



Advanced Fluid Jet Systems For Increased Oil and Gas Production

Wellbore Extender

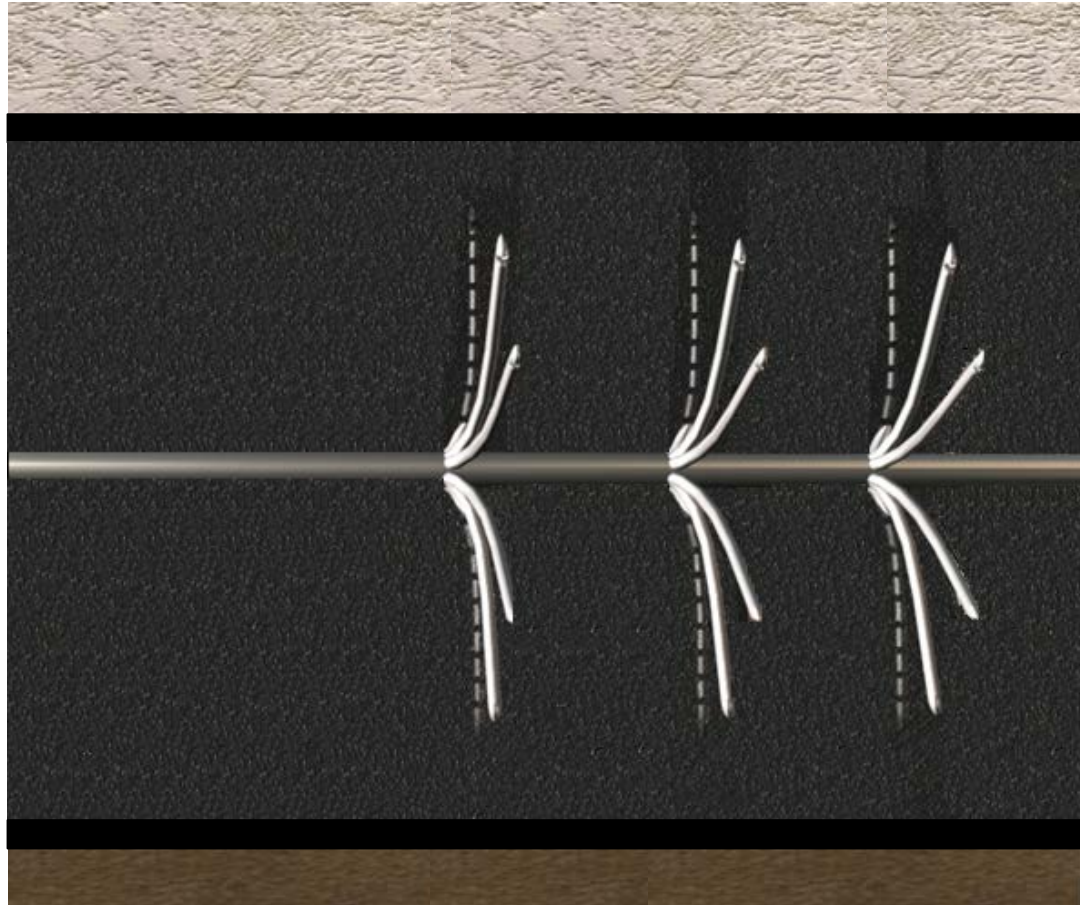
Directed Permeability Channels From Pre-existing Vertical Wells

- Improve reservoir communication
- Increase production
- Increase reserves
- Up to 100 m in length
- 100% permeability
- Flexible diameter hole
- Penetrate multiple horizons

