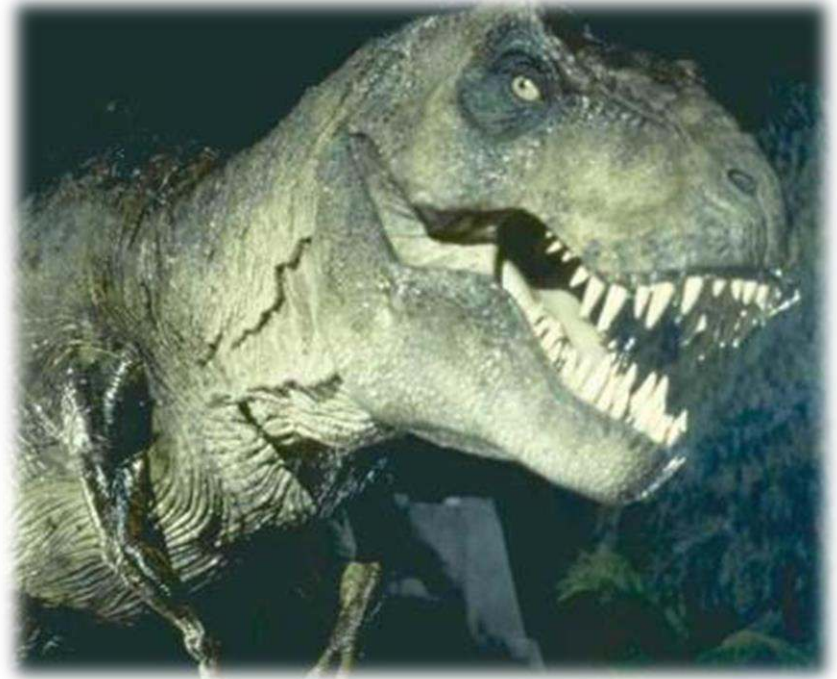


## Introduction to the contouring and topographical representation – *Digital Terrain Modeling*

What does this image of a dinosaur and digital topography have in common?

Both relied on a digital terrain model for representation. For the dinosaur, millions of tiny facets (triangles along a surface) define the shape and form. Graphics software systems include many features that are not required for site planning, so sorry, you cannot draw dinosaurs, but the same techniques are used for Virtual Reality (page 585).

Geometric accuracy is critical throughout the LandMentor processes, but for topography, exact location is not critical. This is because the depiction of the surface is defined by contour lines. A contour line communicates a particular elevation along the surface of the ground.



The surface data must come from a source either from a land surveyor in the field or from an aerial photograph translated in digital form. The initial topographical knowledge of a site will likely be from contour lines. Today, because of automation, it is likely that a Digital Terrain Model (DTM) already exists from a source file of the site. This is the best way to get topographic data if the land surveying calculations came from another firm using CAD. If LandMentor is used for land surveying, this section of the textbook will teach you how to create the DTM.

**There *must* be a DTM to use LandMentor Virtual Reality.**

## LandMentor

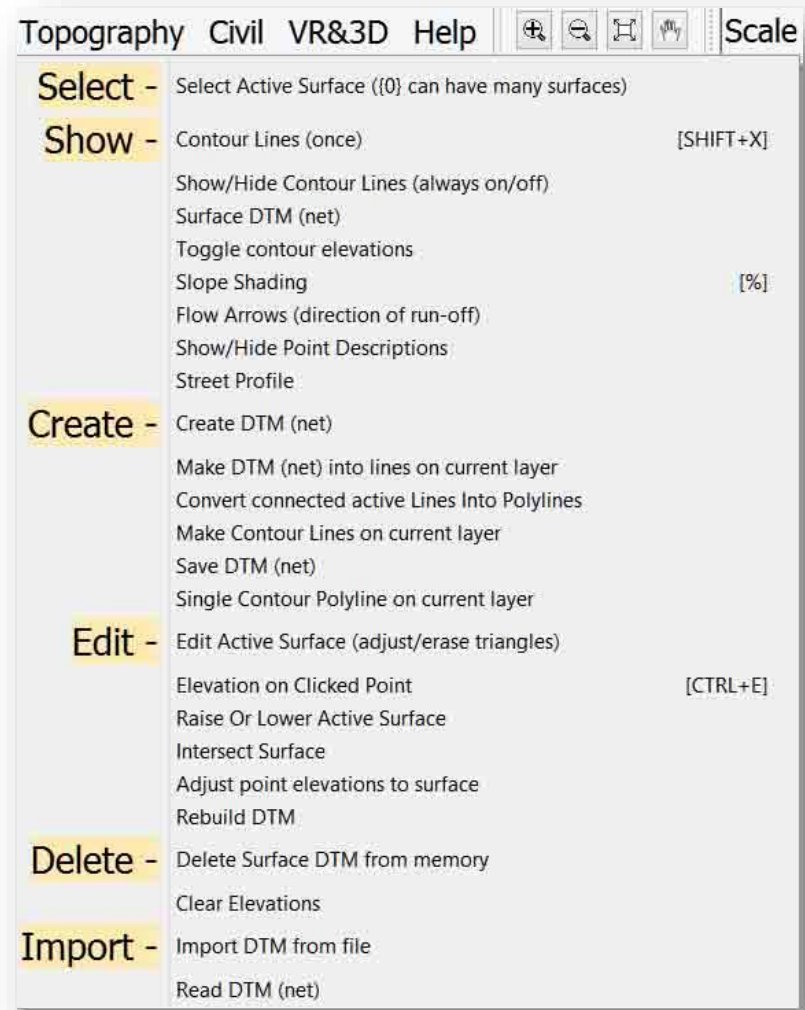
Your **LandMentor** system will generate a DTM from (surveyed) random points, contour lines with elevations attached, or from DTM lines from another software. ***The Virtual Reality requires that the site have a clean DTM!***

*High-level site engineering would require the skills of a civil engineer outside the scope of this textbook, thus the engineering abilities (when available) will be sold separately from the base system.*

The topographical features are located at the **Topography** pull-down:

The contour generation is intended to be an aid to the design process, site engineering when available, and serve as the foundation for virtual reality. **LandMentor** contains some features found in engineering software, however, there is no facility to assign templates for street construction or determine actual earthwork.

Engineering tasks should be left only to professionals specifically trained in site engineering. **LandMentor** is intended for the designer to interpret the surface of the land to influence the design, minimizing disturbance of the land for development. In that capacity **LandMentor** creates the opportunity for more sustainable solutions that will not need revisions once the design goes to engineering professionals.



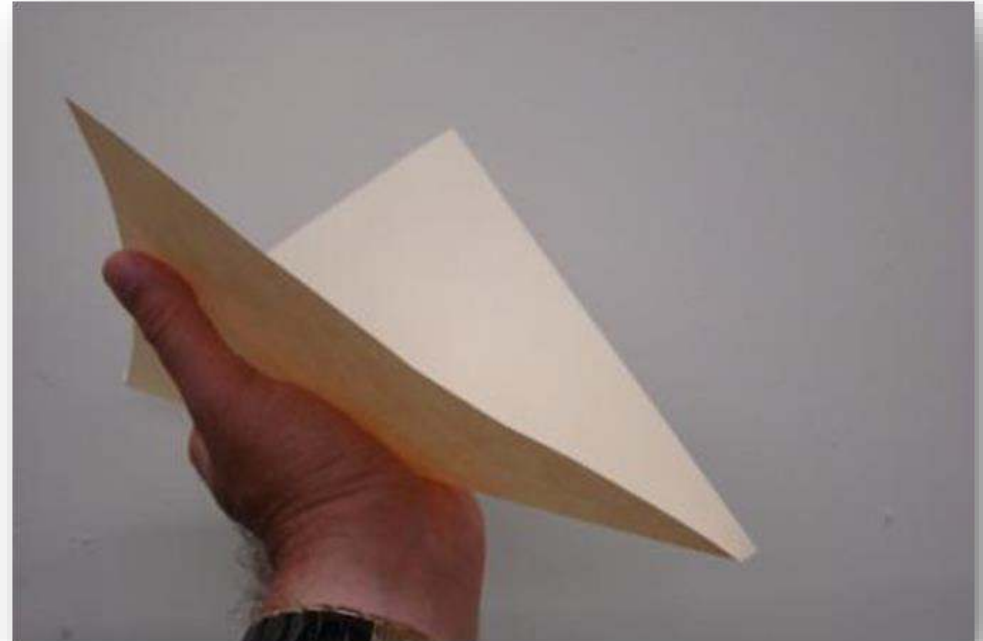
The triangular method of developing contour lines was pioneered by HASP, a Colorado software firm serving the civil engineering industry decades ago. Before then, software approximated contour location using a grid that could only give a vague representation. Also, while appearing to give a correct interpretation of the surface, triangles are 100% dependent upon someone familiar with the actual surface of the land to determine if the contours are correct.

To demonstrate this problem, look at the folded paper in this picture. When the paper is folded, it creates two triangular surfaces, right? Well, no. It actually creates 4 different triangles. Held as shown, the surface results in a valley down the palm of the hand.

Another possible surface results if the paper were flipped to have its edge at the top gap. The point locations would not have moved, yet the same locations would yield a hill instead of a valley!

Which is the correct answer? It's unlikely that you will know, yet your design will rely on the contours represented by the surface.

Luckily, it's also unlikely that the contour has triangles so large that it would result in large errors (see cautions at the end of this chapter).



If the topography was from aerial photography there can be many other problems. Why fly over land for topography instead of using ground surveys? Cost. It is more economical for an aerial photographer to create a contour map than a survey crew.

### **Accuracy of the aerial data?**

National mapping standards allow the elevation shown or interpolated (at any given point on the map) to be within a ½ contour interval of being correct. However, with heavy vegetation, it is not possible to obtain accurate aerial mapping data (LIDAR claims this limitation is eliminated). Imagine a surface with a grade of 1 percent – a one foot difference vertically for 100 feet of horizontal distance. If the contour is from an aerial source within national standards, the elevation shown may only be accurate within a 50 foot wide swath (in theory)! Typically, this might not be problematic, unless a government agency requires a particular minimum elevation (like in a flood plain). In this example, that minimum elevation could be within 50 foot margin of error. In theory, you could be legally placing homes in a flood plain during the design and approval process, at least until someone ultimately provides the precise elevation (contour location) based upon accurate field studies.

### **Excessive data**

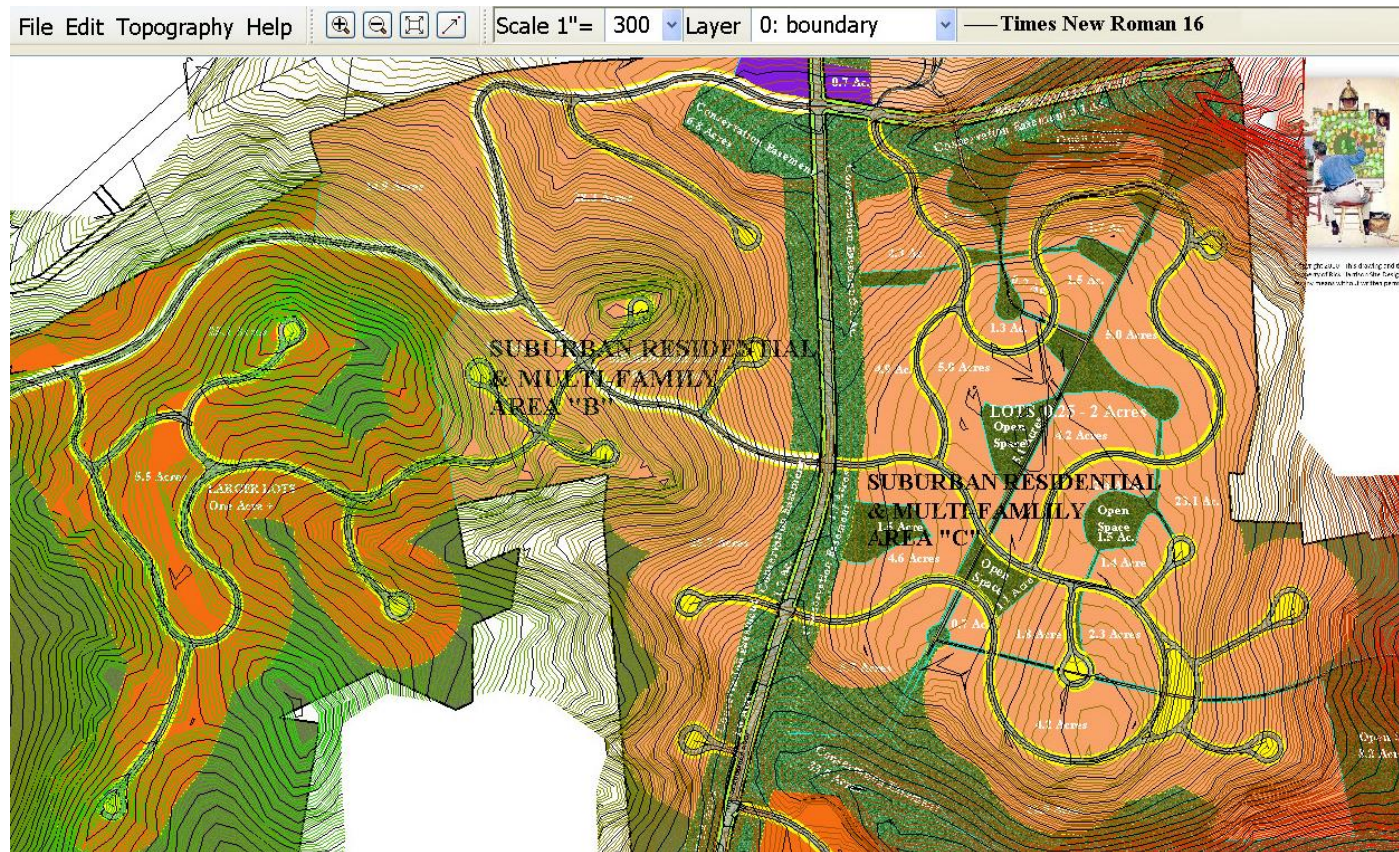
The contour seen on the next page comes from LIDAR data furnished from an aerial mapping company that did not possess software that could electronically strip excessive data from the data file. This 1,030 acre site, in South Dakota contained 36 million points to define what was essentially rural forested terrain. There is no viable way to use 36 million points within DTM-based software without overloading the capacity of even the most powerful computers and operating systems. Also this amount of data would render Virtual Reality useless.

