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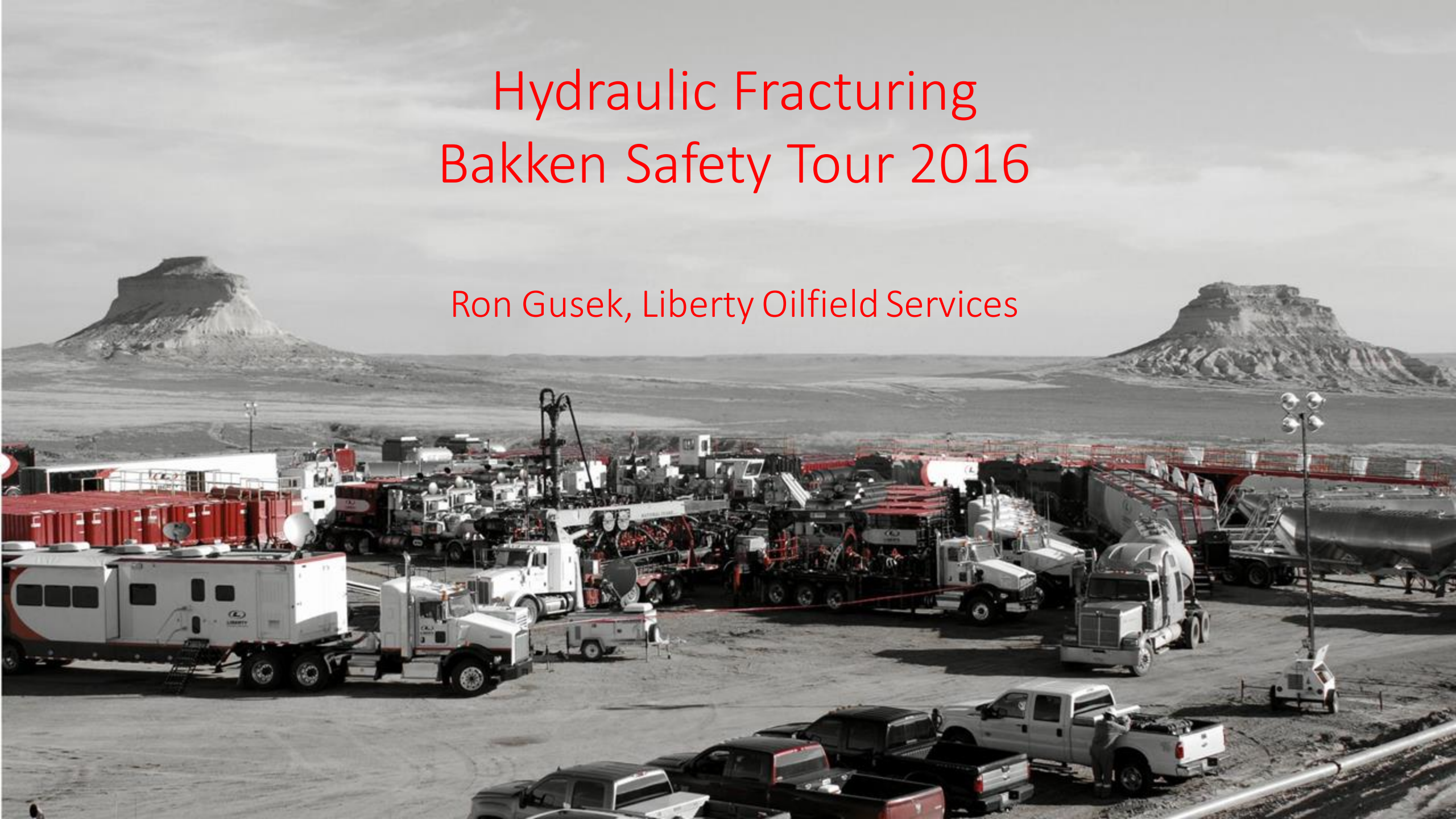
UNITED STATES

Hydraulic Fracturing
Bakken Safety Tour 2016

Ron Gusek, Liberty Oilfield Services

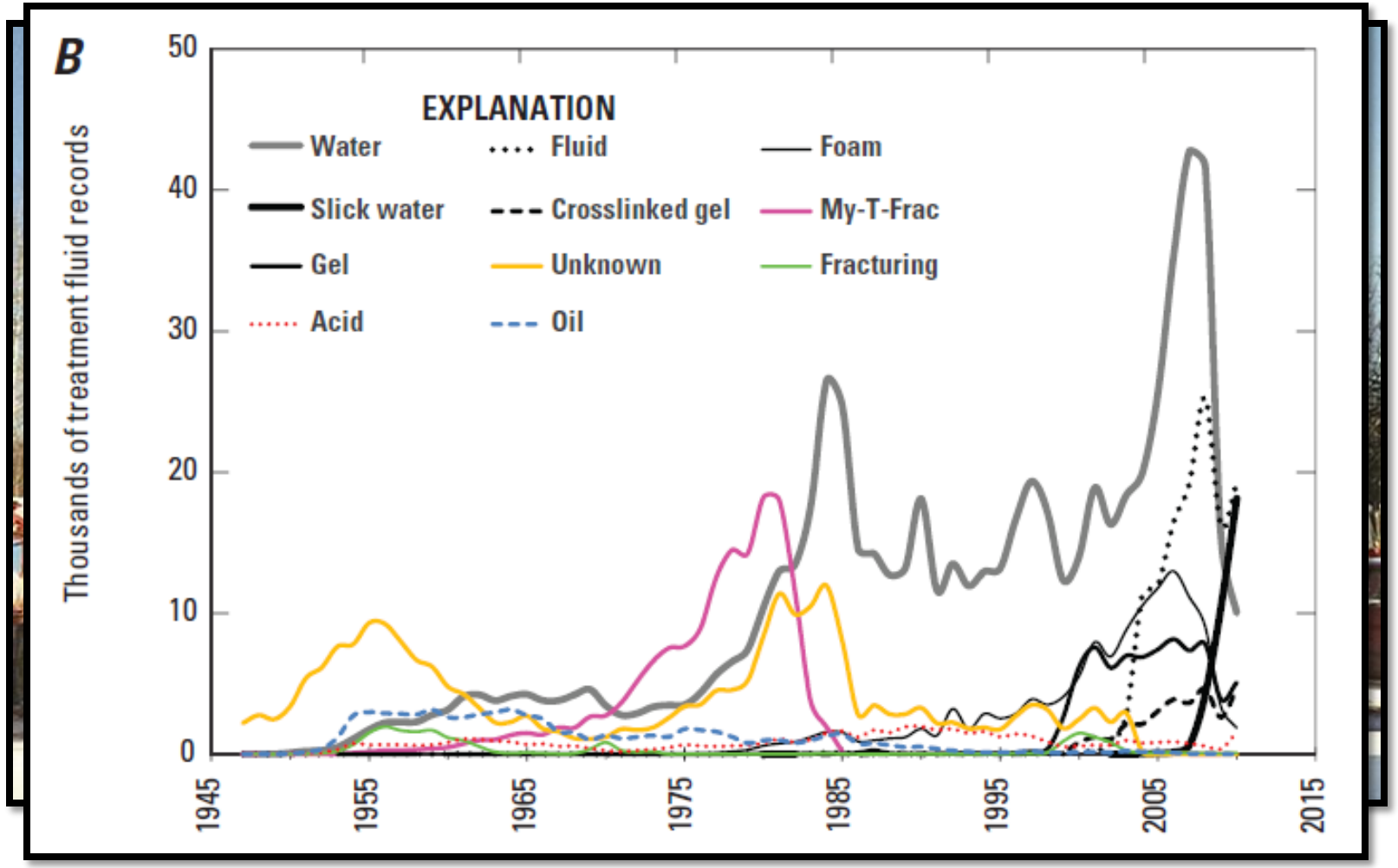


Outline

- Vorteq Manifold Trailer
  - Current Challenges & Improvements-to-Date
  - Isobaric Pressure Exchanger & New Missile
  - Operational Changes
  - Yard & Field Testing
  - Anticipated Benefits
- The “Quiet Fleet”
  - Noise Exposure – Regulations and Reality
  - Benefits of the Quiet Fleet
  - Some Basics About Sound
  - The Final Product
- Questions

