Assessments of Regional Gas Accumulations at the Department of Energy (NETL)

AAPG Hedberg Conference
"Understanding Tight Gas Sands"

April 28, 2005
Vail, Co.

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Outline

- **The Program - DOE/NETL resource assessments**
- **The need to define and understand both terms**
  - "resource" & "assessment"
- **The nature of DOE/NETL assessments**
- **Our findings and their relation to key assumptions**

DOE's National Energy Technology Laboratory

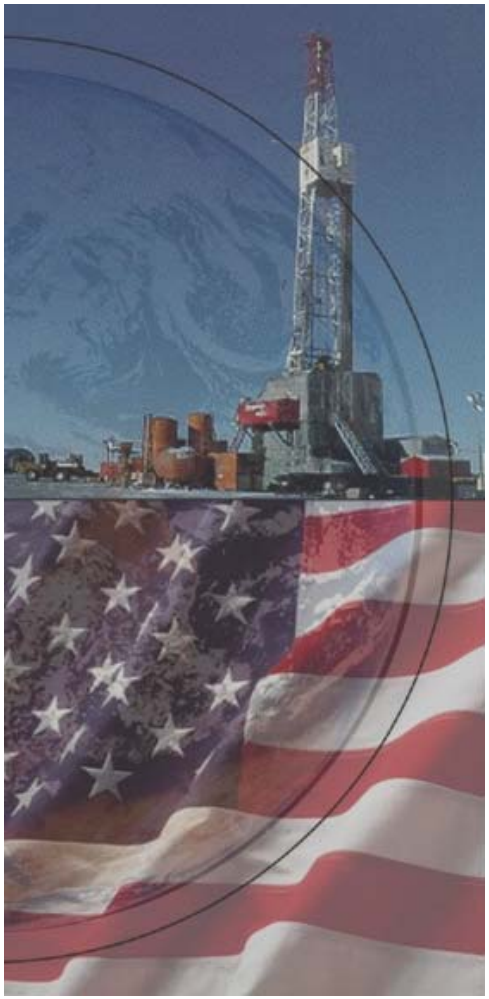
Home of the Strategic Center for Natural Gas and Oil

- Only Office of Fossil Energy lab among DOE's 15 national labs
- Government owned and operated
- R&D conducted on-site and in partnership with…
  - Industry
  - Academia
  - National labs
  - Federal Agencies
- More information about NETL/SCNGO studies and programs: www.netl.doe.gov/scngo

The Strategic Center for Natural Gas and Oil

DOE's National Energy Technology Laboratory

- **The Natural Gas E&P Program**
  - GOAL: assure future supplies of affordable natural gas
  - PROGRAMS: develop technologies at the margins of the gas resource base:
    - Marginal Wells
    - Deep Gas
    - Methane Hydrates
    - Tight Gas

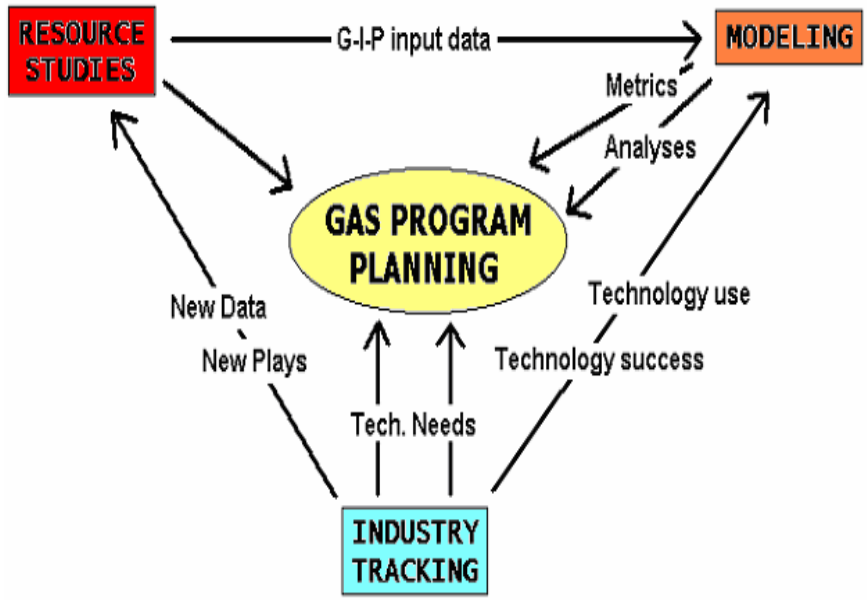


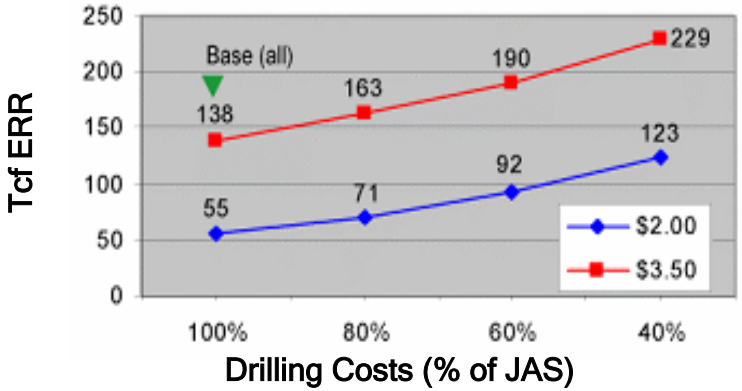
Tight Gas R&D at NETL

- **R&D**
  - **1974-1990: Western Gas Sandstones Program**
    - MWX, etc.
  - **1992 - present: Tight Gas Exploration**
    - Natural fracture detection & prediction
    - Water detection and avoidance
  - **2005: Recent Solicitation on Tight Gas Fundamentals**
    - Petrophysics, conceptual models
    - Pay identification from logs
- **Resource Assessments**
  - **1987 - 2000: USGS in-place assessments**
    - Piceance, GGRB, WRB, Bighorn
  - **1992 - 2005: NETL assessments**
    - Appalachian, GGRB, WRB, Uinta, Anadarko

Why NETL does assessments

- **Support R&D Program Planning & Justification**
  - Not interested in estimating likely future outcomes
  - But seek to model alternative R&D approaches to evaluate which advancements might provide the greatest impacts
- **Existing assessments not suitable**
  - They are based on data with inherent technology assumptions,
    - for example past completion practices thereby burdening future modeling with past decisions or technologies
  - Insufficient detail for technology sensitivity modeling