Essentially, the LIDAR (developed by the military) uses a laser or optical system to gather information from an aircraft as it flies over an area.





In theory, LIDAR works well in rural or undeveloped areas, especially if the excess data is filtered out using special software. In reality, too much data renders the software unusable. Eventually, the data was manually filtered down to 30,000 points without destroying accuracy, but it took about 50 hours of painstaking labor that could have been reduced to a button press had the information been filtered. The result of this filtering is seen below.



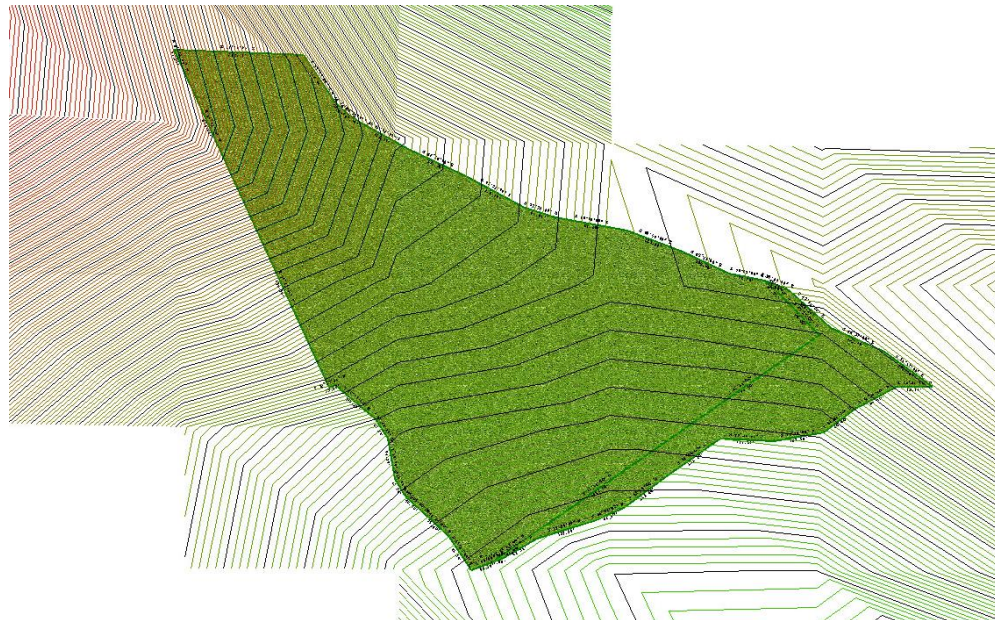


## How about USGS or Google Earth data?

### SUSTAINABILITY RECIPE 14

USGS Data should be viewed as highly unreliable, at least for detailed site planning. The same applies to Google Earth (a DTM from that source is shown below):

Shown below is a 14 acre site in Jamaica with contours at 2 foot intervals. You can tell by the blocky contour lines that there are about 4 or 5 total points that determine the surface of the tract of land. There is a deep ravine that runs in the northern portion of this site that would dictate its design. With 4 or 5 total points, the deep ravine cannot be located, thus the design would be useless based on this data readily available for free on the internet.



All of this information is important for one reason – contours and vertical design should be viewed as an approximation, not exact figures. For the purposes of training and use, the extreme accuracy of geometry enforced elsewhere in this text book will not be necessary for vertical planning locations.

## The cost of dirt

### SUSTAINABILITY RECIPE 15

A bulldozer is a tree-haters friend. Most new developments do not look like this beautiful wooded area, but instead they began as farmed fields. So what could be the problem with plowing down old corn furrows?

A large bulldozer moves a huge volume of dirt quickly. Not all 'dirt' is equal. Imagine if this site were comprised of rock. With a hard surface like that, any alteration of the surface is difficult *and costly*. Soft gooey surfaces, like wet clay, pose problems to the bulldozer, as it slides to and fro trying to do its work.

Also, if you thought moving dirt was bad, hauling off excessive dirt or hauling in dirt from offsite will be far more expensive. You might think you have done a great job using the tools and geometric education LandMentor provides, but you could have created a site out of 'dirt' balance that the developer goes broke!

Remember, the intent of LandMentor is not to provide a civil engineering education (to become fluent in balancing the earthwork), but to become aware of the importance of designing in the third dimension. Ideally, you are working with a talented civil engineer at the initial planning stage. He or she can advise you on earth volumes, where detention might be needed, and how large those areas must be designed to consume.

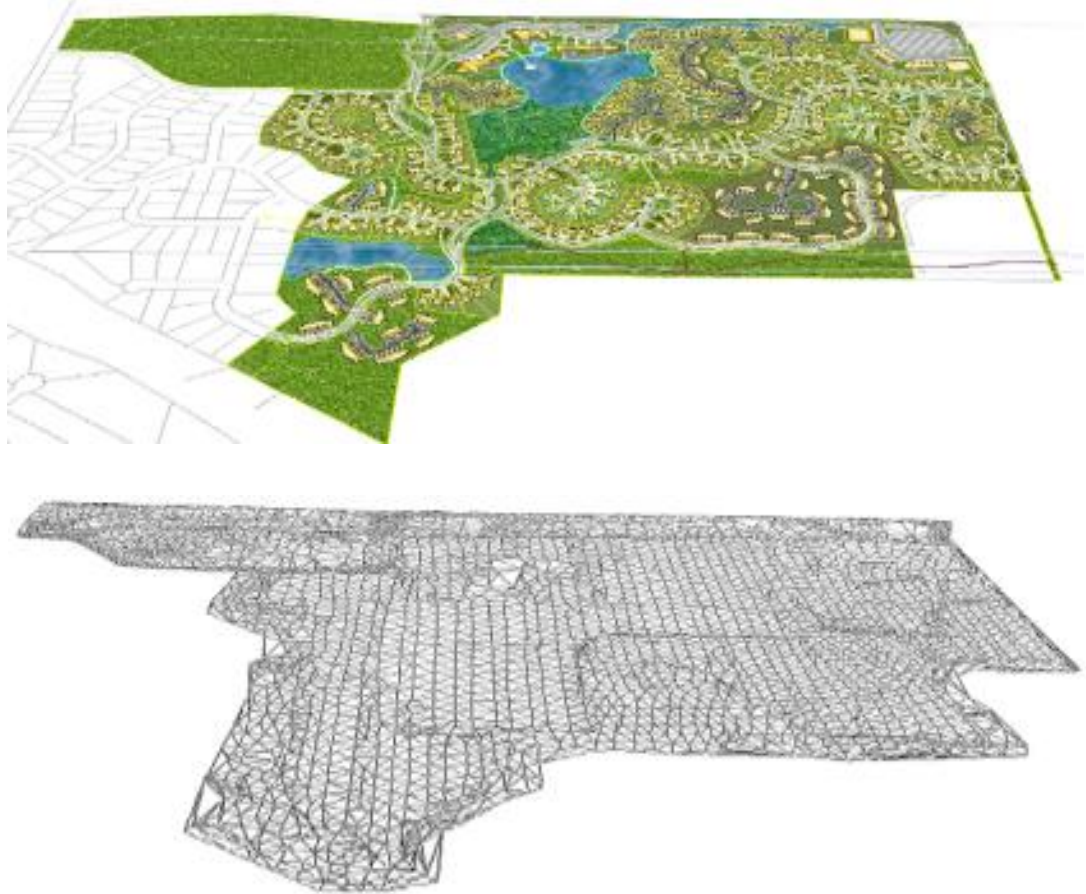


The land surface (DTM) is a separate data structure from the geometry (entities, surfaces, groups, etc.).

If the land surface used the same data as the site plan, there could be terrible repercussions, as a change in the design could alter the natural ground. The natural ground as it exists before construction is protected. LandMentor does have the ability to hold multiple surfaces for design contours (surface generation).

All data is saved in a single job file, so you do not need to worry about how the information is saved nor what the internal data structure looks like.

To get started, you will need some form of existing topography data. This needs to be in a three dimensional form, either original surveyed data in the form of a 'point file' (Pt#,N,E,Elev format), or a DTM in CAD format, or three dimensional contour lines (not suggested because of the time it will take to manually edit and strip the data for use in DTM form).





## Creating contours from an existing DTM source

Using an existing DTM file from a surveyor or civil engineer is the best option. This way you are assured that all edited data is correct (or at least someone else assumes the responsibility of mistakes).

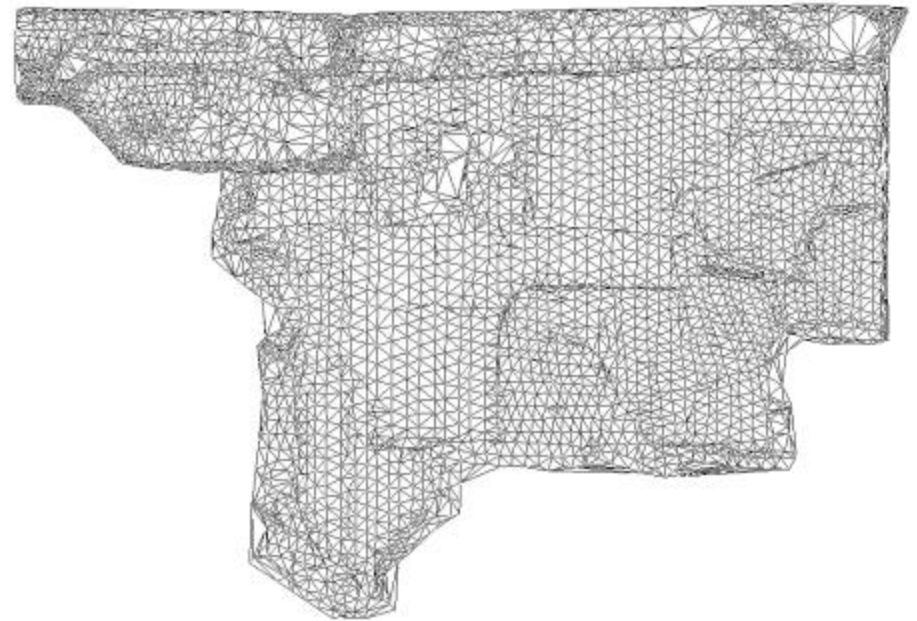
A DTM will look something like the triangle net in this example. There may be long edge triangles on the net that tend to loop contours along the edges.. These can be erased in **LandMentor**.

**LandMentor** will not be able to generate a contour surface if there are no elevations at the corners of the triangles. Do not assume that the net arrives in your possession with three-dimensional coordinates. One way to find out is simply to press the mouse middle button for point snap mode and snap to any point. Any data with an elevation of zero (0) will be ignored.

When the DTM is read in and displayed, the next step will be to create a mathematical surface to generate information.

Under the **Topography** pull-down select:

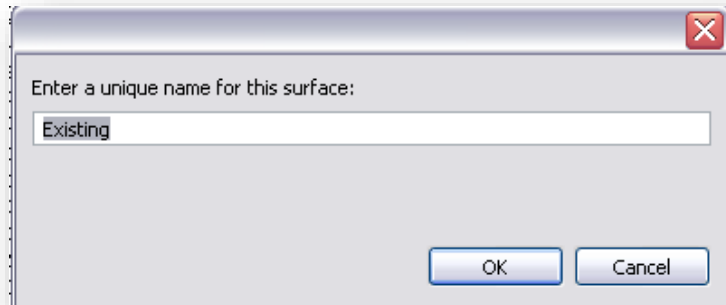
**Create DTM ( Net)**



Create - Create DTM (net)



Wait until the next pop-up appears:

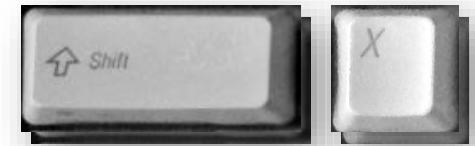


If this is the only surface associated with the job (which is likely unless you will be performing some proposed surface design work), then it is recommended that you simply use the default surface name **Existing**.

Otherwise, specify the name of the surface you desire.

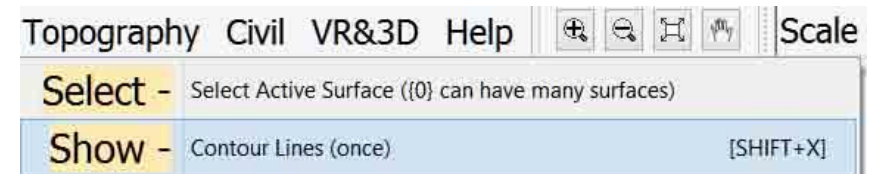
This assumes that the net data had no problems and that there were no crossing 'breaklines'. If there are conflicting lines the software will report it with red diamonds at points of conflict and you will need to edit the data before the terrain is created. If there is a lot of conflicts, snip an image of the screen as a record.