Vorteq™ Manifold Trailer

Some Things Change, Some Things Stay the Same



USGS Scientific Investigations Study 2014-5131

Current Challenges

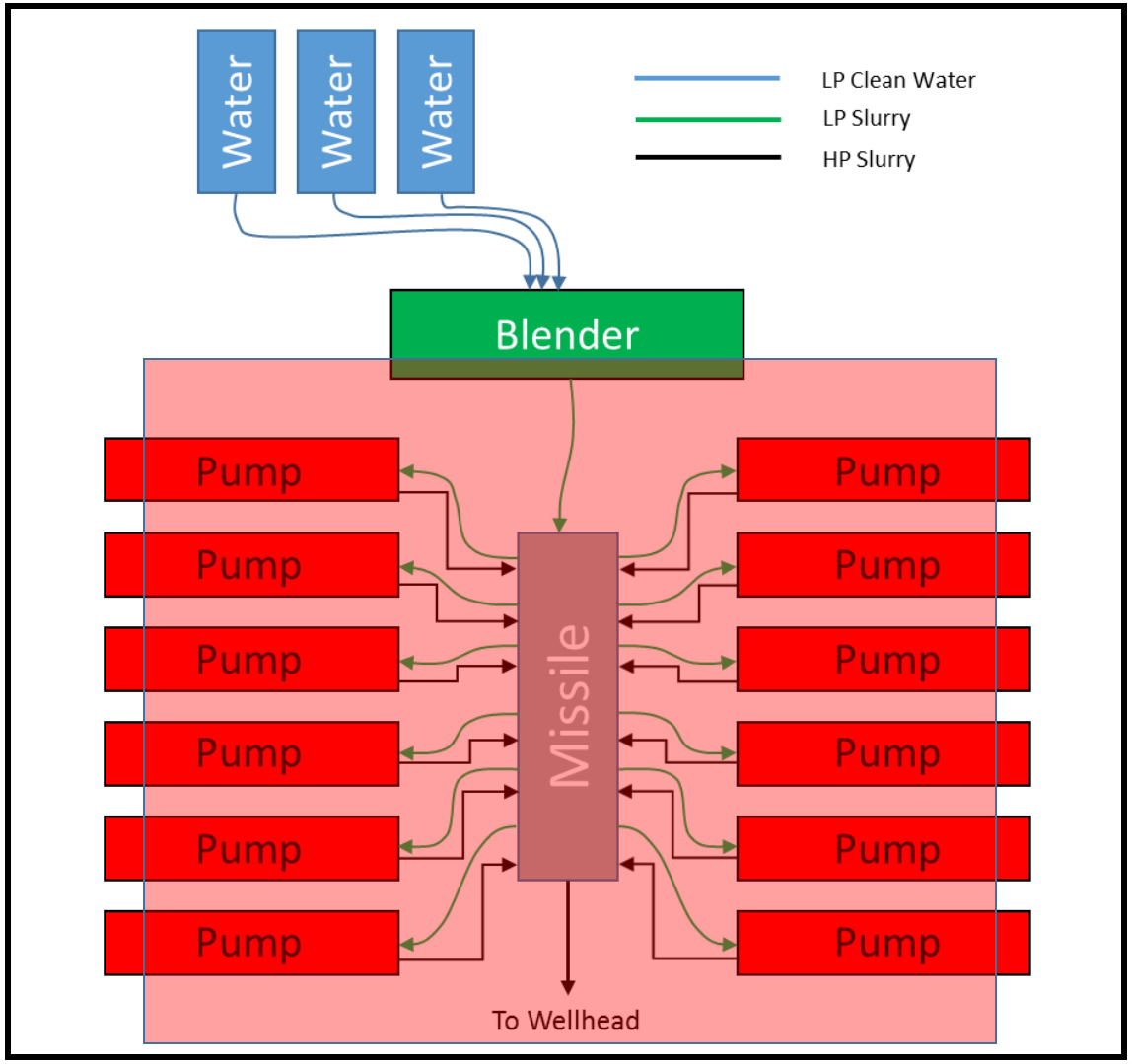
- Low viscosity fluids w/ proppant
- High pumping rates
- High treating pressures

lead to

- Wear/erosion of various pump components
- Increased R&M costs
- Reduced efficiency in fracturing operations
- Work in the “Red Zone”

The “Red Zone”

- The “red zone” is the area of high pressure operations during a hydraulic fracture treatment
- Minimize # of people and amount of time in “red zone” to minimize risk