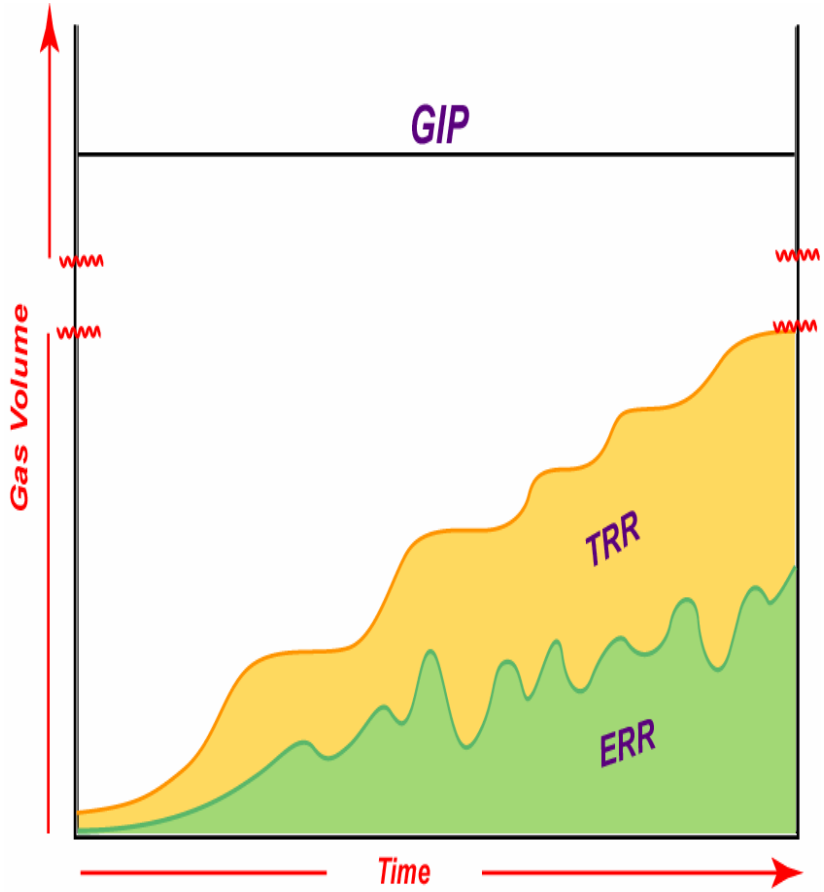
What we Assess

"The gas resource is…"

- **Gas Endowment**
  - Fixed, but not necessarily known

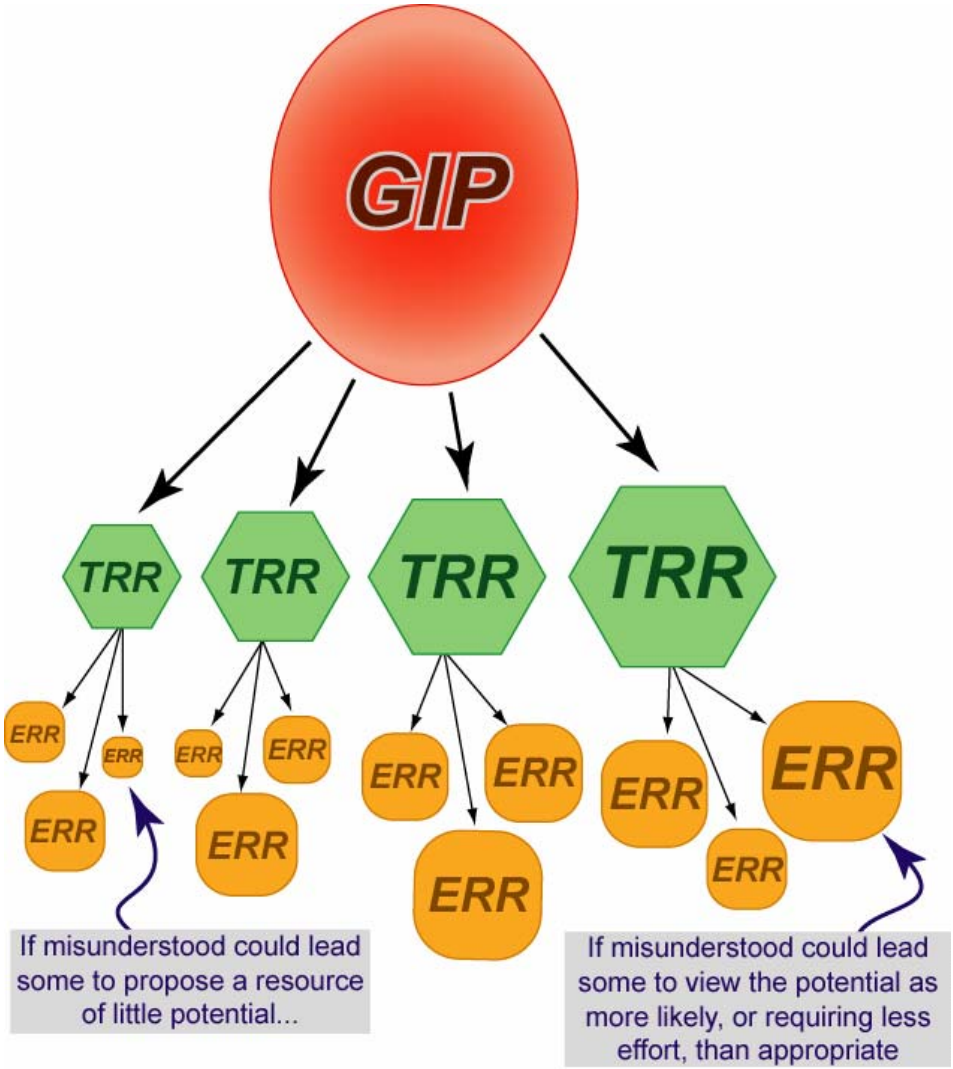
- **Gas-In-Place (GIP)**
  - Dependant on assessment parameters (plays, lithologies, cut-offs, others)
- **Technically-Recoverable Resource (TRR)**
  - Fraction of the GIP volume that can be produced with available technologies at a given point in time.
- **Economically-Recoverable Resource (ERR)**
  - Function of economic conditions

- **All categories of recoverable resource are variable with time**



One GIP; variable TRR & ERR

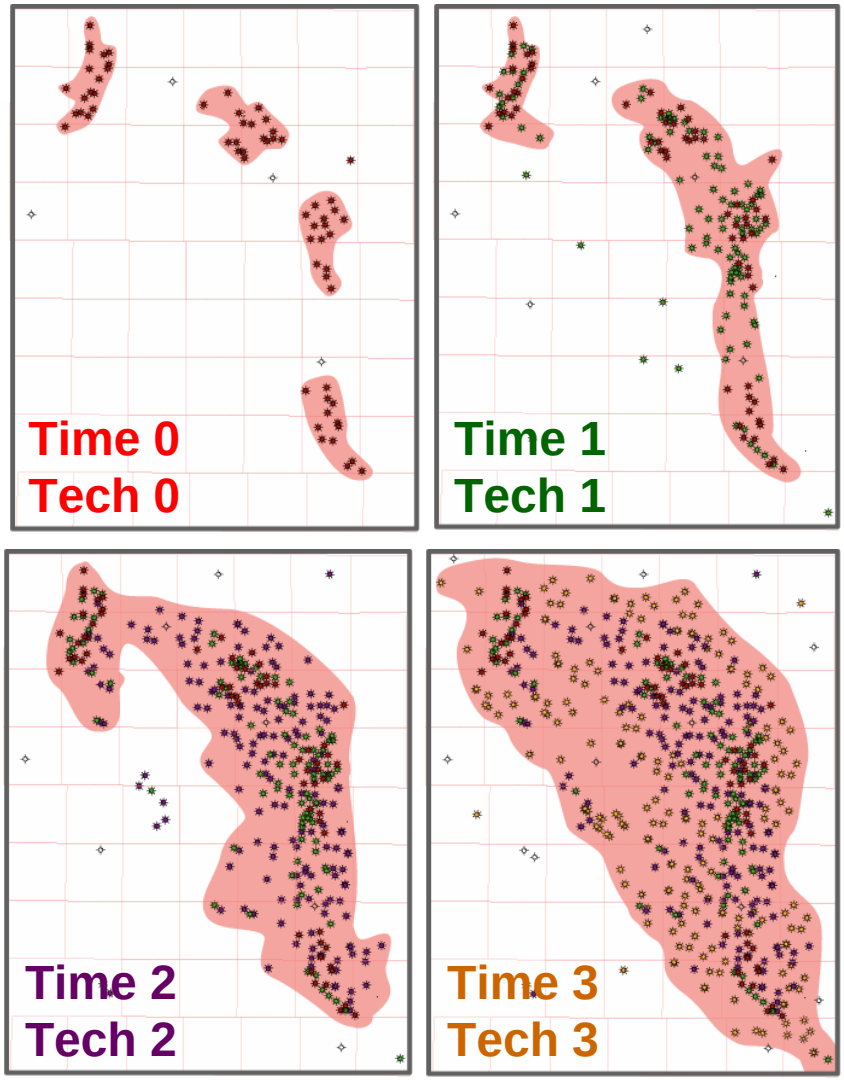
- **A given GIP can provide a wide range of estimates for TRR and ERR depending on Purpose and Assumptions**
- **Technically Recoverable Resources**
  - What is likely or possible given a particular state or advancement of technology
  - Are temporally related
- **Economically Recoverable Resources**
  - Examine impact of gas price or costs of technology
  - Assumed hurdle rates
  - Are temporally related