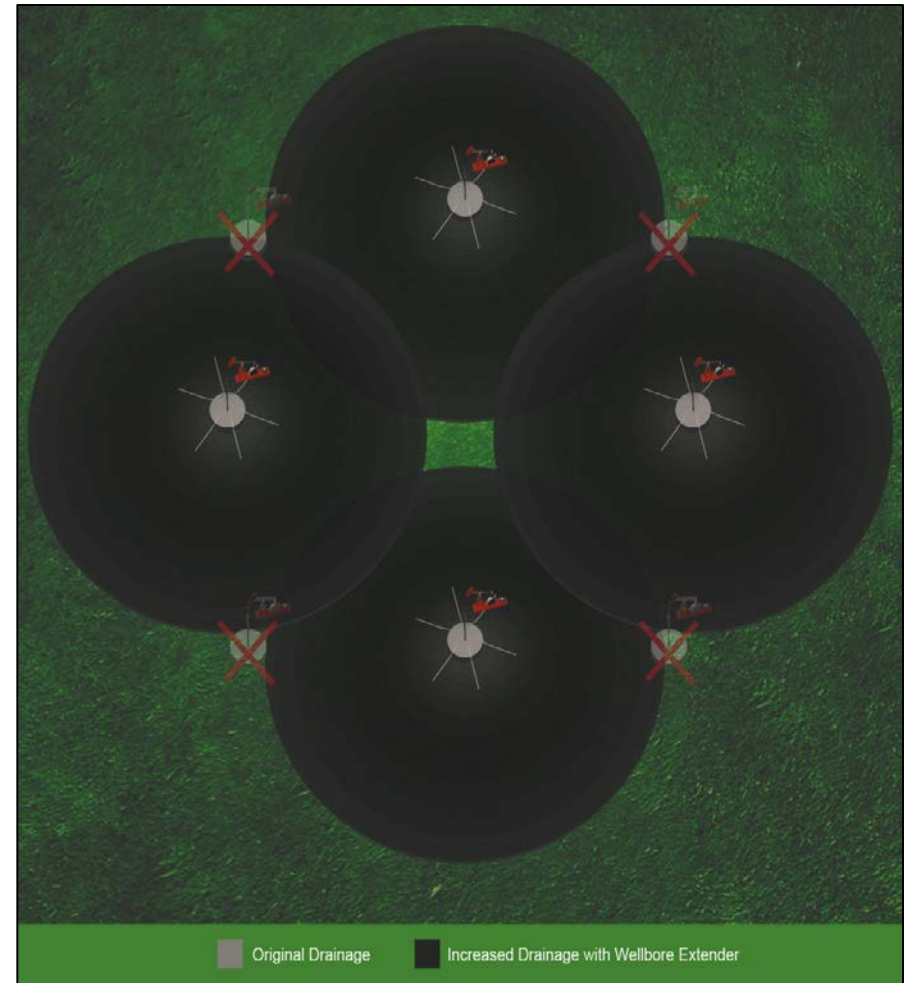
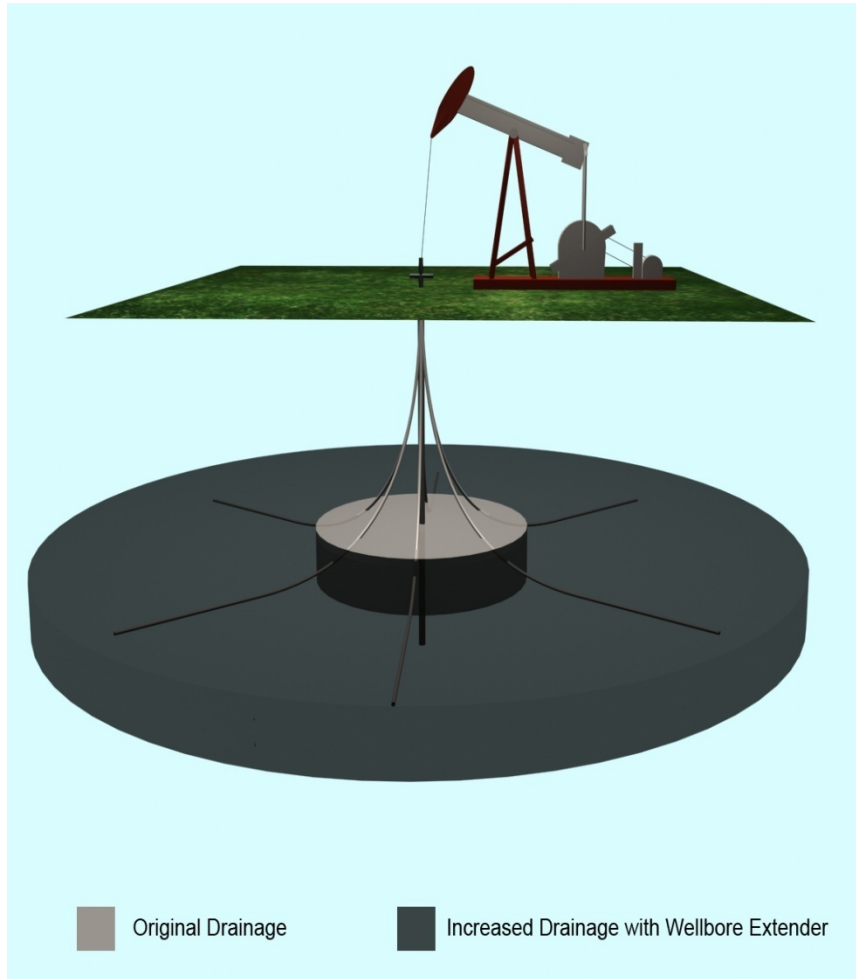


