Two Medicine Cut Bank Sand Unit (TMCBSU)

Phase 3: Geological Mapping

Arkanova Energy Corporation

Operator: Provident Energy Associates of Montana, LLC

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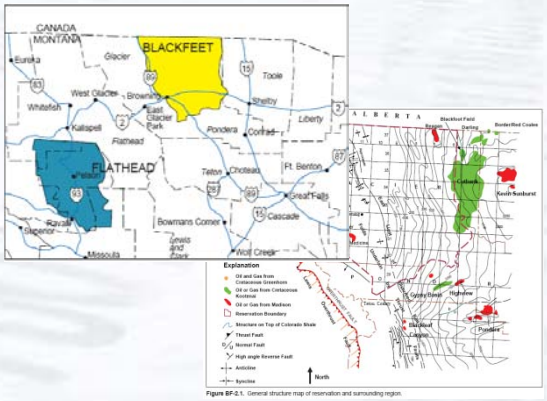
G&G Team, DCS NGC

March 2, 2010

Overview

- TMCBSU Phase 3 – Geological Mapping
  - Review
- Discussion
  - Next Steps



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Phase 3: Geological Mapping

- Objective
  - Update 1972 TMCBSU field maps
  - Reliable structure, isopach and pay maps for well planning
  - Geological model in Petrel for reservoir characterization and field development planning

- Approach
  - Acquire and digitize logs from available wells with raster logs (278) in the TMCBSU and immediate offset wells
  - Construct geological model for TMCBSU field project
  - Correlate and Map Upper and Lower Cut Bank Sand units

Regional Geology

**Reference: BLM Report 1996*

- Lower Cretaceous Sandstone Play in NW Montana
- Monocline situated on the west side of the Sweetgrass Arch
- Cut Bank, largest oilfield, discovered in 1920's
- Lower Cretaceous continental fluvial deposition, sediment transport from west to East and NE
- Cut Bank Fm. has two main sand intervals, productive from Lower oil bearing sand

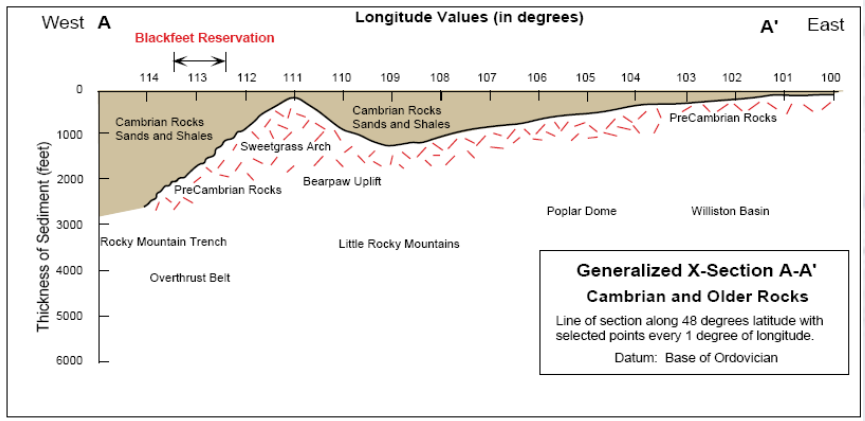


Figure BF-4.1. Generalized time slice cross-section of Cambrian paleo-topography along line of section A-A".

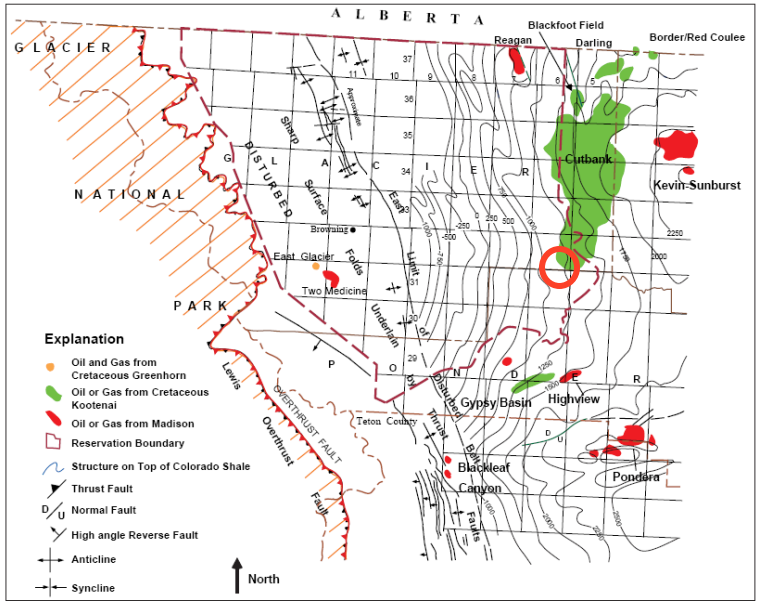
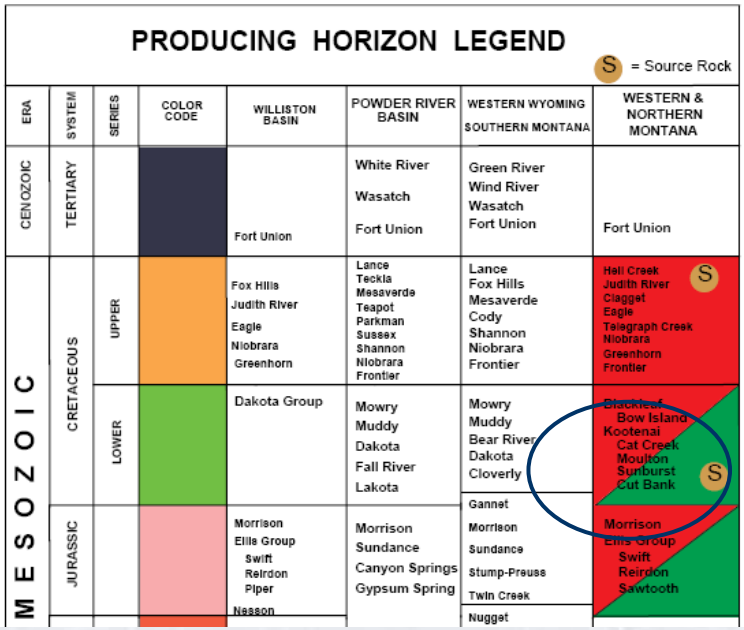
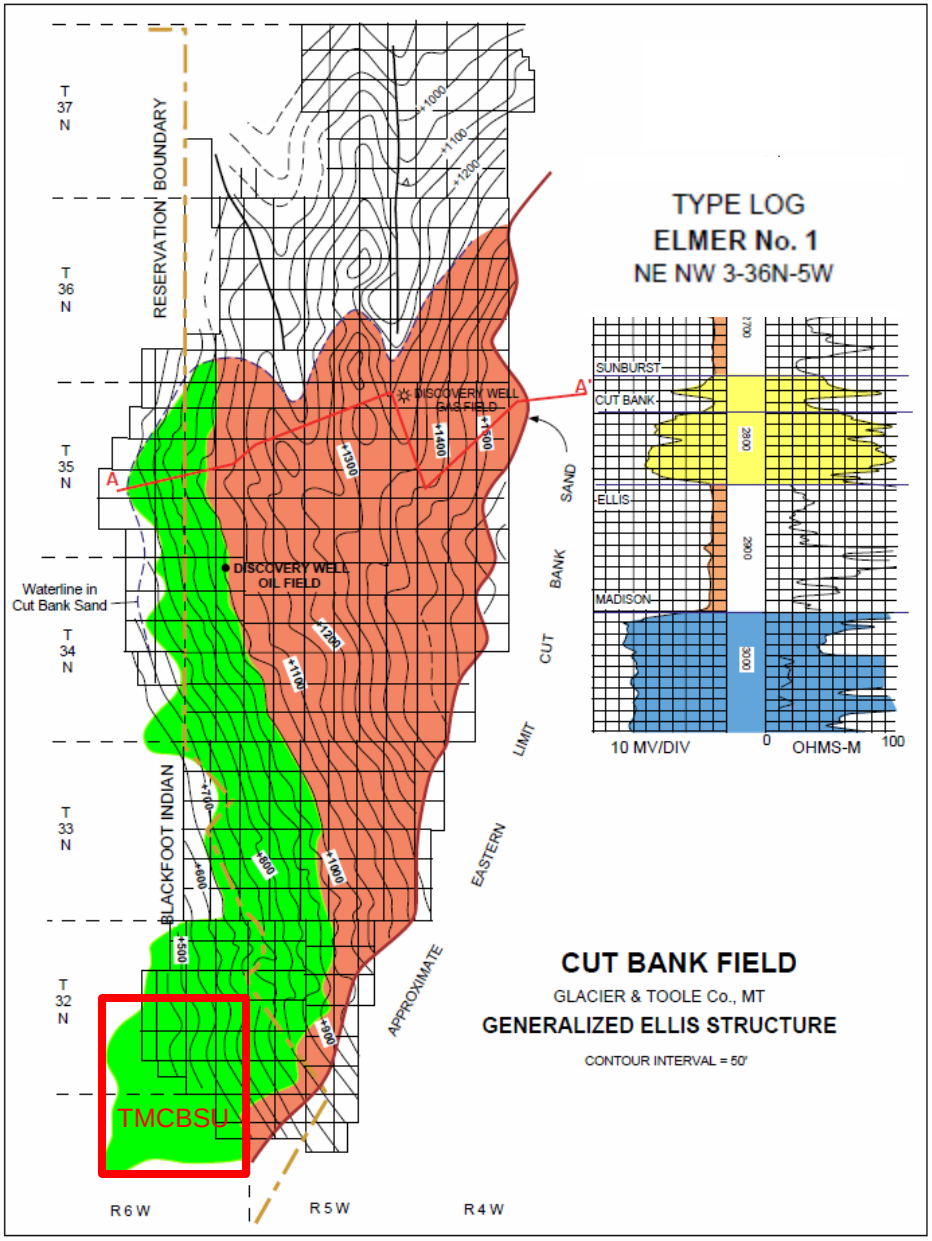
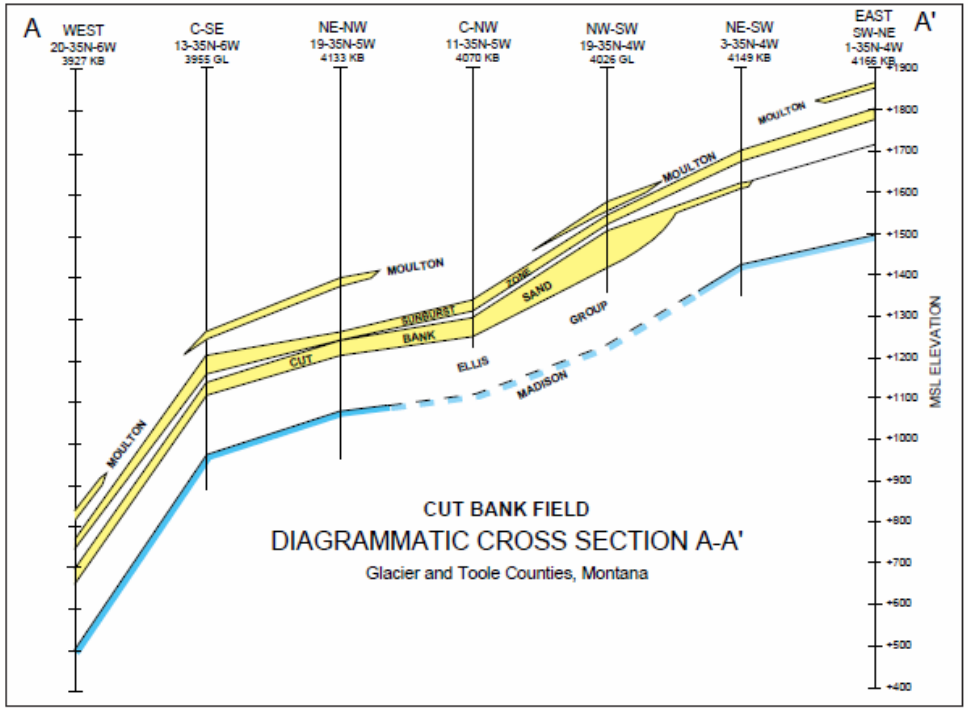


Figure BF-2.1. General structure map of reservation and surrounding region.



Regional Structure





Regional Dip to west
Gradient ~100 ft/mile

k Sand Unit (TMCBSU)

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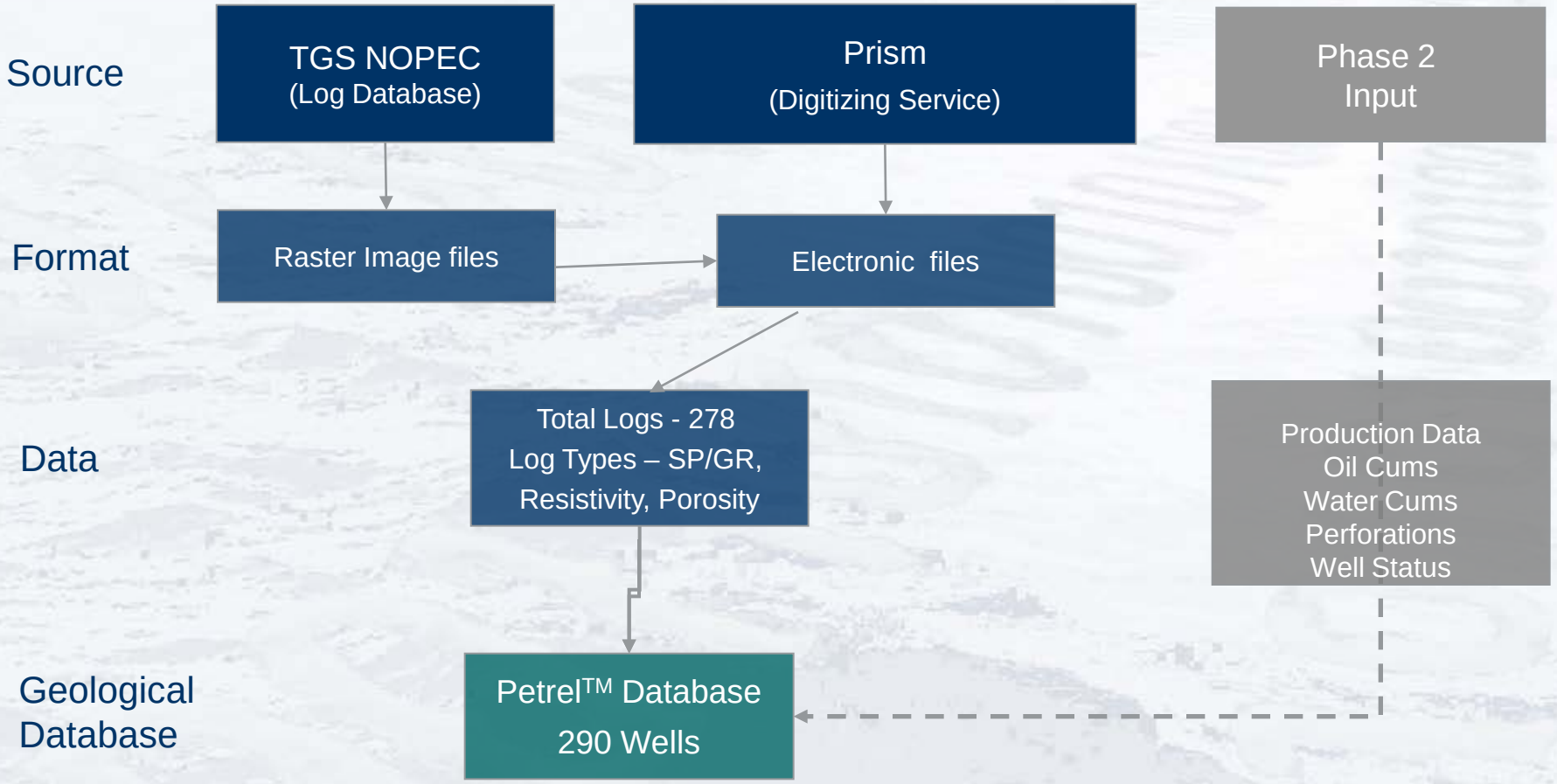
Phase 3: Workflow



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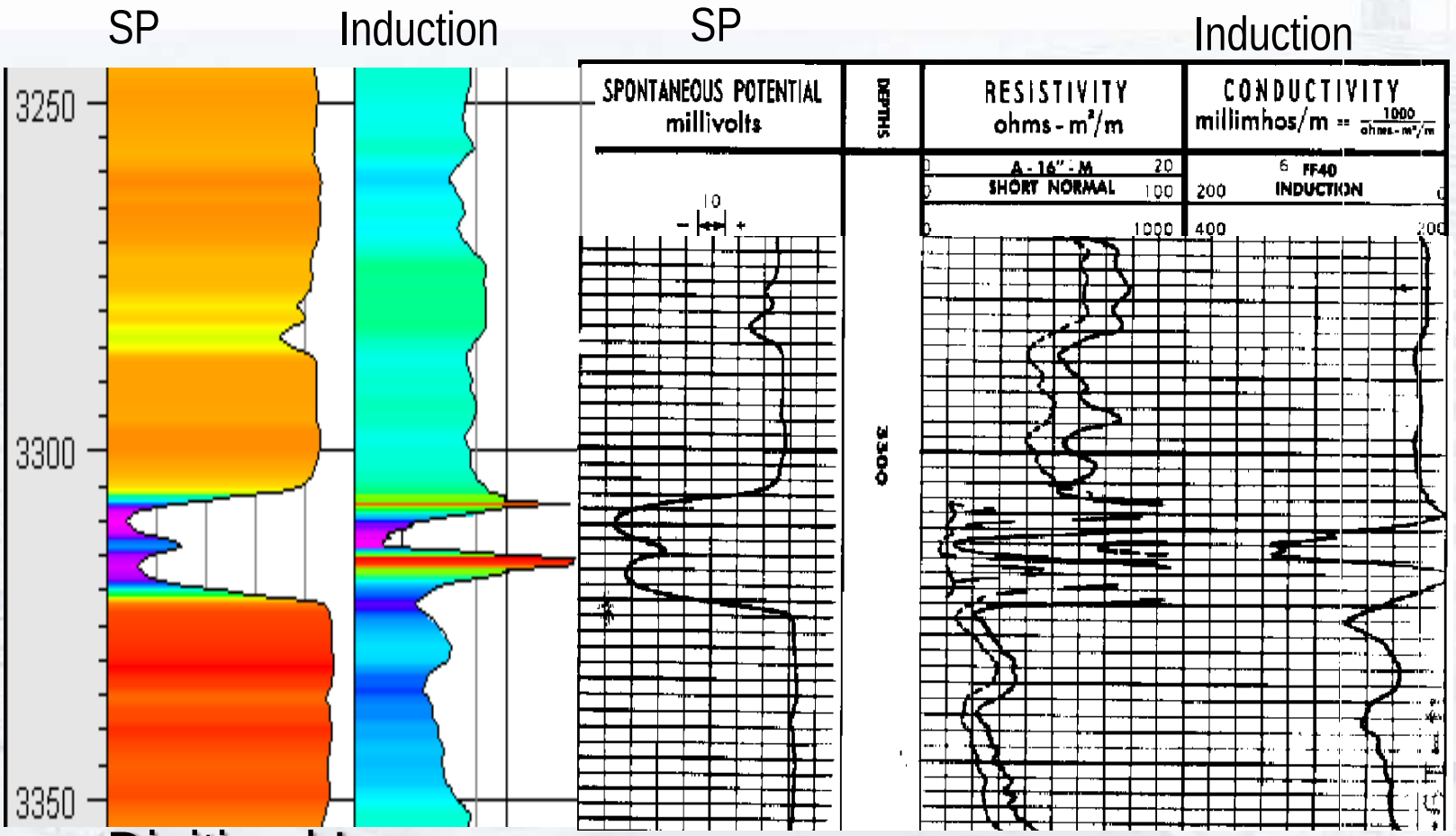
Data Acquisition in Phase 3