One recommended approach

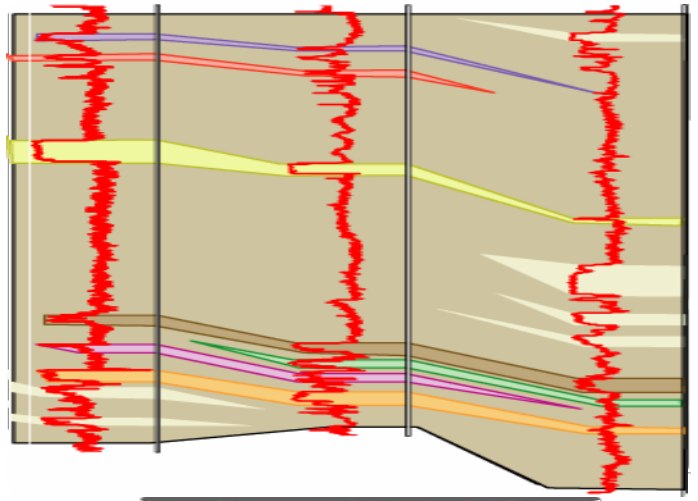
Statistics-based field size distributions

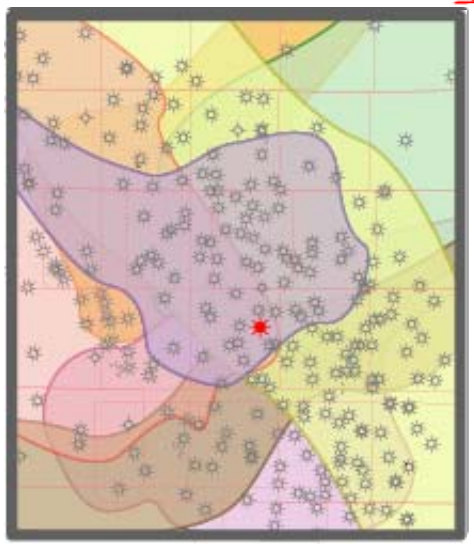
- **What is a tight gas "field"?**
  - Extensive accumulations; thousands of lenticular, strat bodies w/ commingled production and progressive consolidation
- **Does data exist in the US to do "Pool Size Distributions"?**
  - Does recoverable pool size change in response to costs, prices, technology, and operator behavior?



Cell-based Methodolgies/Approaches…

- **Cell based are most appropriate with…**
  - Data density and representativeness, and cell-size.
  - Recognition of lenticularity and heterogeneity within cells…
- **Which cell-based method?**
  - Cell-based Estimated Ultimate Recovery (EUR) analyses
  - Cell-based gas-in-place analyses w/ numerical simulation

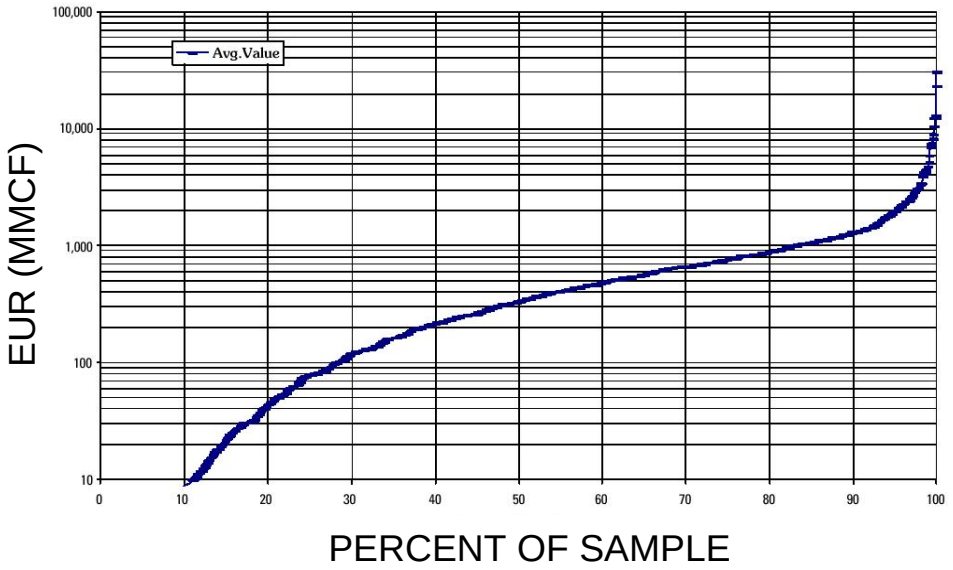




Cell-based EUR Analyses?

A good, efficient method for determining "what to expect"...

- …but, doesn't provide the data needed to model the impact of major technological advances.

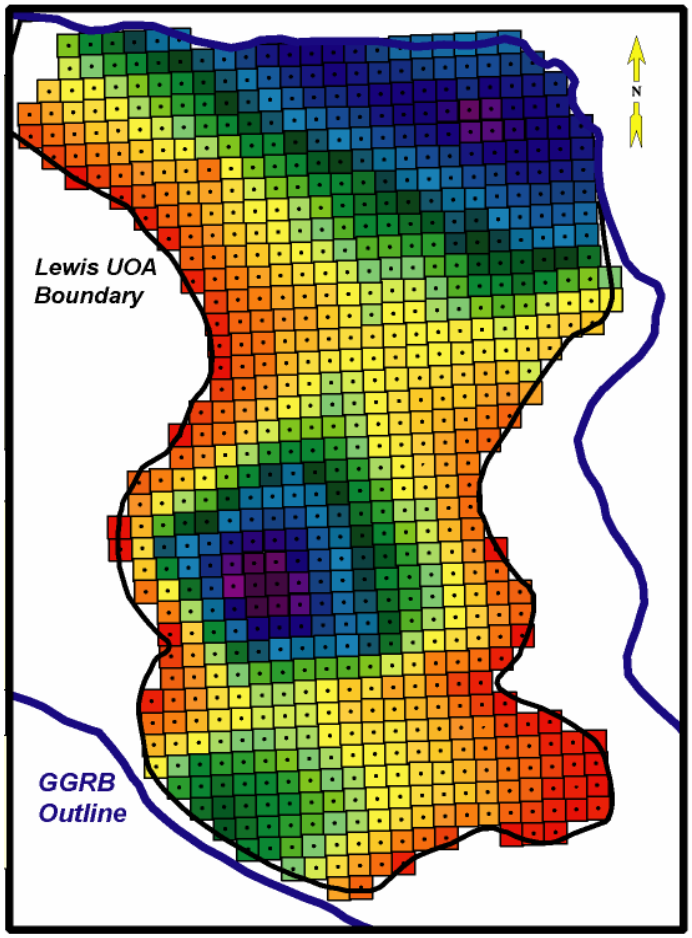


- EURs may be a function not only of the resource, but also past human decision-making.
  - What to produce (what zones to complete)
  - How to produce (what technology to apply)
  - If to produce (all dry holes not equal)

