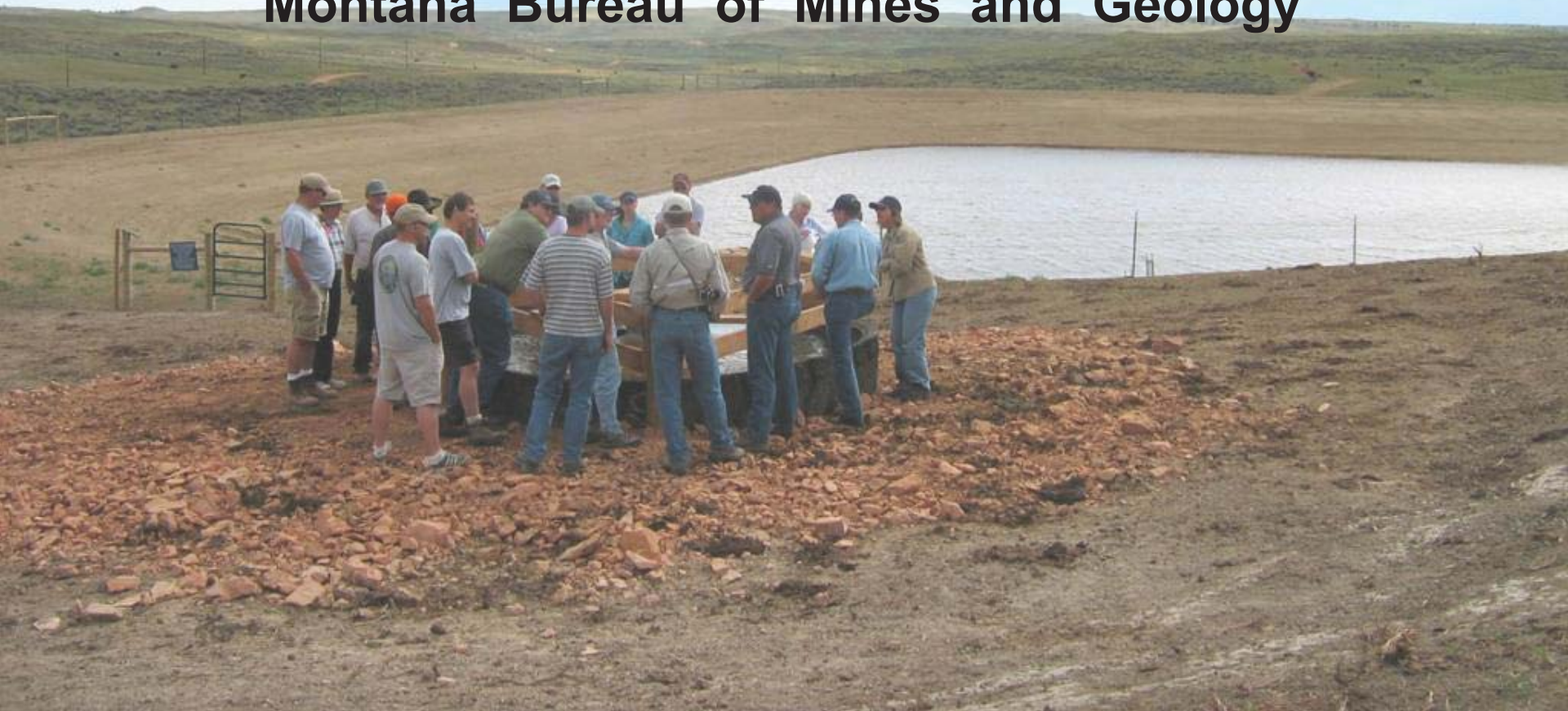


# Montana Regional Coalbed Methane Ground – Water Monitoring Program

John Wheaton  
Elizabeth Meredith  
Andy Bobst

Montana Bureau of Mines and Geology



# Lessons from 40 years of coal hydrogeology in Montana:

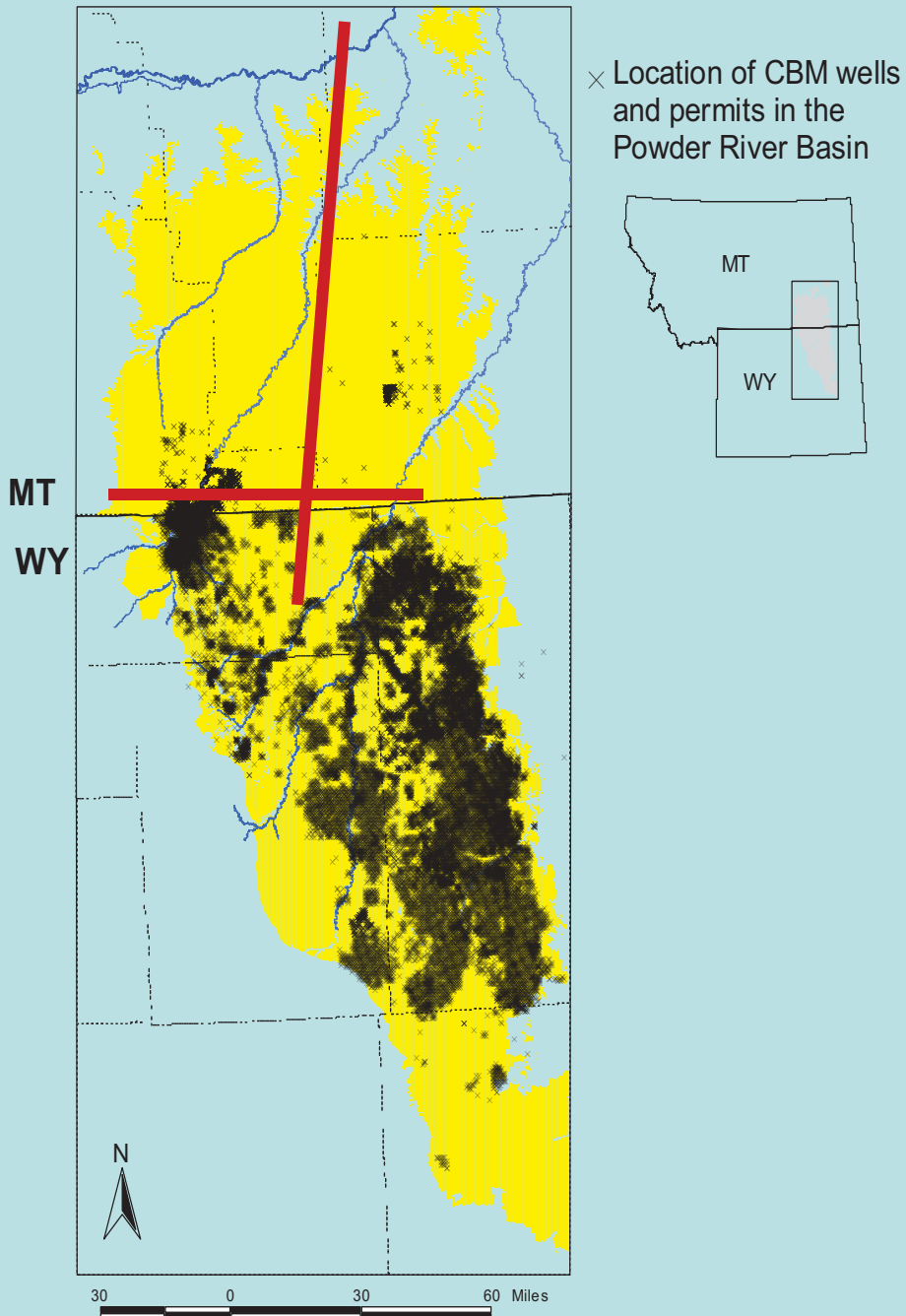
1. Coal beds as aquifers in Montana
2. Monitored impacts ( and lack of impacts ) to quantity of water
3. Predictive tools : Monitoring data and computer Modeling



**MBMG publishes a report each year that includes description of data and interpretations available on-line**

**All data are public and available to you at: <http://mbmggwic.mtech.edu/>**





## CBM wells during 2009

Montana:

Producing: 885  
4,591 ac-ft water

Wyoming: adjacent to MT

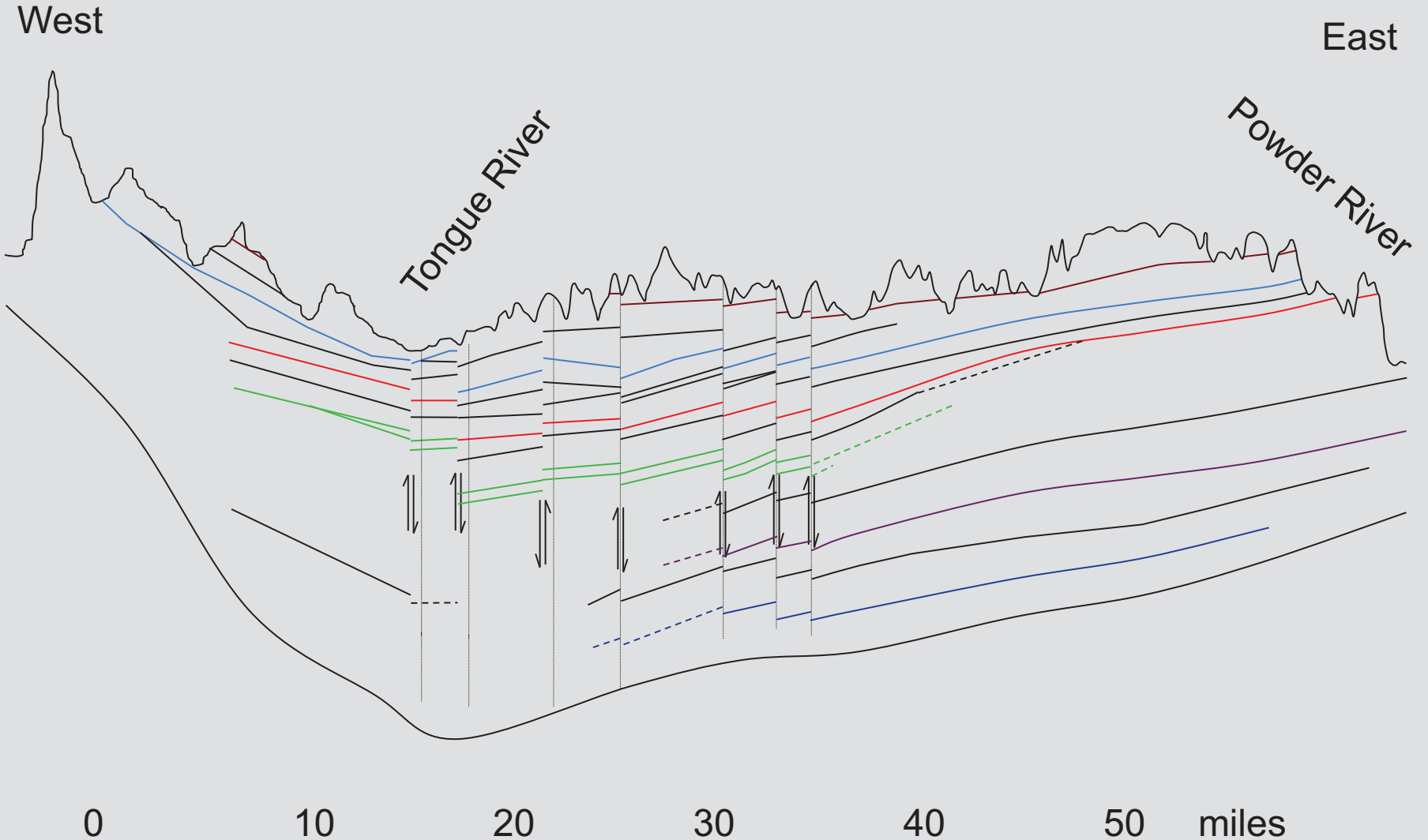
Producing: 2,115  
13,477 ac-ft water

(77,940 ac-ft for all  
wells in WY)

Likely that MT holds  
about 10% of the gas

# Powder River Basin, Montana

## Cross Section along MT / WY Stateline

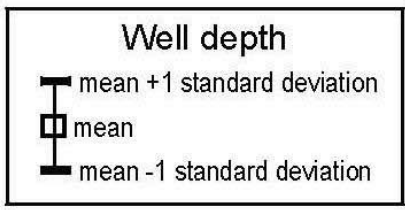
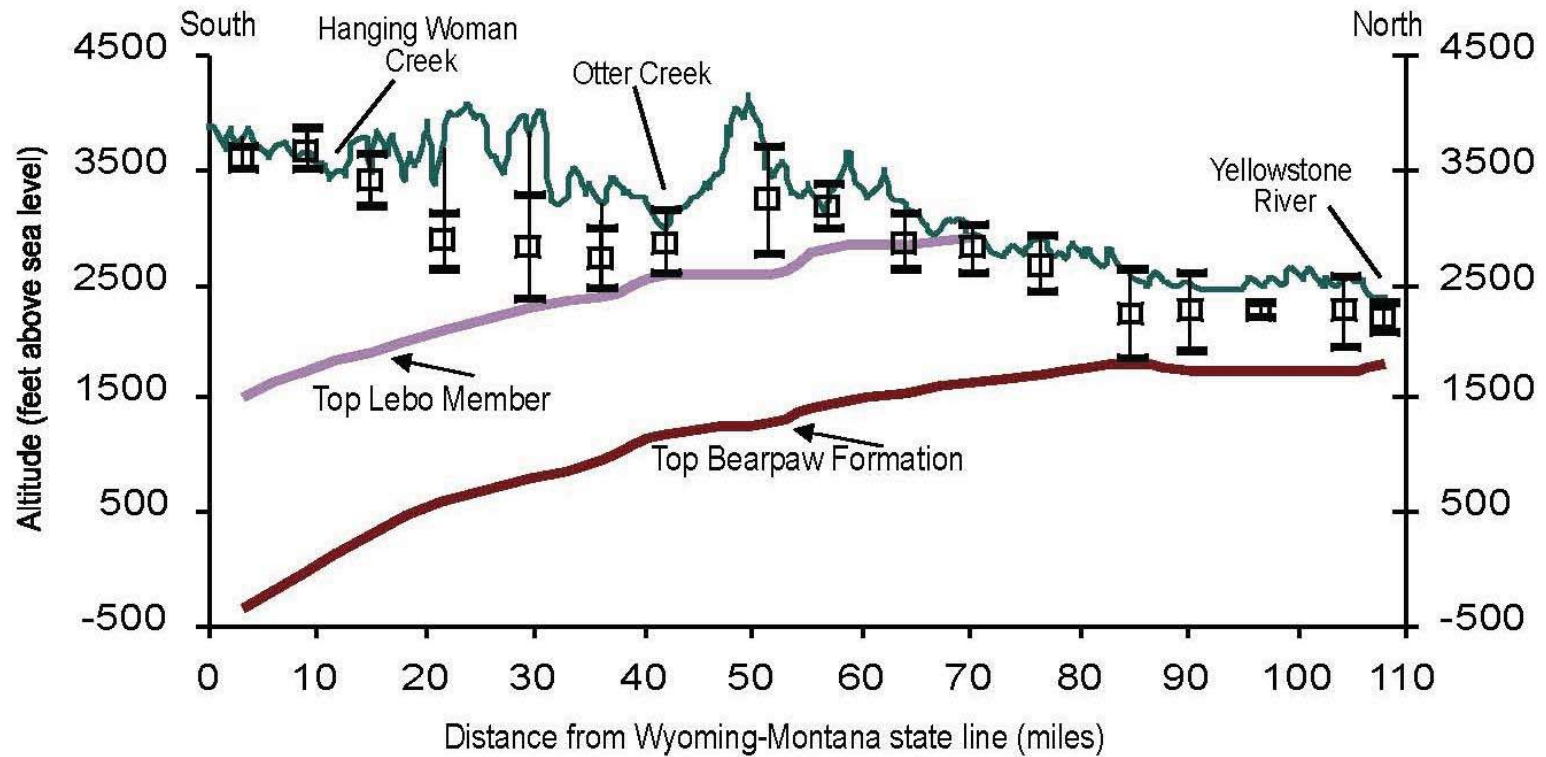
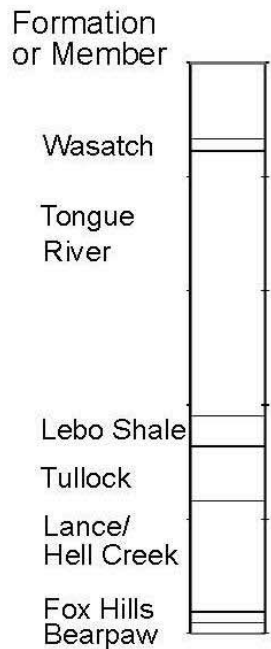


