



Marcellus Shale Development Process

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Marcellus Shale Development



Preparation



Drilling



**Completion
& Production**



Reclamation



Preparation

Geoscientists determine drilling locations

- Surface, sub-surface maps
- 3-D seismic measurements
- State-of-the-art Technology



Seismic Survey

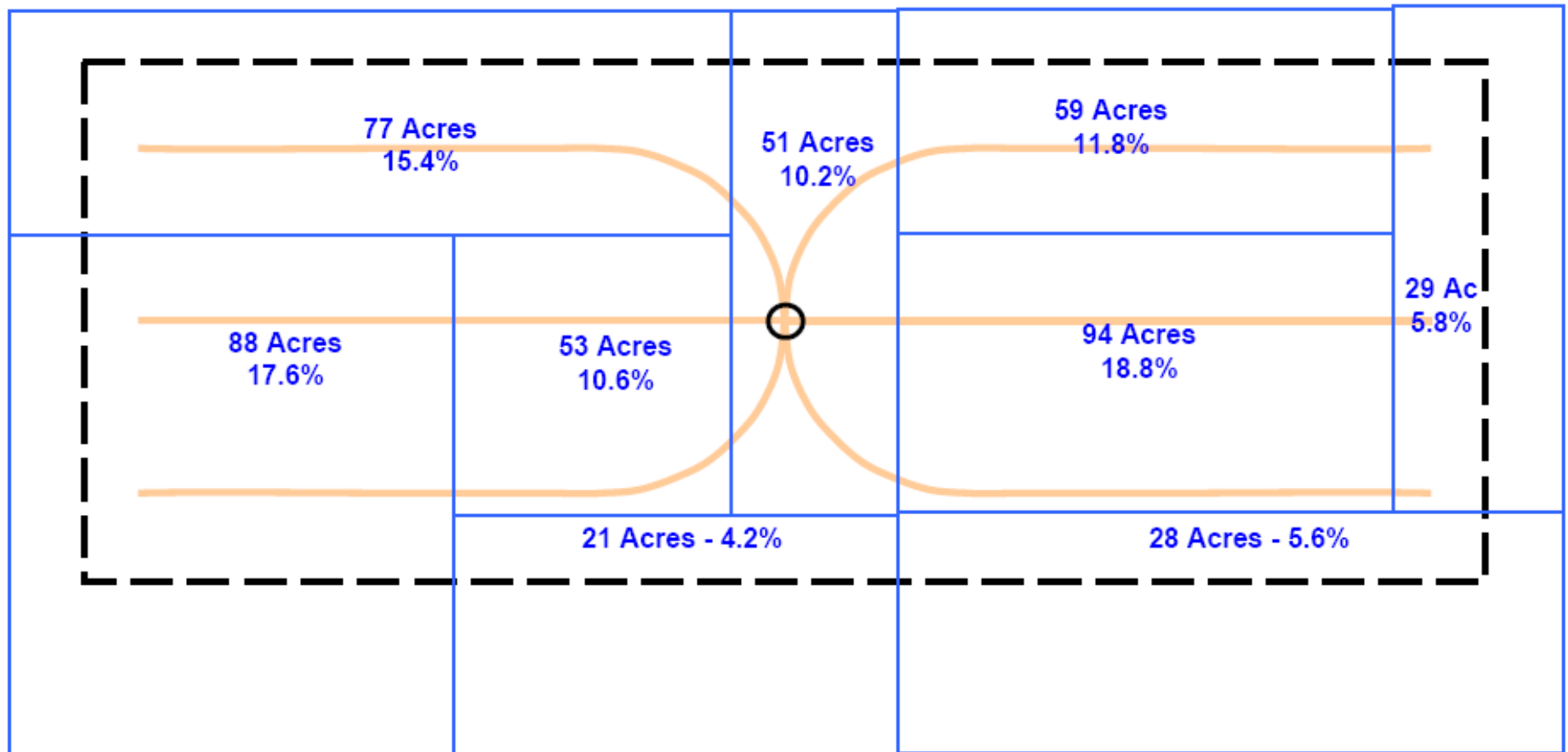


Leases are Acquired

- Oil & gas owners (frequently the surface owner) are offered compensation for leasing rights to their property
- In addition to initial lease payment, oil & gas owners also receive royalties on natural gas sold from the property



Lease Pooling



Royalties are divided in proportion to the percentage of land that each land tract contributes to the total unit