Cell-based Geologic Analyses

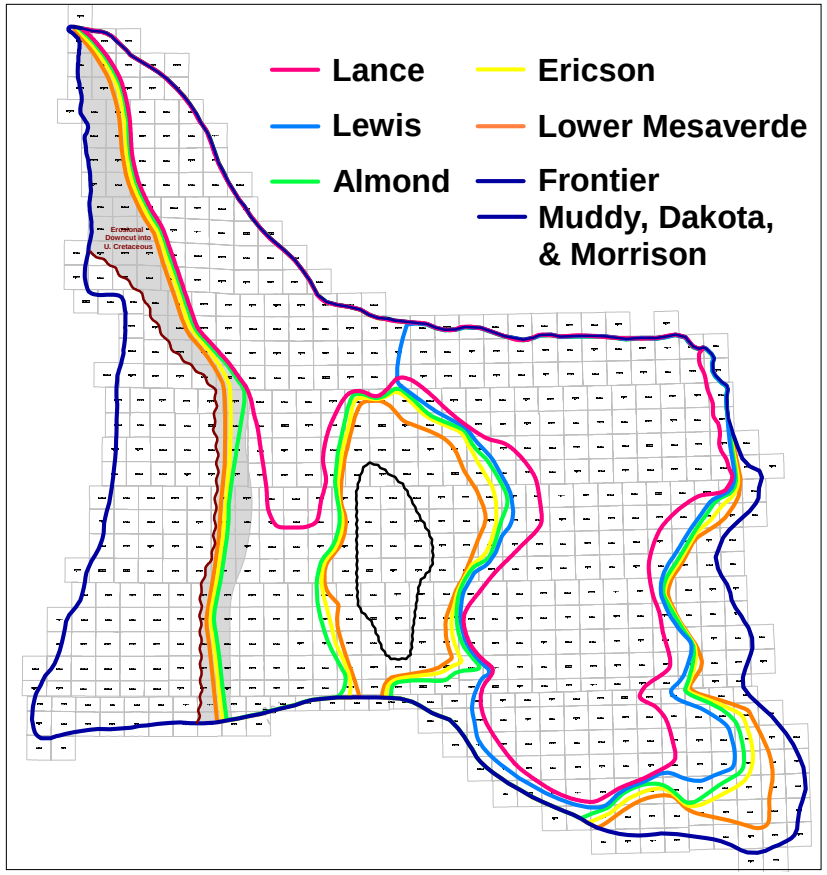
Suitable for allowing determination of GIP, TRR and ERR

- **Gas-in-place**
  - Capture all gas that eventually may be economic
  - Does not assume a recovery factor
- **Permeability estimates**
  - Based on analysis of production data
  - To enable extrapolation of recoverability
- **Extensive detail**
  - For meaningful sensitivity to technology advance
  - Results in a geographically and vertically disaggregated assessment



Determine Geographic Extent

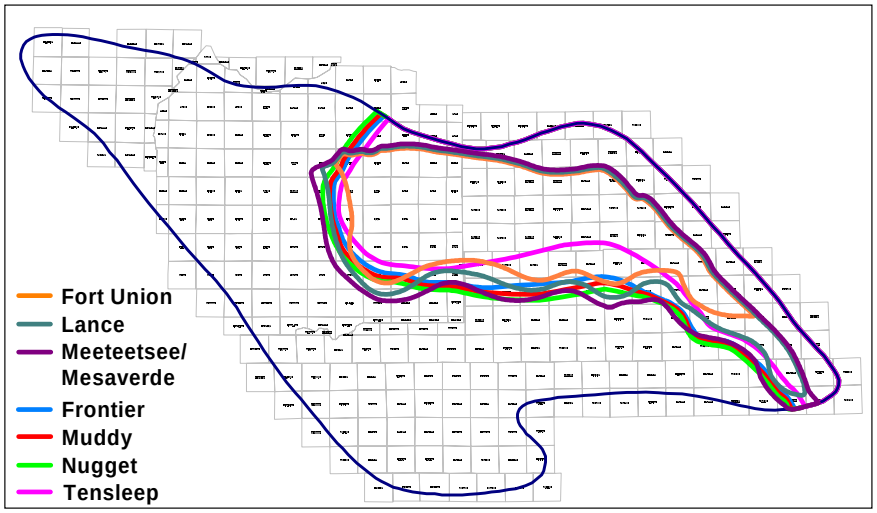
Greater Green River and Wind River basins



Greater Green River Basin

Excluded areas:

