Develop by Vertical or Horizontal Wells? a four mile area (2560 acres)

Vertical wells - 64 vertical wells on 2 acre pads uses 128 acres of land, about 26 miles of roads, 26 miles of pipelines, plus 4 to 8 facility pads to effectively capture the gas reserves.

Horizontal wells – 16 horizontal wells from 1 pad of 6 acres, with 2 miles of roads, 2 miles of pipeline and one facility on the same pad as the wells.

Horizontal well advantages:

- Less land used & placement choices,
- Fewer roads and pipelines,
- Less traffic,
- Less dust,
- Less urban & wildlife disturbance,
- Less air pollution.
- All wells penetrate the ground in the same area – can be easily monitored

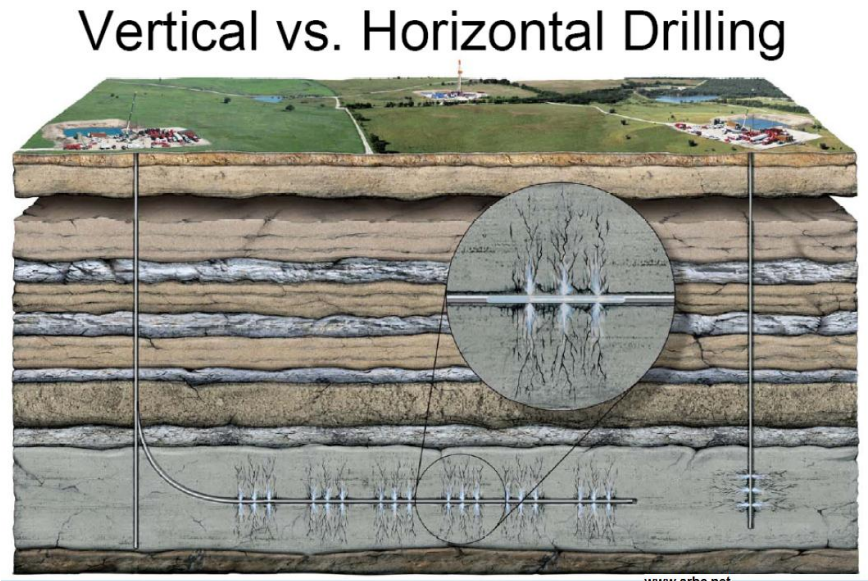
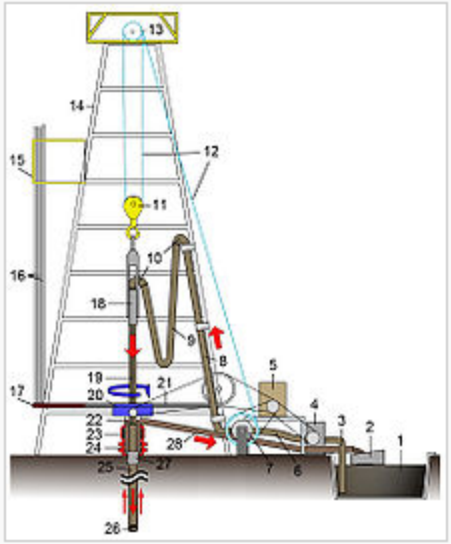


Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*

The Drilling Rig



Simple diagram of a drilling rig and its basic operation

1. mud tank
2. shale shaker - separates cuttings from mud
3. mud intake to pump (recirculates mud downhole)
4. mud pump (pumps mud to the drill pipe)
5. motor for powering pumps and other equipment
6. flow line (mud supply line)
7. lower shieve (pulley) on the draw works
8. stand pipe (rigid)
9. flex hose
10. connection unions
11. traveling block
12. braided lines
13. crown block
14. drilling derrick
15. pipe rack or finger board for supporting joints of drill pipe or tubing
16. drill pipe or tubing joints standing in derrick
17. rig floor
18. rotating head
19. Kelly (turns the drill string)
20. rotary table (turns the Kelly)
21. drive system to the roary table
22. Kelly bushing
23. annular preventer (a bag-like rubber element that seals around irregular surfaces)
24. blow out preventers (BOP)
25. drill pipe in the well
26. drilling BHA (bottom hole assembly - bit and drill collars)
27. surface casing segment with wellhead flange
28. mud return line

Water Storage for Drilling and Fracturing

Fresh water storage tanks eliminate large pits and can be temporarily positioned on land that will be reclaimed to farm or pasture land after the wells are completed.

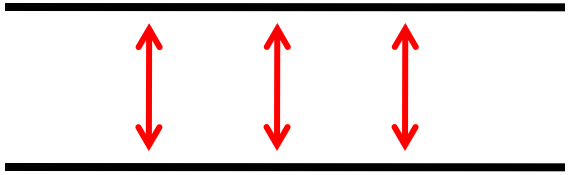
Chemicals do not have to be added until the water is used in the well.

