Contour Plots for Slab Elevation Data using MathCAD

John M. Clark

Clark Engineers, Inc.

May 8, 2013

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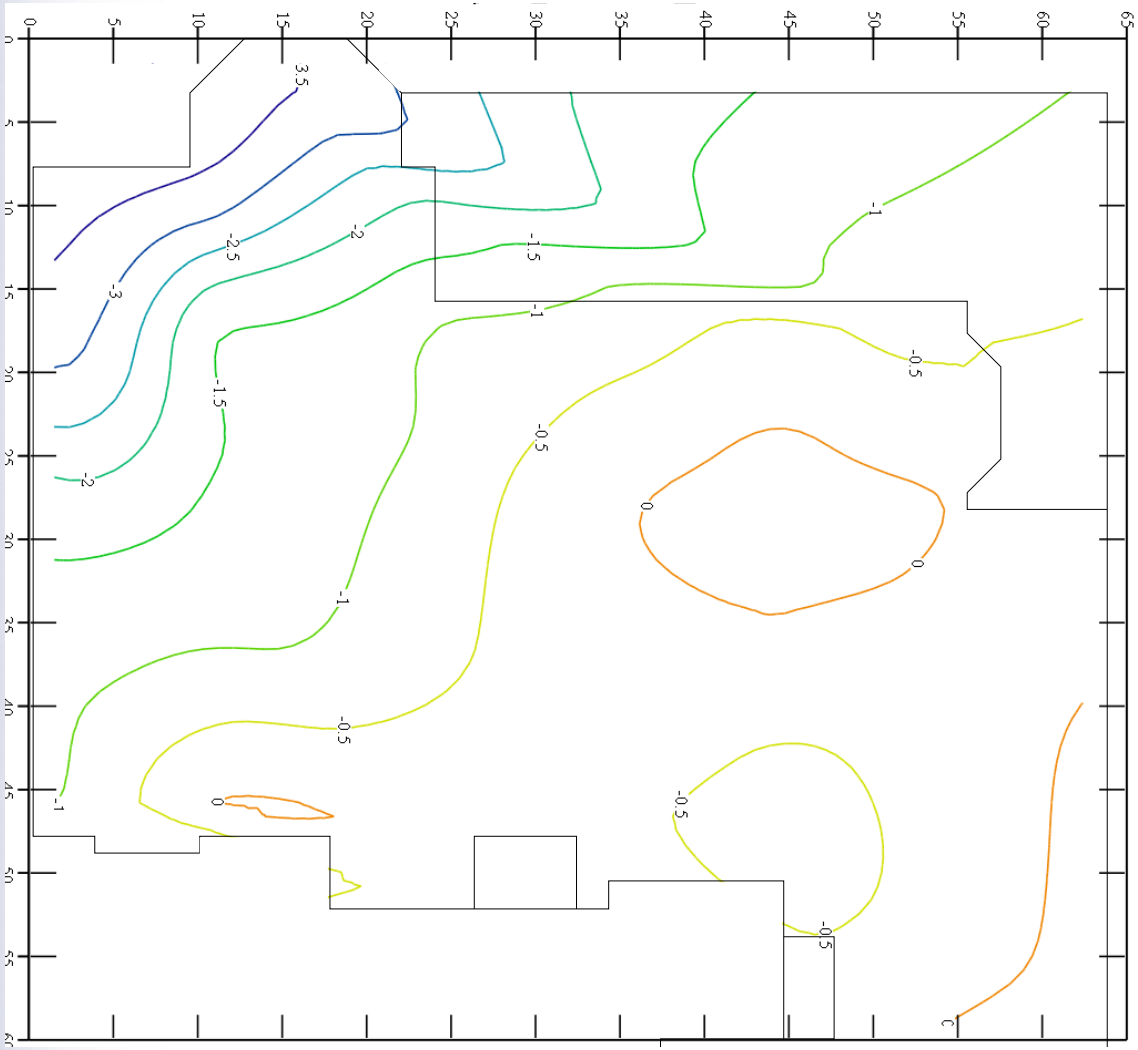

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- Plots in Inches, mm, feet etc.
- **Can be done by competent ACAD operator**

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- **Write small programs for special conditions or functions**

