Characterizing Tight Gas Resources in Western Canada

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Let It *Flow*
Flow of Ideas, Hydrocarbons and Business

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Forward
ENERGY GROUP INC.

Western Canada Tight Gas Resource Characterization Project

Natural Resources Canada - GSC

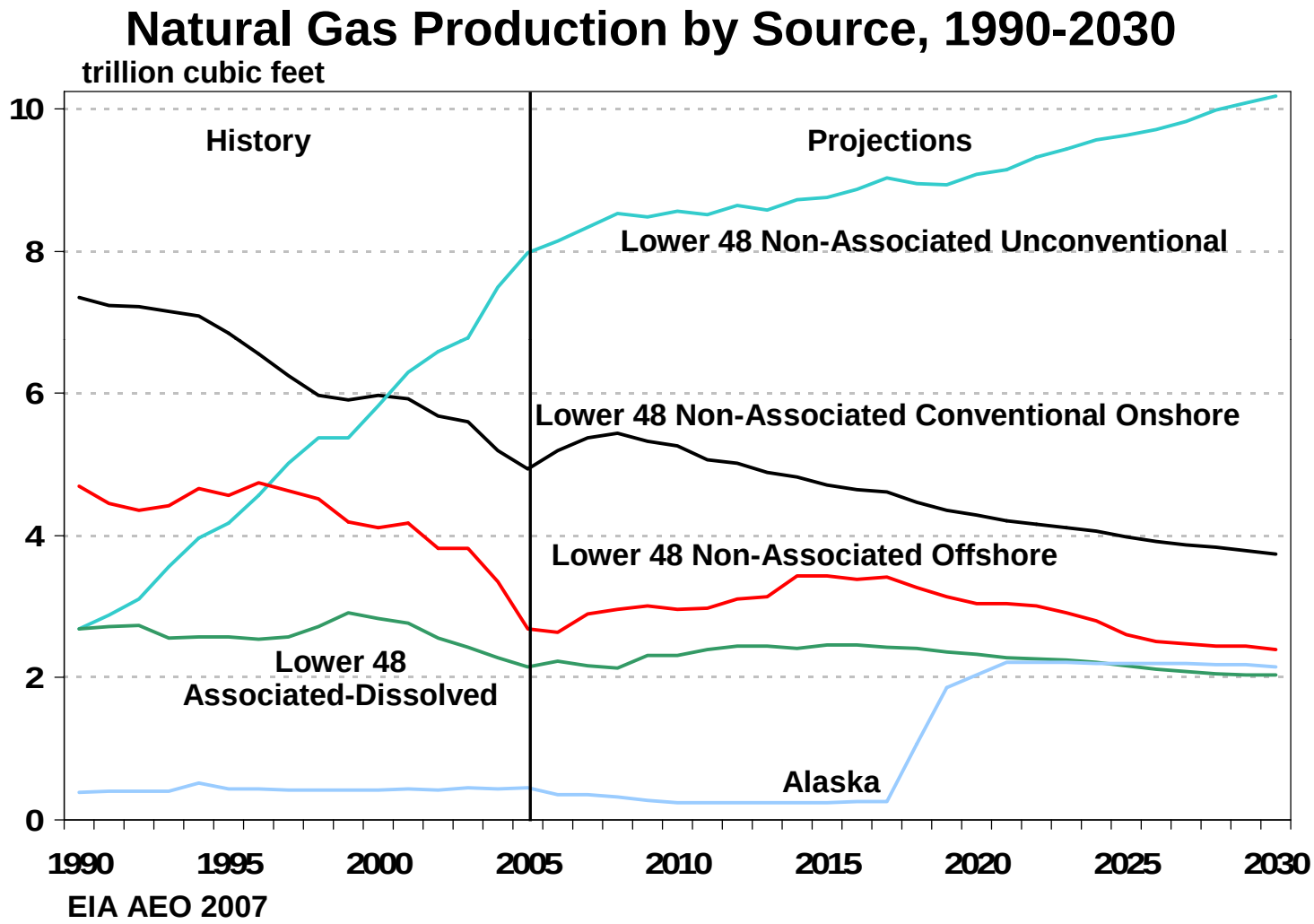
Devon Canada Corporation
Husky Oil Operations Ltd.
Imperial Oil Limited
Petrel Robertson Consulting Ltd.
Talisman Energy Inc.
TransCanada Pipelines Limited

NEB, CGPC, BCMEMPR, EUB, Sask IR, ARI, USGS, EIA

Outline

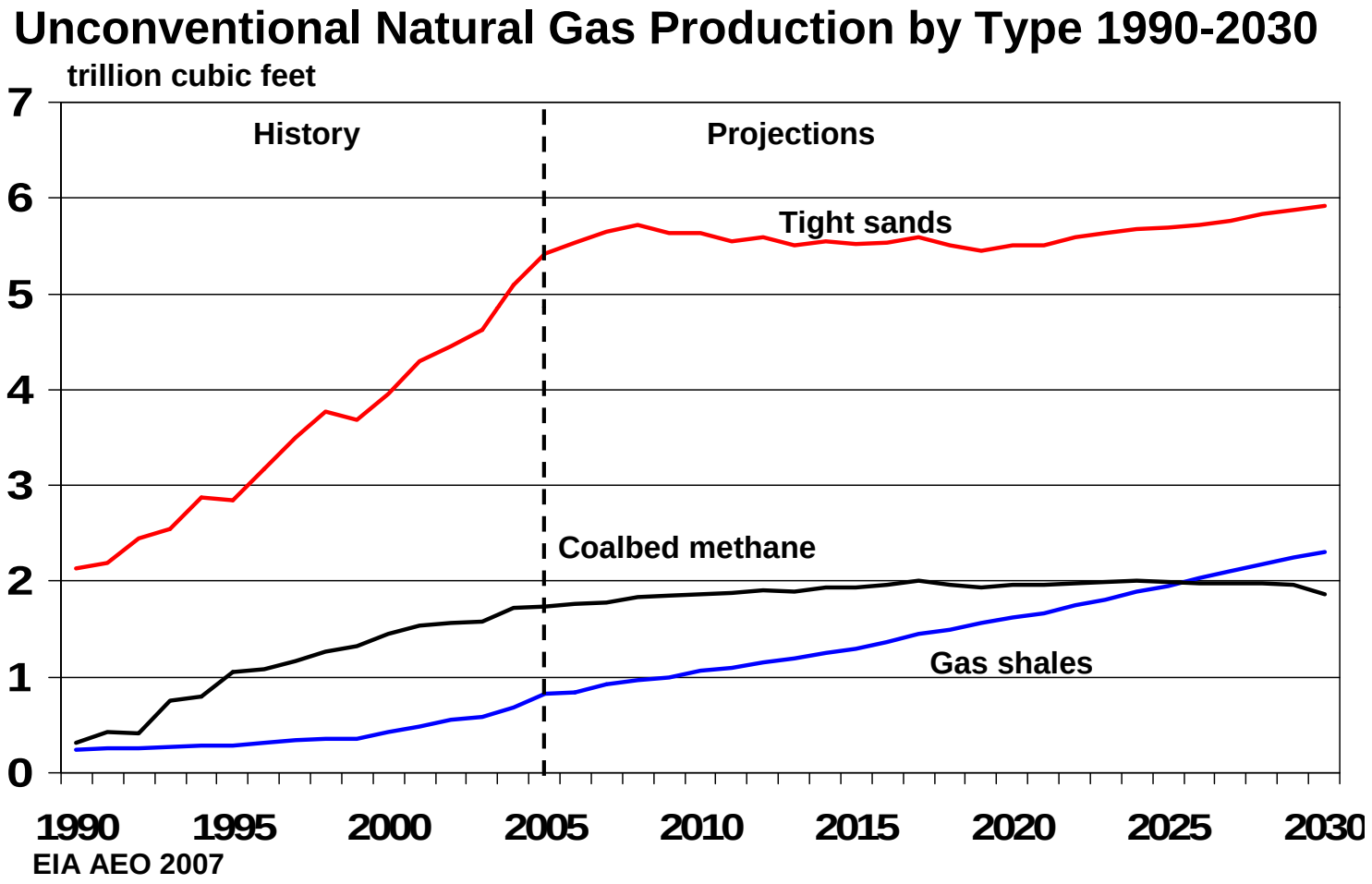
- Project introduction
- Tight gas definition
- Characterization by play
- Resource estimation
- Supply potential and technology

Unconventional gas is largest source in the US



Largest single source of supply since 2000

Tight formation gas is largest unconventional type



Largest single source of supply since 2005

Tight gas in Western Canada

Tight gas is an expression widely used by:

- Publicly-traded firms to describe plays and activity in financial disclosure
- Technical associations, professionals and academics
- Journalists in trade publications
- Government agencies (rarely)

According to these sources:

- Tight gas is developed and producing in Western Canada
- The undeveloped resource base is believed to be large
- Supply from tight gas will increase as industry learns to develop and apply appropriate technology

High expectations

Tight gas not reported in Canada

- Tight formation gas is not defined and distinguished from “conventional”
- Current tight gas production and size of future opportunity remain uncertain
- Geographic and stratigraphic distribution and reservoir characterization of tight gas plays not available in public reports
- Tight gas resource potential not included in CGPC, federal or provincial agency estimates
- Supply potential and opportunities to increase tight gas supply not founded on consistent definition, play characterization and resource estimates

GIP estimates up to 1500 Tcf in the early 1980s
Is the resource really there?

What's in a name?