278 Wells with log curves (SP, Gamma, Resistivity) in the project

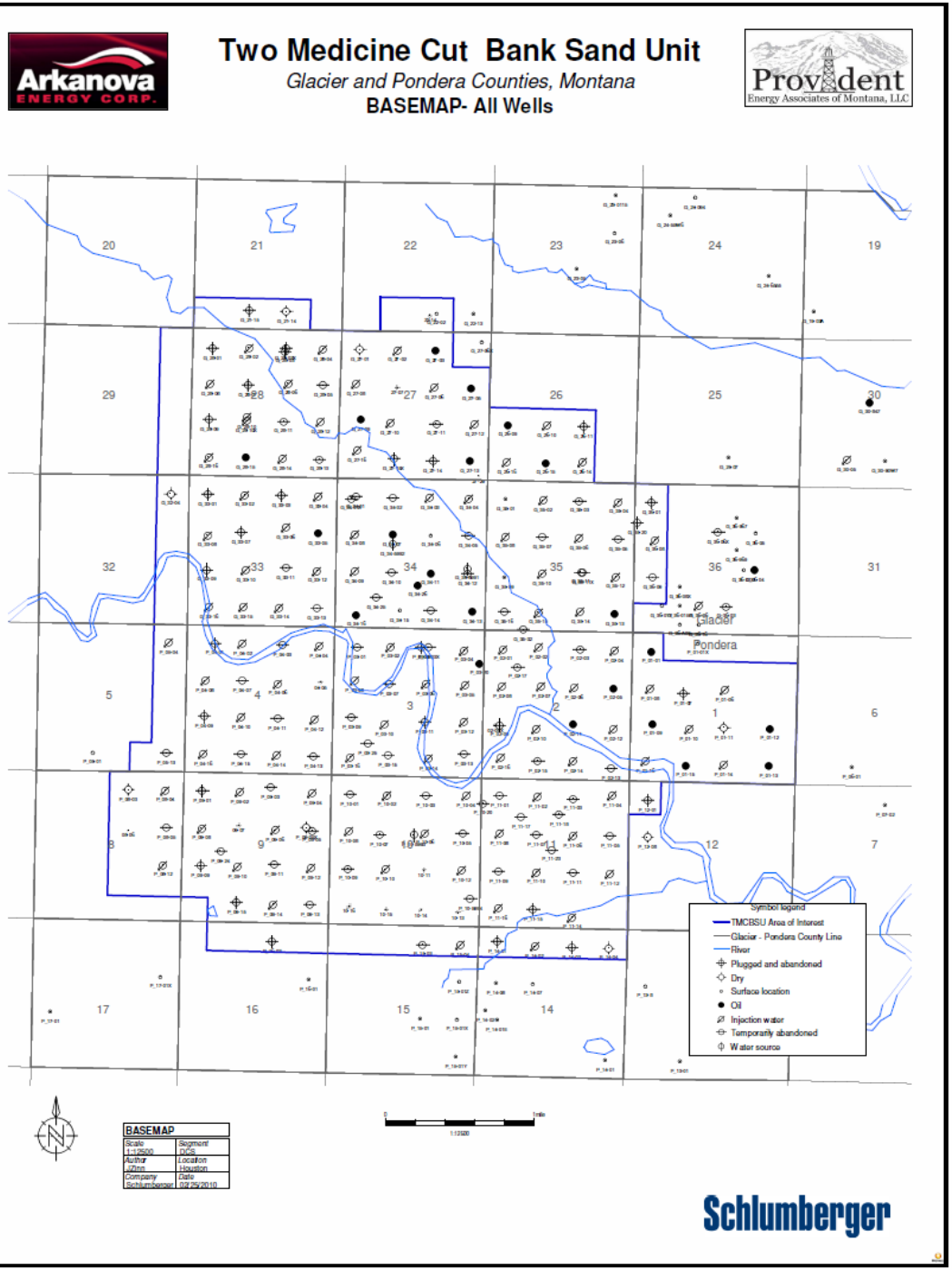
- 228 Wells with digitized logs in TMCBSU
- 50 Wells with digitized logs outside TMCBSU
- 71 Wells with porosity logs
- 43 Wells with porosity curves in TMCBSU

QC - Raster Image to Digitized Log

25035050240000



Petrel™ Geological Project Basemap



278 Wells with digitized logs

Symbol legend

- TMCBSU Area of Interest
- Glacier - Pondera County Line
- River
- Plugged and abandoned
- Dry
- Surface location
- Oil
- Injection water
- Temporarily abandoned
- Water source

(MCBSU)

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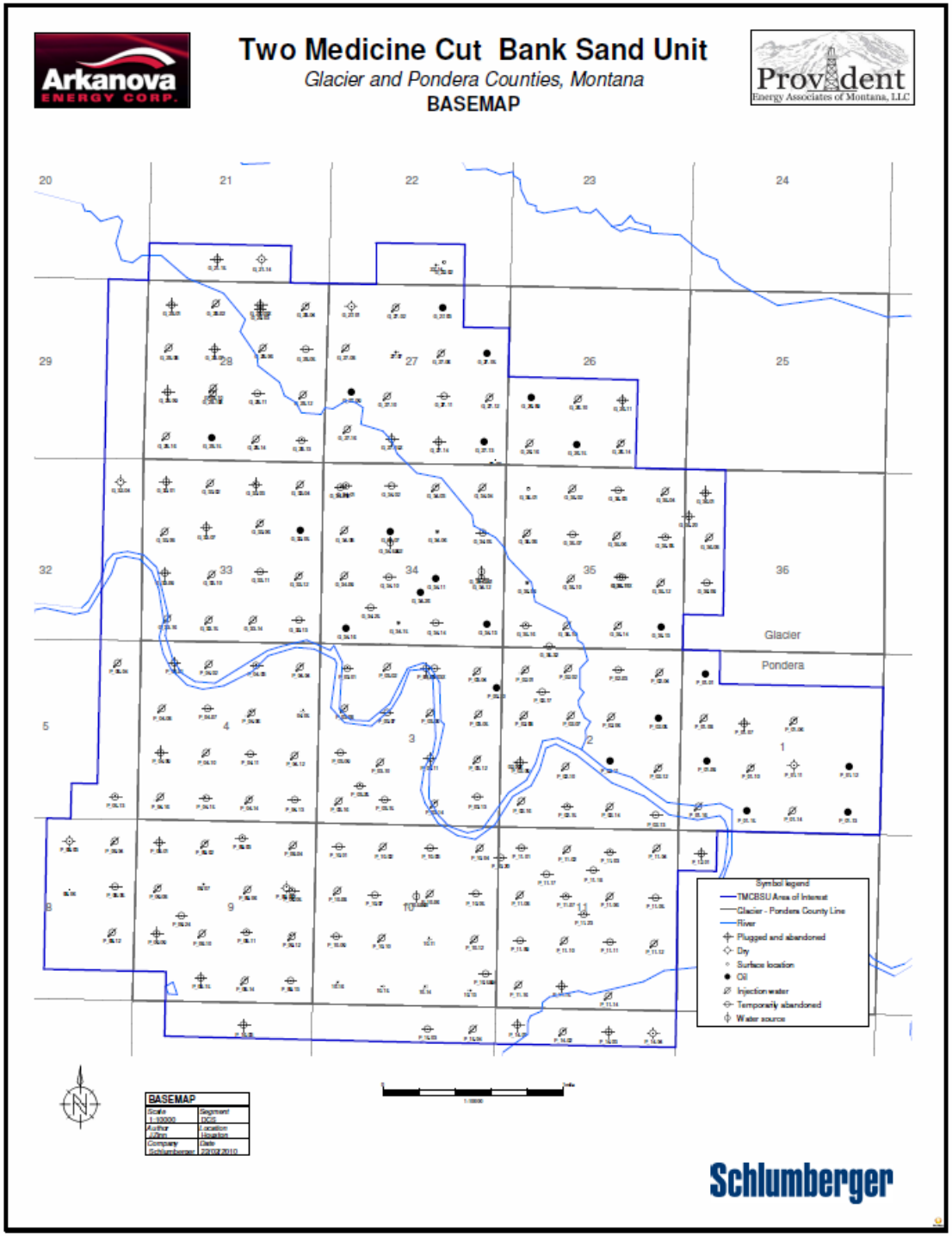

TMCBSU Basemap

CUT BANK Formation : 233 Wells

- 22 Active Producers
- 66 SI or TA Producers
- 31 P&A Producers
- 104 P&A Injectors
- 9 Dry Wellbores
- 1 Water Supply (5992)

MADISON Formation: 3 Wells

- 1 SI Producer: 5994
- 2 Disposal Wells: 5991 & 5993

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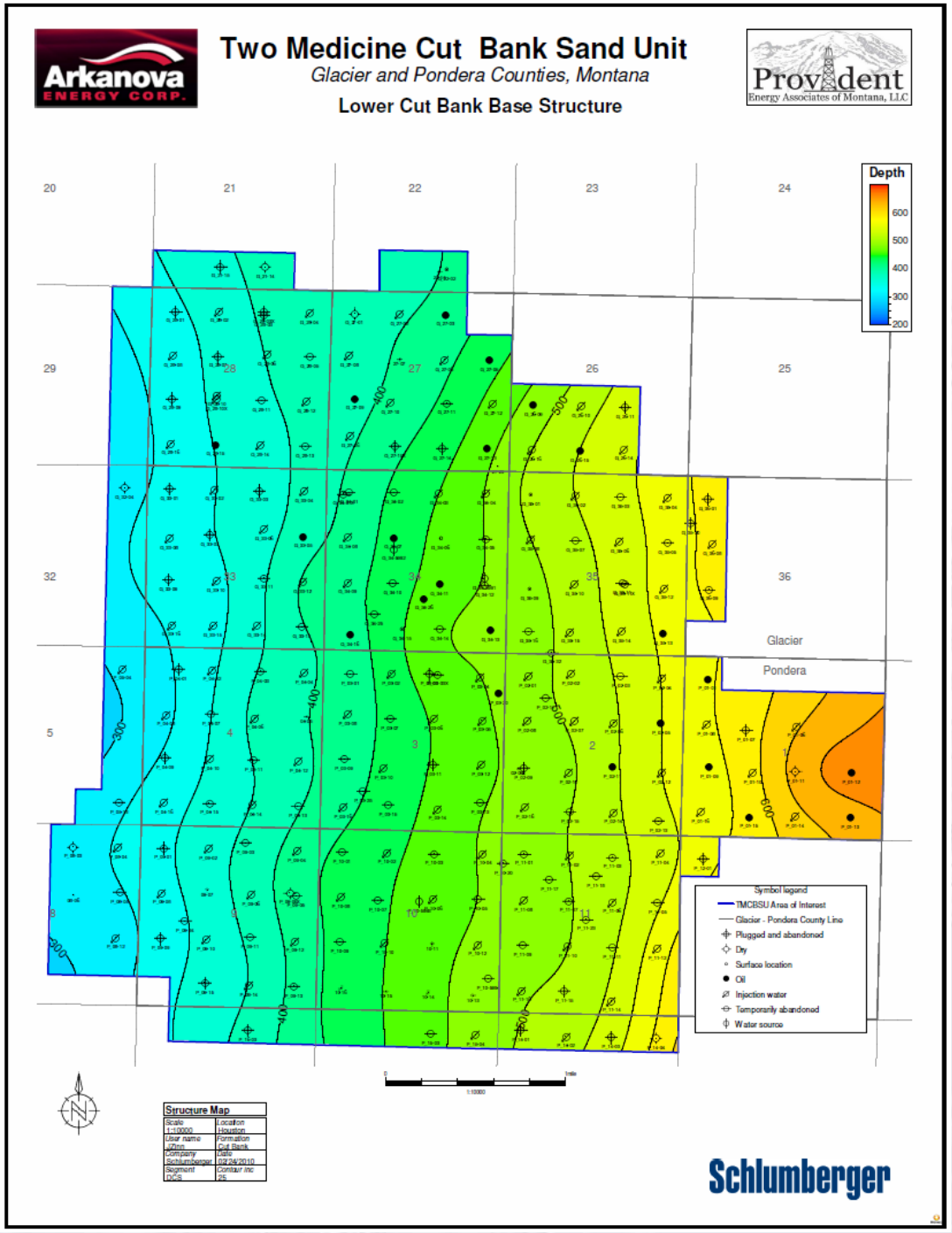
Base Lower Cut Bank Structure Map



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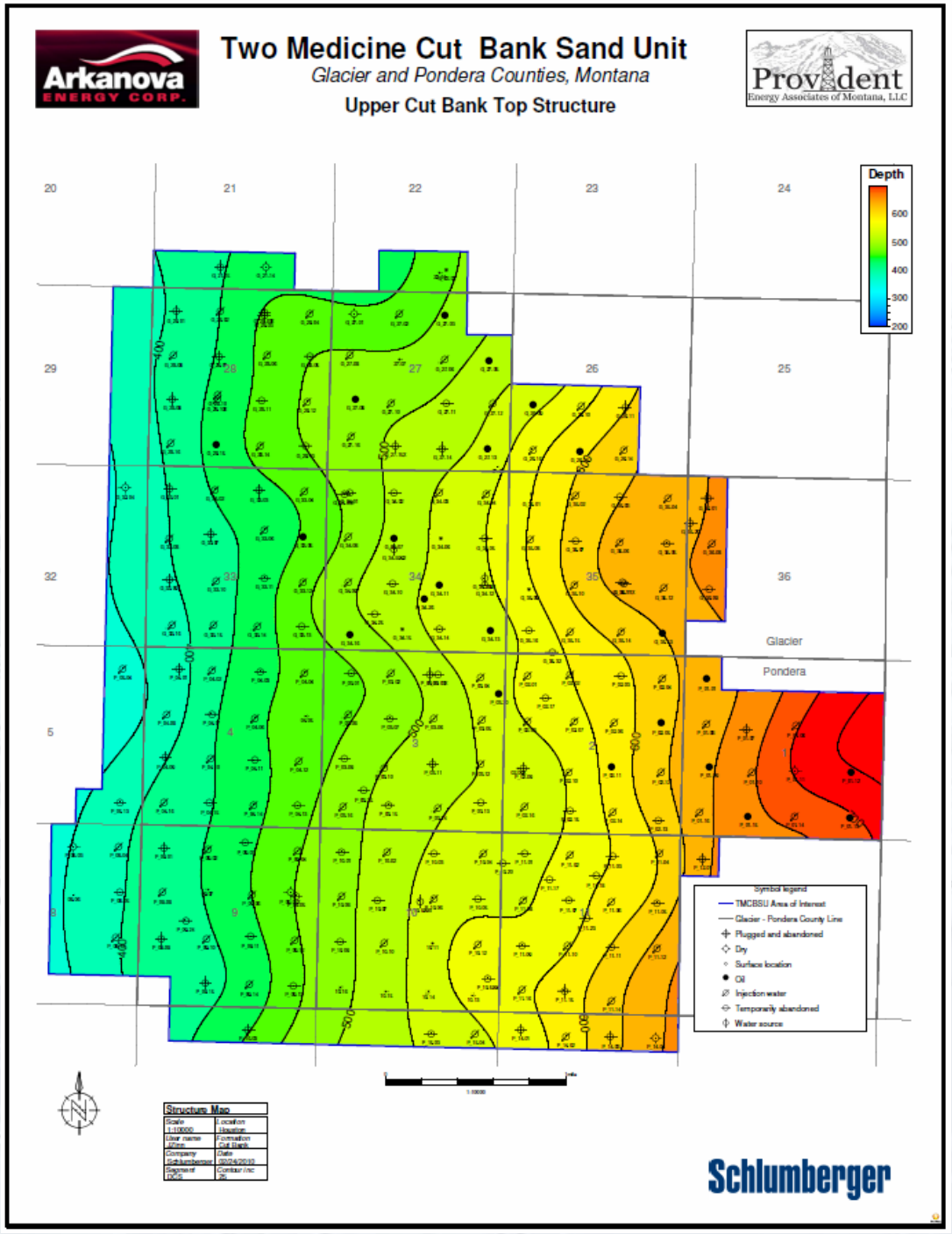
Top Upper Cut Bank Structure Map



