

Anatomy of a 3D Sidewalk Chalk Drawing: Building the Model

by Tannis Ewing
(Ray Tracing Input from my friend, Alan Herron)

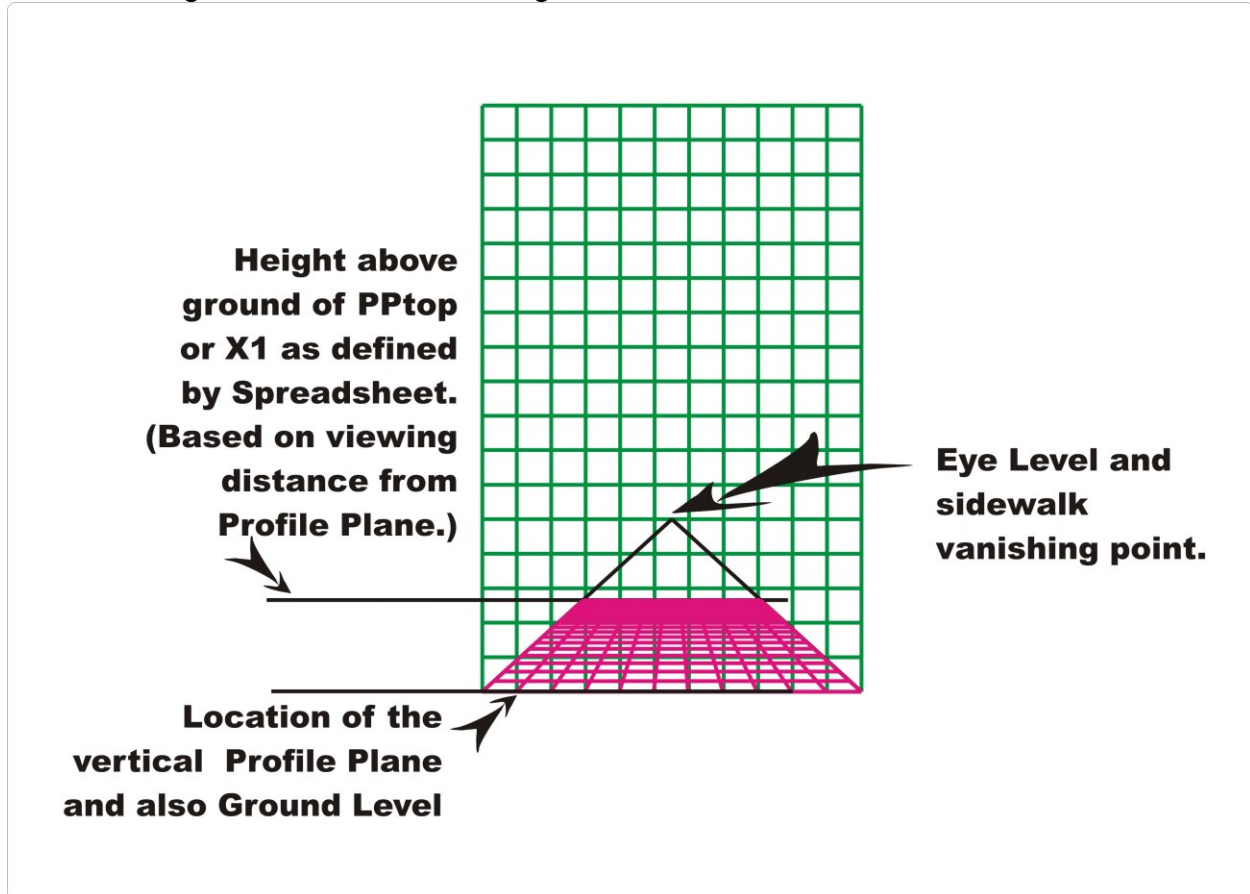
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Preparing the Paper Model

1. **Choose a piece of software in which you can do a perspective stretch.** For example you can do a perspective stretch on all vector files in CorelDRAW.
2. **Draw a regular grid within the program space** that looks like the green grid in the following drawing.