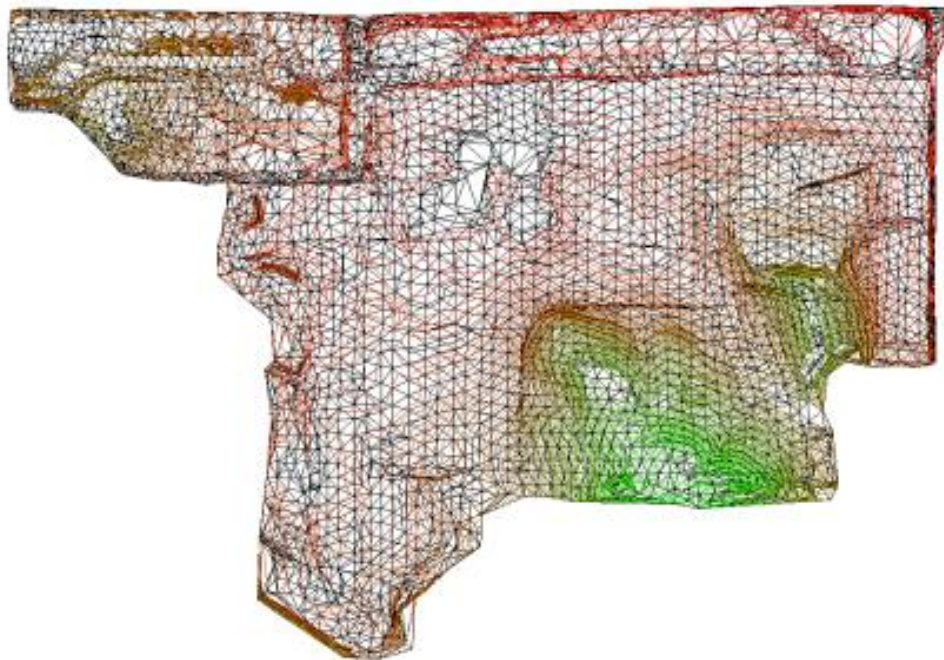


After creating a fresh DTM, it is wise to view the contours. The contours will be shown using the settings located in site plan Preferences (see page 305 of this manual).

To show contour lines select:



The screen will show the contours overlaid on the DTM:

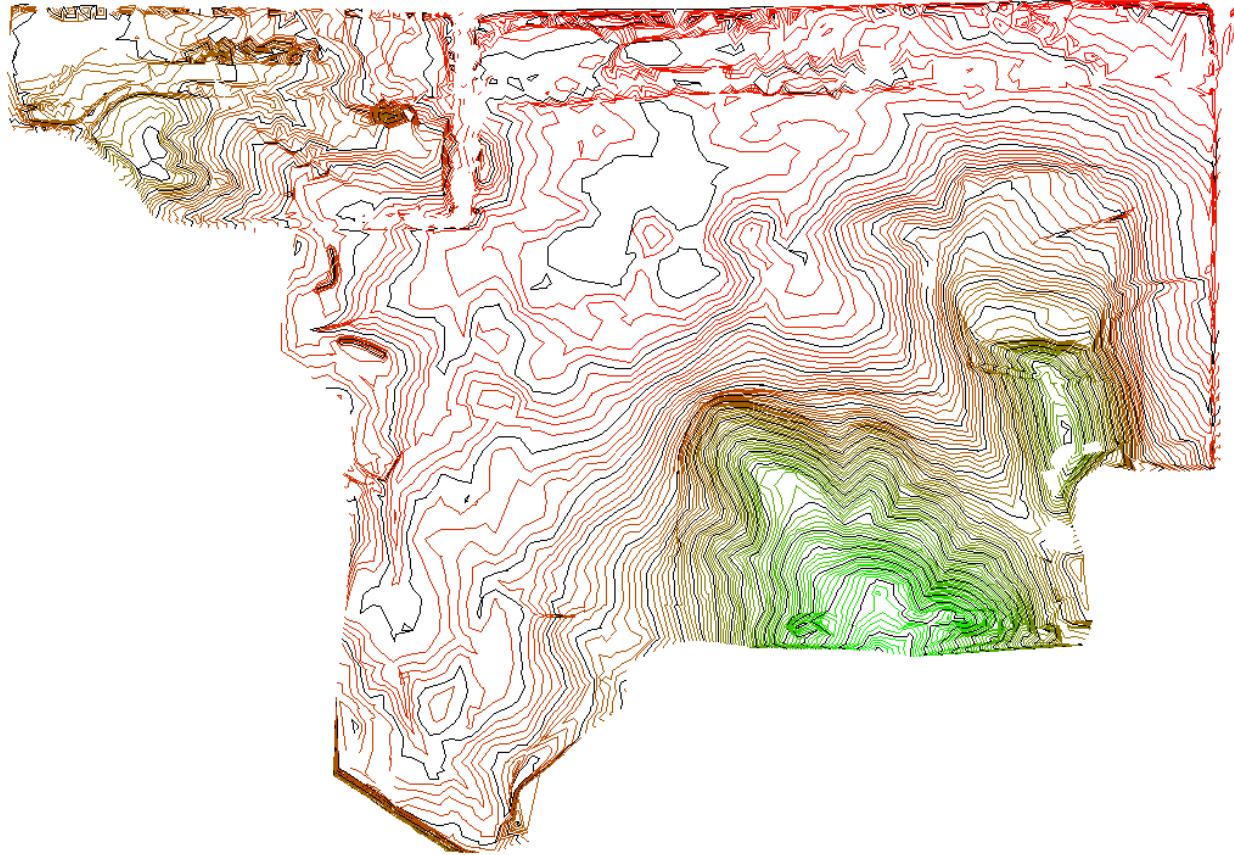


The first time the contours are generated, there is a delay for initial computations.



The best way to view contours is to deactivate the DTM layer (imported from CAD), then refresh the screen and select **Show Contour Lines**:

Contours are shown at the intervals set in **Site Preferences** – they draw from the lowest part of the DTM to the highest. They also transition from Red to Green. The darkest Red represents the lowest point on the site, while the deepest green being the highest point on the site. Once you verify that the contours are correct and are satisfied, save the file with a unique name (do NOT use the same name as the actual boundary or site design).



## Incorporating the surface DTM within the site (if using a DTM source)

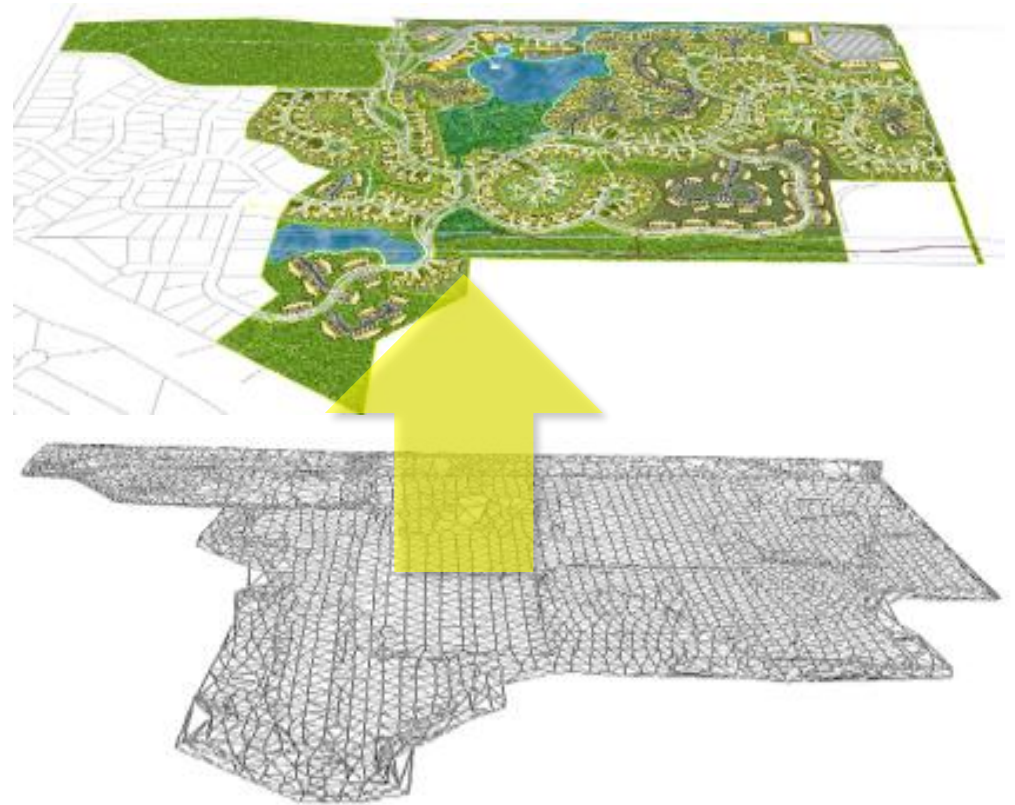
In this last example, you imported a DTM to create a surface. In that case, the surface data was totally separate from the existing boundary information.

Incorporating the surface data as a separate file is a better way to develop the surface than using a DTM that is a 'layer' on your file. This is because the physical DTM line entities are no longer needed (once you have developed the surface mathematically).

It is possible in LandMentor to create a DTM with linework (at any time) in the current job (design) file. To create a surface net, you simply make all layers inactive except those line entities that define the contour surface. The functions that create the surface triangle net will only use the data on the active layers. Then after creating the net, you could later erase the linework on the layers used to create the surface. Once you create and verify the surface net, the linework used to create the surface should be erased. You can also do what this example demonstrates: carry the surface as a separate data file than the job file, then incorporate it into the job as a separate step.

This next set of instructions will explain how to incorporate a surface file into your design file.

First, you need to read the boundary file into LandMentor as the base file.

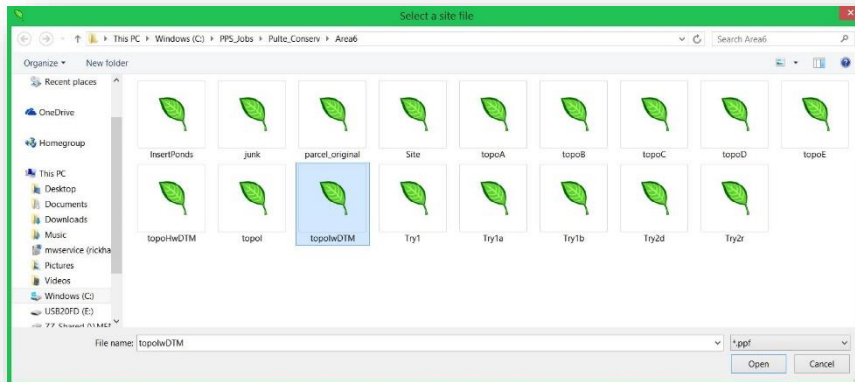


Under the **Topography** pull-down, select **Import DTM**.

The file selection pop-up appears:



Select the name of the DTM file that you created (assuming you created a surface, named it, verified the contours, and saved the file under a unique name).



It is that unique file that you want to read into your job file.

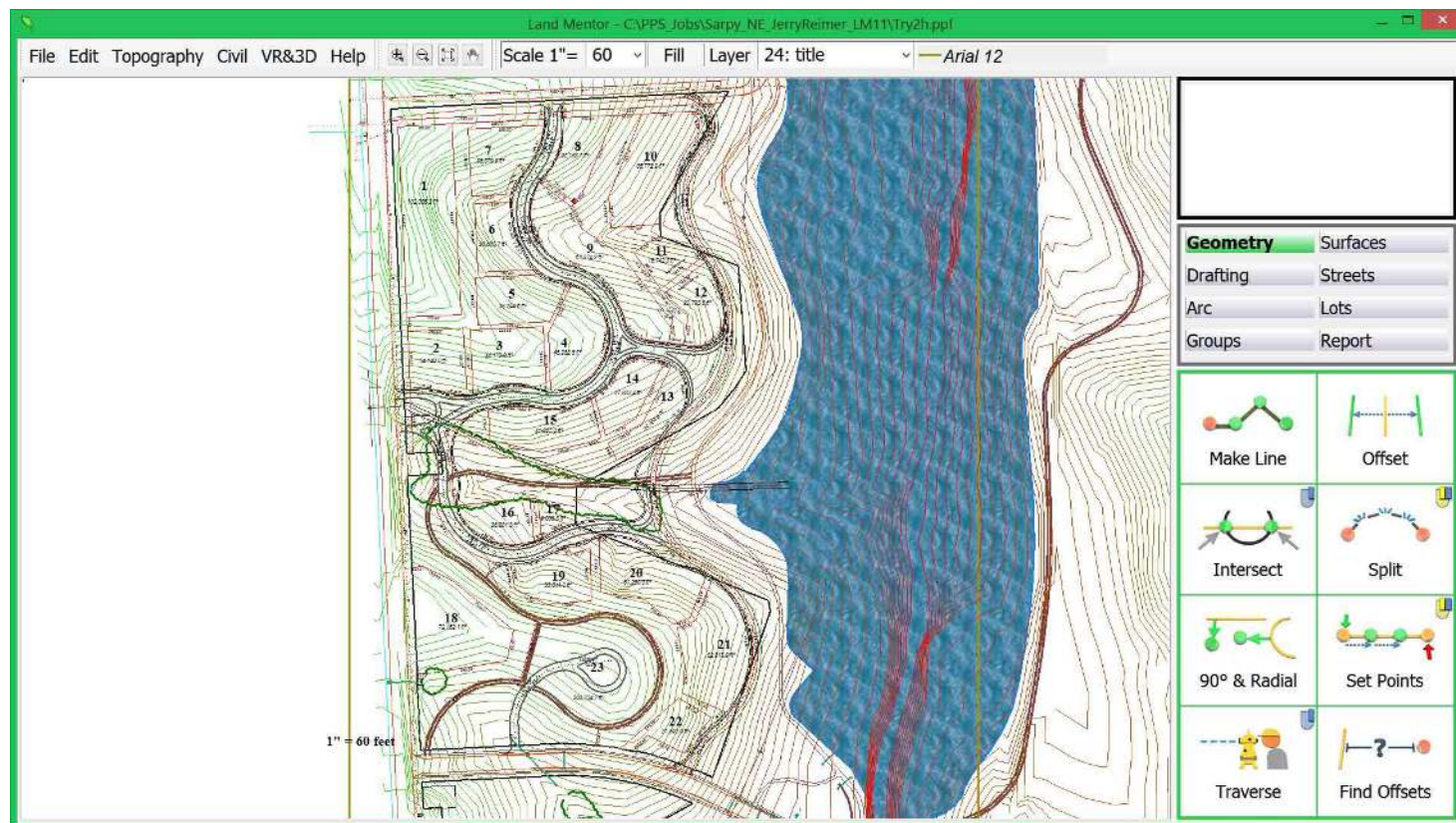
Under the **Topography** pull-down, select **Show Contour Lines** to verify the DTM has been incorporated.