Wellbore Extender

....Or from Horizontal Wells



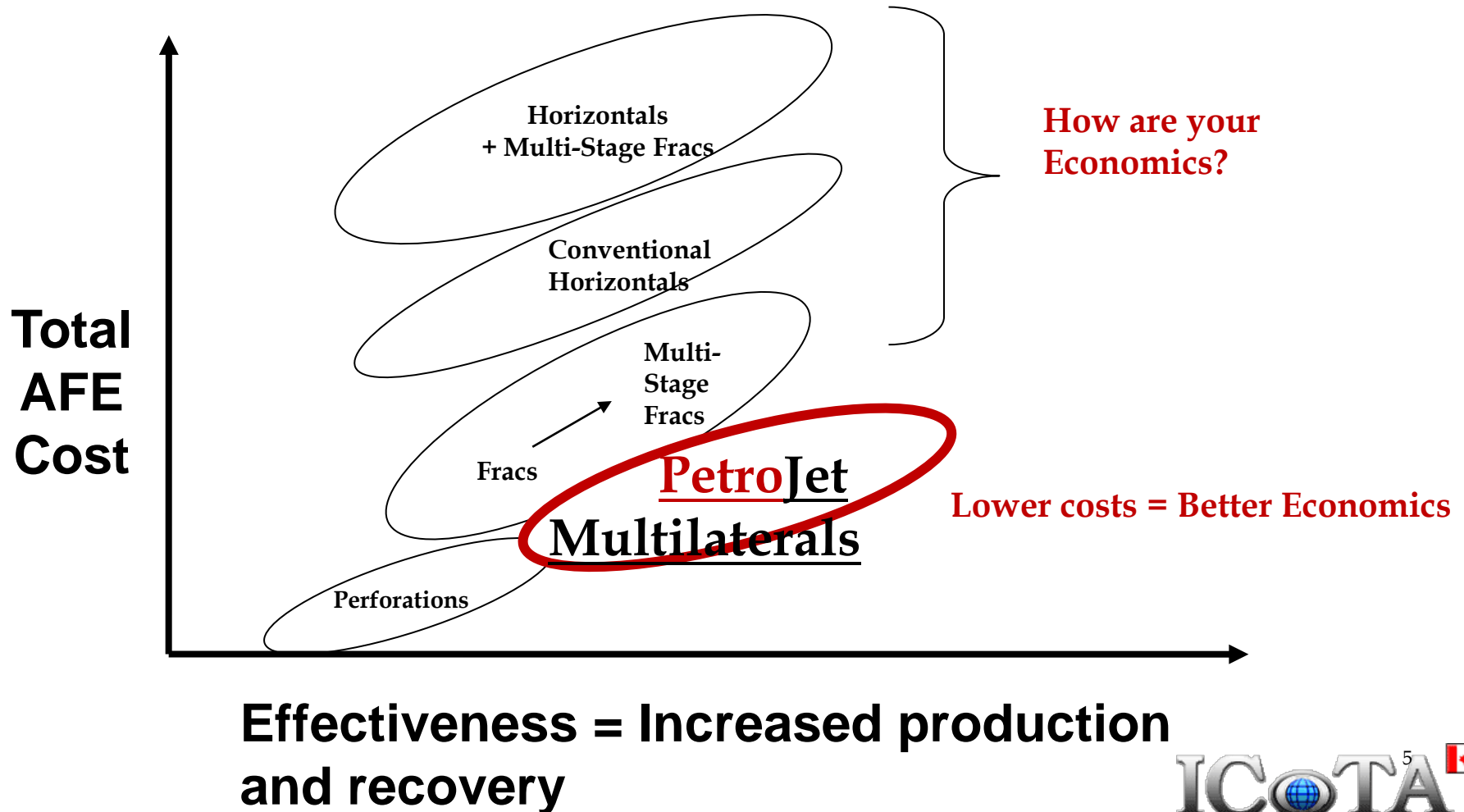
Increase drainage area



- ✓ fewer wells
- ✓ Greater production & recovery rates

Well Stimulation Value Grid

Well Stimulation at a fraction of the cost



Core Sample



Flexible Borehole Configurations



Fluid Jet Drilling

- **Advantages**

- Generally lower cost alternative
- No weight-on-bit.
- Can make short radial curves.
- Can place permeability channels in desired trajectory
- Multiple configuration options (some)
- Utilizes less fluid than fracturing.
- Can be used in loss circulation environments
- Can drill underbalanced (some)
- Can utilize variety of fluids (e.g. H₂O, N₂, frac oil, acids, abrasives etc.)

