HDD Training

Hydraulic Fracture and FracOut

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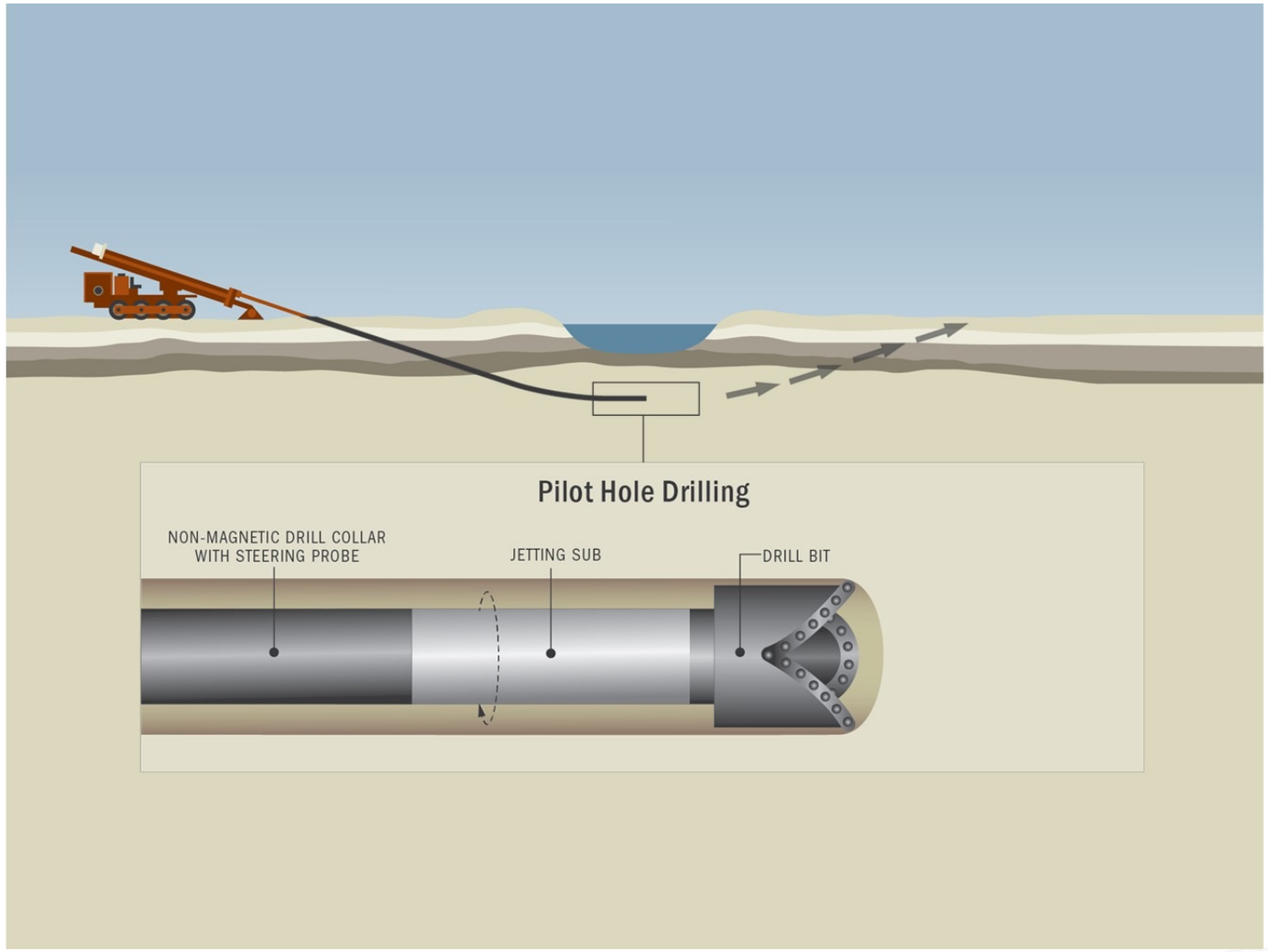
Fluid Loss and Hydraulic Fracture

The total drilling fluid pressure at the cutting tool is a function of pumping pressures, the elevation difference between the drill rig and the cutting tool and friction losses. Formations along the drill path experience maximum drilling fluid pressures in the immediate proximity of the drill bit or reaming tools. The energy (pressure) of the drilling fluid is steadily diminished along its path from the drill rig to the cutting tool and back through the annulus to the entry and/or exit pits. Thus, the pumping pressure required to circulate the drilling fluid increases as the length of the drilling fluid flow path increases.



Drilling fluid circulation can be reduced or lost during HDD operations. This is usually the result of either drilling fluid loss to the surrounding formation or by the accumulation of cuttings downhole that create a blockage of the annulus, thereby increasing the potential for hydraulic fracture to occur.

