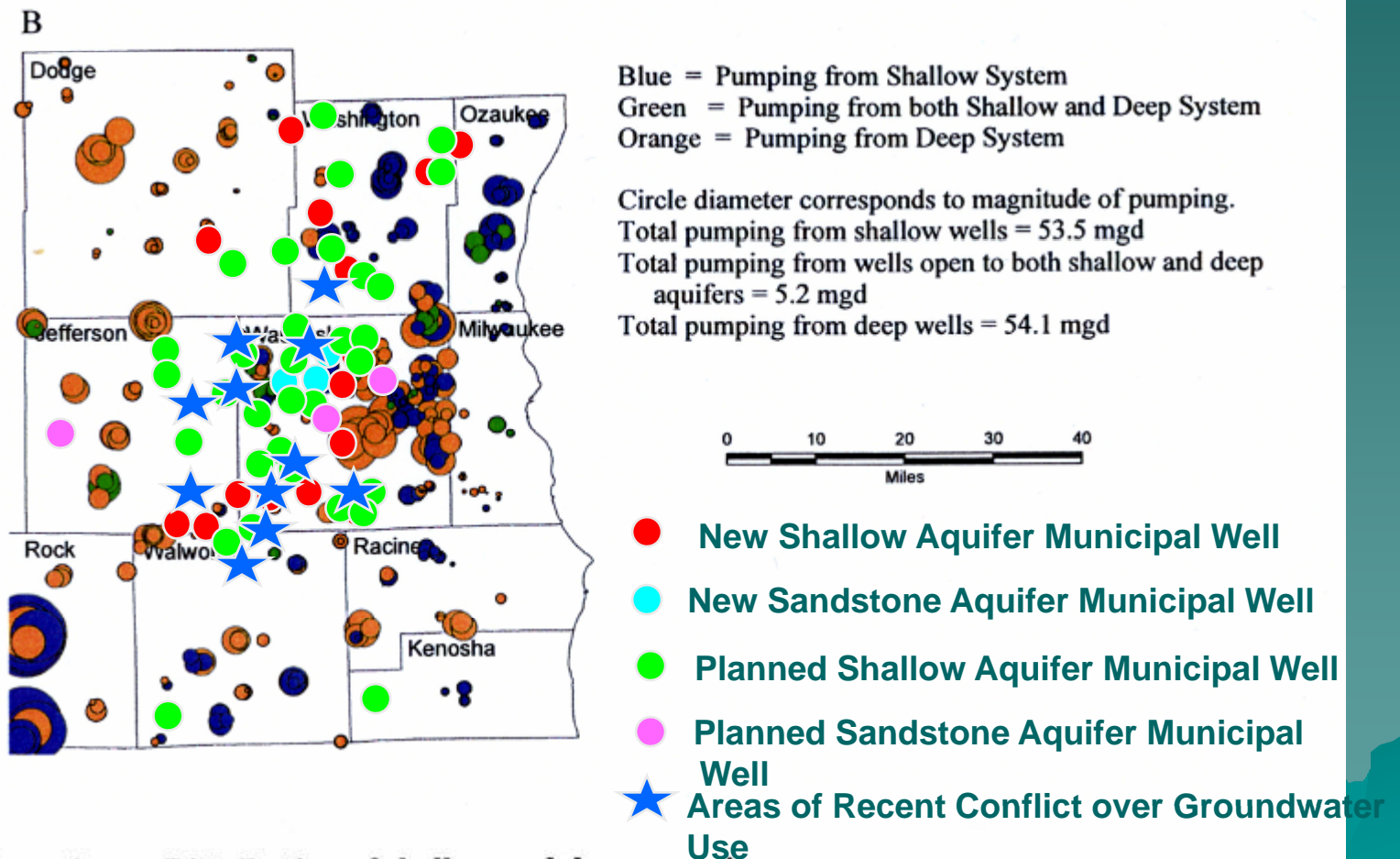
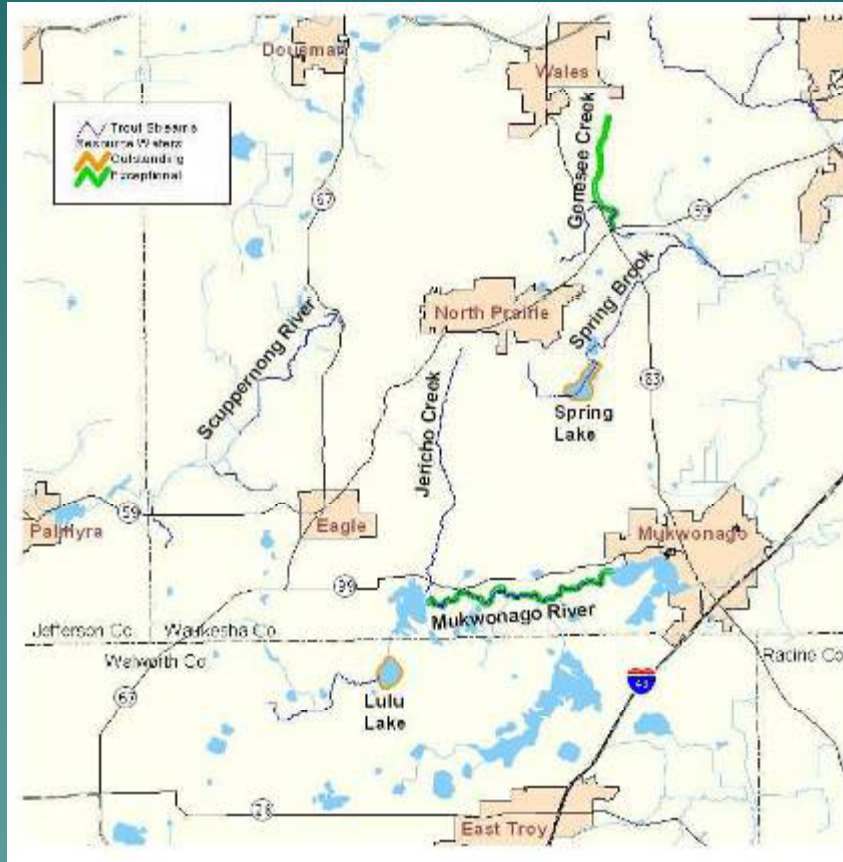


Figure 4. Distribution of shallow and deep pumping.
 A. 1950. B. 2000.

Slide courtesy of John Jansen

Recent conflicts in the Mukwonago River watershed



- ◆ Lake residents concerned about new municipal well sitings
- ◆ Communities needing new sources of water
- ◆ Downstream flows, water budgets, water quality concerns
- ◆ Conflicts also spurred by urban sprawl and development patterns
- ◆ Litigation/cooperation

Role of Climate Change

Exacerbation of Existing Problems

- ◆ Increased flooding and erosion
- ◆ Pressure to increase water extraction from the Great Lakes
- ◆ Mining of deep aquifers increases pressure on shallow groundwater
- ◆ More reliance on irrigation to grow crops
- ◆ **Anthropogenic impacts may enhance or counter long term regional trends**



Source: Dave Hansen, MN Extension Service

Which one is the future?



Maybe both!

Wisconsin Water Law

- ◆ Riparian rights
- ◆ Reasonable/
beneficial use
- ◆ Navigable
waters
- ◆ Public Trust
Doctrine
- ◆ Statutory
authority



DNR's Statutory Authority

- ◆ “The purpose of this subchapter is to grant necessary powers and to organize a comprehensive program...for the enhancement of the quality management and protection *of all waters of the state, ground and surface, public and private.*” *Wis. Stats Ch. 281.11*

Surface Water Withdrawals



- ◆ For any agricultural or irrigation purpose
- ◆ 2 million gpd level for other uses
- ◆ 10-year permits
- ◆ Riparian rights & beneficial uses
- ◆ Cumulative impacts
- ◆ Public rights flows

Groundwater Withdrawals

- ◆ Over 100,000 gpd subject to state approval
- ◆ Over 2 million gpd, then must not impair public water rights
- ◆ Over 5 million gpd in Great Lakes basin require approval from all states & provinces
- ◆ Great Lakes Compact negotiations currently underway



So what are we worried about?



“There’s a gap in Wisconsin’s water law...”

- ◆ No limits on groundwater withdrawals unless exceeding 2 million gallons per day
- ◆ No explicit authority to deny approval of high capacity well if impacts surface waters
- ◆ No requirements for water conservation
- ◆ No consideration of cumulative impacts

The “New” Groundwater Law - 2003 Wisconsin Act 310

- ◆ Requires notification of all new well construction and water use reporting
- ◆ Expanded DNR authority to consider environmental impacts in issuing high cap approvals in certain situations
- ◆ Established Groundwater Management Areas in 2 parts of state
- ◆ Created Groundwater Advisory Committee to advise department and make recommendations for future legislation

Environmental reviews of high capacity wells – acute impacts

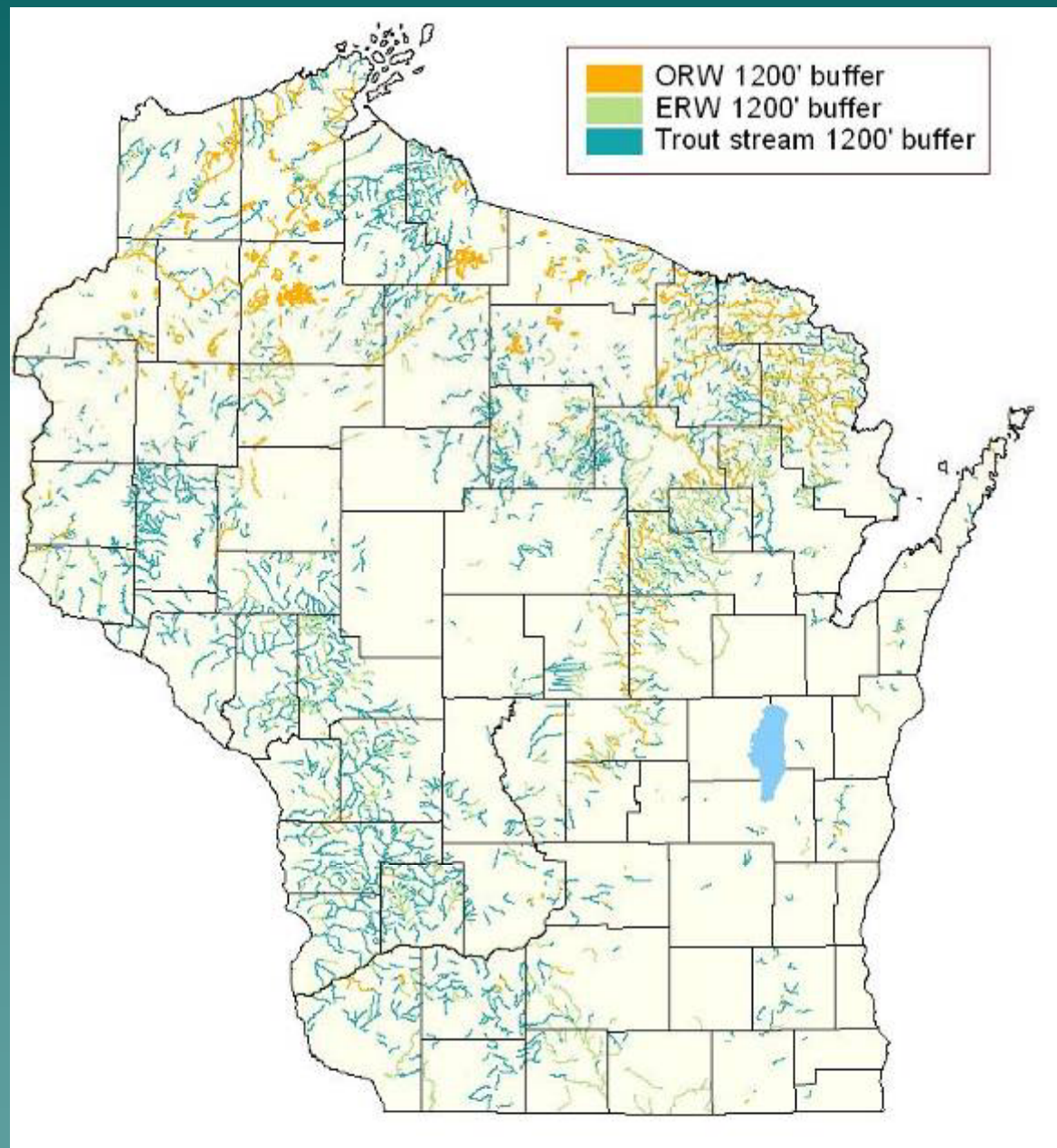
- ◆ Groundwater Protection Areas (GPAs)
 - within 1200 feet of critical surface water resources
- ◆ High water loss
 - withdrawals that result in water loss of >95%
- ◆ Potential impact to a spring
 - defined as >1 cfs at least 80% of the time