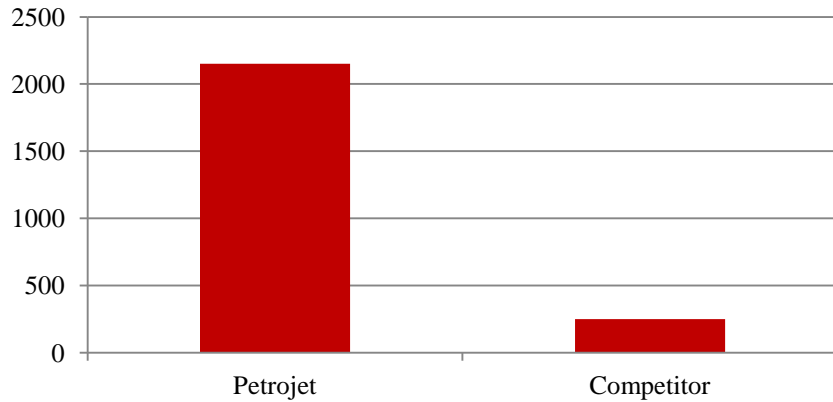
Fluid Jet Drilling

Disadvantages

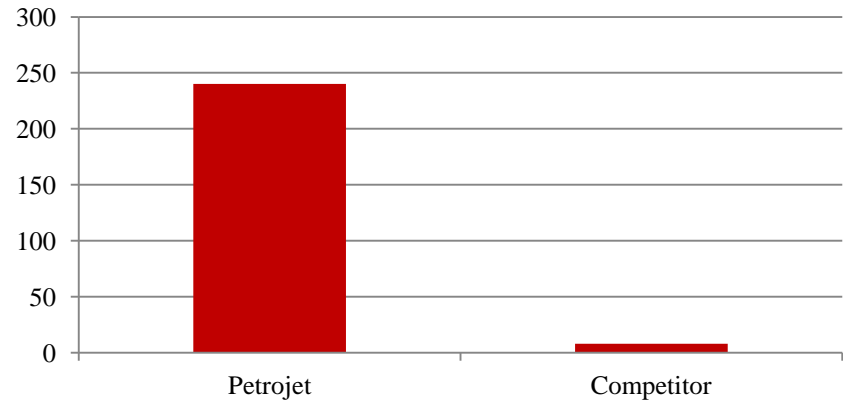
- Inconsistent performance / Multiple providers / technology platforms
- No tools capable of measuring position / trajectory....yet
- Is not a precision steering instrument.
- Not well understood by industry
- Not effective for deeper wellsyet

Coiled Tubing versus Hose

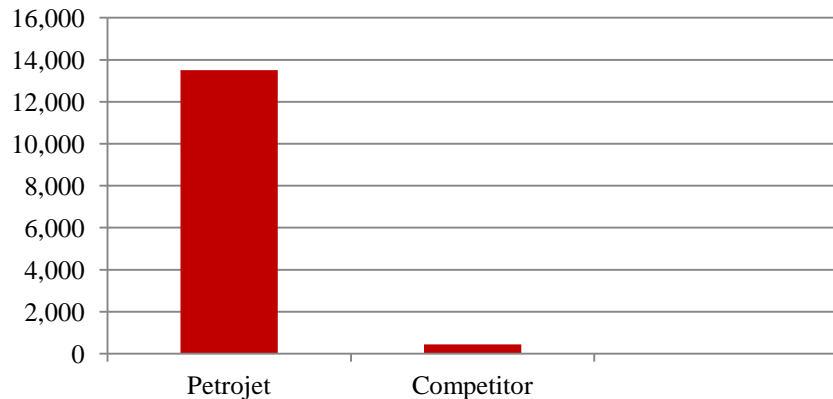
Horsepower



Flow (Gallons per minute)



Down hole pressure (PSI)



Petrojet



Competitor

PetroJet® History

- **Bechtal (1970s to early 1980s)**

- Conceptual design and preliminary engineering
- Alberta Oil Sands



- **Petrolphysics (early 1980s to 2006)**

- Research and Development
- Over 1,000 laterals in hundreds of wells
- Focus on California heavy oil

UNOCAL 76



Imperial Oil



- **PetroJet (2006 to present)**

- Refine and optimize
- Incorporate new and updated technology
 - Coiled tubing rigs
 - Higher pressure equipment
 -
- Commercialize



Ingenuity takes energy™



Why lack of previous commercial Success?

- How long did it take for horizontal drilling and fracturing to become accepted practice?
- Need for improvements to pumps and related high pressure equipment e.g. HP threaded pipe, coiled tubing
- Economics
 - Lower cost of support equipment
 - Fluctuating hydrocarbon prices

Recent History

Williams CBM Pilot

- ✓ Powder Basin, Wyoming
- ✓ 5 wells – 1,400 – 1,500 ft.
- ✓ CBM dewatering
- ✓ 35 ft. laterals x 4 laterals per well.



Ingenuity takes energy.

Result

- ✓ < 2 days per well including set up and rig move
- ✓ Up to 95% increase in water production