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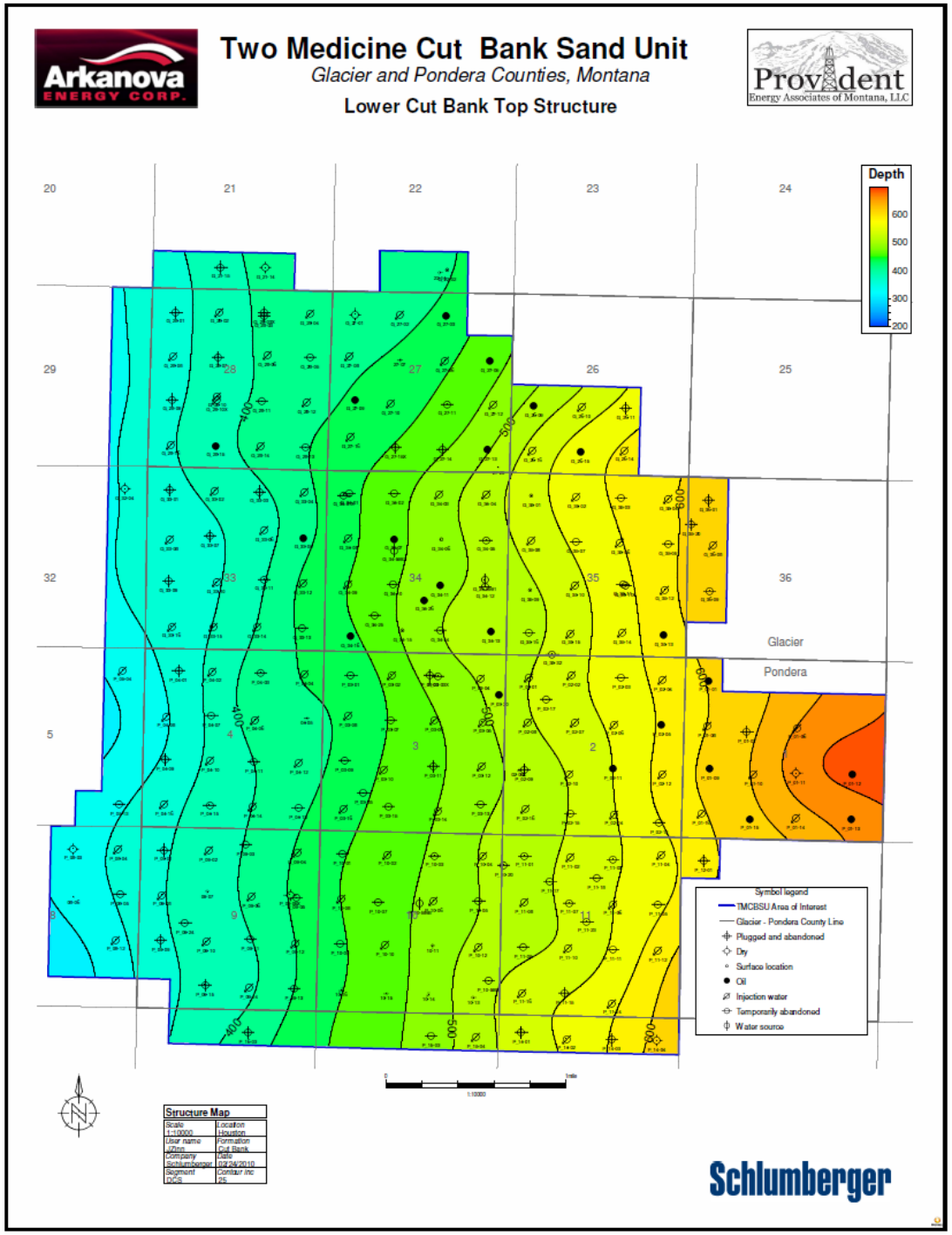
Top Lower Cut Bank Structure Map



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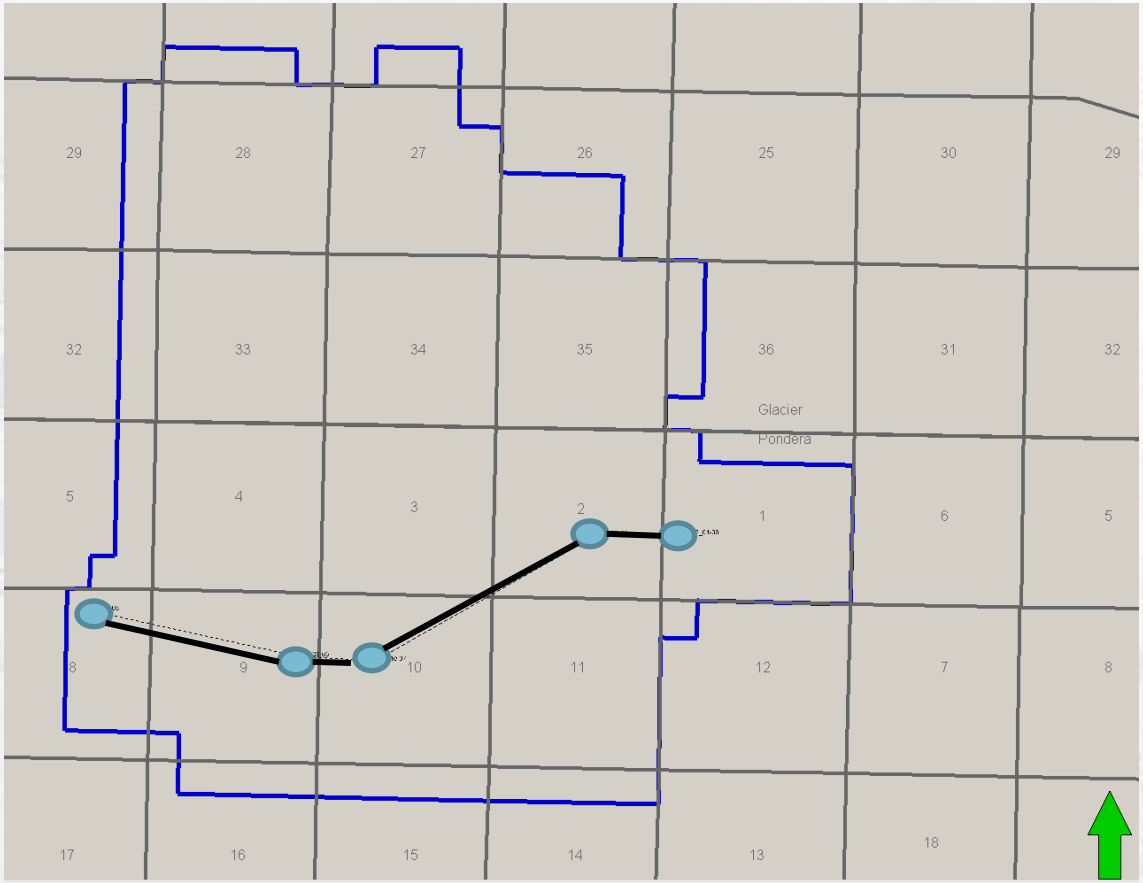
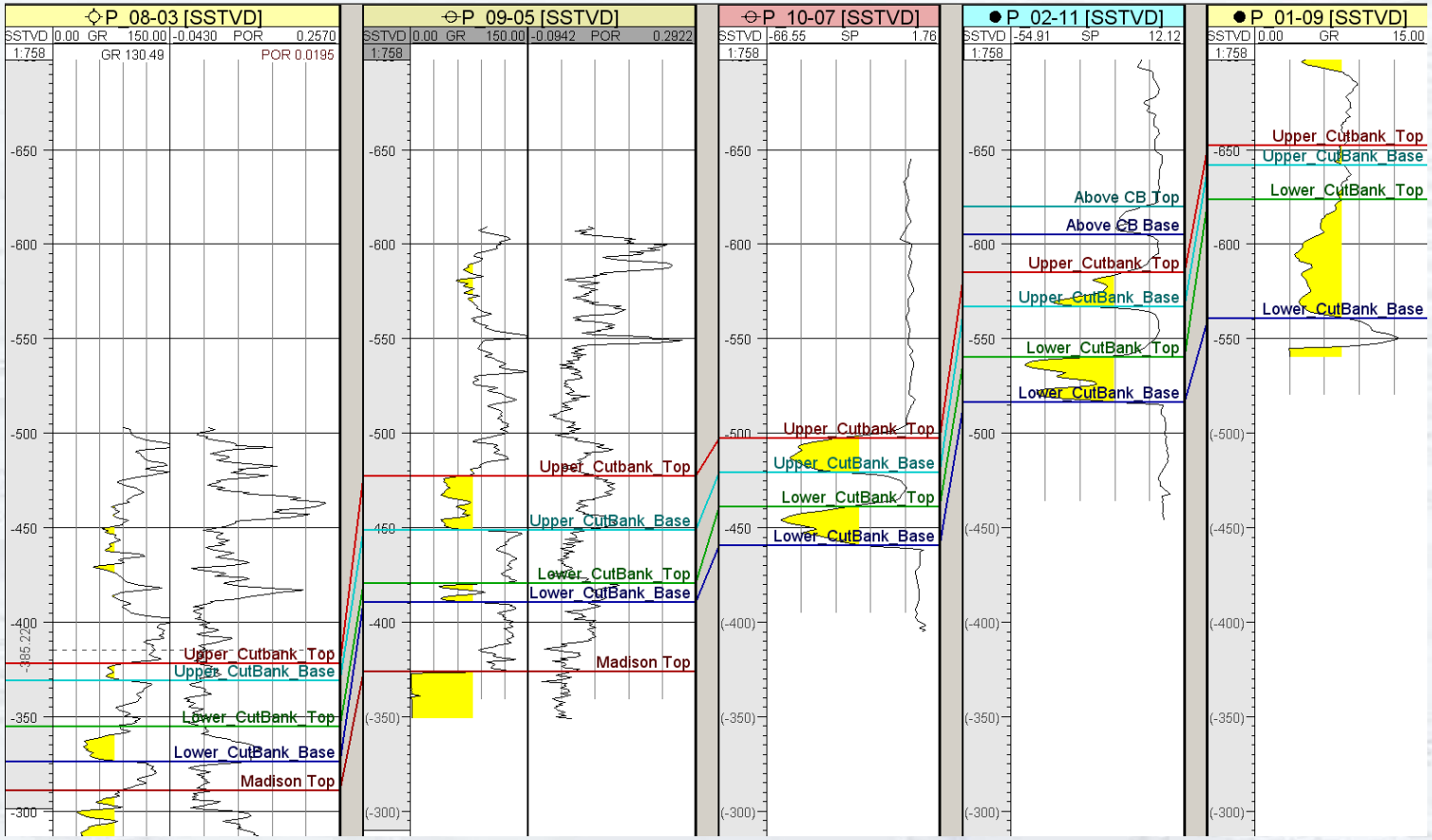
East-West Structural Cross Section

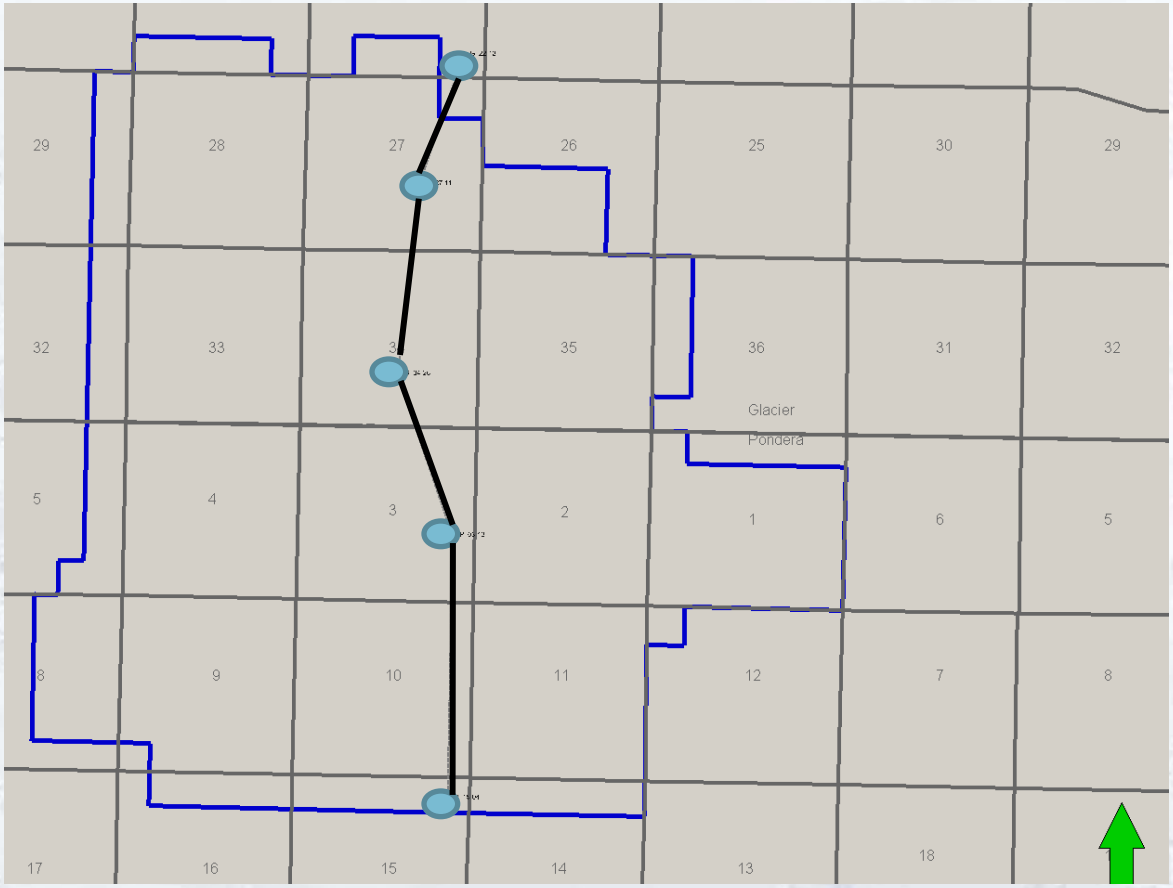


Structural Cross Section West-East

W E



North-South Stratigraphic Cross Section



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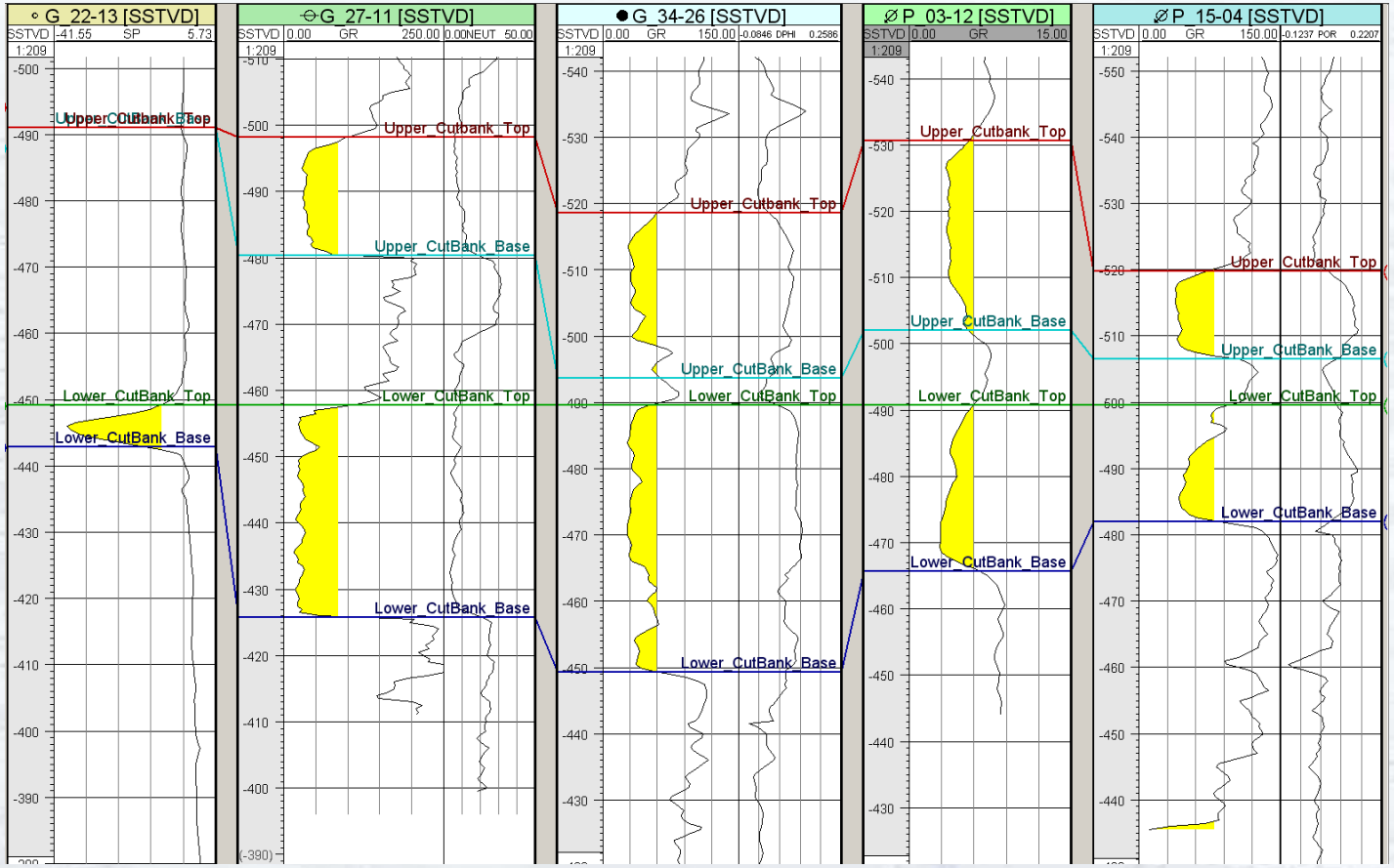
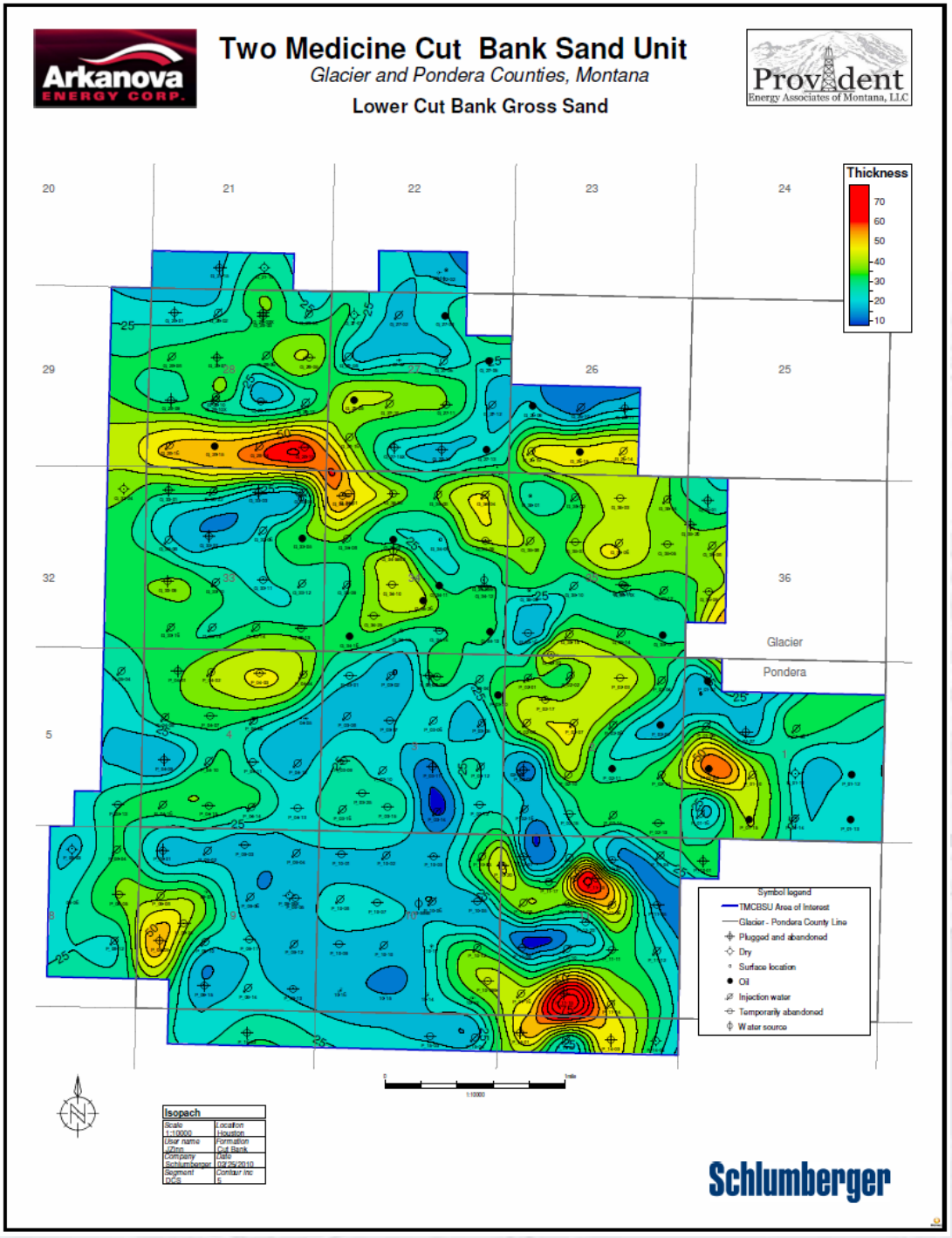
Stratigraphic Cross Section North-South