Preparation

Construction

- Well pad
- Access Roads
- Impoundments
- Pipelines
- E&S Plan Onsite
- BMP's in Place





Site Preparation



Drilling

- State-of-the-art technology
- Multiple wells, single site
- Footprint is 3-5 acres

Range's pioneering spirit continues...Patterson 315 was the first "walking" Marcellus Shale drilling rig

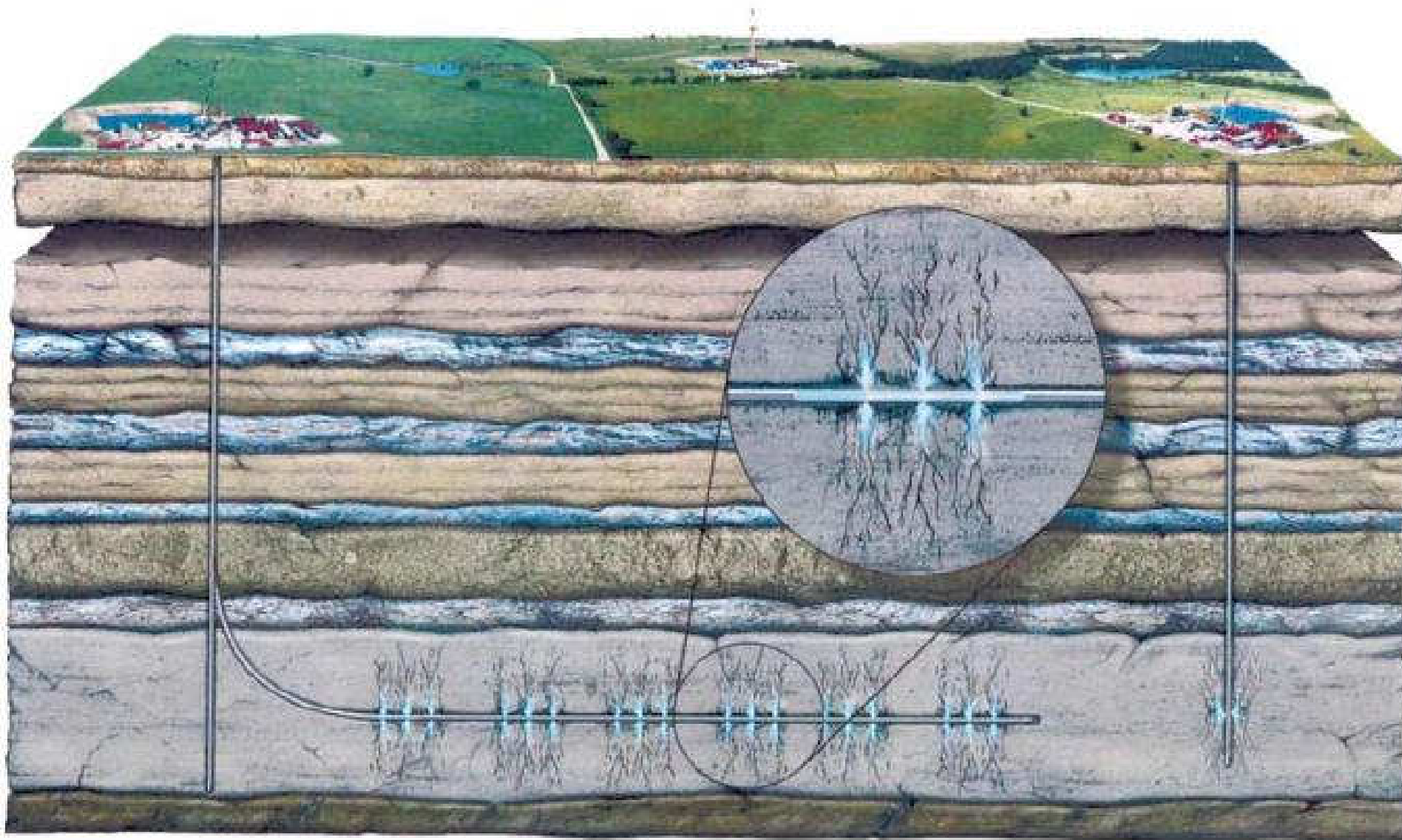


Horizontal Technology

- Drill 5,000-8,000' vertical up to 3,000' horizontal
 - Roughly 2 miles of drilling, spot-on accuracy
 - Reduce surface disturbance, with less environmental impact