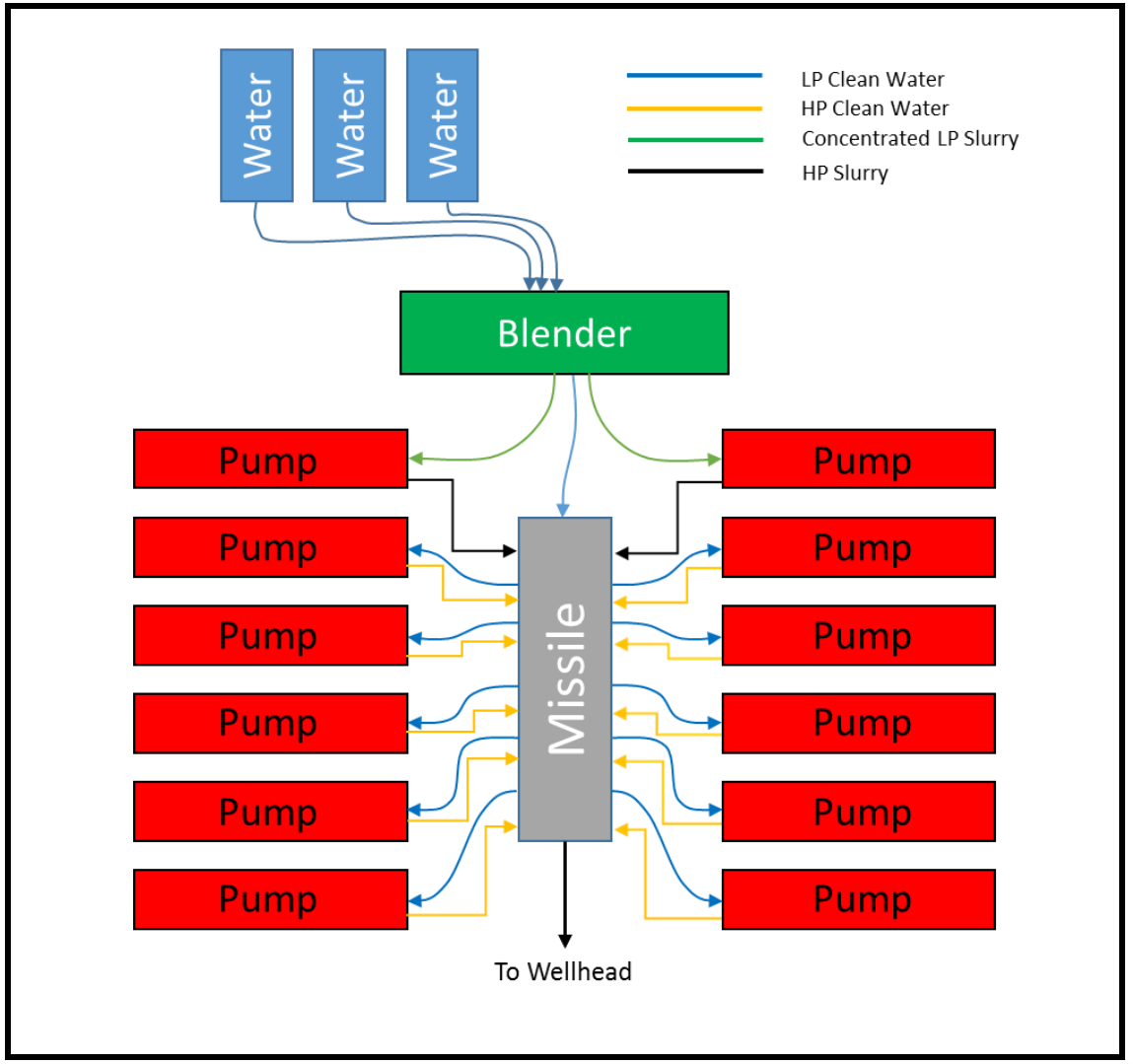
Improvements to Date

Mechanical Improvements

- Flow geometry changes
- Metallurgy changes

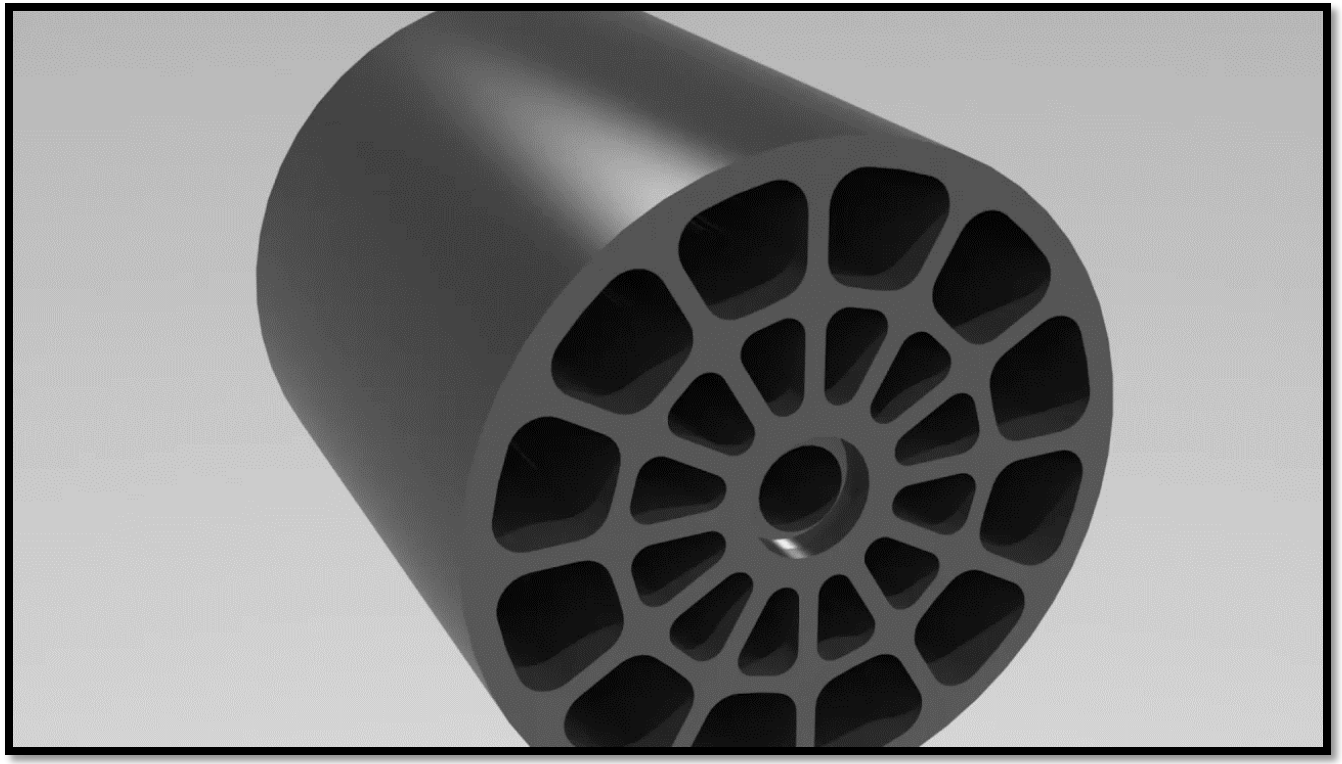
Operational workarounds

- Split stream fracturing



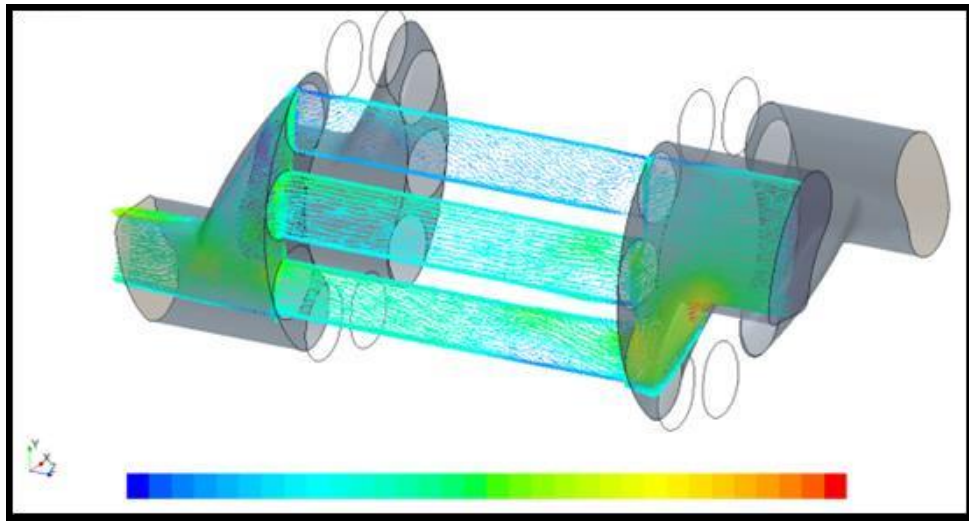
Isobaric Pressure Exchanger (PX)

- Free spinning rotor driven by fluid flow
- Pressure transfer from one fluid stream to another via positive displacement
- Bearing support in the form of a hydrodynamic film between the rotor and the sleeve/endcaps



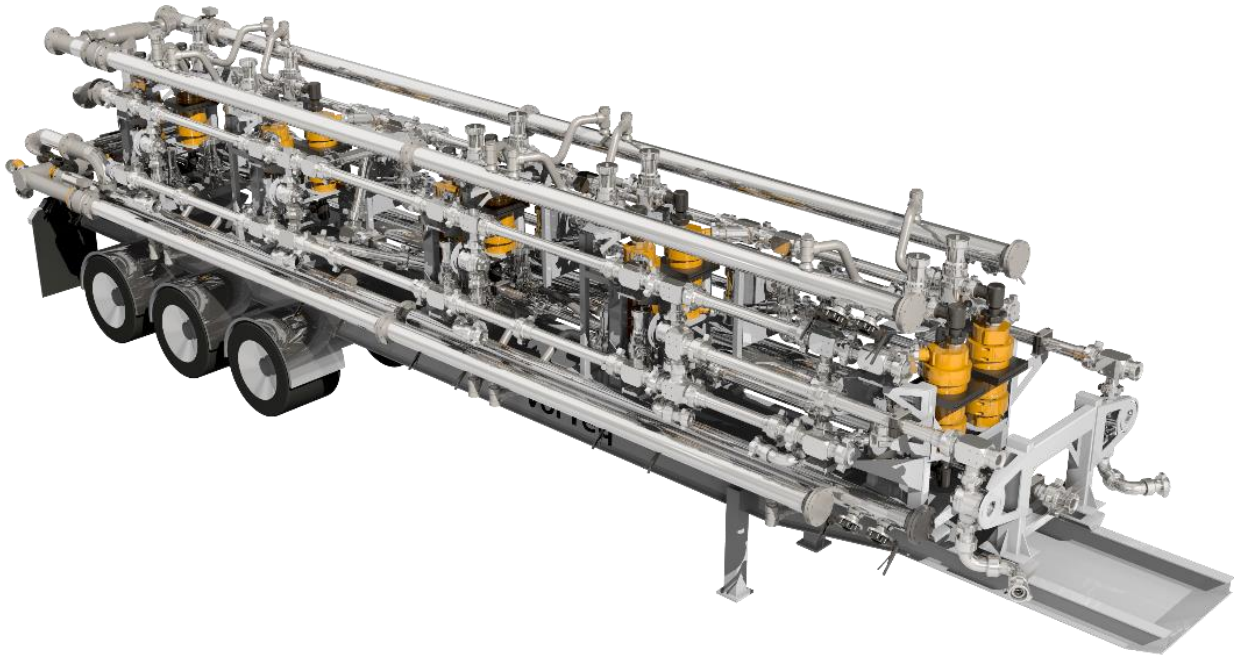
Isobaric Pressure Exchanger (PX)

- Manufactured from tungsten carbide
  - Abrasion resistant
  - Structural integrity
  - High stiffness
- Rated to service pressures >15,000 psi
- Efficiency >95%
- Mixing levels of ~3%
- 5 to 8 bpm per PX



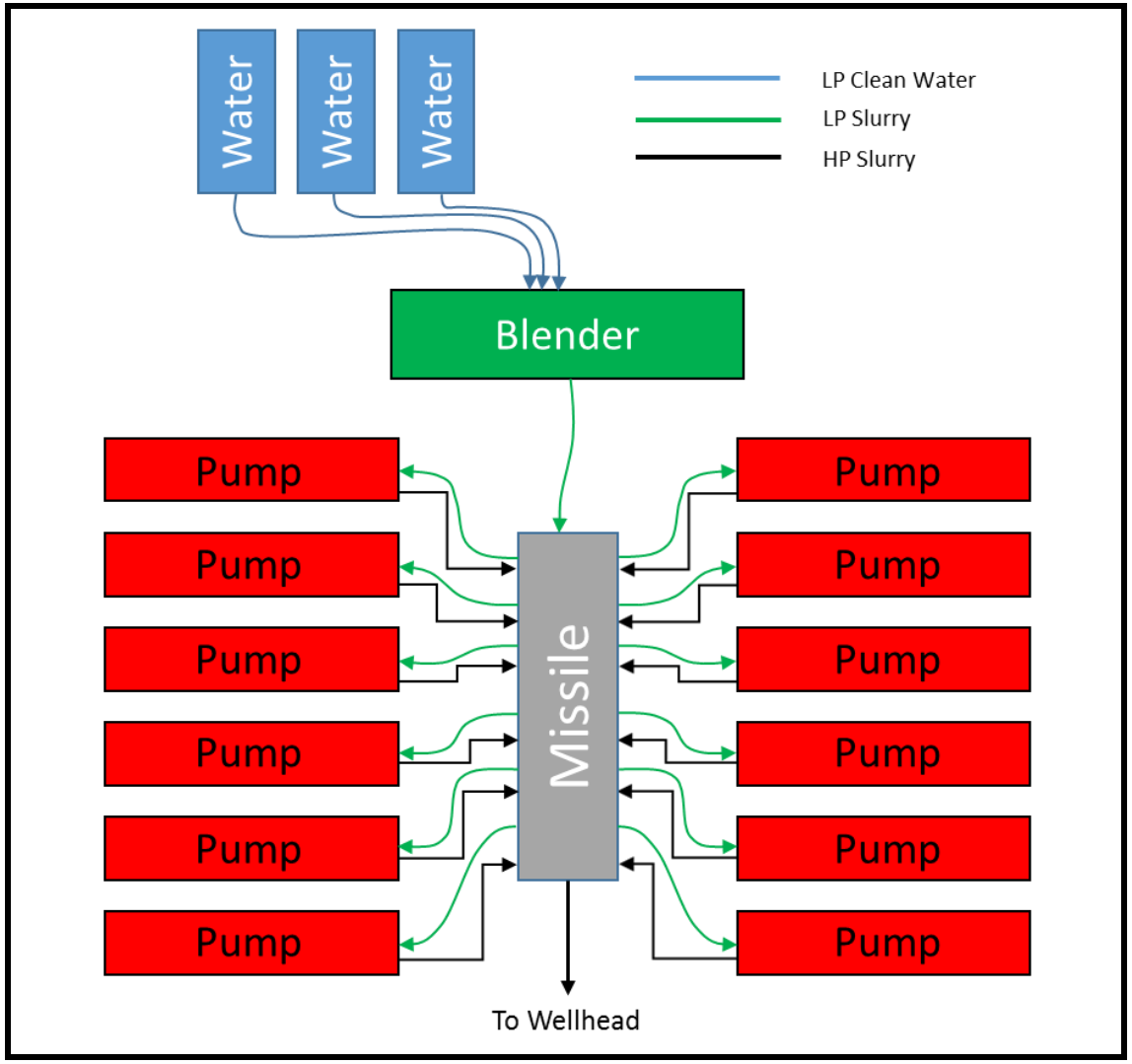
Manifold Trailer

- 10 station manifold trailer
- Isolation valves at each PX
- 2 high pressure manifolds
- 3 low pressure manifolds
- Instrumented with flowmeters, pressure and temperature sensors, valve position sensors and RPM sensors



