General Outline

- Introduction
- Beginning the Project
  - Formation of the team
  - Monitor wells and data acquisition
  - Early well design
  - First horizontal
- Lessons Learned
  - Wellbore stability issues
  - Well construction and design
- Current Drilling Techniques
  - BHA design
  - Directional planning/considerations
  - Geosteering
- Future Plans
  - Drilling/Completion optimization
Beginning the Project

- Spreading our HES culture
  - New area, same culture

- Formation of Highly Integrated Team
  - Diversified, yet focused

- Ensure overall project success
  - Efficiency
  - Adaptability
  - Flexibility
  - Creativity
General DJ Basin Information

- Ranges from 275 to 400 feet thick in the DJ Basin
- Thickness increases to the west
- Interbedded brittle chalk and ductile shale
- Three main carbonate-rich benches 10 to 25 feet per bench, total thickness up to 70 feet thick
- 5 to 12% porosity
- Small faults are common in Niobrara
- Oil is self-sourced from interbedded organic-rich shales
Evaluating the Niobrara

- Monitor/Test Wells
- Data Acquisition
  - Drilling data
  - Geological samples
  - Extensive wireline logging
  - Reservoir data
  - Frac Monitoring/Evaluation
  - Vertical Seismic Profiles
- Permit two possible horizontals, choose one.
- Establish development areas/techniques
Sh-max/Sh-min orientation and lateral placement

Drill the lateral as perpendicular to SHmax as possible (parallel with Sh-min) in order to maximize the hydraulic fracture stimulation.
Coring Operations

354.5 ft of whole core

A
B
C

Sharon Springs
UB
B
C

Fort Hays

Greenhorn (calcite-rich siltstone showing Inoceramus traces)

Natural fracture stained with oil (core depth at 6873 ft)

Fault and N. Fractures showing N 58 E strike directions in line with the present day stress Field.

Oil seeping out from Niobrara chalks and marls
Early Horizontal Well Design

- Set 20” conductor at +/- 90’
- Drill 17-1/2” hole to +/- 750’
- Set 13-3/8” surface casing
- Drill 12-1/4” intermediate hole
  - Vertical to KOP @ +/- 5500’
  - Drill curve w/ 6 deg./100’ BR – land @ ~90 deg.
  - Drill +/- 5000’ lateral to +/-11000’ TMD
- Set 9-5/8” intermediate casing
- Drill 8-3/4” production hole
- Set 5-1/2” production casing
Obviously, we ran into a few problems...

- Not getting BR’s, TOH to dial up motor multiple times
- Multiple wiper trips due to Sharon Springs
- Drill out of 9 5/8” casing
- Run drillable casing with reamer shoe to get through Sharon Springs
- Ran 9 5/8” casing - could not get through Sharon Springs
- Attempt to run 7” liner multiple times
Lessons Learned

- In-house drilling specialists conducted wellbore stability research from horizontal well data, monitor well logs, & directional plan
  - Discovered root cause – mechanical instability, not chemical
  - Back to the drawing board
  - Tailored directional plan to incorporate findings

- Well Construction:
  - Smaller hole sizes, smaller directional tools, higher build rates, less shale exposure

- Discussed with company men the importance of monitoring hole conditions through curve
Current Niobrara Well Design

- Set 16” conductor at +/- 90’
- Drill 12-1/4” hole to +/- 750’
- Set 9-5/8” surface casing
- Drill 8-3/4” intermediate hole
  - Vertical to KOP @ +/- 5500’
  - Drill curve w/ 10-12 deg./100’ BR
  - Land curve in Nio B interval at +/-90 deg. inc.
- Set 7” intermediate casing
- Drill +/- 5000’ of 6” lateral to +/- 11,000’ TD
- Run 4-1/2” cemented liner
Drilling Issues - Faulting

Courtesy of Geophysical Pursuit, Inc - Geokinetics
Saw most faults on seismic, able to plan wellbore through them, threading the needle.
Geosteering - Faulting

Horizon Key:
- Sharon Springs
- Niobrara A
- Niobrara B
- Mid B
- Lwr B

Heel, assuming 700’ from SL

*Depth Lines every 50’

18’ fault
12’ fault
35’ fault
BHL

Courtesy of Geophysical Pursuit, Inc - Geokinetics
Thrust Fault
60' of throw
Not seen on seismic

Bed dips of ~10°/100°
Wellbore incs of over 103°
Where we are now

Horizontal Wells Days vs. Depth
Moving Forward

- Pushing the technical limit
  - Implementing drilling technology/equipment
  - Evaluation of current contractors and service

- Multi-well pads
  - Reducing rig move distance/time

- Evaluating fracs through monitor wells – optimizing design

- Deeper horizons?
Niobrara Resource Play

Questions?