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- Like a live visible program
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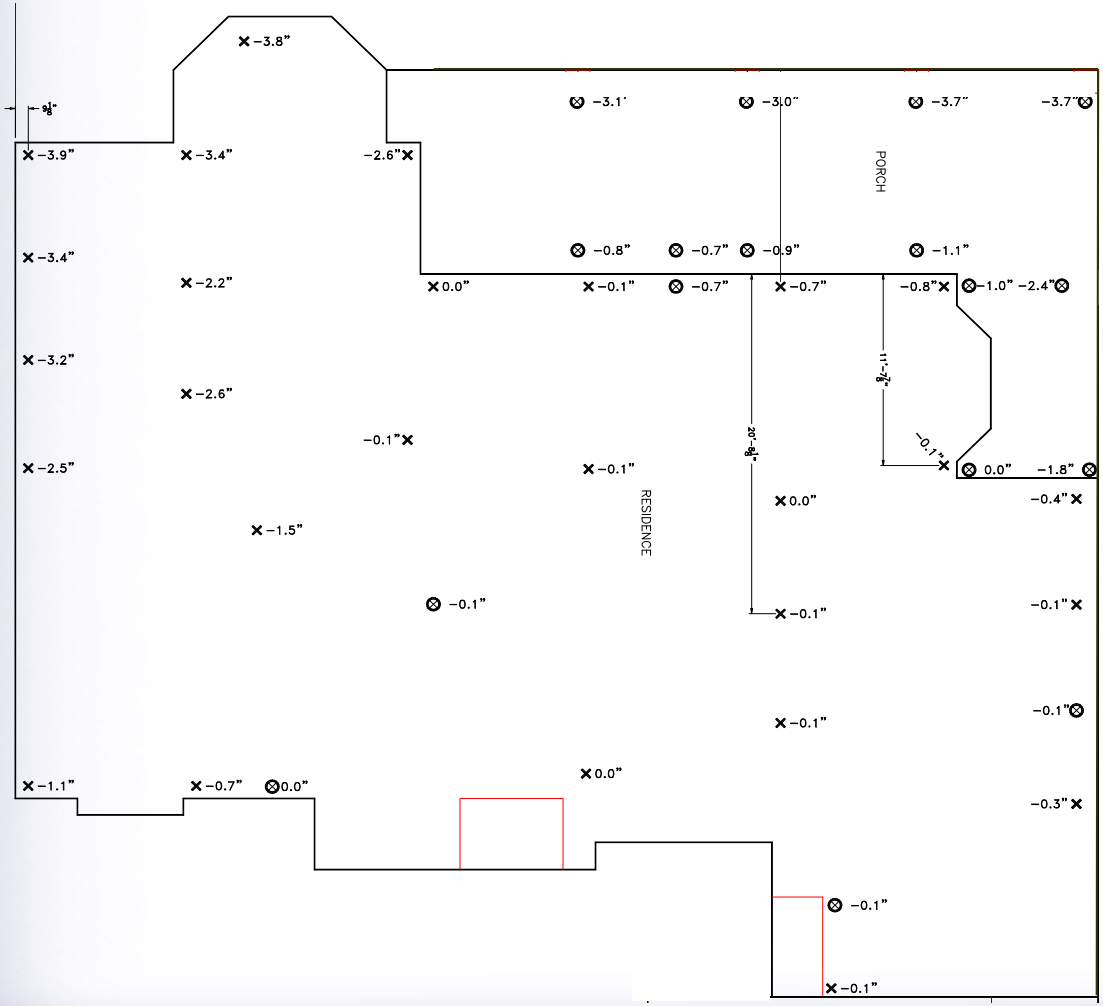
- Clark Engineers, Inc. has used MathCAD since 1996 for all calculations
- **Built design sheets for our clients**