- prone to oil
- shallow
- previously produced
- (later) calculated water wet

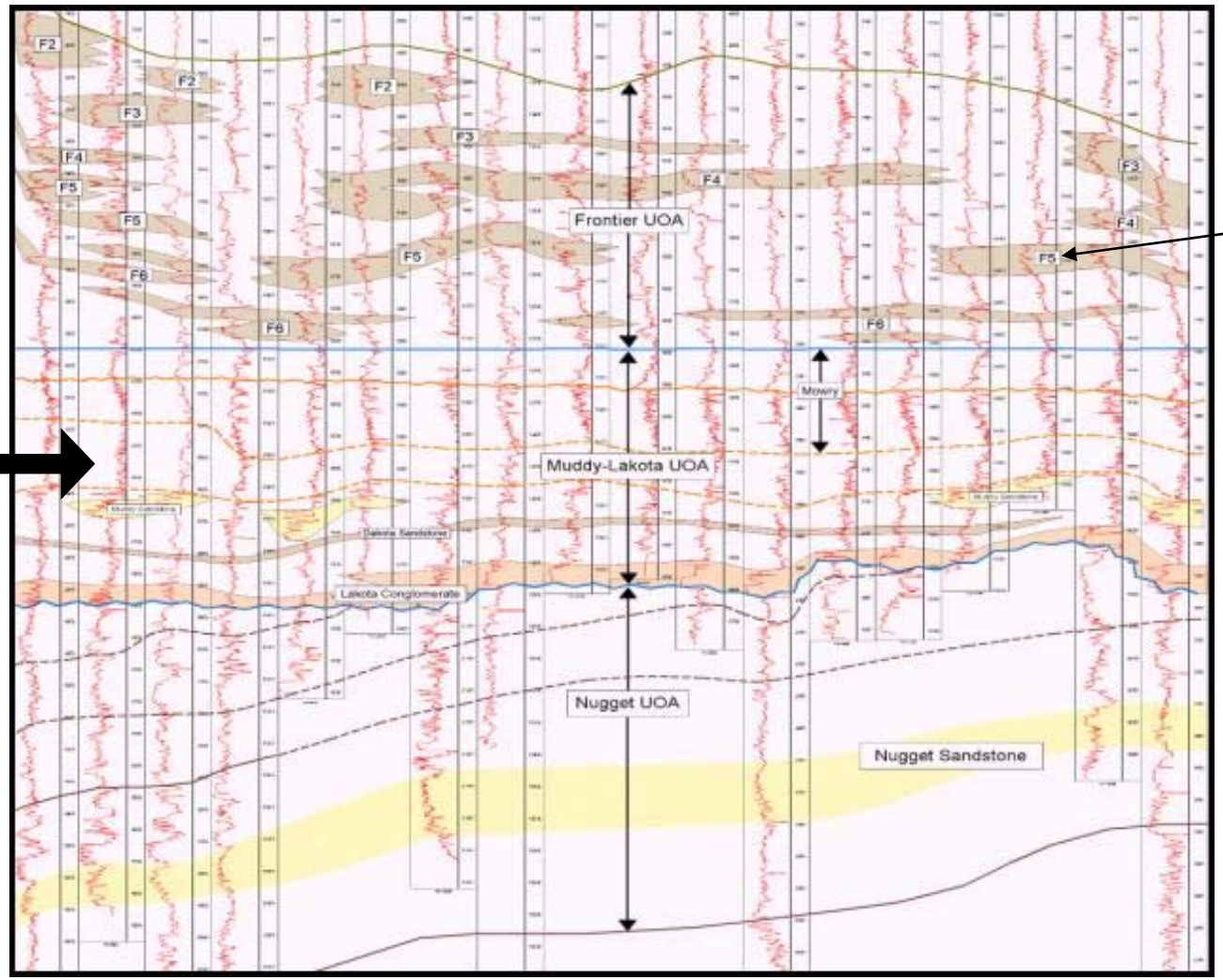


Wind River Basin

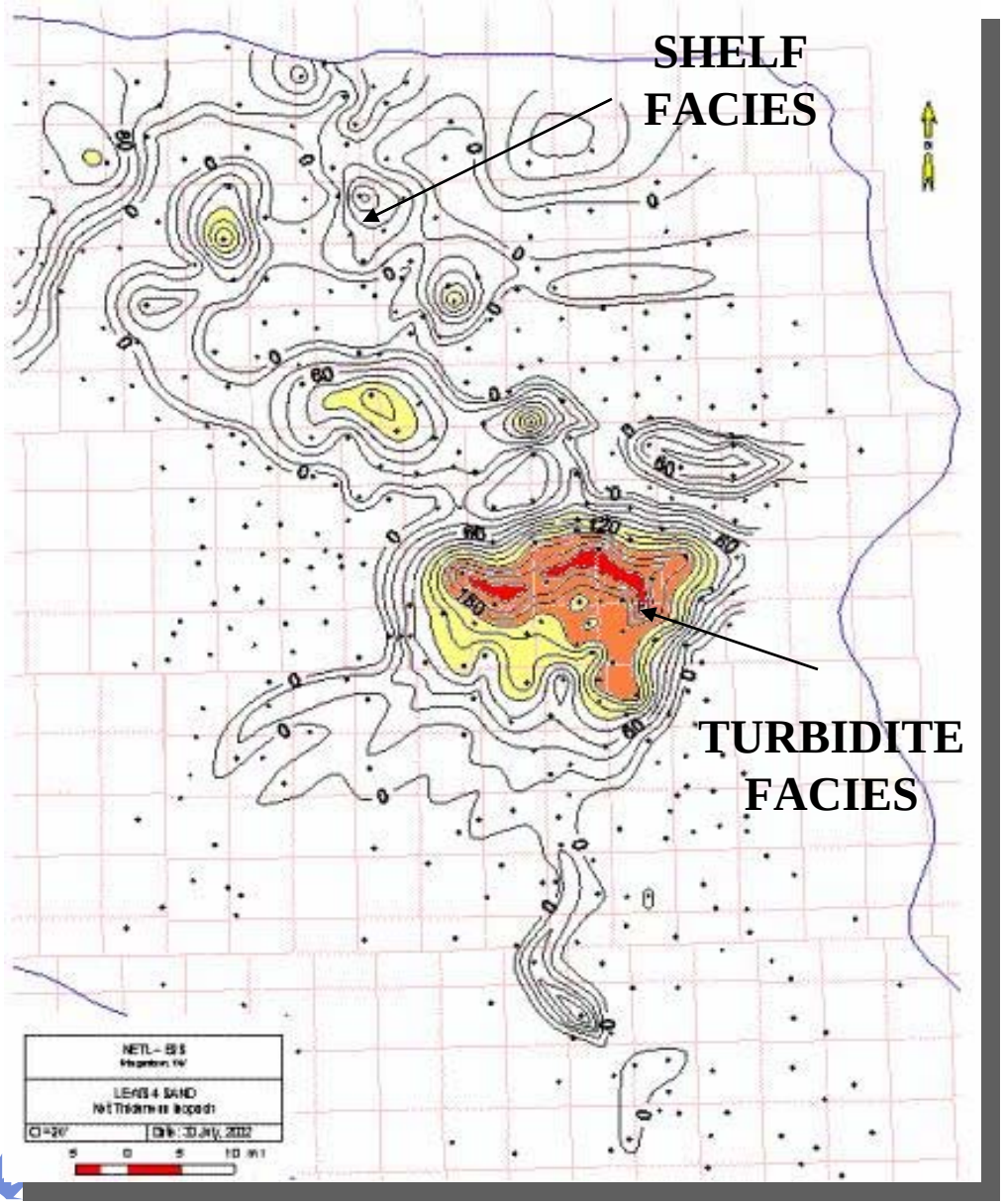
Determine Stratigraphic Extent

Sandstone Isolith Maps for UOAs

Drilling depth to UOA midpoint



Isopach maps on individual sandstones (Lewis, Almond, Frontier, Muddy-Dakota UOAs)