Functions of Drilling Mud

1. Well Control – this is the front line, real time, active barrier between the formations drilled and the surface until the casing is set and cemented.
2. Cuttings removal from the well.
3. Fluid loss control
4. String lubrication
5. Bit lubrication and cooling

Well Control

- Drilling mud density is selected for a “window” of pressure operation:
  - It must control the highest pore pressure (lower limit of mud weight),
  - Increasing the mud weight may help control shale “heaving” of movement at the borehole.

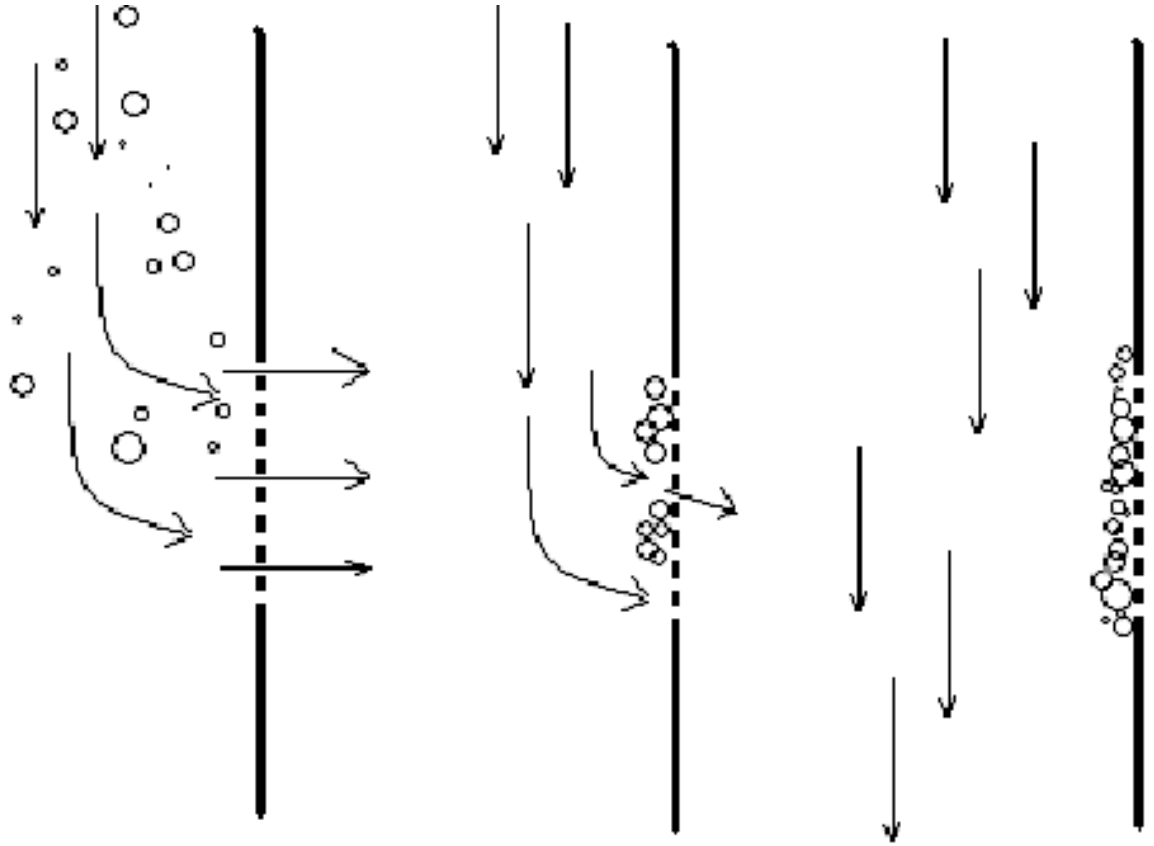


  - The mud must be low enough density to avoid accidently fracturing the weakest exposed formation, resulting in mud loss from the wellbore into a pay zone.