Also check that the main job and the topography are on the same coordinate base and rotation (they sometimes might be two separate data structures, depending upon the source of the data). If all appears well, save (update) the original job file.





**The topography cannot design the site for you.** No technology or software package can tell you where to place streets, buildings or roads at the best location based upon a mathematical model. Even if it were possible, there are so many other factors of a great neighborhood design that a computer generated plan would not be able to replicate. As such, you need to use this information to balance the design-reducing earthwork without reducing the living standards for the residents nor the success of business owners that lease properties within the development. As you can see by this drawing, the red areas (low points) were used for storm water detention and small lakes.



## Viewing the slope of a surface

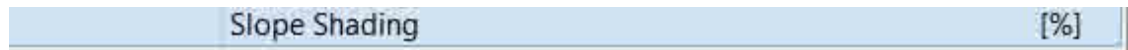
Contour lines are great, but they do not tell you what the slope of the surface actually is. The municipality will have reasonable restrictions for streets and buildings setting maximum slopes where these improvements are allowed.

Looking at your contour map, you might be able to tell where slopes are steep and where they are more relaxed, but you cannot tell what range the slopes fall into.

The color changes allow you to see the high point of the site (green), but again no idea the actual slope information.

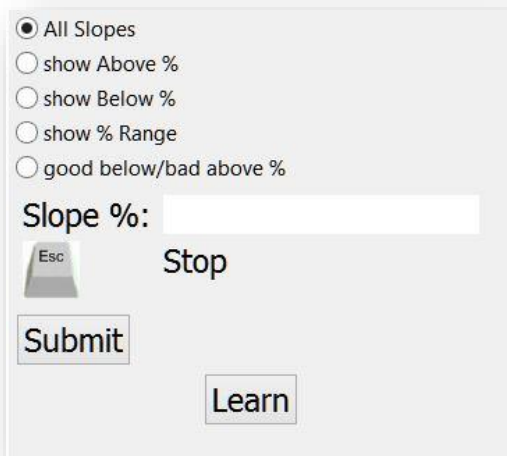
Under **Topography** select **Slope Shading**.

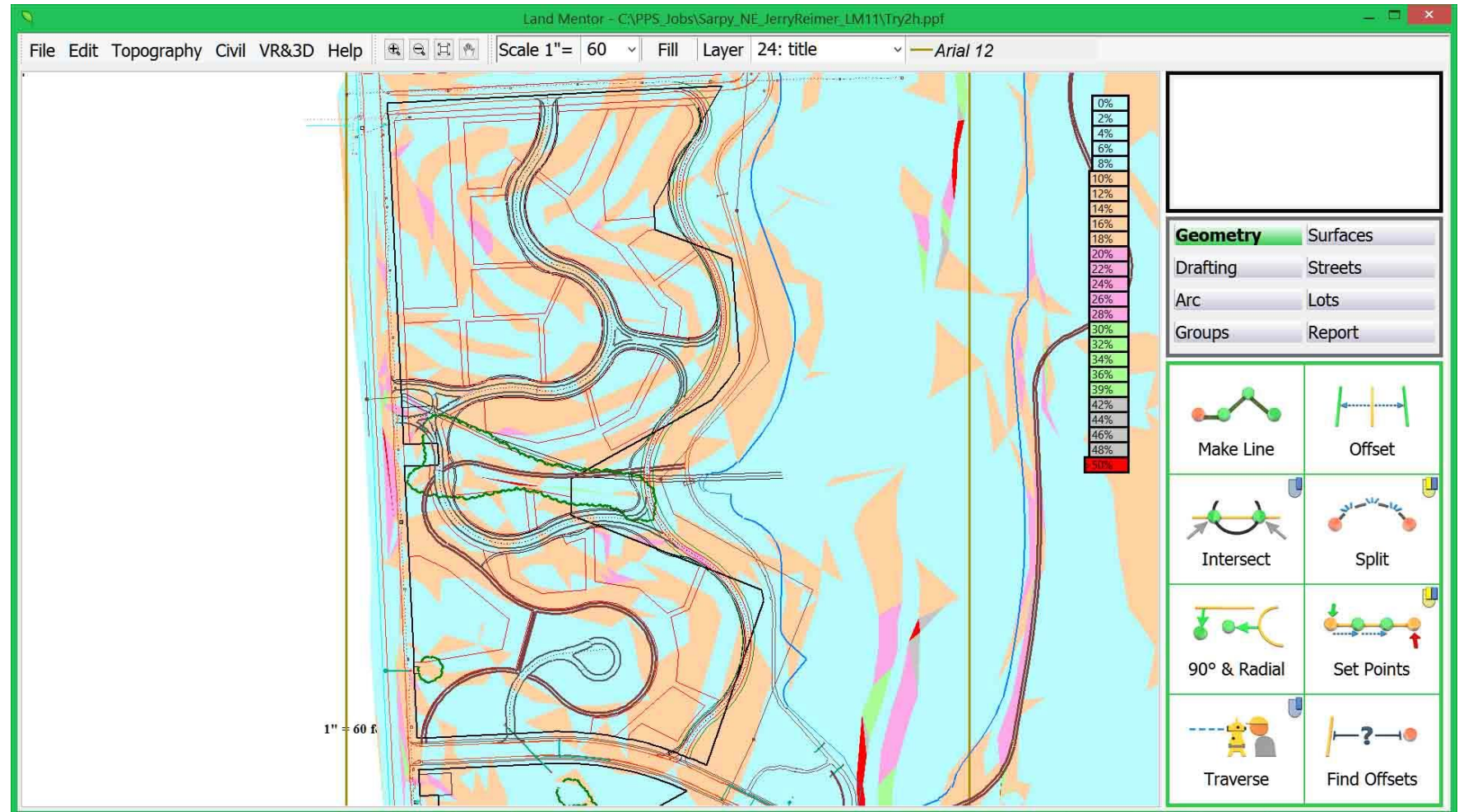
A menu option panel appears:



For this example, press **[Submit]**.

For all slopes and the display shows:





A chart on the right indicates the range of slopes colored in 10% increments (changing colors every 10% of the range). If improvements are not allowed to be built on slopes above 20%, then blue and brown areas are fine for your site.



For the next example, we will only show slopes in a particular range:

**Shows slopes only below the percent entered below.**

**Shows slopes only above the percent entered below.**

**A combination of slopes.**

☒ All Slopes  
☐ show Above %  
☐ show Below %  
☐ show % Range  
☐ good below/bad above %

Slope %:

Esc Stop

Submit

Learn

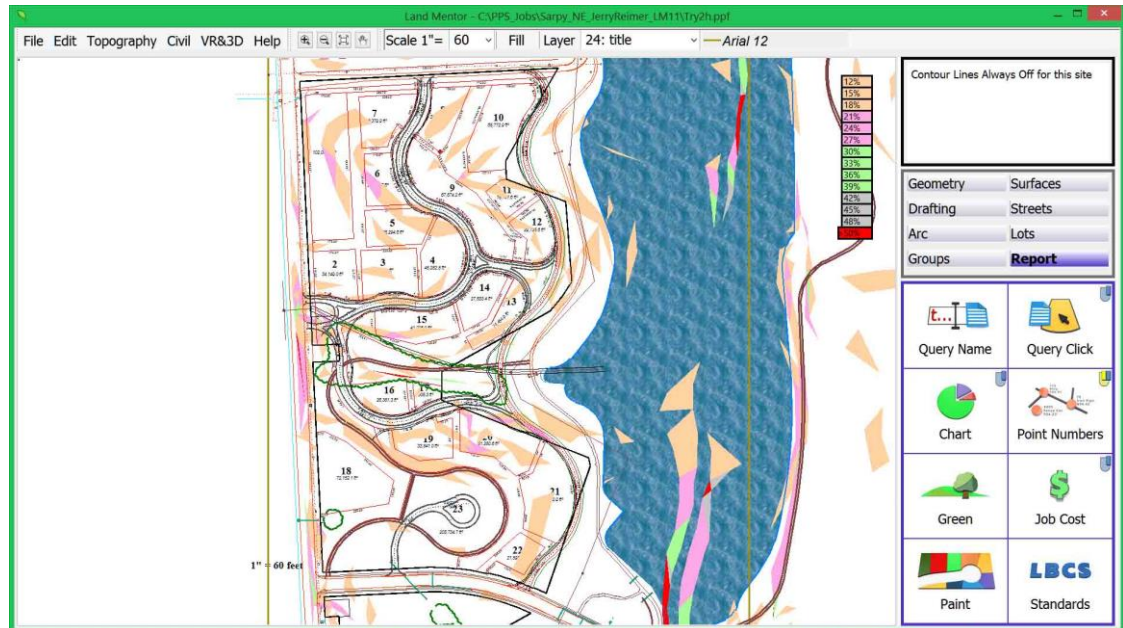
**Enter values here.**

For example, if you only want to see slopes above 12% shaded, you would select **show Above %**, then enter **12** and **[Submit]**, and the display would appear...



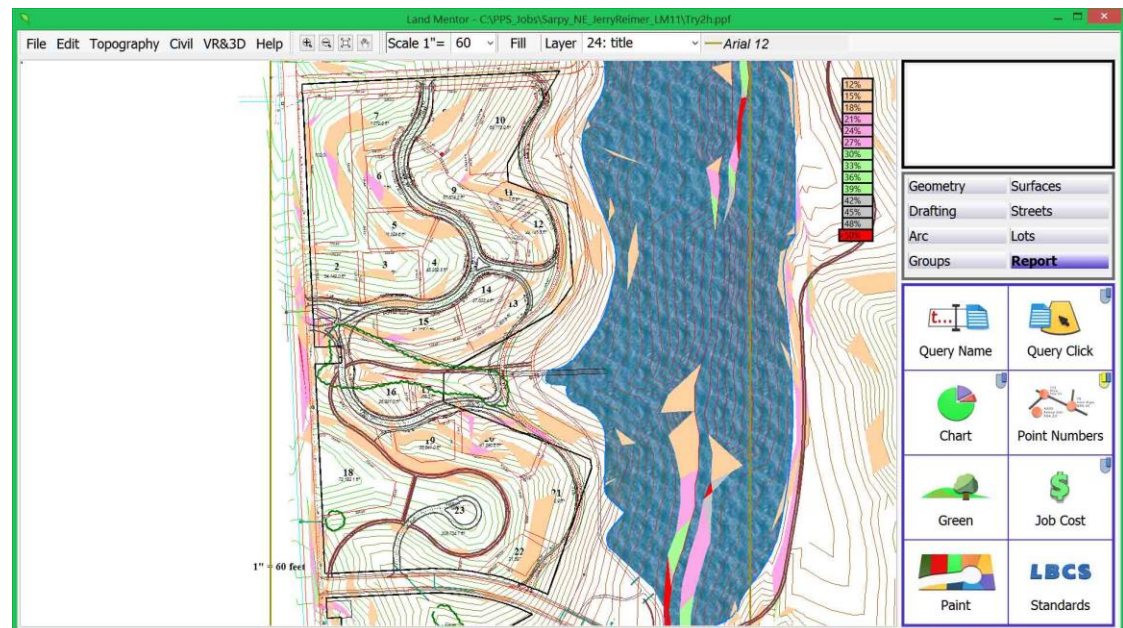
This shows the few areas you might want to avoid.

You can use a combination of any of these features. For example, showing the slopes above 8%, then afterwards showing the contours would give a more clear story of what to design around:



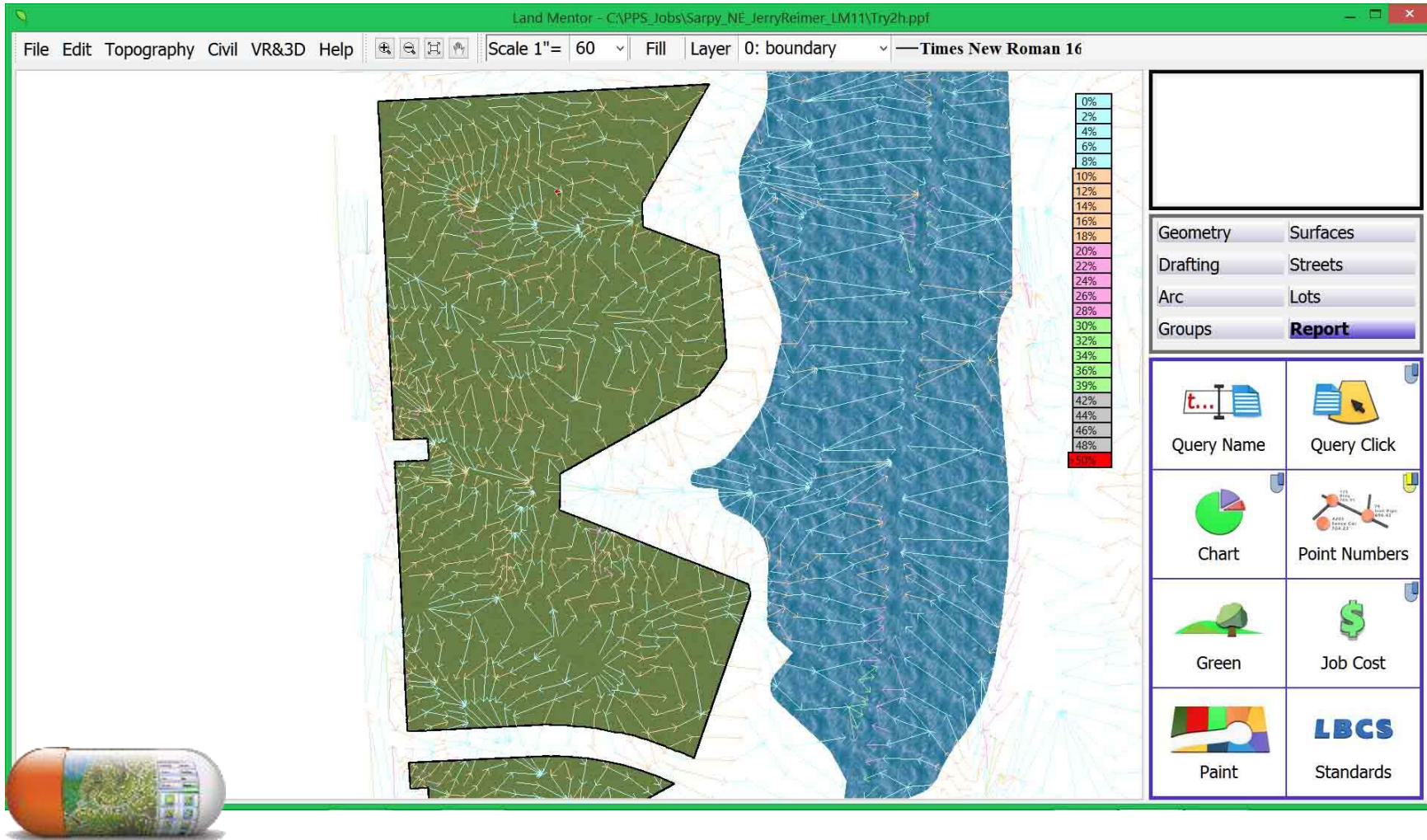
By selecting more than one surface display function, it is possible to have **LandMentor** pinpoint the critical aspects of the topography better during planning decisions.