... an 8-1/2" hole 2 miles long

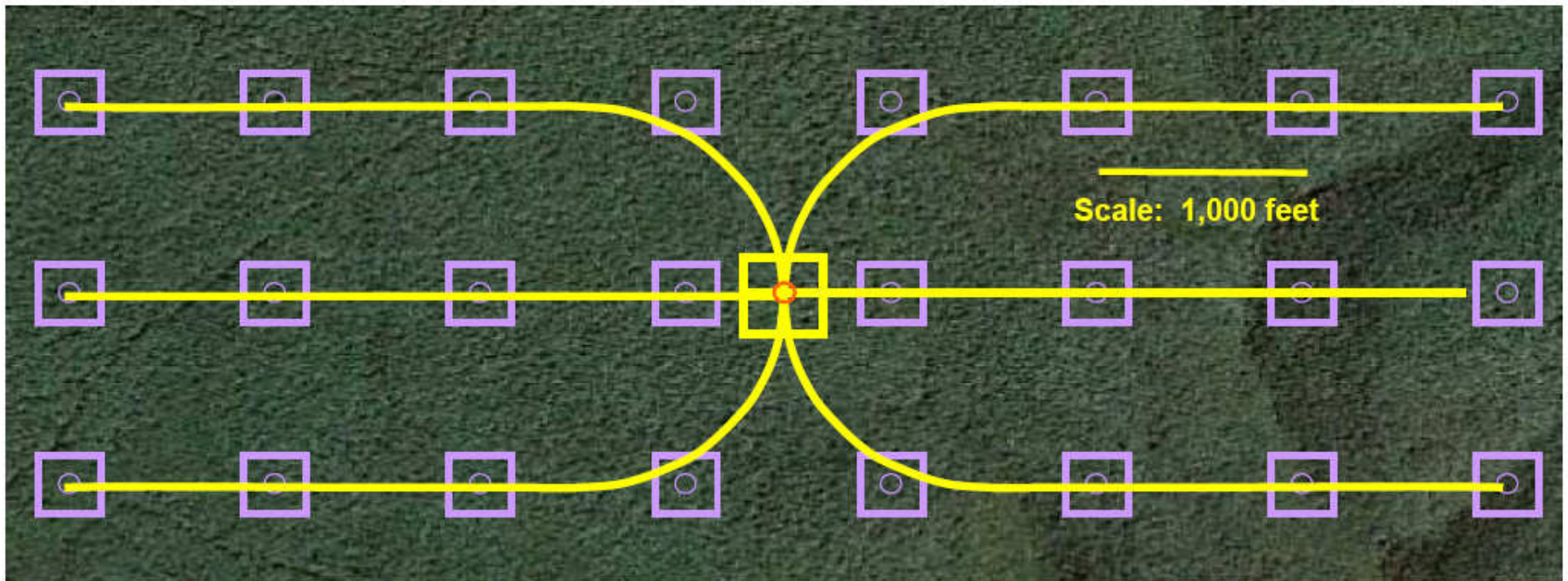


Horizontal Technology

John Perez Graphics



Horizontal Drilling



Total surface disturbance during drilling, including access road, drilling pad and required pipeline infrastructure:

- **Horizontal (yellow) develop 500 acres per pad with 2% surface disturbance**
- **Vertical (purple) on 1,000-foot spacing develop 23 acres per well with 19% total surface disturbance**



Horizontal

- **Greatly reduce surface impact**
- **Disturbance minimized**
- **Decrease construction time**



Vertical

- **More costly**
- **More surface disturbance**
- **Longer construction time**

General representation for visualization purposes



How Do You “Drill Horizontally”?