CONVENTIONAL

1. Discrete gas pools in ocean of water
2. Only high quality reservoir accumulates gas in place
3. Discovery is uncertain, recovery is certain
4. Discovery process is efficient
5. R&D to increase success
6. Remaining resource, in small undiscovered pools, is small
7. Official view of WCSB remaining resources

"Glass is mostly empty"

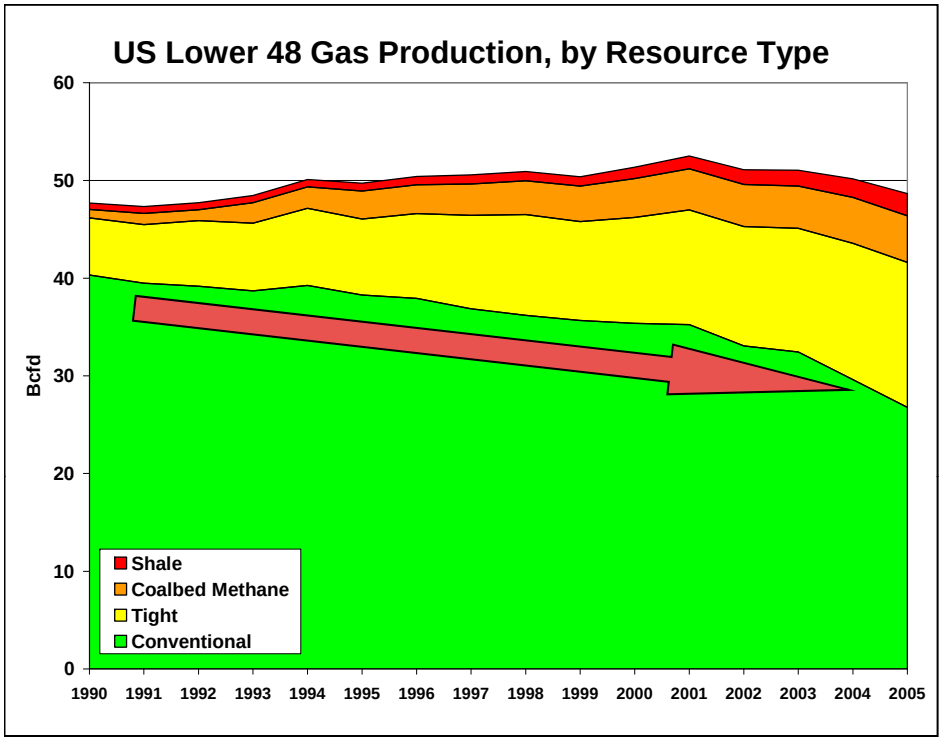
UNCONVENTIONAL

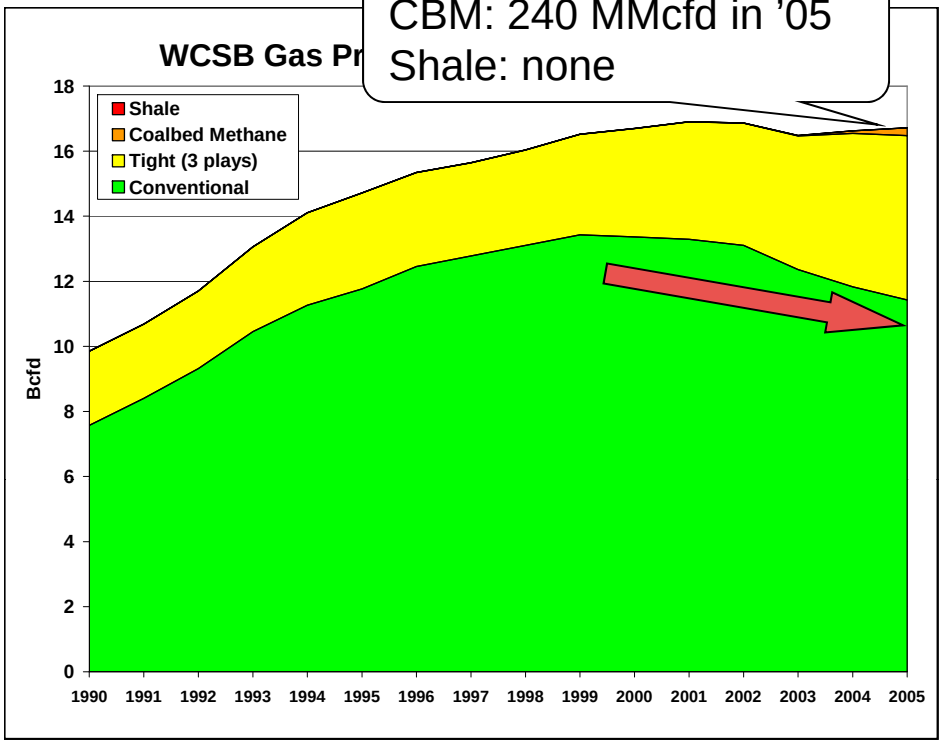
1. Pervasive gas saturated accumulations
2. Very large gas in place in reservoir of all qualities
3. Discovery is certain, recovery is uncertain
4. Recovery is inefficient but improves with technology
5. R&D to improve recovery and characterization
6. Remaining resource in lower quality reservoirs is large
7. US and industry view of WCSB remaining resources

"Glass is mostly full"

Models define how we evaluate potential

Gas Production Profiles





CBM: 240 MMcfd in '05
Shale: none

US Lower 48

- Conventional gas in decline
- Tight gas in lower 48 over 30% of 2005 total
- CBM and shale gas significant

Western Canada

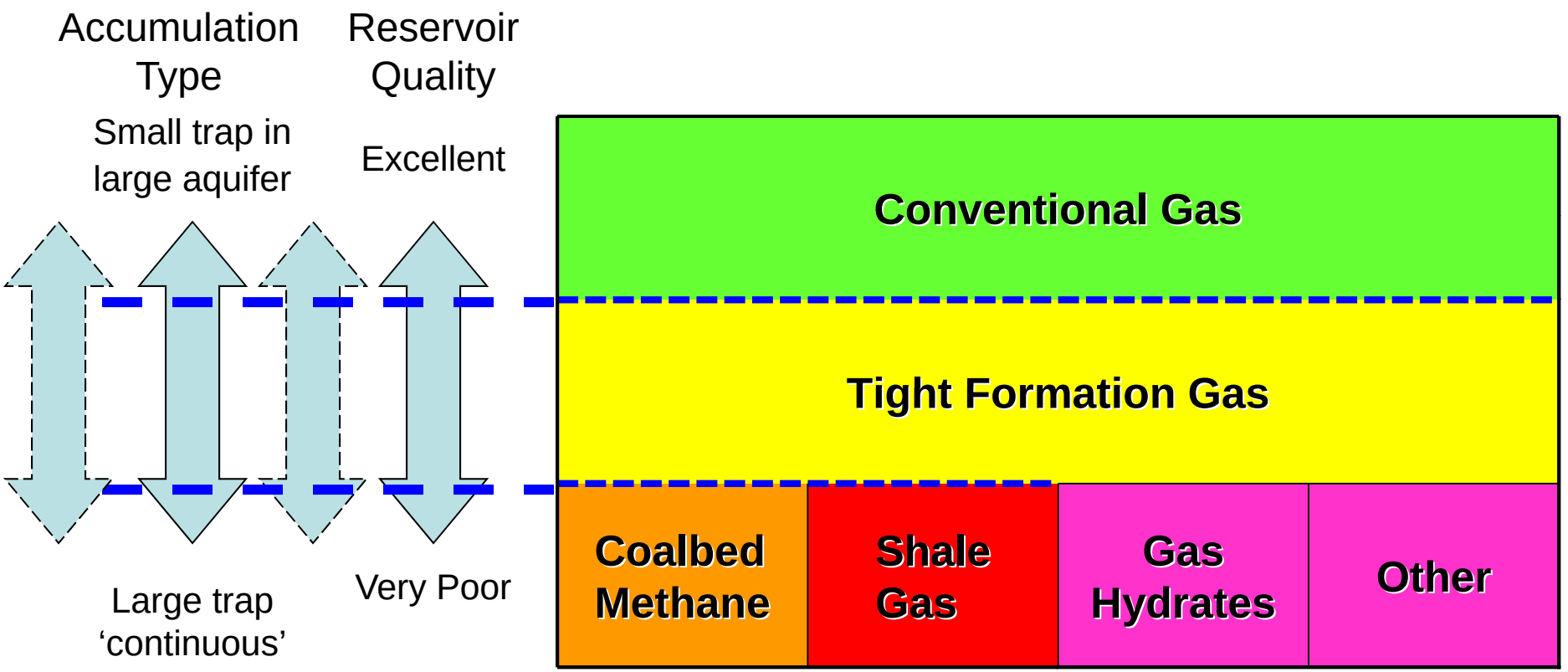
- CBM growing rapidly
- Tight gas not reported
  - estimate over 30% of 2005 total
- Conventional gas in decline

Better understanding of tight gas is important

Project Objectives

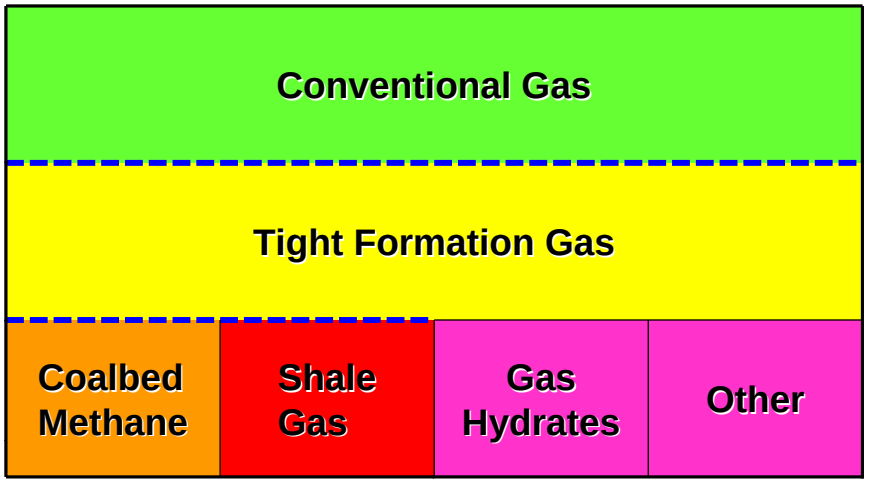
1. Communicate clearly the tight gas opportunity by establishing a **workable definition** for tight gas accepted by stakeholders
2. **Characterize** the tight gas opportunities into play types and analyze their supply trends
3. **Estimate** remaining tight gas resource potential and model its future conversion into supply.
4. Summarize resource and **supply potential** and **identify technology** and opportunities to maximize development of tight gas in Western Canada.

Gas Resource definition issues



What are the dimensions?
What are the limits?

