Summary of Gradient's National Human Health Risk Evaluation Report

Gradient has prepared a report (*National Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives*) setting forth its analysis of the use of additives in hydraulic fracturing ("HF") operations and their potential impacts on drinking water. The report covers operations in shale basins, tight sands and other tight formations across the country. It addresses both (i) the intended use of HF fluids, *i.e.*, pumping them into a target formation as part of the HF process, and (ii) potential impacts associated with unintended spills of HF fluids or flowback fluid. Gradient's conclusions include the following:

Zonal isolation: The report first examines the fluids as they are pumped down a well as part of the HF process. Gradient notes the standard steps taken in well construction to isolate the fluids in the interior of the well from drinking water aquifers ("zonal isolation") and the conclusion of the New York State Department of Environmental Conservation that the likelihood of fluid leaking from a properly constructed well and contaminating a drinking water aquifer is less than 1 in 50 million. The report concludes that the likelihood that fluids would escape from a properly constructed well is extremely low.

Implausibility of upward migration of HF fluids from target formation: The report next examines whether HF fluids could migrate upwards from a target formation to contaminate drinking water aquifers and concludes that this scenario is simply not plausible.

- Tight oil and gas formations are found in geologic settings that greatly restrict upward fluid movement due to the presence of multiple layers of low permeability rock and other factors, as demonstrated by the fact that the oil and gas and the brines have been trapped for millions of years.

- The HF process itself does not create conditions that would overcome these natural restrictions on fluid movement and allow HF fluids to migrate upwards thousands of feet to reach drinking water aquifers: First, the pressures associated with the HF process are too short-term and localized to push fluids through thousands of feet of low permeability rock. Second, the fractures created during HF operations are of limited height. This is confirmed by data collected by Pinnacle from over 12,000 HF operations in shale plays and other formations across the country, which show that in all cases there were at least 1,500 feet (and usually more than 3,000 feet) of intact bedrock above the fractures. These data are consistent with the limits on fracture height growth suggested by basic geophysical principles. Finally, the same data show that the presence of natural faults in the bedrock does not significantly contribute to the upward movement of fluids.

Gradient found that even if the HF fluids could migrate upward through hundreds of feet of bedrock, the fluids would be so highly diluted that the concentrations of the chemical constituents would be well below levels that would begin to give rise to any human health concerns. Accordingly, the report concludes that the fluids pumped into a target formation as part of the HF process do not present a risk to human health, a conclusion that is consistent with the findings of a number of other reports.

<u>Fluid spills would not adversely affect human health</u>: Gradient also analyzed the potential for spills of HF fluids (or flowback fluid containing HF chemical constituents) to reach either drinking water wells or surface waters that might be used as a source of drinking water. Gradient used a "probabilistic" approach that took into account the broad spectrum of conditions found in the areas of shale plays and other tight formations across the country as well as a wide range of spill scenarios. Moreover, in conducting its analysis Gradient used a number of very conservative assumptions. For example, Gradient assumed that no spill mitigation measures were in place even though such measures are standard in the industry. Gradient also assumed that 100% of the amount spilled would reach a surface water and would reach a drinking water aquifer, even though this would not occur under actual conditions.

Using this comprehensive but conservative approach that would substantially overestimate risk, Gradient determined the concentrations at which HF constituents might be found in surface water or a drinking water well as a result of a spill. Gradient determined these concentrations by analyzing the extent to which a number of key mechanisms would result in the dilution of the fluids and a reduction in the concentrations of any chemical constituents in the spilled fluids (this analysis was also conservative because it did not take into account all processes – such as adsorption of chemicals to the soil – that would naturally decrease the concentrations of chemicals as they move through the environment). Gradient compared these predicted concentrations of chemical constituents to concentration levels at which health effects might become a concern. Gradient found that any human health risks associated with HF constituents in the spilled fluids would be insignificant because various dilution mechanisms would further reduce the already low concentration levels of HF constituents before they ever reached drinking water sources.

<u>Overall conclusion</u>: Gradient's overall conclusion is that when used in their intended manner HF fluids are not expected to pose adverse risks to human health because wells are constructed to prevent HF fluids from coming in contact with shallow aquifers and it is implausible that fluids pumped into a target formation would migrate through overlying bedrock to reach shallow aquifers. Even in the event of surface spills, environmental dilution mechanisms would reduce concentrations of HF chemicals in either groundwater or surface water below levels of human health concern.