N S



Lower Cut Bank Gross Sand Map



- Lower Cut Bank Sand
- Oil bearing Zone
- Thickness: 10-78 ft
- Irregular fluvial sand geometry
- Thin LCB locally in south and north areas

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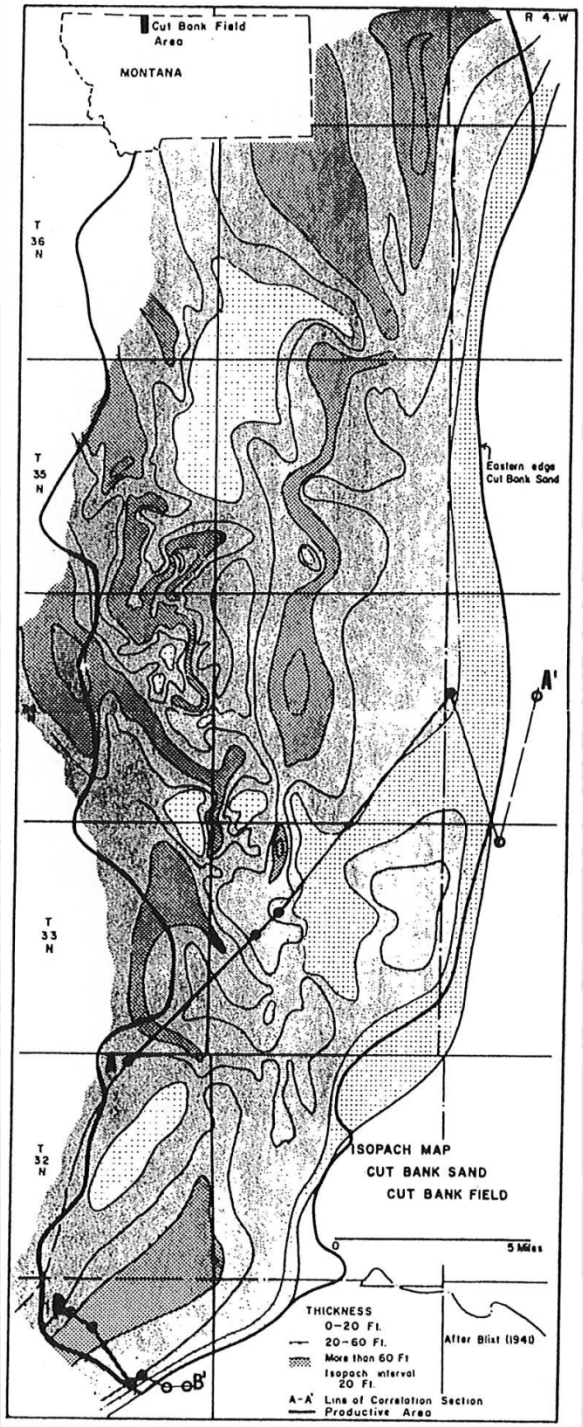


Cut Bank Depositional Characteristics

Lower Cretaceous regional drainage to N/NE

Fluvial meandering channel complex, broad paleovalley ~20 ml. width, multistory meander-belt sand bodies

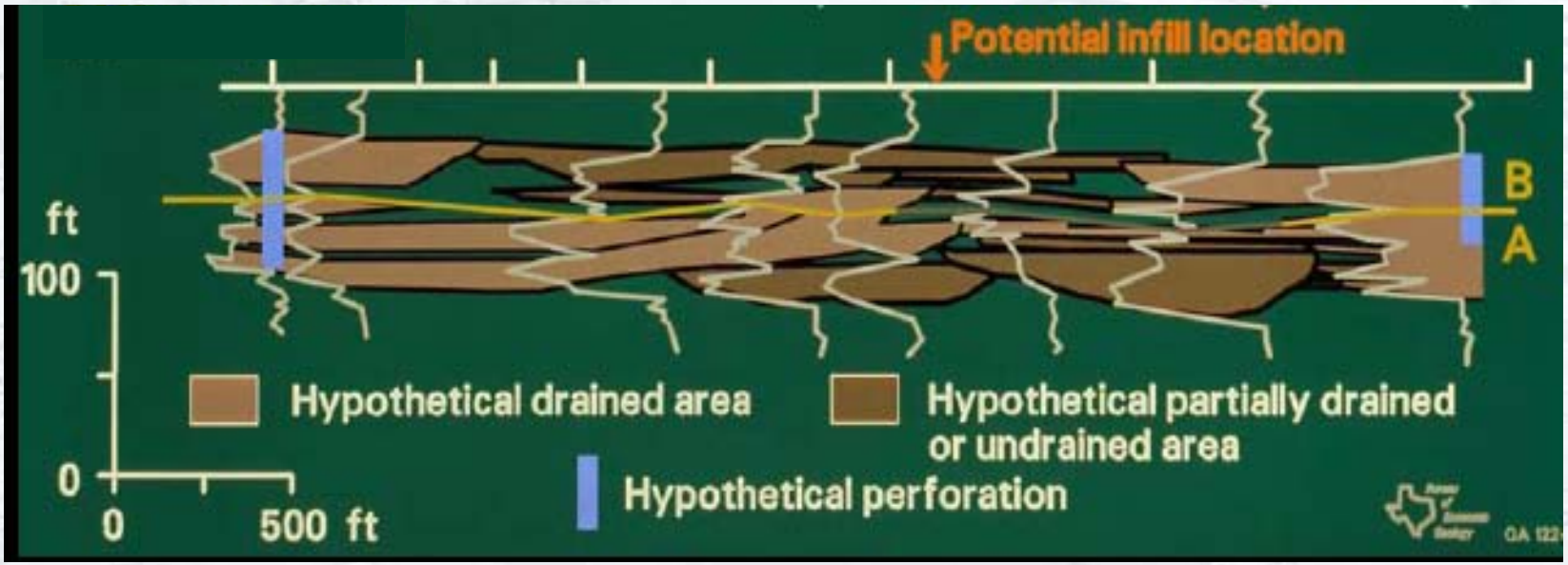
Geometry: Sinuous, channelized sand bodies, ~100ft. to several 100ft. in width, good continuity parallel to channel axis, multistory stacked sands

Thickness: <100ft Field wells, 200ft Outcrop

Lithology: medium grained, cross-bedded sandstone, clay mineralogy (premature waterflood failure)

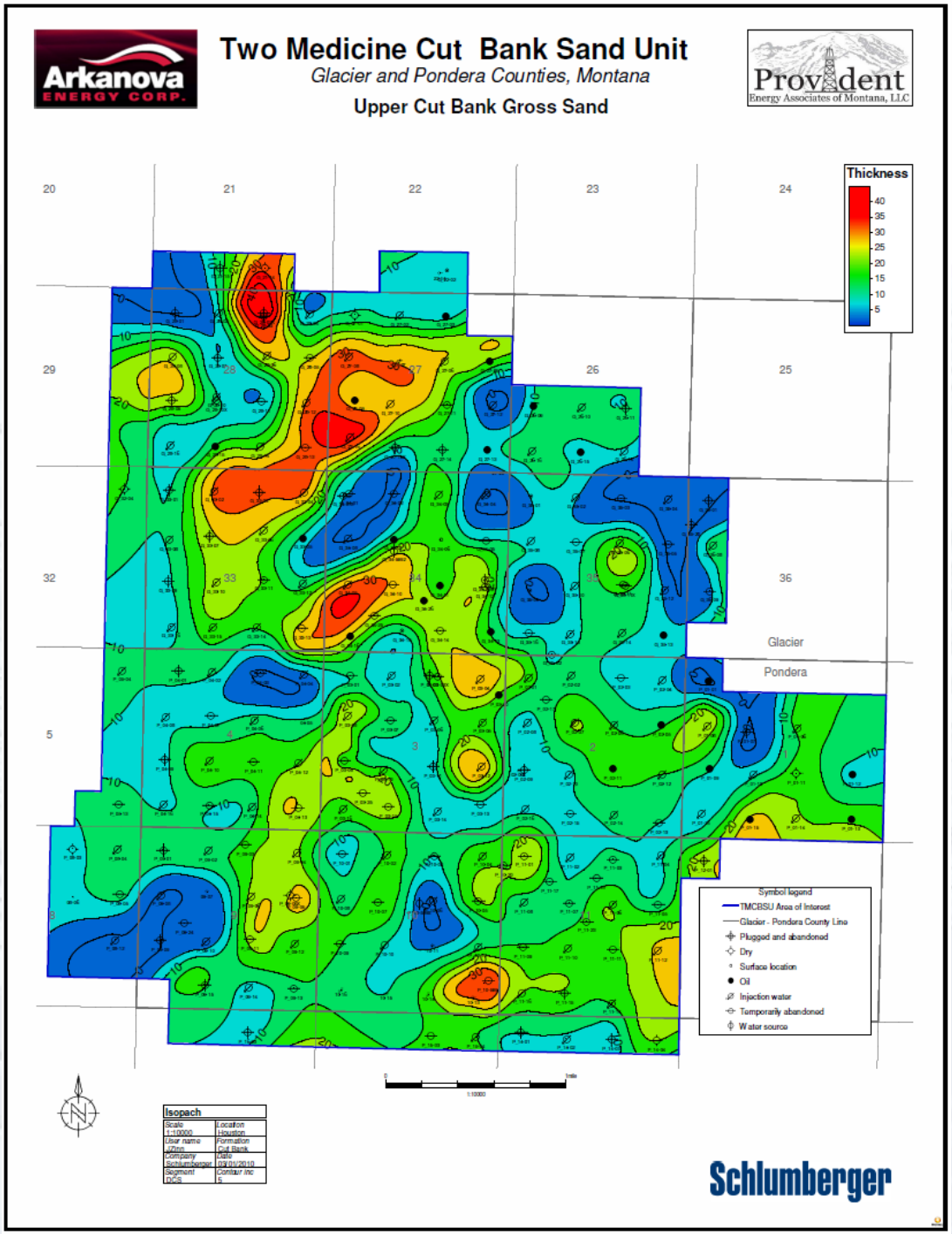
Cut Bank Fluvial Reservoirs - Concept Cross Sectional View

Reservoir: stratigraphic, lateral pinchouts, erosional cross-cutting relationships; directional permeability, heterogeneous flow units



after Jackson et al. (1988)