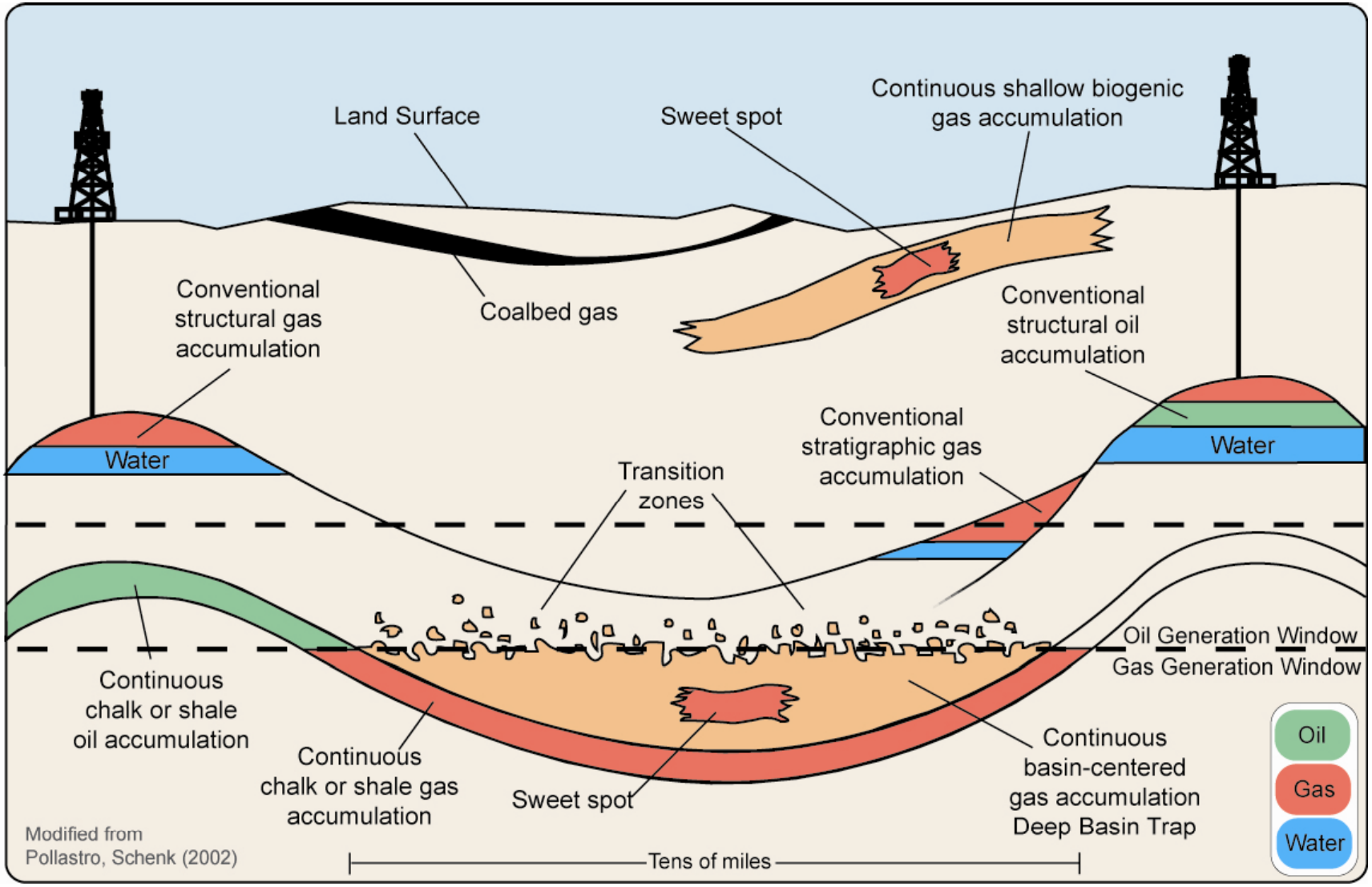
Tight Gas Resource Definition Criteria



- ✓ Continuous accumulation
- ✓ Free gas produced by gas expansion
- ✓ Clastic and carbonate reservoirs
- ☒ Reservoir quality continuum
- ☒ Technology application
- ☒ Economics

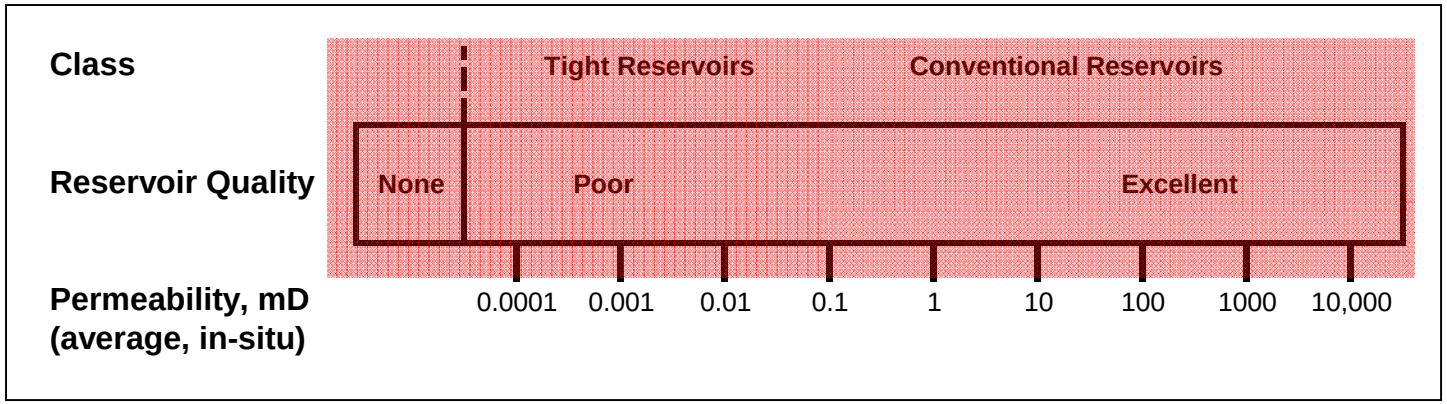
Workable

Gas Accumulation Types



Low K reservoirs contain GIP only in Continuous

Reservoir quality: The 0.1 mD Myth



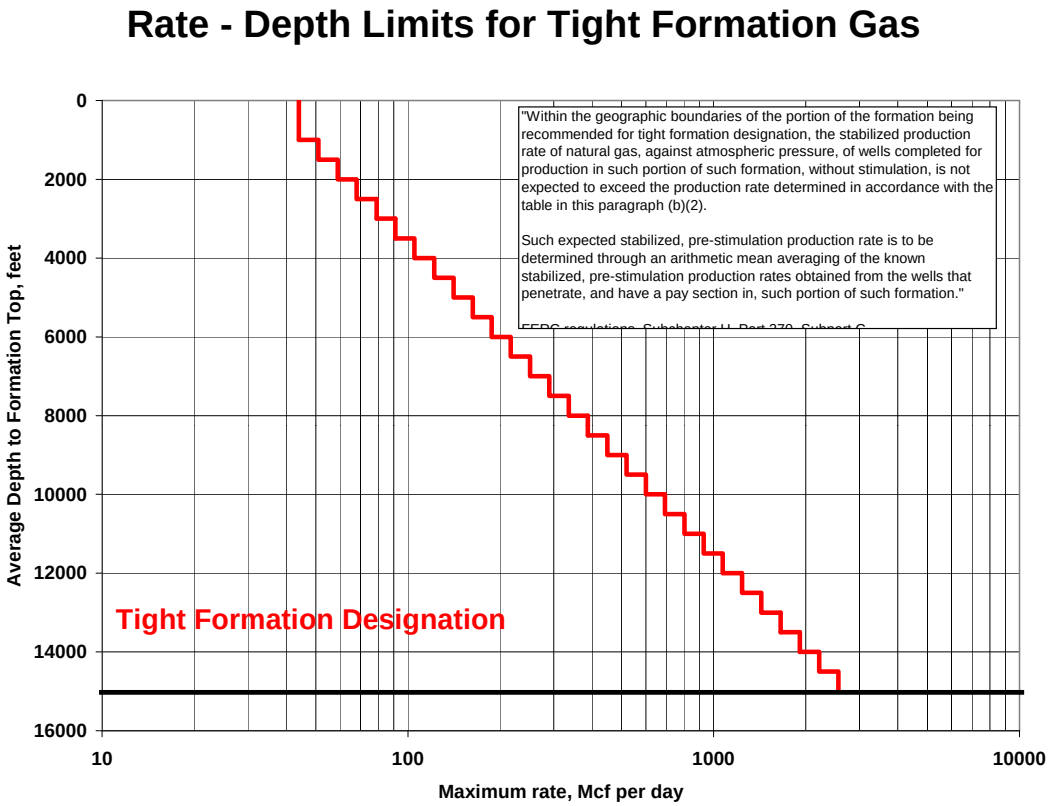
Tight Formation Designation

- US tax credit program for wells drilled 1977 to 1992
- Area-average in-situ formation permeability < 0.1 mD
- Historical tight gas designation generalized to basin-formation and field-formation – includes areas previously excluded
- New plays included based on USGS continuous accumulation criteria – not screened by permeability criteria

- In-situ permeability is difficult to measure and average
- Average permeability is only one of several factors that determine flow rate, ultimate recovery and economics

US tight gas plays include all reservoir qualities

Reservoir quality: The 0.1 mD Myth



- Rate-depth limits classified formations with low productivity for their depth as tight formation gas
- Shallow biogenic gas

US tight gas plays include all reservoir qualities

Definition Workshop Outcomes

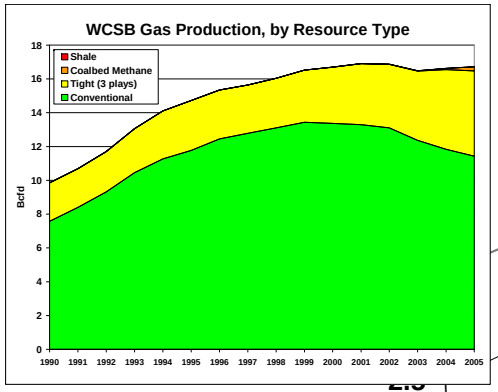
Definition: All gas resources occurring as free gas in the pores of clastic and carbonate reservoirs in regionally-pervasive continuous gas accumulations will be defined as tight gas resources. ***Adopted working definition.***

Characterize the resource potential of **the complete spectrum of reservoir qualities** within these gas accumulations

