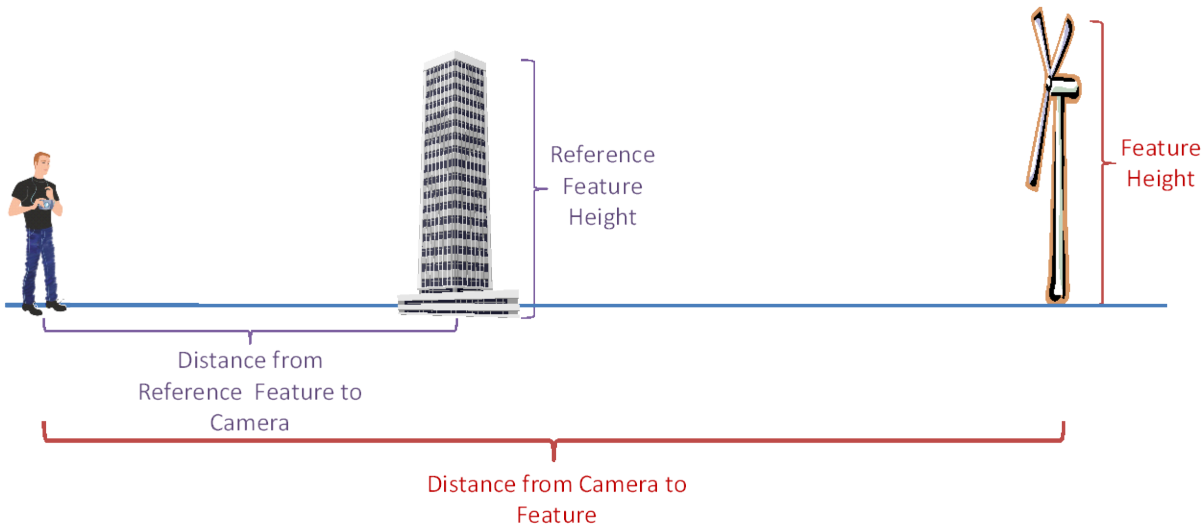
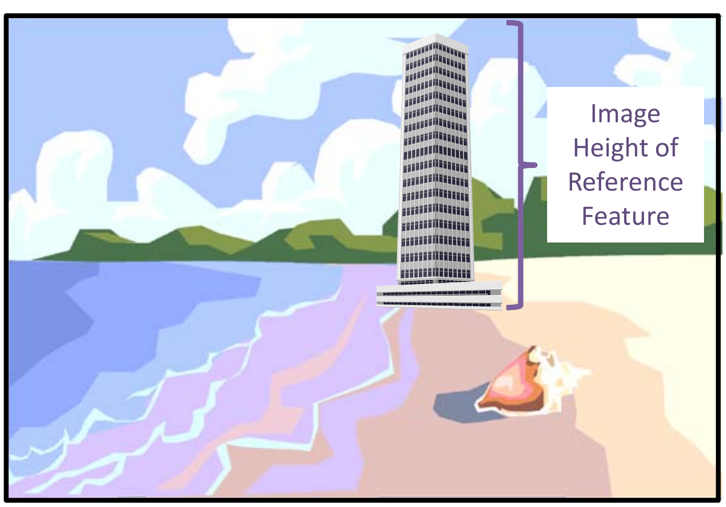
# CanVis Distance Calculations

This document offers general guidelines on how to estimate the height of a feature or object in CanVis given its distance from the camera and actual height. Please note that there are many other ways to perform these calculations. This is for basic estimates only. More advanced software and calculations are required for added precision.

## Relative Distance and Heights




To calculate the image height of any feature, you need a calibration photo of another feature (referred to as a reference feature) taken at a known distance and height, using the same camera at the same focal length (zoom) as that used to photograph the original feature. The calibration photo will give the "image height" if the image is neither cropped nor zoomed. CanVis assumes both images are the exact same size—8x12 inches, 5x7 inches, and so forth. It also assumes the principal plane of the feature is perpendicular to the camera.




## Variables:

Dr : Distance from Reference Feature
Df: Distance from Feature:
Ar: Actual Height of Reference Feature
Af: Actual Height of Feature
Ir: Image Height of Reference Feature
If: Image Height of Feature

Determine Image Height

$$If = \frac{Af}{Ar} \times \frac{Dr}{Df} \times Ir$$

Example:
In a photograph, how tall would a 400-foot (Af) wind turbine that is 10 miles (Df) away appear to be? A reference photograph taken at 1000 feet (Dr) from a hotel that is 150 feet (Ar) high reveals that on an 8x12 inch image the hotel appears to be 5 inches (Ir) tall.