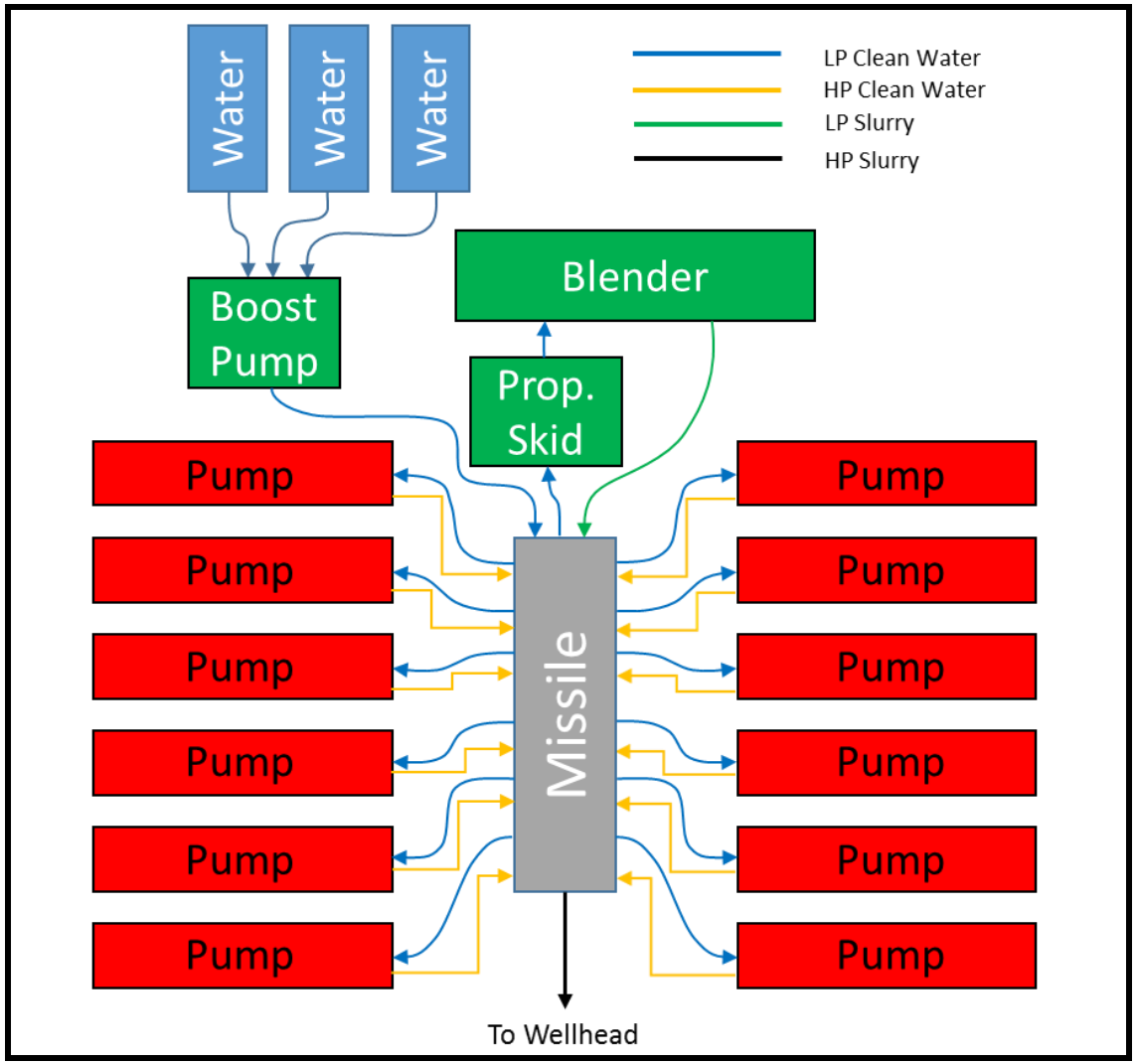
Fluid Flow Path – Current Manifold Trailer

1. Water tanks
2. Hydration unit (if required)
3. Blender
4. Low pressure manifold on missile
5. Reciprocating plunger pumps
6. High pressure manifold on missile
7. Wellhead



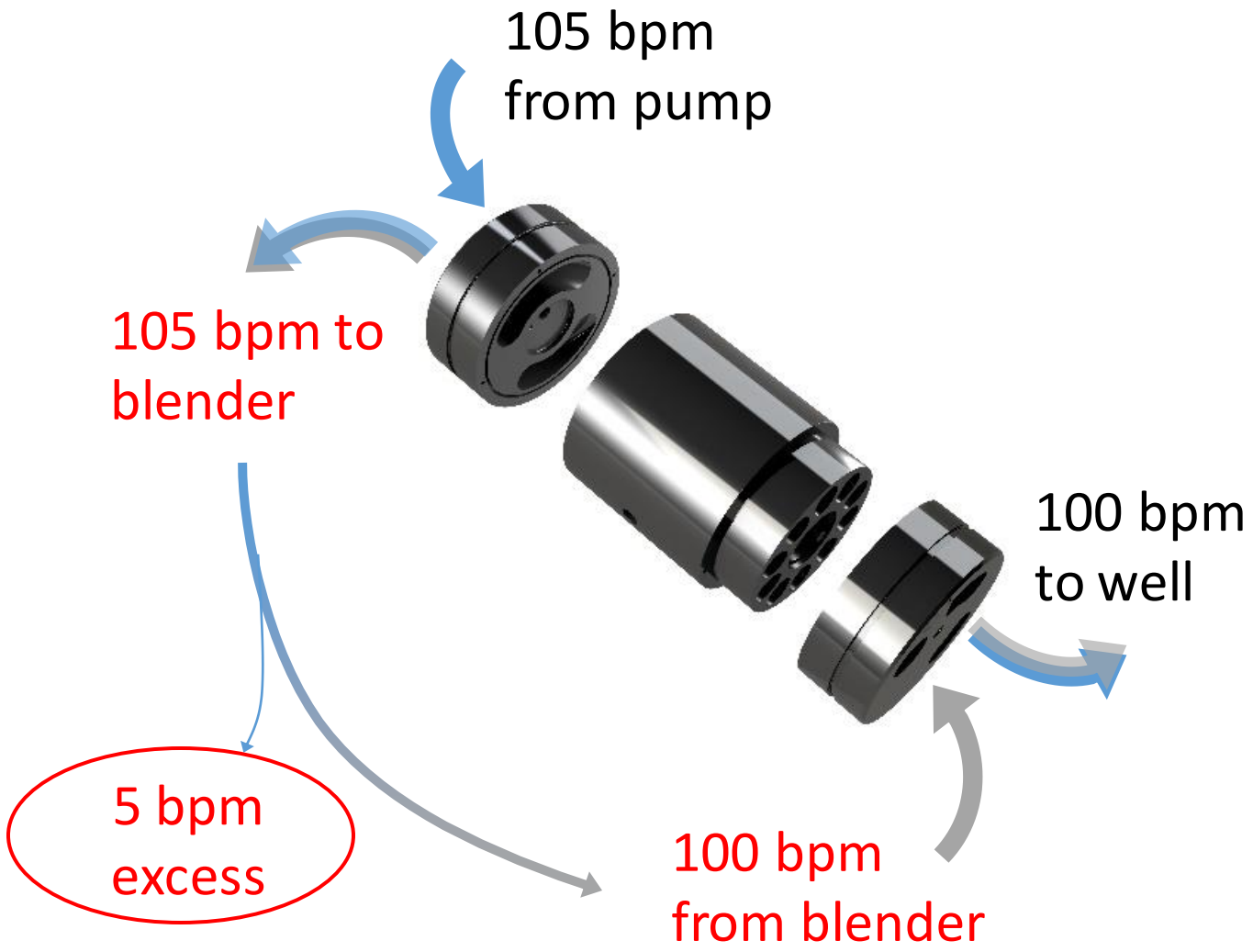
Fluid Flow Path – New Manifold Trailer

1. Water tanks
2. Boost pump skid
3. Low pressure manifold #1 on missile
4. Reciprocating plunger pumps
5. High pressure manifold #1 on missile
6. Pressure Exchanger
7. Low pressure manifold #2 on missile
8. Proportioning skid
9. Hydration unit (if required – not shown)
10. Blender
11. Low pressure manifold #3 on missile
12. Pressure Exchanger
13. High pressure manifold #2 on missile
14. Wellhead