GPAs:

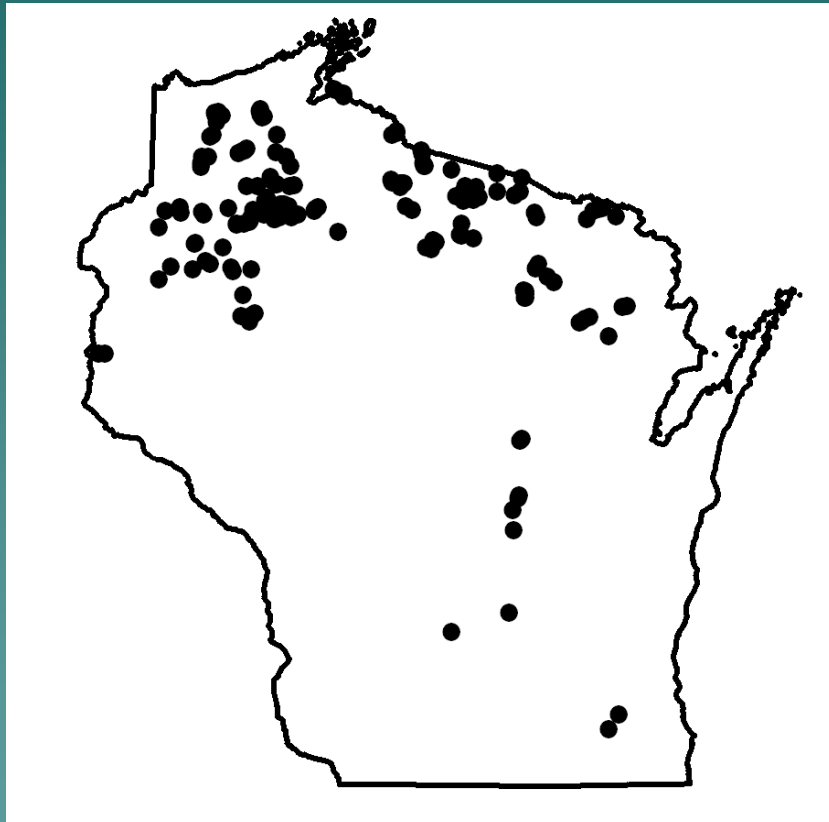
ORW =
Outstanding
Resource Water

ERW =
Exceptional
Resource Water

Trout Streams
include Class I,
II, and III



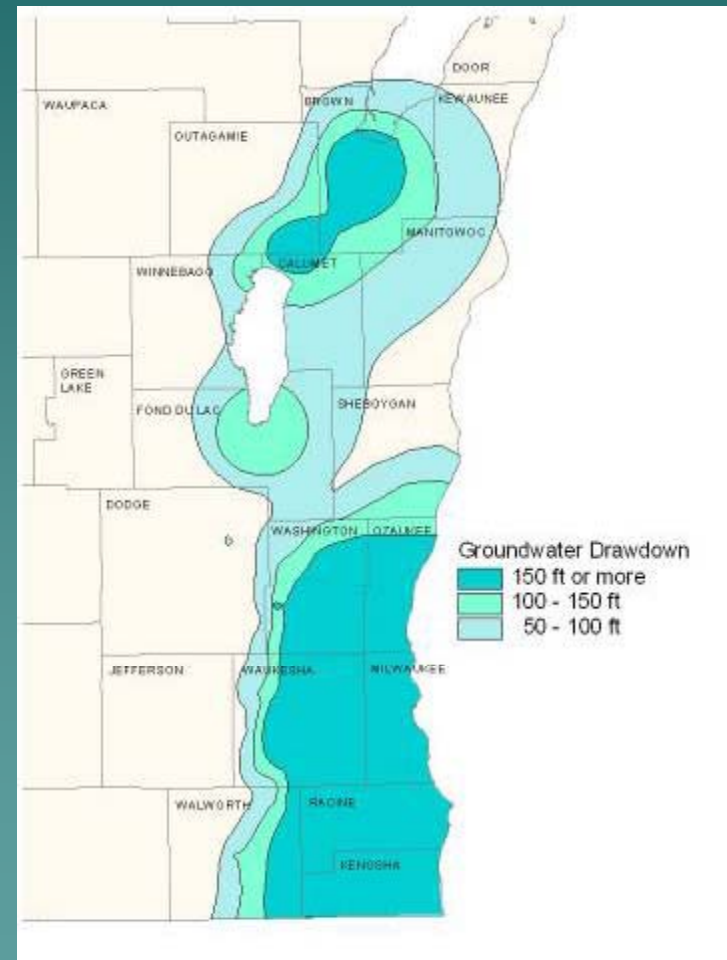
ORW Lakes



- ◆ 105 out of 15,082 lakes
- ◆ ORW designation intended to protect against point source discharges
- ◆ Mostly pristine lakes in forested areas
- ◆ Recent petition to add waters to list

Groundwater Management Areas – Chronic Impacts

- ◆ Areas of significant drawdowns and over-pumping
- ◆ 150-ft drawdown contour
- ◆ Water quality problems (arsenic, radium, salinity)
- ◆ Need for a coordinated management strategy



Groundwater Advisory Committee

- ◆ Began meeting in April 2005
- ◆ Members appointed by Governor and Legislature
- ◆ Municipal, industrial, agricultural, & environmental interests represented
- ◆ Staffed by DNR
- ◆ Science and policy advisors
- ◆ Advise on rule development and further legislation




Groundwater Advisory Committee

- ◆ Wrapped up work in Dec. 2007
- ◆ Reports delivered to legislature on schedule
- ◆ Recommendations did not include future legislation, but offered several alternative regulatory frameworks

Goals of Workshop

- ◆ Better understanding of lake and groundwater interactions
- ◆ How to sort out climate from human impacts on lake levels?
- ◆ Predicting potential impacts of proposed wells as well as determining if impacts are already occurring
- ◆ Tools and Resources from a lake scale to a watershed scale
- ◆ What can one lake do (AKA when do you need to bring in the experts)?

Workshop Overview

- ◆ Science of groundwater/surface water interactions
 - ◆ Tools for Understanding Groundwater and Lake Interactions
 - ◆ Case studies from Wisconsin
 - ◆ Future Opportunities, Policy Directions, and General Discussion
- 
- A decorative graphic at the bottom of the slide consisting of a silhouette of a mountain range in various shades of teal, extending from the right side towards the center.


Science of groundwater and lakes (surface water) interactions



Tools for Understanding Groundwater and Lake Interactions

- ◆ Citizen work (with limited assistance) (Nauta)
- ◆ Expanded watershed studies (Nauta)
- ◆ Multi-watershed studies (Nauta or Dunning)
- ◆ Grants (Asplund)
- ◆ Technical Assistance (Dunning)

Case Studies for Understanding Groundwater and Lake Interactions

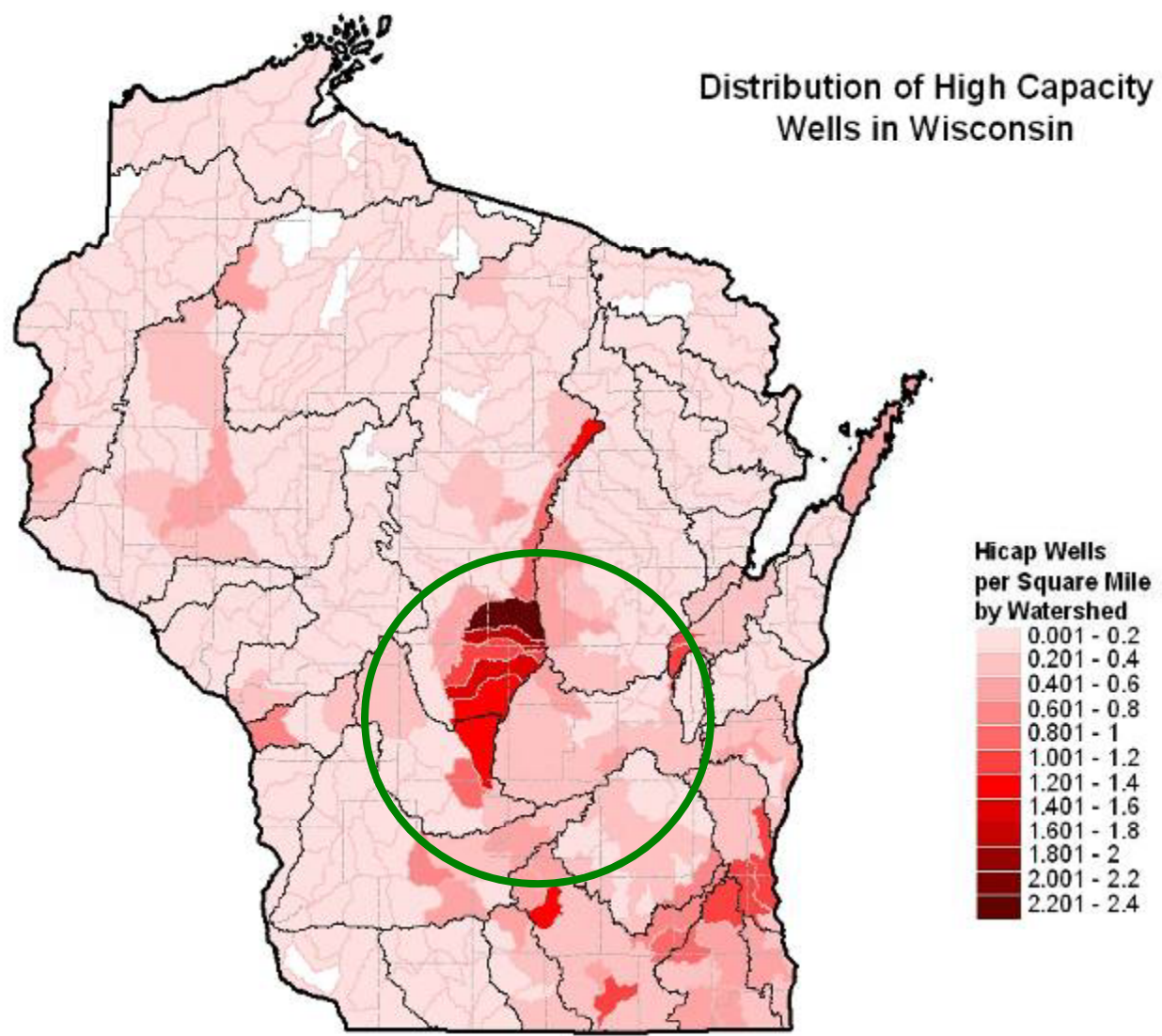
- ◆ Middle Genessee, Walworth Co (Dunning or Garn)
 - ◆ Silver Lake, Waukesha Co (Dunning or Garn)
 - ◆ Crystal Lake, Sheboygan Co (Nauta)
 - ◆ Central sand plains (Asplund)
- 