# 1. Coal as aquifers in Montana



**Canyon Coal**

**Spring for livestock**

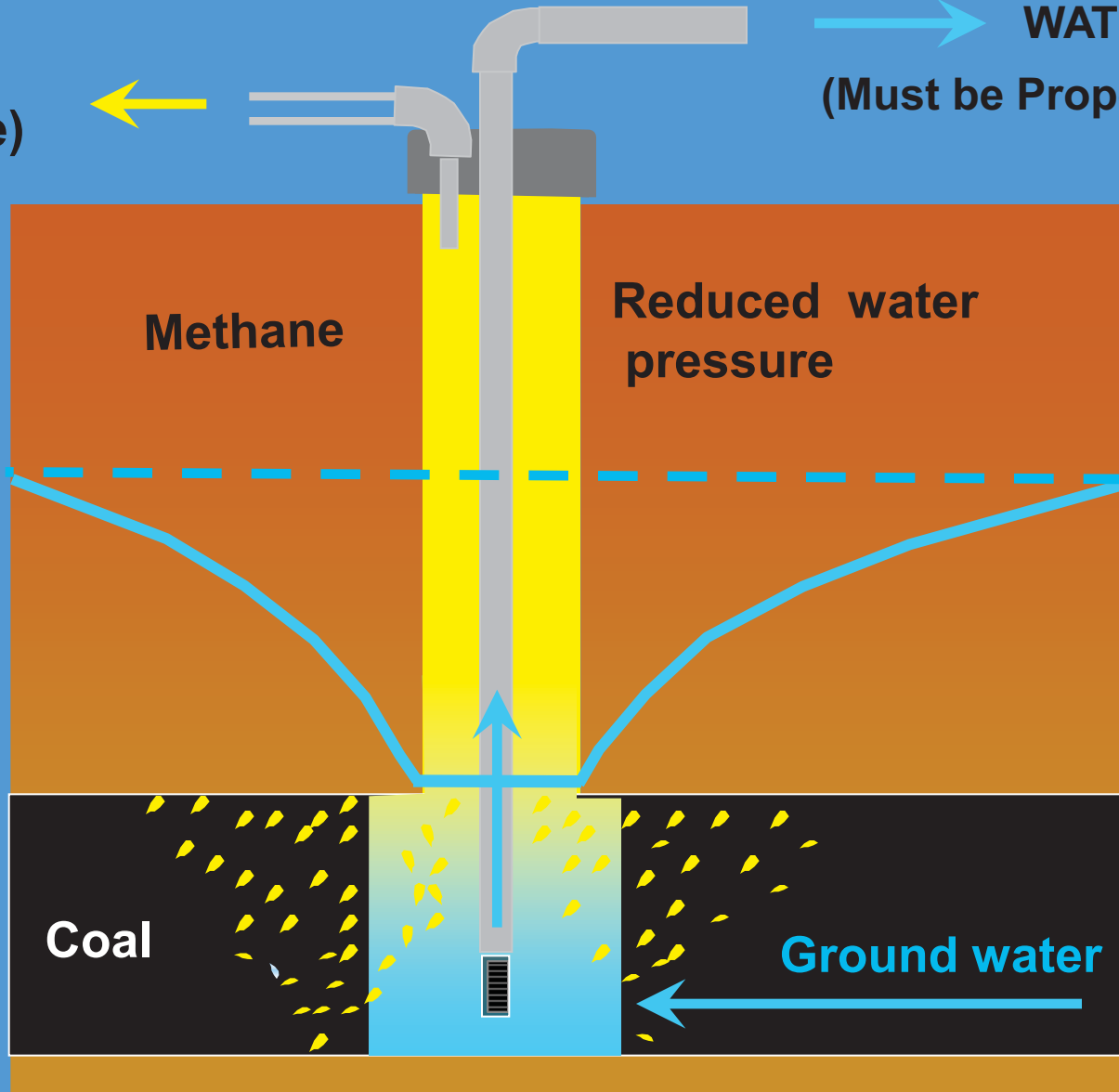


Vertical exaggeration 53x

# TRADITIONAL CBM WELL CONSTRUCTION

**METHANE**  
(to pipeline)

**WATER**  
(Must be Properly Managed)





Precipitation

# Conceptual Ground - Water Drawdown by Coalbed Methane Wells

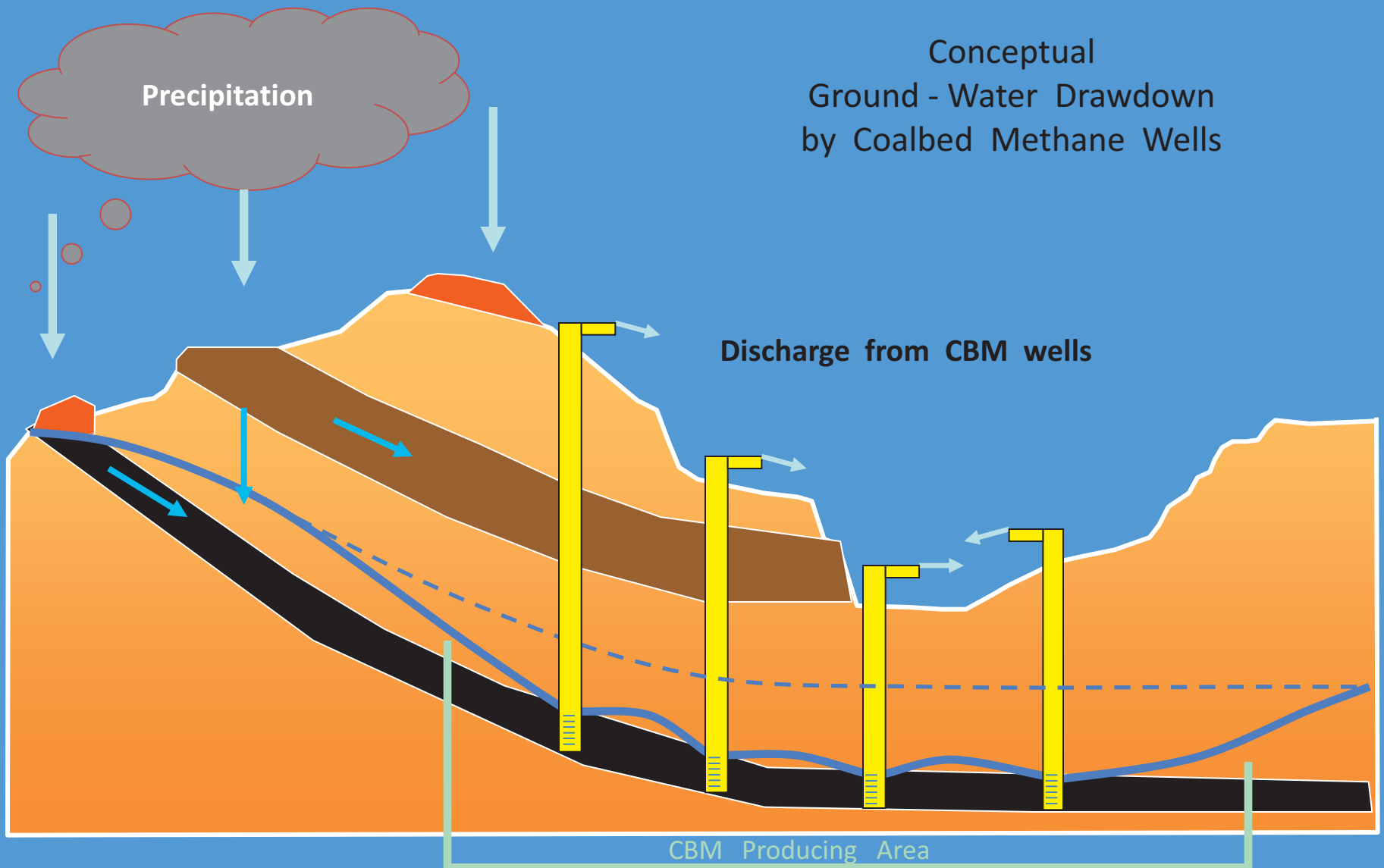
Discharge from CBM wells