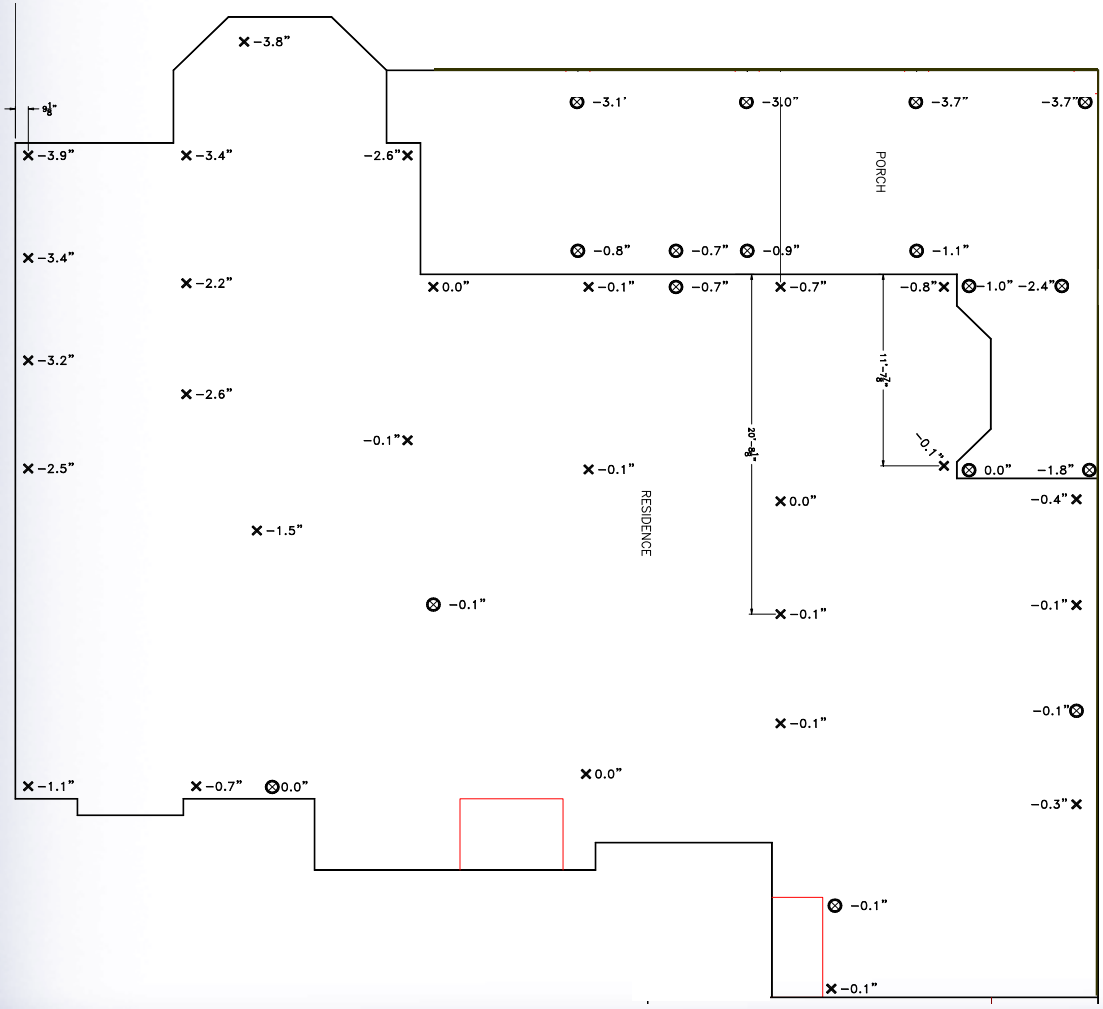
Method

- **Plot data in AutoCAD**



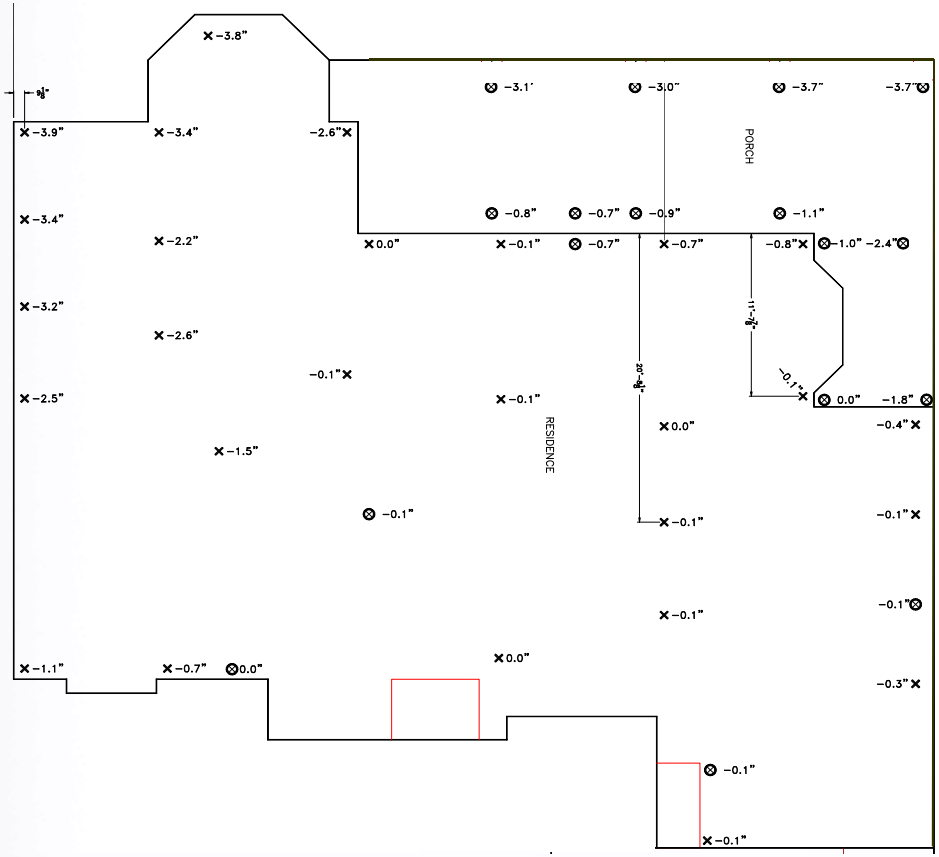
Method continued

- Plot data in AutoCAD