3. **Copy the green grid and turn the new copy red.** Then do a perspective stretch on the new red grid to turn it into a tilted grid as illustrated below.



Note in the above diagram:

- each of the squares, both green and red, represent a square foot on the ground when the sidewalk model is drawn i.e. consecutive green and red lines are each 1 foot apart.
- each square will also represent 1 inch on the printed page when you print your completed model. In this document we will work with a piece of 11" x 17" paper.
- in this example, ground level is located at the bottom of the green grid. At ground level both the green grid and the red grid are the same width.
- eye level is located 5 feet above the ground. (Count the number of green squares between ground level and the triangular point)
- this triangular point represents the vanishing point of the sidewalk, which is at the same height as eye level.

4. **Preparing for Calculations:** You can now modify your tilted grid to create the conditions that will suit your particular drawing. To do this you should do calculations to trace the rays of light according to the details for your image. You can find my Excel spreadsheet on this web site and copy it to your own machine. You can use the spreadsheet to do the calculations. You can calculate numbers by hand. Or you can just "wing-it" and forget this step! Don't be frightened! Explanations follow...

Elevation View to Define Spreadsheet Variables

The diagram illustrates the geometry of an elevation view from a viewer's perspective. Key variables and components are labeled as follows:

- Viewpoint**: The observer's eye position, marked with a sun icon.
- Standing Height of Viewer**: The vertical distance from the ground level to the viewpoint.
- VPHeight**: The total height from the zero base line to the viewpoint.
- Fr.Viewpoint to End of Image**: The horizontal distance from the viewpoint to the right edge of the image.
- Total Image Length**: The total horizontal width of the image.
- Theta1** and **Theta2**: Angles defining the field of view from the viewpoint.
- Foot of Image**: The horizontal line representing the base of the image.
- Profile Plane**: A vertical plane used for projection, shown as a green line.
- PPTop** and **PPBottom**: Vertical distances from the ground level to the top and bottom of the profile plane.
- Ground Level Plane of Sidewalk**: The horizontal reference line for the ground.
- X1** and **X2**: Horizontal distances from the zero base line to the profile plane and the end of the image, respectively.
- ZeroBaseLoc.fr.VP**: The horizontal distance from the zero base line to the viewpoint.

But where do you locate ground level on the sidewalk, given that part of your image is above ground and part is below?

6. The contents of the spreadsheet:

To locate ground level we need to do a calculation.

Check out the spreadsheet. You can make your own spreadsheet, do calculations by hand, or you can use the Excel spreadsheet that is located on this web site.

On the spreadsheet, the orange squares are available for input. The other squares are protected but the spreadsheet does not require a password if you wish to modify it. To do so, you must remove the protection.

Regarding input, my choice was that the top of my image (i.e. the point just above the princess's head) would be approximately 2.5 feet above the ground. I also chose that the hole where she was standing would be approximately 2.5 feet deep. Because the hole in the image spreads in front of the princess, the below-ground image will cover approximately 3.5 feet on the regular (green) grid. (See the input for "PPBottom" below.) My viewpoint height (eye level) is 5 feet and I used a distance along the ground between the viewer and the profile plane of 10 feet.

See input below. You need to insert the four values described above in the orange cells.

Input:

	Input
Height of Viewpoint Eye above Ground	VPHeight= 5 feet
Dist. from viewpt. along ground to intersection of profile plane with ground:	ZeroBaseLo 10 feet
	c.fr.VP=
Distance above ground of top point of profile plane	PPTop= 2.5 feet
Distance below ground of bottom point of profile plane	PPBottom= 3.5 feet

Results measured from Zero base Location:

	Output
Furthest distance on Sidewalk from profile plane projection to top of image	X1= 10.000 feet
Closest distance on Sidewalk from profile plane projection to bottom of image	X2= 4.118 feet
Total sidewalk length required for image	Total Image Length= 14.118 feet
Distance from Viewpoint to extreme end of image	Fr.Viewpoint to End of Image= 20.000 feet

Intermediate Calculations:

To calculate Theta1:	$\text{Theta1} = \text{ATAN}(\text{VPHeight} - \text{PPTop}) / (\text{ZeroBaseLoc.fr.VP})$	Theta1= 0.244979 radians
To calculate Theta2:	$\text{Theta2} = \text{ATAN}(\text{VPHeight} + \text{PPBottom}) / (\text{ZeroBaseLoc.fr.VP})$	Theta2= 0.704494 radians
To calculate X1:	$X1 = \text{PPTop} / \text{TAN}(\text{Theta1})$	X1= 10 feet
to calculate X2:	$X2 = \text{PPBottom} / \text{TAN}(\text{Theta2})$	X2= 4.117647 feet

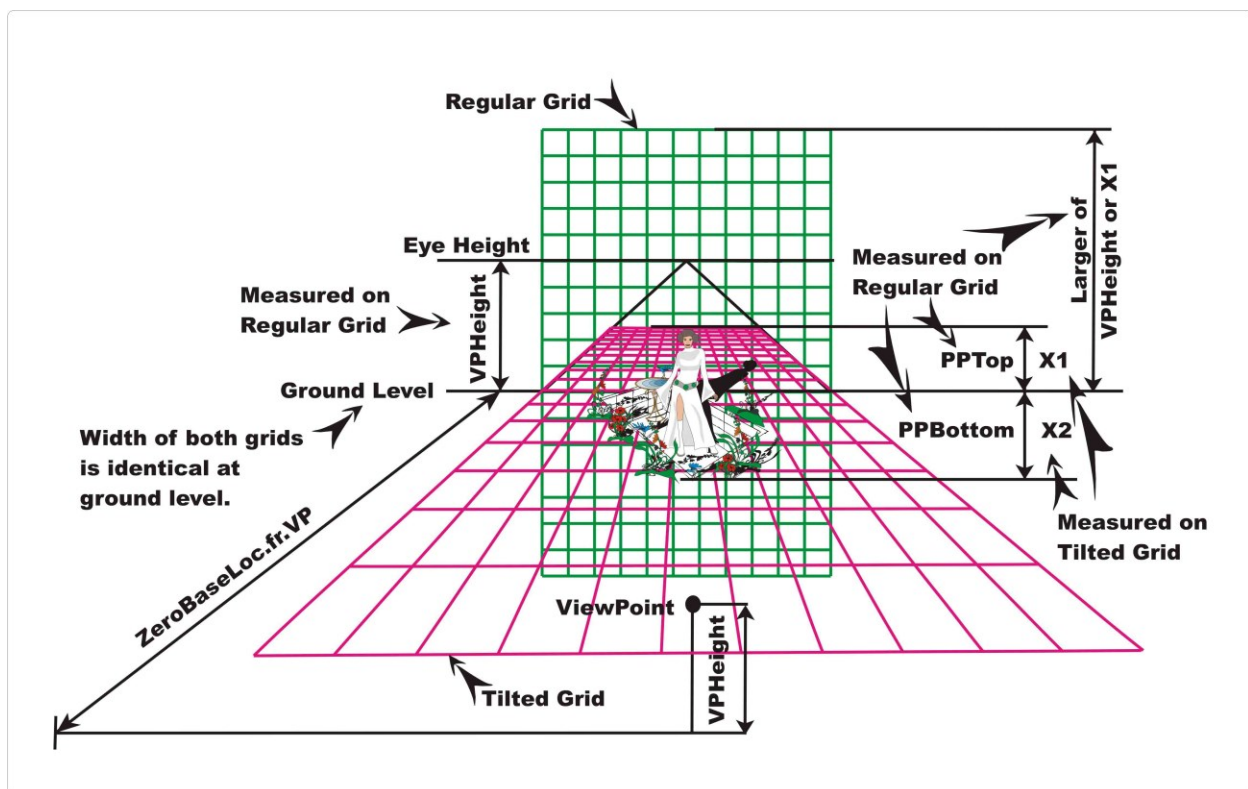
Using the above output we can make the princess approximately 5 feet in height. Part of her body will be above ground and part of it will be in the hole below.