Upper Cut Bank Gross Sand Map



Upper Cut Bank Sand

Thickness: 0-44 ft

No UCB locally in North and SW areas

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Net Sand Calculation

Lower CB Net Sand =

Lower CB Gross Sand – Shale Break

Lower CB Gross Sand =

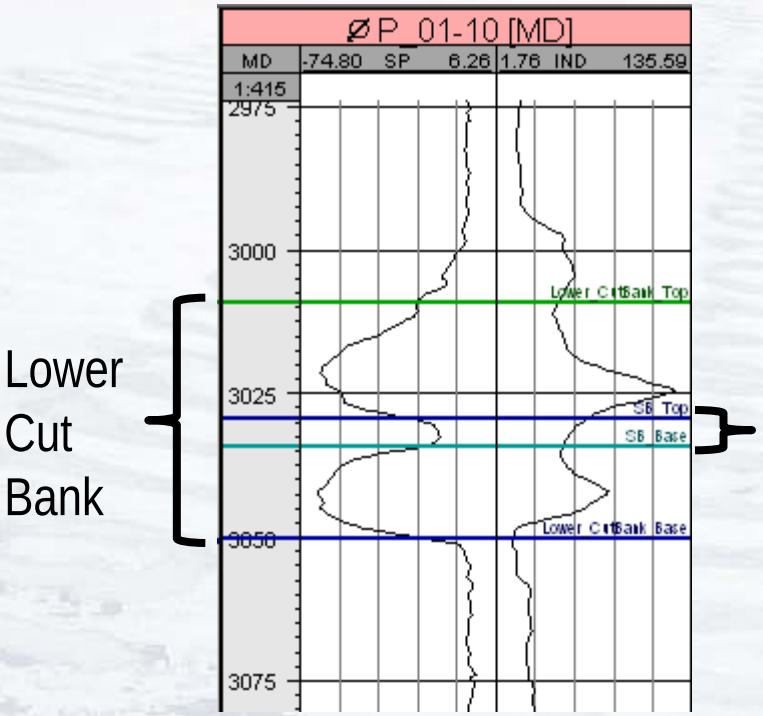
LCB_Top - LCB_Base = 41ft

Shale Break =

SB_Top – SB_Base = 7ft

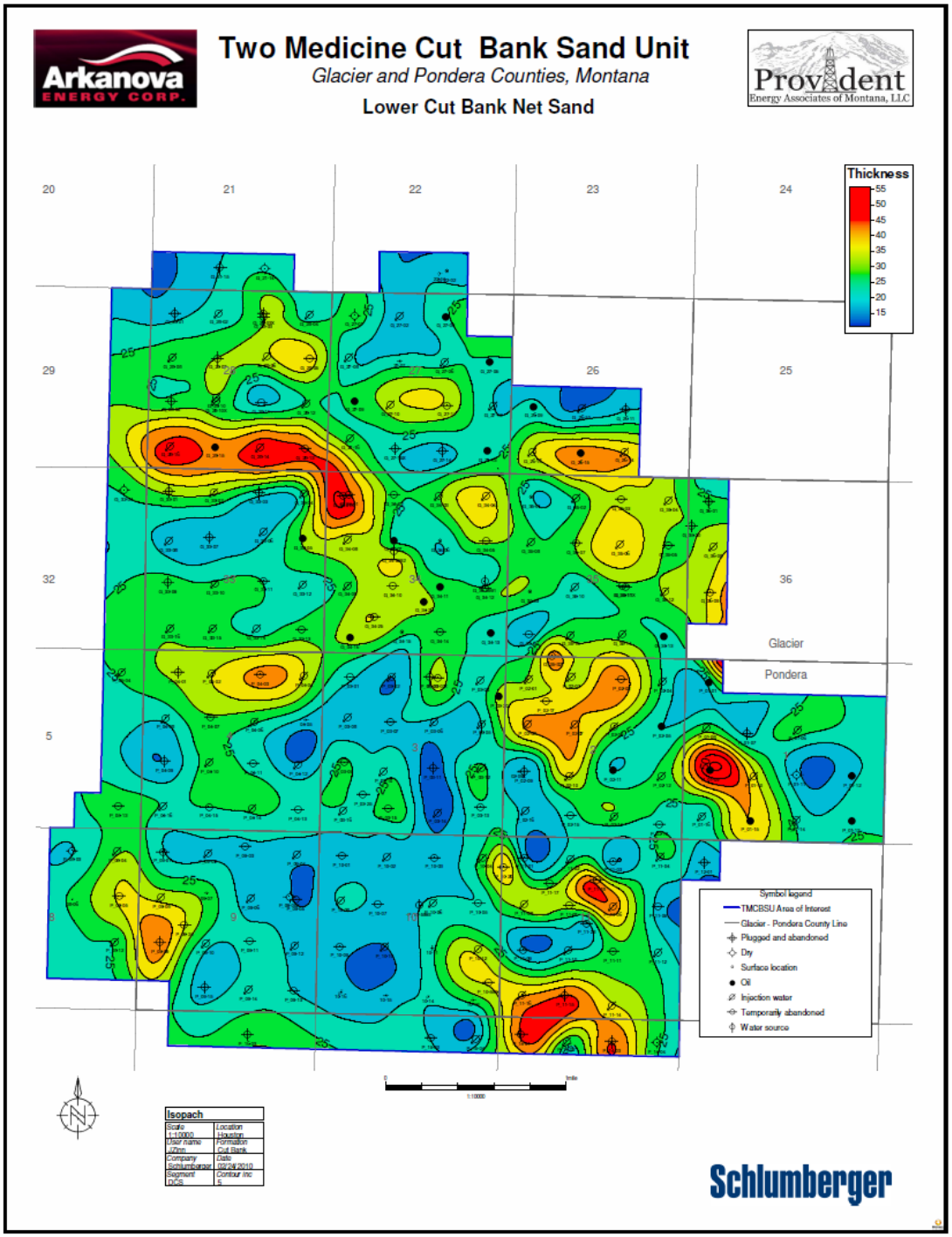
Lower CB Net Sand =

41ft-7ft =34ft



Lower Cut Bank Net Sand Map

Net Sand Thickness:
10-55 ft



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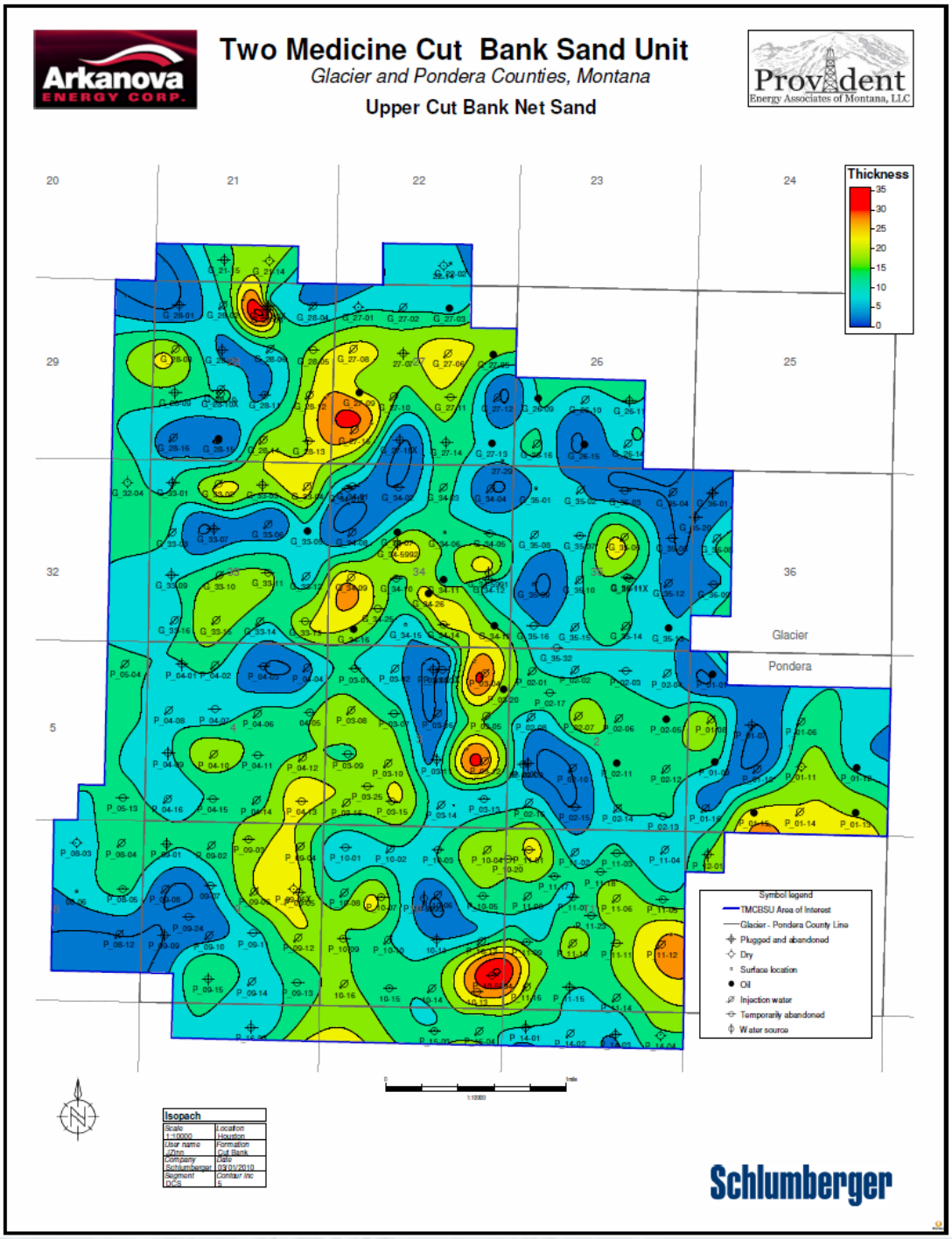
Upper Cut Bank Net Sand Map

Net Sand Thickness:
0-38 ft



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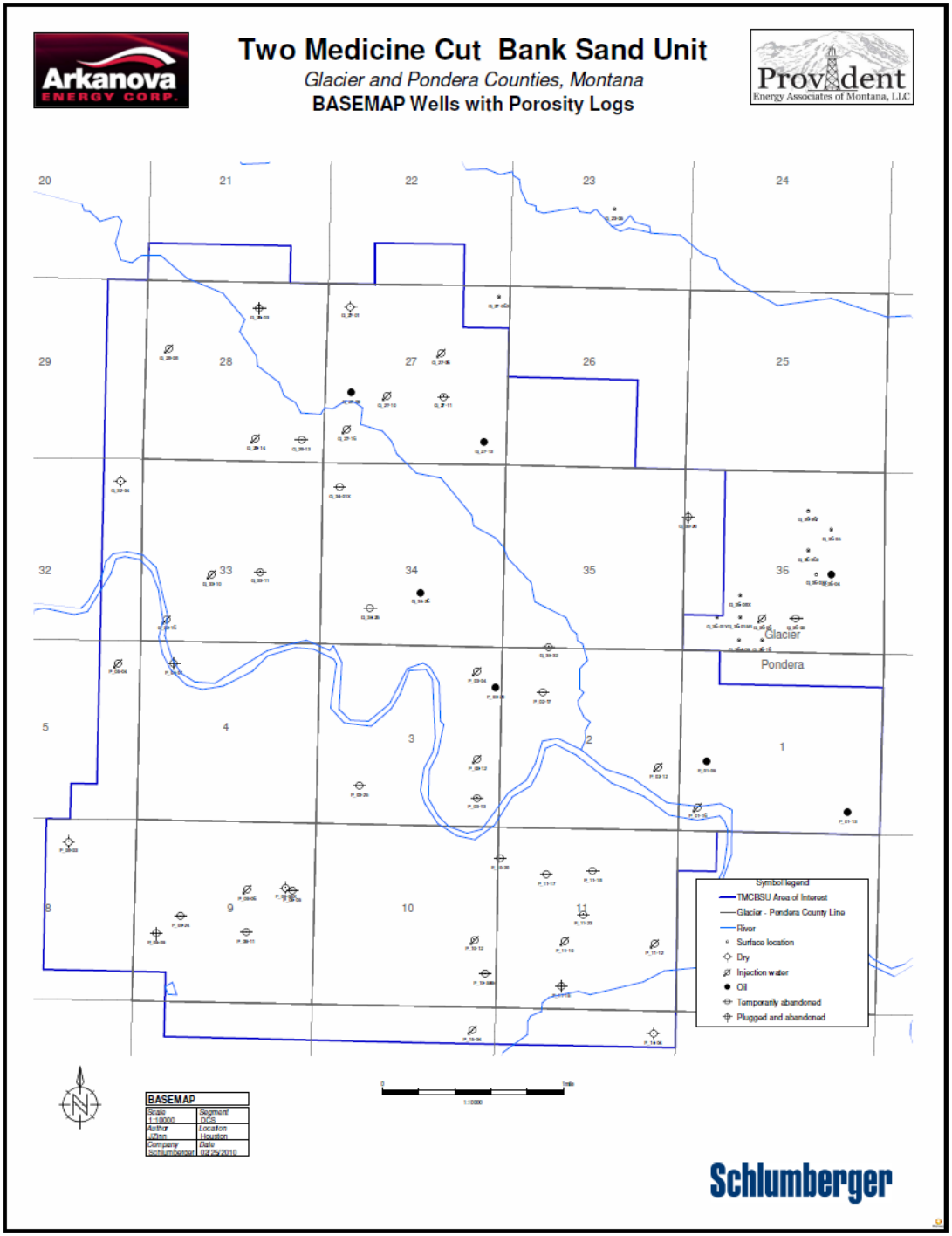

Porosity Data

71 Wells with Porosity logs

43 Wells inside TMCBSU

5 Wells outside TMCBSU

4 Porosity Curve Types:
Por, Neut, DPHI, NPHI

1972 Core Analysis Results:

Porosity (Φ):12.7% (avg)
range 1 to 18%
Permeability (k): 44.6 mD (avg)
range 1mD to 897 mD

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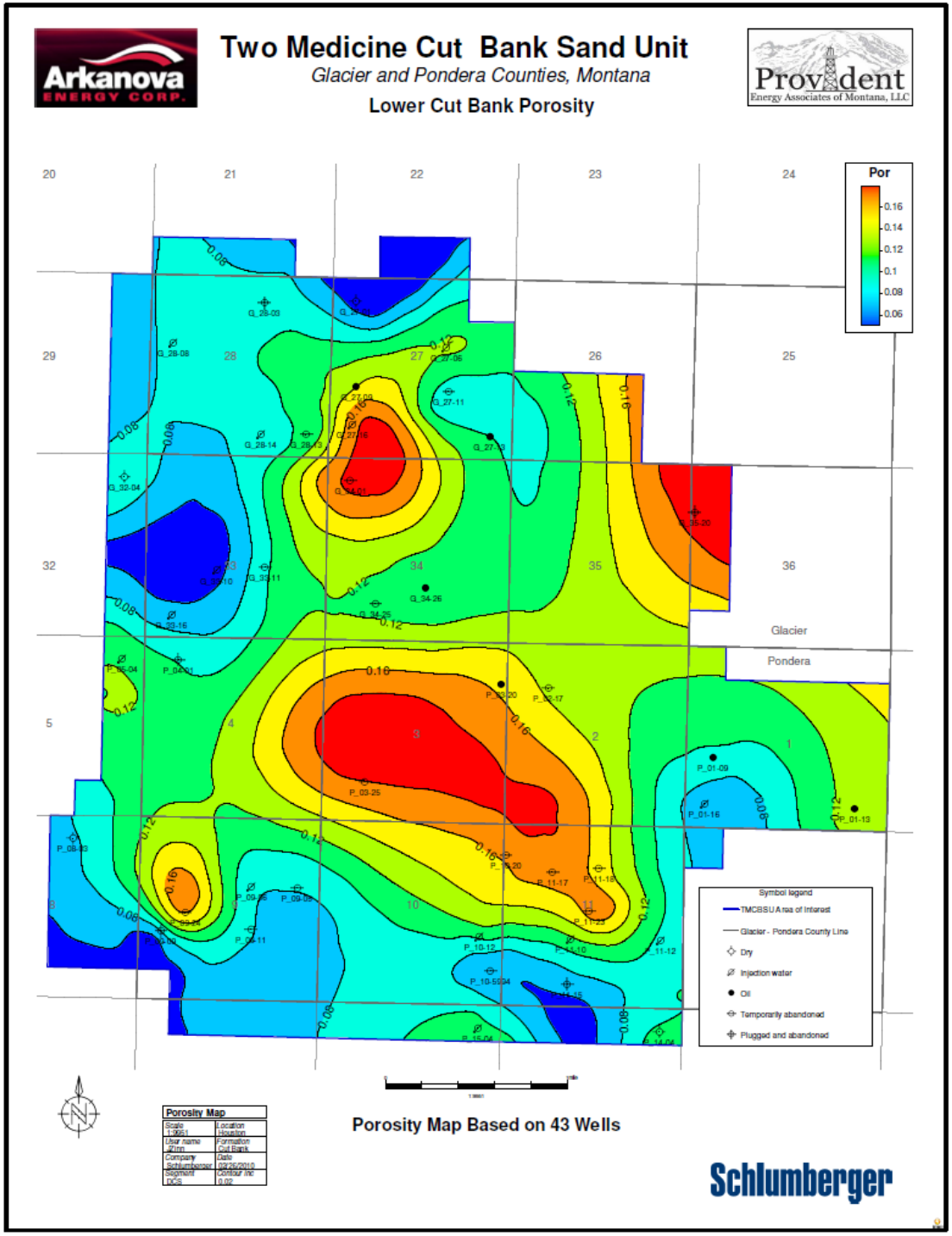

Lower Cut Bank Porosity Map

Porosity Map based on

43 Wells in TMCBSU,

5 Wells outside TMCBSU

Av Porosity range 5 – 19 %

Average 11%

G 27-01 ϕ 5% Dry

Cut off 6% Contour

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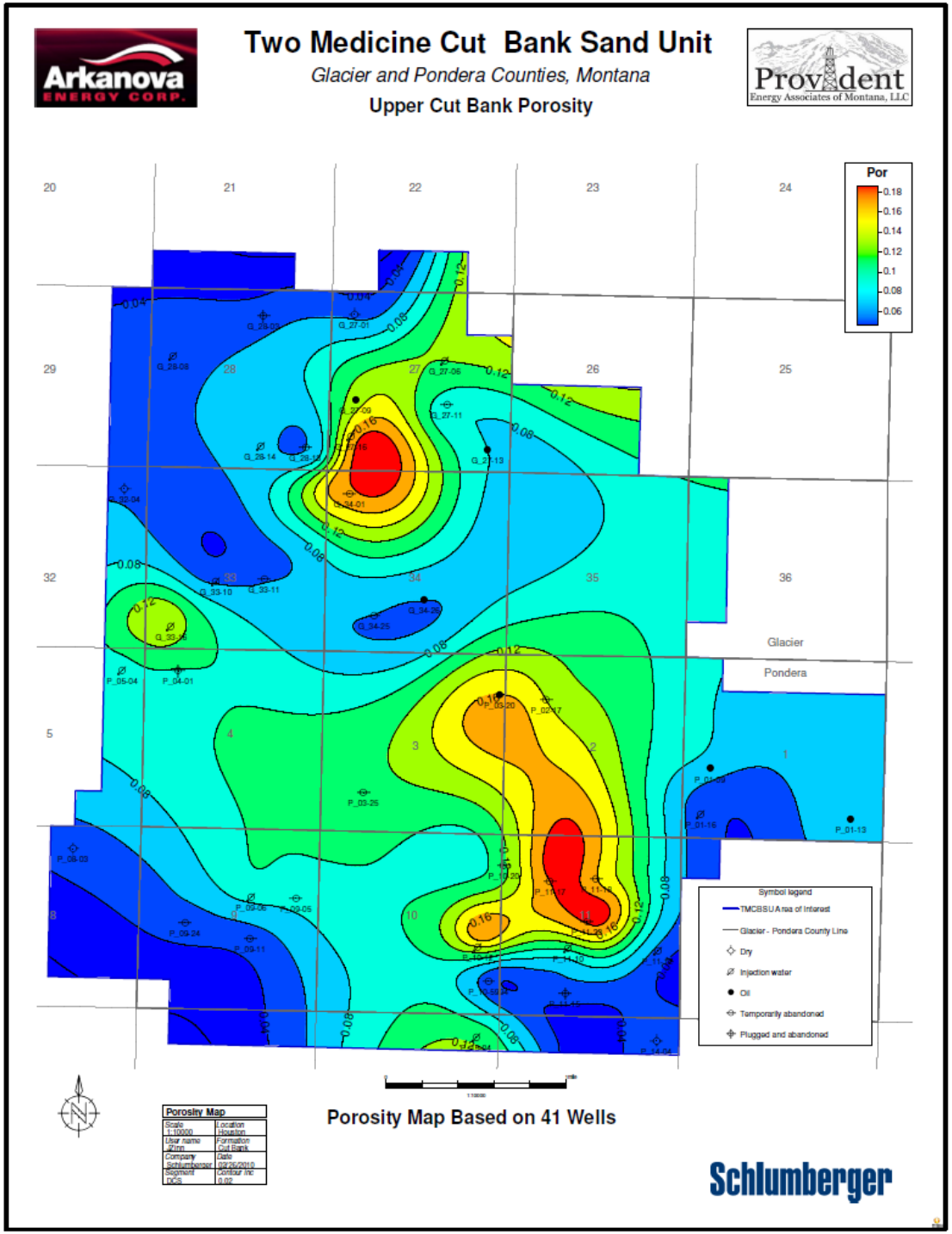

Upper Cut Bank Porosity Map

Porosity Log Control

41 Wells in TMCBSU

5 Wells outside TMCBSU

Av Porosity range 5-18%

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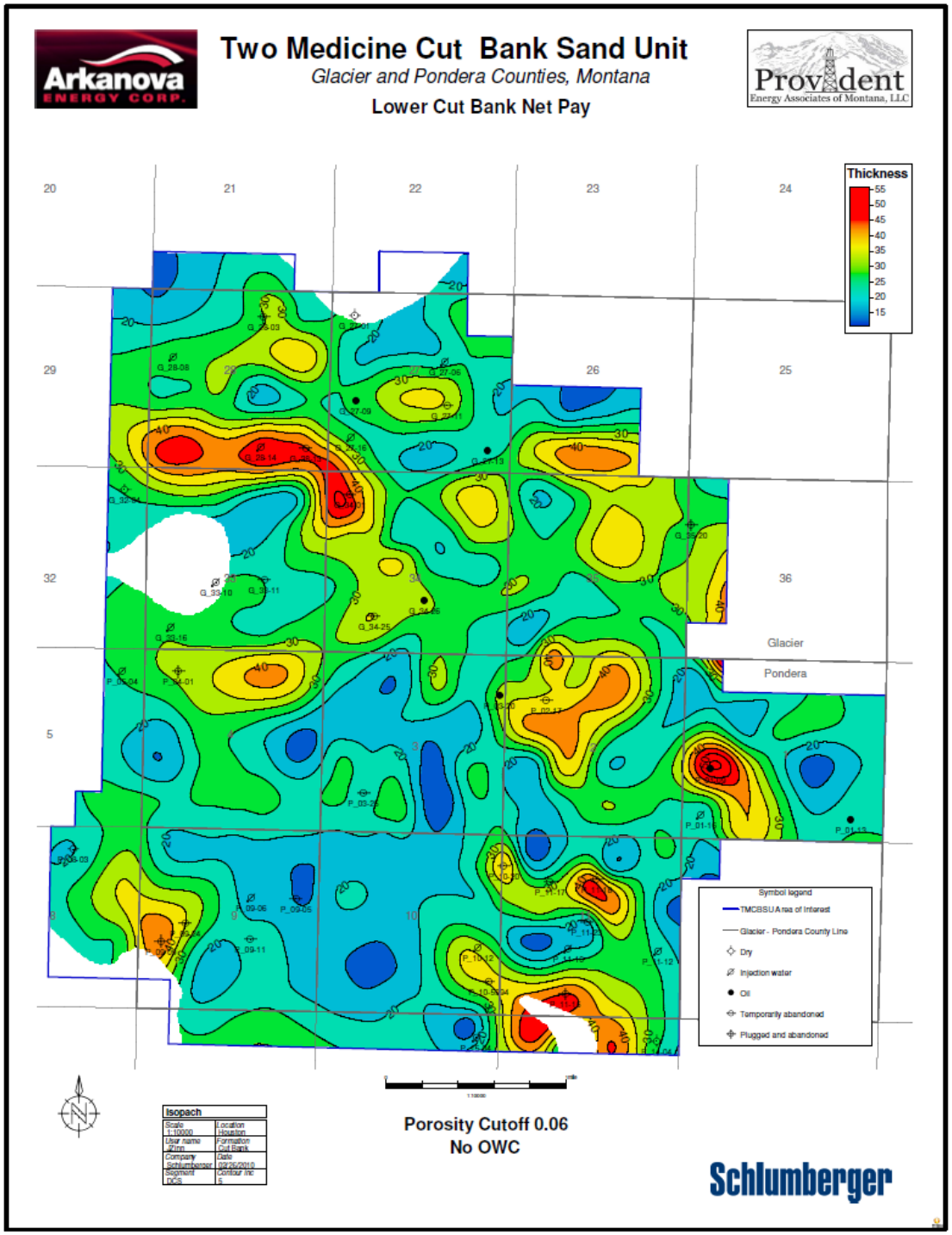