- **Export X, Y, Z coordinates to Excel**



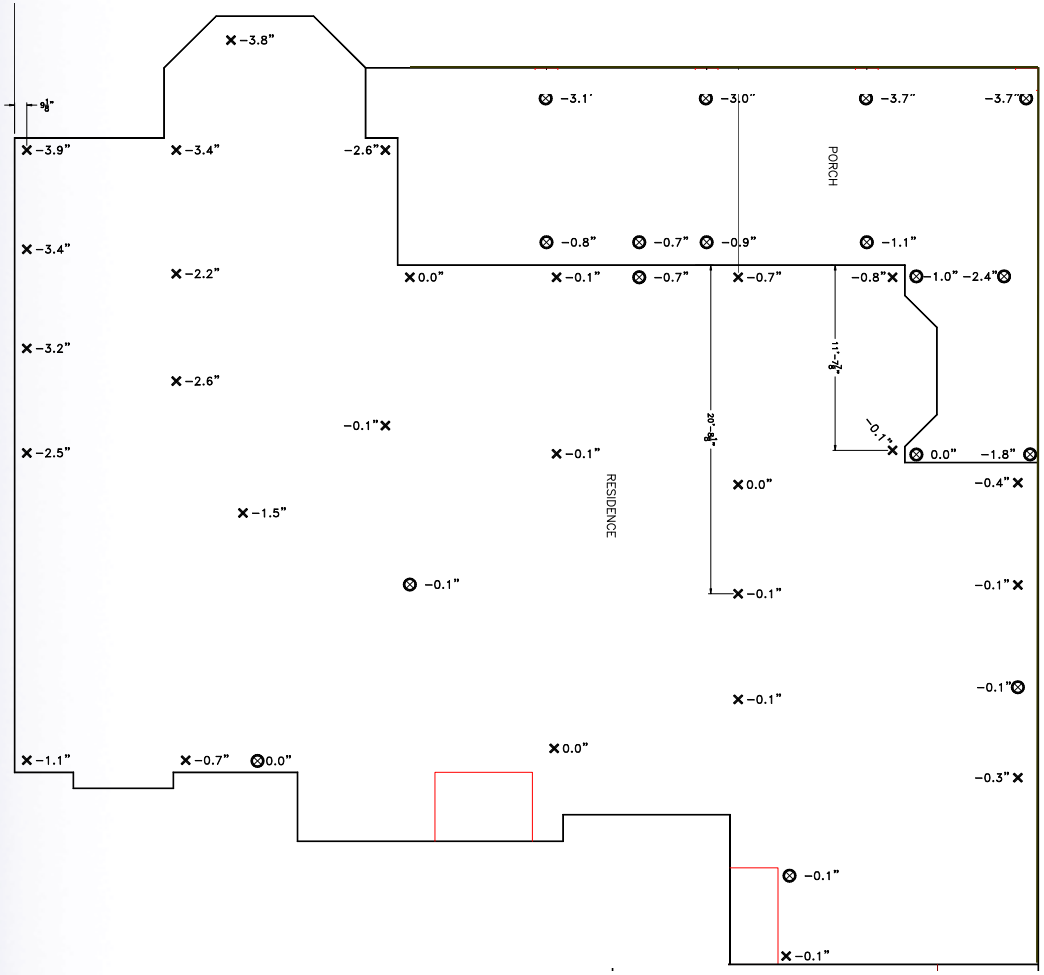
Method continued

- Plot data in AutoCAD
- Export X, Y, Z coordinates to Excel
- **Copy data vectors to MathCAD**