Recent History

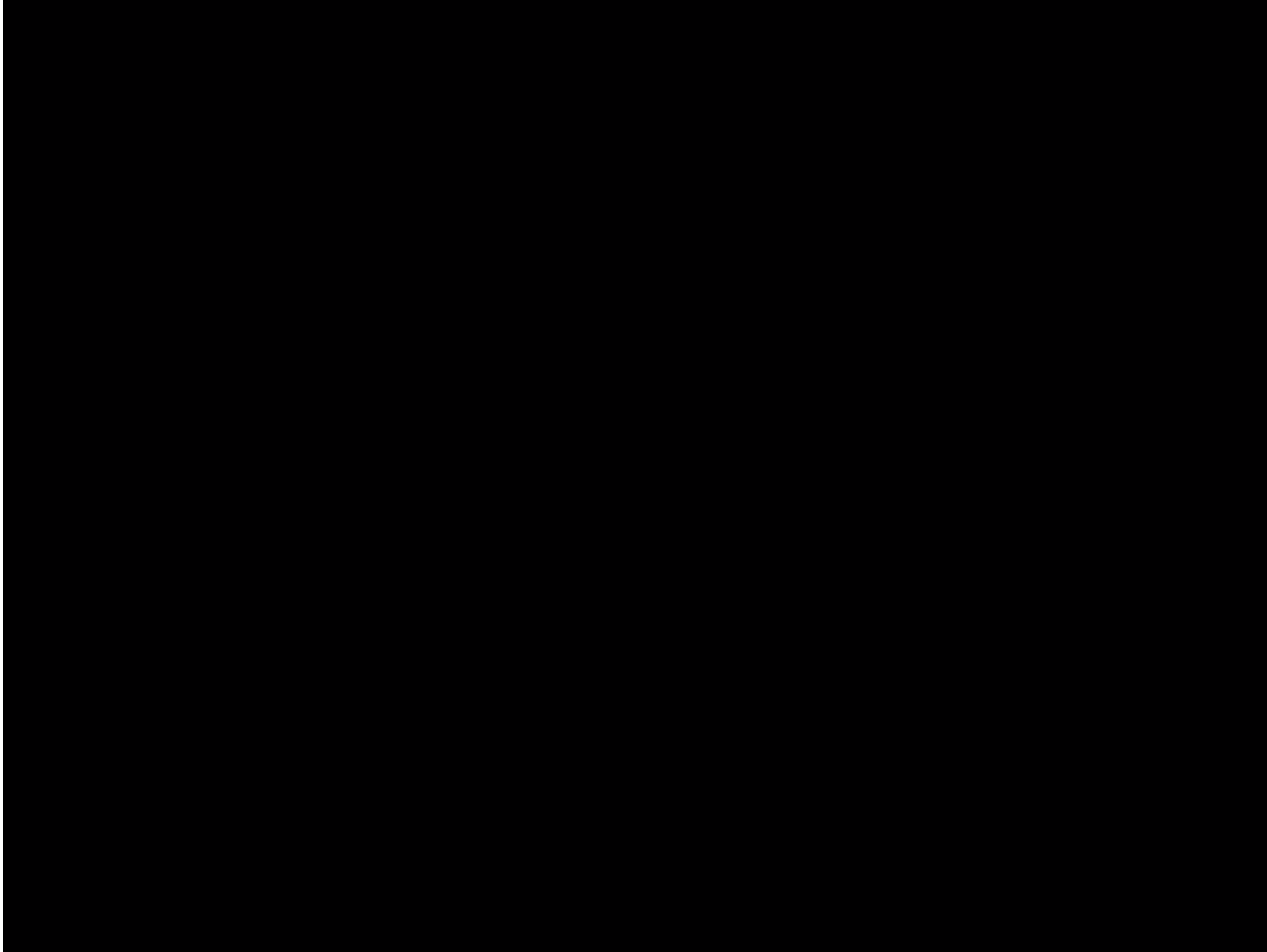
Tight Carbonate – Pilot Well

- ✓ Banff Formation, Alberta
- ✓ Suspended Well - No production
- ✓ Low permeability
- ✓ 1,770 m depth
- ✓ Placed 1 x 15m lateral

Result

- ✓ Preliminary result: Average 1.5 m³/d + 2k m³/day gas
- ✓ Candidate for additional and longer laterals