(Note that nothing on your profile plane can be located above your eye level, because at eye level you have to draw to infinity on the sidewalk, in order to create the illusion.)

7. The frontal view of the above variables:

Note in the diagram below, ground level is located 10 squares below the top of both the red and the green grid. This is because the larger of “VPHeight” or “X1” is 10. See the spreadsheet result above.

The entire princess-image must fit on top of the red grid. There are 10 red squares above ground level to encompass the upper portion of the image per the calculation of the “Larger of VPHeight or X1”. At the same time, the height of the red grid (PPTop) is only 2.5 units as measured on the green grid. Ground level has to be located at least 10 **green** squares below the top of the regular green grid, and 10 **red** squares below the head-end of the tilted red grid



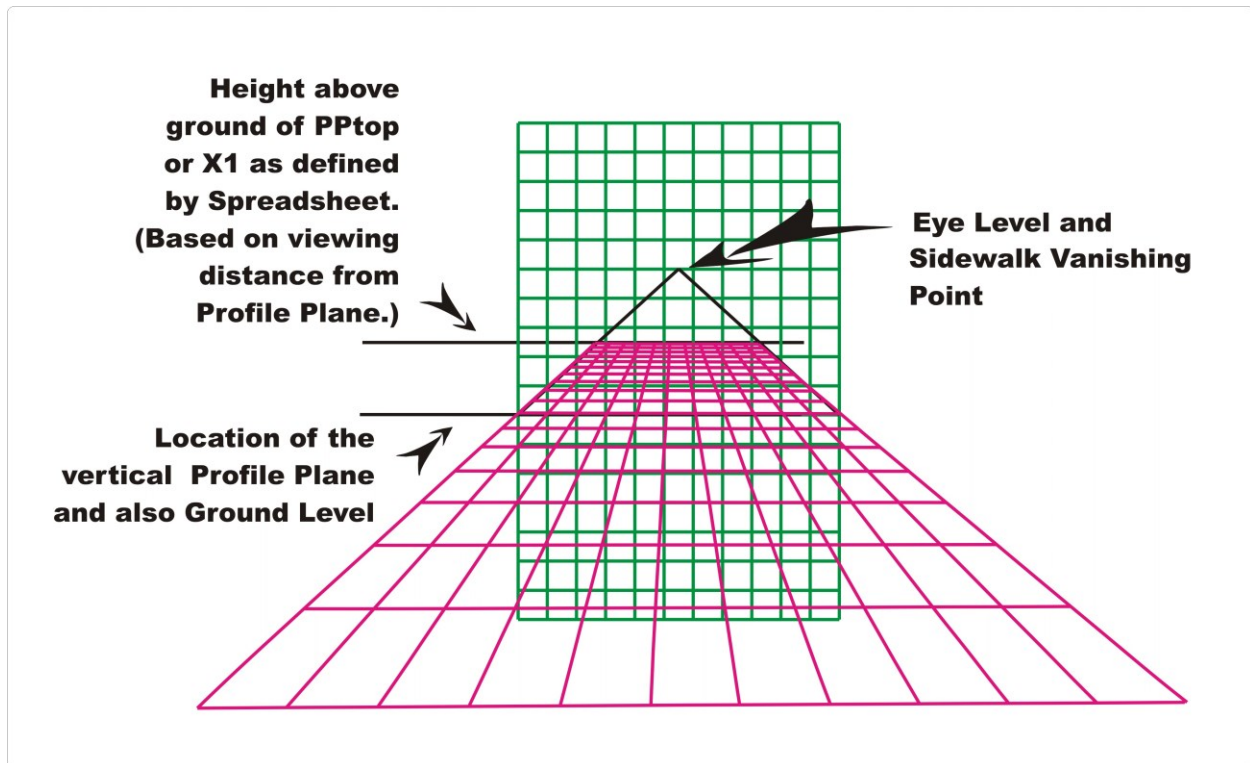
In summary, ground level will be located at 10 **green** squares below the top of the regular grid. It will also be located 10 **red** squares below the top of the tilted grid.