CBM Producing Area

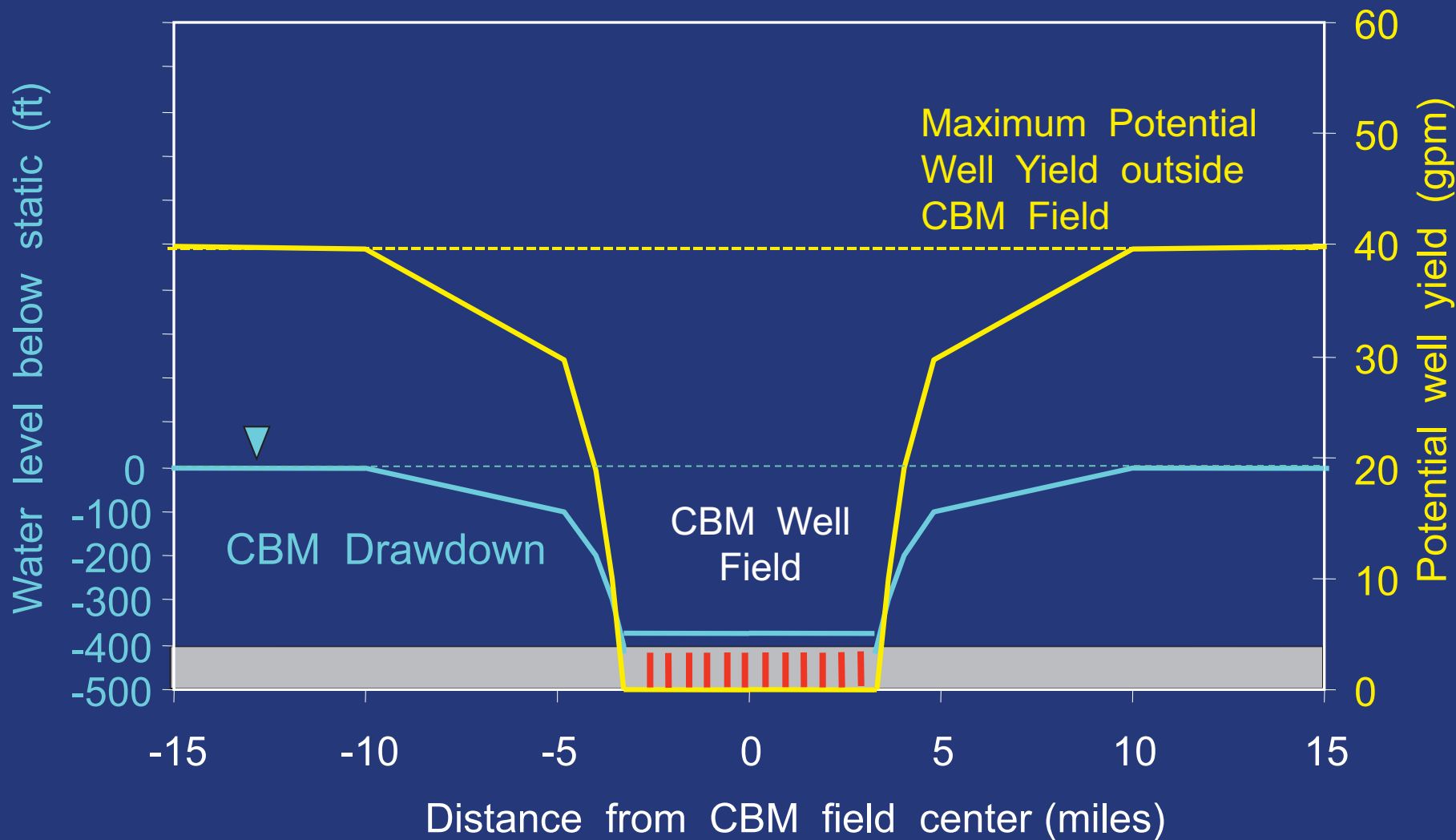
GROUND WATER FLOW DIRECTION

GROUND WATER PRESSURE

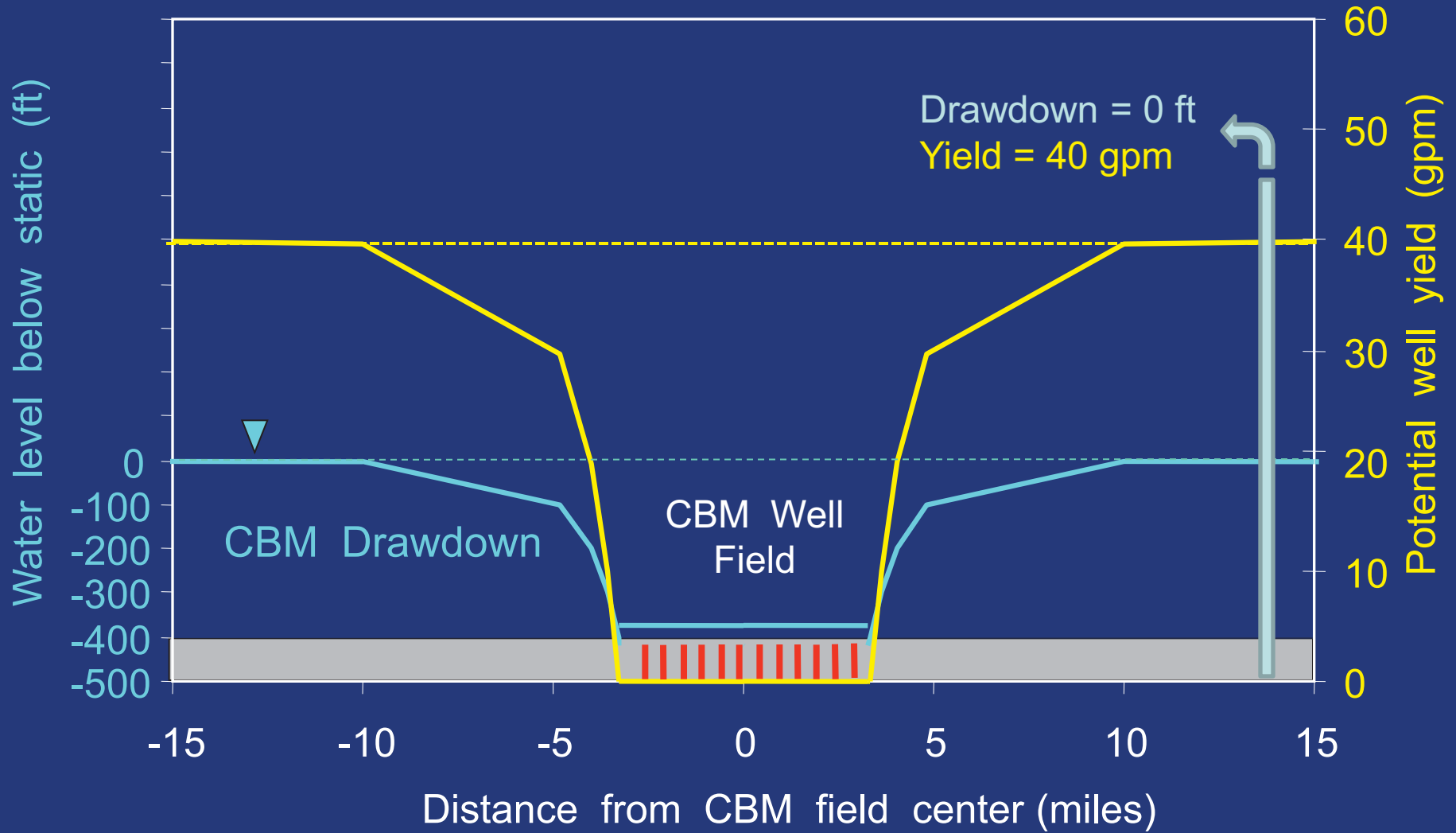
STARTING GROUND WATER PRESSURE



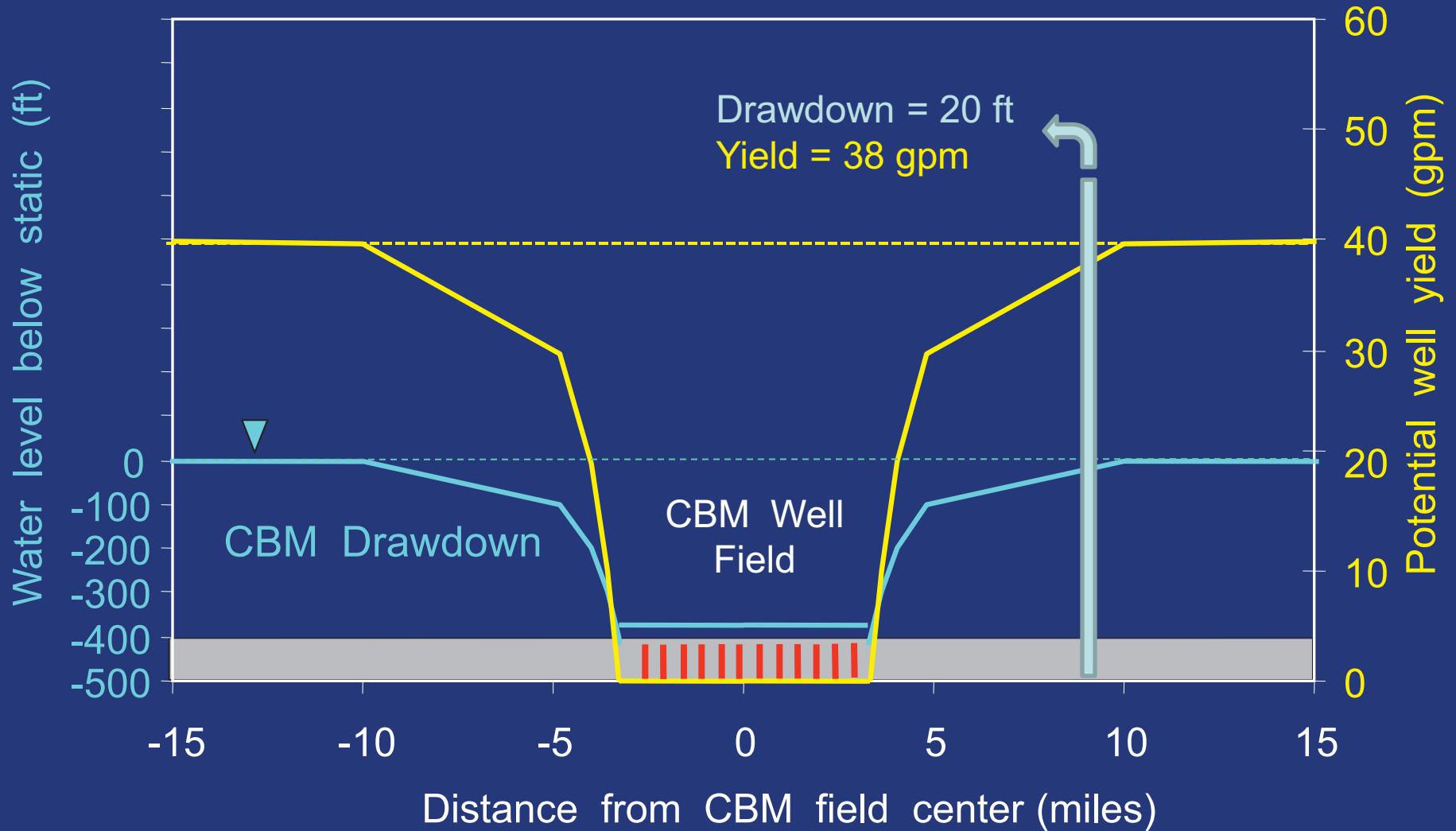
# Relationship between CBM drawdown and impacted well discharge



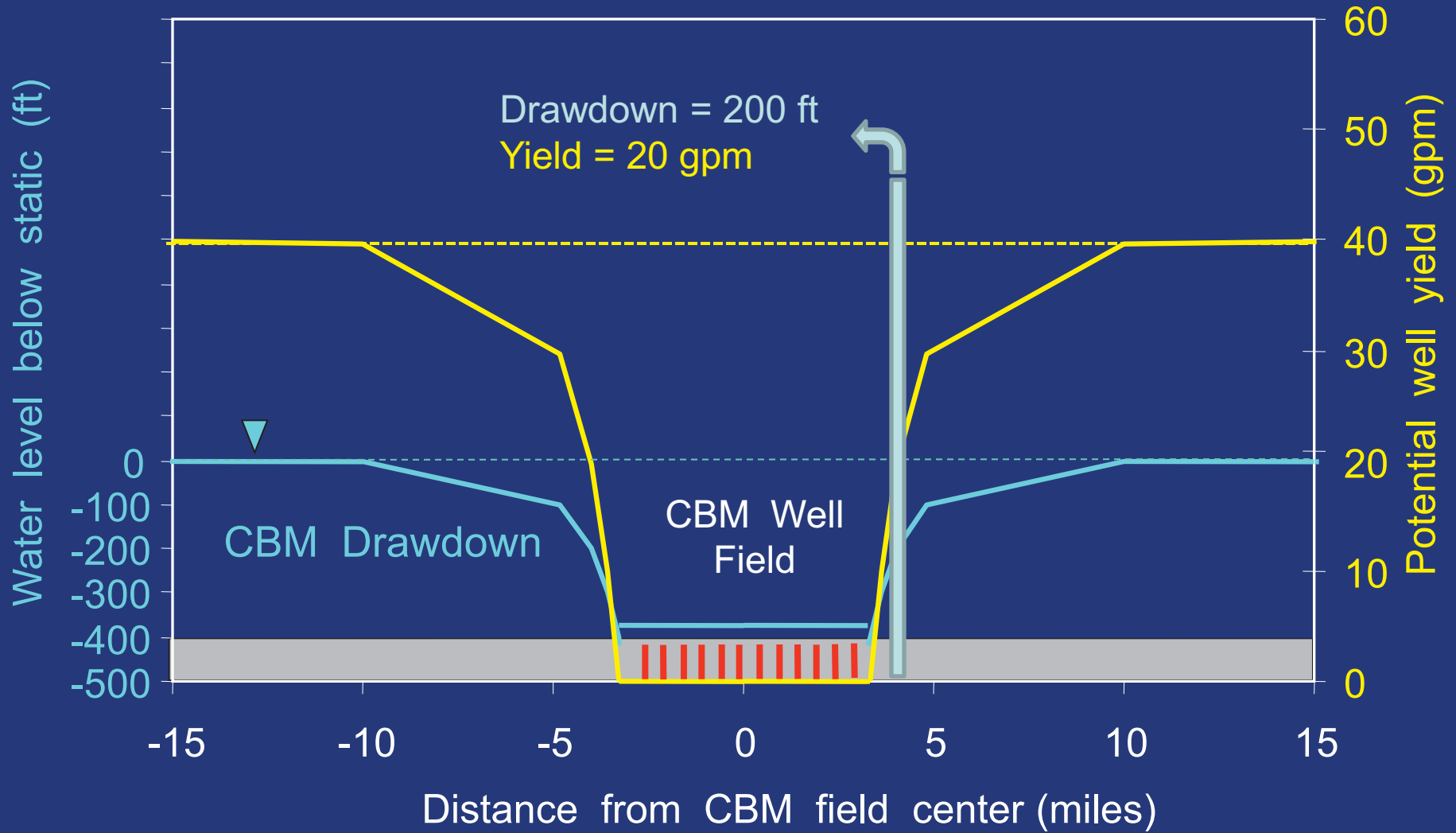
# Relationship between CBM drawdown and impacted well discharge