Using the above equation: If = (Af/ Ar) x (Dr /Df) x Ir

If = (400 feet /150 feet) x (1000 feet/52800 feet) x 5 inches
If = 2.66 x 0.019 x 5
If = 0.25 inches on an 8x12 inch image

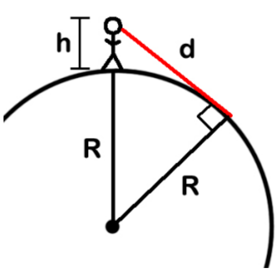
To calculate Df:
1 mile = 5,280 feet
10 miles = 52,800 feet

**This calculation does not consider the amount of the feature concealed by the horizon. This is a factor if the feature is over 3 miles away (assuming the camera is at 6 feet above sea level). The impact of the horizon is not usually significant enough to worry about when doing basic estimations.**

# Distance to Horizon

From a height of about 6 feet the horizon is about 3 miles away. If the feature is further away than the horizon it needs to be cropped to reflect this. Distance to horizon calculations can also tell you how far away a feature must be to be totally invisible from the camera.
Note: These calculations do not take into consideration haze, wave height, or weather conditions all of which may impact the view.

Determine Distance from Camera to Horizon
Note: There are several versions of this equation, many slightly different. An on-line "Distance to Horizon Calculator Tool" is available at http://boatsafe.com/tools/horizon.htm




$$Distance\ to\ Horizon = 1.312\ x\ \sqrt{height\ in\ feet}$$

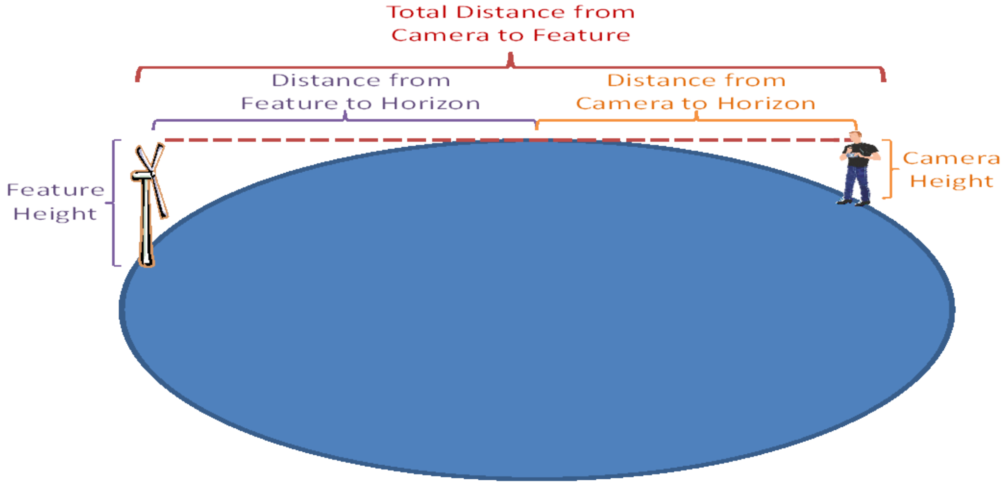
Source: http://adsabs.harvard.edu/abs/1913Natur..92..344B

http://blogs.discovermagazine.com/badastronomy/2009/01/15/how-far-away-is-the-horizon/

Note: Camera height is the distance from sea level to eye level. If the photograph is taken from an elevation this needs to be included in the equation.

Example:
If you are standing on a balcony 60 feet above sea level, how far away is the horizon?
Camera height: your height + elevation = 6 feet + 60 feet = 66 feet
Distance to Horizon: 1.312 x √66 = 10.7 miles (statute miles, not nautical miles)

## Determine Distance from Camera to Feature




Distance from Camera to Horizon (miles) = 1.312 x √camera height (feet)
Distance form Feature to Horizon (miles) = 1.312 x √feature height (feet)

Total Distance from Camera to Feature = Distance from Camera to Horizon + Distance form Feature to Horizon

Line of Sight Calculator: http://www.qsl.net/w4sat/horizon.htm

Example:
Let's assume the wind turbine is a total of 400 feet tall and the photo is taken at 6 feet.
The distance of the photographer from the horizon is: 1.312 x √6 = 3.21 miles
The distance of the wind turbine from the horizon is: 1.312 x √400 = 26.24 miles

The total distance from the camera to a turbine emerging from the horizon would be: 3.21 + 26.24 = 29.45 miles

Or, a 400-foot wind turbine would have to be at least 29.5 miles away to be invisible from the shore.