8. Mark ground level so you will not lose track of where it is located. In addition you need to mark the location of eye level and its equivalent vanishing point. See below.

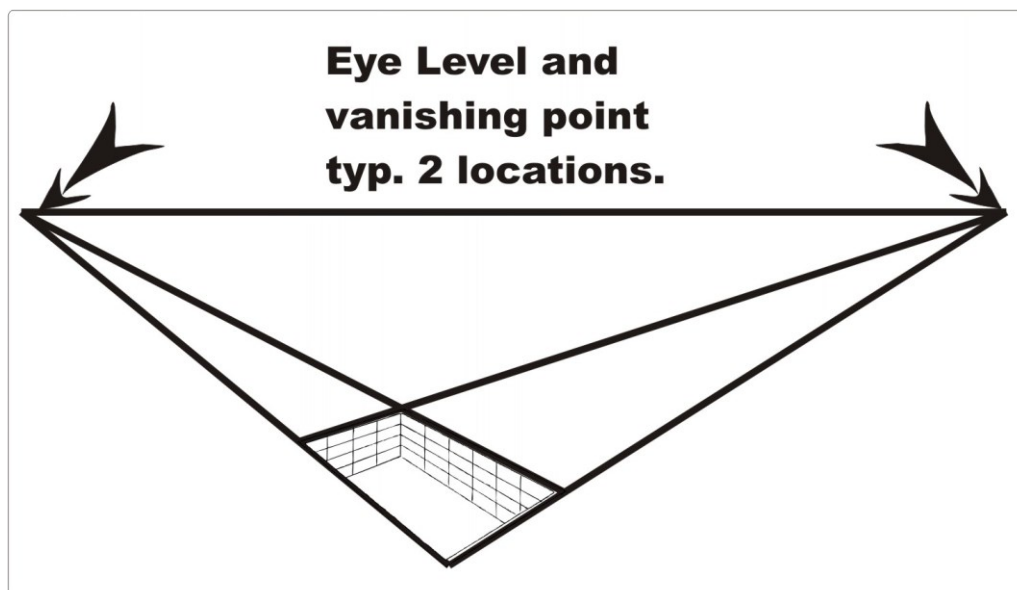
9. You can now locate your red grid by doing a perspective stretch on it, in such a way that the top of the red grid lands at two and a half feet above ground, as measured on the green grid. (Note: this 2.5 feet is PPTop, and is part of the input you entered into the spreadsheet to do your calculation.) In addition the width of the red grid should sit

within the triangle that disappears to the vanishing point. Also the width of the red grid should match the width of the green grid at ground level. The rest of the red grid can stretch as per the drawing program's algorithm.

The diagram below shows where your stretched red grid should sit, using the information above...