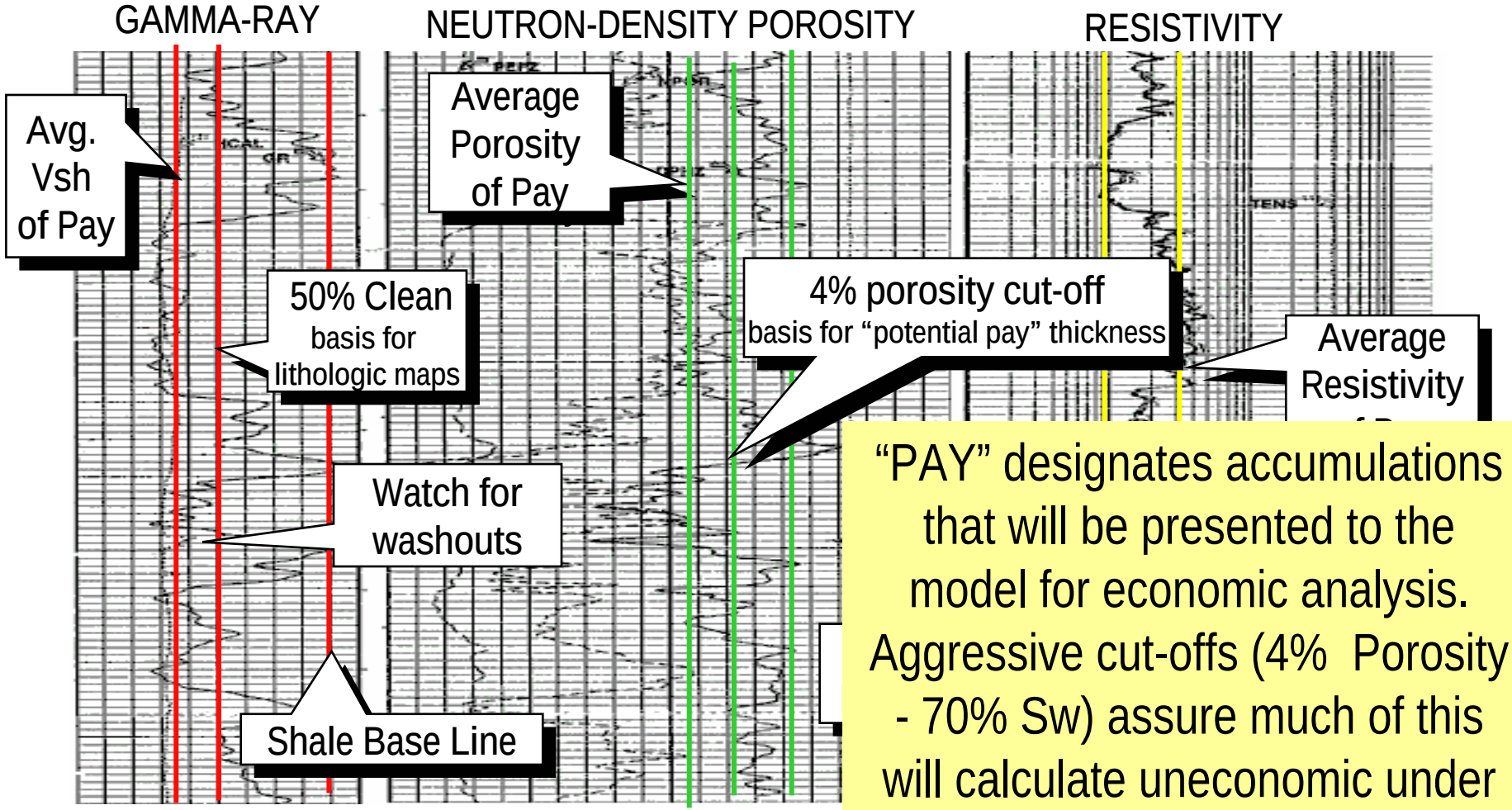


Map Gas-bearing Units

Lewis "4" sand: Eastern Greater Green River Basin

Conduct Well Log Analysis

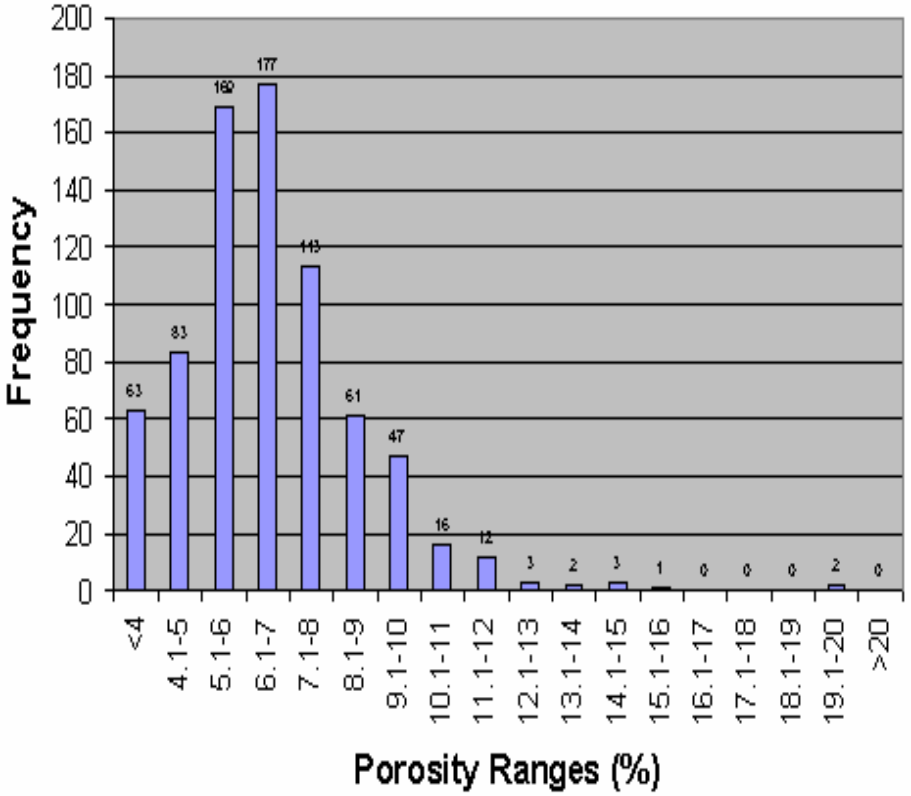
Example from Frontier Fm. Wind River Basin

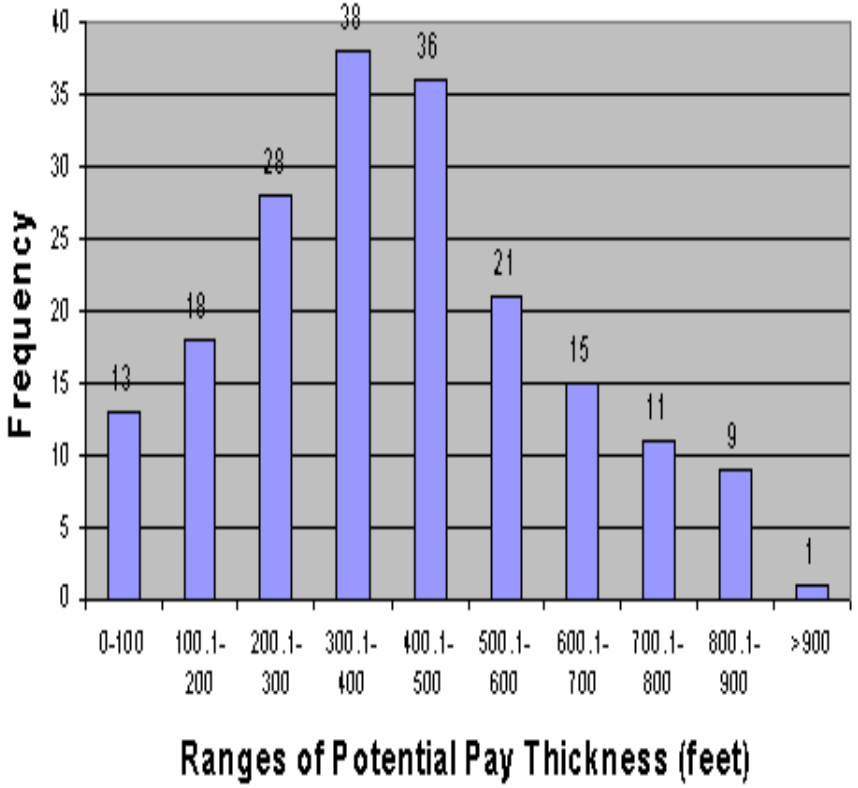


"PAY" designates accumulations that will be presented to the model for economic analysis. Aggressive cut-offs (4% Porosity - 70% Sw) assure much of this will calculate uneconomic under most technology scenarios

Typical Distribution of Volumetric Parameters

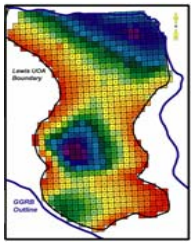
Lewis Porosity – Fort Union "Pay"





EVERY CELL WITH A UNIQUE VALUE

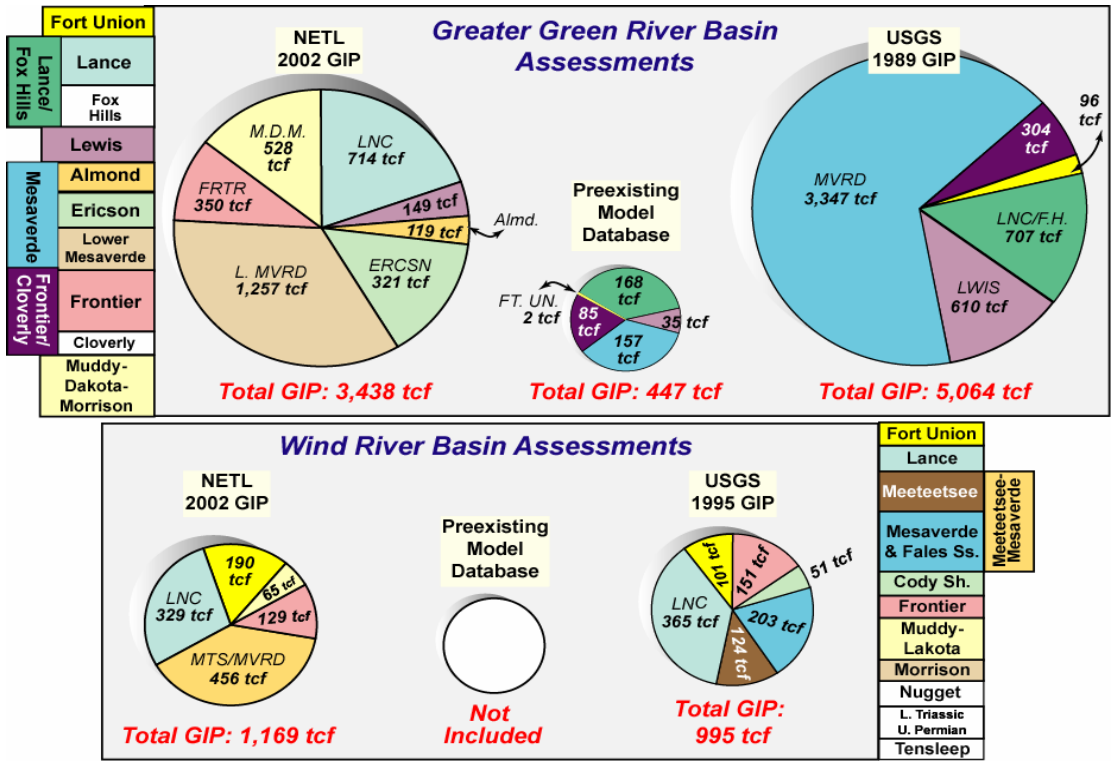
Allowing for greater modeling sensitivity to changes in costs and risks