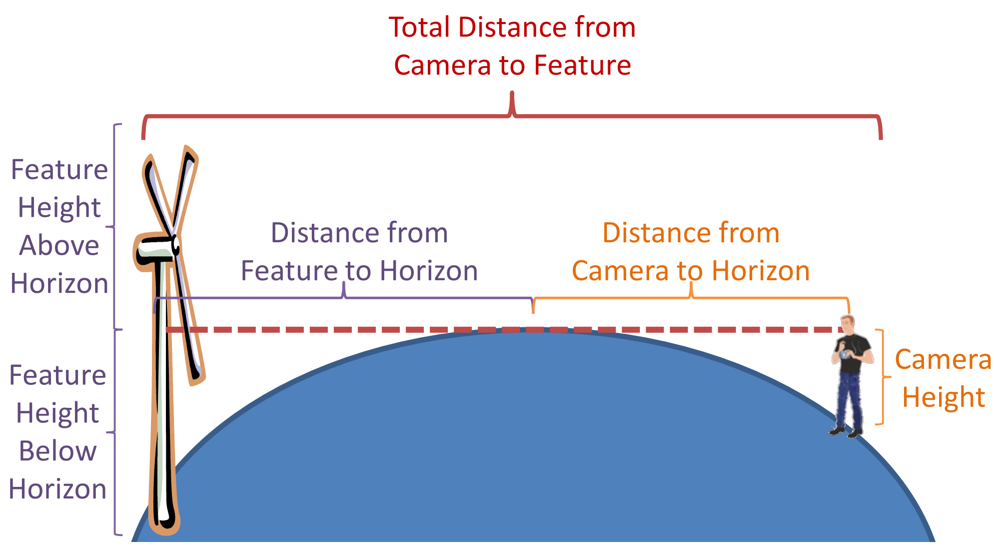
## Determine Amount of Feature below the Horizon

$$\boldsymbol{Feature\ Height\ (ft)} = \left(\frac{\boldsymbol{Distance\ from\ Feature\ to\ Horizon\ (miles)}}{\mathbf{1.312}}\right)^{2}$$

Distance from Feature to Horizon (miles) = Total Distance (miles) – Distance from Camera to Horizon (miles)

Example:
Using the same wind turbine, we decide to place it 10 miles offshore. How much of it will be visible?

First we need to determine the distance from the feature to the horizon using:
Distance from Feature to Horizon (miles) = Total Distance (miles) – Distance from Camera to Horizon (miles) = 10 miles – 3.21 miles = 6.79 miles




Next we need to determine how much will be below the horizon using:
Feature Height Below Horizon (feet) = (Distance from Feature to Horizon (miles) ÷ 1.312)$^2$
= (6.79 ÷ 1.312)$^2$ = 26.8 feet

Therefore 26.8 feet of the structure will be below the horizon.
Visible Height (Feature Height Above Horizon) = Total Height – Height Below Horizon
= 400 feet – 26.8 feet = 363.2 feet

## Bringing it all Together

Using the previous example:
How tall would a 400-foot (Af) wind turbine that is 10 miles (Df) away appear in a photograph? A reference photograph taken at 1000 feet (Dr) from a hotel 150 feet (Ar) high reveals that on an 8x12 inch image the hotel appears to be 5 inches (Ir) tall.

We would substitute 363.2 feet for 400 feet to accurately reflect the amount of visible wind turbine due to the horizon impact.

Using the above equation: If = (Af/ Ar) x (Dr /Df) x Ir

If = (363.2 feet ÷ 150ft) x (1000ft ÷ 52800ft) x 5 inches
If = 2.42 x 0.019 x 5
If = 0.23 inches on an 8x12 image

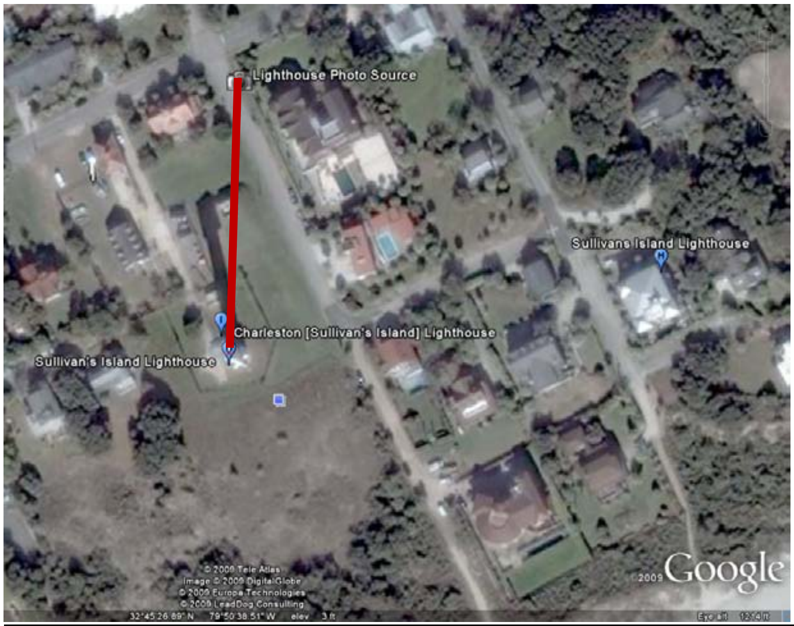
The original height was 0.25 inches, therefore 0.02 inches would have to be removed from the feature.