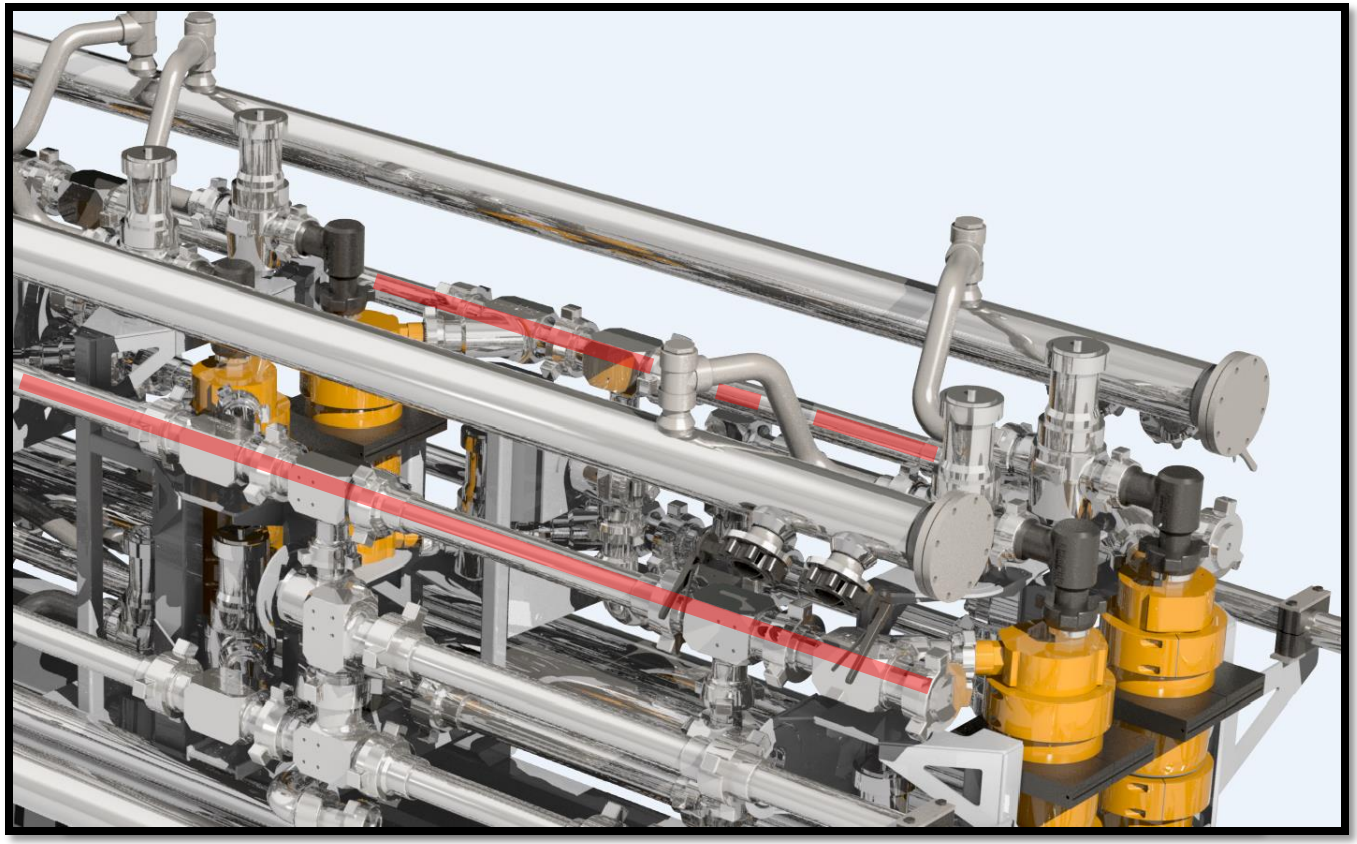
PX Operations

- 95% efficient w/ 3% mixing
- Manage excess fluid
  - Return to tank (may need to remove proppant)
  - Pressurize and pump downhole (dilution)



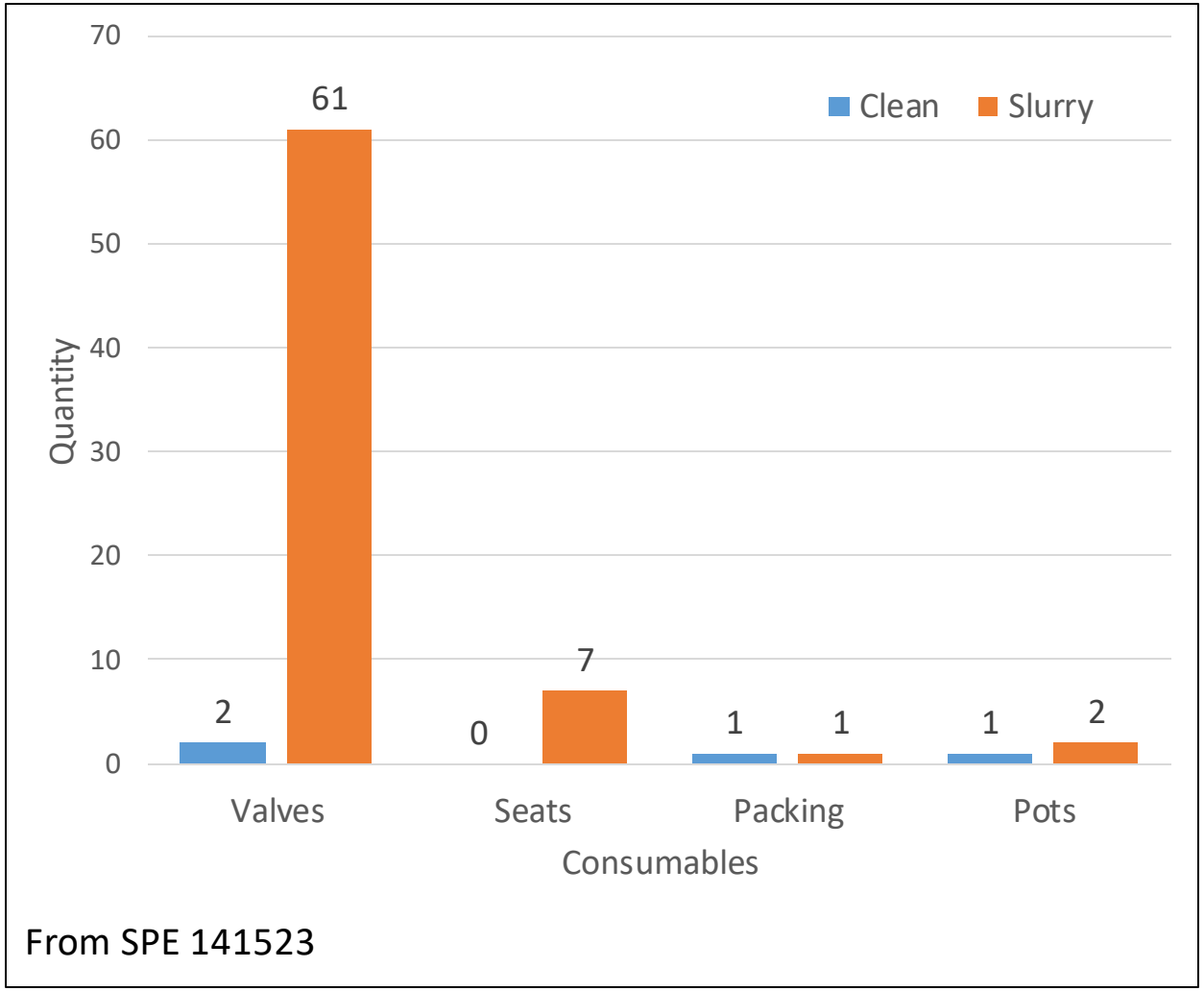
Yard & Field Testing

- Validated control system and proportionate flow device
- Static pressure tests to 10,000 psi and pumping operations to 7,250 psi
- Stable operation of PX devices
- Resolved issue with over-constrained system
- Utilized prototype missile on Bakken frac location (Dec 2015)
- Testing with gelled fluid systems underway



Anticipated Benefits

- Improved safety and operating conditions
- Reduction in R&M costs, and specifically consumable parts
- Less NPT = Increased efficiency
- Less redundant equipment on location
- Opportunity to use high pressure multi-stage centrifugal pumps



From SPE 141523


The Quiet Fleet ™
LIBERTY
OILFIELD SERVICES

Occupational & Community Noise Exposure

- Actionable limit is TWA of 85 dBa over an 8 hour period
- No regulations governing employee protection against noise measured on the C-weighted scale

- Community noise is commonly measured in equivalent continuous sound pressure levels
- Commonly expressed as DNL (Day-Night Average Sound Level)
  - Daytime Average Sound Level (7am – 10pm)
  - Nighttime Average Sound Level (10pm – 7am)
- Common recommended DNL is 55 dBa (EPA)
- Community noise ordinances commonly based on A-scale, but public concern about C-scale noise is growing

COGCC Noise Zone Regulations

Zone	7:00 am to next 7:00 pm	7:00 pm to next 7:00 am
Residential/Ag./Rural	55 dB(A)	50dB(A)
Commercial	60 dB(A)	55dB(A)
Light Industrial	70 dB(A)	65dB(A)
Industrial	80 dB(A)	75dB(A)

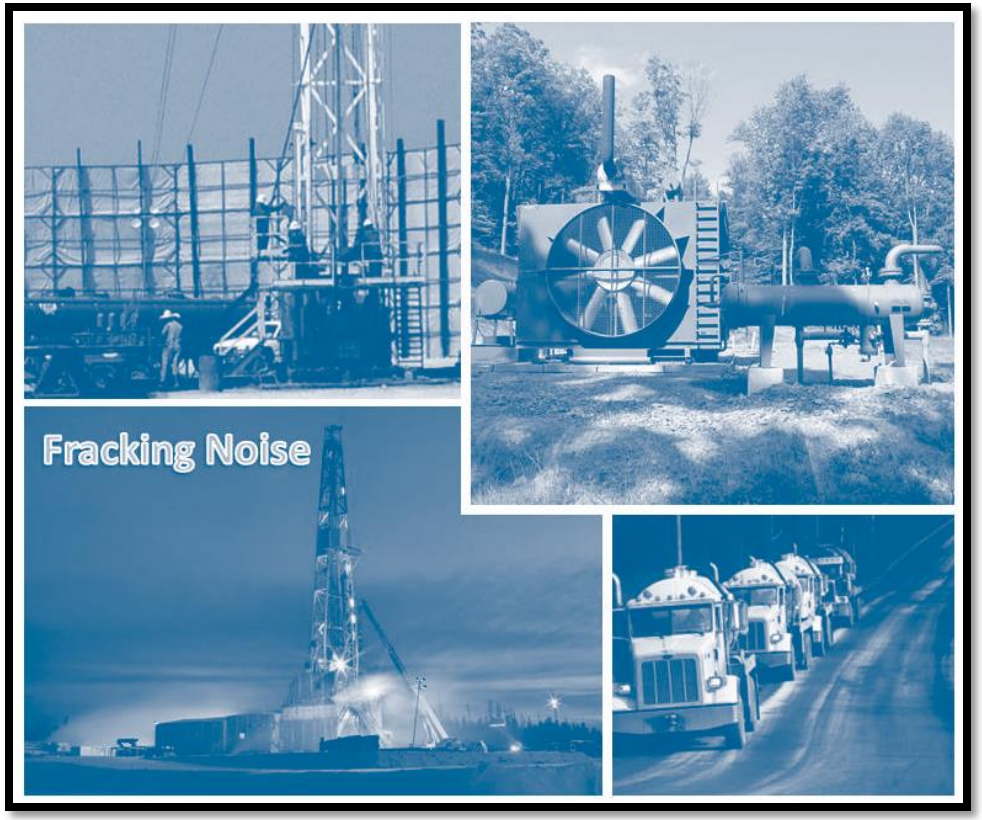
- In response to a specific complaint, COGCC requires that noise measurements be taken 350 feet from the source
- For C-scale noise, readings >65dBC at a distance 25 feet from a residence require further action to reduce low frequency noise