# Relationship between CBM drawdown and impacted well discharge



# Relationship between CBM drawdown and impacted well discharge

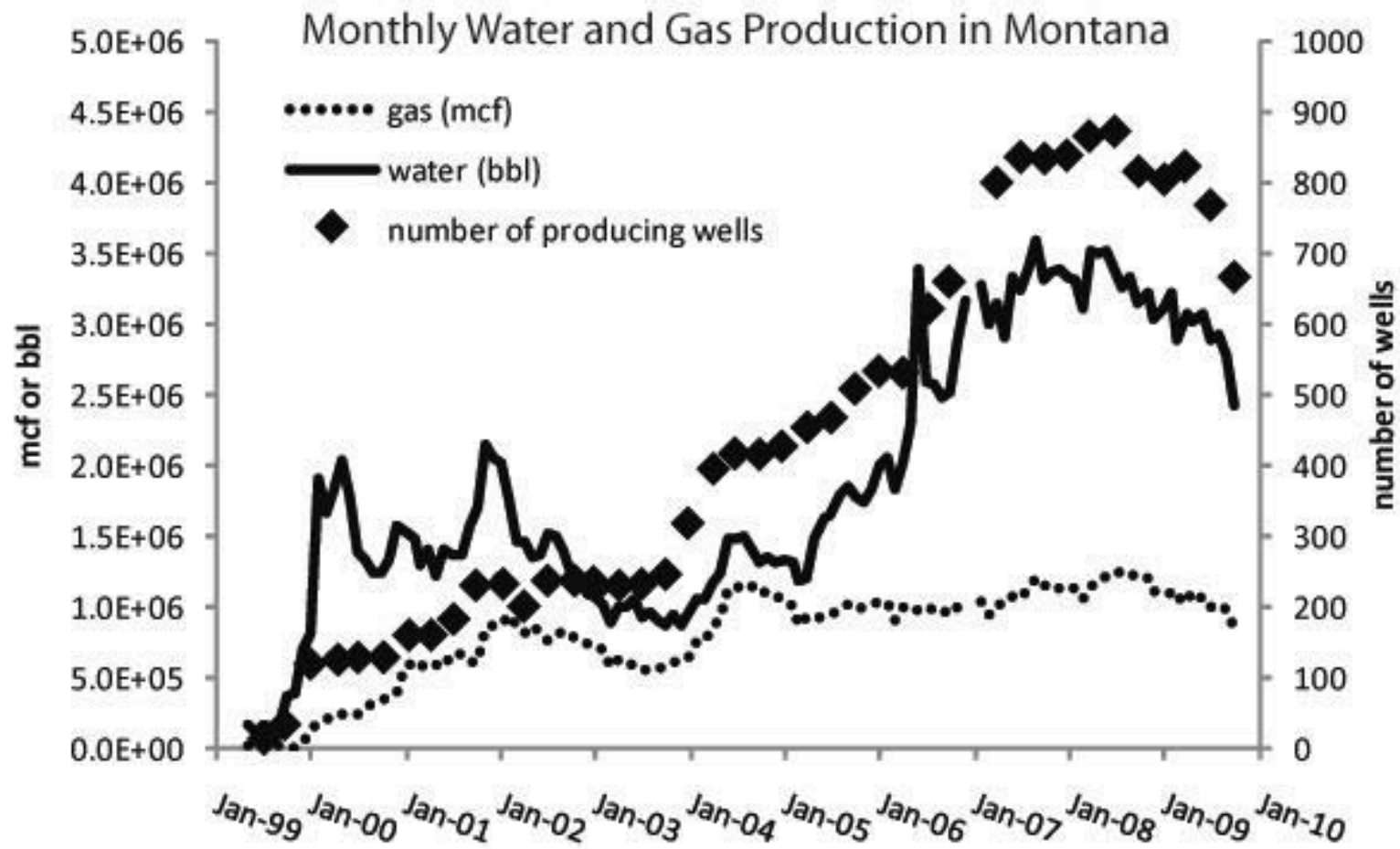


## 2. Regional Monitoring Program:

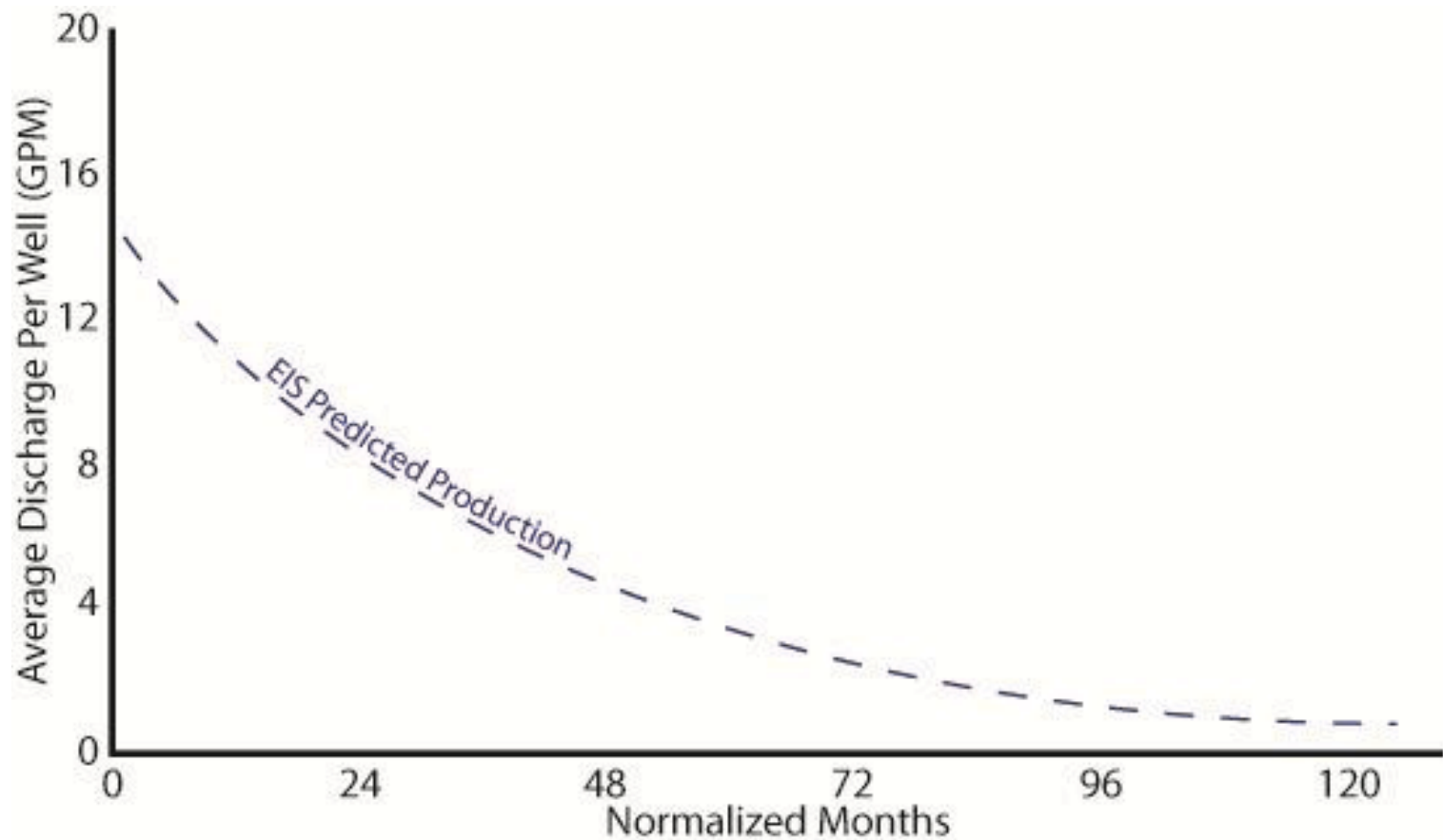
Data collection

Annual interpretation



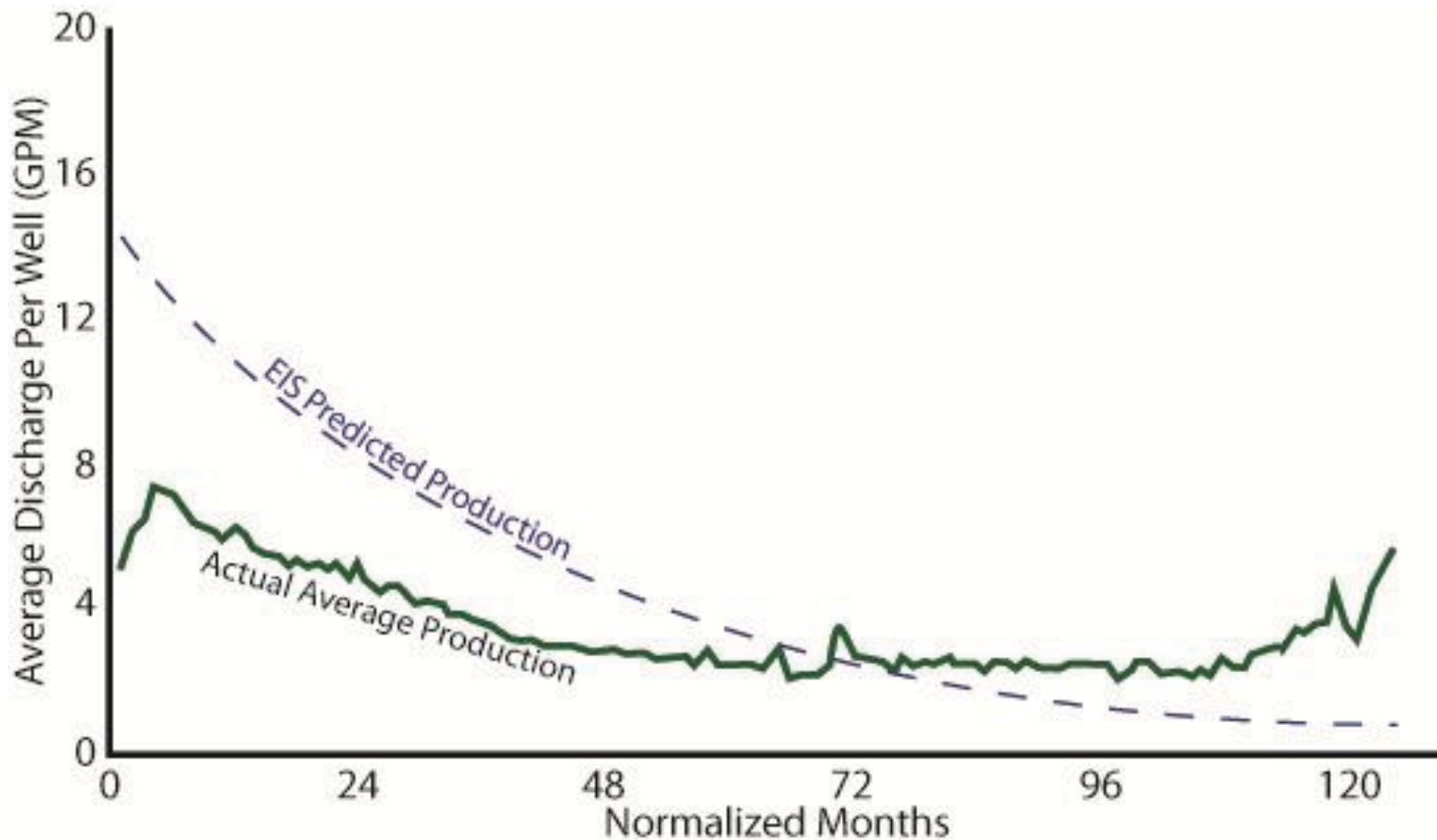


B



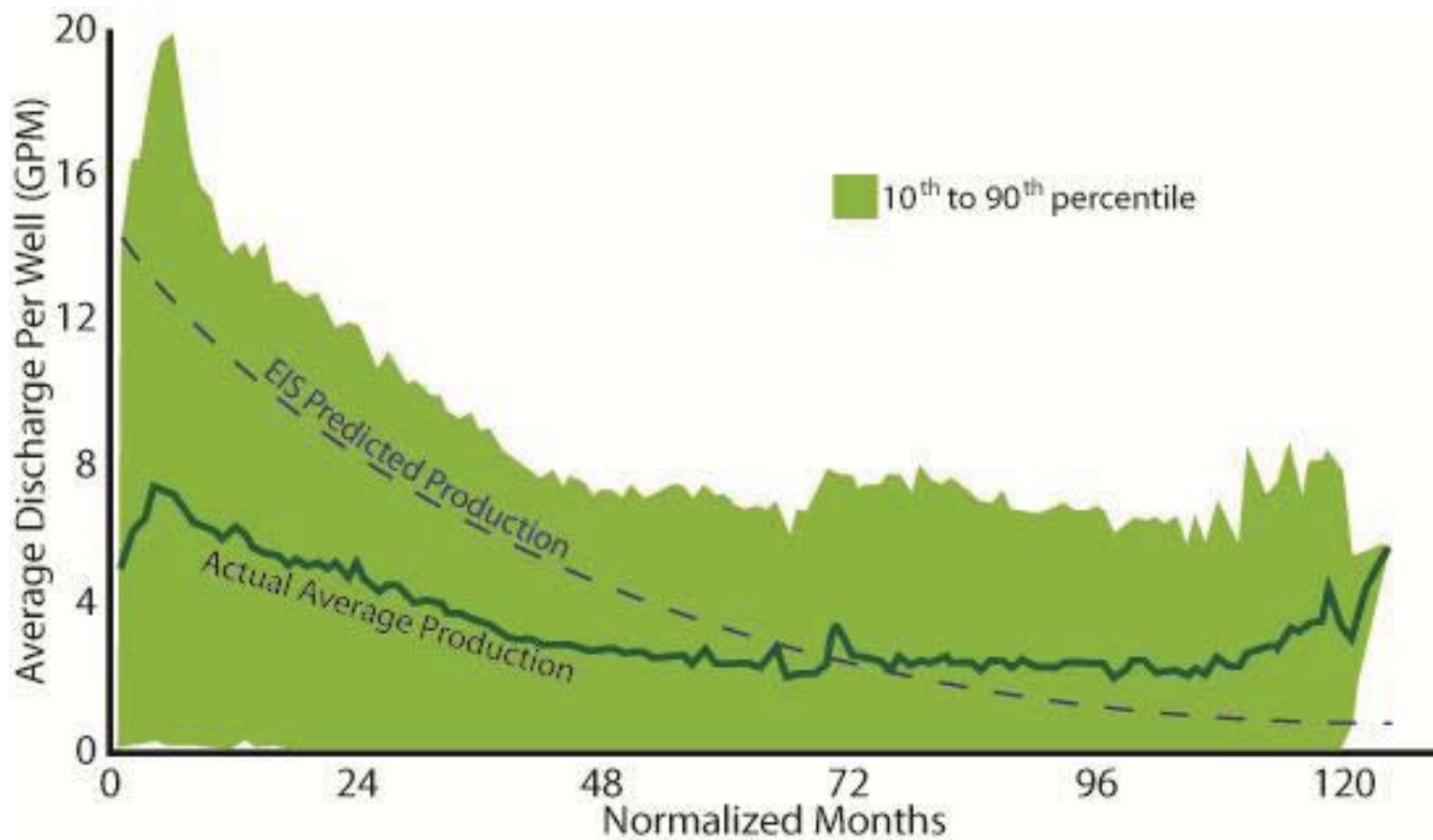
EIS predicted production from an individual CBM well in gallons per minute (GPM):  
 $y = 14.661 e^{(-0.0242x)}$ ; U.S. BLM, 2003)





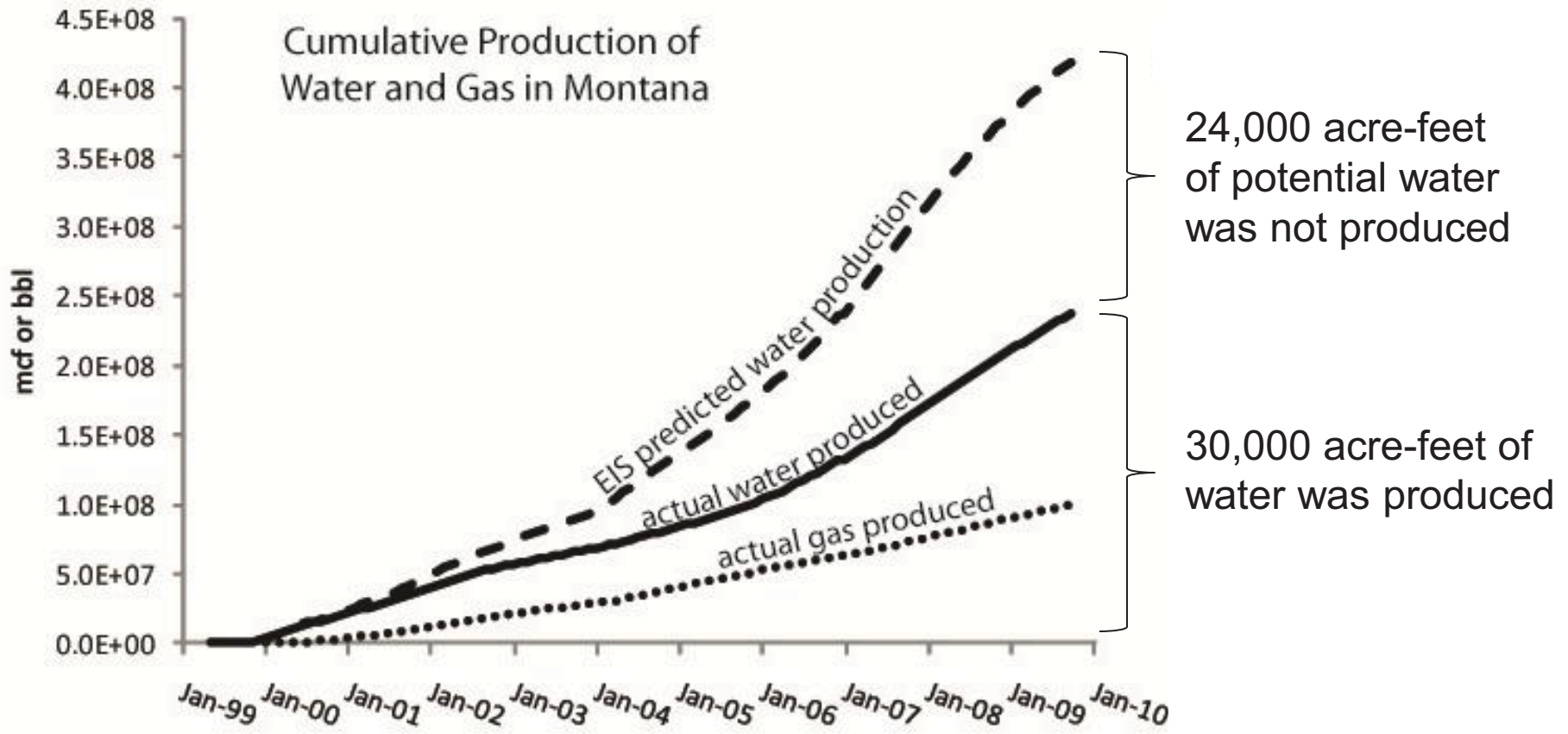
The actual production (solid line) falls below the EIS predicted production for the first 6 years of production. After 6 years, the production is greater than anticipated. The difference between the predicted and actual production is the amount of water anticipated but never produced.

(Montana portion of the Powder River Basin; data from the MT BOGC web site).

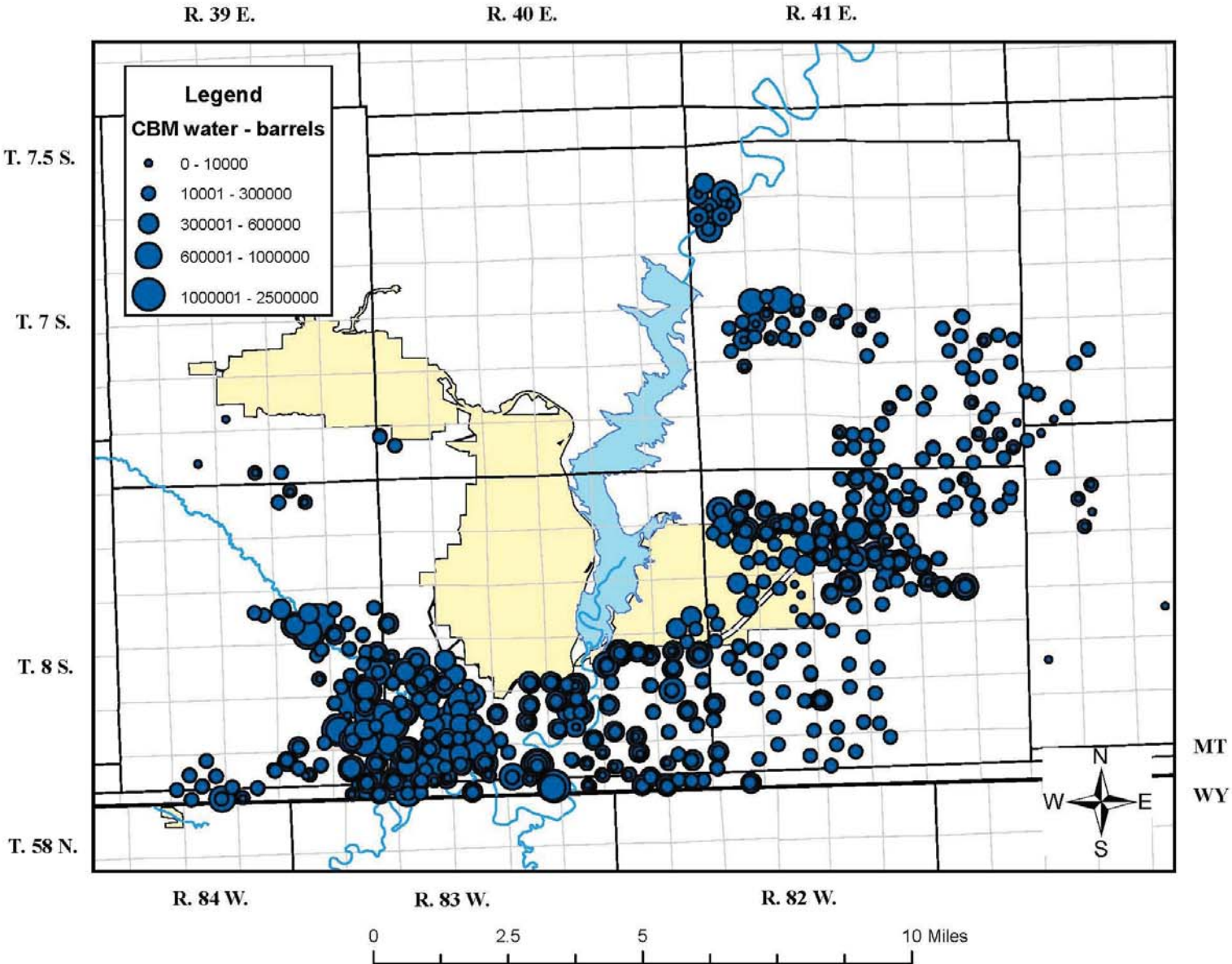


The range of production from individual wells varies greatly. The 90<sup>th</sup> percentile encompasses the production predicted by the EIS.