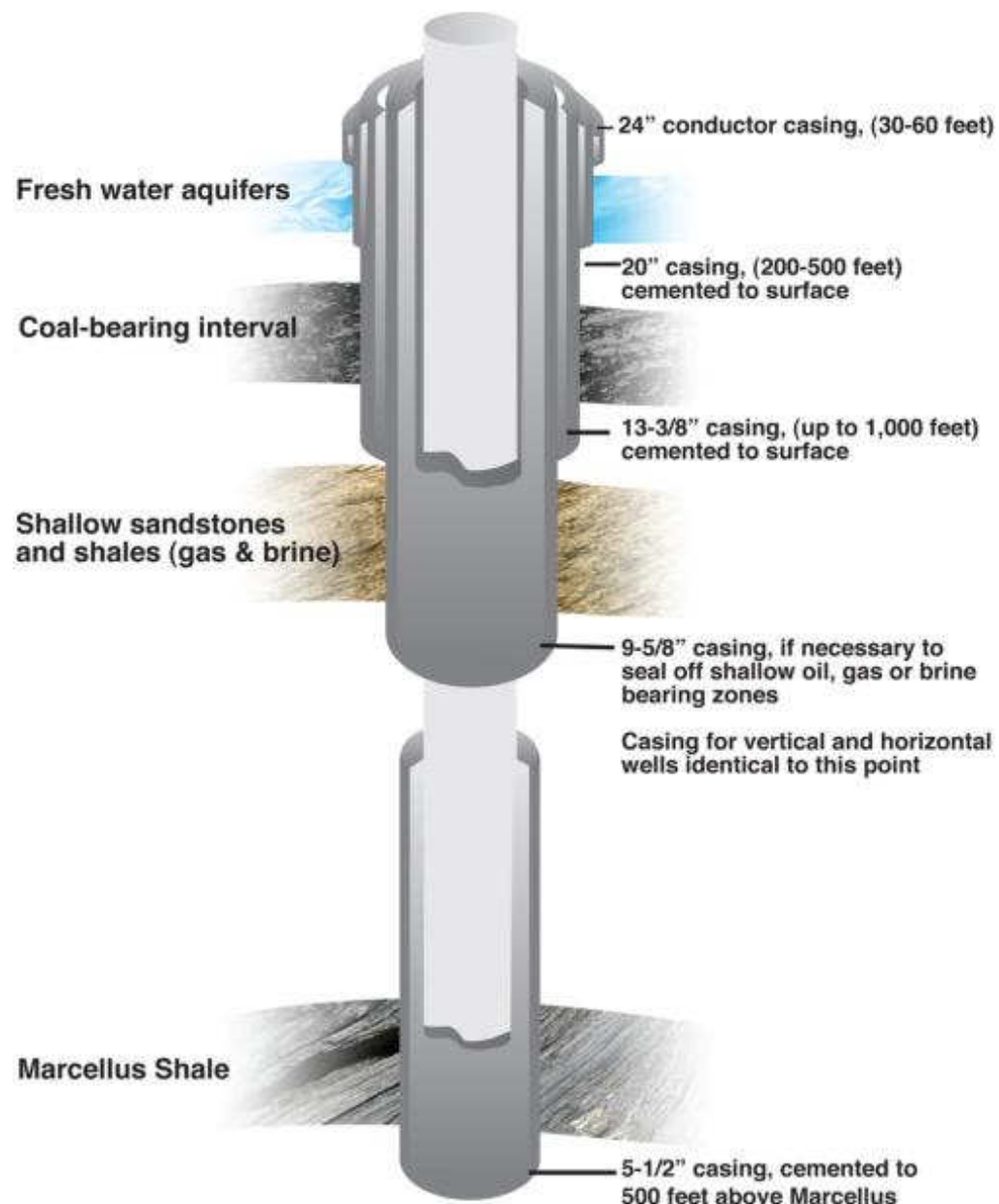
Small bend in drilling motor assembly, roughly $1-2^\circ$, drills the curve over the course of 900', at a rate of 10° per 100' to achieve a 90° turn horizontally.

It's not abrupt, rather a gradual sweeping motion.