Hydraulic Fracturing and the Community

- Today's hydraulic fracturing operations are more environmentally friendly
  - Dual Fuel Fleets have lower emissions
  - Newer proppant transport systems generate less dust with less silicosis risk
  - Greener chemicals are used with more disclosure of what is pumped
  - Pad operations minimize land use
- Noise generated during 24/7 operations can be an issue when operating near to communities and homeowners
- The Quiet Fleet™ will dramatically reduce frac spread noise down to about the level generated by the few electric fleets available today. It generates less noise at a distance of 500' from the center of a frac location than a conventional fleet would generate from 1000' away

Benefits of the Quiet Fleet Technology

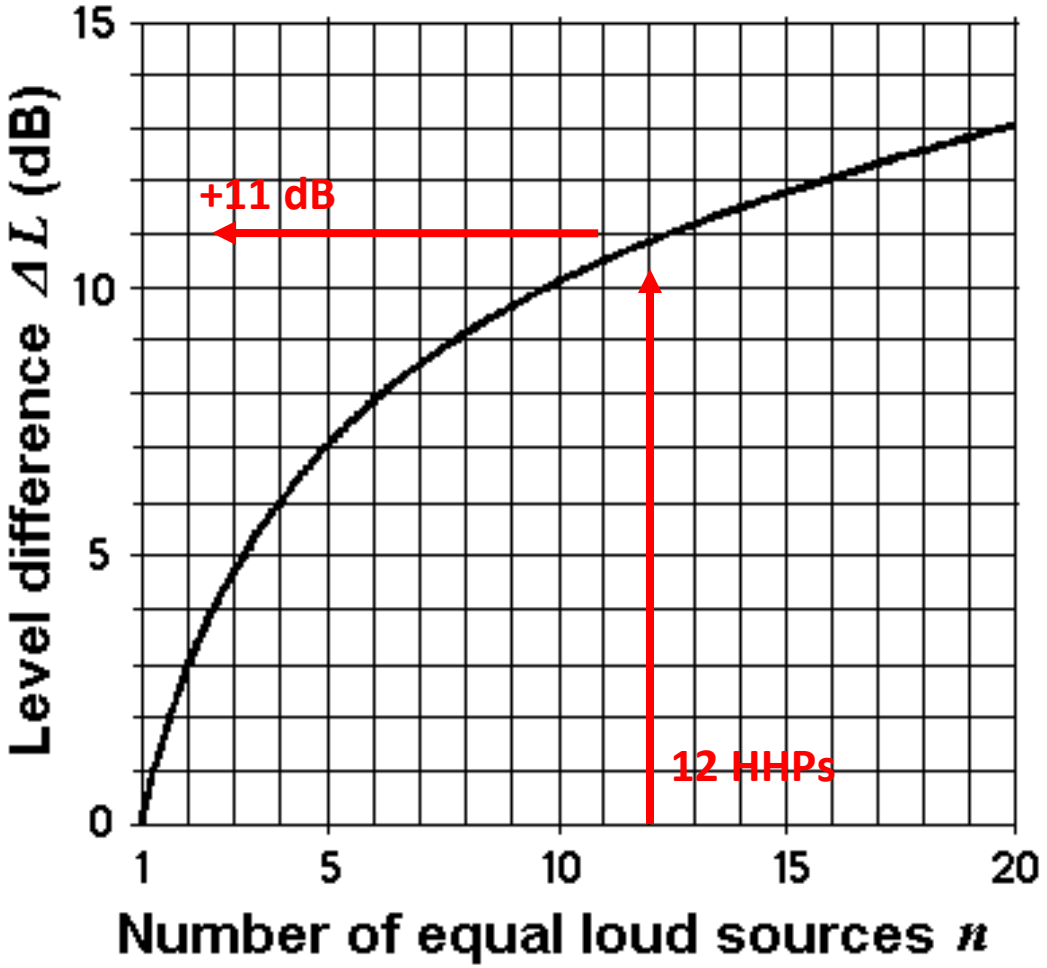
- It’s important to be a good neighbor
- Reduced fatigue and stress levels of onsite personnel
- Operational flexibility for E&P companies
  - Reduced setback distances while meeting noise compliance requirements
- May reduce or eliminate the need for sound walls specific to noise mitigation issues



First - Some Definitions

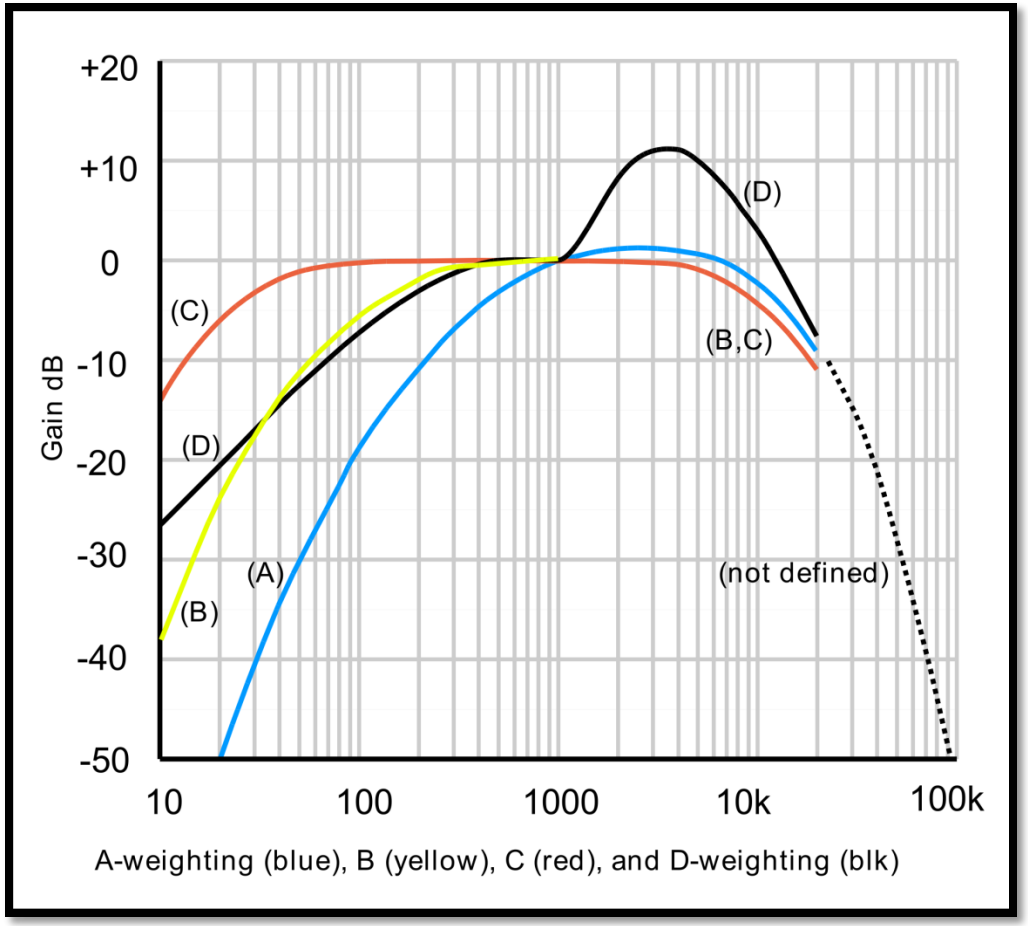
Volume vs pressure vs intensity

- Doubling of the volume (loudness) should be sensed as a level difference of +10 dB – acousticians say.
- Doubling the sound pressure (voltage) corresponds to a measured level change of +6 dB
- Doubling of sound intensity (acoustic energy) results in a calculated level change of +3 dB.