Lower Cut Bank Net Pay

Pay Criteria:
Net Sand Thickness
Porosity cut off 0.6
No OWC - resistivity logs

Net Pay Thickness
Range 12 to 55 ft
>25 ft over >50 % Field

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Observations

Structure Dip ~350 ft E-W, ~90ft/mile

Average LCB Gross Sand thickness 29ft

Average Porosity 0.11

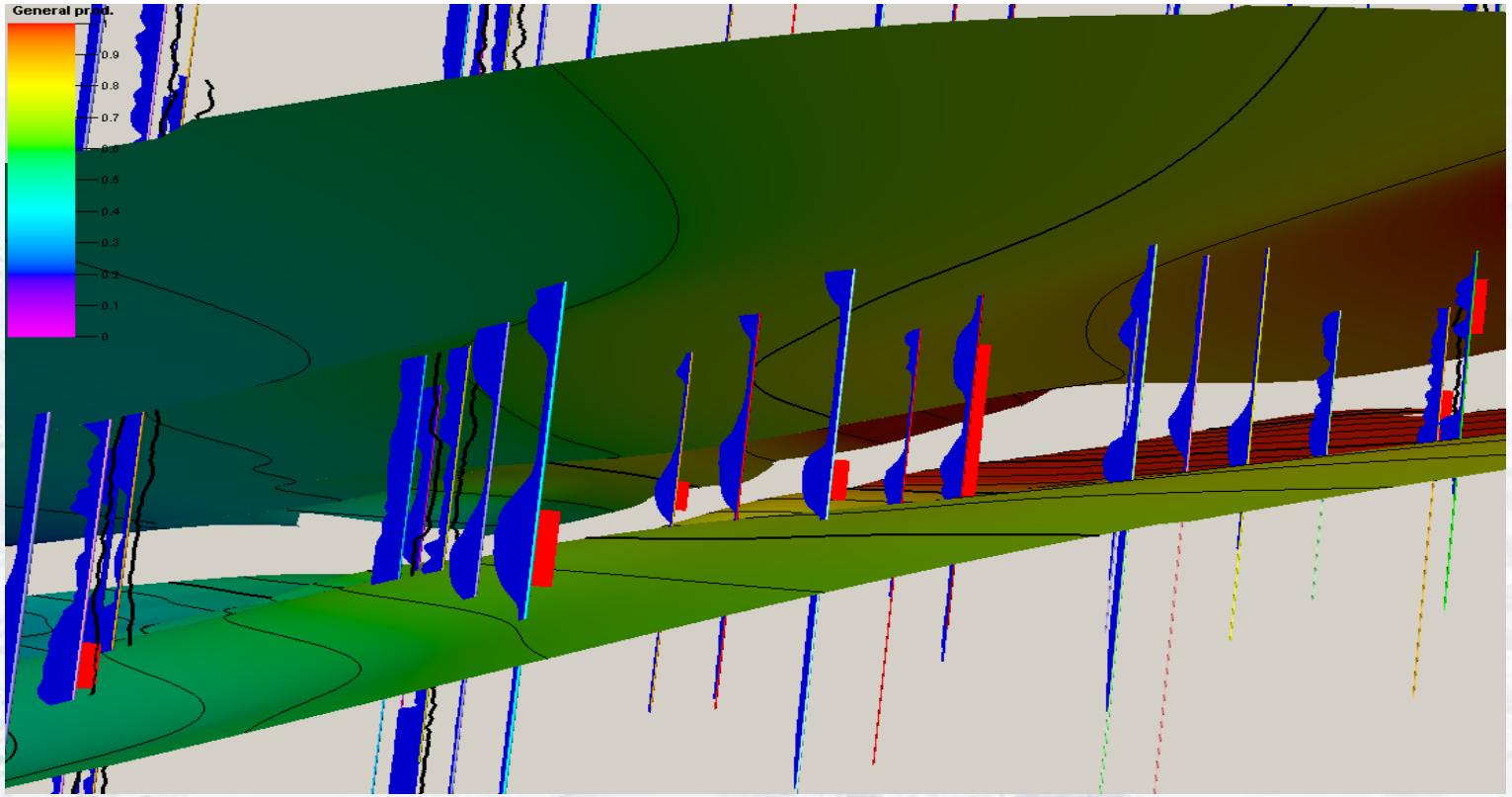
Average LCB Net Pay Thickness 26 ft, range 12 to 55ft

No OWC confirmed in LCB

Reservoir Heterogeneity observed in sand distribution and reservoir quality (porosity)

South part of the field has more areas with low reservoir quality (porosity and net sand).

Geological Model in Petrel



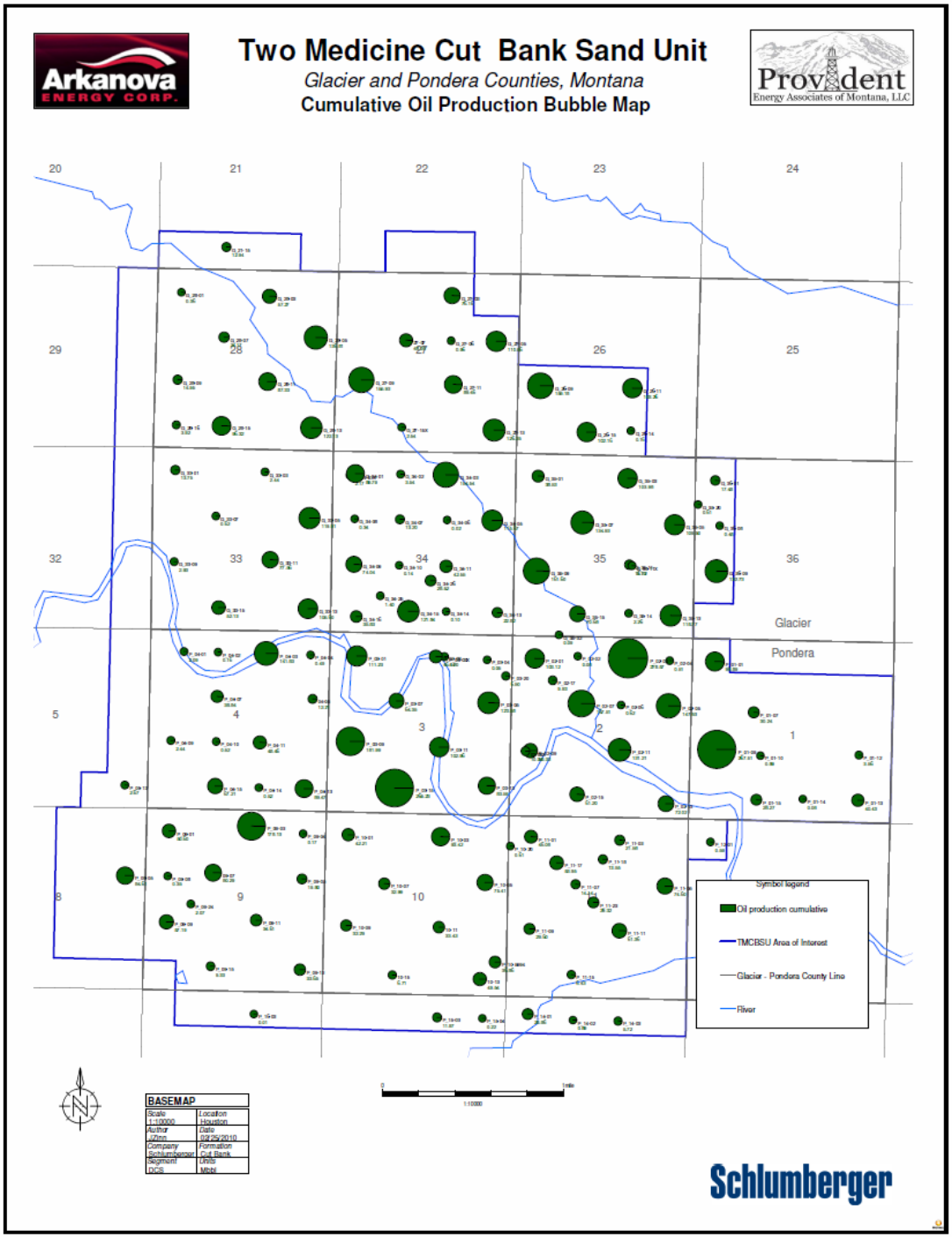
Petrel Project - Wells, Logs, Surfaces, Geological Markers, Production Cums, Perforations, Cultural data

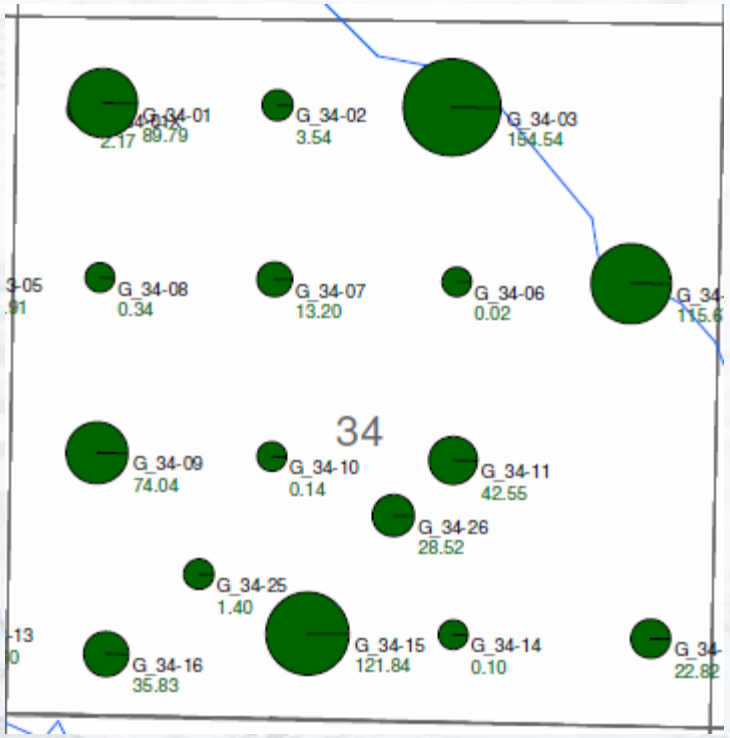
Initial Geological Review:

Geological Control on LCB Production

- LCB Net Pay relative to TMCBSU Production
- Top 10 Producers
- Focus Area - Section 34

Oil Cum Bubble Map
Lower Cut Bank





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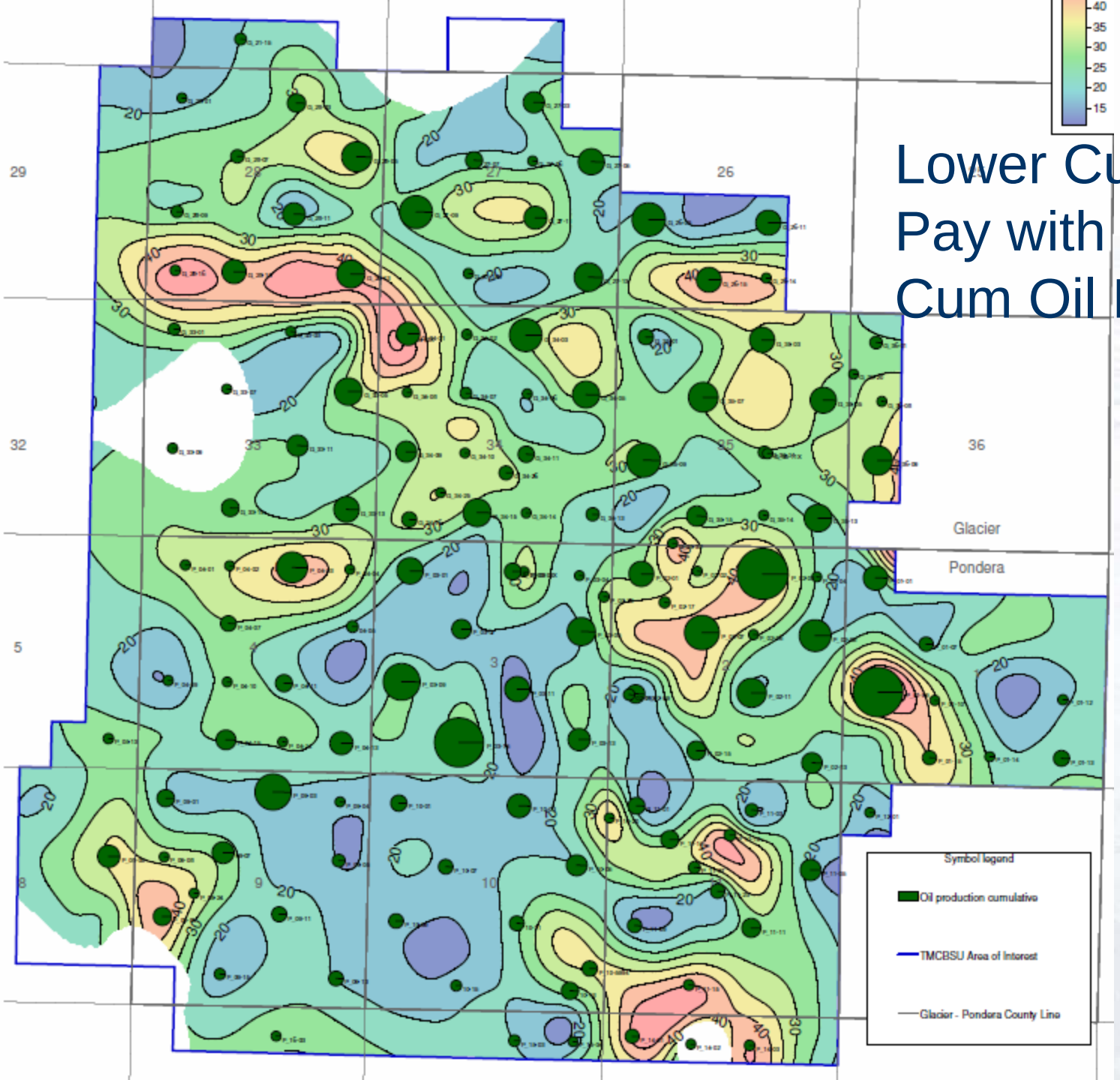
Lower Cut Bank Net Pay with Cum Oil Production