1. Formational fluid loss occurs when drilling fluid flows into surrounding permeable formations either within the pore spaces of soil units or along preexisting fractures or voids in soil and rock formations.

2. Hydraulic fracturing can occur where the combined resisting force of the available overburden pressure and the shear strength of the surrounding formation is less than the hydrostatic pressure applied to the formation from the drilling fluid within the annulus of the hole.

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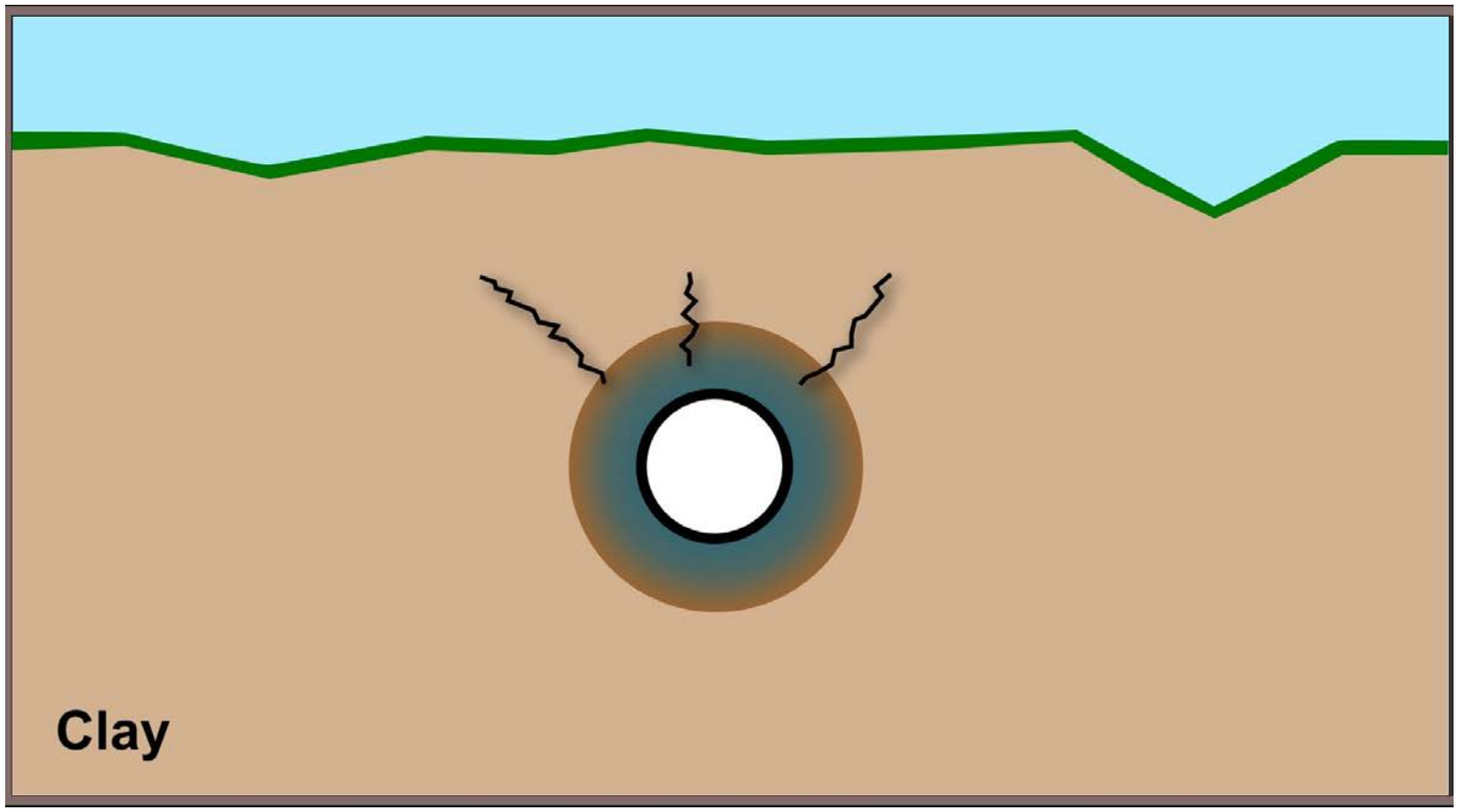
Hydraulic Fracture

Hydraulic Fracture

Hydraulic fracture is a term typically used to describe the condition in which the downhole drilling fluid pressure exceeds the overburden pressure and shear strength of the formation above a drill path. Hydraulic fracture typically occurs when the drill path passes through relatively weak cohesive soils with low shear strength or loose granular soils. Very loose to loose sands and silty sands and soft to medium stiff silts and clays typically have a higher hydraulic fracture potential. Medium dense to very dense sands and very stiff to hard silts and clays generally have a low to moderate hydraulic fracture potential. HDD installations with drill paths, which target higher shear strength soils, may reduce the potential for hydraulic fracturing. Rock formations, because of their relatively high shear strength, typically have a low susceptibility for hydraulic fracture at the pressures typically utilized during HDD operations.