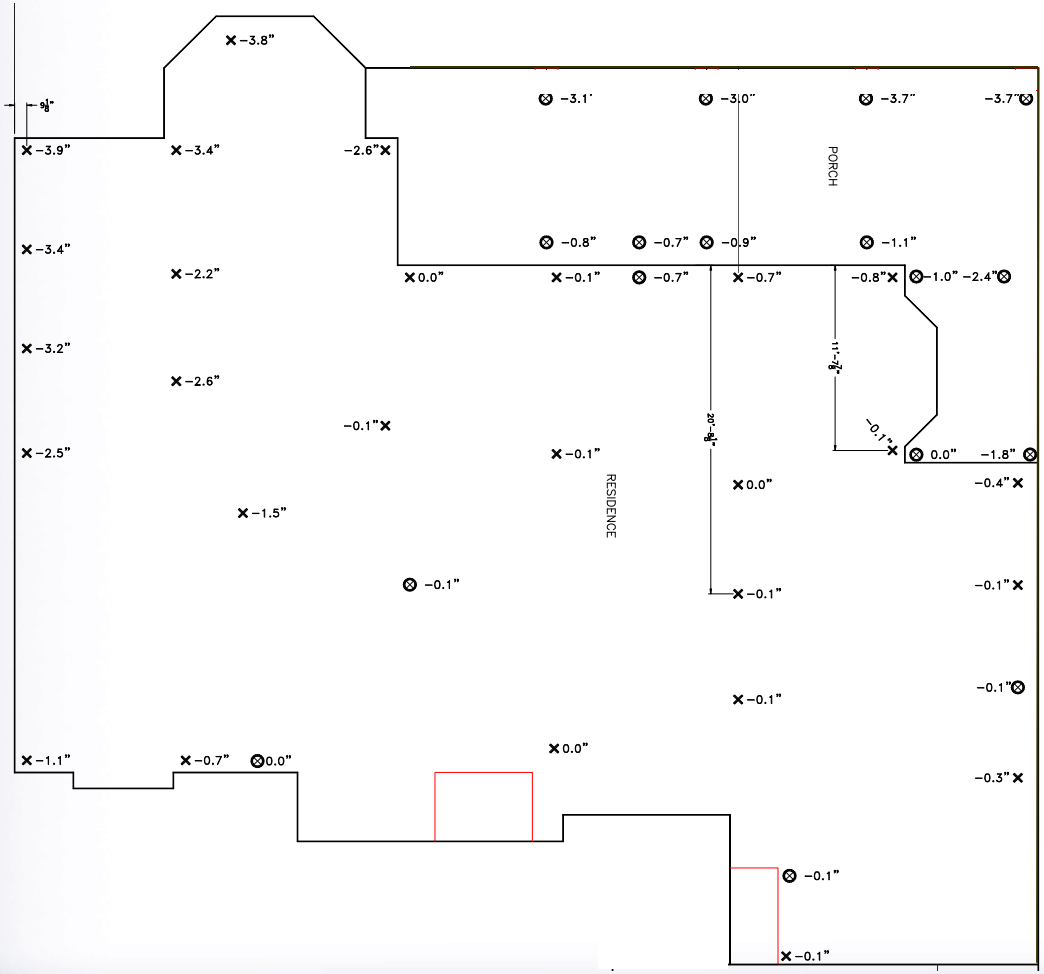
Step 1

- Take accurate elevations of the foundation



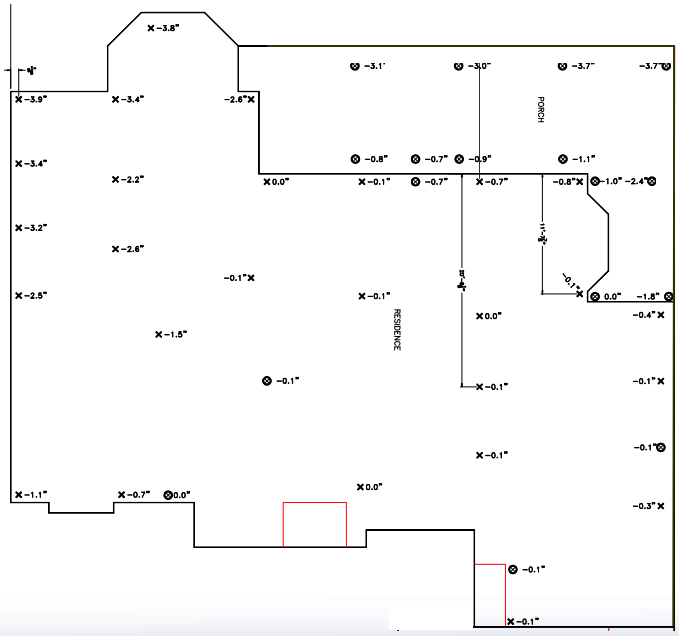
Step 1 continued

- Take accurate elevations of the foundation
  - **See FPA paper SC012 for more information on data points**



Step 1 continued

- Take accurate elevations of the foundation
  - See FPA paper SC012 for more information on data points
- **Locate points on accurate field drawing to ± 6” to 12” each way**
  - **If there is an architectural floor plan available, use this to record points**