PetroJet® What We Do



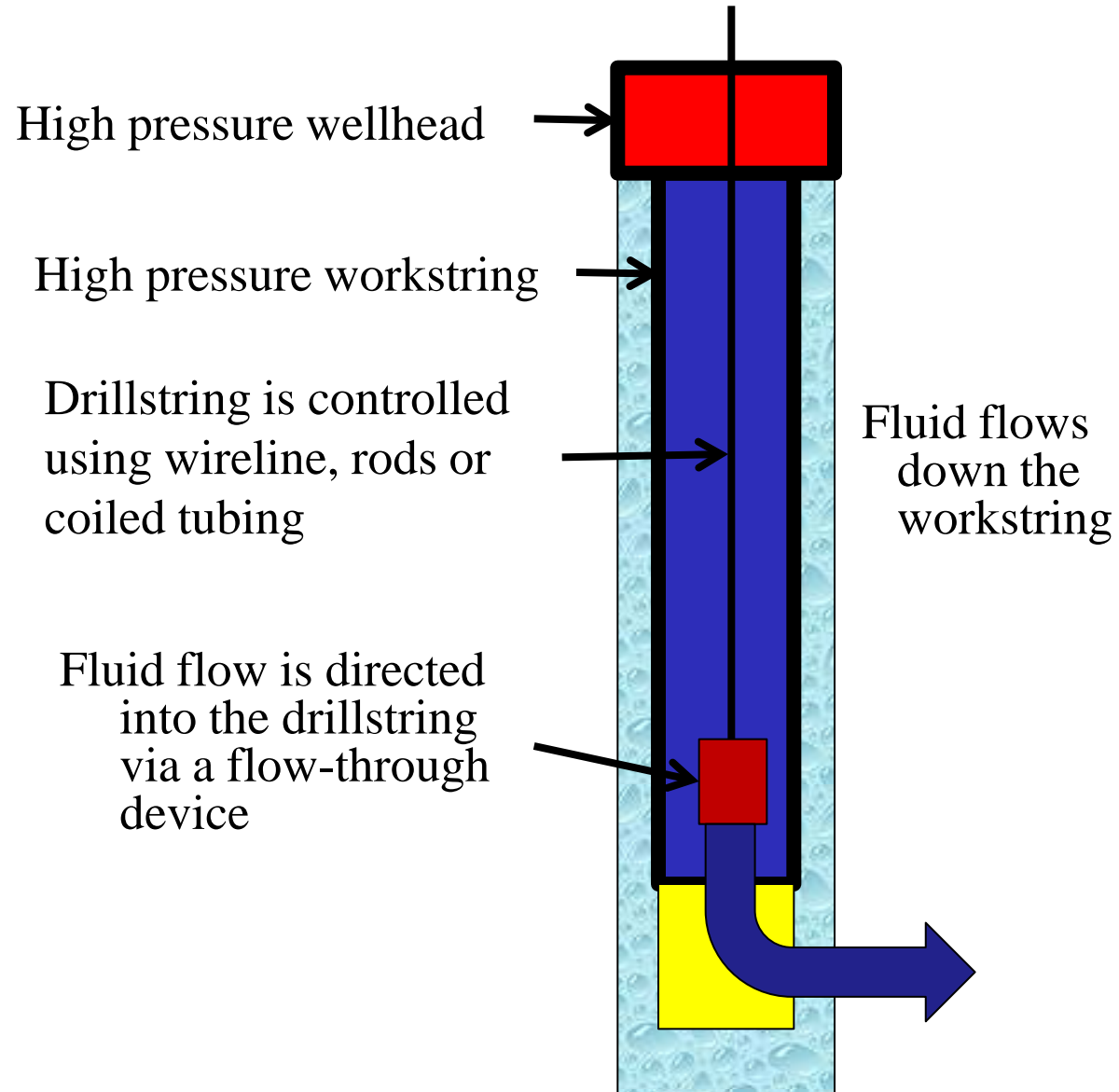
TRADITIONAL METHOD

Advantages

- Delivers higher pressure and flow to nozzle.
- Safety – High pressure flow direct from frac iron to wellhead

Challenges

- Workstring movement
- Requires premium thread workstring.