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Drilling Fluid Surface Release

Drilling Fluid Surface Release

Drilling fluid surface releases (FracOut) occur when drilling fluid emerges at the ground surface or in any other undesired location such as wetlands, utility trenches, basements, roads, railroads, and water bodies. Inadvertent drilling fluid returns, whether by formational drilling fluid loss or hydraulic fracture, have the potential for releasing relatively large volumes of drilling fluid over a short period of time, particularly if the high pressure drilling fluid pumps are not disengaged.

In practice, drilling fluid surface releases typically occur in close proximity to the entry and exit points where the soil cover is thin and the shear strength of the near surface soils can be weaker. Drilling fluid surface releases can also occur at locations along a drill path where there are low shear strength soils, where the thickness of soil cover is thin or along preexisting fractures or voids. Other locations where drilling fluid surface releases can occur include exploratory boring locations, or along the edges of existing subsurface structures such as basements, piles or utility poles.

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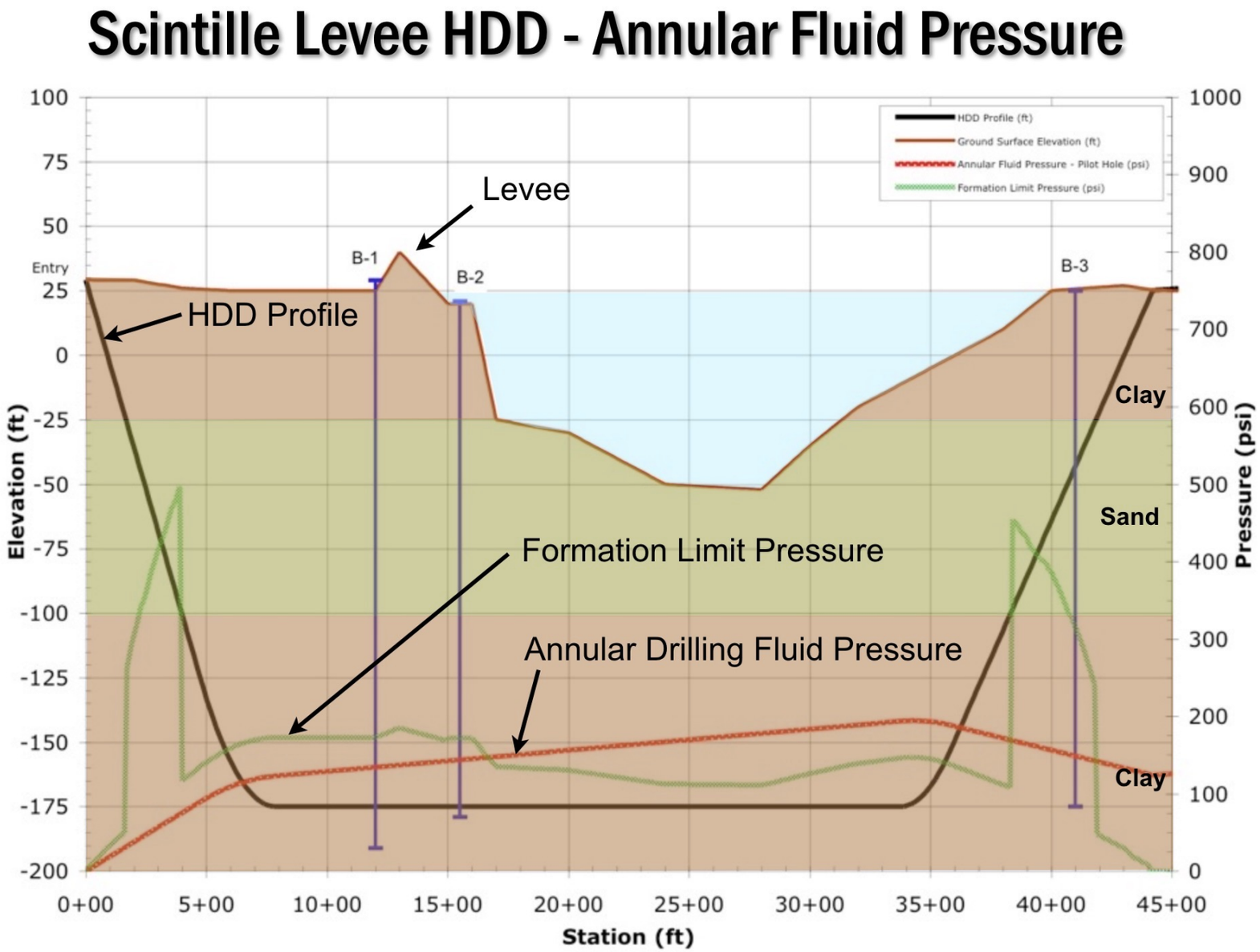
Hydraulic Fracture Model



In the hydraulic fracture model, the formation limit pressure varies depending on the soil and bedrock encountered along the HDD profile shown as the green line. The estimated drilling fluid pressure is shown as the red line in and represents the estimated drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties.