For example you can show slopes and flow arrows and then contours.



## Viewing general flow of drainage

To view the general direction of the drainage flow, select **Show Flow Arrows** under the **Topography** pull-down. The display will show the general flow direction of the drainage of the site. Like contour lines, these are not permanently stored. In addition to showing flow, they are color coded using the same methods for slope shading.

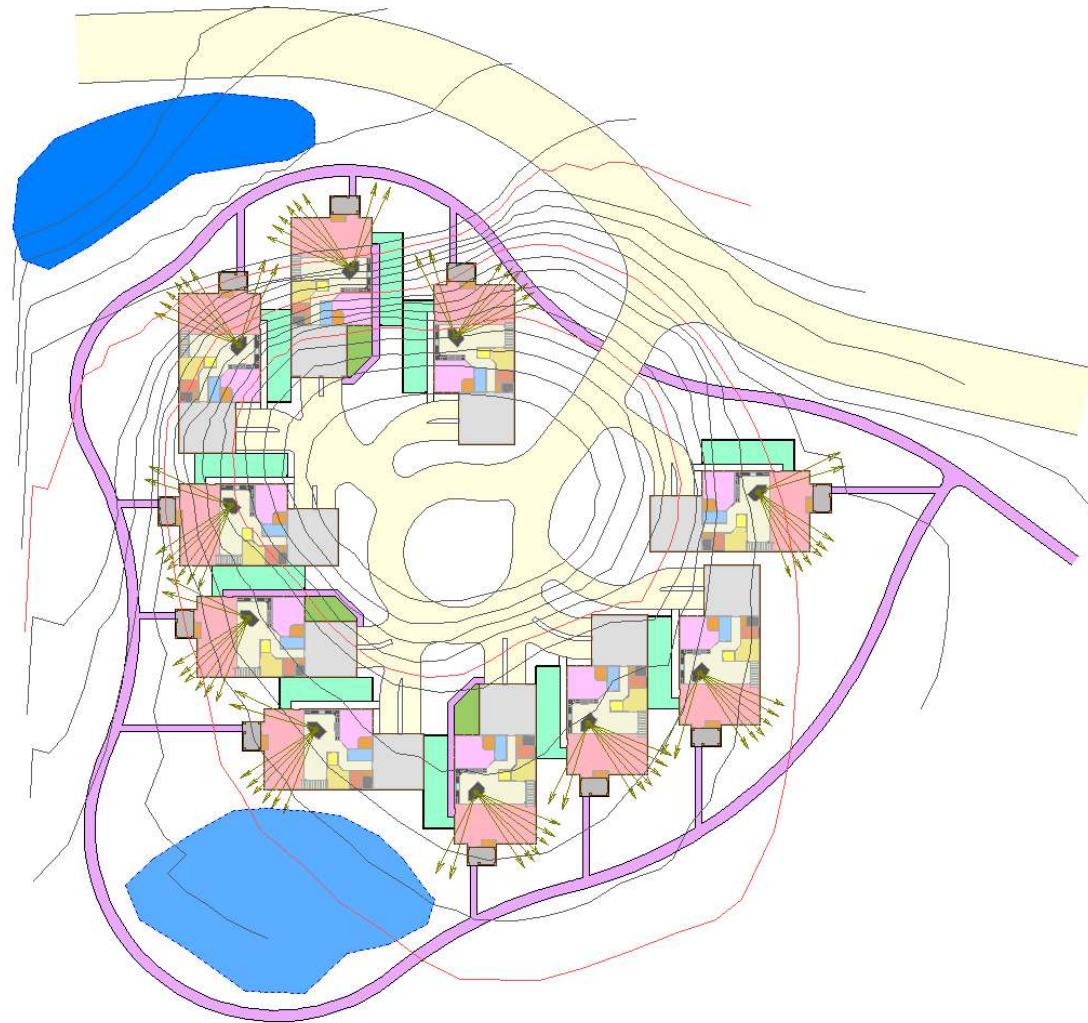




## Considerations in the design process

### SUSTAINABILITY RECIPE 16

Here is a site plan displayed in a system other than **LandMentor**. Can you spot several design problems from the depiction of this information? (1 foot contours shown)

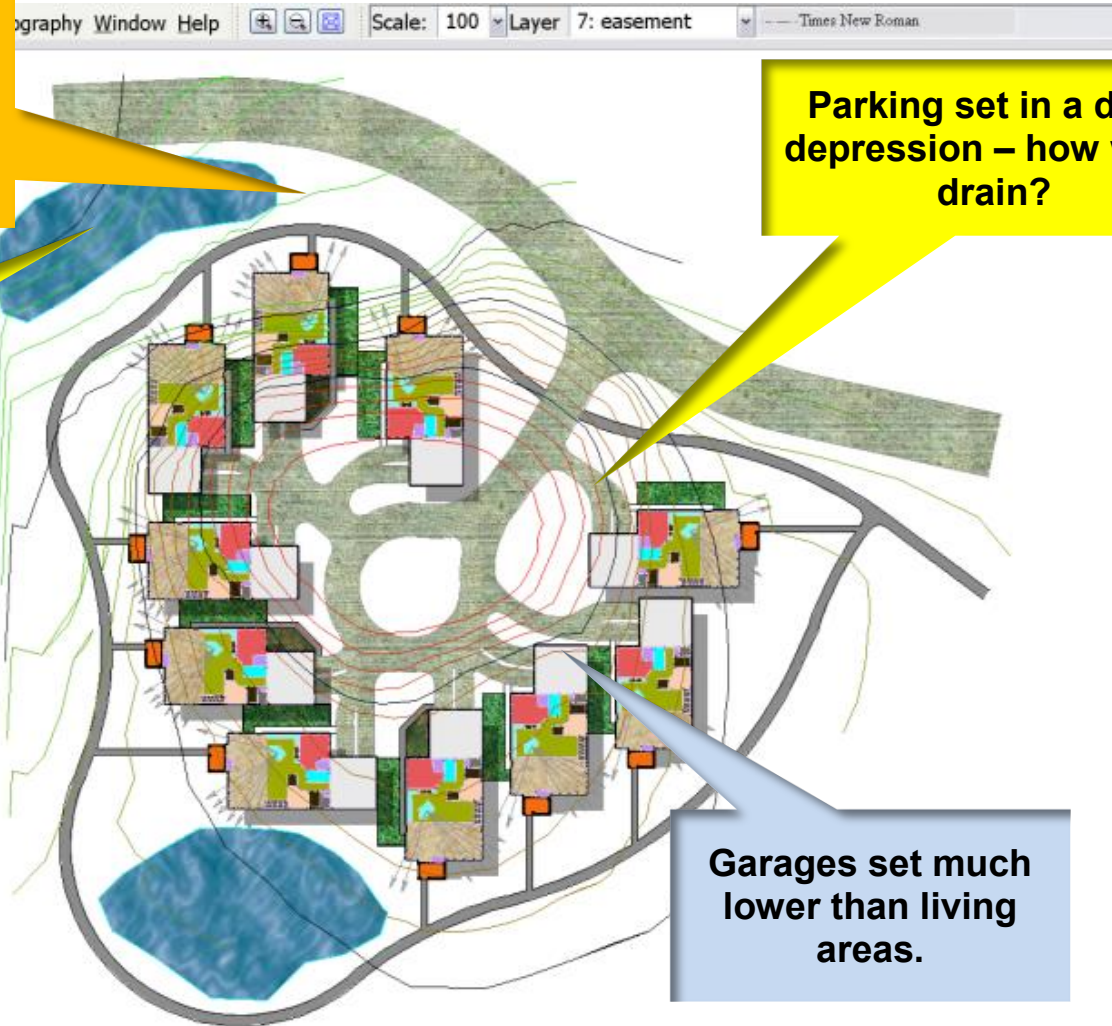


This is the same data in LandMentor – does this depiction make it easier to spot problems? (1 foot contours shown)



**Remember –  
Green contours  
indicates high  
ground – red  
being low areas.**

**Ponds were  
placed on top of  
the hill!**



**Parking set in a deep  
depression – how will it  
drain?**

**Garages set much  
lower than living  
areas.**



## LandMentor

If you think that any civil engineer will call to ask you to change your design given the incorrect contour data, as in the last example, look at these pictures.

There are very few vehicles that could reach this garage. Note: the foliage has fallen off the trees – this indicates that the home was built in a cold climate.

How much value do you think the steep slopes add?

How did this happen? The client, the surveyor, the city inspector, and the civil engineer looked at the planner's drawing and assumed this is what was envisioned! Never assume mistakes will be noticed – even one's this drastic.

The residents of the townhomes shown here in Vernal, Utah cannot get into their garages. Instead they parallel park across their driveways.

Want to know how to make 4 parking spaces function as if they were one? From a 'plan' (birds-eye) view, the driveways would have looked perfectly normal.

This is where the LandMentor Virtual Reality abilities can prevent these situations from being missed!



Every municipality will have different opinions as to what is 'steep'. One might think an 8% grade (an 8 foot drop in 100 horizontal feet) is too steep; whereas the next municipality might render 15% (a 15 foot drop in 100 feet) just fine. While opinions may change in varying locations, there are a few design considerations good planners should follow whenever economically feasible. In many cases, these general rules will be easy to follow; but in areas of steep terrain and oddly shaped sites, these techniques may not be possible.

**Home – Street Relationship:** Place the garage on the up-hill side of the home whenever possible. There are a multitude of reasons for this. The garage at the low point would have residents enter their home at the lower level. In general, most home designs in this situation would mean that the garage would be placed in the basement. Homes look better when elevated above the street as shown here.



These are the same homes, only they are set lower than the street – a perfectly acceptable practice in most areas. This has many negative consequences. The most important ones being less curb appeal and the illusion that the home is smaller than it actually is. Another problem is that driveways direct storm water down into the garages, plus run-off from the front yard drains into the home.

When the site gets topographically challenging, it may not be feasible to have every home above street grade as moving earth and building retaining walls can be expensive. Mounds of earth or retaining walls may also restrict views from within the home to the front yard.





**WARNING:**

This is a section of the manual that should be left to those who understand how contours are generated and how to edit a surface. The following set of instructions also will explain how to use LandMentor as a dedicated land surveying package.

This is the only section of the manual that intentionally does not fully explain why you need these features and how to use them. If you do not understand why these features are needed, then you should not be editing the surface areas. Instead, call in a professional to help, or contact Neighborhood Innovations, LLC to edit your data.

### Creating a Net directly from Land Survey Data (or CAD contour lines)

LandMentor allows the surface net to be created from random survey points, as explained in the Land Surveying section of this textbook.

Point files must end with a '.txt' extension and be in the following format (space or comma separated):

Pt#, Northing, Easting, Elevation

or:

Pt#, Northing, Easting, Elevation, Description

After reading in a point file, the display will show floating points not tied to entities. Using the Survey Section of this manual explains how to create entities on floating points: these can be used for DTM breaklines.