Weatherford drilling technology



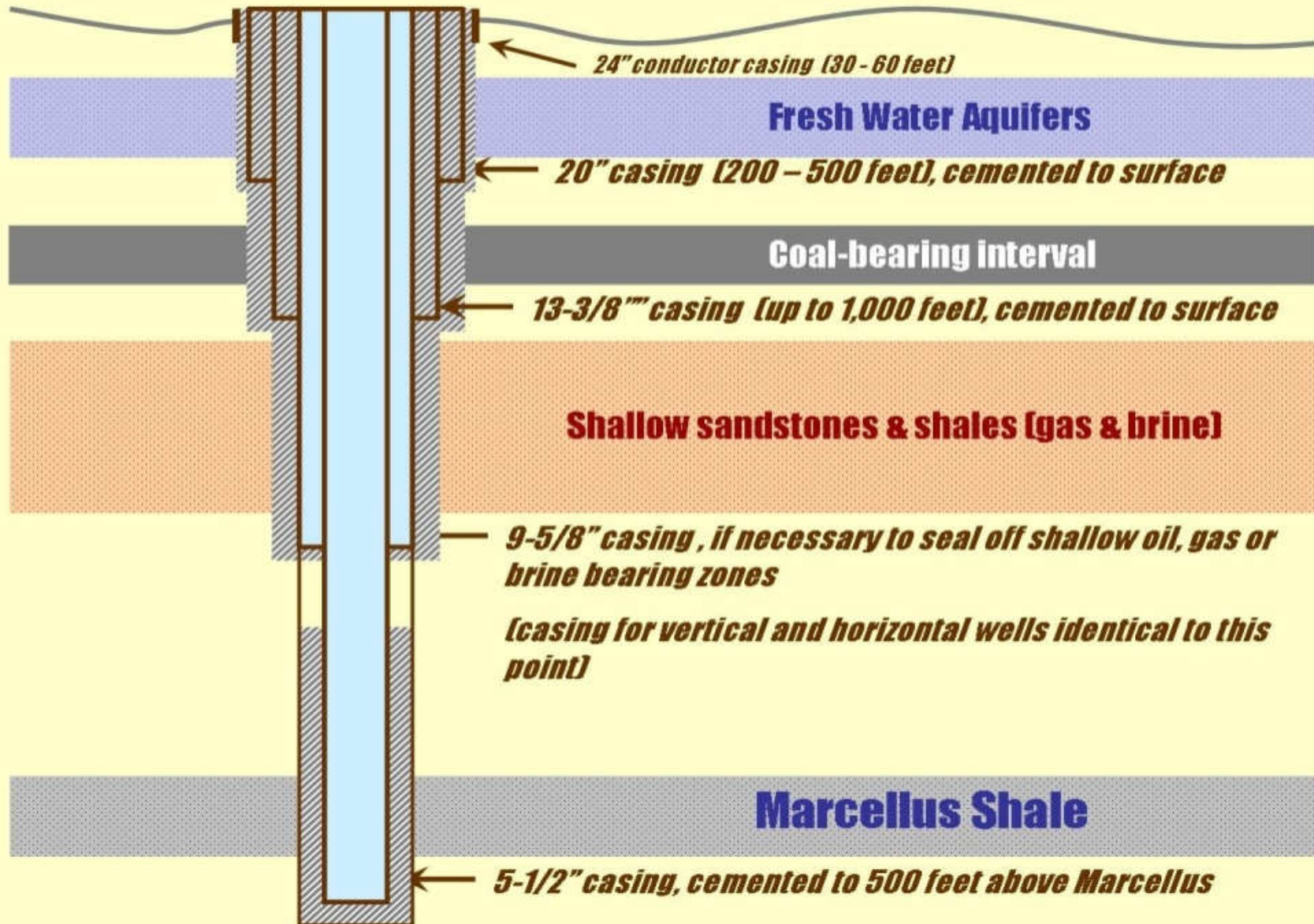
Generalized casing design for a Marcellus Shale gas well



Protection of Water Aquifers and Shallow Zones

Zonal isolation provided by multiple layers of steel casing and cement

Generalized casing design for a Marcellus Shale gas well



Another Look at Protections



Steel Casing



Drilling



Drilling



Drilling



Drilling



Drilling



Drilling



Drilling



Completion

Hydraulic Fracturing

- Fresh water and sand are pumped at high rates and pressure into the formation creating fractures.
- The water is flowed out leaving the sand to prop open the fractures.
- The propped fractures represent an increase in surface area allowing economic volumes of natural gas to travel back to the wellbore



Fracturing



Fracturing



Frac Van



Command Central



Fracturing



Fracturing



Water Impoundment



Water Transfer



Production

- Following frac, water is flowed back and gas flow is tested to ensure proper completion
- Small footprint – wellhead, separator, produced water tanks



Production, roughly size of a 1-2 car garage



Production



Production



Production



Production



Production



Reclamation

Work hard to
restore
property to a
condition the
same as or
better than
before the
process began



Flowback and Testing



5 Months Later

Paxton #1H, Washington County, Pennsylvania



Renz #1H, Washington County, Pennsylvania

First Modern Marcellus Well, initial reclaim



Partial Reclamation



Partial Reclamation



Final Reclamation



Reclamation



Reclamation



Thank You, Questions?

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