Step 2

- **Make an accurate floor plan in AutoCAD**

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- **Set units to decimal**

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- **Set bottom left and corner to 0,0**

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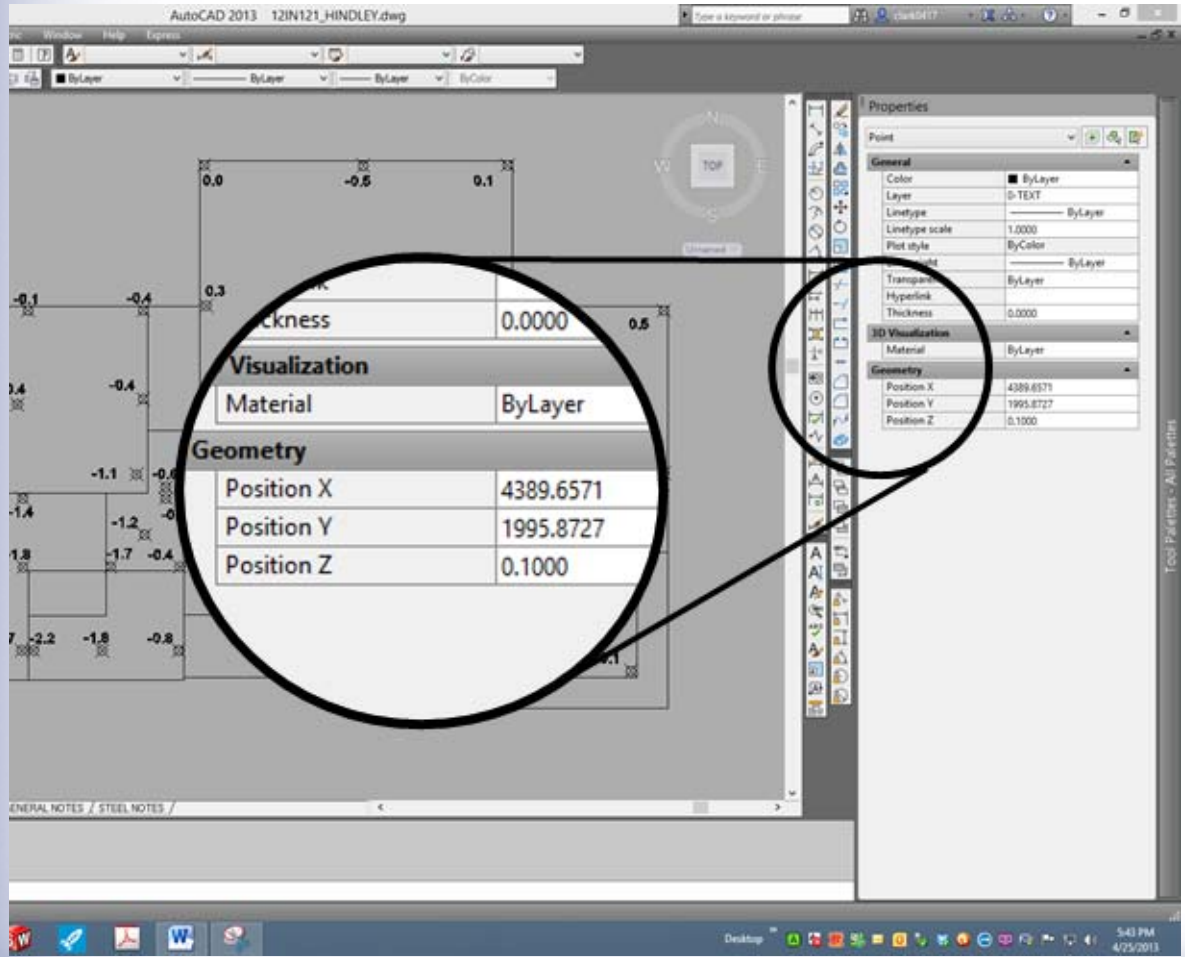
- Make an accurate floor plan in AutoCAD
- Set units to decimal
- Set bottom left and corner to 0,0
- **Add data points to AutoCAD drawing**
  - **Must use AutoCAD point command**
  - **Add Elevation labels as text**