Volumetric Results

Geologic-based GIP determination; GGRB and WRB

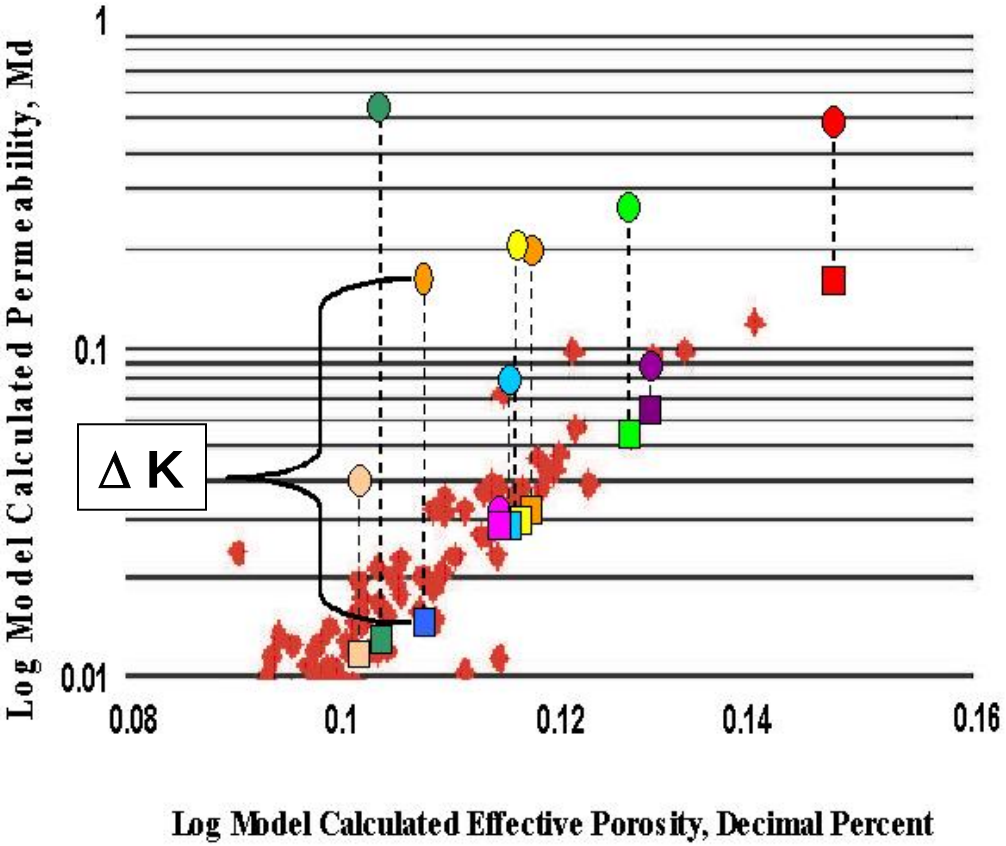
- Analyses of more than 500 well logs confirm prior estimates of vast volumes of gas-in-place.
- GGRB = 3,438 tcf
- WRB = 1,169 tcf



Geologic characterization and volumetrics conducted by ***EG&G Services***

Estimation of Permeability

Permeability analyses conducted by ***Advanced Resources Int'l***

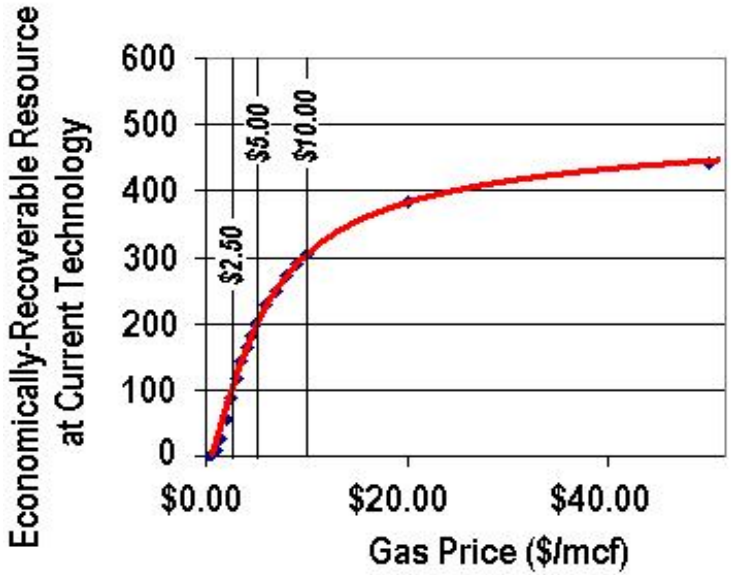


- Use Production type curve matching techniques to establish regional distribution of likely permeabilities...
- Incorporate aspects of both matrix and fracture permeability

Recoverability – Results

GGRB & WRB: for a case approx. current conditions

- **Technically-Recoverable**
  - GGRB: 363 tcf (10% of GIP)
  - WRB: 122 tcf (12% of GIP)
- **Economically-Recoverable**
  @ $3.50/mcf price
  - GGRB: 105 tcf (2.8% of GIP)
  - WRB: 33 tcf (3.3% of GIP)



- Goal: not necessarily absolute values, but relative changes in recoverability between alternative scenarios

Sensitivity Analyses – Our assumptions

- **What to include in the GIP total?**
  - 4% porosity
  - 70% Sw
  - Rw, dependent on formation
  - M and N = 2
  - Form of the Sw equation used, Simandoux

- **Two independent phases of sensitivity analyses:**
  - Analyzed the impact of different limitations on the GIP and TRR assessments
    - Porosity (6/8%) and
    - Sw (60/50%) cutoffs
  - Calculation of Water Saturation
    - Rw
    - M and N
    - Form of the Equation