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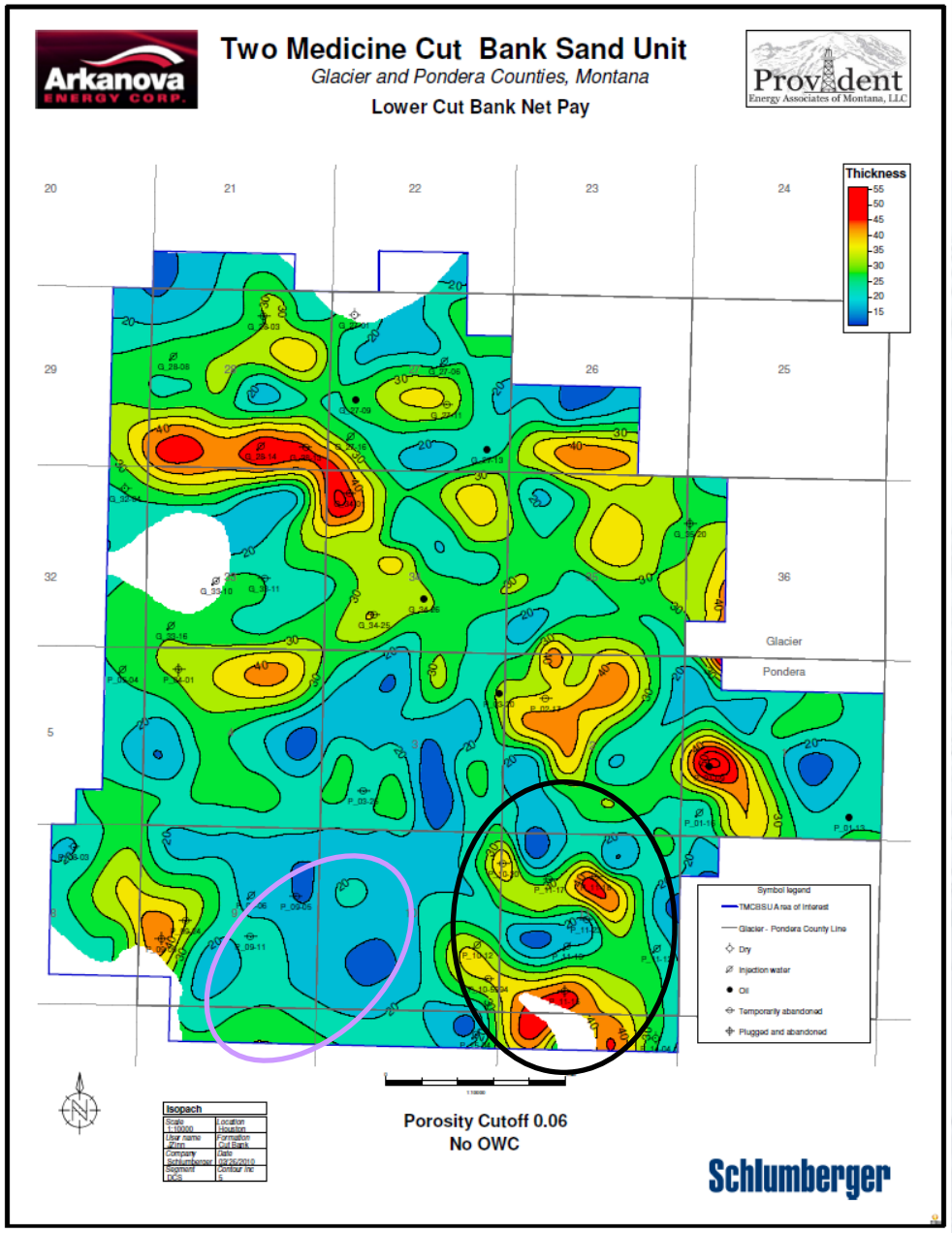
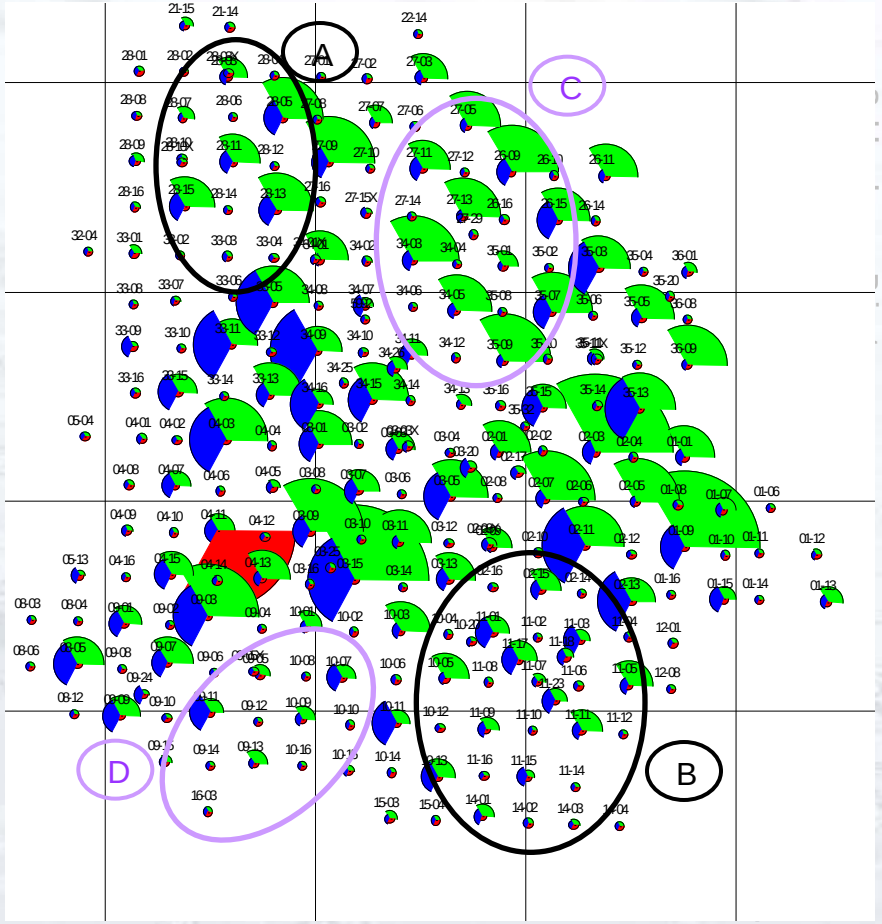
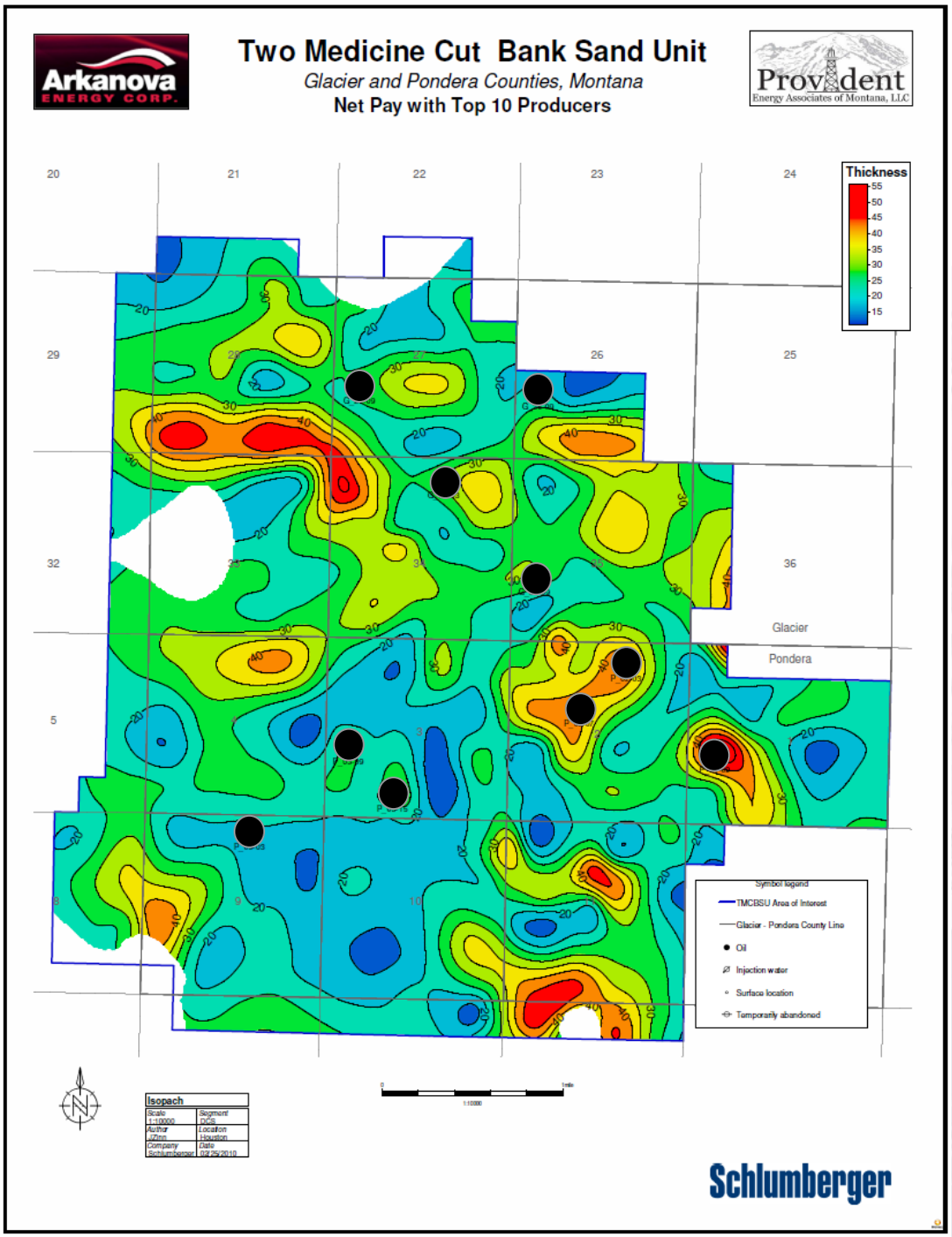
Lower Cut Bank Quality affecting Production







Top 10 Producers Lower Cut Bank

Cum oil production >150 Mbbl

Range 155 – 279 Mbbl

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TMCBSU Top 10 Producers – Lower Cut Bank

TMCBSU TOP PRODUCERS

Well Name	Cum Oil Production Mbbl	Perf Interval ft.	Years on Production	Top LCB TVDSS ft.	LCB Gross Th ft.	LCB Net Pay Th ft.	LCB Av. Porosity
P 02-03	279	27	13	566	42	42	0.12
P 01-09	268	38	27	617	58	54	0.07
P 03-15	265	24	21	461	28	28	0.17
P 03-09	182	14	13	432	26	26	0.19
P 09-03	178	11	24	393	17	17	0.13
P 02-07	168	20	10	545	44	41	0.13
G 35-09	162	30	13	517	29	29	0.11
G 26-09	159	18	20	504	21	21	0.07
G 27-09	156	21	17	432	40	26	0.10
G 34-03	155	2	15	492	36	30	0.13

AVERAGE GROSS THICKNESS FT.	29
AVERAGE PAY THICKNESS FT.	26
AVERAGE POROSITY	0.11
TOP LCB STRUCTURE	670

Observations - Top Producers >150Mbbl

Structurally higher locations

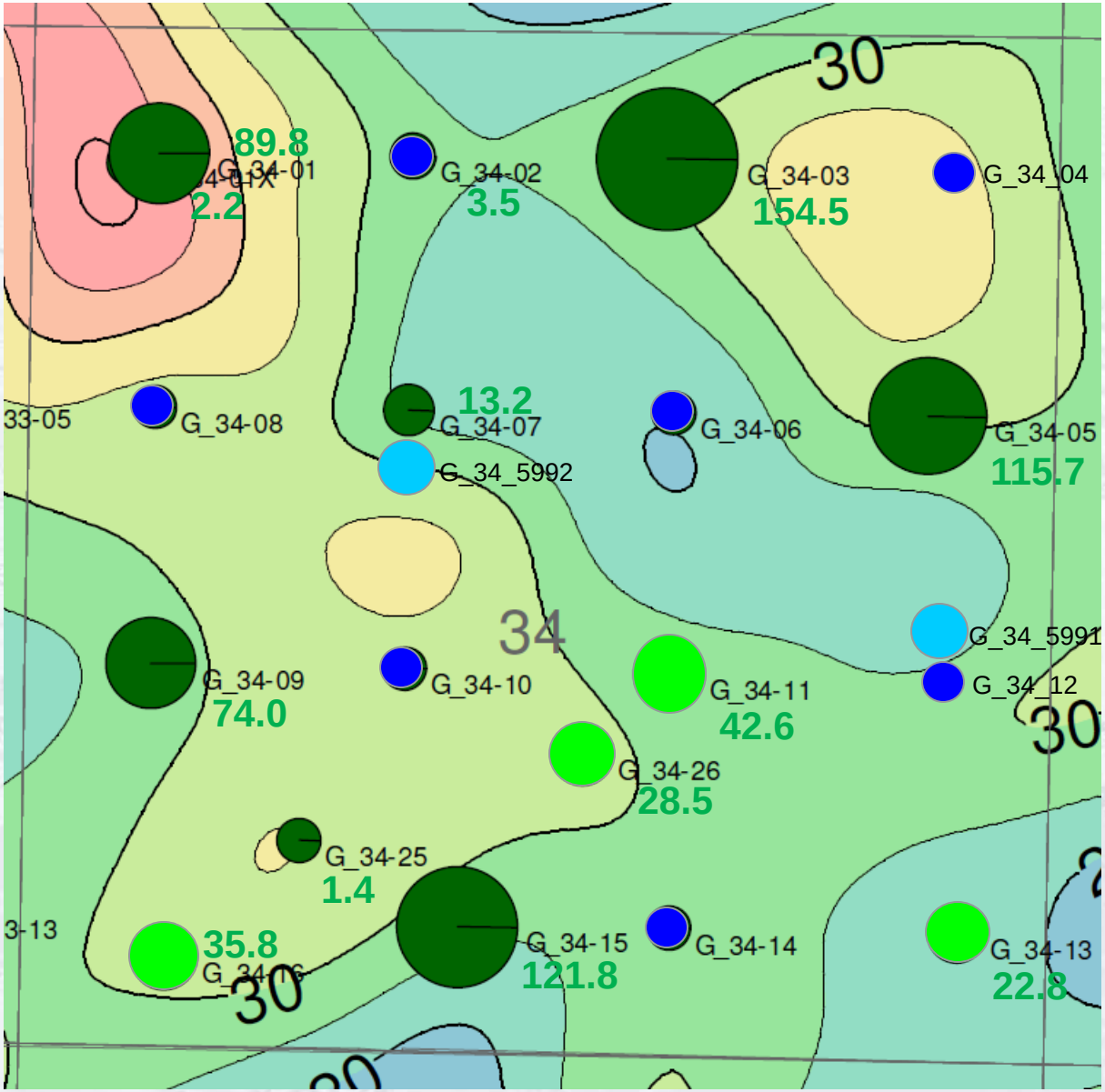
Gross and net pay thickness above field average
LCB Gross (29ft) and Net Pay (26ft) thickness,

Sand porosity above 0.11

Years on Production >10

Perforation interval variable 2 – 27ft

TMCBSU Glacier Section 34 Production – Lower Cut Bank



Representative Section from Field
21 wells
12 Producers
4 Active Producers

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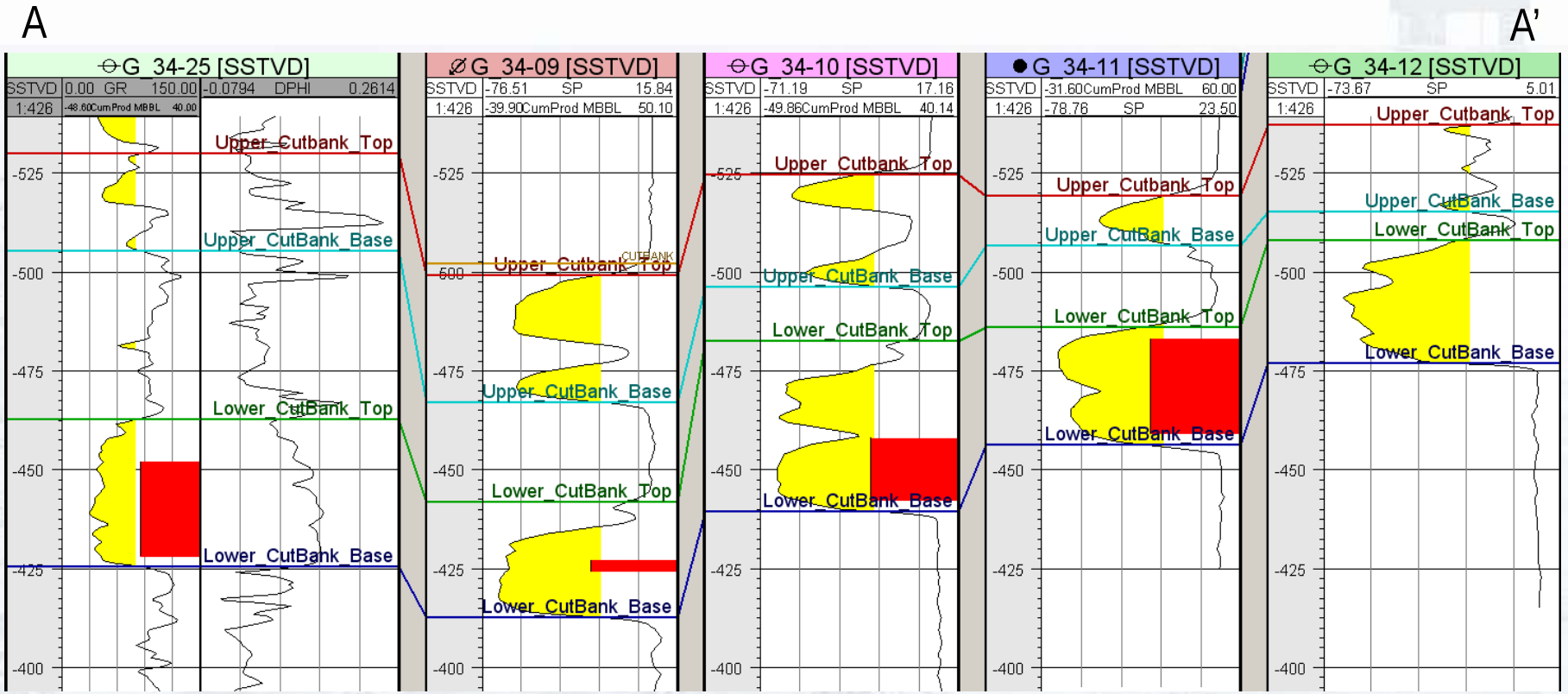
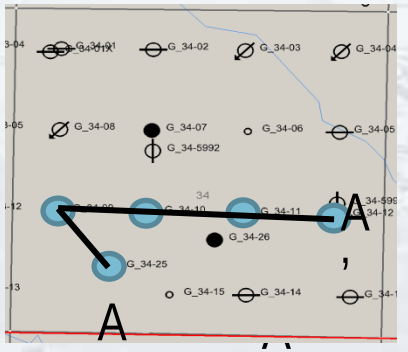
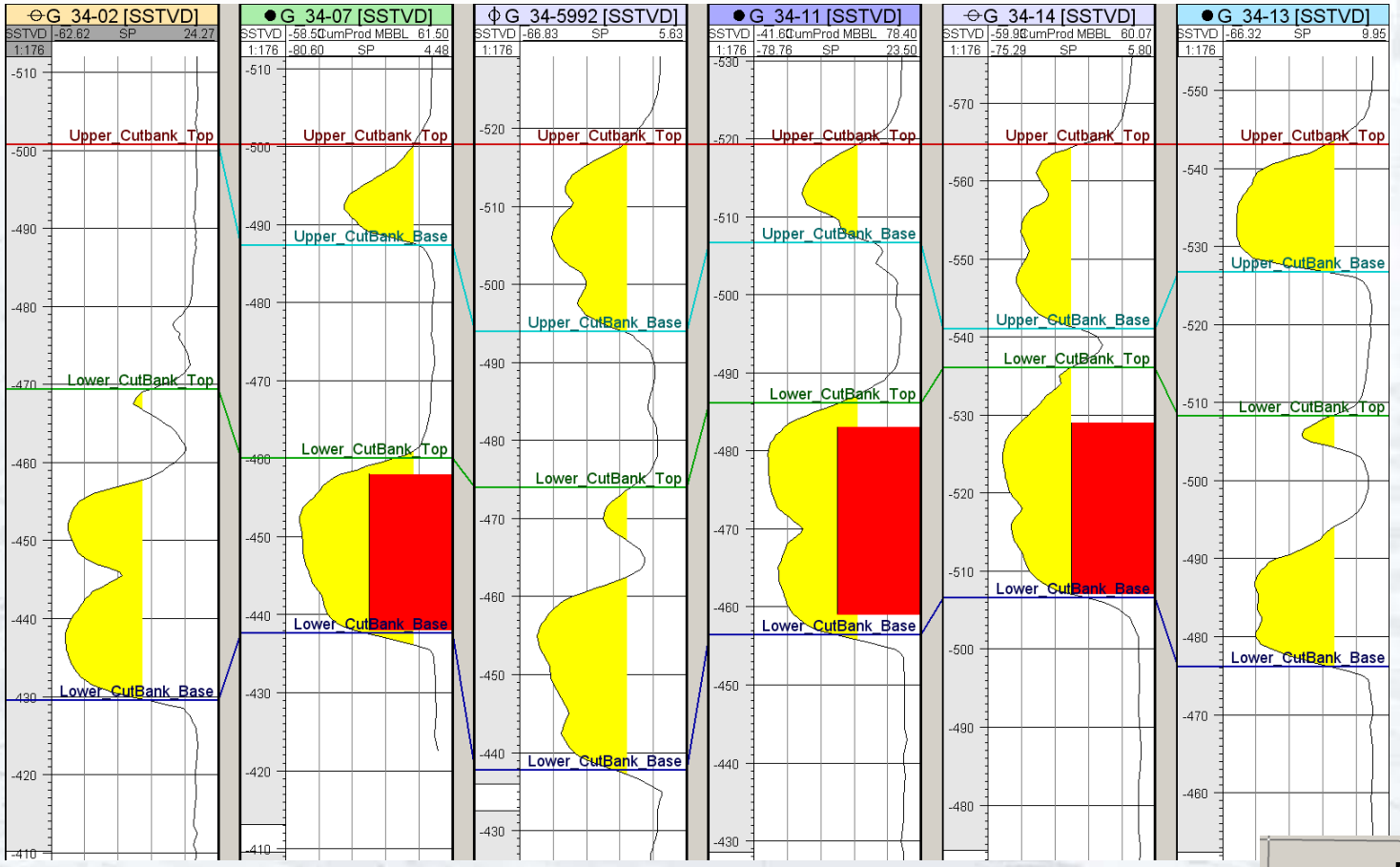
TMCBSU Glacier Section 34
E-W Cross section





TMCBSU Glacier Section 34
N-S Cross section

B



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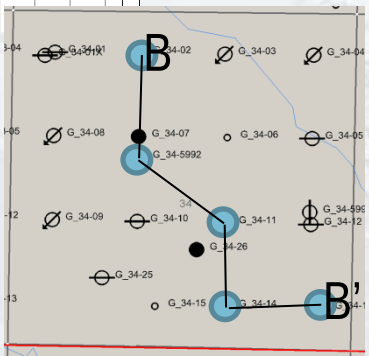