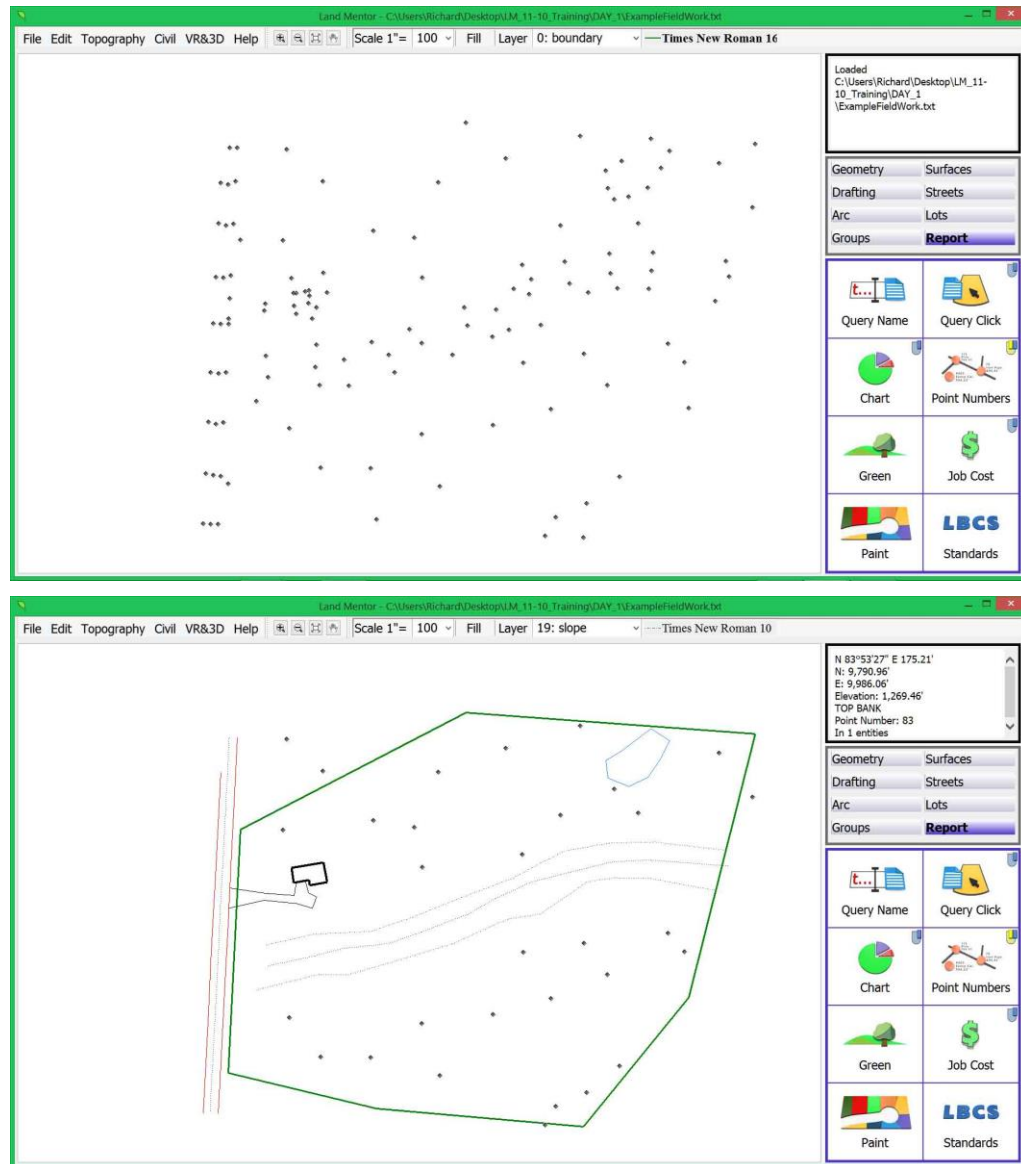
Random field points cannot create a correct contour. You will need to guide the contours with breaklines.

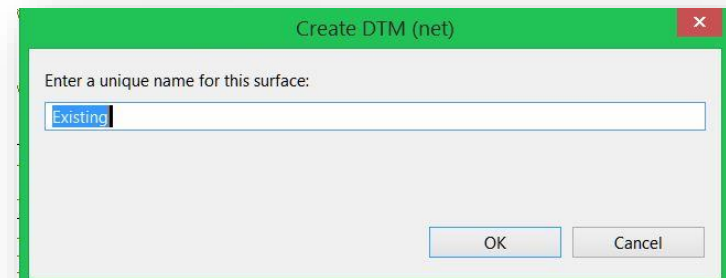
When you have finished connecting lines for boundary and other topography features, you must delete these temporary lines.

After connecting the dots to create boundary and topological items, the upper and lower reference lines initially created are no longer needed.

Caution: You need to either deactivate layers that are not breaklines (like the site boundary) or make the layer(s) **Overlay** before creating a DTM. It's a good idea to create the topo BEFORE boundary work.

When done with the setup steps, select **Create Surface From Points** under the **Topography** pull-down.





A prompt asks you to name the surface. It is recommended that you use the default name of **Existing** and press **[OK]**. If you select **Show Contour Lines**, they will be displayed!

You can then save the job away.



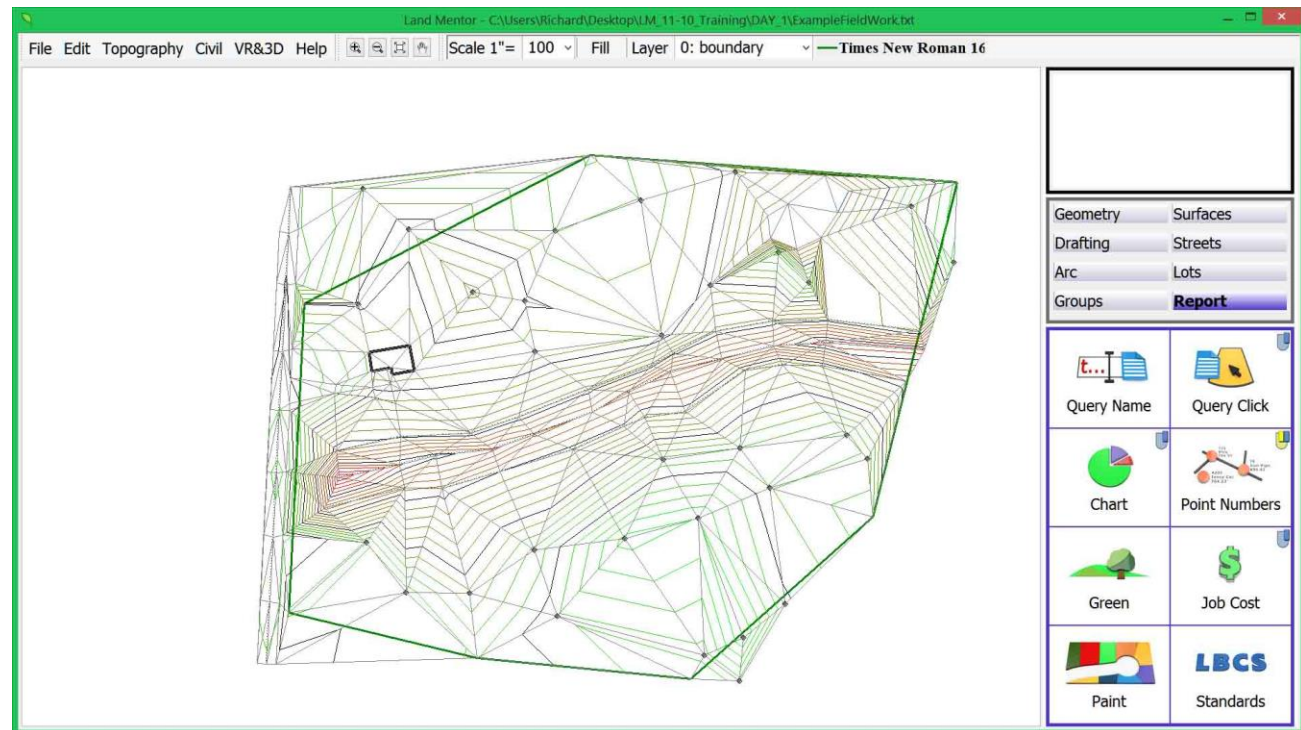


## LandMentor Editing the surface net

In the original example, the surface net was separate from the site plan, then later incorporated into the job. In the past example, the boundary work and surface generation were completed in related steps then saved as a single file. As with any contour generating software system, you must choose if it is better to turn off some or all of the drawing layers while editing the surface net (assuming the net is retained in memory while at the same time the drawing linework is being created). For this next example, we will have the drawing in memory and layers on.

Select **Show Surface DTM (net)** and the display shows:

At any time you can display the surface net to see how it relates to the site. You can then overlay the contours to determine if something needs to change. The net overlay is thus temporary and will disappear.

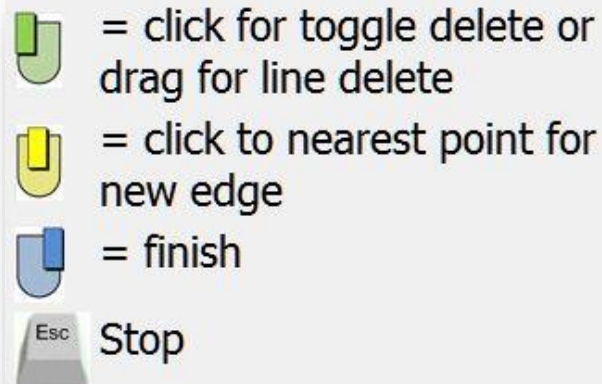


Select:

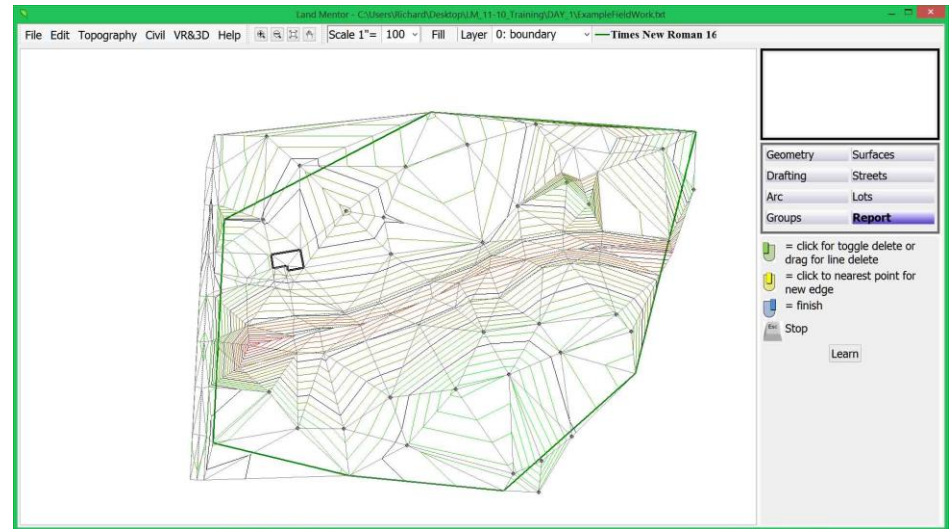


In edit surface mode, the net stays on the screen while you are manipulating the data.

There are two different ways to edit the net: one is to erase unwanted triangles (contours will not be shown in erased triangles), and the other is to flip a triangle or series of triangles.



[Learn](#)



The **left mouse button** allows you to snap to a triangle and toggle it on or off. You can also hold the button down and drag a line through a series of triangle to erase.

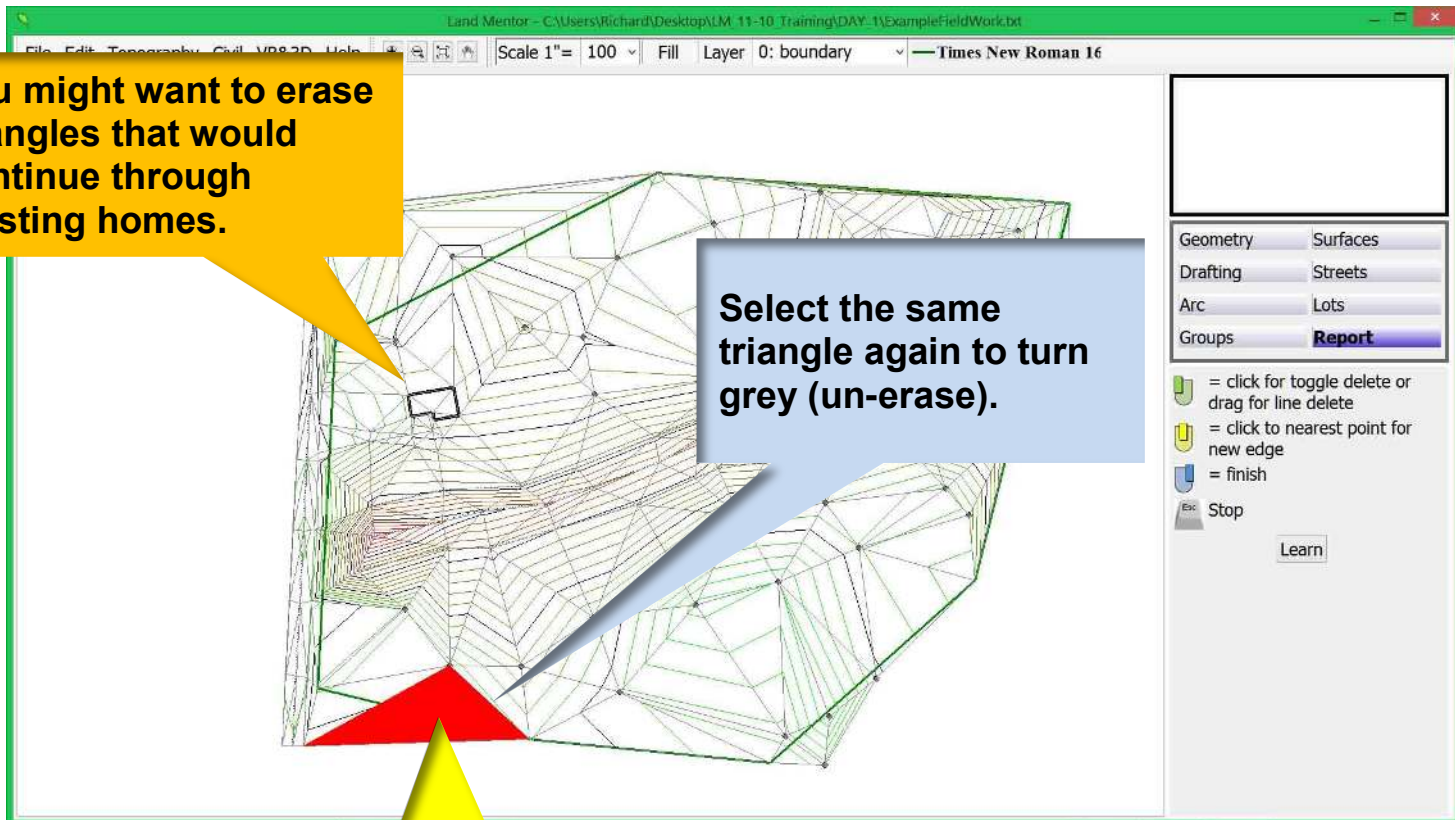
The **middle mouse button** allows triangles to be flipped. This will route the contour lines differently.