Case Studies for Understanding Groundwater and Lake Interactions

- ◆ Middle Genessee, Walworth Co
- ◆ Silver Lake, Waukesha Co
- ◆ Crystal Lake, Sheboygan Co
- ◆ Central sand plains



Distribution of High Capacity Wells in Wisconsin

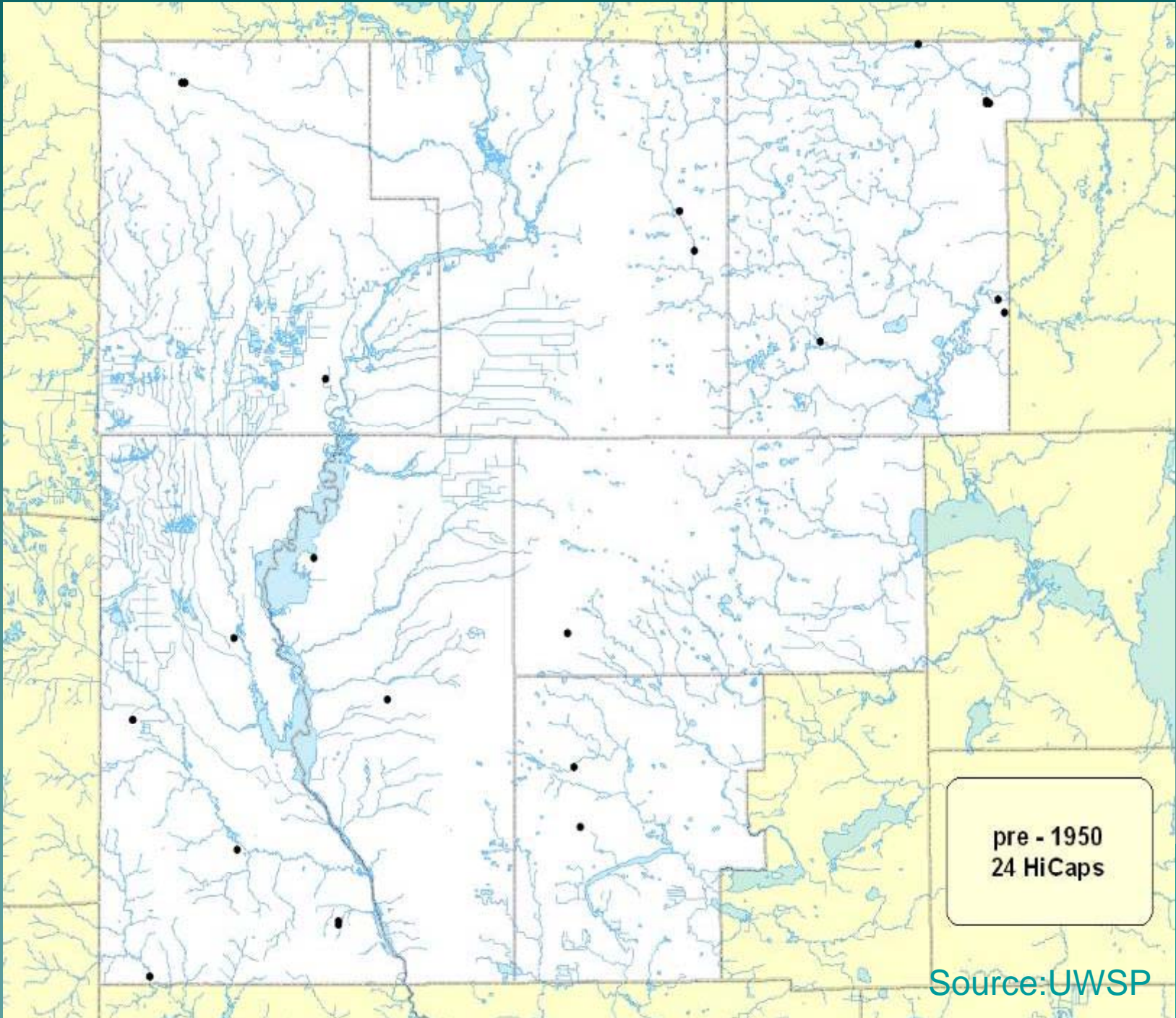




The present position
of the theory of
the origin of the
universe

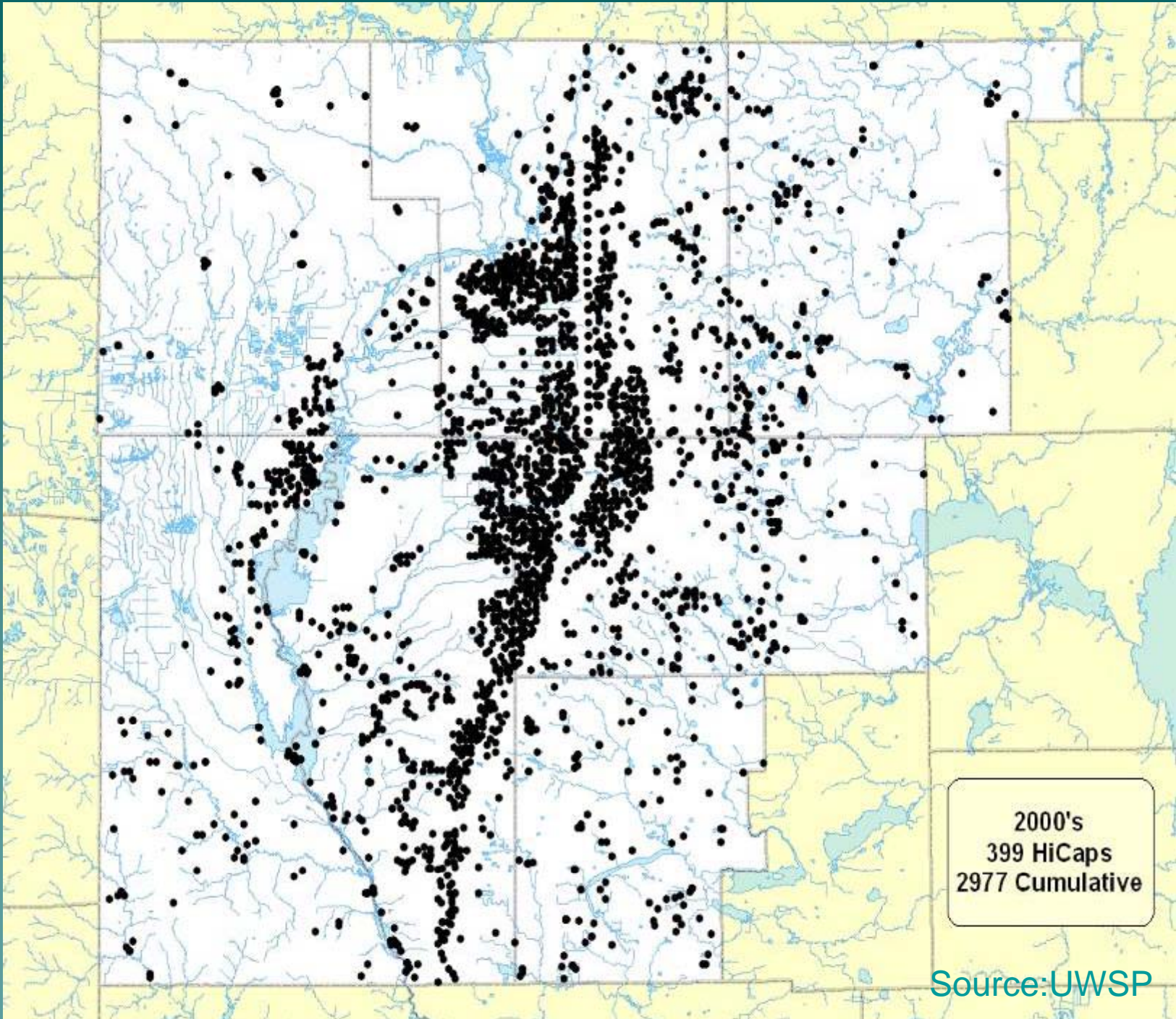
WISCONSIN
UNIVERSITY
LIBRARY
EQUIPMENT

WISCONSIN



pre - 1950
24 HiCaps

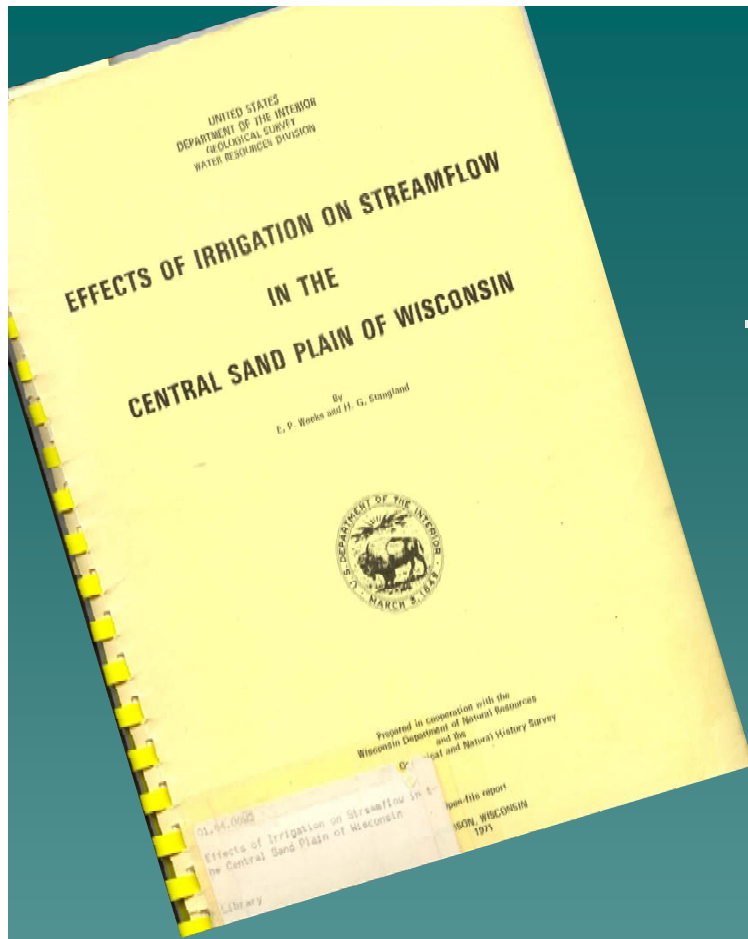
Source: UWSP



Effects of irrigation

1970 – 1/4 of the area irrigated

- normal summer stream loss:
25-30%
- normal summer water decline:
1/2 foot
- drought stream loss:
70-90%
- drought water decline:
2-3 feet