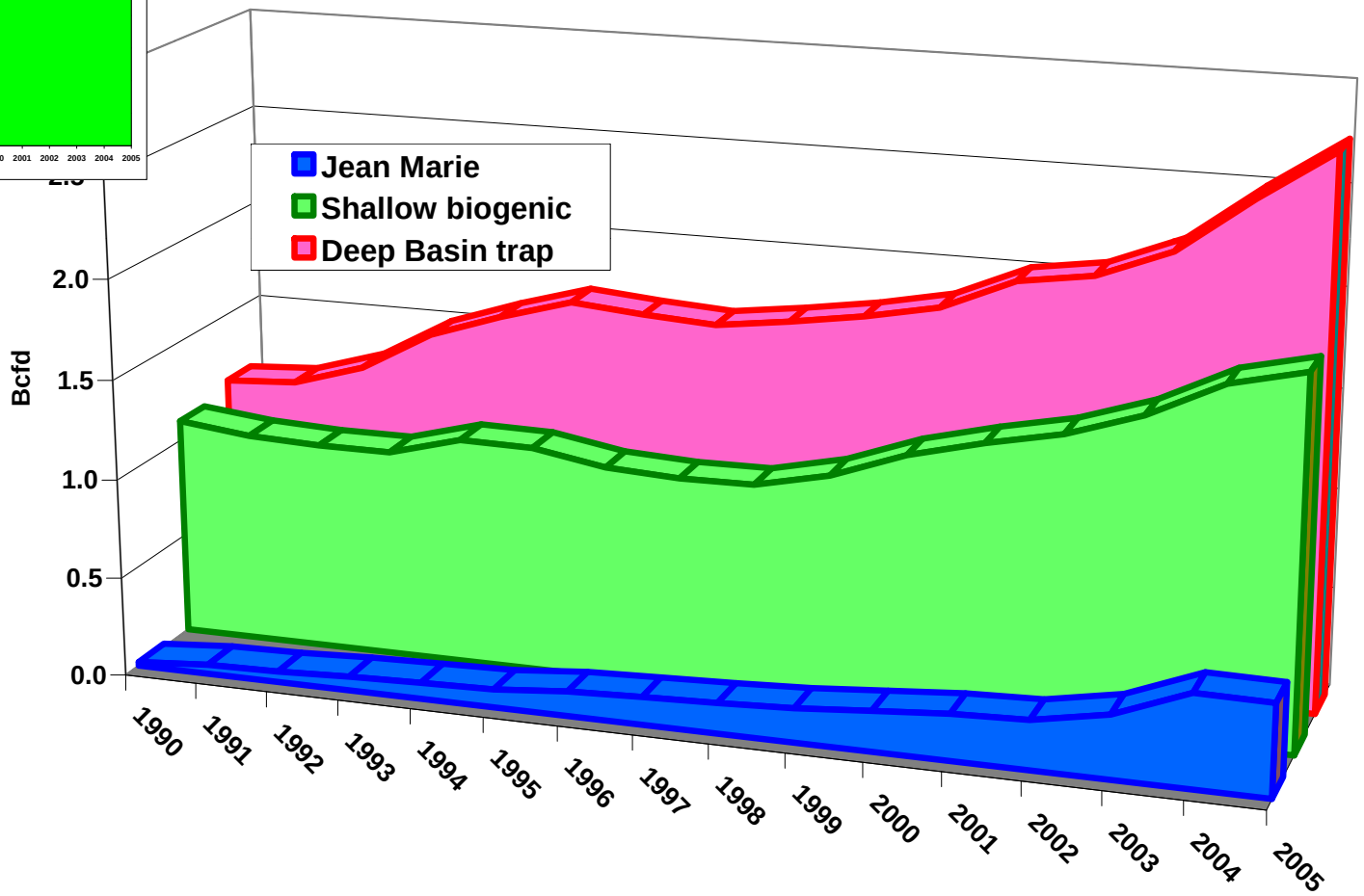
Regionally-pervasive gas accumulations be classified as tight gas areas and reviewed in the following priority:

- Deep Basin trap ***Primary characterization focus***
    - Shallow biogenic gas ***Low priority***
    - Jean Marie Fm, B.C. ***Low priority***
    - Additional accumulations ***Low priority***

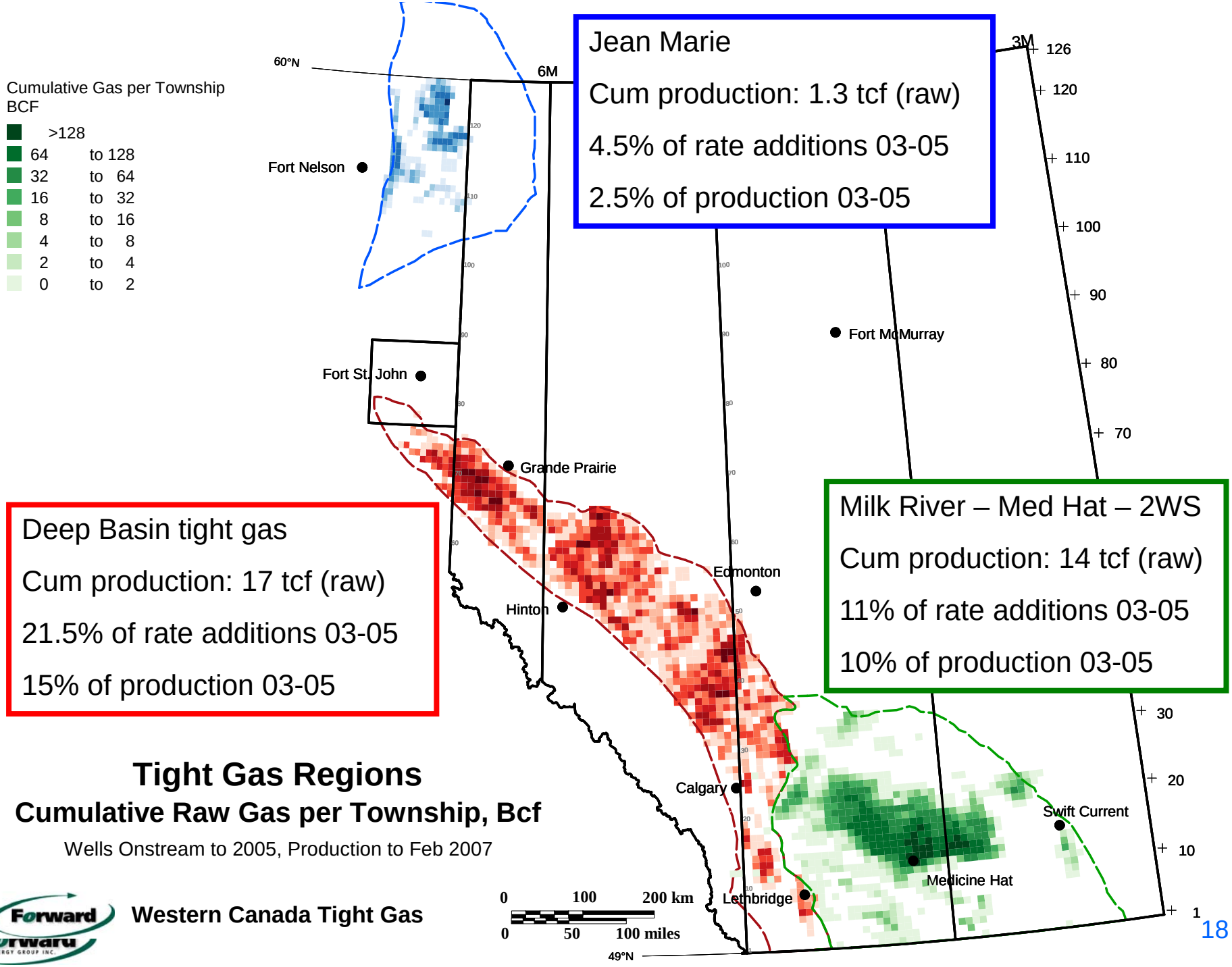
Plays and Characterization



Production by Tight Gas Region



Three major tight gas regions – all on growth trends



Tight Gas Regions

Cumulative Raw Gas per Township, Bcf

Wells Onstream to 2005, Production to Feb 2007

Western Canada Tight Gas

Deep Basin Play Definitions

Geologic Age	Strat Interval	Deep Basin Play, this study	CGPC Play	Undiscovered Mktb Potential, Bcf
Tertiary & Upper Cretaceous		**Younger**	Various	
	Cardium	**Cardium Gas**	B065P Cardium, *includes oil*	1,237
	Dunvegan	**Dunvegan Gas**	B083P Dunvegan, *includes oil*	2,623
Lower Cretaceous	Viking interval	**Cadotte & Viking Gas**	C113R Paddy/Cadotte and Viking Deep Basin	1,865
		Viking Oil		
		Bow Island		
	Upper Mannville	**Spirit River**	C133R Spirit River and Upper Mannville Deep Basin	4,998
		Upper Mannville South		
		Bluesky & Glauconitic	C143R Bluesky Deep Basin	853
	Lower Mannville	**Gething**	C163R Gething Deep Basin	6,274
		Ellerslie		
		Lower Mannville South		
		Cadomin	C173R Cadomin/Nikanassin Deep Basin	2,790
Jurassic	Nikanassin	**Nikanassin**		
	various	**Multiplay**	Included in all of above plays	
Triassic+	various	**Older**	Various	

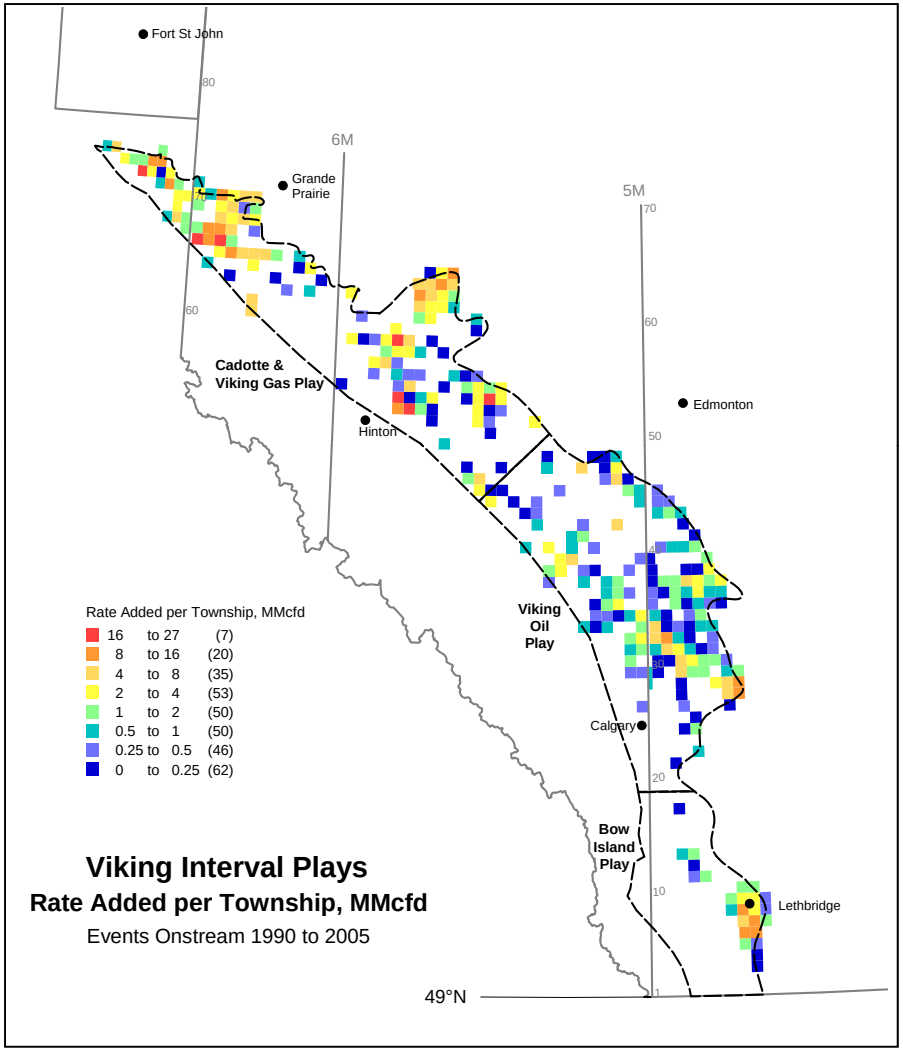
Play Definition Process

- CGPC Lower Cretaceous resource plays
  - Anomalous pressure area generalized by CGPC from Rakhit to classify pools
- Cardium and Dunvegan where commingled with L. Cret
- Adjust boundaries and subdivide, considering
  - Alternative Deep Basin definitions
  - Distribution of gas, oil and water production
  - Stratigraphic nomenclature and mappability
  - Alignment with EUB and BCMEMPR play boundaries
  - Eastern limit of significant faulting in Lower Cretaceous
- Sources
  - Petrel Robertson tight gas report, Deep Basin memoir, published papers
  - Oil and gas pool data (g/w contacts, pressure - elev)
  - Maps of reservoirs and seals controlling fluids