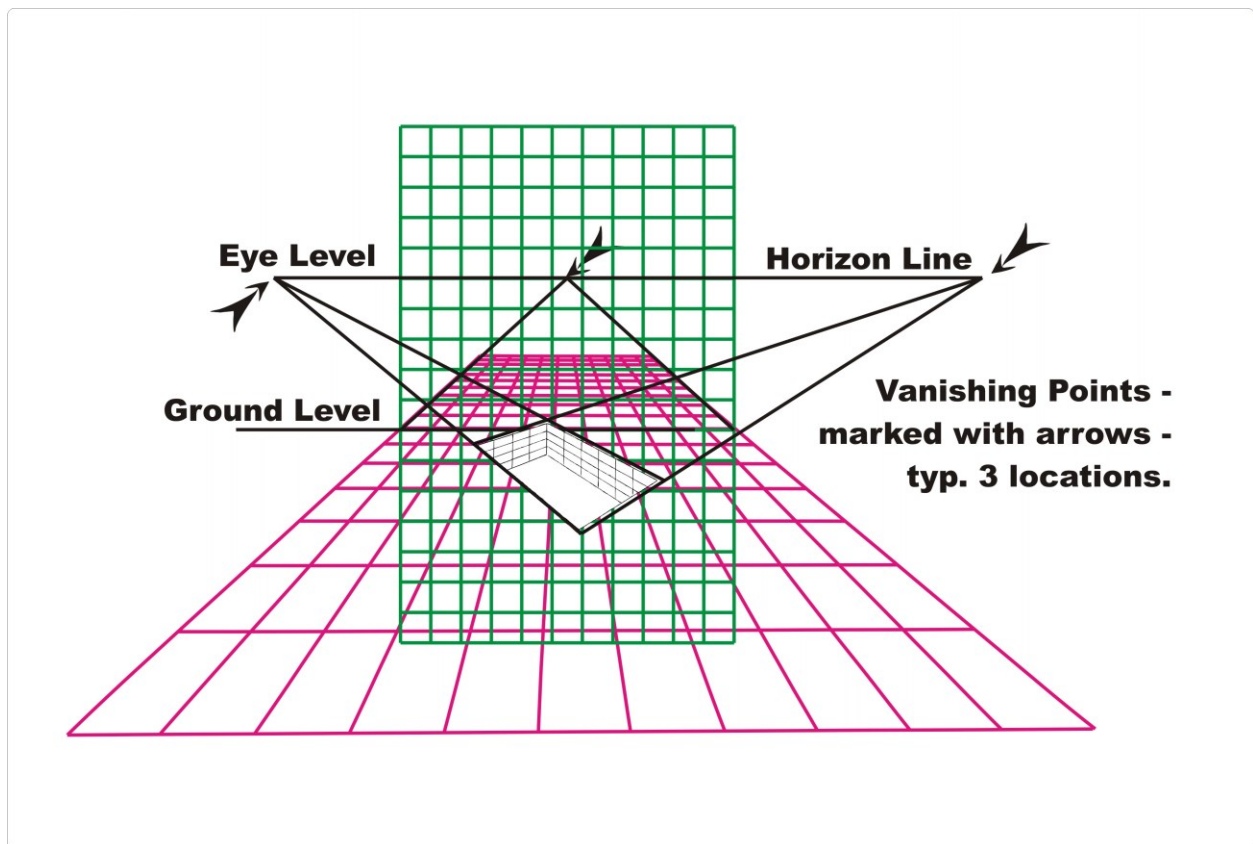
10. Create your hole complete with vanishing points:



11. You are now ready to add your hole to the model.

Whenever an object has horizontal planes that are parallel to the ground, vanishing points are on the horizon line. When the object's planes are inclined to the ground, vanishing points will be above or below the horizon line, depending on the direction of the inclination.

In our case the lines depicting the sides of the hole are all parallel to the ground and therefore should converge to vanishing points on the Horizon Line just as the sidewalk lines converge to the vanishing point on the horizon.