TMCBSU Glacier Section 34

Well Name	Status	Cum Oil Production Mbbl	Perf Interval ft.	Years on Production	Top LCB TVDSS ft.	LCB Gross Th ft.	LCB Net Pay Th ft.	LCB Av. Porosity
34-03	OIL_SI	154.5	2	16	492	35	28	0.14
34-15	OIL_SI	121.8	23	19	476	30	26	0.12
34-05	OIL_SI	115.7		10	506	41	31	0.11
34-01	OIL_P&A	89.8		10	459	47	45	0.18
34-09	OIL_SI	74.0	3	15	441	29	26	0.12
34-11	OIL_ACT	42.6	24	29	485	29	26	0.11
34-16	OIL_ACT	35.8	16	20	455	32	19	0.12
34-26	OIL_ACT	28.5	22	18	489	41	31	0.11
34-13	OIL_ACT	22.8		8	507	31	21	0.12
34-07	OIL_SI	13.2	20	13	459	22	22	0.15
34-02	INJ	3.5		0.3	469	40	27	0.18
34-01X	OIL_SI	2.2		4	459	54	51	0.18
34-25	OIL_SI	1.4	24	2	462	37	35	0.12
34-08	INJ	0.3		0.1	437	34	32	0.15
34-10	INJ	0.1	16	1	482	43	34	0.12
34-14	INJ	0.1	22	0.5	536	30	28	0.12
34-06	INJ	0.0	16	0.1	482	21	19	0.12
34-04	INJ	0.0		0	518	45	37	0.11
34-12	INJ	0.0		0	507	30	26	0.11
5991	Water Source				497	19	16	
5992	Water Source				474	36	31.2	

AVERAGE GROSS THICKNESS FT.	29
AVERAGE PAY THICKNESS FT.	26
AVERAGE POROSITY	0.11

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Observations – Glacier Section 34

- CB Sand profiles change in thickness, shale breaks, heterogenous fluvial reservoir
- Productive wells (13 - 151 Mbbl) in similar structural position in field (441 – 507 ft TVD)
- Many Producers associated with above average LCB Gross (29ft) and Net Pay (26ft) thickness, and Porosity >0.11
- Years on Production - Broad range 8 to 29 years
- Perforation interval - Variable 8 to 29 ft.
- Waterflood/completion efficiency important factors
- Poor producers 34-02, 34-01X and 34-25 short production life, depletion, ? completion/engineering issues

Summary

Lower Cut Bank - High Remaining Potential

LCB Top producers associated with higher structural locations and greater reservoir thickness and quality, net sand pay >25 ft, porosity >0.11

No LCB OWC observed

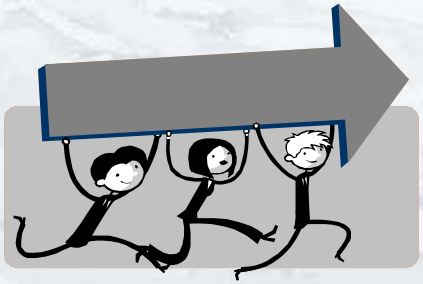
Numerous infill locations from geological standpoint

Upper Cut Bank - Possible secondary target

Deliverables – Phase 3

- Structural maps of upper and lower Cut Bank sand units
- Gross sand thickness maps of upper and lower Cut Bank sand units
- Net sand thickness maps of upper and lower Cut Bank sand units
- Net Pay thickness map of lower Cut Bank sand unit
- Summary presentation in Powerpoint
- 3-D Petrel model
- Digital log files

The Way Forward



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Proposed Next Steps

- Geological Evaluation
  - Integrate geological, production, injection and field data for well location selection
  - Estimate Lower Cut Bank volumetric OOIP using Static Model
- Reservoir Simulation
  - Perform Numerical Simulation and additional Production Analysis for waterflood evaluation, fracture analysis, reserve calculation, etc. concurrent with field data acquisition program
- Field Development Planning
  - Recommend drilling, logging and formation testing plans for both Cut Bank and Baaken in new wells
  - Collaborate on field development strategies
    - Infill Drilling with Pressure Maintenance
    - Waterflood Reinstallation

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Lower Cut Bank OOIP

Validation of OOIP using current Petrel geological model

- OOIP & Reserves Estimates: OOIP: 627 bbls/acre-ft ⇒ **105,390 Mbbls**

  Primary RF: 7.7% (48 bbls/acre-ft) ⇒ 8,068 Mbbls

  Secondary RF: 26% (164 bbls/acre-ft) (w/water flood): ⇒ 27,567 Mbbls

- TMCBSU Cumulative Production of 10.48 MM bbls of oil estimated by SLB (2009) . (Approx. 10% Recovery) and Estimated Remaining OIP: **94.590 MM bbls of oil**
- Reactivation of waterflood could yield an additional 16 -17 MM bbls of oil
- Decline curve analysis of 71 wells suggested a potential recovery of 250,000 bbls – 555,000 bbls.
- Gustavson (2008) estimated 292,109 bbls net reserves from 30 wells (PDP, PDNP and PUD)

**Reference: BLM Report 1996, Gustavson 2008, Arkanova 2008 Annual Report, & Schlumberger 2009*

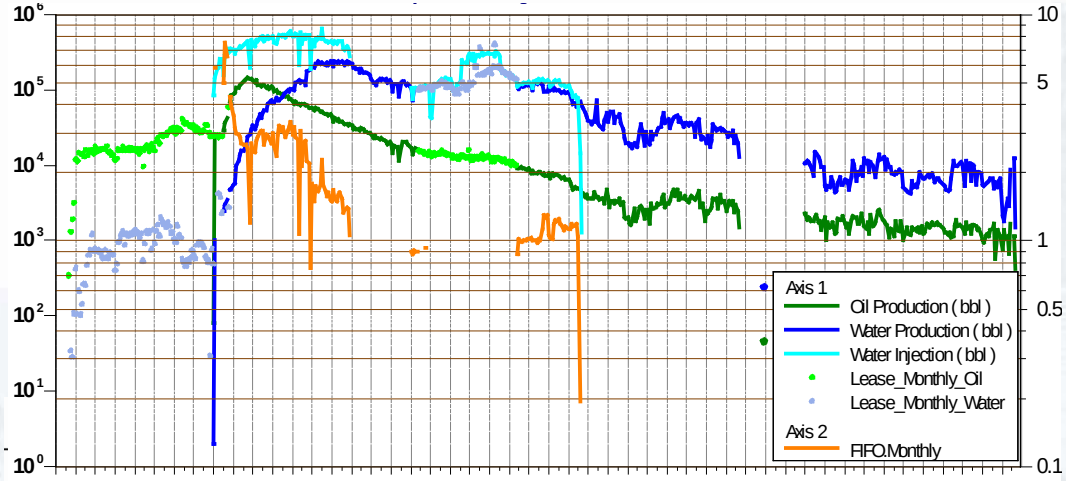
Integration:

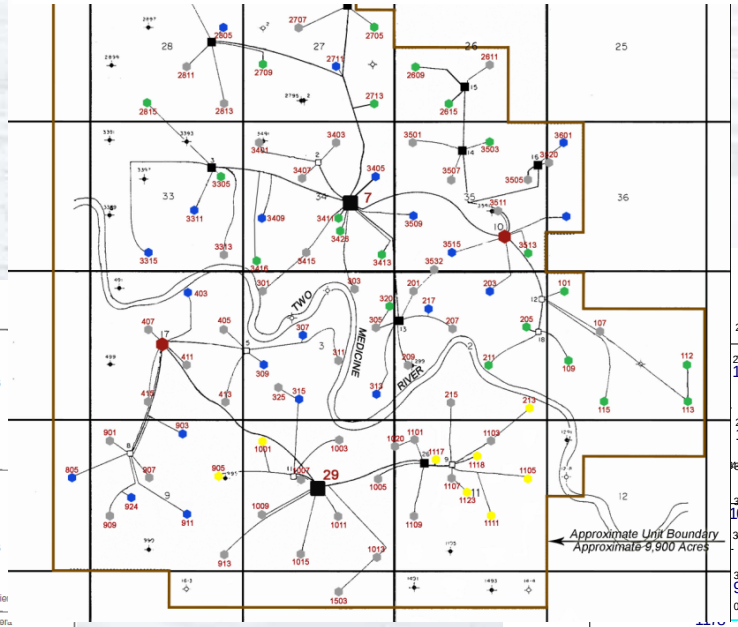
Geology

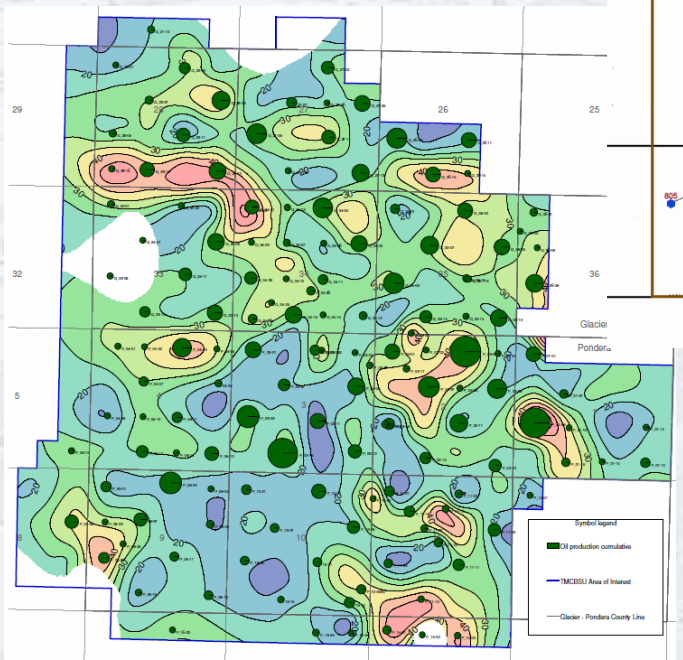
Production

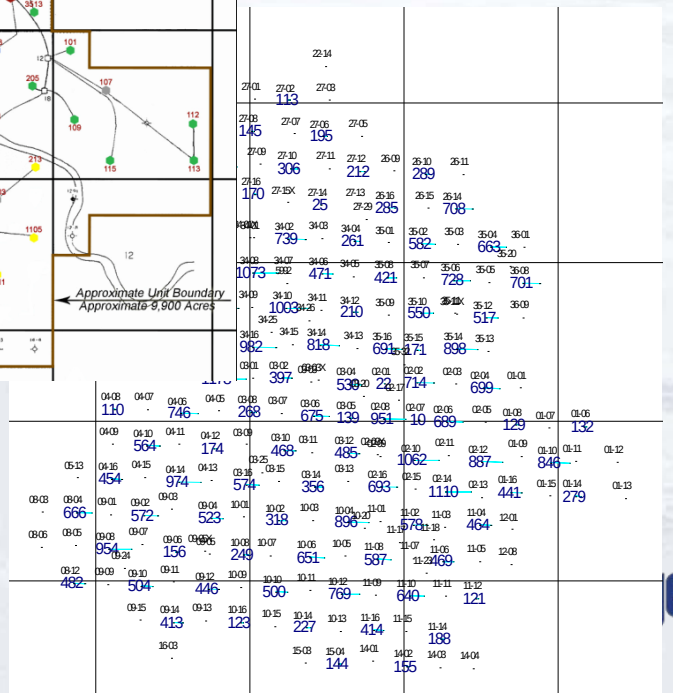
Waterflood

Field History



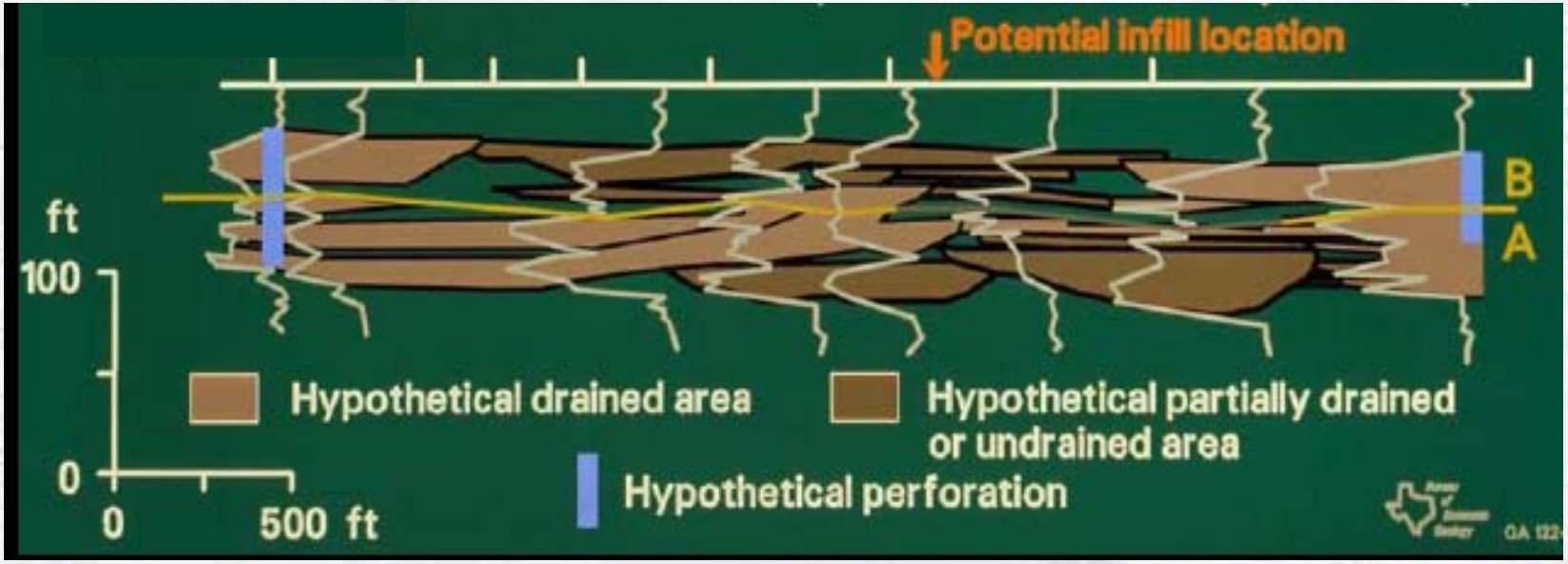






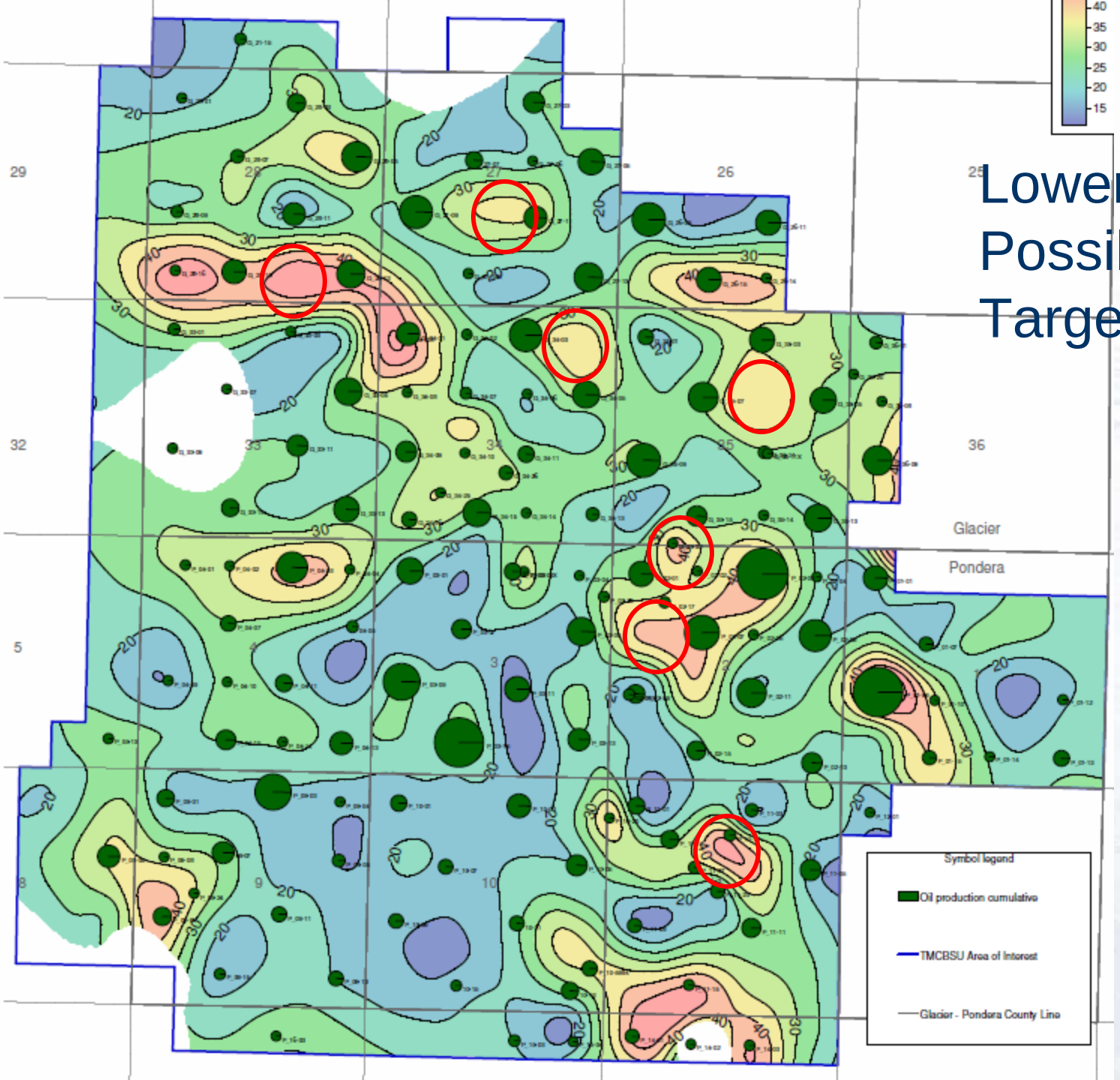
Infill Drilling Locations

Selection of new well locations in areas of good reservoir quality and structural position with remaining unswept potential.



after Jackson et al. (1988)

Lower Cut Bank Possible Infill Targets



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Next Phase - OOIP & Well Locations

- Geological Evaluation – Follow on to Phase 3 Mapping
  - Lower Cut Bank volumetric OOIP estimate using Static Model – 1 week (geologist)
  - Integrate geological, production, injection and field data to select new well locations – 3 to 4 weeks (geologist and production engineer)
  - Recommendations on infill vertical wells for 2010 drill locations
  - Completion by end March.

Thank You

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