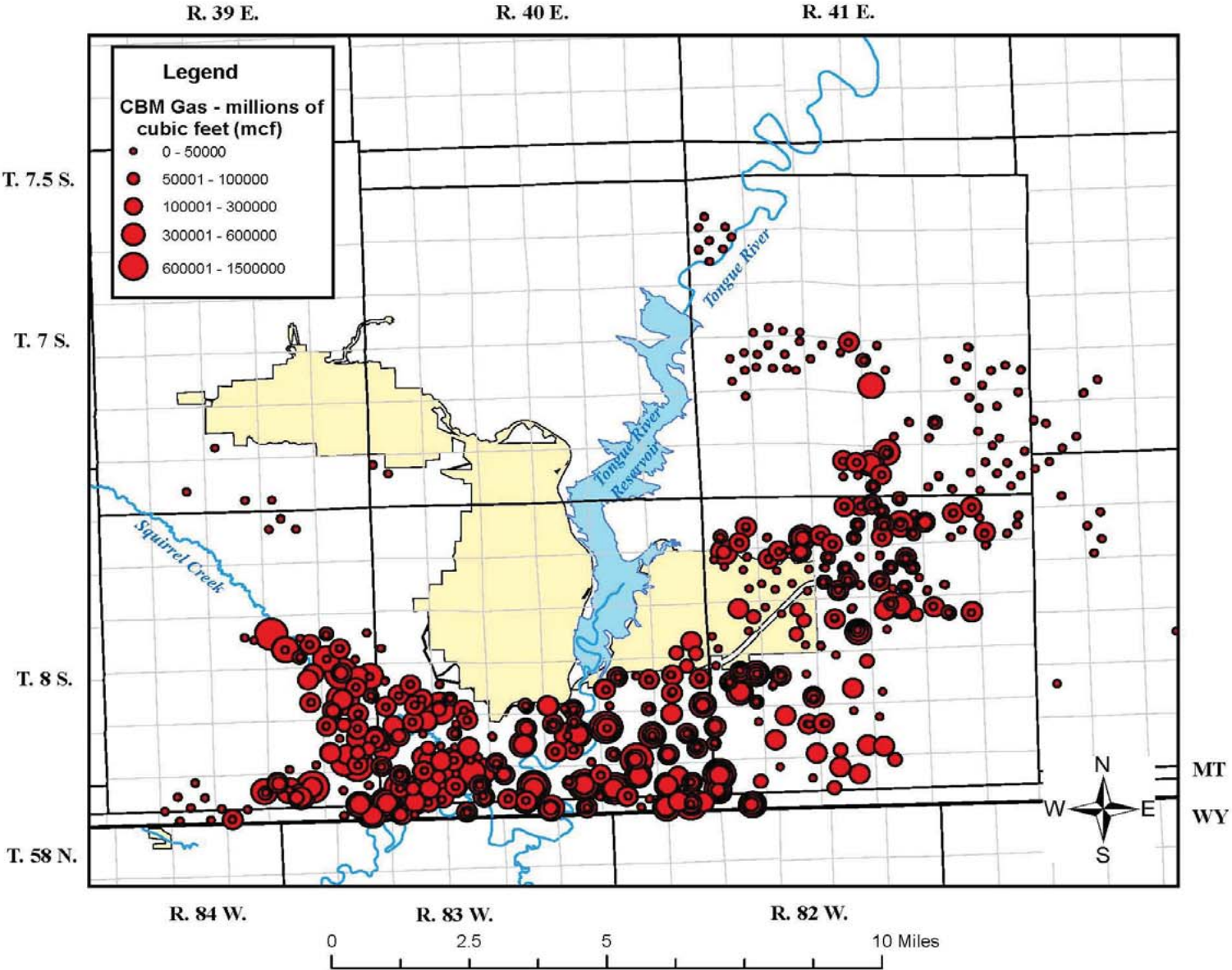
# Cumulative Production of Water and Gas in Montana



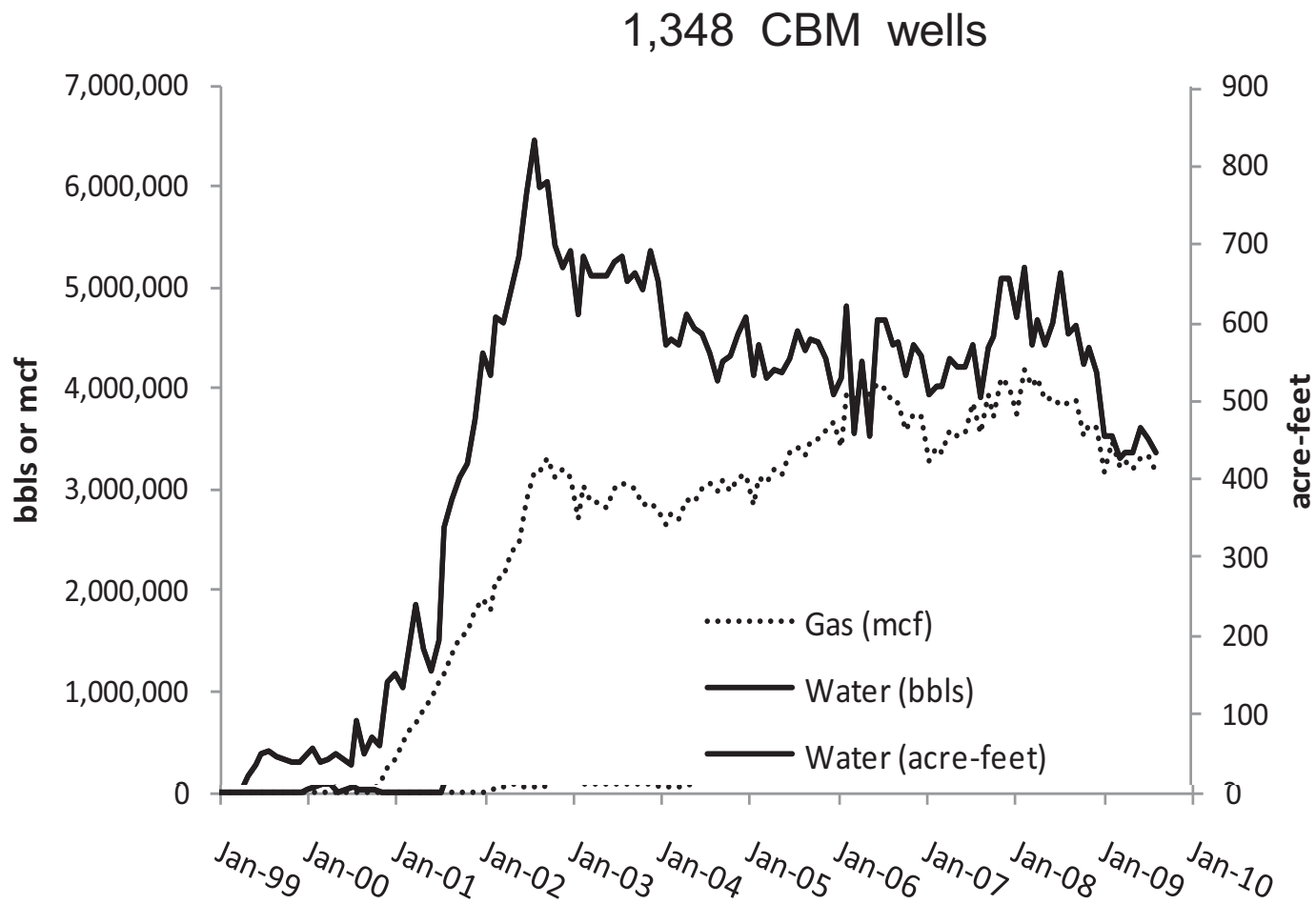
# CBM Water Production

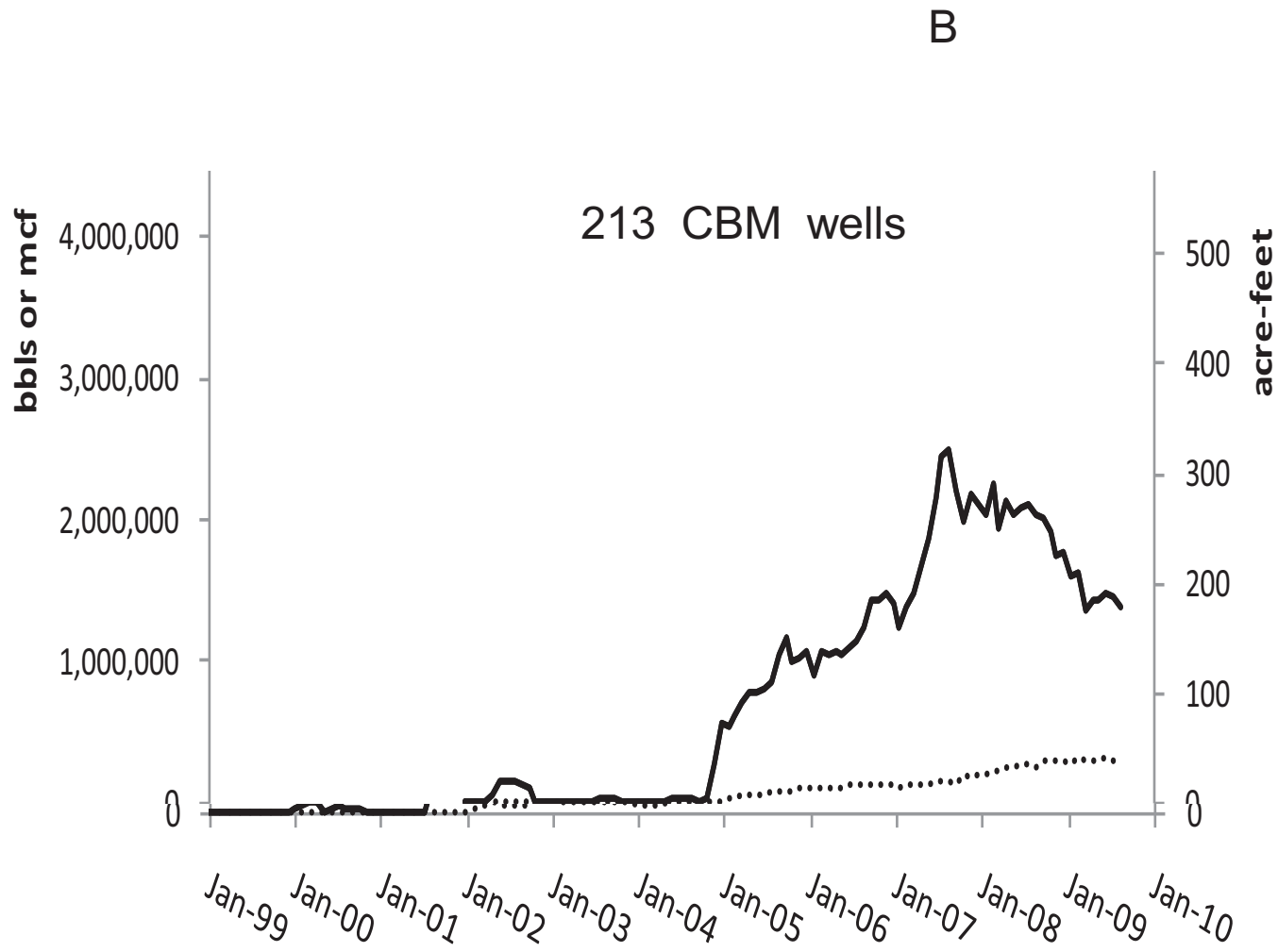
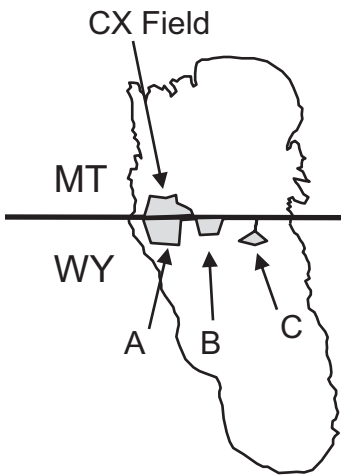


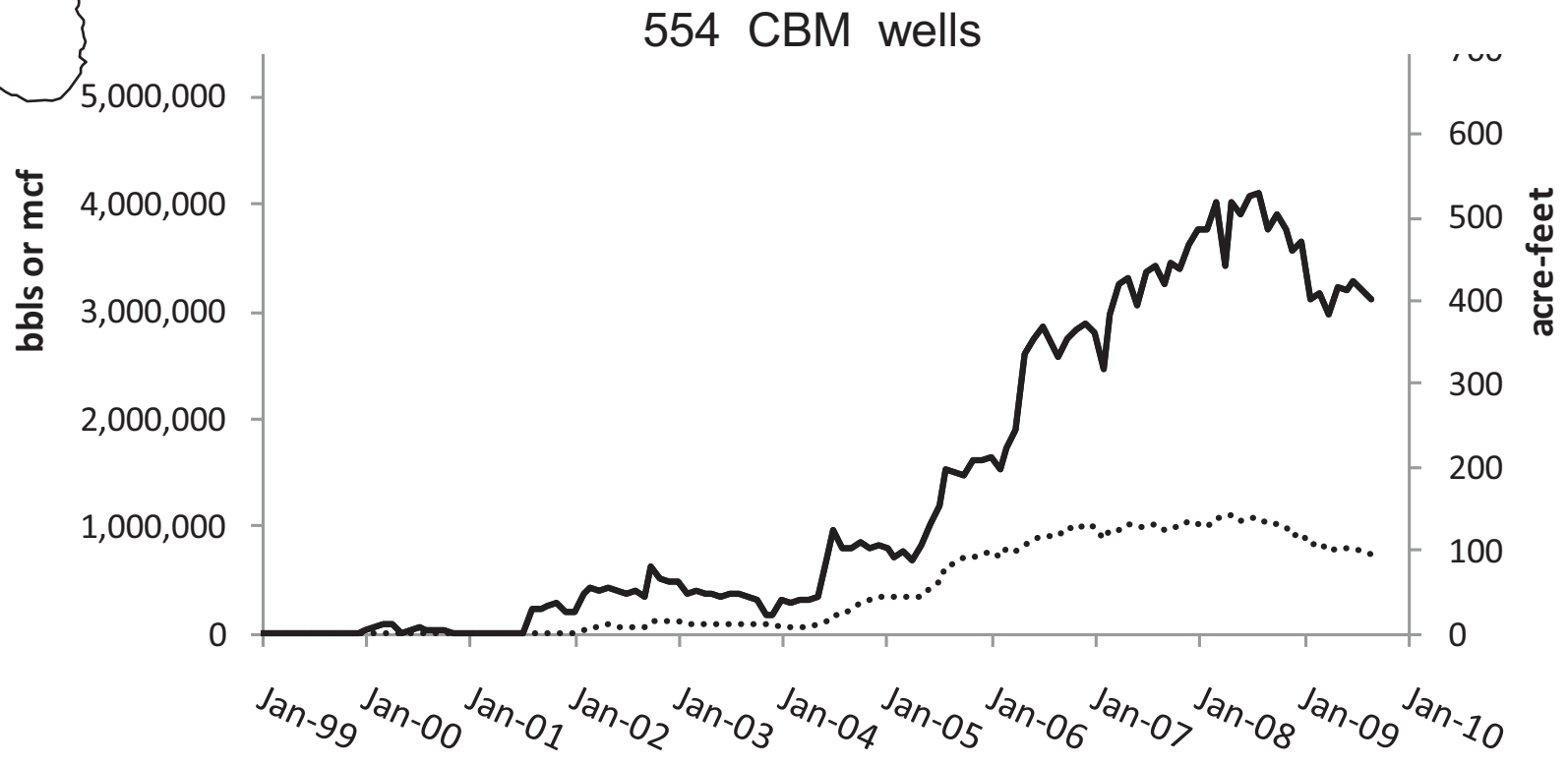
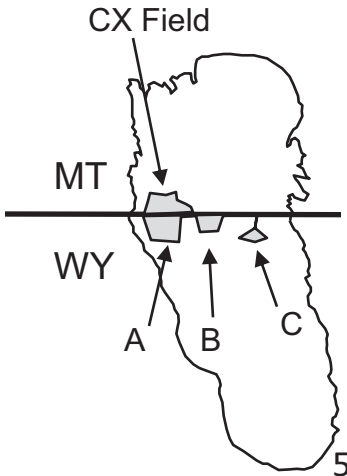
# CBM Gas Production