Effects of irrigation

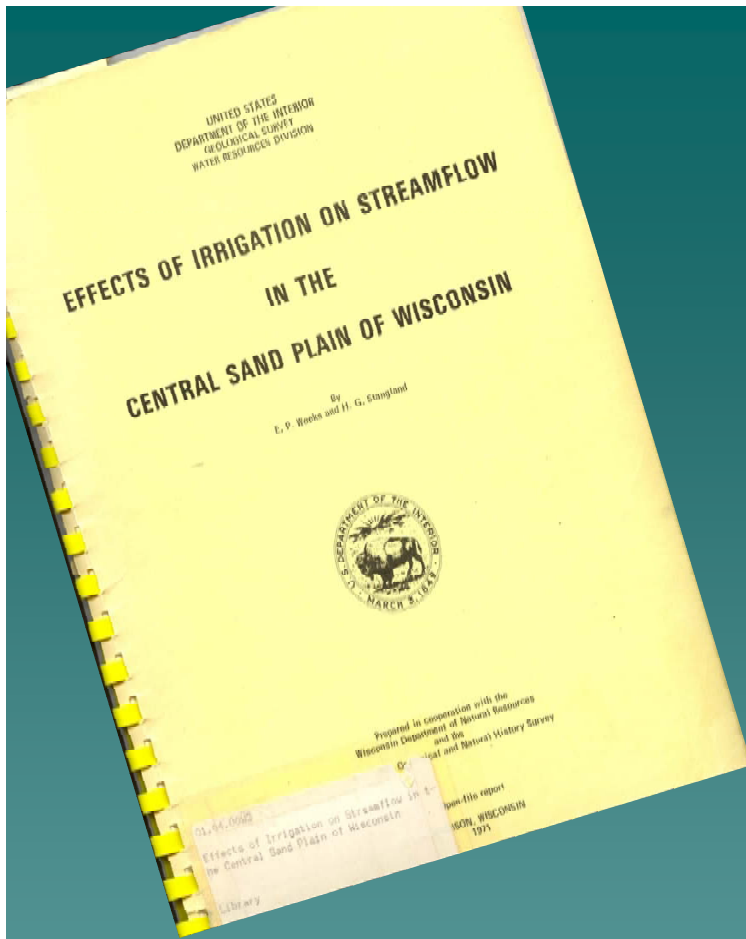
If 50% of area irrigated

-drought stream loss:
100%

- drought water decline:
4 - 5 feet

2007:

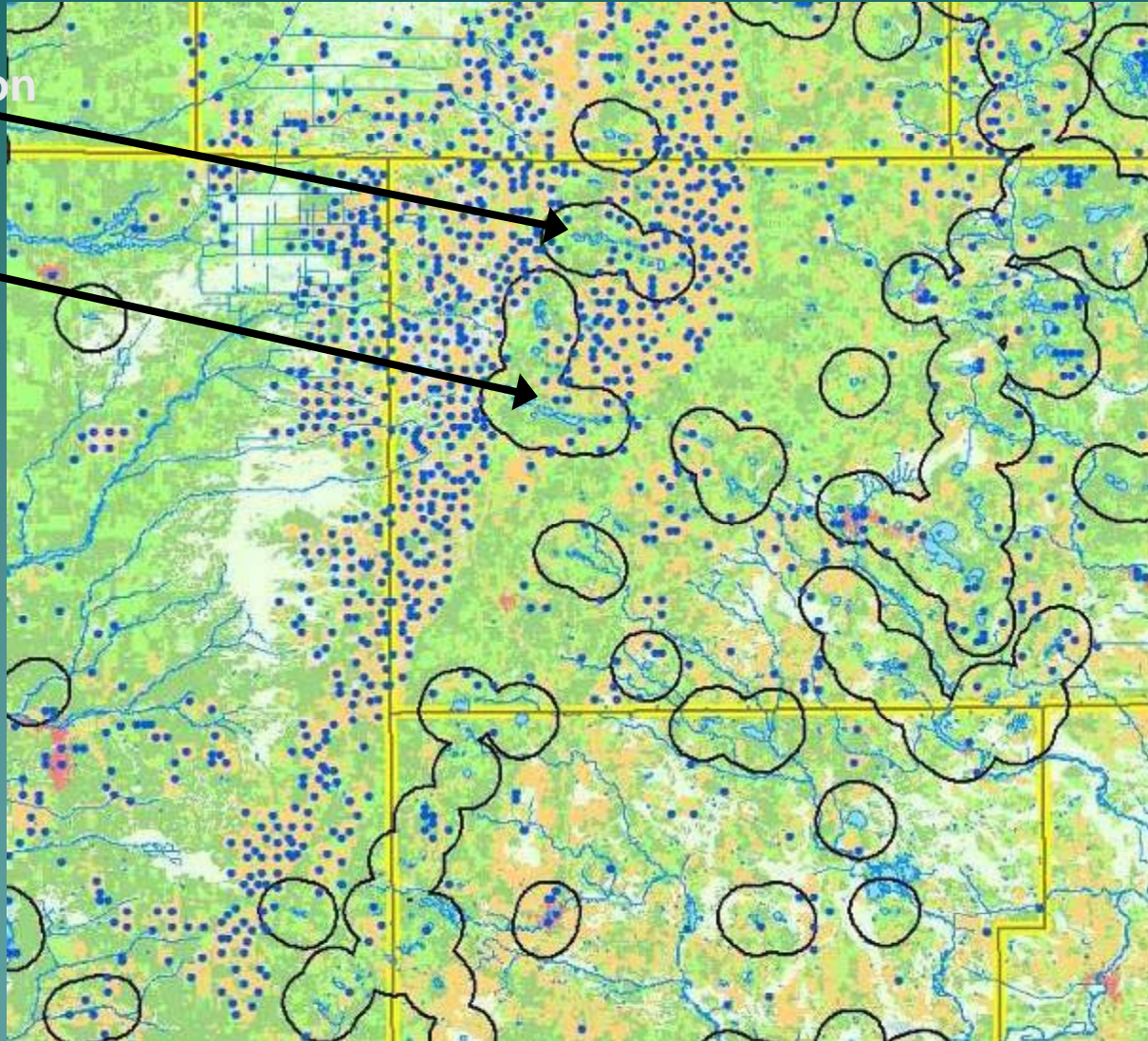
50-75% of area irrigated



Waushara County Lakes

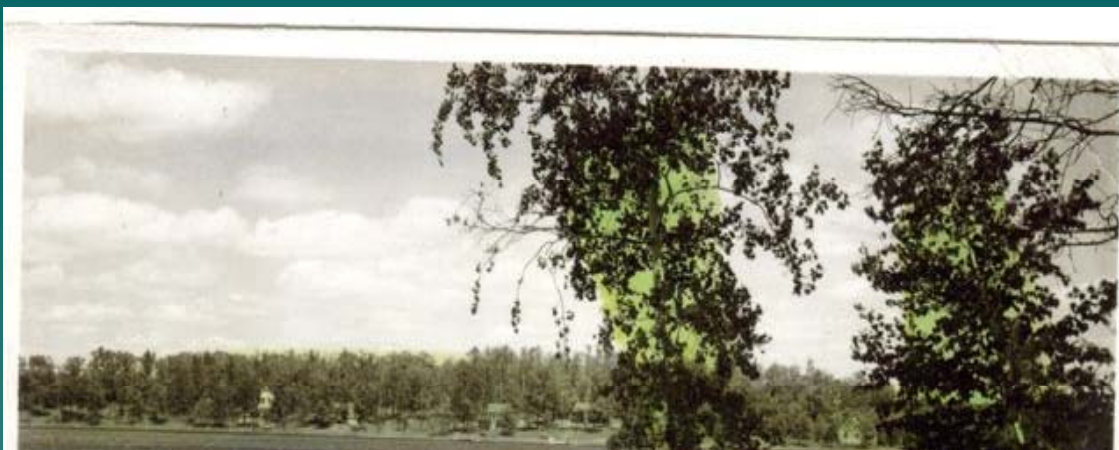
Long, Huron

Fish, Pine



Source: UWSP

1950s

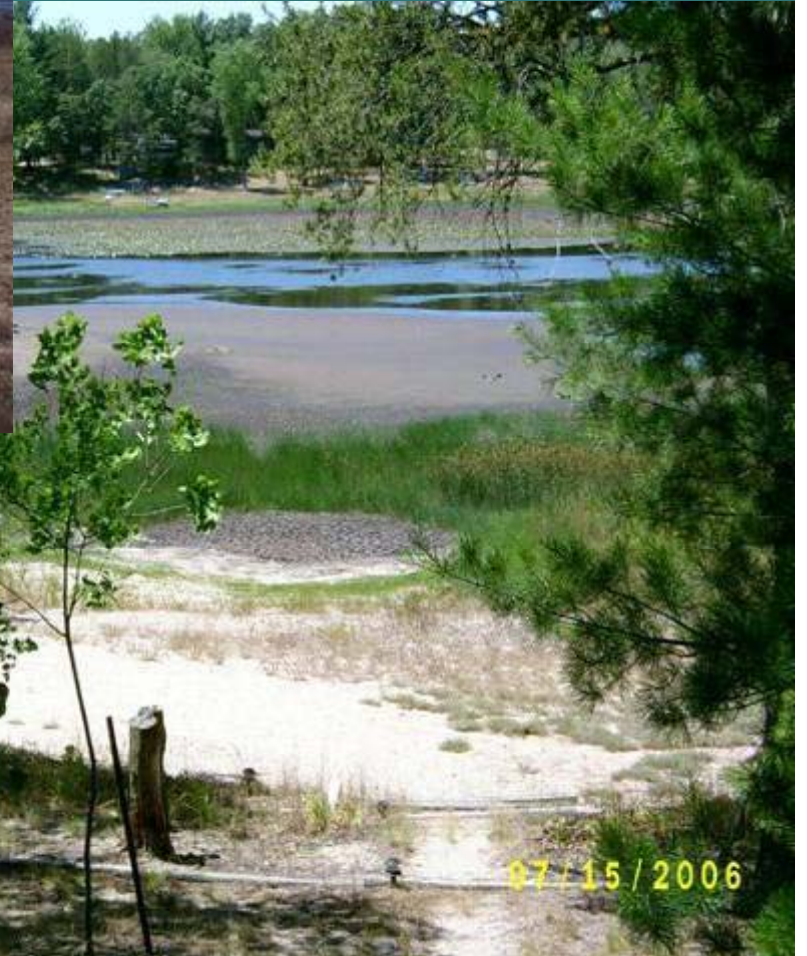


NORTH SHORE LONG LAKE PLAINFIELD

1994

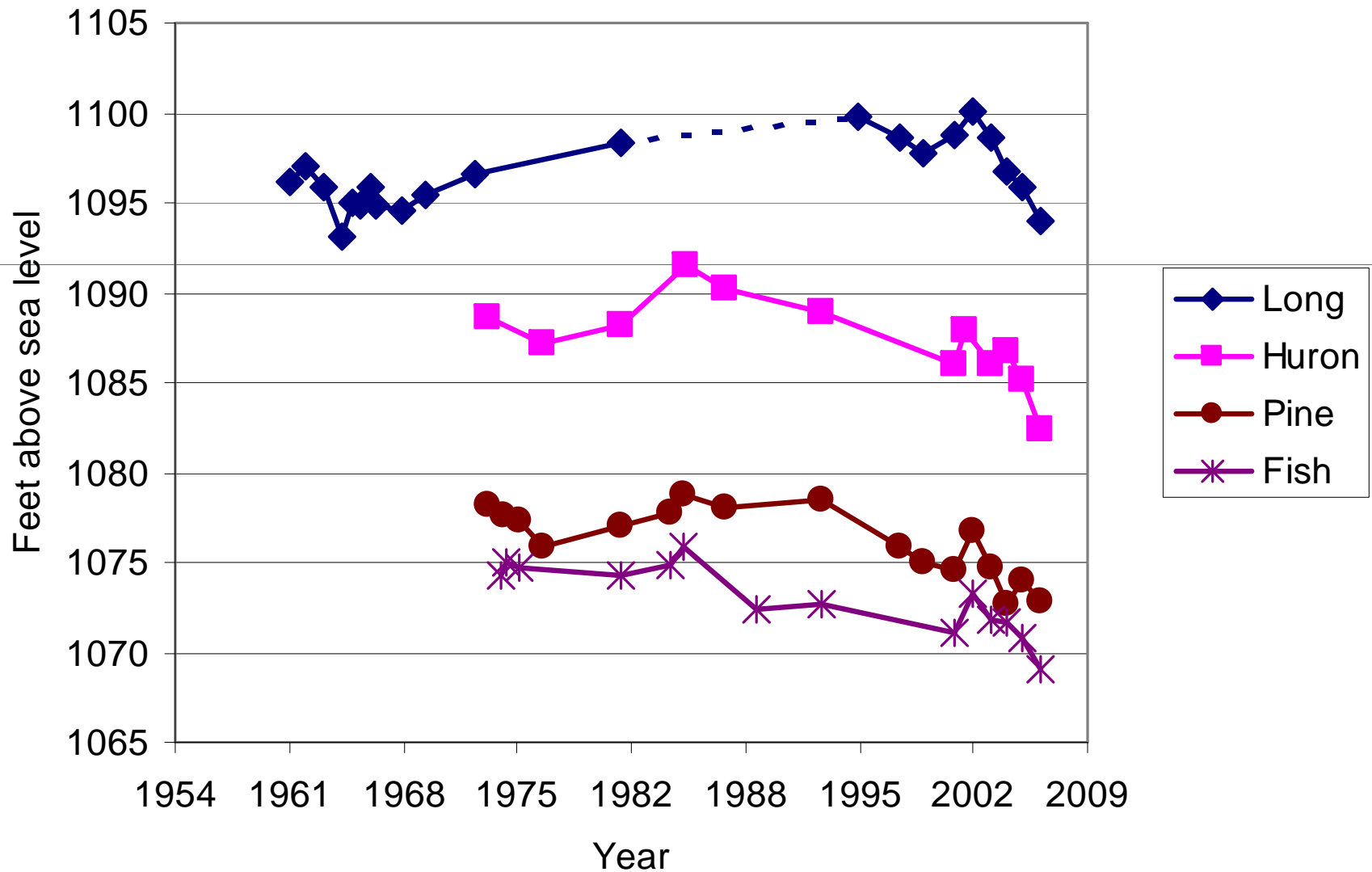


Spring 2006



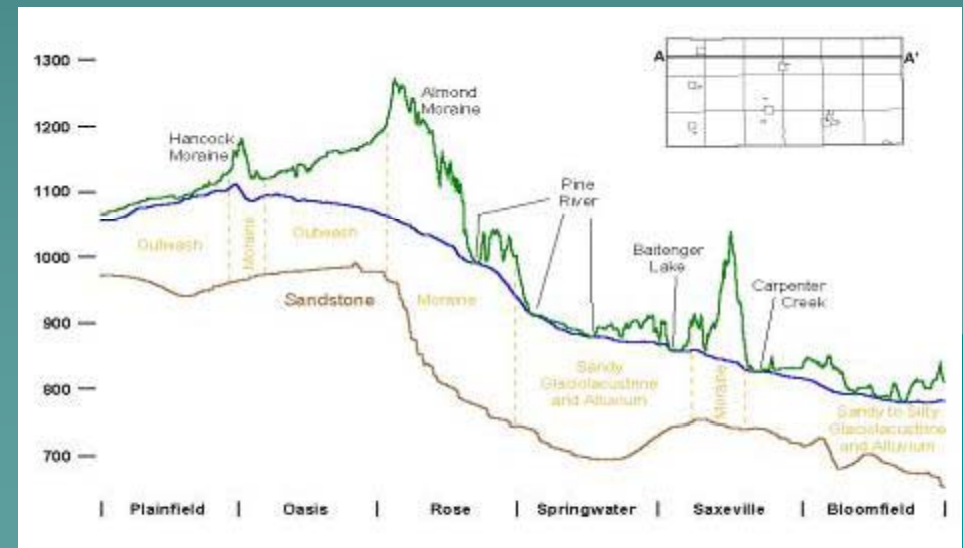
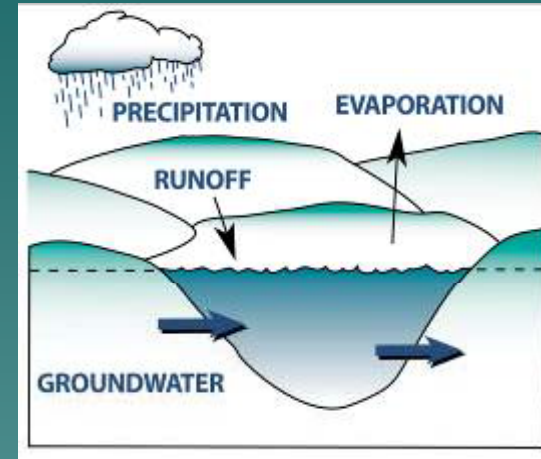
July 2006

NW Waushara County Lakes

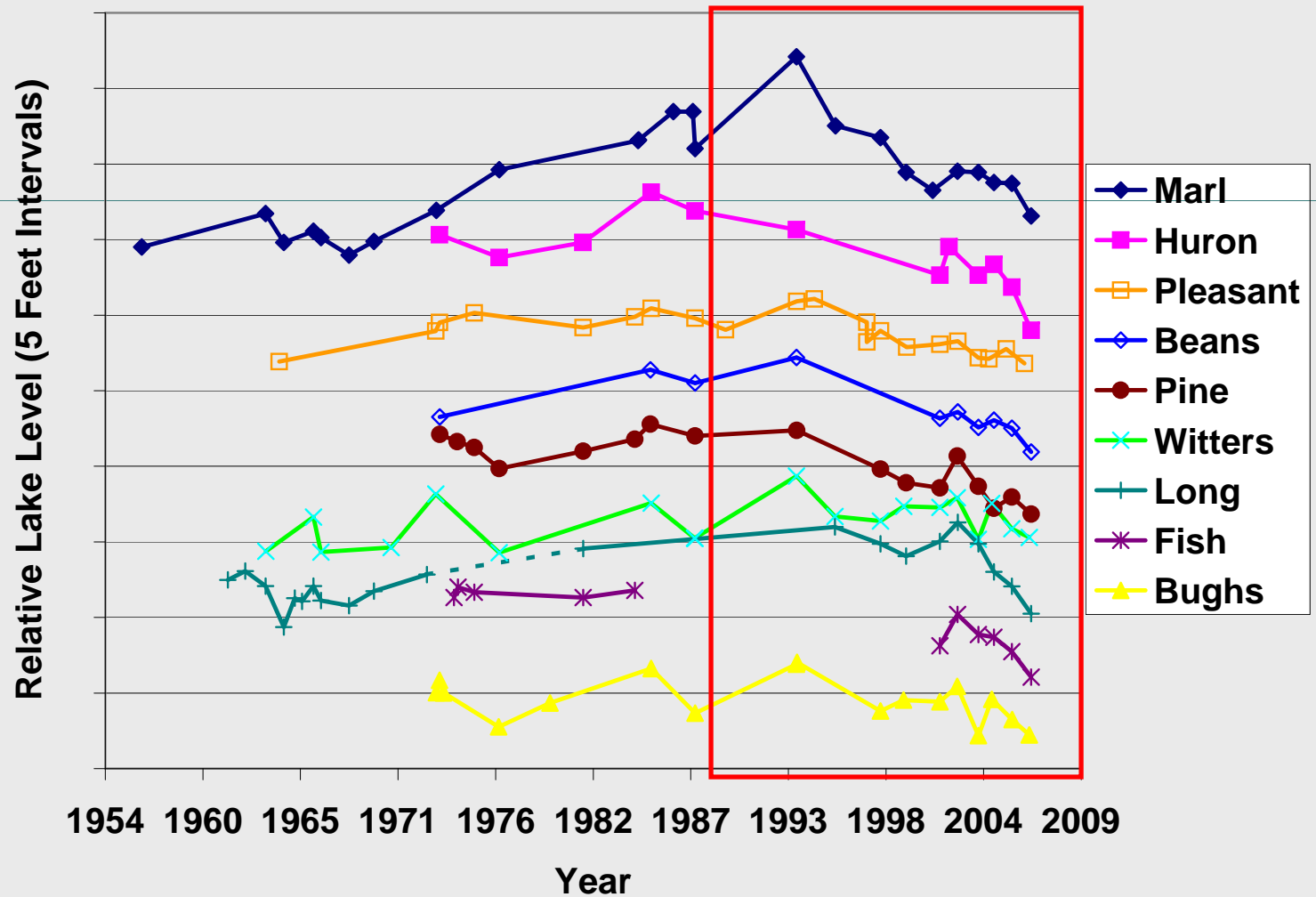


NW Waushara County Lakes

- ◆ Landlocked lakes, no outlet
- ◆ Sandy soils
- ◆ Lakes near major regional groundwater divide
- ◆ Recent declines after unusually high period in the 1990s
- ◆ Short-term drought in Central WI
- ◆ Major pumping center

