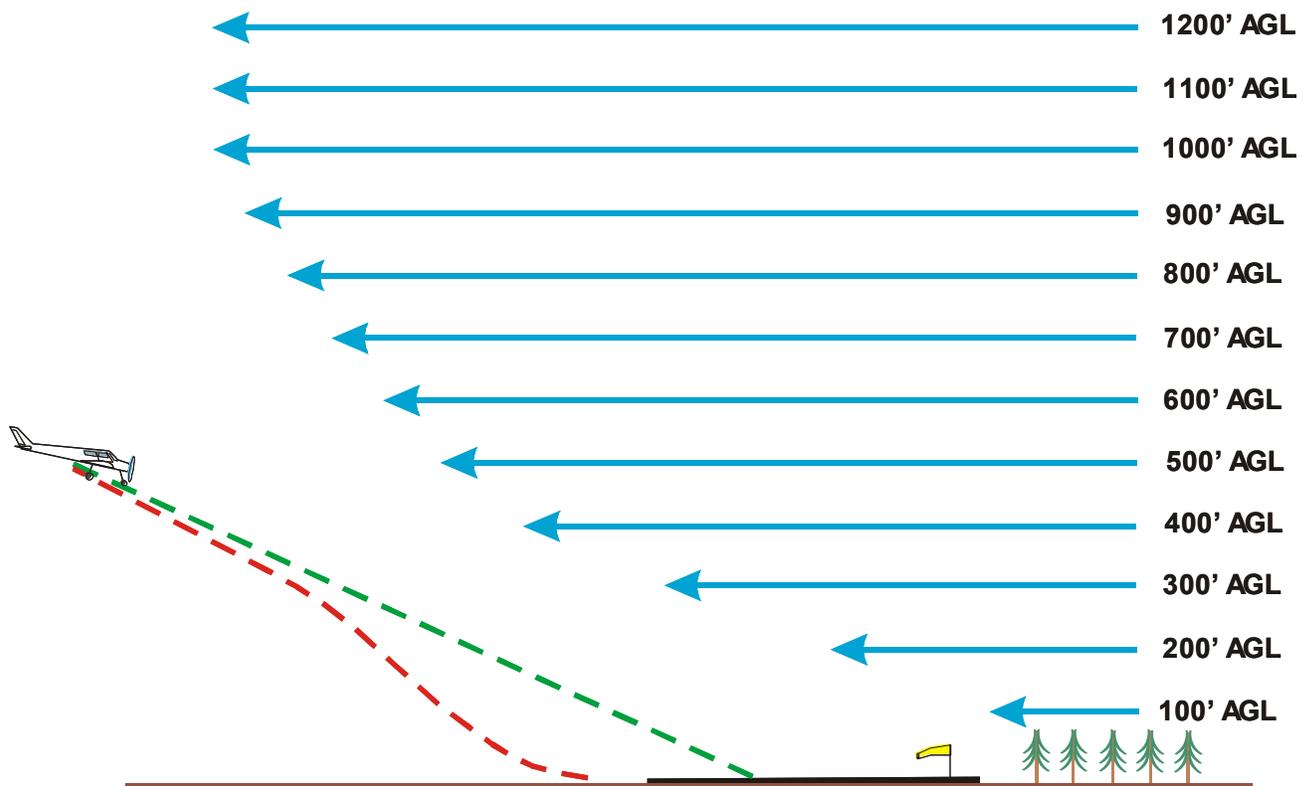


## Wind Velocity Gradient

The subject of wind velocity gradient and its effect on landing approaches is commonly presented in texts for glider pilots. While a thorough understanding of this dynamic is critical when operating unpowered, fixed-wing aircraft without the ability to execute go-arounds, pilots of airplanes can utilize this knowledge to increase the quality of their approaches. Additionally, this knowledge can increase the probability of a successful outcome in the event of an emergency landing.

It is common knowledge that wind velocity varies with altitude. In the boundary layer of the atmosphere, defined as the first 1000 feet, the change is normally an increase in wind speed with an increase in altitude. Friction between objects on the earth's surface and the air flowing across them decelerates the flow at the surface contact. The effect of this friction decreases as distance from the surface increases. The rate of this change, or wind velocity gradient, is non-linear.

In the figure below, the blue arrows represent force vectors of wind velocity. Notice that the wind velocity is relatively constant above 1000 feet AGL. Below that altitude, the velocity decreases exponentially, with the greatest decrease occurring below 300 feet AGL.



The pilot of the airplane in this figure has established a pitch/power condition that will result in an approach path, depicted by the green dashed line, that will achieve the

touchdown zone of the runway. As the airplane descends through 300 feet AGL, it will be encountering a rapidly-decreasing headwind. If a constant power setting is maintained, pitch must be decreased to maintain proper approach airspeed. The result will be an increased rate of descent that will result in an approach to a spot short of the intended touchdown point (the red dashed line). If pitch is increased to maintain the planned approach path without an increase in power, the airplane will have insufficient energy at touchdown, and a hard landing will result.

### **Approach strategy**

Since the last 300 feet of an airplane's landing approach occurs in a few seconds, it is vital that the pilot anticipates the effect that the wind velocity gradient has on the approach, and takes corrective action before the condition becomes critical. Simply stated, the pilot should be *proactive* rather than *reactive* in dealing with the wind velocity gradient.

The most obvious approach strategy when encountering this condition is to modify power management. As the airplane approaches 300 feet AGL, an application of power will counter the loss of lift energy, and the original planned approach path will be maintained. This power application in piston-engine aircraft will result in a relatively instantaneous increase in lift due to the rapid response to throttle inputs and accelerated slipstream over the wings from the propeller. Turboprop engines respond to power increases more slowly, so pilots of these aircraft will be required to apply additional power sooner in the approach to achieve the same results. Turbojet or turbofan airplanes do not normally benefit from accelerated slipstream, so the application of additional power must be initiated even sooner.

Another strategy for countering the effects of the wind velocity gradient is to choose an aim point for the approach that is further down the runway and accept the increased sink rate in the final approach segment. This is the *only* strategy available to the pilot when additional power is not available, such as an approach due to engine failure (for in a glider).

### **Detection and evaluation**

Successful execution of an approach in the presence of a wind velocity gradient is dependent on the pilot's ability to detect its existence and evaluate its effect. When landing in a headwind, there is *always* a wind velocity gradient, but it will be noticeable only when there is significant wind. As overall wind velocity increases, the wind velocity gradient steepens, resulting in a greater sink rate when the boundary layer is encountered. So a greater power application should be anticipated as surface winds increase.

Absolute wind velocity is not the only factor that determines the severity of the gradient. Surface conditions play a vital part in decreasing the wind velocity in boundary layer of air. Structures, vegetation, and terrain relief increase surface resistance and enhance the

effect on the approach. An airport that is surrounded by buildings, trees, and/or hilly surface features will have a steeper wind velocity gradient than an airport with the same absolute wind velocity that is situated in the middle of flat grasslands.

Astute observation of the wind conditions and the surface features in the airport environment will allow the situationally aware aviator to develop a workable proactive approach plan that will result in a safe and pleasant landing.