Building a filter cake:

Requires three things:

1. Permeability
2. Solids in the fluid
3. Pressure differential toward the formation

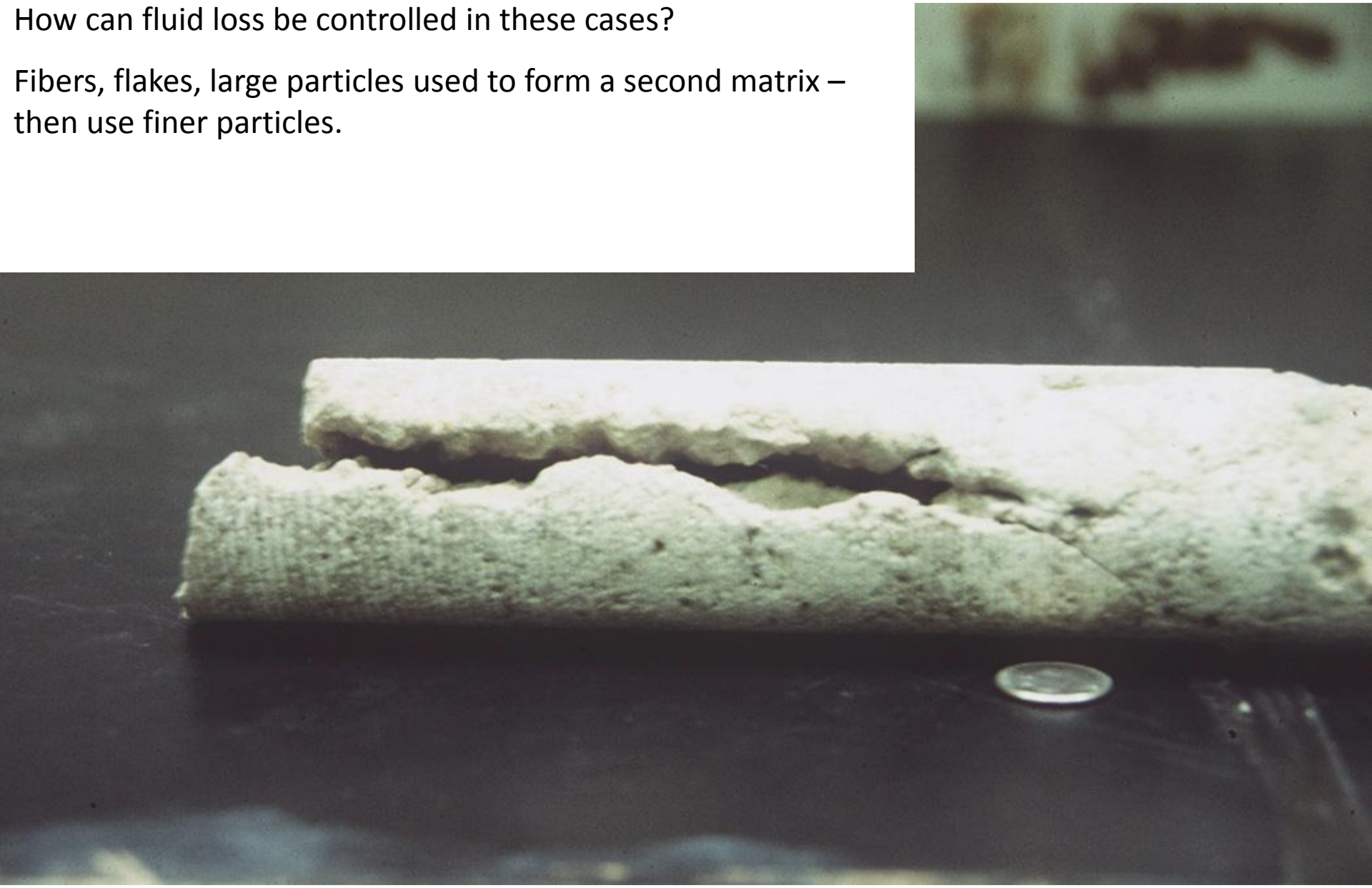


Fluid loss control may be achieved with a range of large, medium and small particles.

Fluid loss may be severe through wide natural fractures.

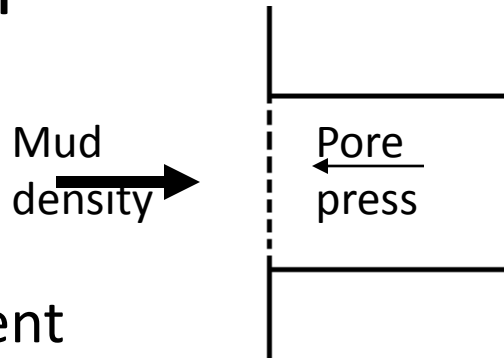
How can fluid loss be controlled in these cases?

Fibers, flakes, large particles used to form a second matrix – then use finer particles.



Drilling and Completion Overbalance - how much is enough?

- Overbalance is the amount of fluid density applied at the formation in excess of the pore pressure in the formation.
- Mud density determined by:
  - highest pressure exposed formation
  - swabbing and surge loads during string movement
  - influxes of fluids



- **Examples? - good crew & equipment, single zone = 200 psi**
- **Average? = 500 to over 1000 psi**
- **Special cases? – 2000 to 5000 psi overbalance (severe damage?)**