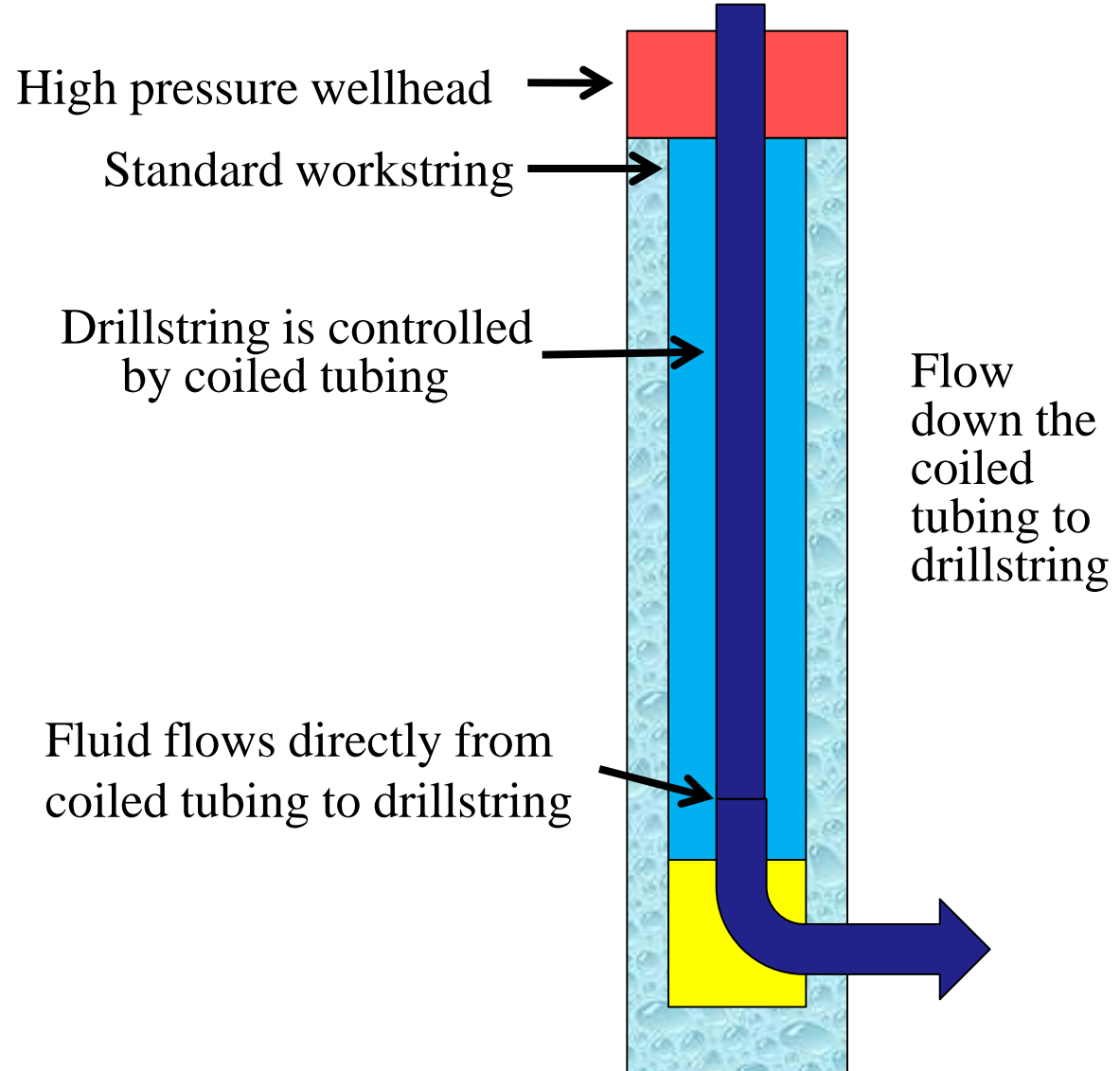
COILED TUBING METHOD

Advantages

- Standard wellhead
- Standard workstring
- No workstring movement

Challenges

- Higher pressure losses
- Surface pressure limits
- Cannot “work” drill string under pressure