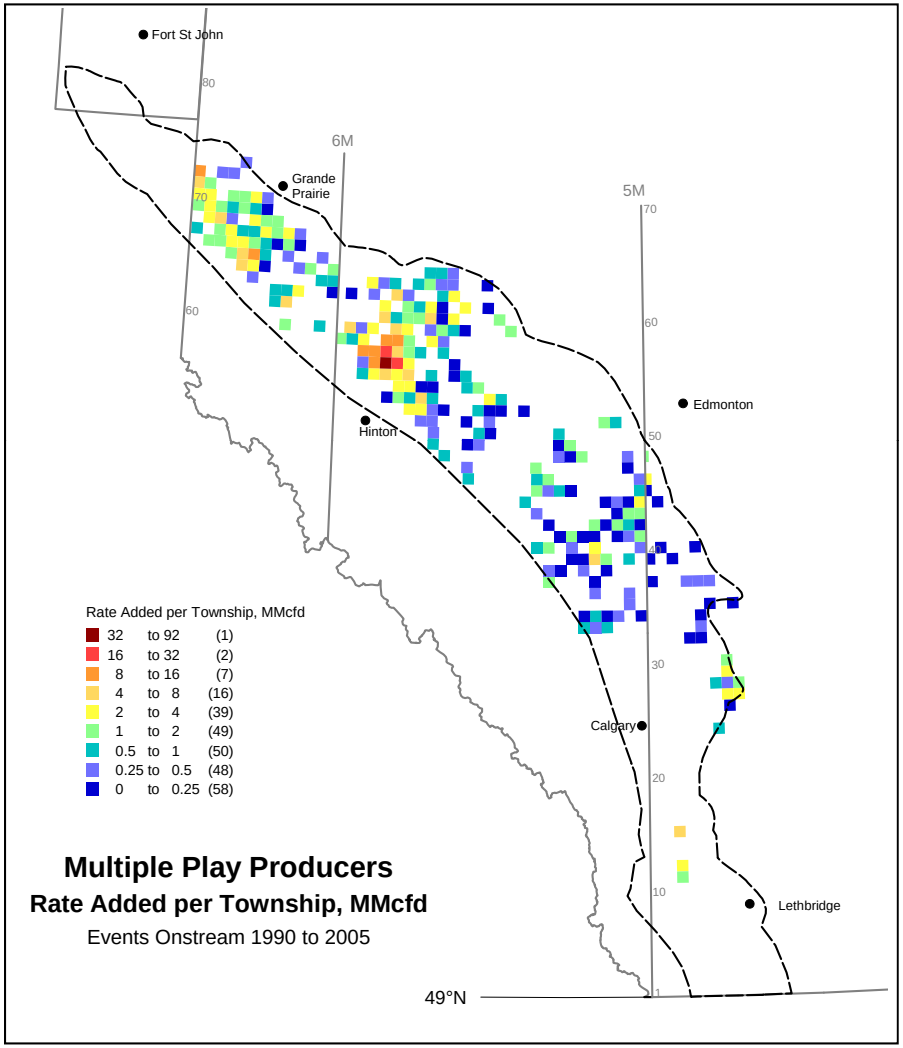
Play Definition Issues

- Some areas of the CGPC resource plays are not pervasively gas charged
  - Viking Oil, Upper Mannville South and Ellerslie plays have a higher probability of oil and water
  - Characterization for gaswells
  - Estimate resources for non-associated gas
- Multiplay producers
  - Increasing commingling with regulatory changes
  - Commingled production from zones in different plays
  - Dominant producing play cannot be identified
  - Multizone pools and metering units (MUs)
  - Wild River + Wapiti + Cecilia + Elmworth > 185 MMcfd
- Commingling zones affects play characterization

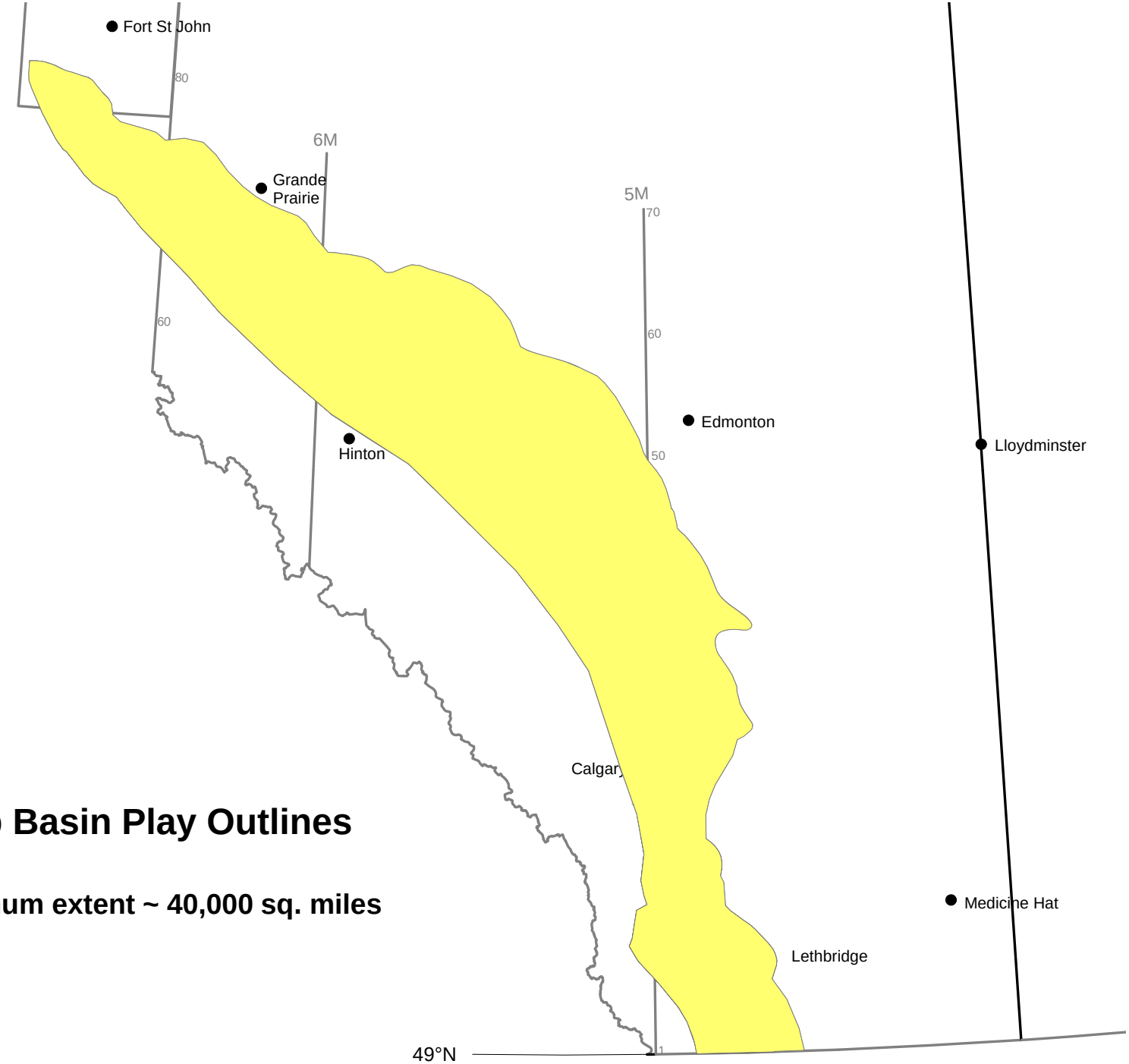
Play Definition and Boundaries



Edges compiled from multiple sources



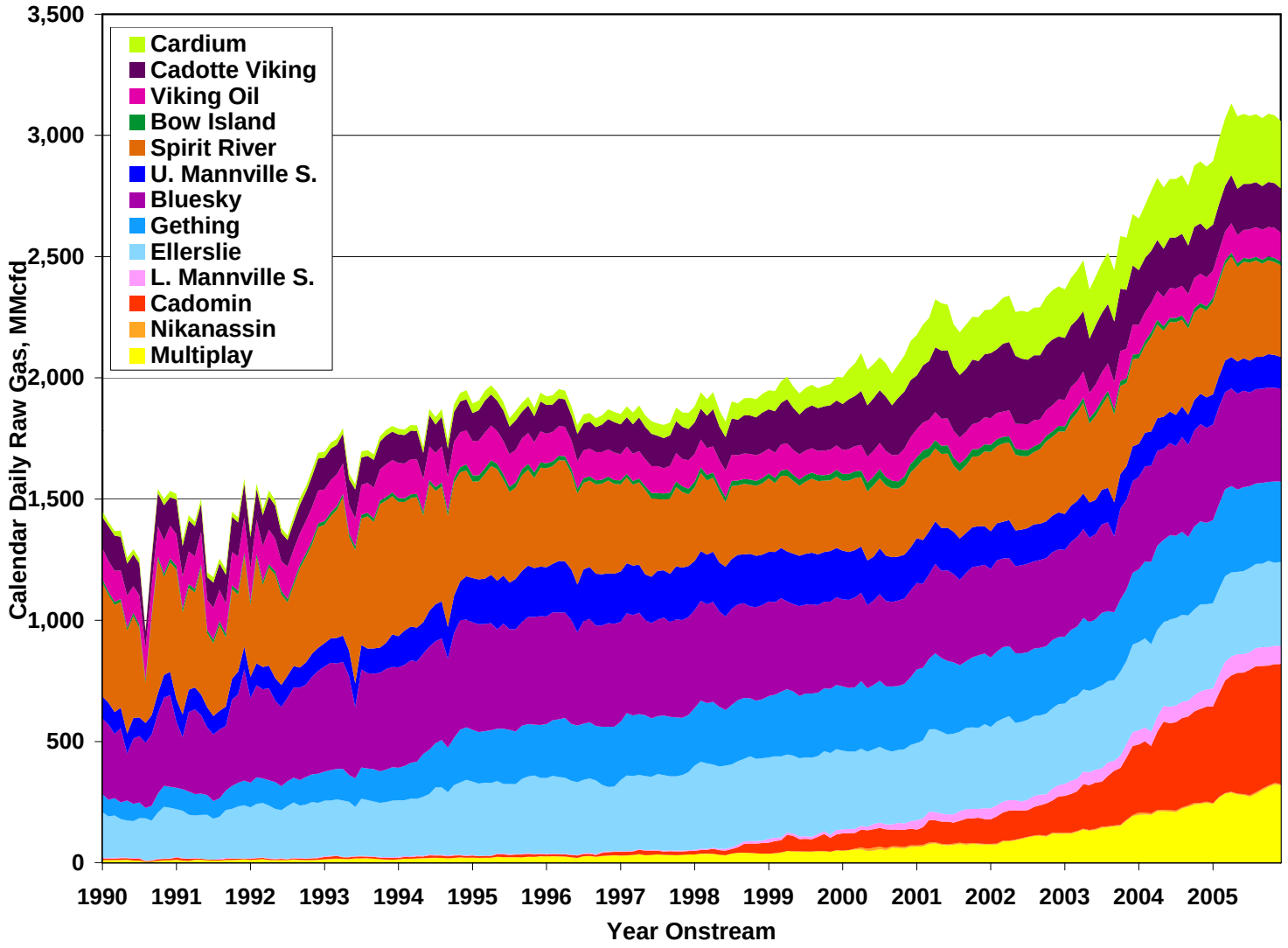
Commingled producers analyzed by well, not play