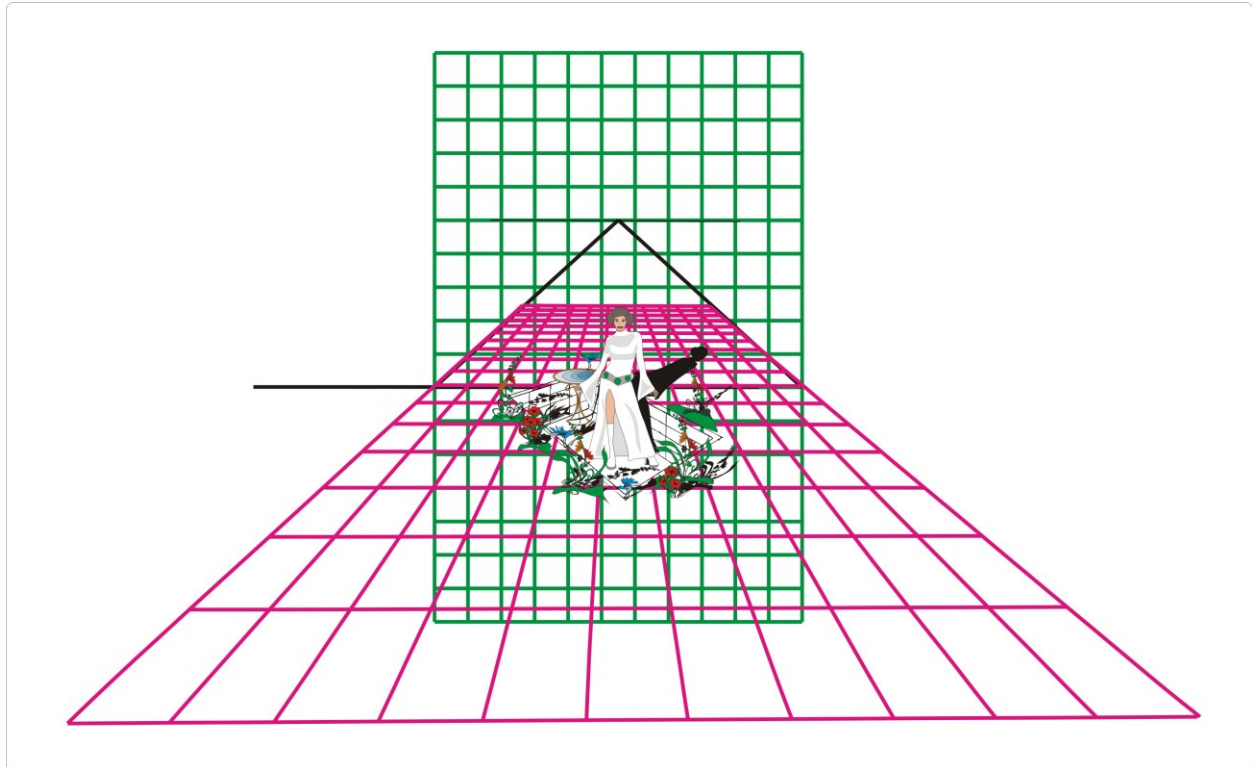


In general, all lines in your drawing that are parallel to the ground have to disappear to vanishing points that are located on a line at eye level on the horizon. This VP level, if you are looking from an eye height of 5 feet above the sidewalk, would be at 5 units above ground on your grid drawing. The eye point VP is represented by the triangular point in the grid drawing. The 5 foot height would be measured at the profile plane, i.e. the plane where your drawing would appear to be standing. (Reminder: this is also the point at which the sidewalk grid and the tilted grid both have the same width.)

12. Complete your image:

Some things to consider that will make your image more likely to be interpreted as three dimensional

- i. add shadows – to do so you might need to consider where you are going to place your drawing, and where the sun is most likely to be when it is viewed.
- ii. size the image realistically. For example in this case, since the princess is supposed to be 5 feet tall then her image should span the equivalent of 5 of the green squares, 2.5 ft. above ground, 2.5 ft. below.



All the plants and animals in the drawing need to be located below the vanishing point level. Why? Any object that is located at the same height as your vanishing point (5 feet in our example) would have to extend to infinity on the sidewalk. So the princess is in a hole and only 2-1/2 feet of her body is above ground level. In general, this problem of not wanting to draw to infinity explains why a lot of the 3D chalk drawings you find on the internet, contain objects that are either close to ground level or alternately, below ground level – in a hole.

You can use the tilted grid to measure and adjust the heights of other objects if you want them to appear to be located either further forward or further back on your profile plane.