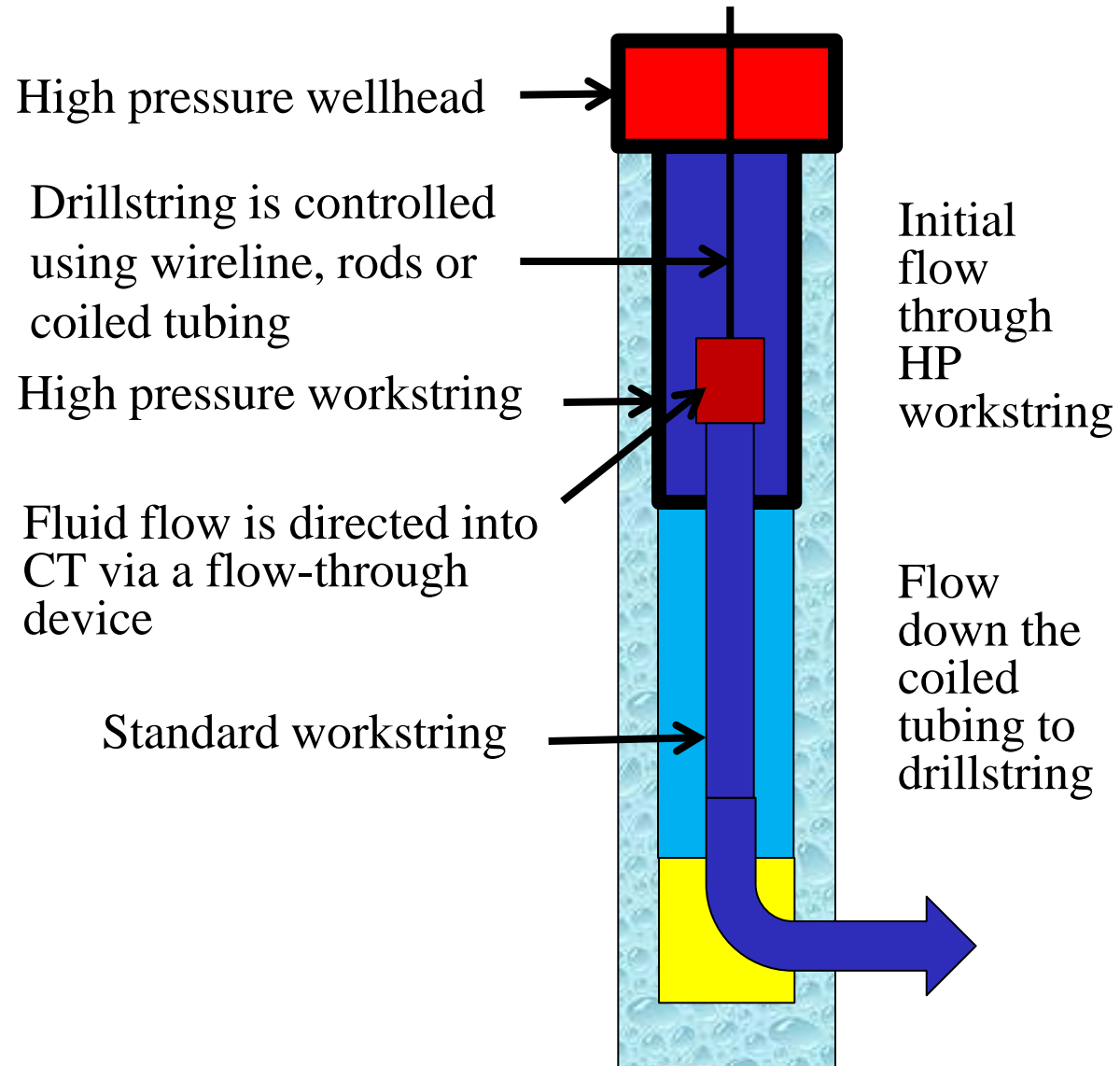
HYBRID METHOD

Advantages

- Delivers higher pressure and flow to nozzle.
- Safety – High pressure flow direct from frac iron to wellhead
- Less workstring movement
- Less risk of workstring leaks

Challenges

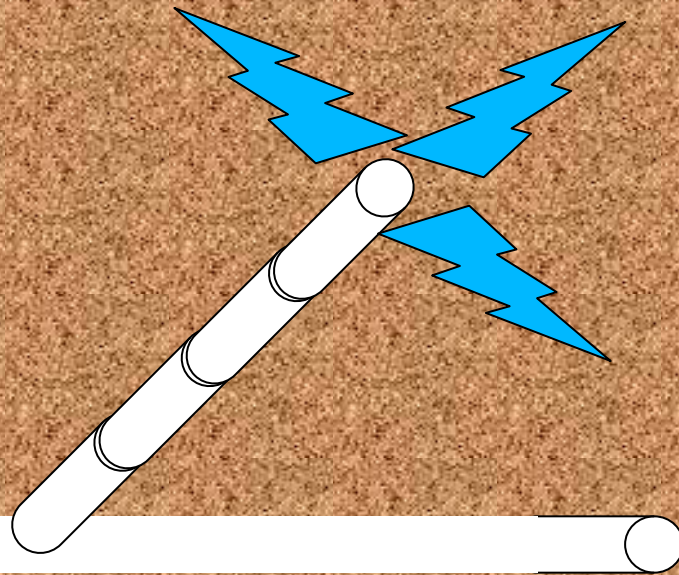
- Not yet field tested



PetroJet® Opportunities

Thinking Outside of the Wellbore

**Connect
Measure
Manipulate**



Opportunities

- **Imagine what one could do in a well with PetroJet Laterals:**

- **Connect the formation**

- Create high permeability conduits (ghost holes)
- Penetrate barriers and baffles (Injectors and producers)
- Install permanent lateral liners to tie back to the main liner

- **Measure the formation**

- Take samples
 - Oil, water, gas, bitumen or sand
- Take measurements
 - Orientation, elevation, temperature, pressure, conductivity, gamma ray, porosity, ...
- Place permanent measurement instruments

- **Manipulate the formation**

- Smart completions
- Heat the formation
 - Inject Steam, install electrical heaters, microwaves, ...
 - Direct the steam to where you want it.
- Inject fluids
 - Solvents, biogenic or biological liquids, acids, surfactants, foams, emulsifiers, de-emulsifiers, ...

Opportunities

- **Directed permeability channels where fracturing is ineffective or impossible.**
 - Zones prone to lost circulation/leak offs
 - Zones with pre-existing fractures
 - Unconsolidated sandstone
 - Oil sands
 - Bitumen in Carbonate
 - Zones where natural fracture path is suboptimal
- **Greater control over permeability channel trajectory.**
- **Lower fluid requirements.**
- **Reduced risk of fluid leak offs.**

Opportunities

- **Place fractures in optimal locations**
- **Increase length and effectiveness of fracturing.**
 - Reduce flow path tortuosity = reduced friction loss = fractures further from main wellbore.
 - Alternative method for placing multiple fracs along open or cased hole
 - Alternative method for fracs along vertical or horizontal wellbores.

Opportunities

SURVEY TOOL



- Measure the trajectory of the laterals
- Incorporate gamma to log reservoir characteristics away from main wellbore

Technical Benefit Summary

1. **Maximize reservoir contact and drainage area**
2. **Reduce pressure drawdown - mitigate sand influx and water and gas coning**
3. **Increase steam, water or solvent injectivity**
4. **Allow higher flow rates at lower pressure drops**
5. **Intersect natural fractures**
6. **Connect intervals separated by vertical barriers or permeability contrasts & gradations**
7. **Multiple laterals at multiple depths**
8. **Penetrate near wellbore damage, independent of lithology or stress state of formation**
9. **Utilize fluids to suit formation (e.g. H₂O, KCl, acid, N₂, CO₂, abrasives, etc.)**
10. **Multi-Fracs from toe of laterals**



Questions?