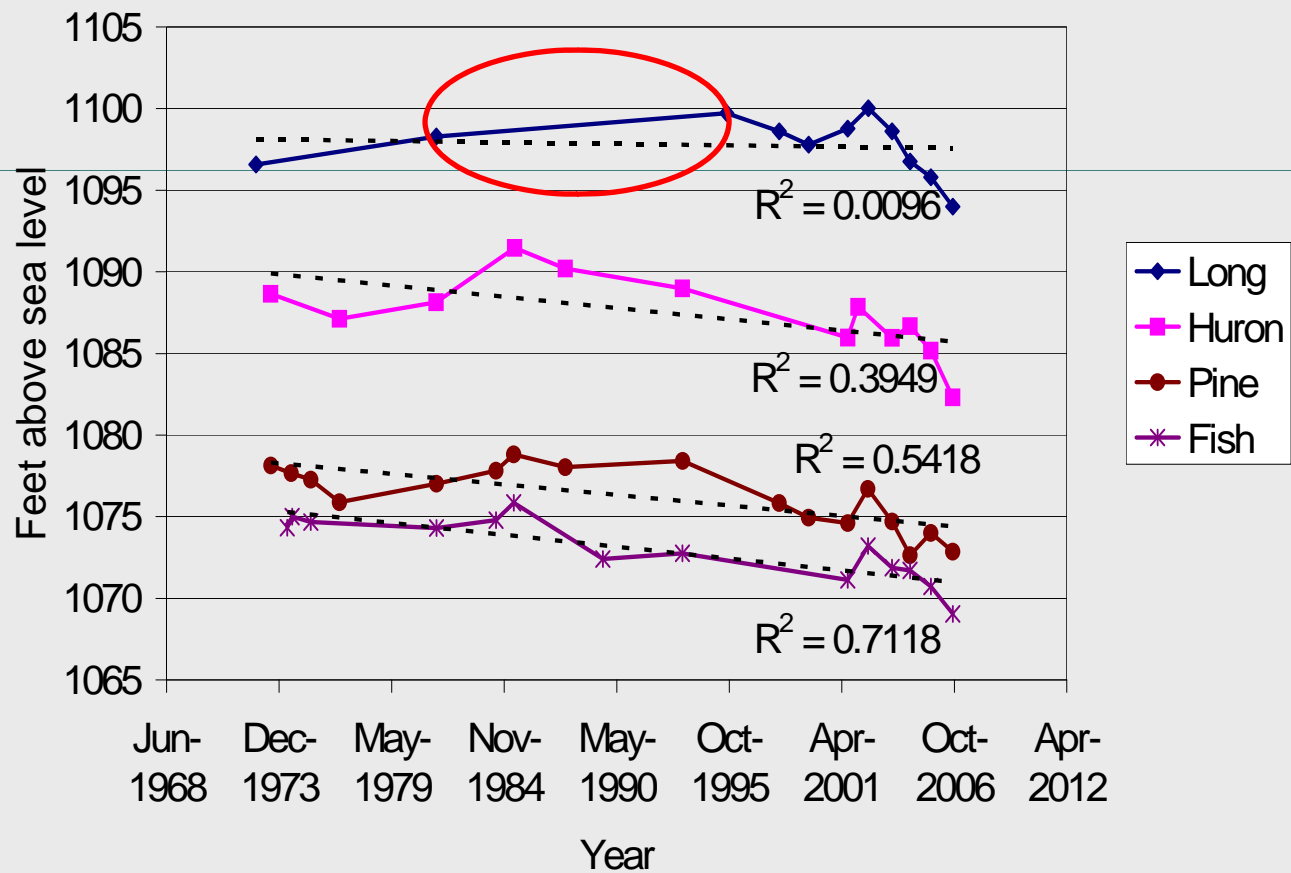


Waushara Co Lakes

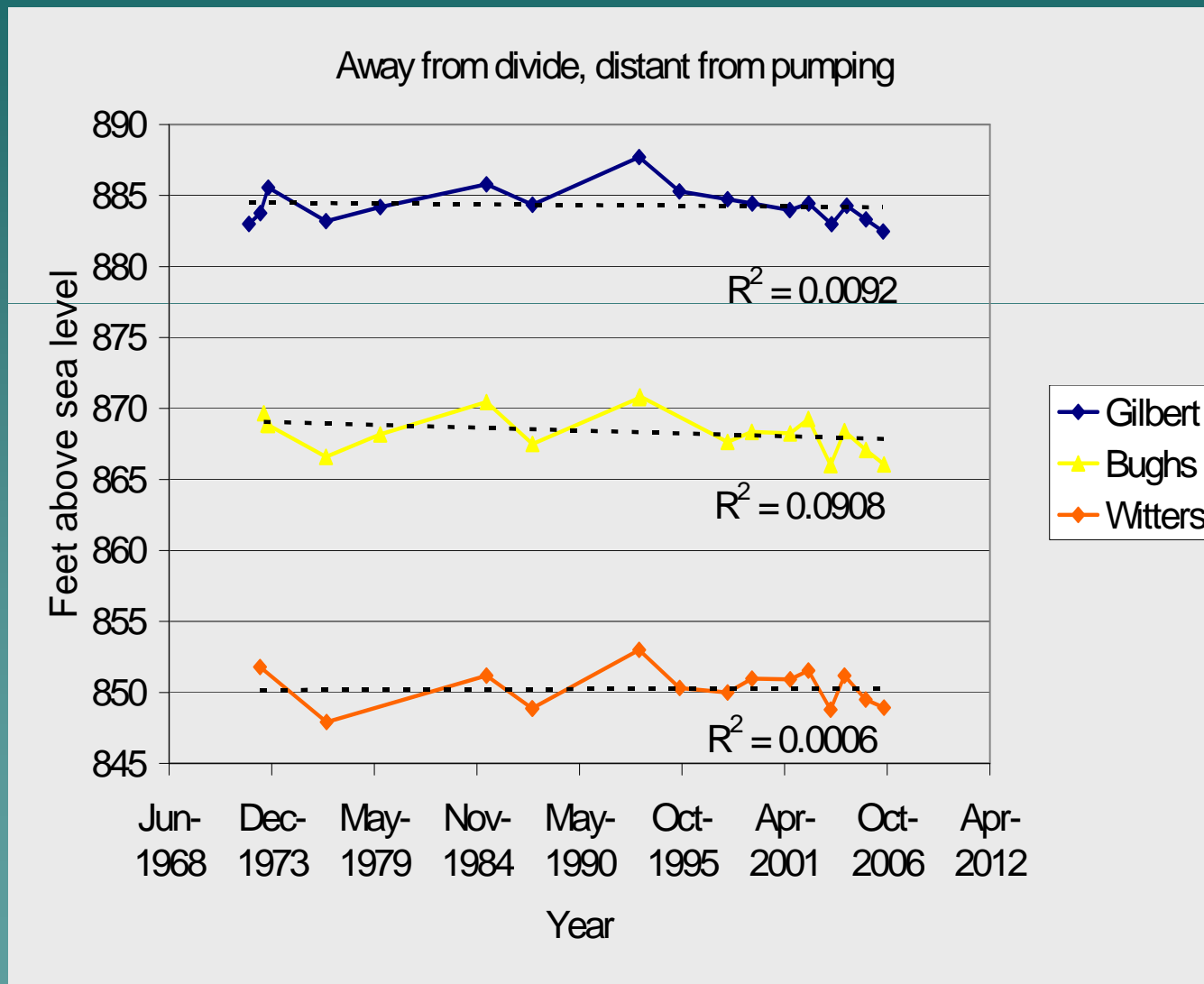


Waushara Co. Lakes

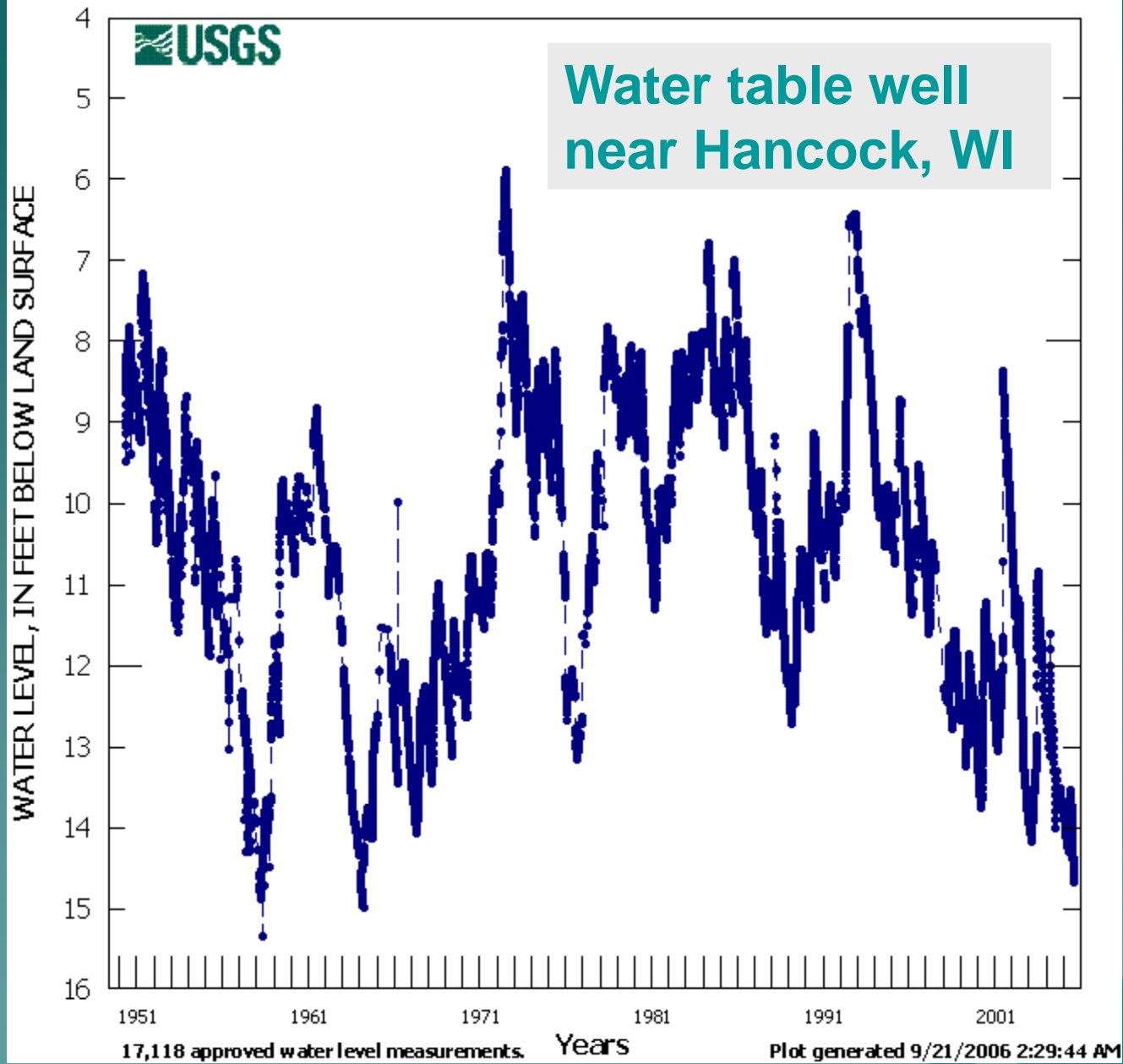
At sub-continental divide, near pumping



Waushara Co. Lakes



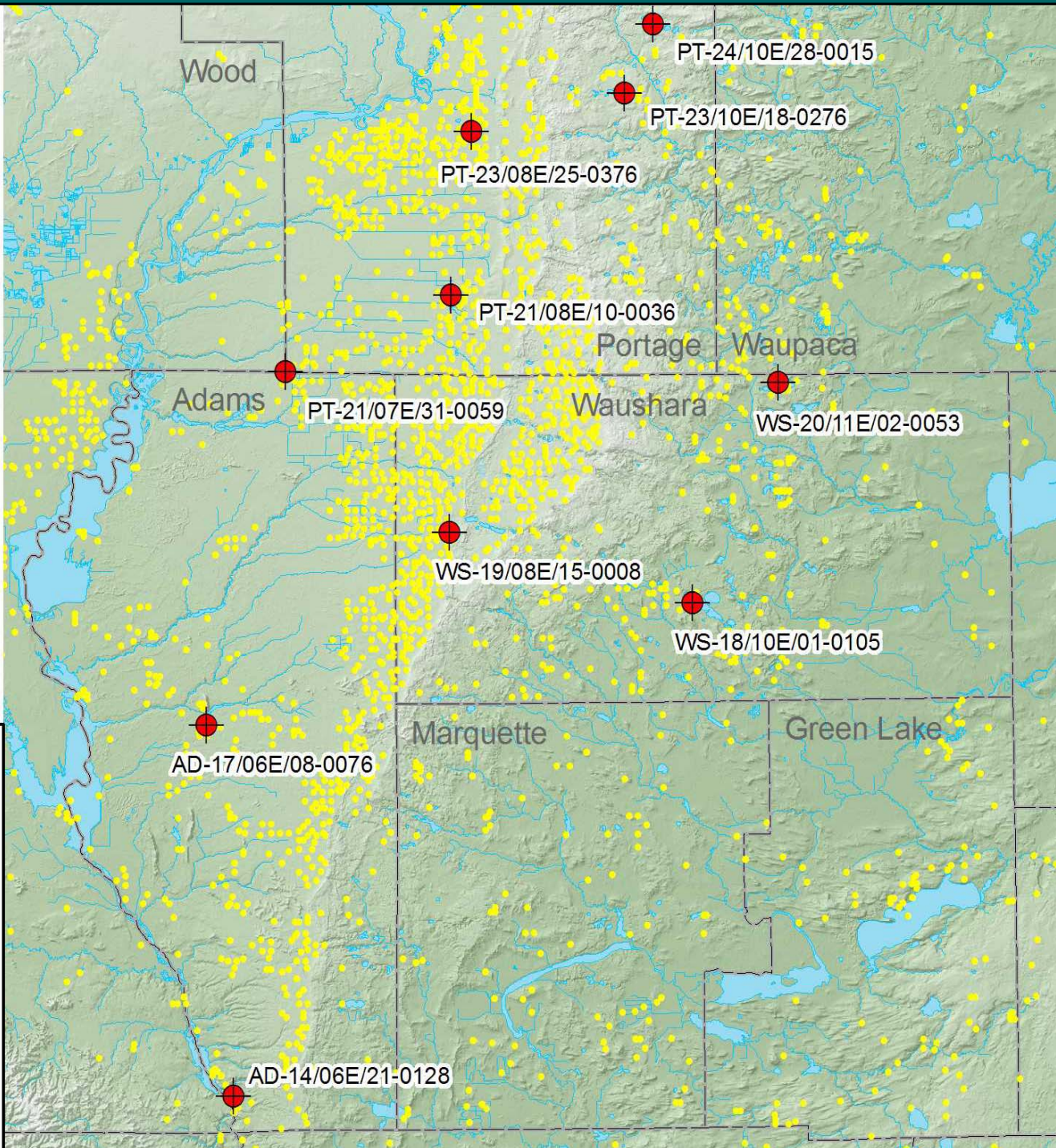