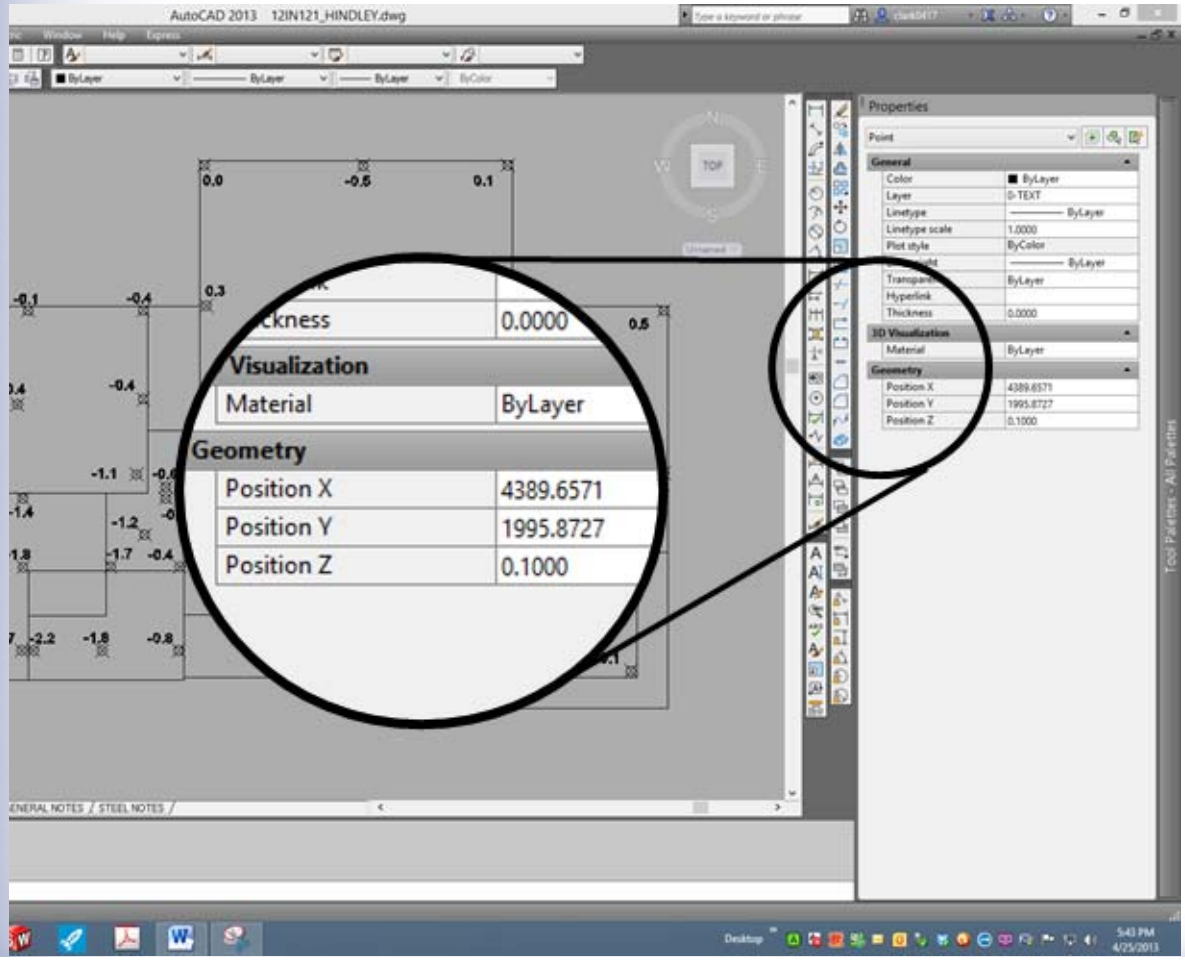
Step 3

- **For each elevation point,**