Deep Basin Play Outlines

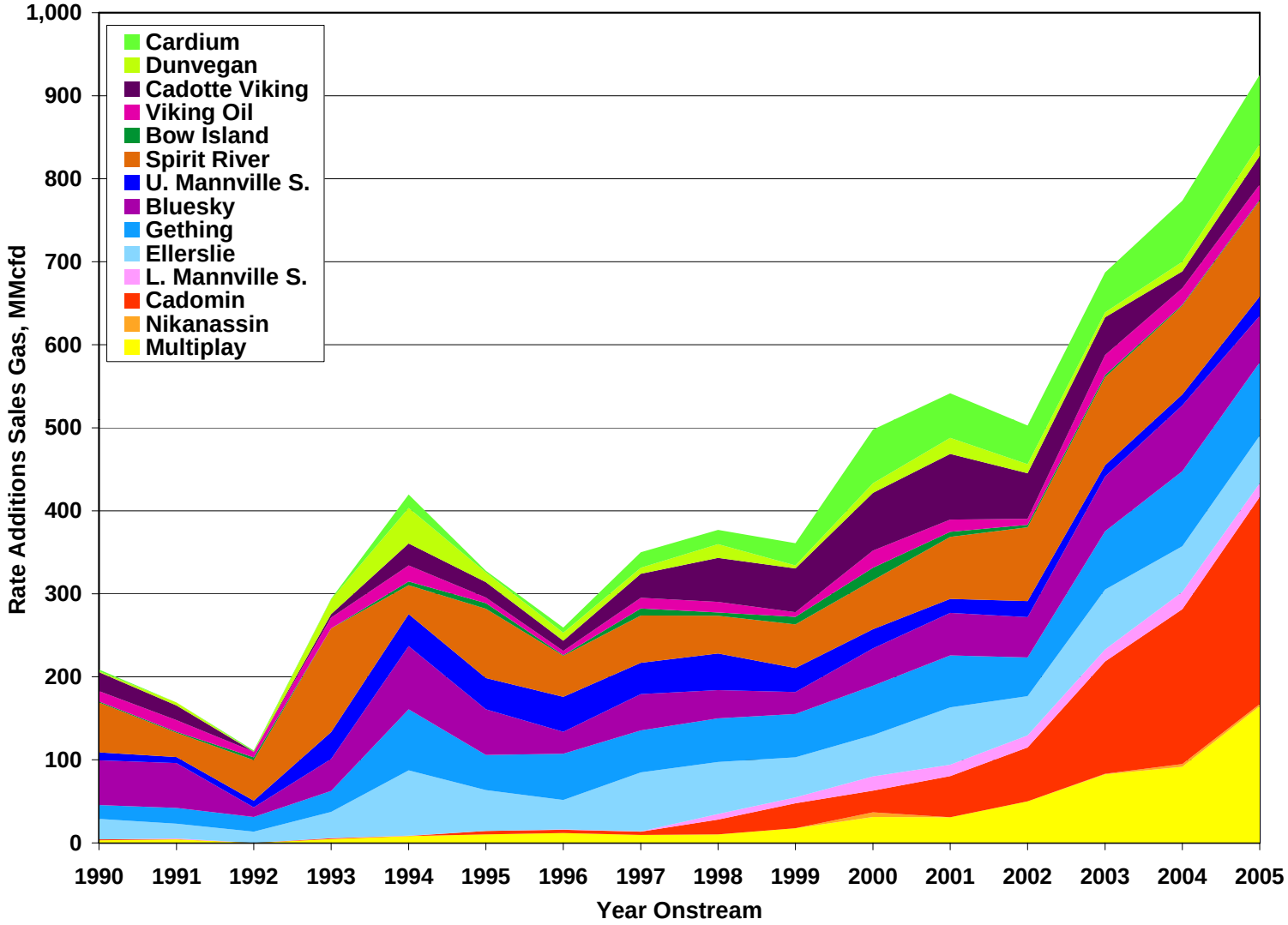
Maximum extent ~ 40,000 sq. miles

Raw Gas Production by Play



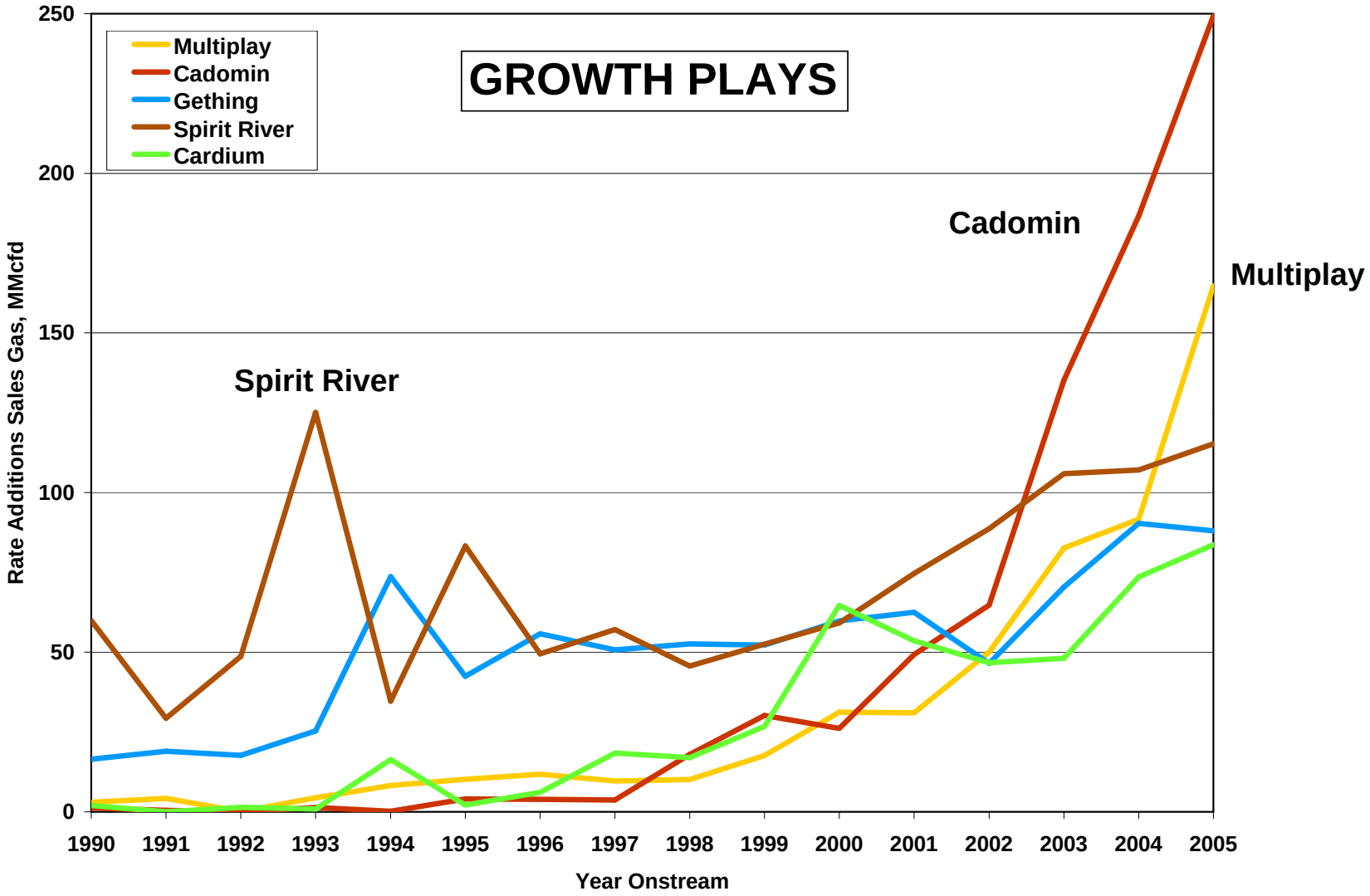
Deep Basin production growing to over 15% of WCSB

Rate Additions by Deep Basin Play



Deep Basin plays growing source since 2002

Rate Additions by Deep Basin Play



Growth plays in recent years

Deep Basin Play Production Summary

Producing Play	Gas Events On-stream 1990 to 2005	Rate added, MMcfd	Extrapolated Recovery, Bcf	Single zone wells 1990 to 2005	Average Rate added per well, Mcfd	Average Extrapolated recovery per well, Bcf	Average Feet Drilled	Average Decline Rate, % per year
Cardium Gas	867	461	809	775	559	0.980	8,160	20.8%
Dunvegan Gas	193	187	446	161	930	2.250	7,520	15.3%
Cadotte & Viking Gas	609	541	870	405	977	1.620	7,983	22.7%
Viking Oil	668	213	367	473	331	0.610	5,901	21.1%
Bow Island	274	69	108	160	243	0.410	4,001	23.2%
Spirit River	892	1,137	1,580	557	1406	2.100	8,004	26.3%
Upper Mannville S.	486	397	659	321	929	1.650	6,725	22.0%
Bluesky & Glauconitic	1,077	765	1,712	821	737	1.710	7,551	16.3%
Gething	1,143	824	1,428	880	741	1.360	7,985	21.0%
Ellerslie	1,216	783	1,303	888	700	1.180	7,584	21.9%
Lower Mannville S.	204	113	211	179	572	1.070	8,129	19.6%
Cadomin	868	774	888	692	938	1.020	9,652	31.8%
Nikanassin	19	12	19	10	683	0.730	11,006	23.4%
Multiplay	969	530	730	517	627	0.870	8,895	26.5%
Total	9,485	6,806	11,129	6839	763	1.292	7,840	22.3%