The **right mouse button** accepts the changes and ends the function.

**You might want to erase triangles that would continue through existing homes.**

**Select the same triangle again to turn grey (un-erase).**

**There may be areas along edges that should be erased (red).**

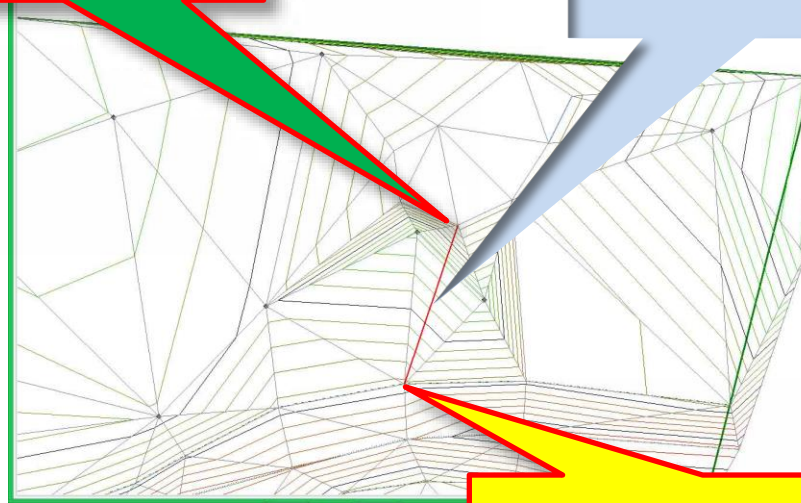




**Flipping triangles:**

1) Use the mouse middle button to snap to the first corner.

A red line appears as you move the mouse to the nearest corner.

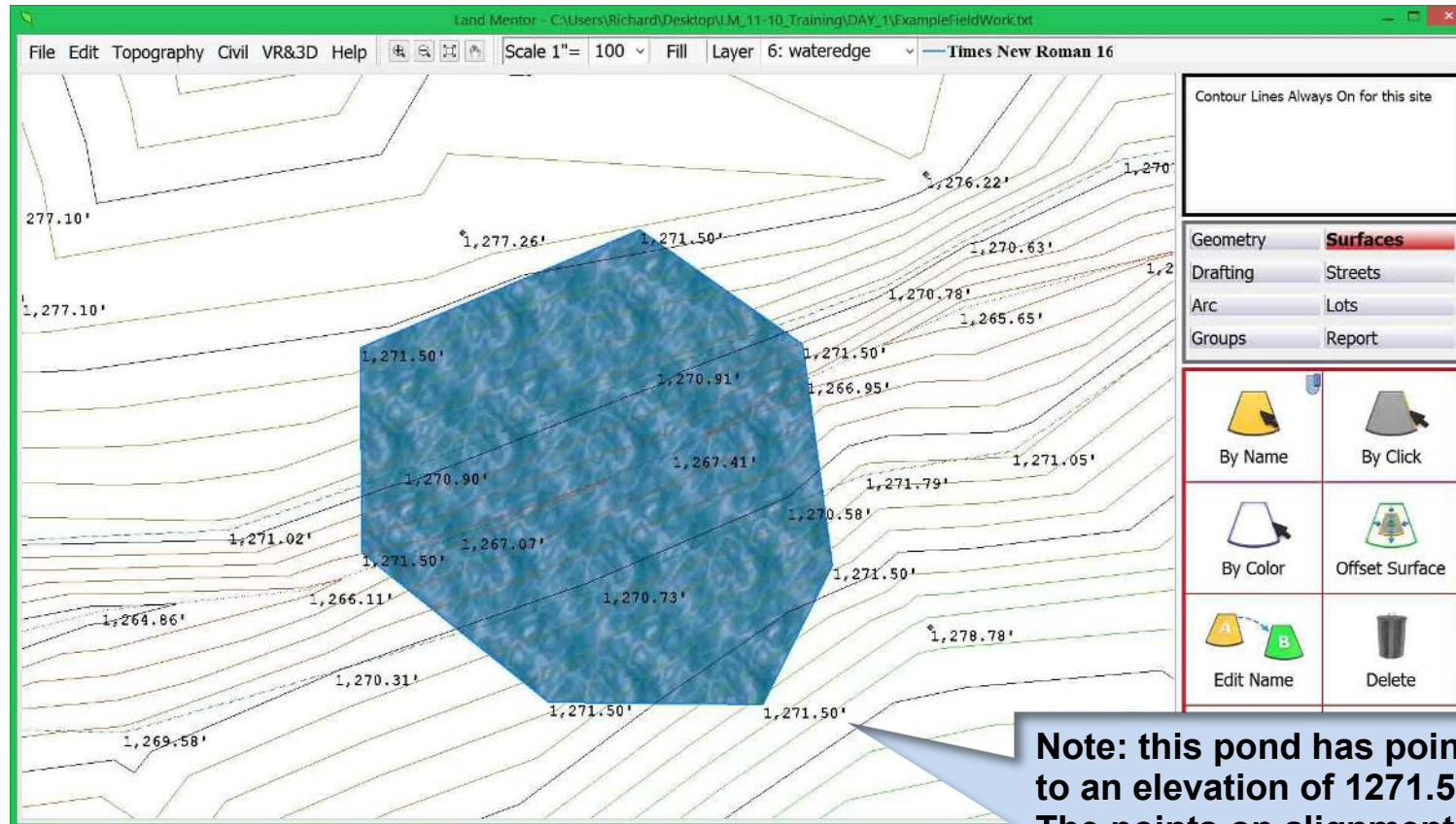


2) Press the mouse middle button again to select the desired corner.

These two basic functions can perform the changes you desire. Note that nothing will be set if you choose to escape [Esc] from the function. To set all of the changes, press the **mouse right button**.

## LandMentor Intersecting slopes

This feature of **LandMentor** will intersect a surface in memory with a surface or alignment. Every point along the surface or alignment **MUST** have elevations assigned to them for this feature to operate. As an example, we intersect the surface with the bottom of the pond indicated on the below drawing. The pond is at an elevation of 1271.5.

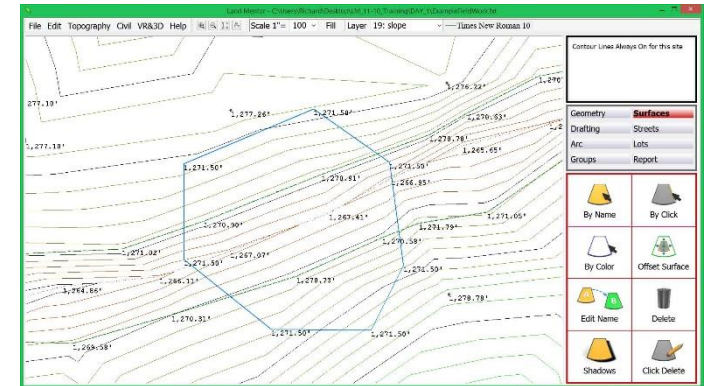


**Note: this pond has points set to an elevation of 1271.5. The points on alignments can be at various elevations and alignments or surfaces can have curves!**



When working with slope intersections, it is recommended that you temporarily disable fills.

Also activate a unique layer where you want to place the proposed contour data. The default layer (slope) in LandMentor is layer 19, assuming you had not already assigned a different layer for proposed surfaces.



The default settings for slope intersection is found on the **Contour** tab at the bottom of the **Global Preferences** or **Site Preferences**.

At the bottom under 'Intersections', you can set the colors for cut (below) and fill (above) lines that will be created on the active layer as well as side slopes for cut (rise) and fill (drop).

The maximum distance before a point is set along the surface is defined as **the Maximum slope distance**.


This example will use defaults as shown.


Since most of the 'design work' was accomplished before using this feature, there is no extra work to do.


Intersect Surface


First you must select **Intersect Surface/Alignment** from the **Topography** pull-down. The prompt area will show:

Full name:

 = displayed surface

 = smallest surface

 = all surfaces

 Stop

Just like any other feature where you select a surface, you can enter its name or point to it. Alignments are not easily pointed to, so you should use the name of the alignment.

Because you are likely to manually enter alignment names, it's wise to keep them simple.

After you enter the surface or alignment, the prompt area shows...





**For this example, the intersections will be set outside the pond, so 'B' will need to be selected.**

**This sets the interval – for this example it will be changed to set every 20 feet. You could select how many samples along an entire surface or alignment**

**The slope intersection defaults automatically fill in here – you can select your own values. This example will use the defaults.**

**These are important as they set the direction of the slopes – you must choose A, B, or both.**

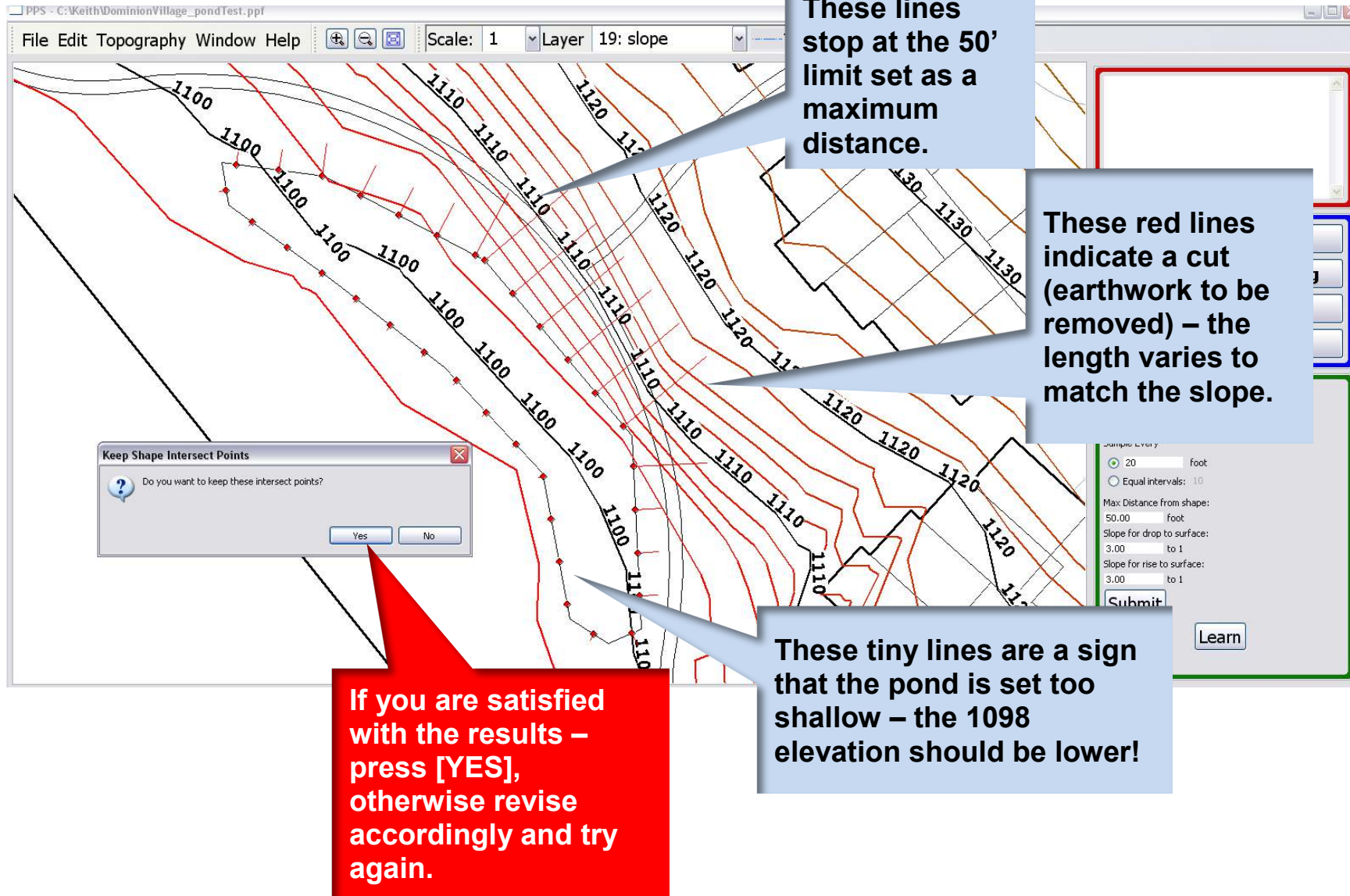
**After all of the settings are satisfactory press [Submit].**

Land Mentor - CIVIL  
File Edit Topography Civil VR&3D Help  
Scale 1"=

277.10'  
1,277.10'  
1,271.02'  
1,271.50'  
1,266.11'  
1,264.86'  
1,270.90'  
1,267.07'  
1,267.41'  
1,270.73'  
1,271.50'  
1,270.58'  
1,271.79'  
1,271.05'  
1,265.65'  
1,266.95'  
1,278.78'

Geometry  
Drafting  
Arc  
Groups  
Report

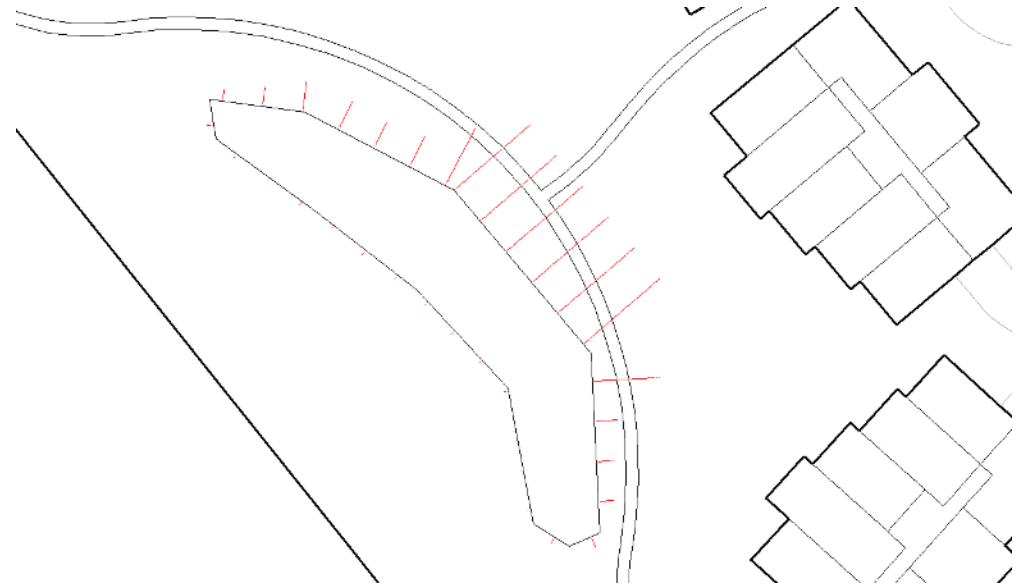
☐ only A side  
☒ only B side  
☐ both sides  
Sample Every  
☒ 20 foot  
☐ Equal intervals: 10  
Max Distance from surface:  
50.00 foot  
Slope for drop to surface:  
3.00 to 1  
Slope for rise to surface:  
3.00 to 1  
Submit  
Learn



### LandMentor

As you can see, the walk runs through the side slope of the pond. Without using the slope intersection feature, you could easily be placing walks and other improvements in locations that would be revised later by the civil engineer, and it's likely that your beautiful sweeping walk will be replaced by a linear system!