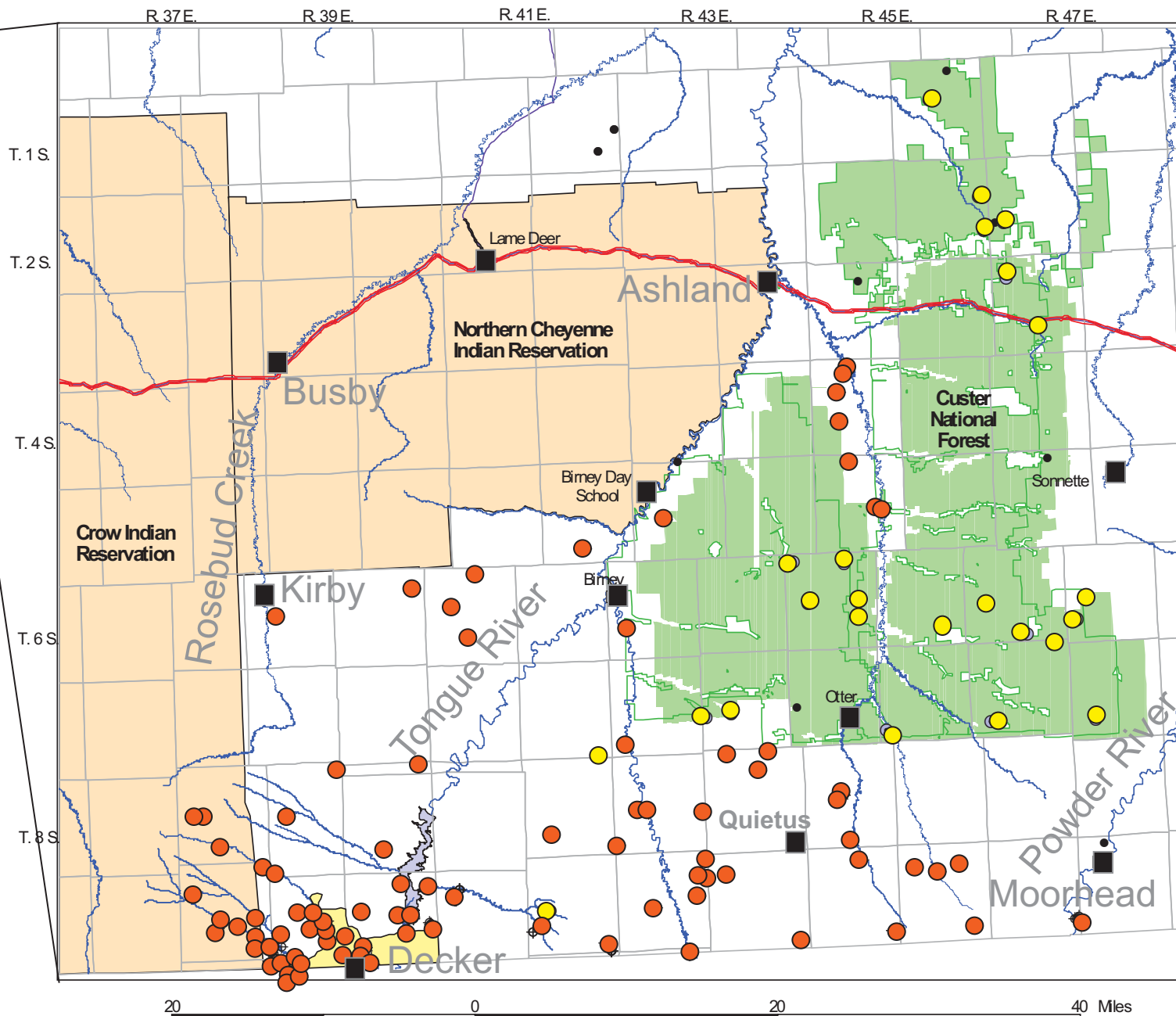
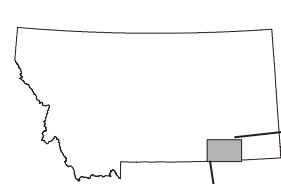
A











234 Wells  
15 Springs  
2 Streams

Monthly  
to Quarterly  
Gauging

Monitor  
Sites

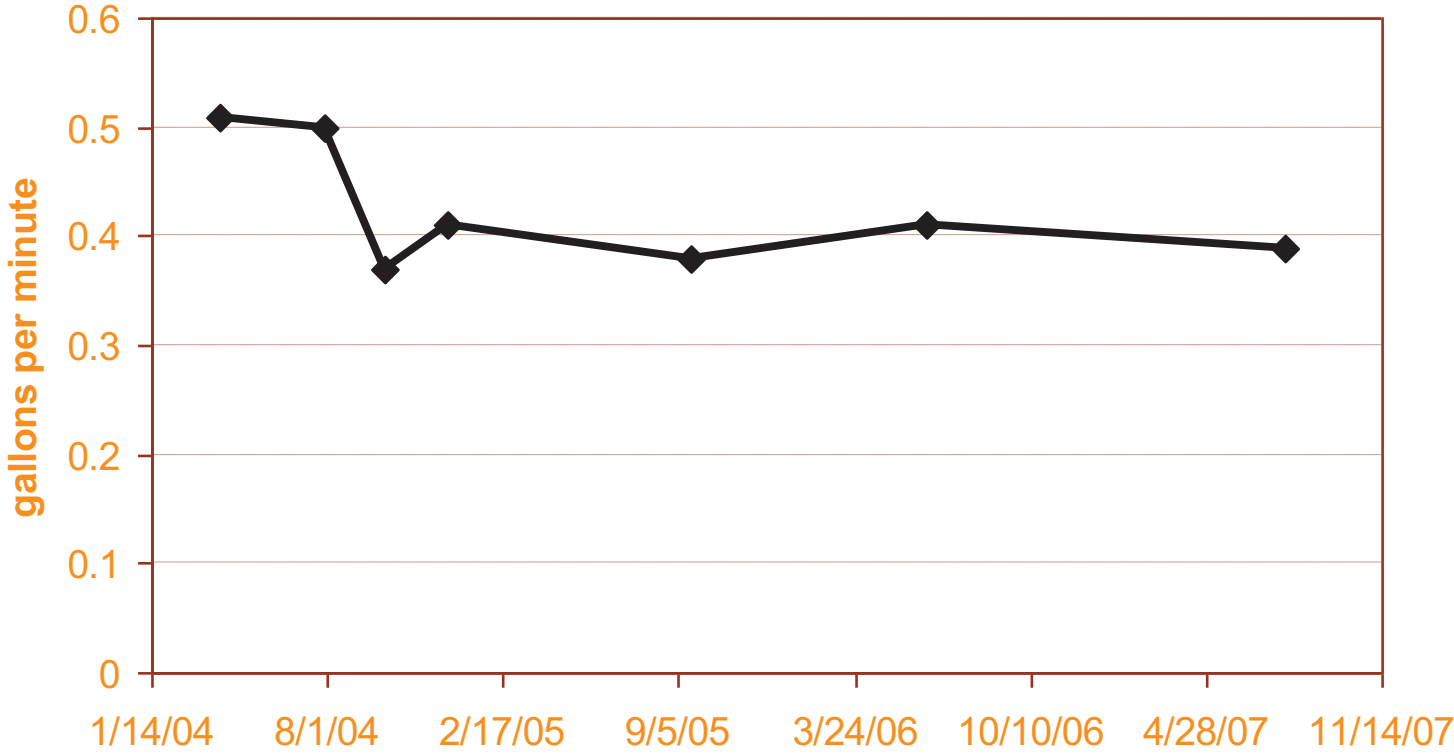
- Springs
- Wells

20 0 20 40 Miles



# Landowner Monitoring (no CBM impact here)

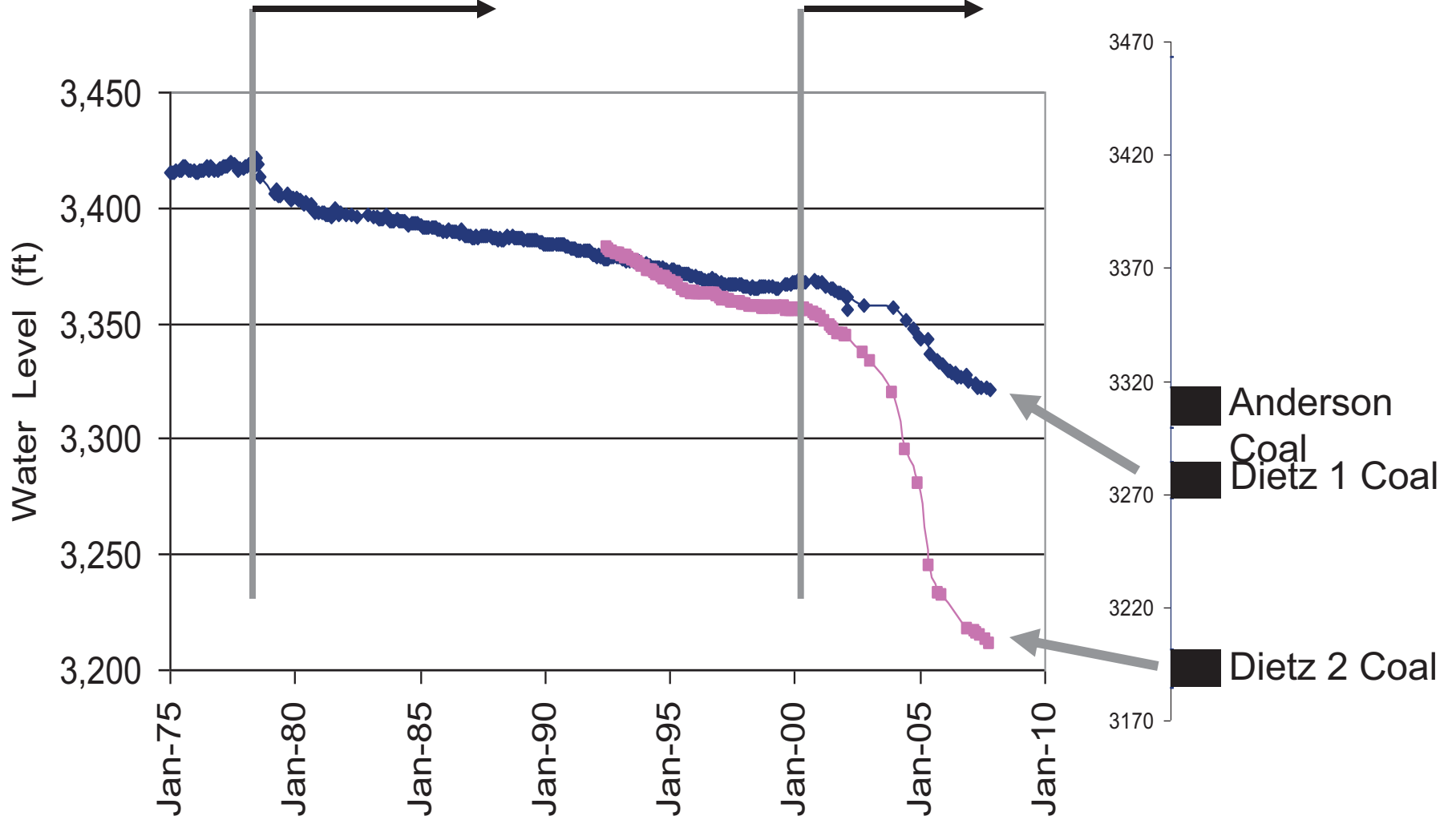
## Parish Place Spring



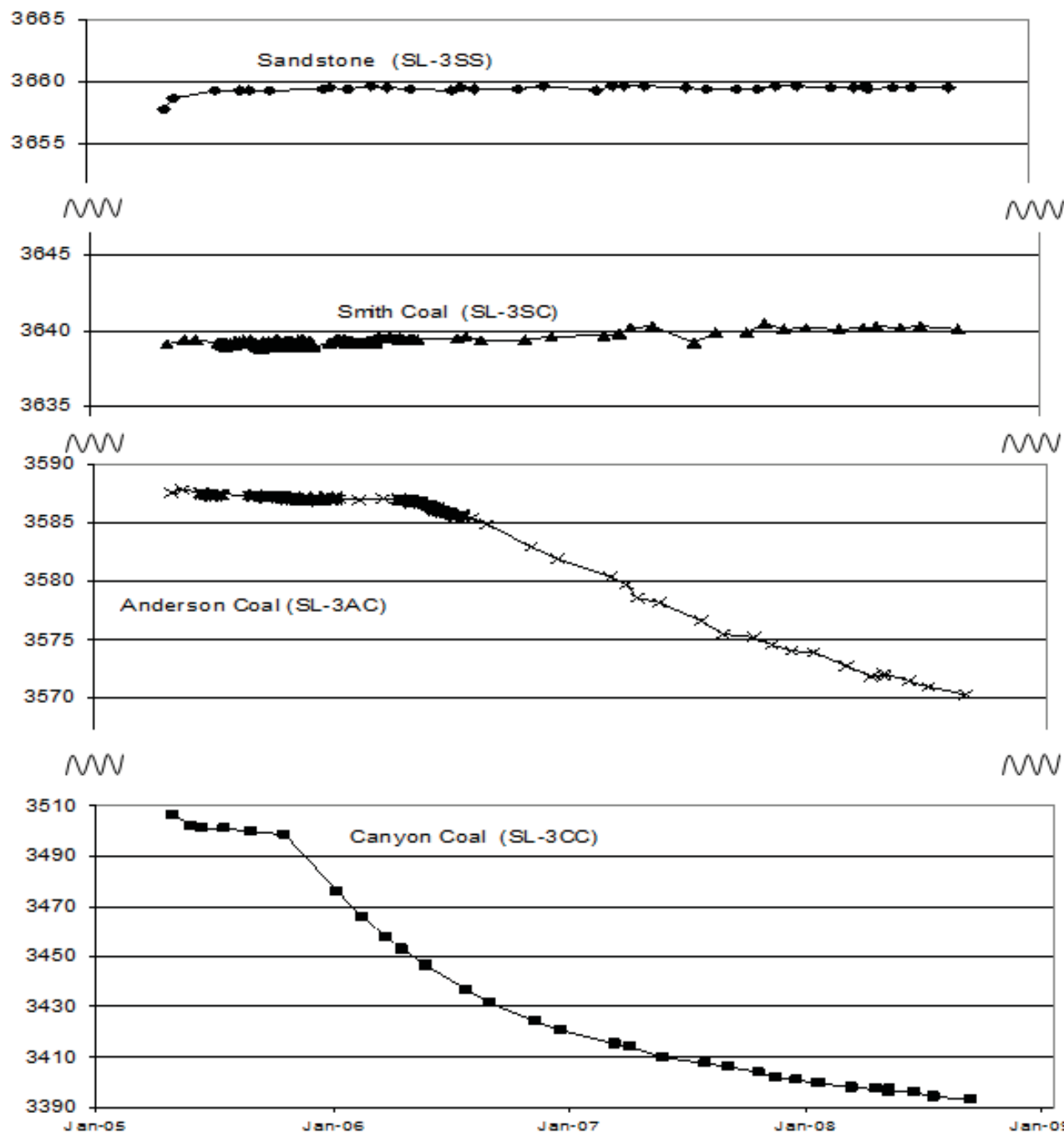
# Ground – Water Drawdown Coal mine

# CBM + mining

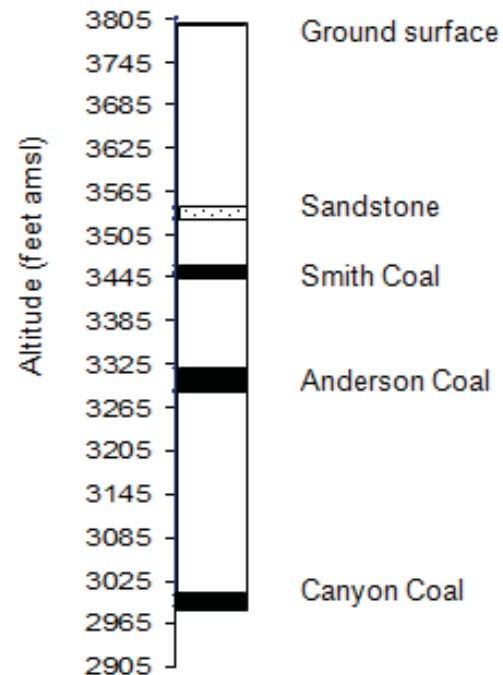
# Stratigraphy



Water Level Altitude (ft-amsl)