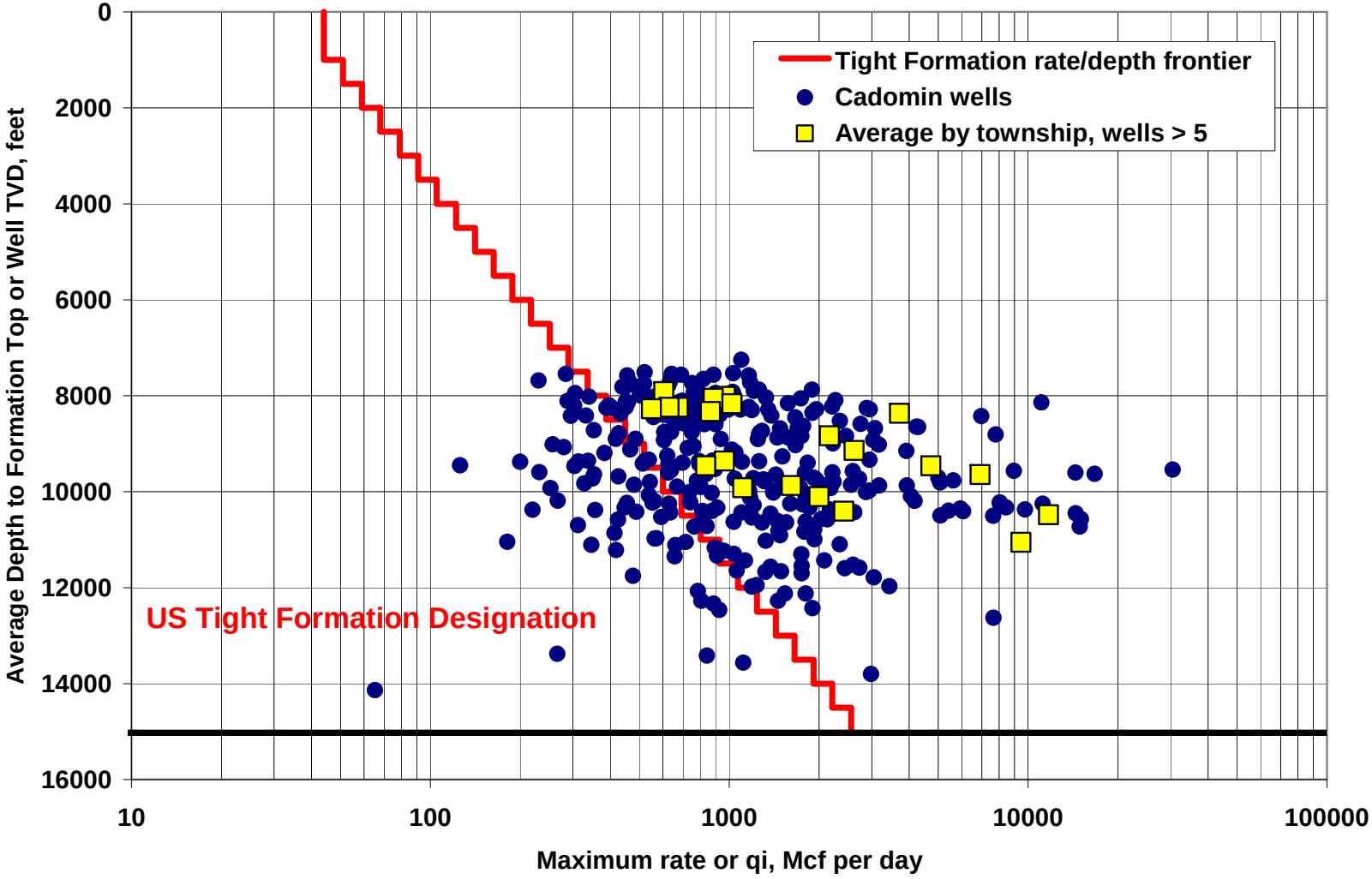
Rate added and extrapolated recovery are net after surface loss.

Deep Basin plays added >14% of new supply 1990-2005

Cadomin Single Zone Wells

q_i vs well TVD where analysis type is decline

Rate - Depth Limits for US Tight Formation Gas



Evaluating use to distinguish "tight" gas

Resource Estimation Methods

- Discovery process / Arps-Roberts / TPDM / Petrimes
  - Discrete pools in play where discovery history exists
  - Where are the pool boundaries in a continuous gas accumulation?
  - Could method be applied with appropriate framing?

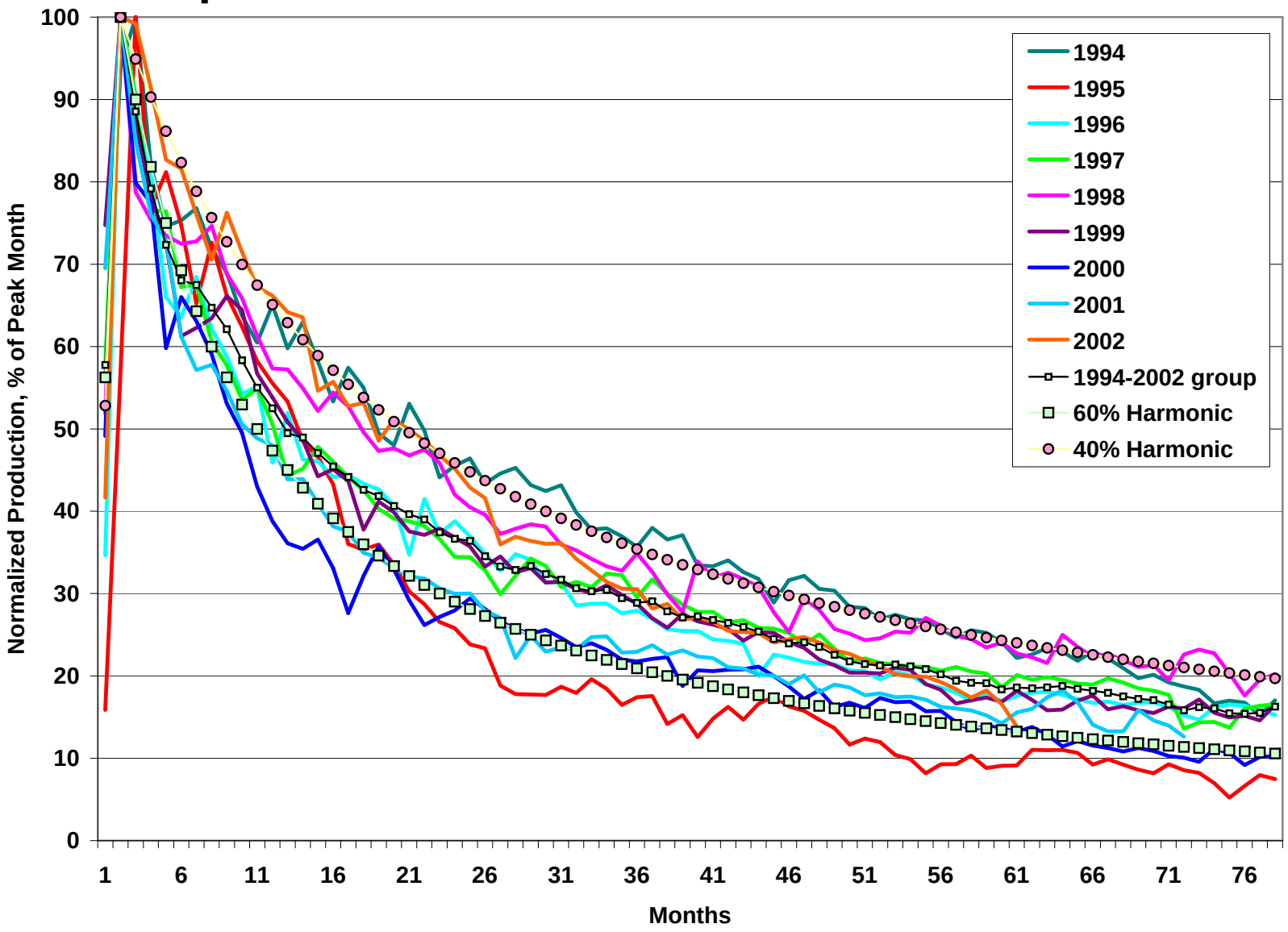
- GIP volumetric from petrophysics and mapping
  - Subsurface basin study from logs, measuring and mapping structure, isopach, gross and net sand, porosity, saturations, pressure, permeability
  - Output is interpreted subsurface grid models of GIP for further technology and economic modeling
  - Data generation beyond scope of current project

- Cellular methods
  - Extrapolate resources from drilled and evaluated cells (tracts) to undrilled cells based on well recovery, success rate, etc.

Applying cellular method similar to USGS & ARI

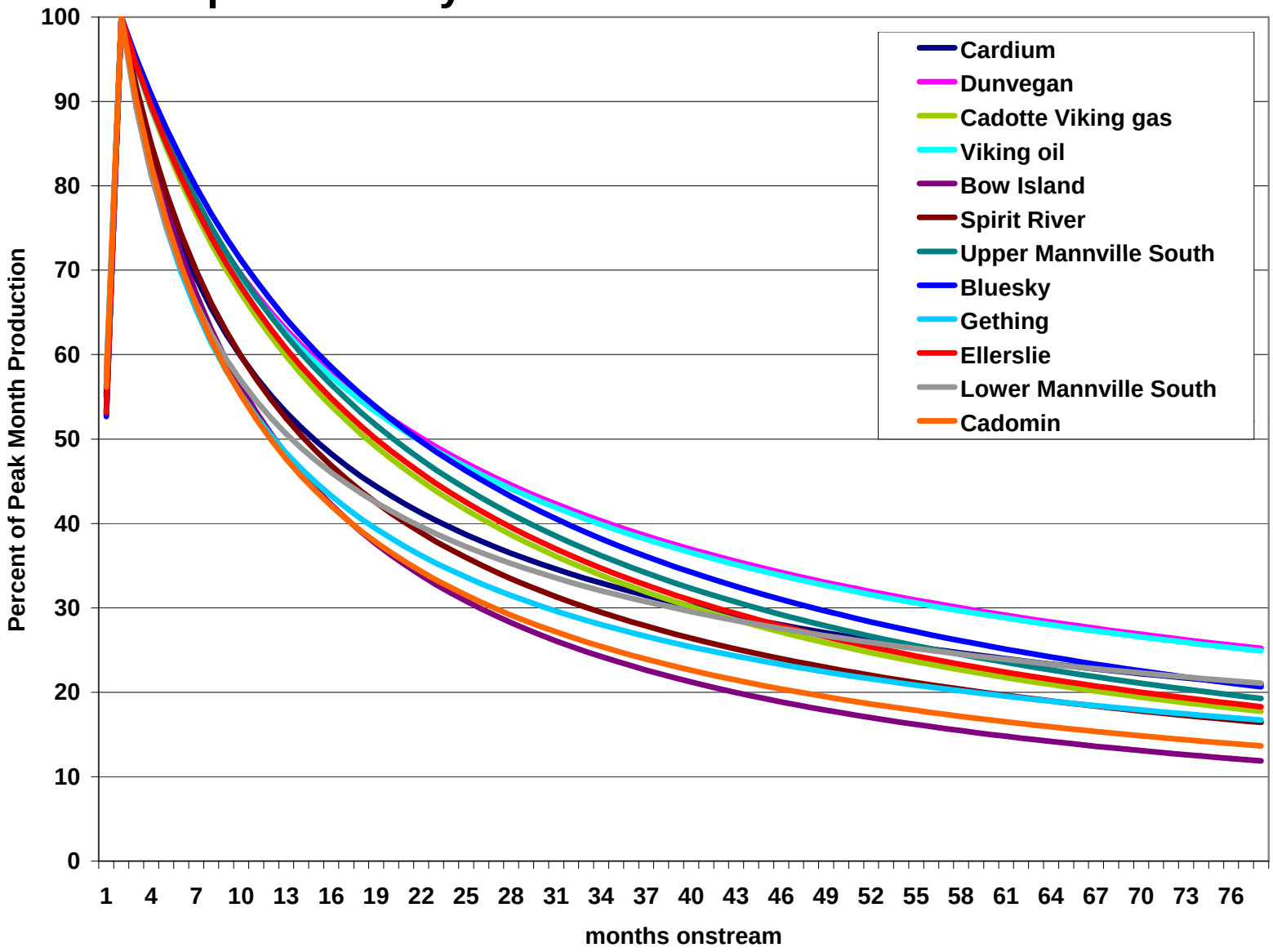
Recoverable resources = area * EUR/well * success rate