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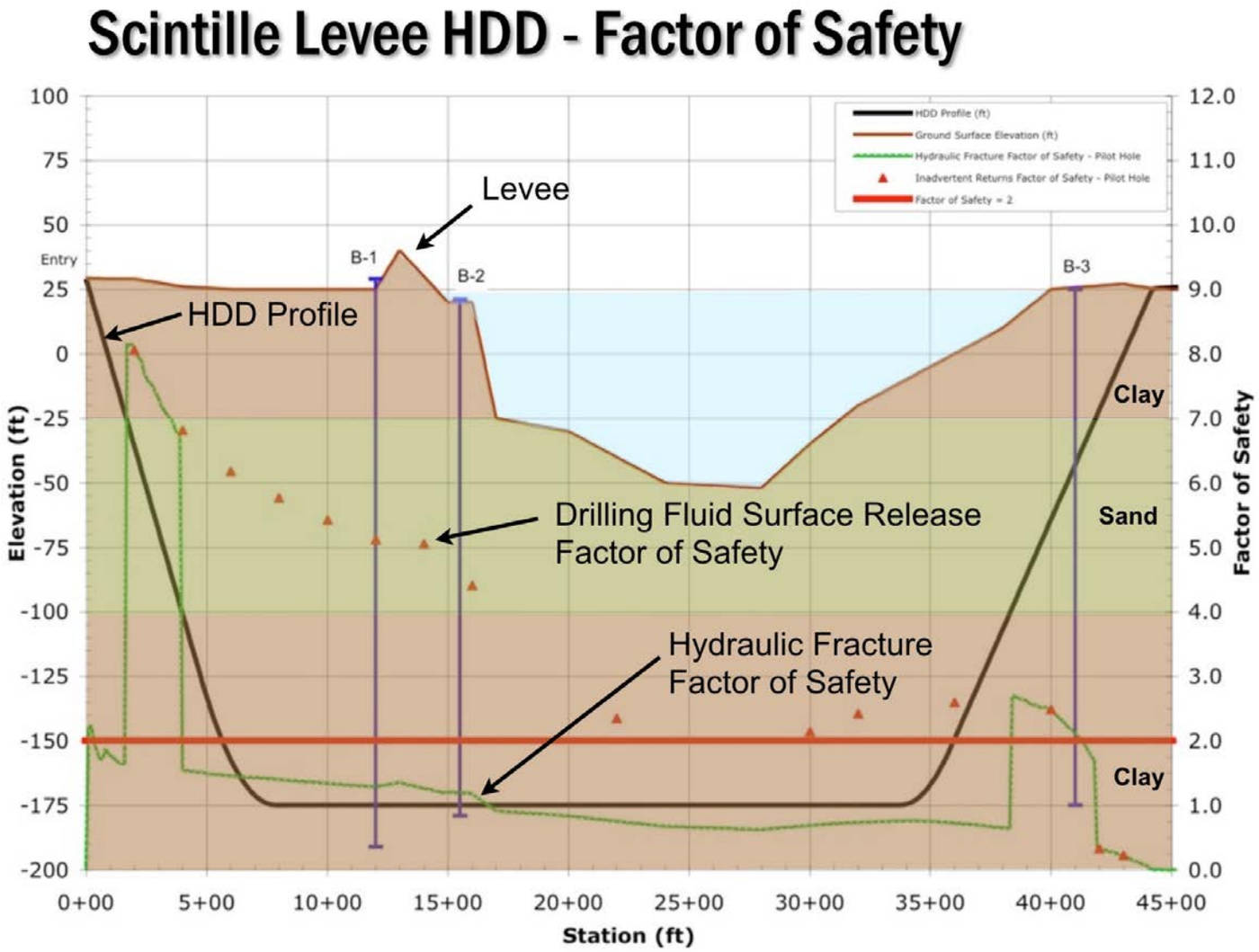
Factors of Safety

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

1. Factor of Safety against localized hydraulic fracture

2. Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.



Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil and rock units above a specific point along the planned HDD profile to the anticipated drilling fluid pressure at that same point. The factors of safety against drilling fluid surface releases are shown at selected points shown as red triangles.

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