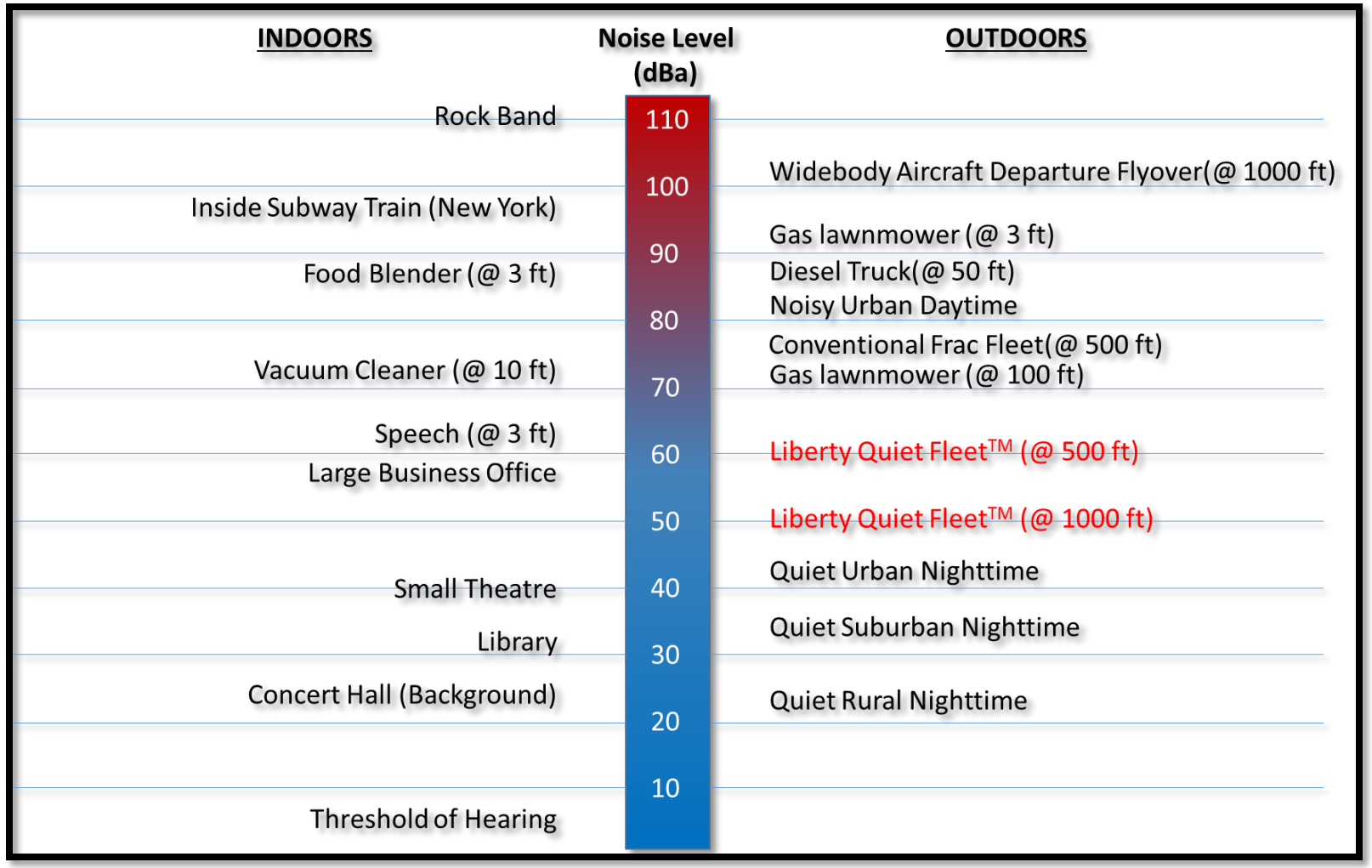


Some Definitions (cont'd)

- Compared with total dB, A-weighted measurements (dBA scale) underestimate the perceived loudness, annoyance factor, and stress-inducing capability of noises from low frequency components, especially at moderate and high volumes of noise. dBA is currently the reference scale used for most measurements of sound
- Another system of adjustment is C-weighting, the dBC scale. dBC is sometimes used for specifying peak or impact noise levels, such as gunfire. Unweighted dB readings are also used for this purpose; there is usually not much difference between the two.

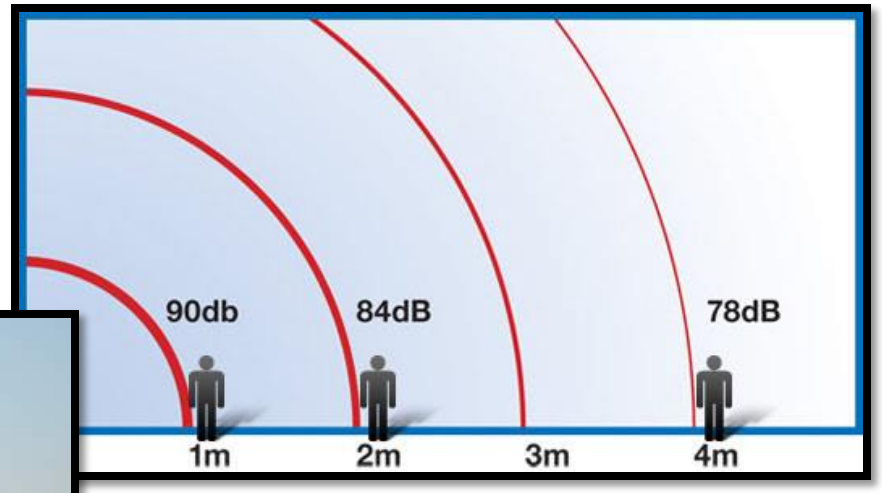


Common Noise Levels



Current Mitigation Strategies

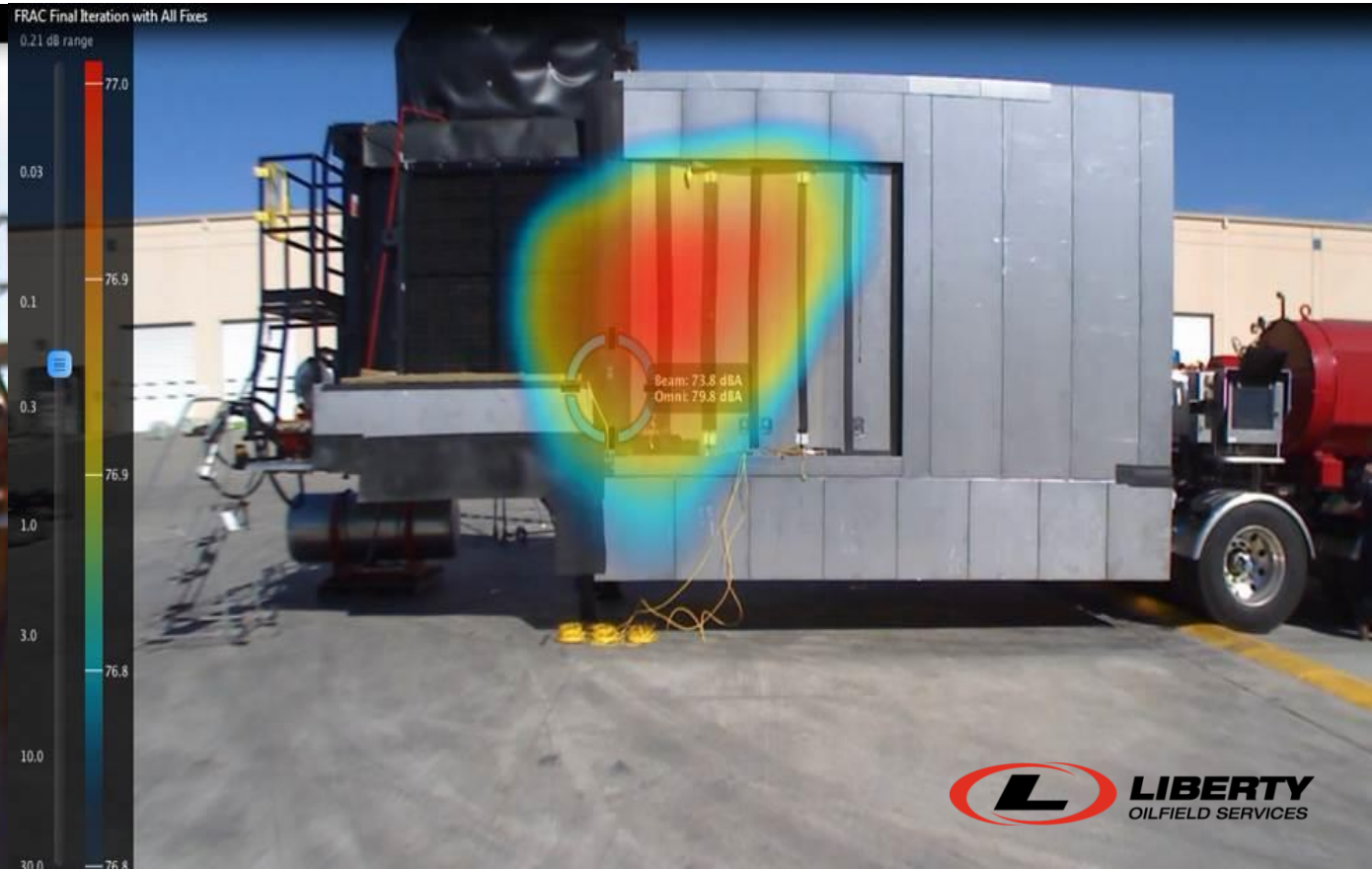
- Offset Distance
  - A doubling of distance reduces the sound pressure level by 6dB
- Sound Walls
- Electric equipment



Single Frac Pump Measurements

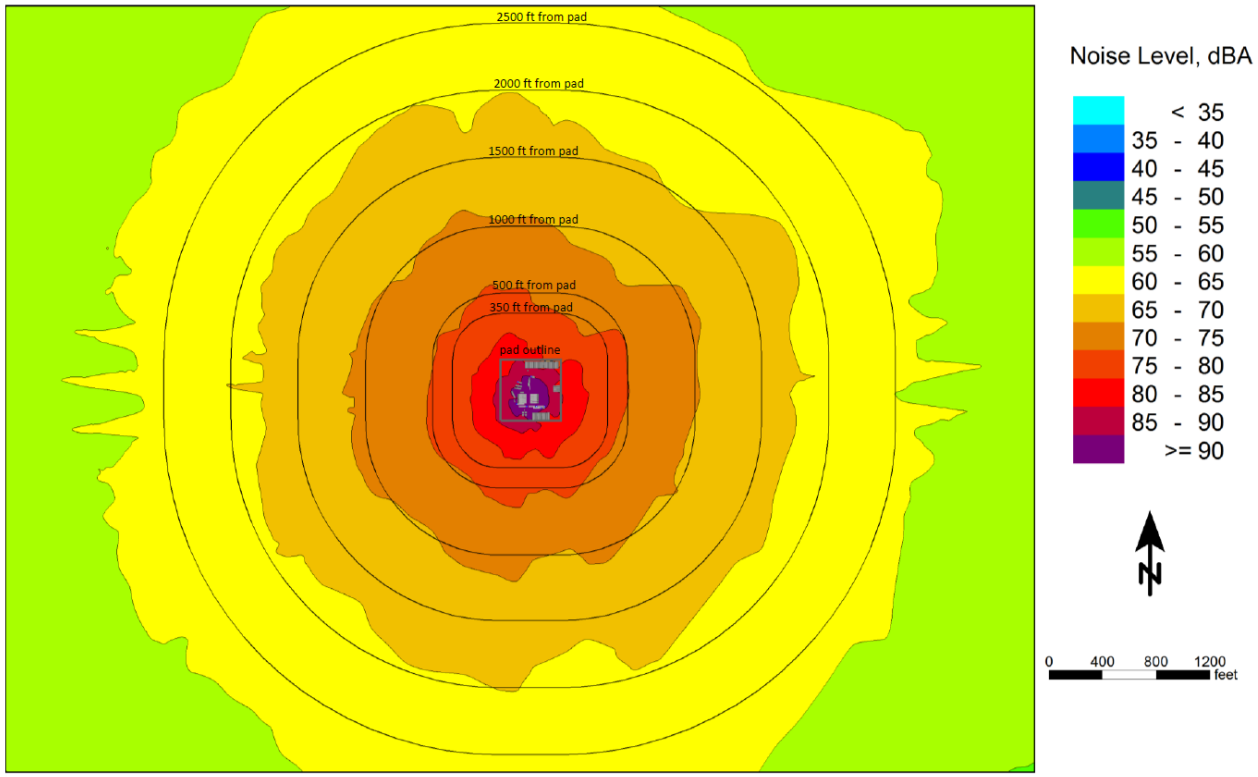
Standard Pump
95-100dBA adjacent to pump