## Example from Isle of Palms

### Method 1 – Known Structure and Google Earth

I took this picture of Sullivan's Island lighthouse (140 feet). I used a Global Positioning System (GPS) to record the location. I could have also looked at features such as houses and street corners. I used Google Earth to figure out the distance between me and the lighthouse (330 feet).

Making sure that the lighthouse picture had the same dimensions as the ocean picture I planned to use, I measured it on-screen using a ruler (8.75 inches)




Method 1 – Known Structure and Estimated Distance/Height

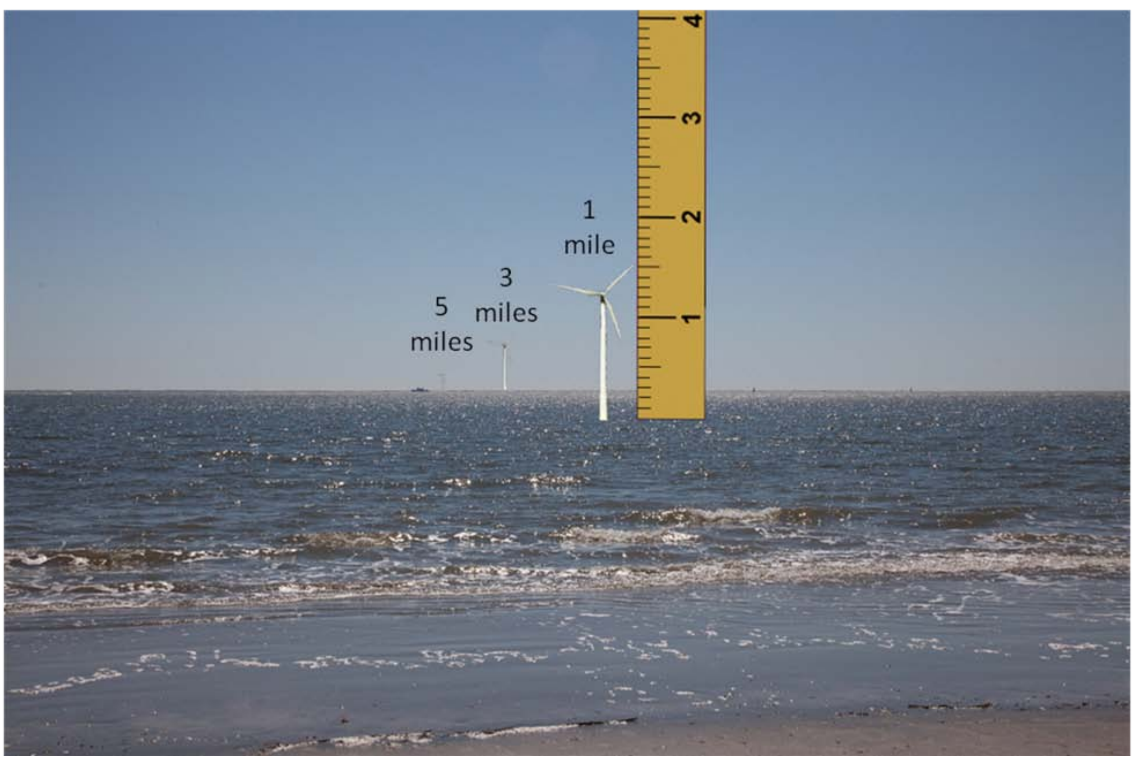
I took a picture of a man on the beach. I drew a line and walked 10 paces (about 50 feet for me) in the opposite direction, then turned around and took this photo.
The man is question is 5 feet, 7 inches. I used 5.5 feet for simplicity.

Making sure that the lighthouse picture had the same dimensions as the ocean picture I planned to use, I measured it on-screen using a ruler (2”).
Note – the CanVis ruler was calibrated using a real ruler. I resized it on the screen until the inch marks matched.


Creating Visualization

The heights of the wind turbines were estimated using:
If = (Af/ Ar) x (Dr /Df) x Ir
(see above for more details)

The results between the two methods were within 1/10 inches of each at the 1 mile distance for a 400-foot wind turbine. The height became less as the turbine moved further away.




Note: all photos were taken using a 50mm lens. This is approximately what the eye can see.