Sprit River Normalized Production Profiles



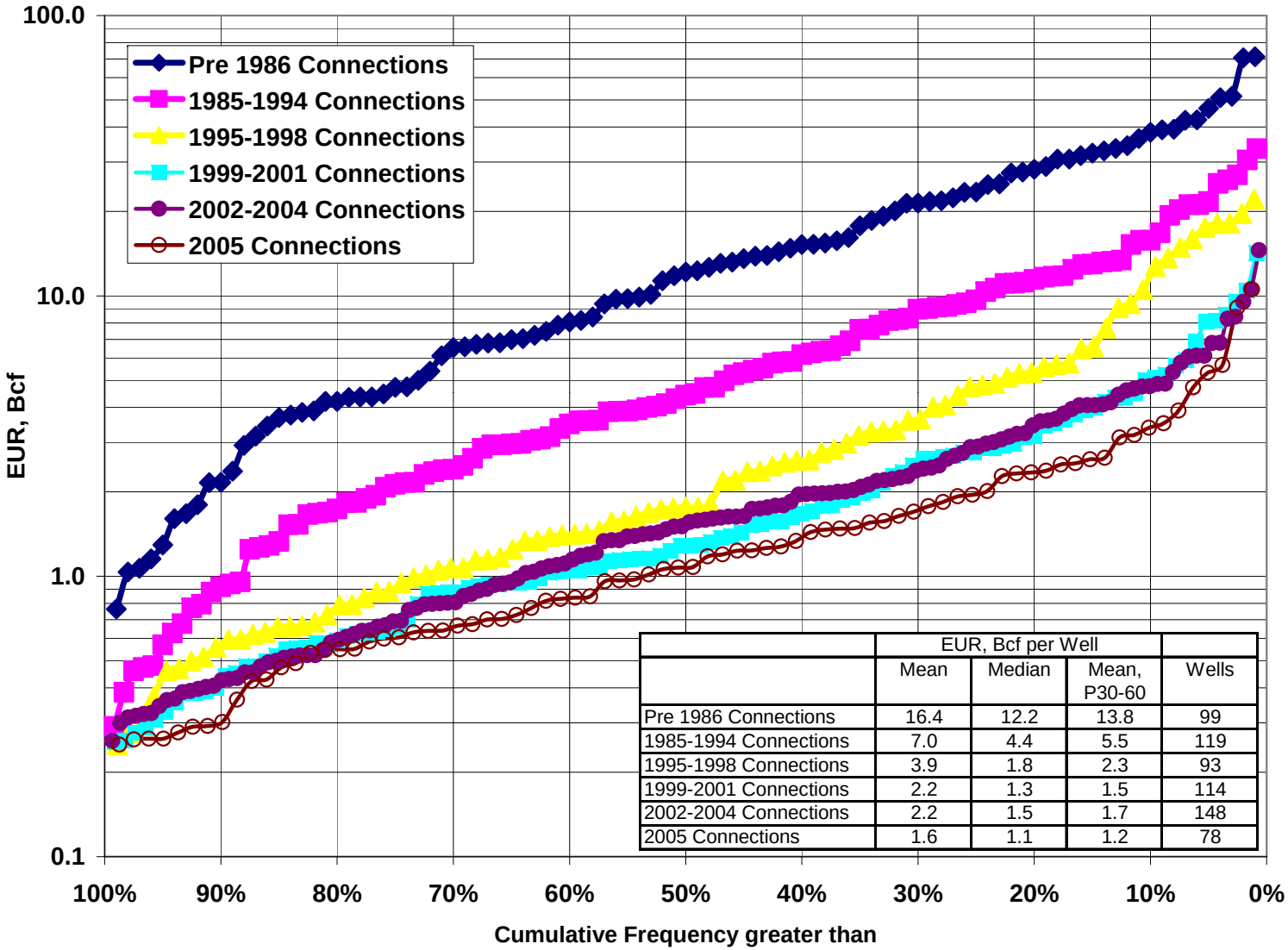
Aggregate production profiles for characterization

Deep Basin Plays - Normalized Production Profiles



Model production profiles for EUR extrapolation by play

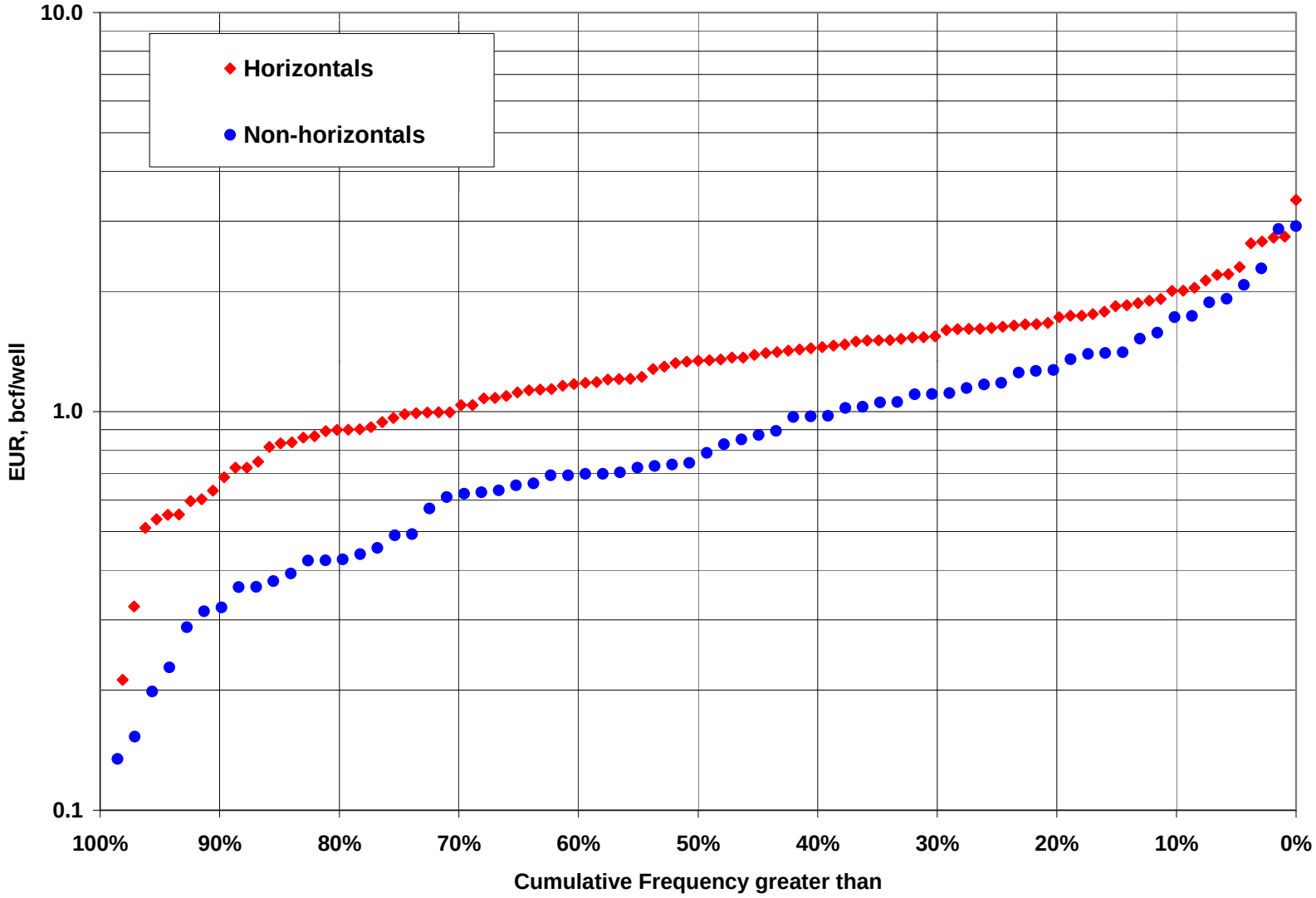
Cumulative Frequency of Well EUR by Connection Period
Spirit River Play wells only with 0.25 Bcf EUR cutoff



	EUR, Bcf per Well			
	Mean	Median	Mean, P30-60	Wells
Pre 1986 Connections	16.4	12.2	13.8	99
1985-1994 Connections	7.0	4.4	5.5	119
1995-1998 Connections	3.9	1.8	2.3	93
1999-2001 Connections	2.2	1.3	1.5	114
2002-2004 Connections	2.2	1.5	1.7	148
2005 Connections	1.6	1.1	1.2	78

EUR per well trends for resource estimation

Cumulative frequency of Well EUR by Well Type
Cadomin Play wells only in the Cutbank-Sinclair area



Horizontals improving EUR per well, accelerating rate

Supply Potential and Technology

- Supply evaluation at well level, not individual play
  - Commingling is norm for future
- Opportunities and challenges to tight gas
  - Economic
  - Fiscal terms
  - Regulatory
- Technology to reduce risk and increase output
  - Sweet spot detection
  - Permeability measurement
  - Drainage optimization
  - Drilling cost reduction
- Innovation will increase recovery - examples

Conclusions

- Regionally pervasive gas accumulations host tight gas resources, regardless of the reservoir quality
  - The 0.1 mD cutoff is a myth
- Production from tight gas areas comprises over 30% of current WCSB production
- Tight gas production is growing while production from conventional sources decline
- Deep Basin trap remains the largest current source of tight gas in the WCSB
- Single play characteristics must be integrated to evaluate supply from commingled stacked plays
- GIP resource estimates by play will be needed.
- Targeted public research on tight gas is needed.

Impact on supply will be evolution, not revolution

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