13. Up close and Personal:

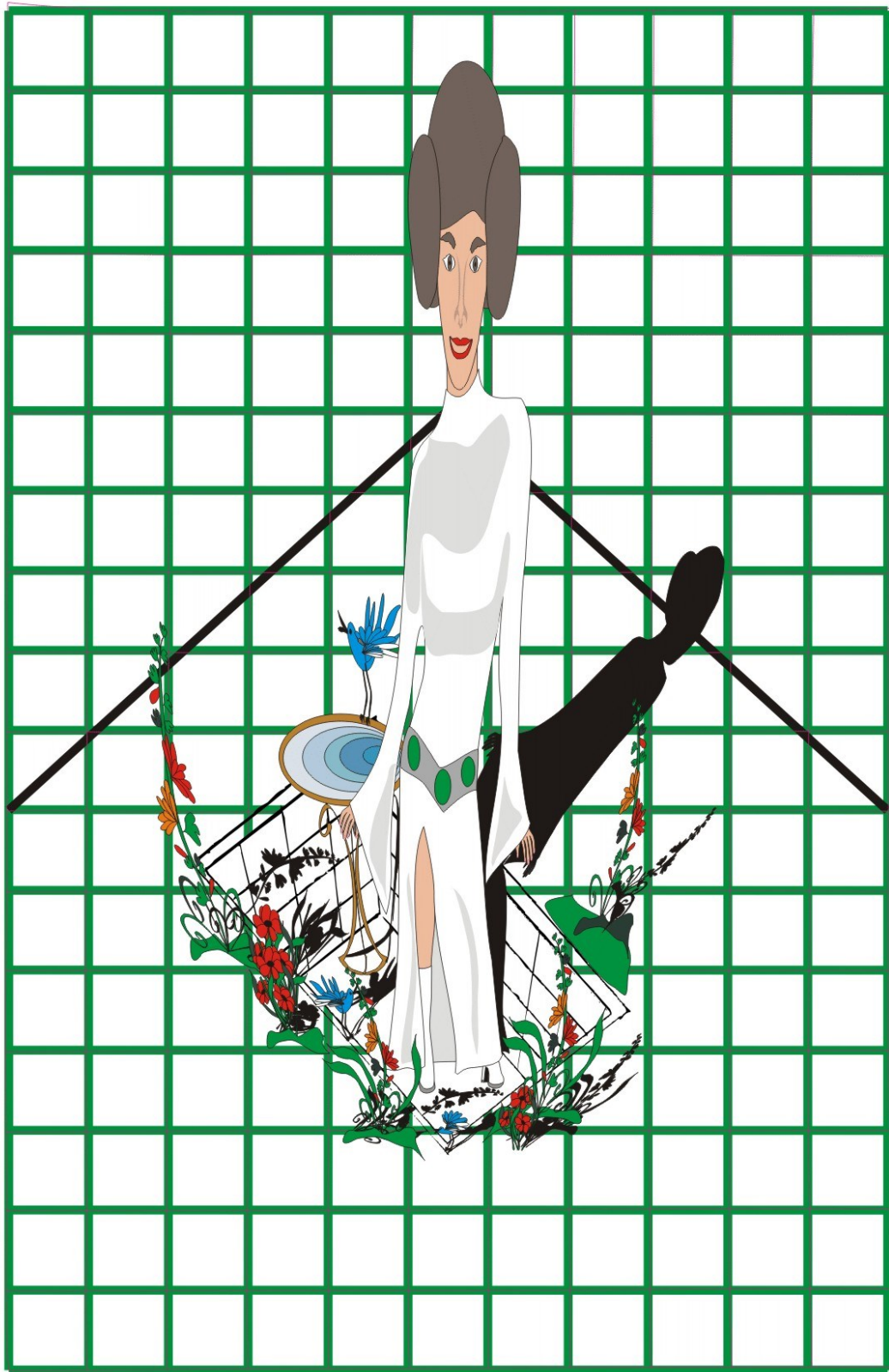
Detail of the above image... the illusion I will attempt to create on the sidewalk...



14. Doing your final Perspective stretch:

Now you need to group your image and the red grid together so that when you stretch one you simultaneously stretch the other. (Please note that you will be doing a perspective stretch, not a linear stretch on the grouped objects.)

When you have completed the perspective stretch, the **red grid** will sit immediately on top of the **green grid** and everything that is above ground will be stretched “out and up”. Everything that is below ground will be stretched “in and up”. In the end you will have a model that looks like this, with the red grid sitting exactly on top of the green grid...



14. Testing the Model:

Will the model actually work when you draw it on the sidewalk? You can make a test bed by setting up a scale model.



And this is what you will see through your hole:



You can compare this photo to the photo of the chalk drawing at the beginning of this document.

So have fun! Head for the sidewalk as soon as you collect together what you will need! See the second document to find out what I learned out on the sidewalk.

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