Quiet Fleet Prototype
75-80dBA adjacent to pump



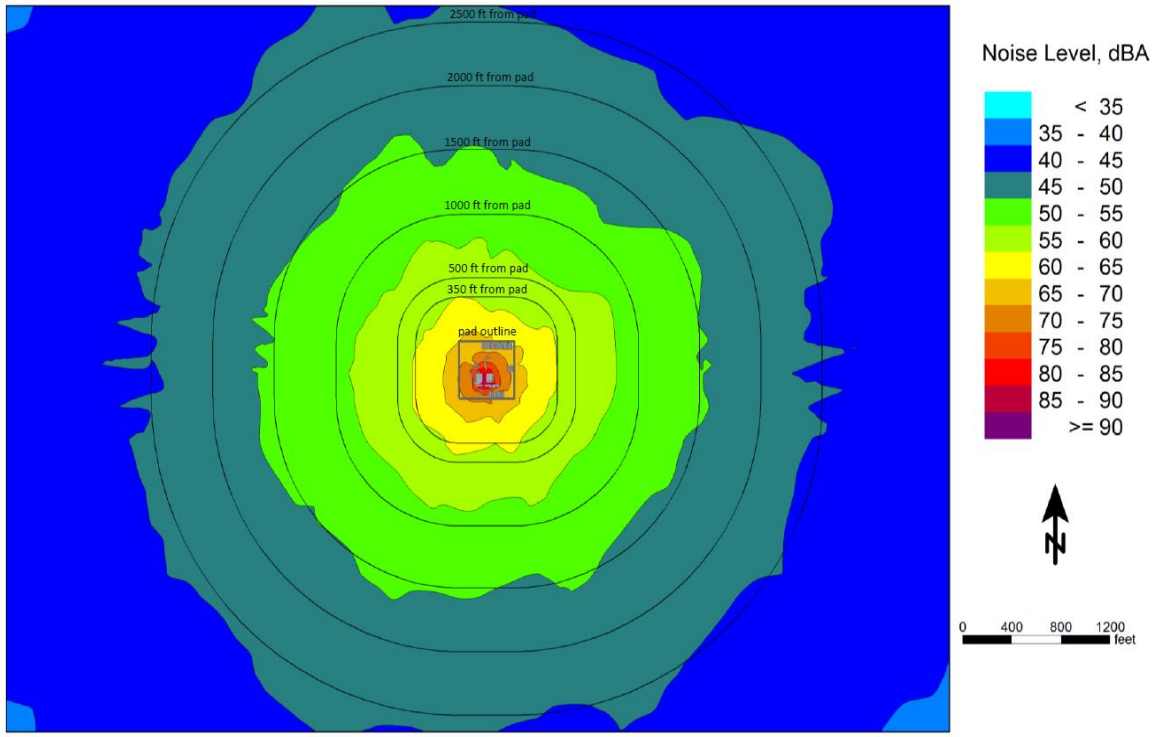
Noise Modeling from Behrens and Associates

Standard 12 Pump Caterpillar Fleet
70-75 dBA at 500' (between a running shower and a toilet flushing in acoustic energy)



Attachment 2
Frac Fleet Unmitigated Noise Contour Map (dBA)

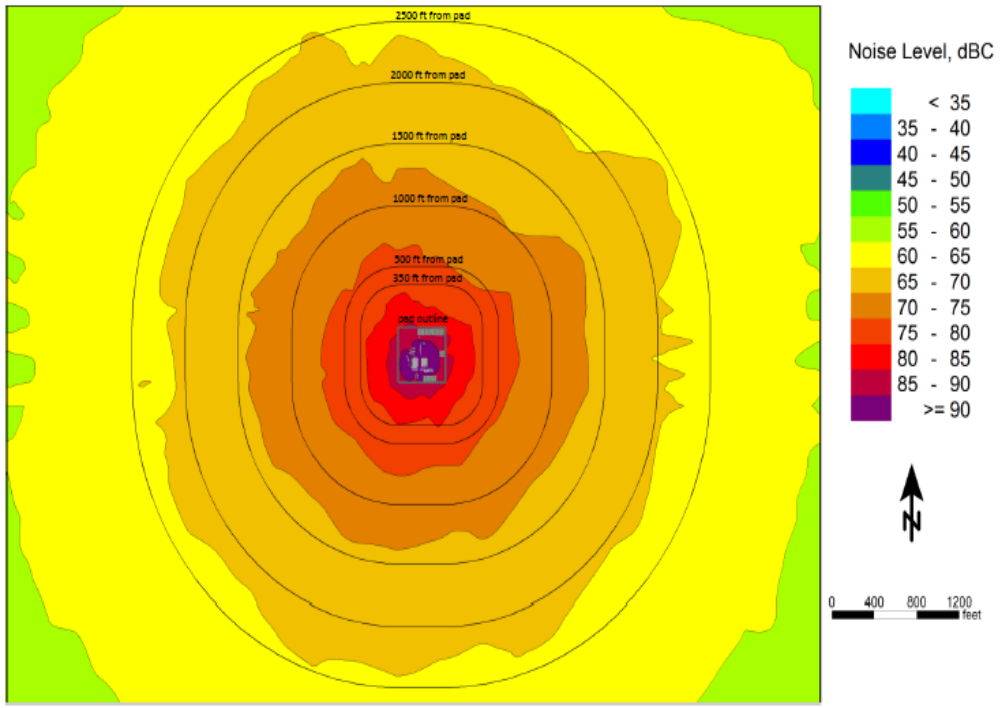
Quiet Fleet 12 Pump Fleet
Est 55-60 dBA at 500' (between light traffic and conversational speech in acoustic energy)



Attachment 4
Frac Fleet Containerized Noise Contour Map (dBA)

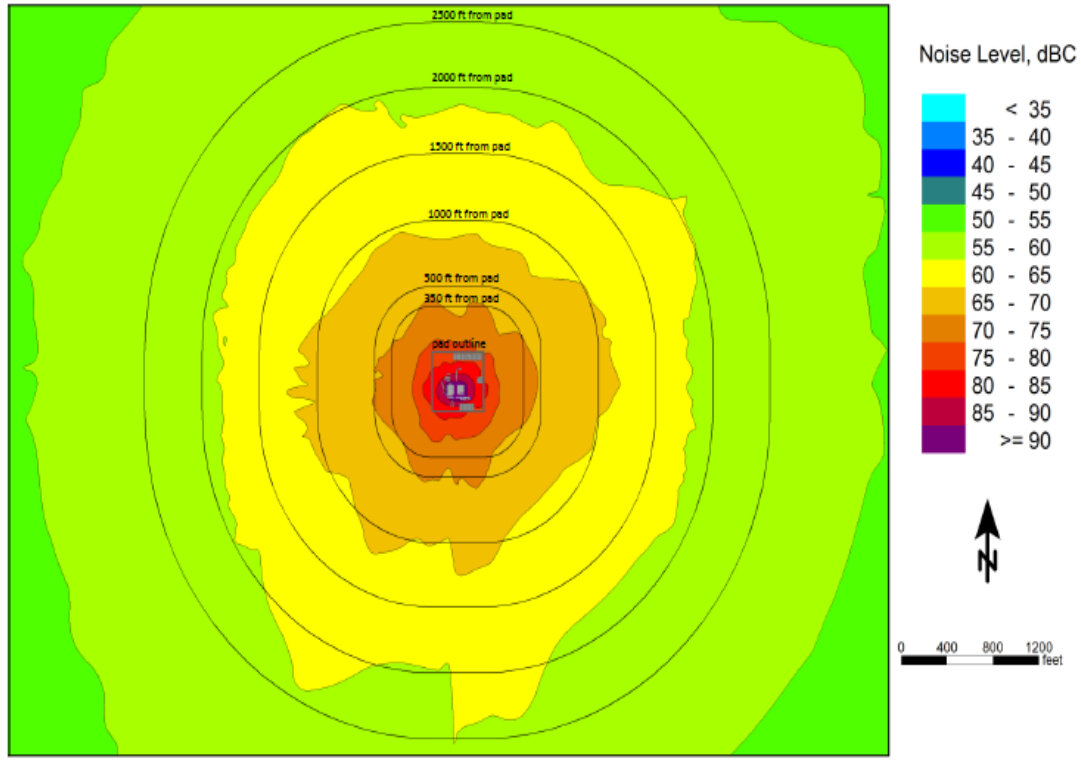
Noise Modeling from Behrens and Associates

Standard 12 Pump Caterpillar Fleet
75-80 dBC at 500' (between a toilet flushing and an alarm clock in acoustic energy)



Attachment 3
Frac Fleet Unmitigated Noise Contour Map (dBC)

Quiet FLeet 12 Pump Fleet
Est 65-70 dBC at 500' (between conversational speech and a running shower in acoustic energy)



Attachment 5
Frac Fleet Containerized Noise Contour Map (dBC)

The Final Product

- 3X quieter than a conventional fleet
- On-site noise levels below PEL
- 3-stage fire suppression system on each pump, blender and hydration unit
- Reduction achieved at moderate cost increase over traditional fleet
- Existing equipment can be retrofit

Questions?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