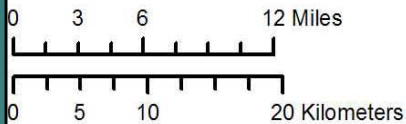
USGS 440713089320801 - WS-0008



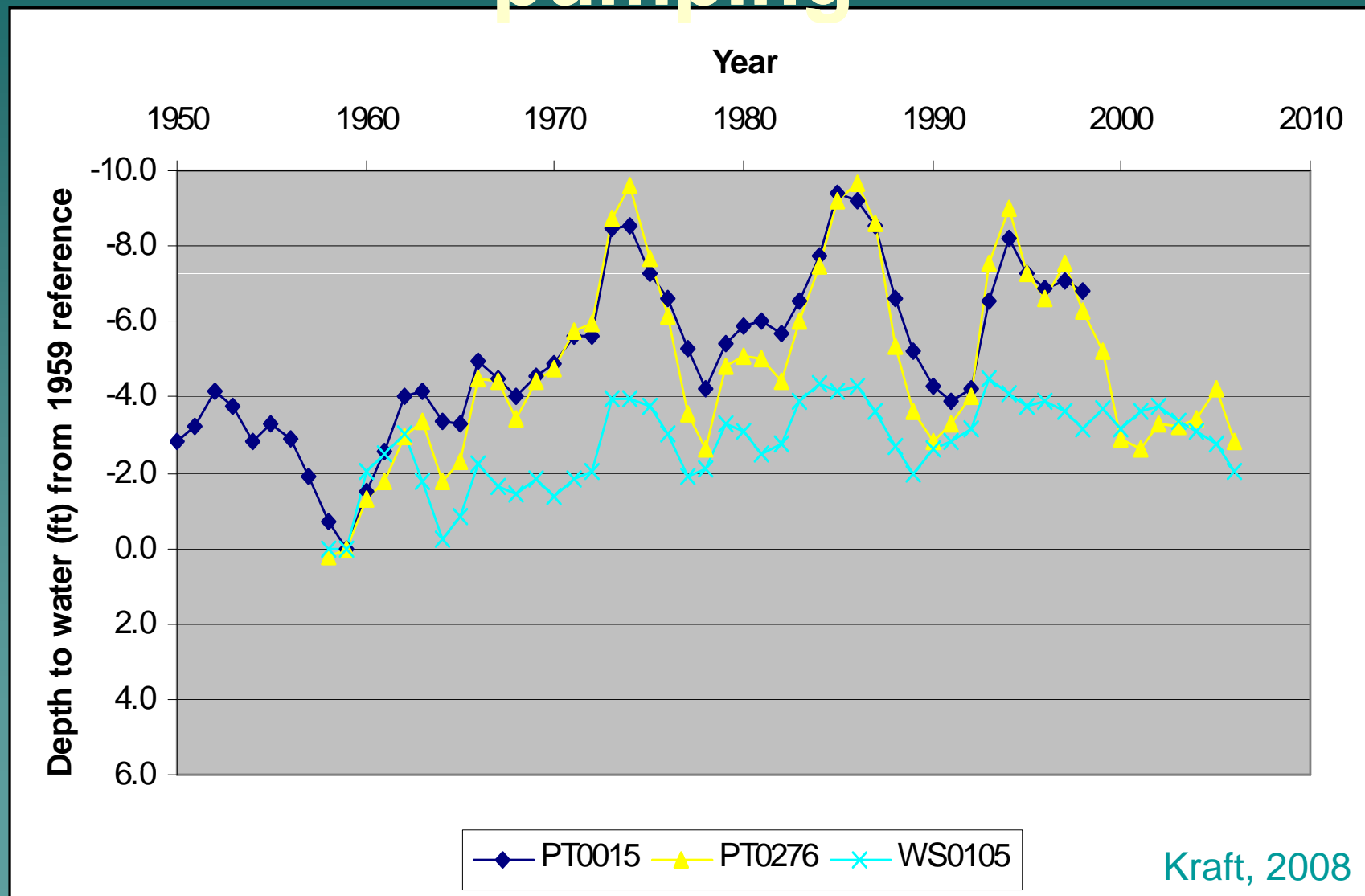
source: US Geological Survey -
<http://groundwaterwatch.usgs.gov>

Kraft, 2008

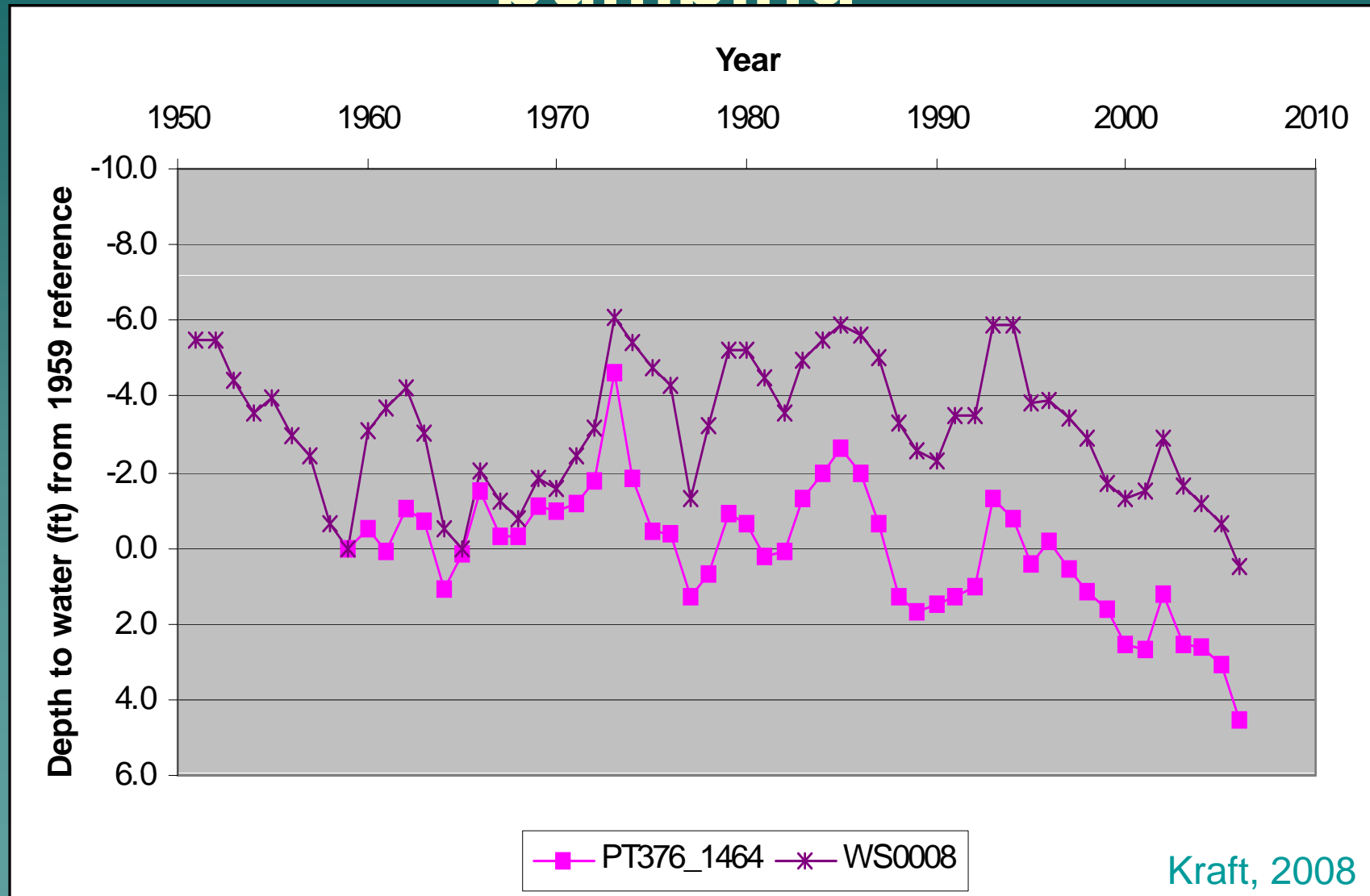
- USGS Water Level Monitoring Well
- HiCap Well



