

**Table 3** Summary of risk time, hazard / cause, consequence and risk type associated with transportation

Phase	Hazard / Cause	Consequence	Risk Type									
			Sop	Sgp	Enw	Ens	Eff	Dpp	Dis	Doa	Prf	
Loading with impermissibility	Equipment failure.	Injury / fatality of workers. Spills of drilling fluid and waste, lubricants, hydraulic fracturing fluids and additives, flow back fluid, foul wastewater and firefighting foam or water. Fire / expl from truck failure.			✓						✓	
	Human failure.				✓						✓	
	Vandalism.				✓							✓
	Truck (human) failure.			✓	✓	✓	✓	✓	✓	✓	✓	✓
Phase	Hazard / Cause	Consequence	Risk Type									
Transport operations	Equipment failure.	Injury / fatality of workers. Spills as above. Pavements damage. Damage of gas and el. supply. Fire / explosion from ignited gas supply leak.		✓	✓	✓	✓	✓			✓	
	Human failure.			✓	✓	✓	✓				✓	
	Vandalism.			✓	✓	✓	✓	✓	✓	✓	✓	
	Road accident.			✓	✓	✓	✓	✓	✓	✓	✓	
	Spills in transit.			✓	✓	✓	✓	✓	✓	✓	✓	
	Truck (human) failure.			✓	✓	✓	✓	✓	✓	✓	✓	
	Road deterioration.			✓	✓	✓	✓	✓	✓	✓	✓	
Phase	Hazard / Cause	Consequence	Risk Type									
Unloading with impermissibility	Equipment failure.	Injury / fatality of workers. Injury / fatality to members of the public. Spills as above. Fire / expl from truck failure. Noise generation.			✓						✓	
	Human failure.				✓						✓	
	Vandalism.				✓						✓	
	Truck (human) failure.			✓	✓	✓	✓	✓	✓	✓	✓	
Risk type abbreviations: ( ✓ the risk type occurs)			Sop	The risk to safety of operating personnel			Eff	Risk to the environment: Flora and fauna				
			Sgp	Risk to the safety of the general public			Dpp	Risk of damage to the property of the general public				
			Enw	Risk to the environment: Surface water and/or ground water			Dis	Risk of damage to infrastructure including local buildings				
			Ens	Risk to the environment: Soil, crops, livestock			Doa	Risk of damage to the operator's assets				
						Prf	Risk to business performance (loss of profit and revenue)					

**Table 6** Breakdown of examples of hydraulic fluids

Hydraulic fracturing fluids are engineered to create and extend fractures in the targeted rock formation and to carry proppant through the production well into the newly-created fractures. While there is no universal hydraulic fracturing fluid, there are general types of hydraulic fracturing fluids. Two types of hydraulic fracturing fluids are described below.	
<b>SLICKWATER</b>	
Slickwater hydraulic fracturing fluids are water-based fluids that generally contain a friction reducer. The friction reducer makes it easier for the fluid to be pumped down the oil and gas production well at high rates. Slickwater is commonly used to hydraulically fracture shale formation.	
71% fresh water	
16% reused wastewater	
13% sand	
0.05% additives (13 chemicals), whereof	
	0.03% acid
	0.01% friction reducer
	0.006% biocide
	0.002% scale inhibitor
	0.0009% iron control
	0.0006% corrosion inhibitor
Bradford County, Pennsylvania	
Well depth = 7,225feet	
Total water volume = 4,763,000gallons	
<b>ENERGISED FLUID</b>	
Energised fluids are mixtures of liquids and gases. They can be used for hydraulic fracturing in under-pressured gas formations.	
58% water	
28% nitrogen (gas)	
13% sand	
1.5% additives (28% chemicals), whereof	
	1.2% clay control
	0.1% acid
	0.08% surfactant
	0.05% foamer
	0.03% corrosion inhibitor
	0.03% biocide
	0.01% friction reducer
	0.008% breaker
	0.006% scale inhibitor
	0.004% iron control
<i>Maximum percent by mass of the total hydraulic fracturing fluid. Data obtained from FracFocus.org.</i>	
Rio Arriba County, New Mexico	
Well depth = 7,640feet	
Total water volume = 105,000gallons	
<b>GLOSSARY OF ADDITIVES</b>	
Acid	Dissolves minerals and creates pre-fractures in the rock
Biocide	Controls or eliminates bacteria in the hydraulic fracturing fluid
Breaker	Reduces the thickness of the hydraulic fracturing fluid
Clay control	Prevents swelling and migration of formation clays
Corrosion inhibitor	Protects iron and steel equipment from rusting
Foamer	Creates a foam hydraulic fracturing fluid
Friction reducer	Reduces friction between the hydraulic fracturing fluid and pipes during pumping
Iron control	Prevents the precipitation of iron-containing chemicals
Scale inhibitor	Prevents the formation of scale build-up within the well
Surfactant	Reduces the surface tension of the hydraulic fracturing fluid