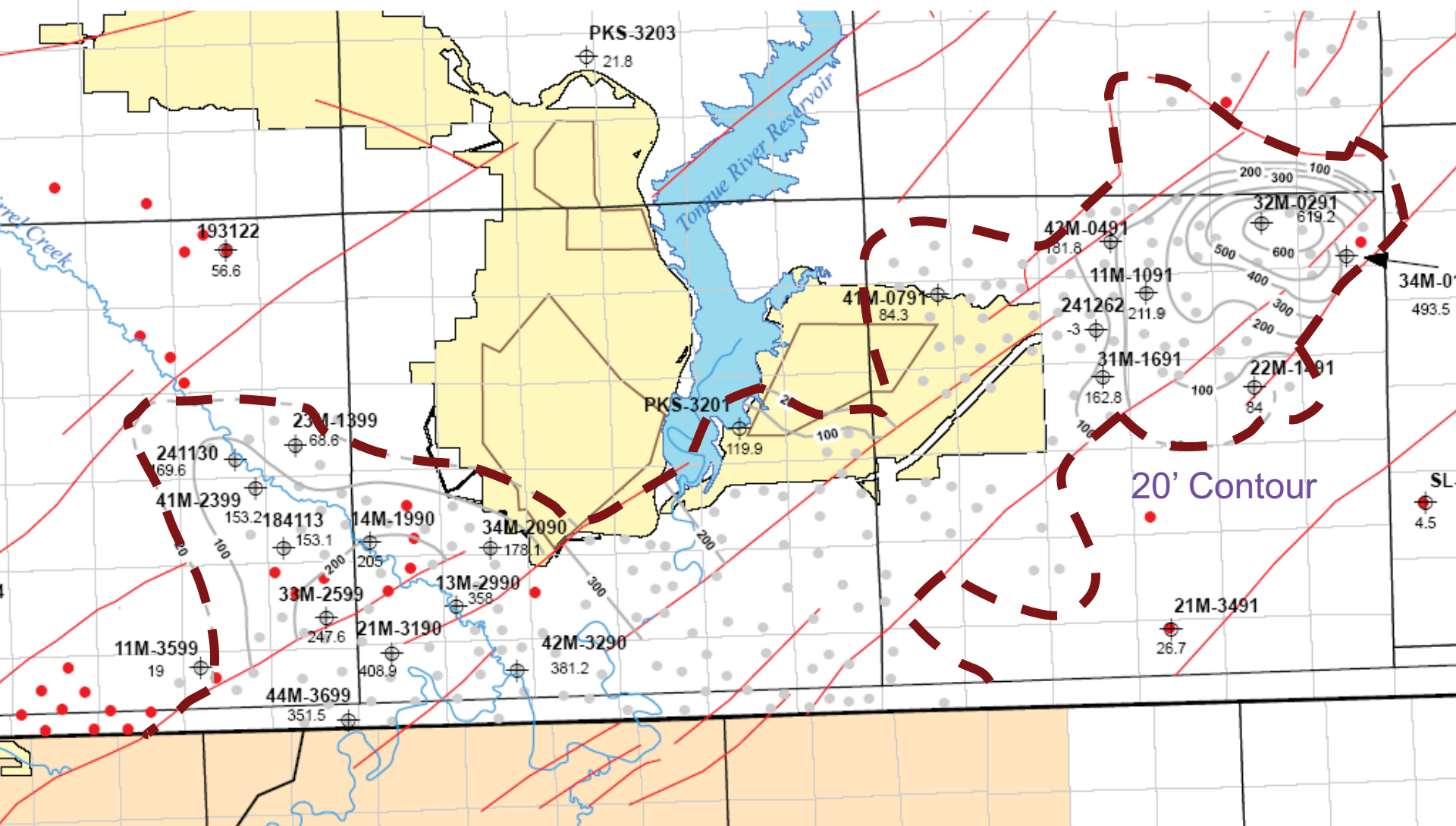
Stratigraphic relationships



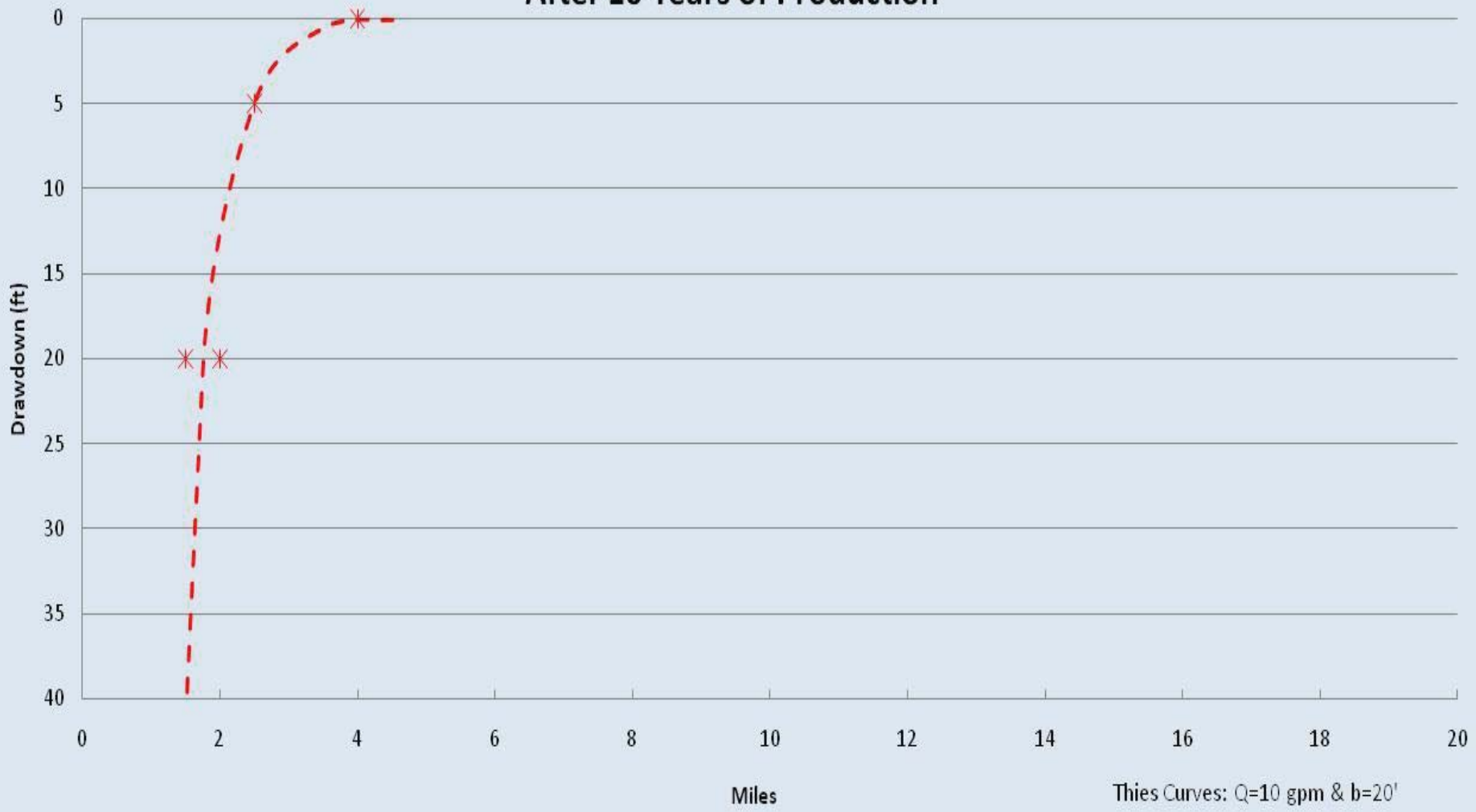
CBM02-  
-0.6

# CBM – related drawdown in Canyon Coal

- ✓ Dedicated Monitoring Wells & 48 hr Shut-in tests on CBM Wells
- 20 ft drawdown : 1 - 1.5 miles outside fields



# Maximum Observed Drawdown from CBM in the Powder River Basin After 10 Years of Production



Thies Curves:  $Q=10$  gpm &  $b=20'$

\* Maximum Observed

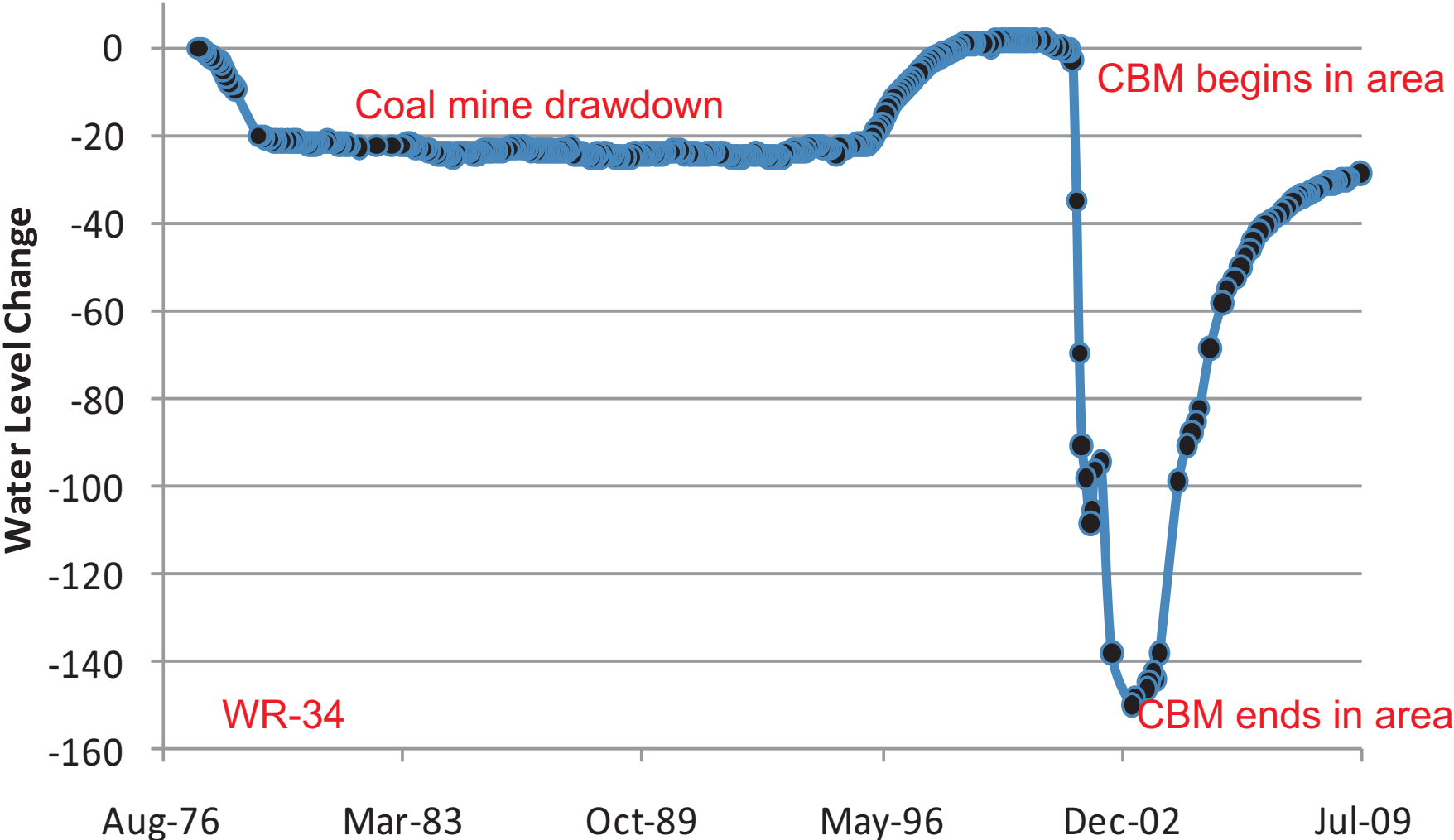
- - Thies Curve for Maximum Observed

**We have drawdown,  
But what about recovery.**

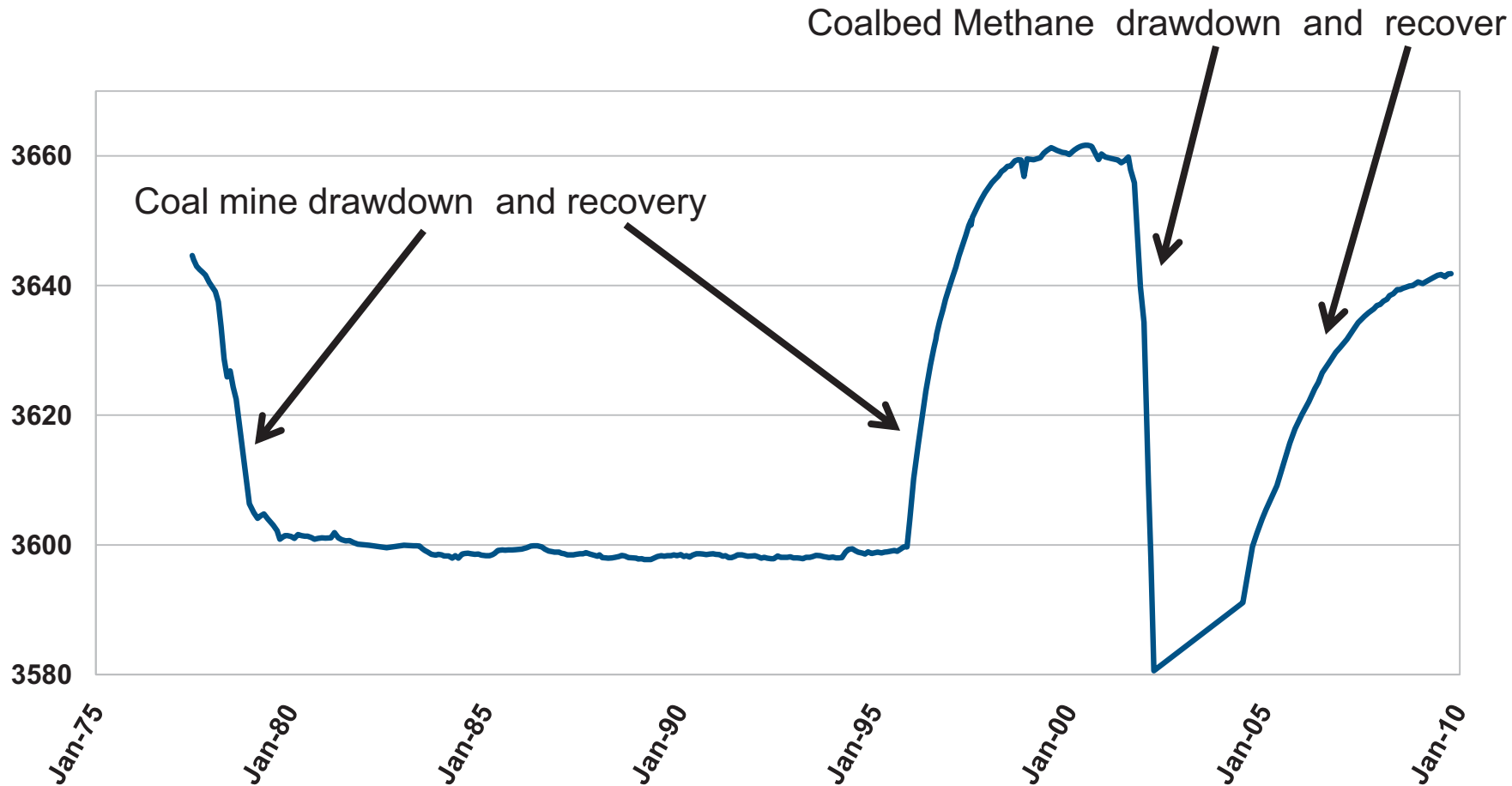
**Individual well examples**



# Mining & CBM Impacts : Anderson – Dietz Coal Near State Line on the Western Side of the CX Field







Drawdown in the Dietz coal (WR-38) due to coal mine operations then by coalbed methane operations.