Water levels unaffected by pumping



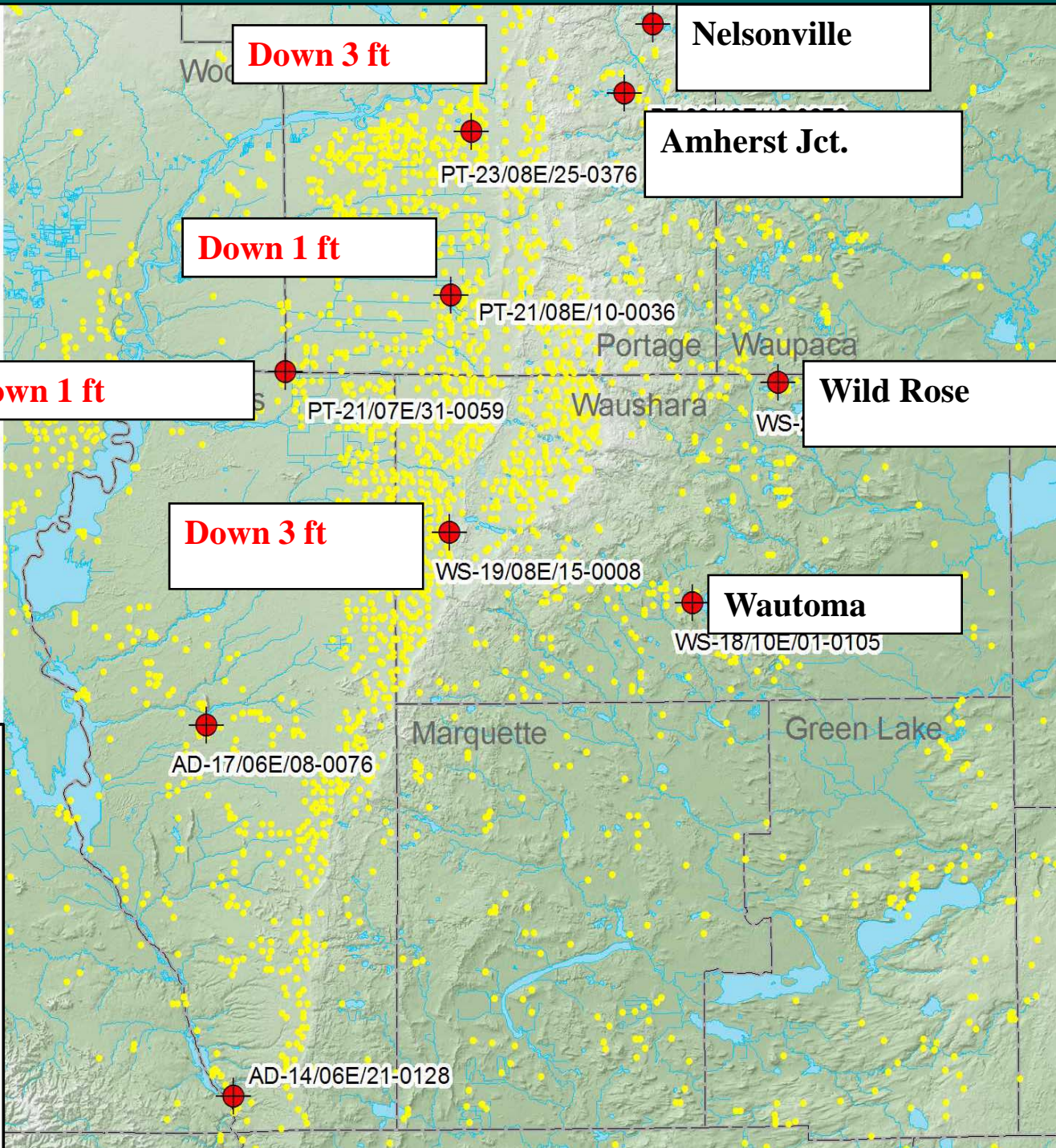
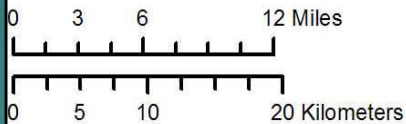
Water levels affected by pumping



Kraft, 2008

Kraft, 2008

- USGS Water Level Monitoring Well
- HiCap Well



Future Opportunities, Policy Directions, and General Discussion

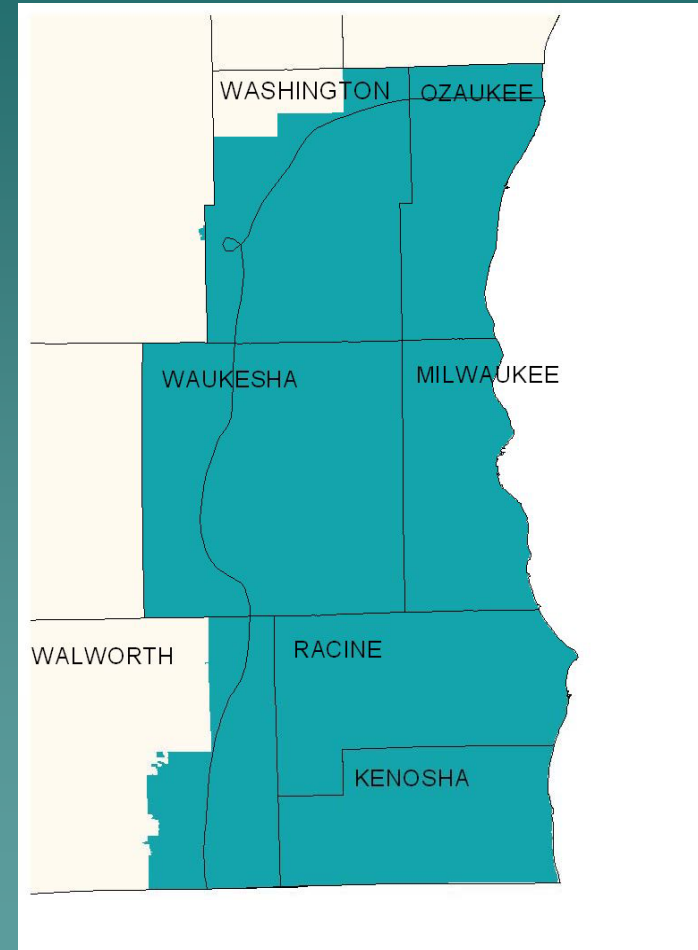
- ◆ Lake Level Monitoring Network
- ◆ Groundwater monitoring and modeling
- ◆ Statewide and Regional Policy Directions
 - Recent Groundwater Legislation
- ◆ Question and Answers
- ◆ Discussion

PROGRESS: Acute Impacts

- ◆ 451 wells approved under new statute since 2005; 369 wells constructed
- ◆ 56 wells constructed within 2000 feet of GPA
- ◆ 26 approvals/14 wells located within GPAs
- ◆ No wells have required full environmental analysis, but many re-located to avoid GPA
- ◆ Approved wells in GPAs conditioned to ensure no significant impact to surface water resource
- ◆ New administrative rules in effect as of Sept. 2007 (NR820)

PROGRESS: GMAs

- ◆ Two Groundwater Management Areas designated by rule
- ◆ Purpose of GMA not defined
- ◆ Process for adding new GMA or removing designation subject to future legislation
- ◆ Groundwater Advisory Committee report



Groundwater Advisory Committee

- ◆ Began meeting in April 2005
- ◆ Members appointed by Governor and Legislature
- ◆ Municipal, industrial, agricultural, & environmental interests represented
- ◆ Staffed by DNR
- ◆ Science and policy advisors
- ◆ Advise on rule development and further legislation



PROGRESS: Groundwater Management Areas (Task 1)

- ◆ Groundwater Management Plans should be developed for each GMA
- ◆ Additional requirements for new *and existing* high cap wells in GMA's after 10 years
- ◆ 2 new Groundwater Attention Areas (GAA) proposed, but no new GMAs
- ◆ Process for reviewing and recommending new potential GMA's, as well as removal of designation
- ◆ Increased funding and support for mitigation and monitoring of groundwater and surface water

Task #2: GPA's – Dec. 2007

- ◆ Better definition of springs
- ◆ Factors to be considered in determining “significant adverse environmental impact”
- ◆ Changes regarding regulation of wells within GPAs, near springs, or with >95% water loss
- ◆ Adaptive management approaches
- ◆ Potential for use of general permits

PROGRESS: Groundwater Protection Areas - consensus

- ◆ No further definition of “significant adverse environmental impact”
 - criteria identified in rule adequate
- ◆ No change to regulation of wells with high water loss
- ◆ Updated springs inventory for rest of state
- ◆ Regular review of regulatory framework every 5 years
- ◆ Comprehensive statewide water management policy

NO PROGRESS: Groundwater Protection Areas

- ◆ No consensus on changing definition of spring, or regulatory approach
 - Need to wait for springs inventory
- ◆ No consensus on changes to Groundwater Protection Area concept or regulatory approach
 - Several alternatives suggested and voted upon
- ◆ No further action on general permits or adaptive management

Groundwater Advisory Committee

- ◆ Wrapped up work in Dec. 2007
- ◆ Reports delivered to legislature on schedule
- ◆ Recommendations did not include future legislation, but offered several alternative regulatory frameworks
- ◆ Track GAC activities on DNR website: <http://dnr.wi.gov/org/water/dwg/>

A first step...

- ◆ Recognizes that all wells have impact on quantity
- ◆ Recognizes connection between surface and groundwater, quality and quantity
- ◆ Many critical waters remain vulnerable
- ◆ Retains protection of public water utility wells
- ◆ Most areas of state and most well approvals will be “business as usual”
- ◆ Acknowledged need for further solutions, including legislation

Future Directions

- ◆ Better science and understanding
 - Lake and groundwater level monitoring
 - Quantify impacts of pumping on regional scale
 - Identify lakes vulnerable to pumping
- ◆ Pursue lake-specific management options
 - Physical/engineering approaches
 - Cooperative arrangements among water users
 - Mitigation/contingency plans in dry periods
- ◆ Regional/Statewide regulations and incentives
 - Better oversight of individual water extractions
 - Coordinated water management

Questions?