Lines from the surface that are green will be above the current slope requiring earth to be brought in. The best situation is to balance the volume of cut and fill.





## Cross section charting with an alignment

This feature will allow you to visualize a cross section along an alignment. This could be a street centerline or simply a line you select to view the cross section through the site. To use this feature, you will need a surface in memory and a named alignment.

Select **Street Profile** and the display shows:

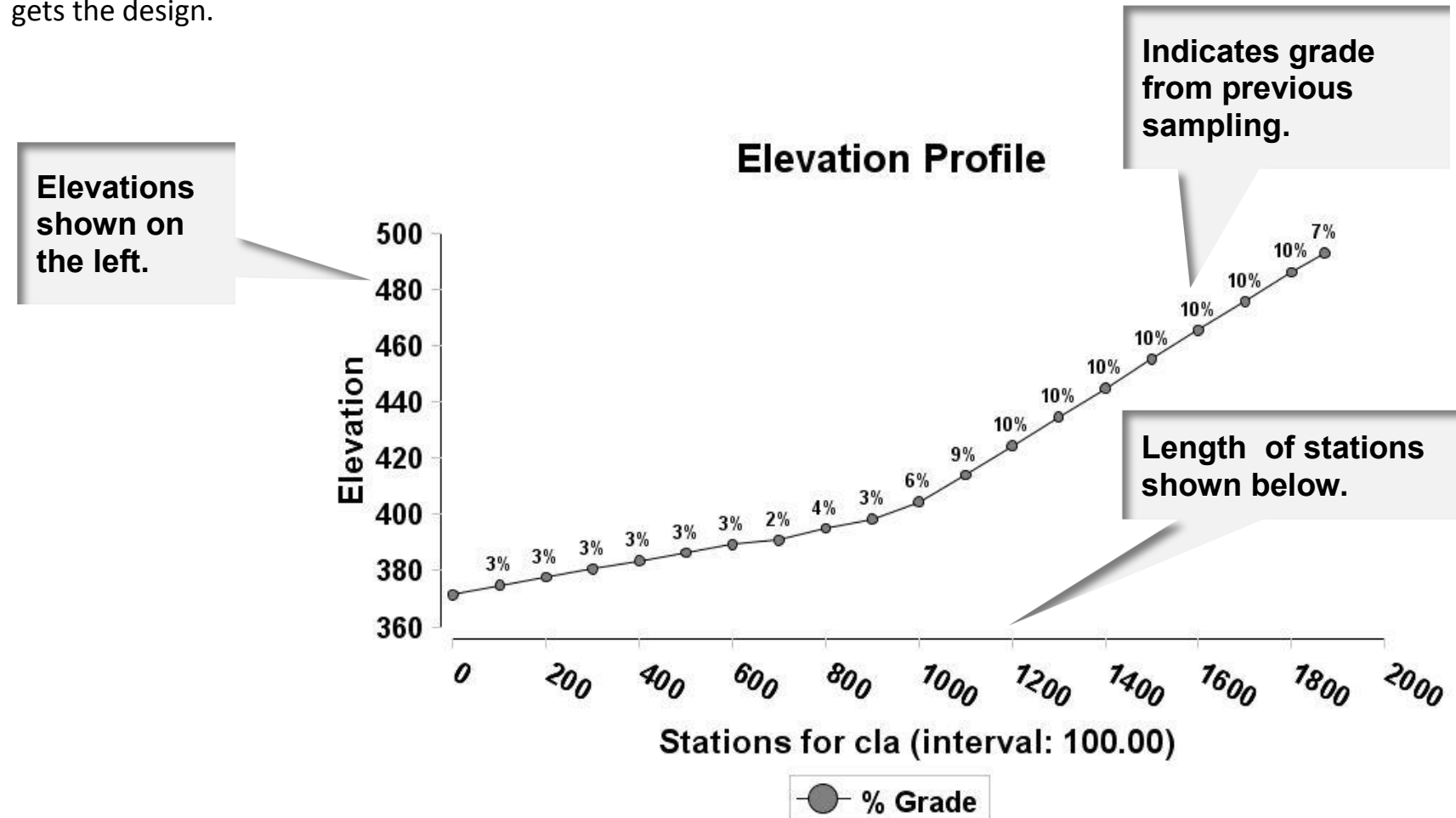
**Street Profile**

The screenshot displays the LandMentor software interface with the 'Street Profile' window open. The window title is 'Land Mentor - C:\PPS\_jobs\Danafinn\_NewHampshire\try1.tpf'. The menu bar includes File, Edit, Topography, Civil, VR&3D, and Help. The status bar shows 'Scale 1"= 100', 'Fill', 'Layer 1: centerline', and 'Times New Roman 10'. The main view is a topographic map with a blue alignment line. Four callouts provide instructions: 'Select alignment.' points to the 'Select alignment' button in the 'Geometry' section; 'Enter title for chart (optional)' points to the 'Description' field; 'Enter desired interval along alignment' points to the 'Interval' field; and 'Click this if the direction needs to reverse' points to the 'Reverse Direction' checkbox. The 'Submit' button is also visible.



If the maximum allowed grade along a street is 12% then this design you selected would work fine. However, if the maximum grade is 8%, you might want a different route at the beginning of this centerline or understand that there would be some earth to move to fit the allowed grading.

This feature allows you to test grades along an alignment to make sure your design is possible before an engineer gets the design.



## Other features of the topography selections

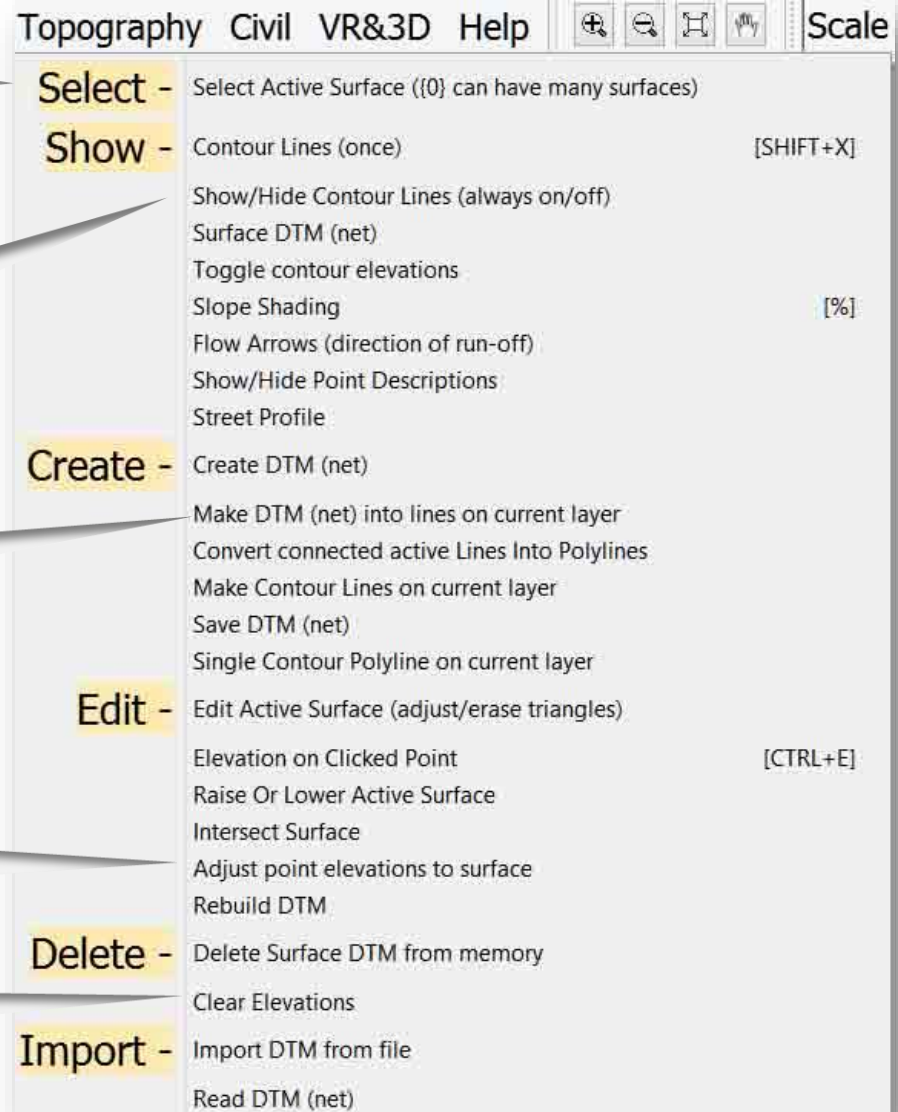
**LandMentor** has the ability to have multiple surfaces in memory – generally intended to serve the future expansion of capabilities.

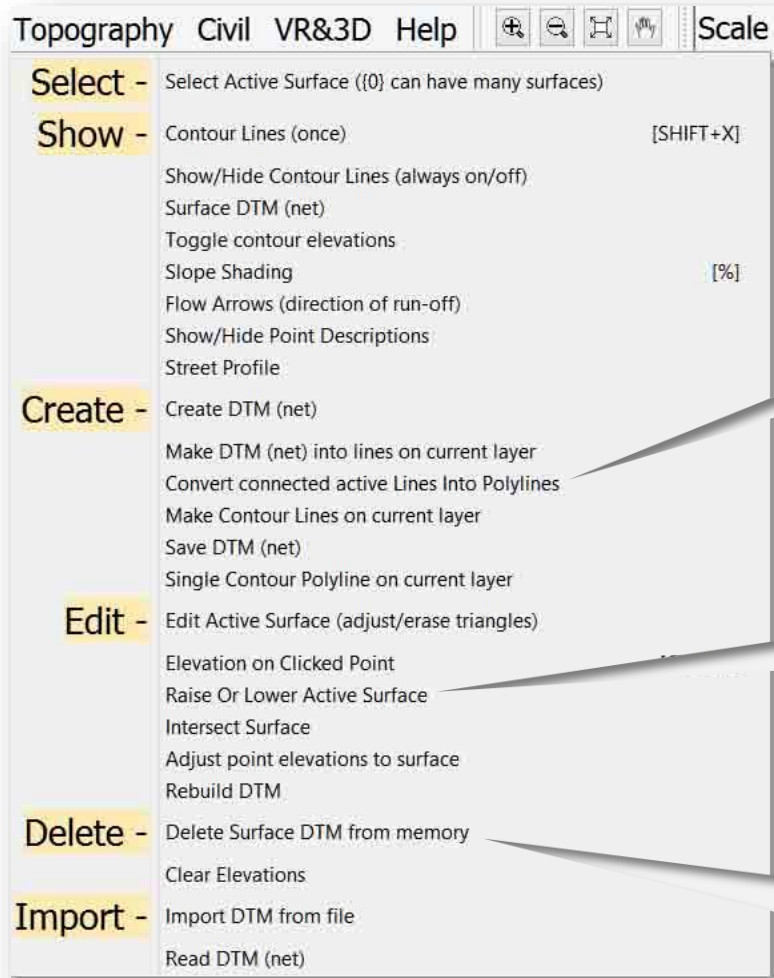
This flips from contours always being shown (on) and always being hidden (off). This setting is saved with the **LandMentor** file.

Creates line entities from the DTM for export to other software packages (if needed).

This feature created for future engineering application will match a series of data by layer with ability to offset to current surface.

This feature erases all elevations from memory or elevations within a range.





**Creates polyline entities from the DTM for export to other software packages (if needed).**

**Allows you to raise or lower an entire DTM.**

**Deletes an entire DTM.**

## Creating Contour Polylines

This feature should be exclusively used just before exporting to a CAD or GIS system. You should NEVER use this feature as part of your everyday work because it not only produces an excessive amount of data, but also produces 'points' that can be snapped to by mistake if the 'layer' is active! To create contour polylines on the current active layer select: **Make Contour Lines on Current Layer** under the **Topography** pull-down.