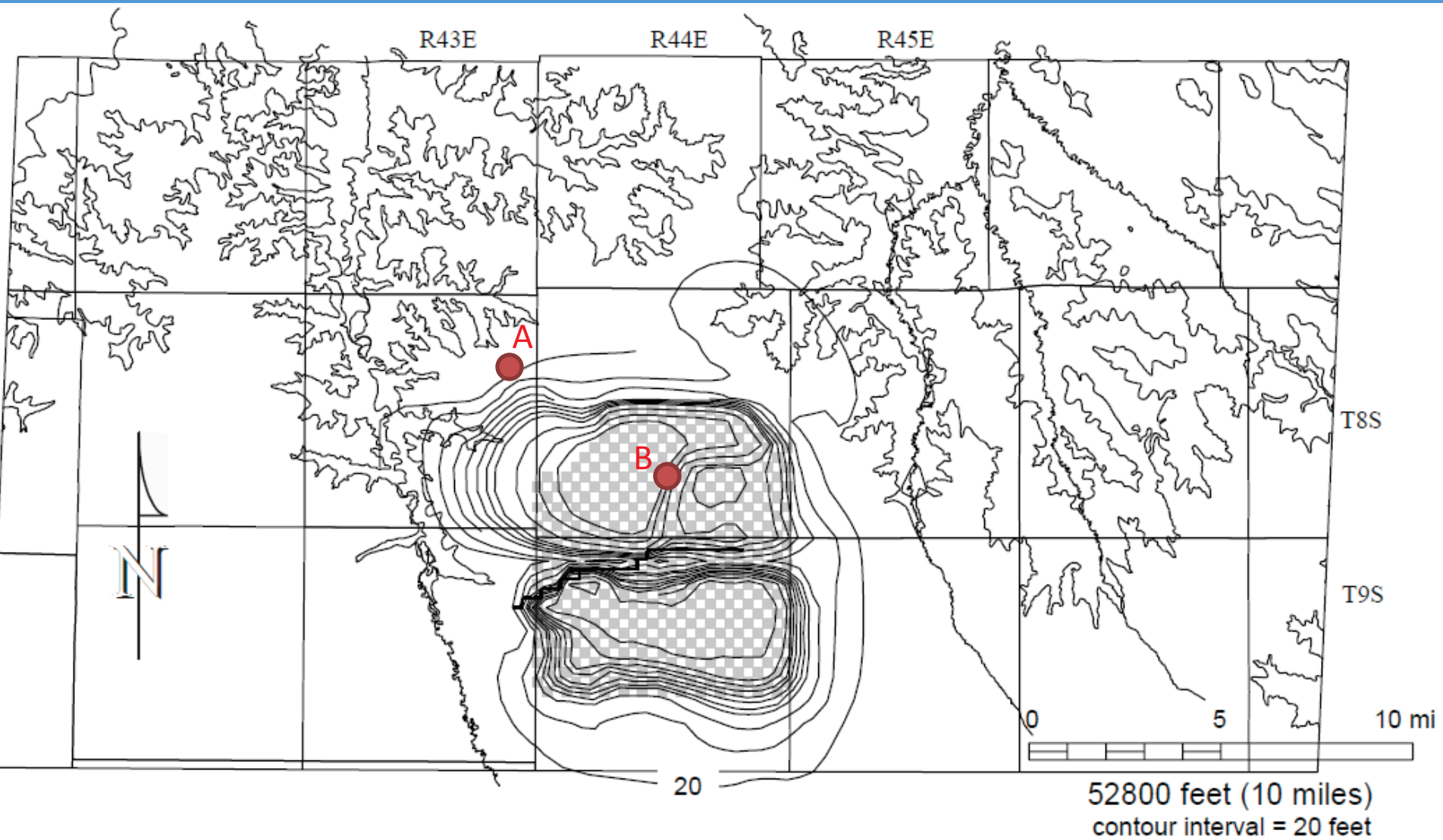
### 3. Predictive Tools

Apply monitoring lessons from other similar settings ( we just discussed )

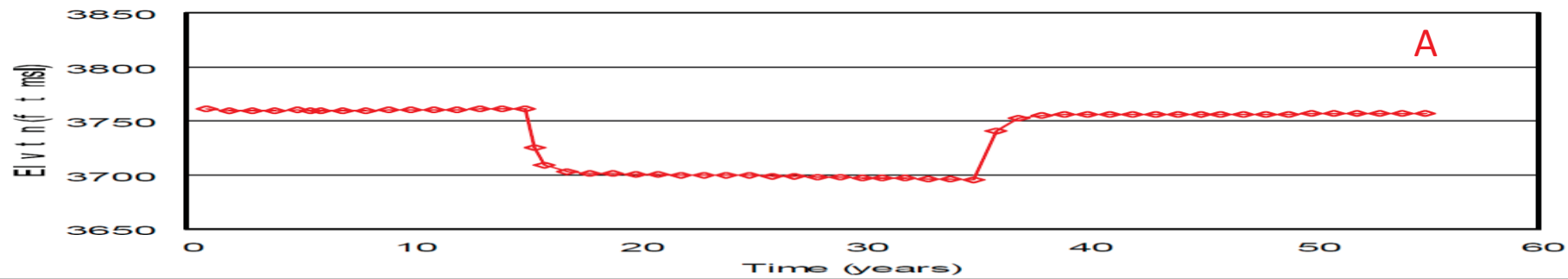
Utilize appropriate Computer Modeling

Combinations of both

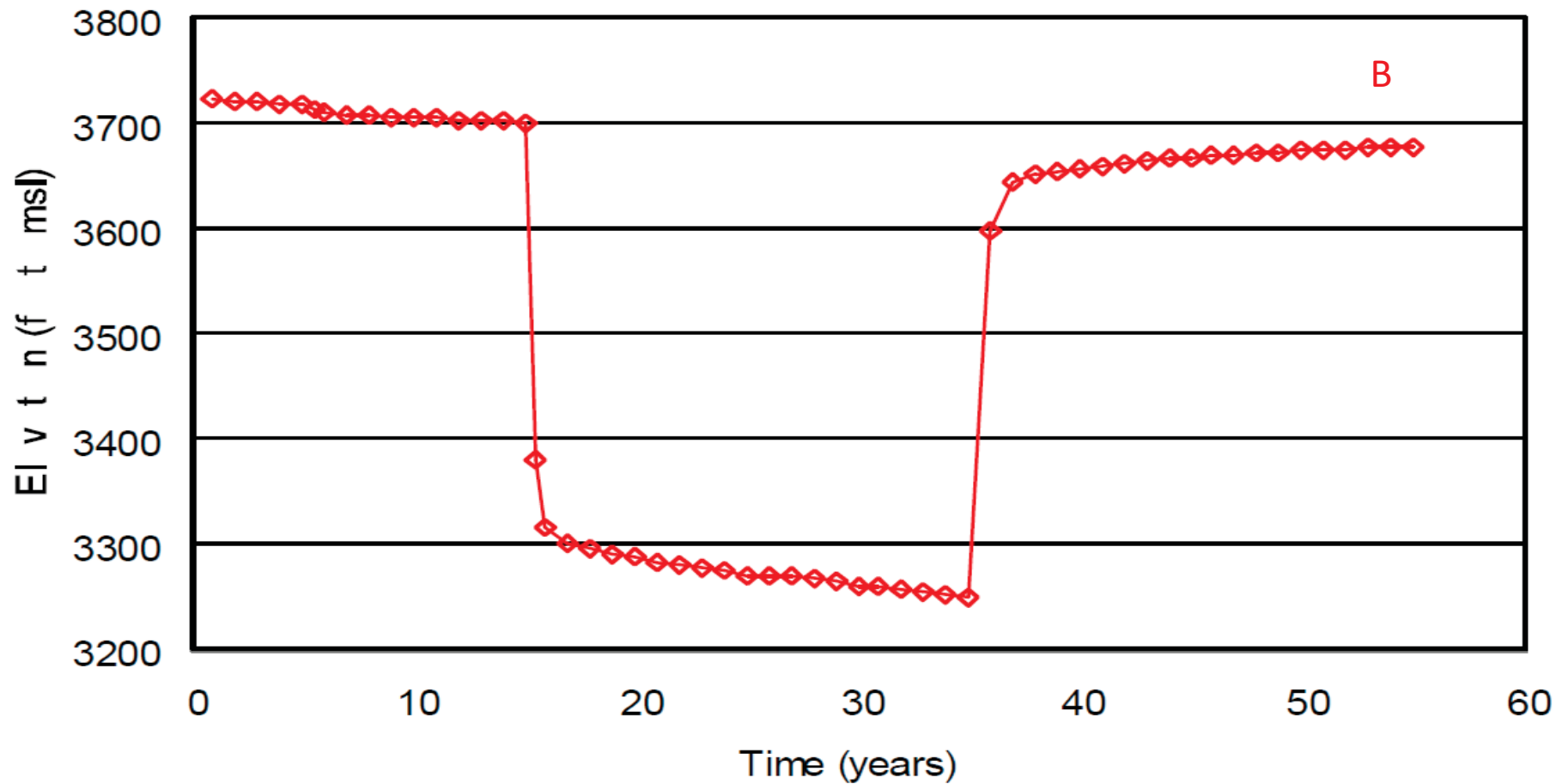




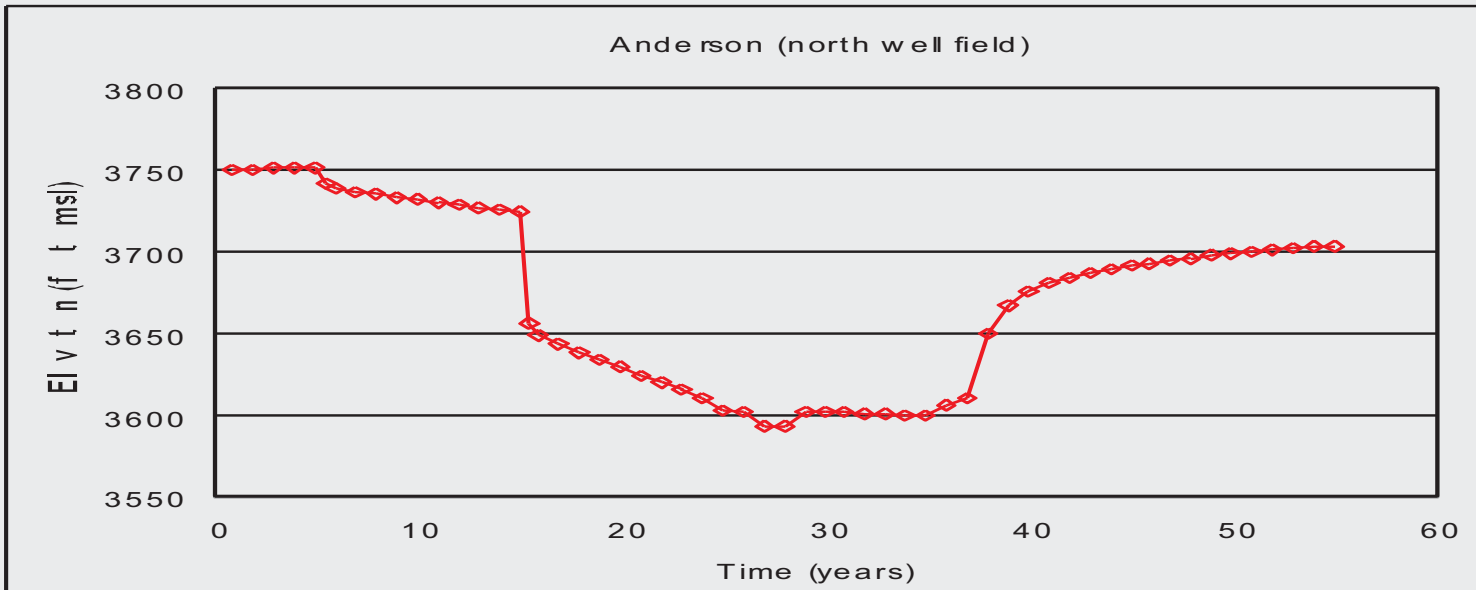
Canyon (northwest)



Canyon (north well field)



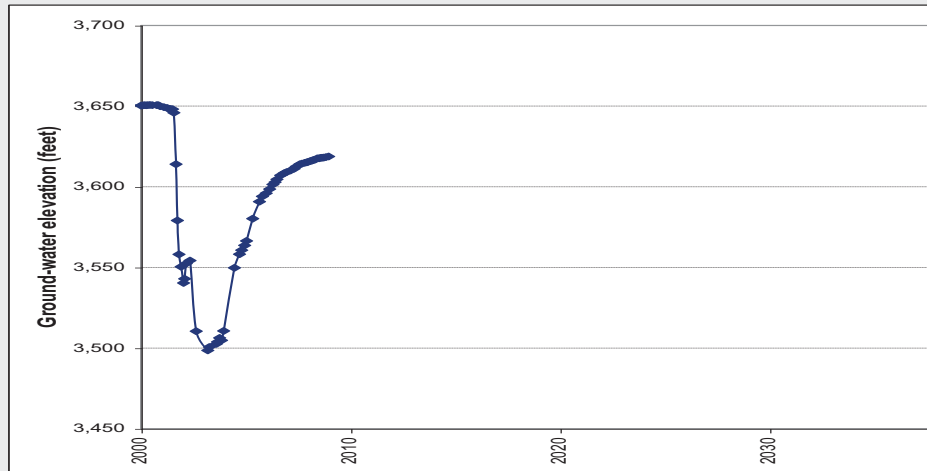
# Anderson Coal in well field



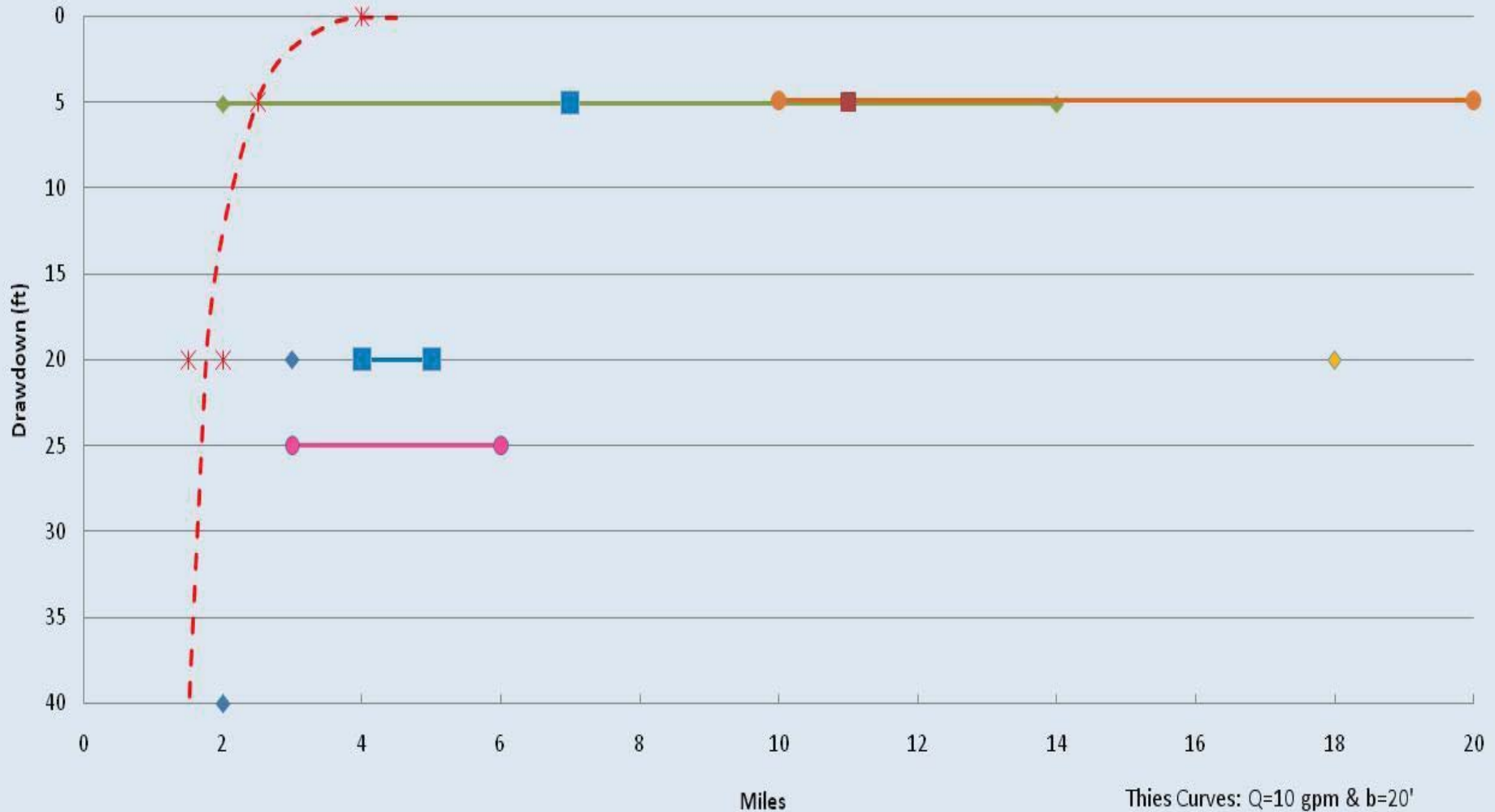
Center of PRB

65% in 10 years

Edge of PRB  
Near recharge  
75% in 5 years



# Modeled and Observed Drawdown from CBM in the Powder River Basin



◆ Wyodack, 1999, Coal Mine Analog, 15 yr

● Wyodack, 1999, 3D, 20 years

■ Wheaton & Metesh, 2001, 2D, 5 yr

◆ Wheaton & Metesh, 2002, 3D, 10 yr

■ Wheaton & Metesh, 2002, 3D, 20 yr

● Applied Hydrology & Greystone, 2002, 3D, 7 yrs

◆ Meyers, 2009, 3D, 15 yrs

✱ Maximum Observed, 10 Years

- - - Thies Curve for Maximum Observed

# Conclusions

- After 10 years of CBM production at the CX Field the 20' drawdown contour extends up to 1.5 miles from the field.
- Recovery in areas where CBM wells have been shut-in, with 73-82% recovery over 5-7 years.
- Coals appear to function as confined aquifers, with little measurable drawdown in adjacent aquifers.

# Conclusions

- Monitoring Program results show the actual extent of impacts.
- Modeling provides a valuable predictive tool.





Questions?