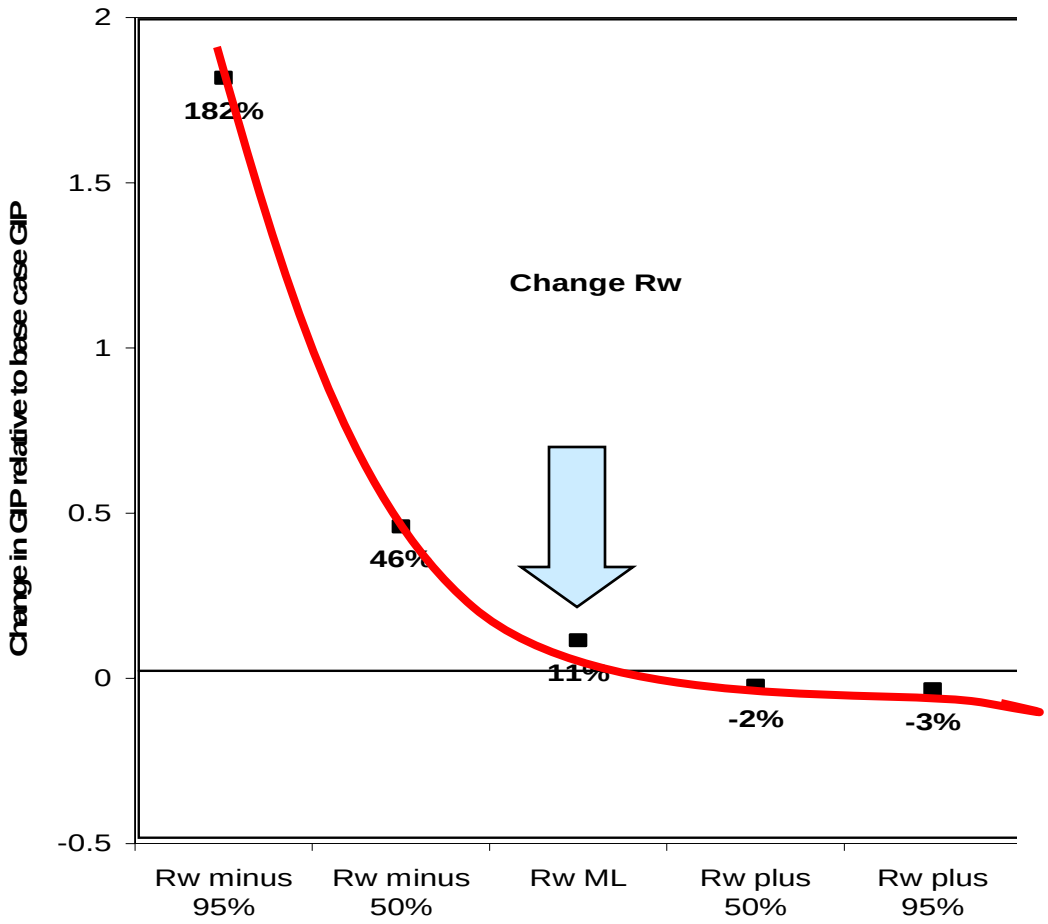
Sensitivity Analyses – What to include in GIP

- **Included***: (Potential pays to be presented to the model for consideration for inclusion in TRR under specific scenarios)*
  - Porosities down to 4%
  - Sw's up to 70%

- **For all of the UOA's assessed the overall change, if limited to:**
  - phi > 6%: GIP and TRR drops ~10%
  - phi > 8%: GIP and TRR drops ~40%
  - Sw < 60%: GIP and TRR drops ~15%
  - Sw < 50%: GIP and TRR drops ~40%

Sensitivity Analyses –
Sensitivity of Rw Variability

- **When calculated with a constant Rw value;**
  - the GIP estimate was 11% less than the most likely case which utilized variable Rw.
- **If Rw is….**
  - Decreased by 50% from ML than GIP increases by 46%
  - Increased by 50% from ML than GIP decreases by only 2%
- **Increased Rw appears to have a minimal impact on the overall GIP value**



ML = Most Likely

Sensitivity Analyses – M and N

M = 2; N = 2

Possible Low

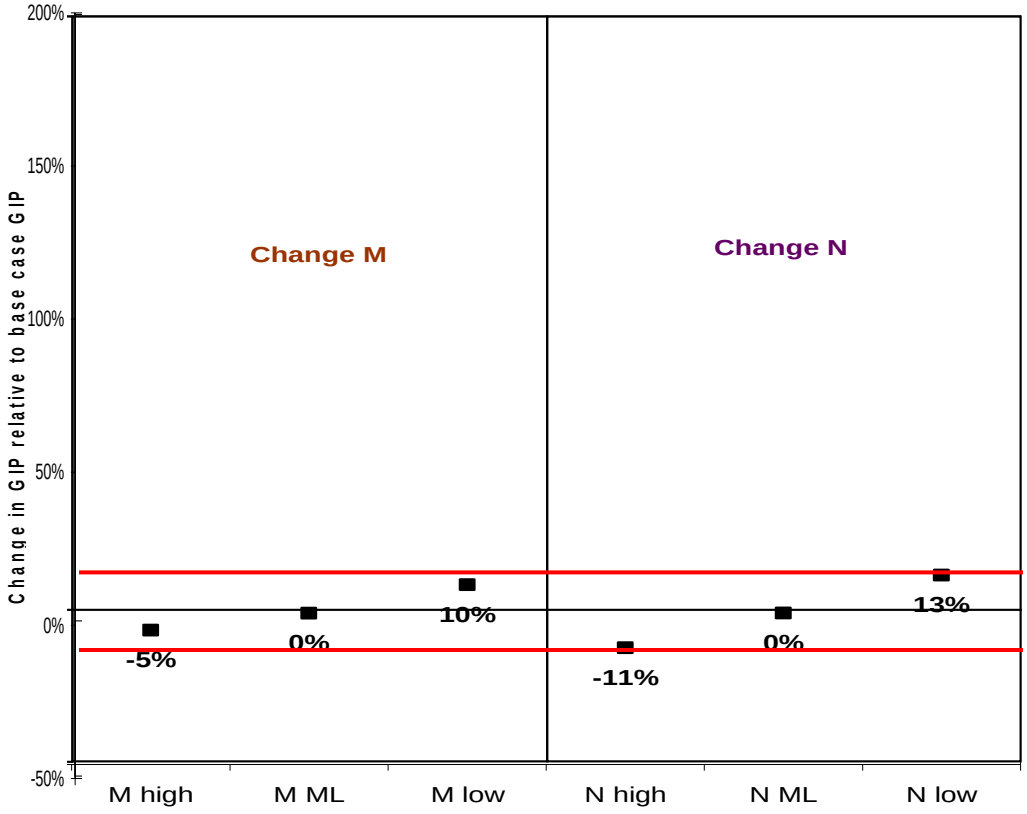
- **M = 1.66 (GIP + 10%)**
- **N = 1.48 (GIP + 13%)**

Possible High

- **M = 2.04 (GIP -5%)**
- **N = 2.22 (GIP -11%)**

Likely no more than 10% error in GIP due to M and N assumptions.

Likely no more than 20% error in GIP due to M, N and Rw



Sensitivity Analyses – Form of the Sw Equation

- **Simandoux Equations:**
  - Asquith and Krygowski, 2004
    - Adds 14% to the values
  - Crain (Petrophysical Handbook)
    - Adds 15% to the values
- **Therefore changing the form of the equation results in an increased resource value.**

Conclusions

- **Important to understand definitions and "nature" of resource numbers**
- **Assessments done by NETL are designed to facilitate DOE natural gas program planning and analysis purposes,**
  - they use a cell based approach for flexibility
  - and point-forward modeling in order to conduct "what-if" technology advancement scenarios
- **Our GIP numbers, appear to be conservative based on the initial sensitivity analyses and variables that contribute to the GIP calculation.**

Thanks To...

- **US DOE**
  - Jim Ammer, Brad Tomer, Joseph Wilder
- **EG&G Services**
  - Ashley Douds, Skip Pratt, Jim Pancake, Jim Dean
- **Advanced Resources International**
  - Randy Billingsley, Vello Kuuskraa, George Koperna, Greg Bank, Taylor Graham

For More Information…

www.netl.doe.gov/scngo

Information available on all of SCNGO's R&D projects, including deliverables such as data cd's, final project reports, analyses, etc…

Questions???