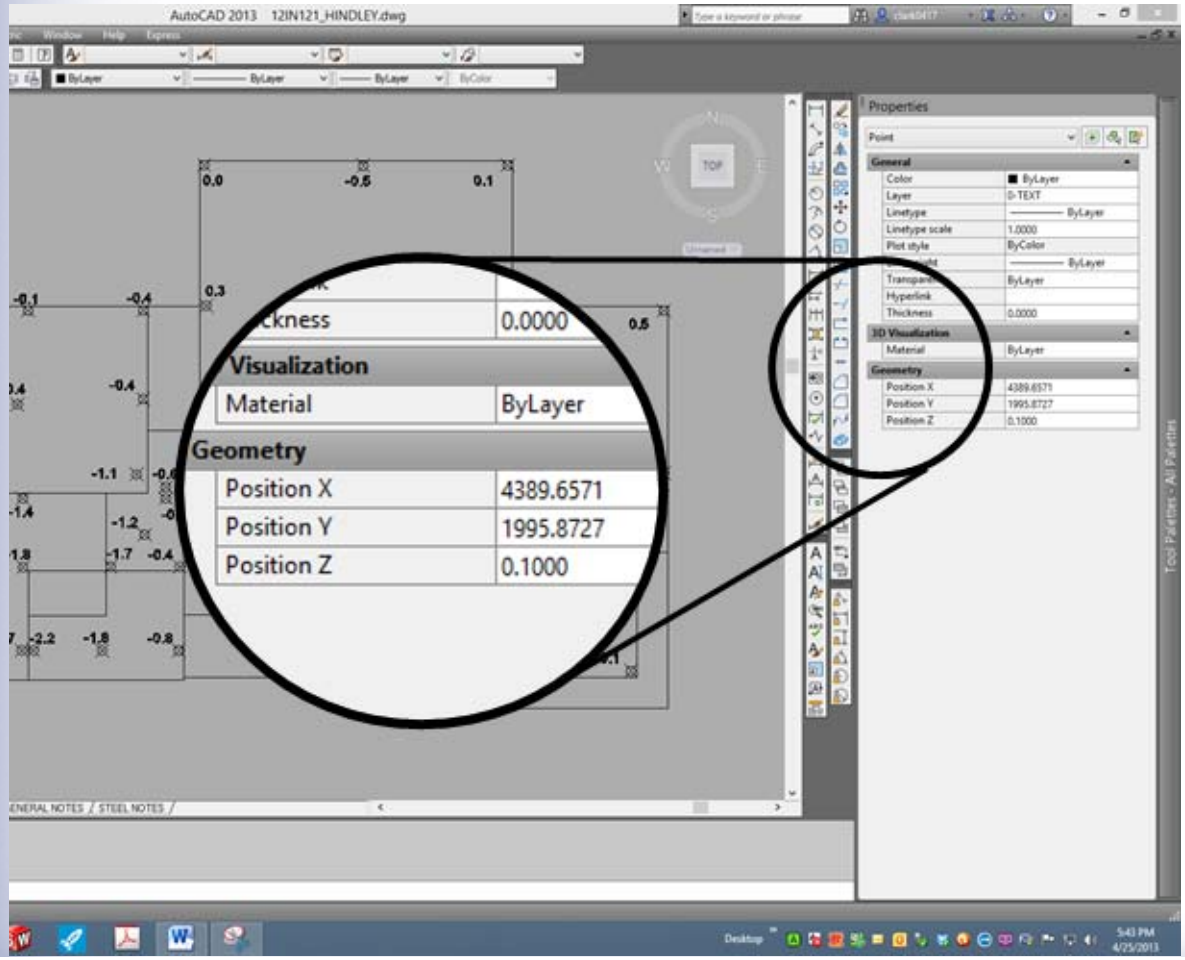
Step 3 continued

- For each elevation point,
- **Click on a single point**



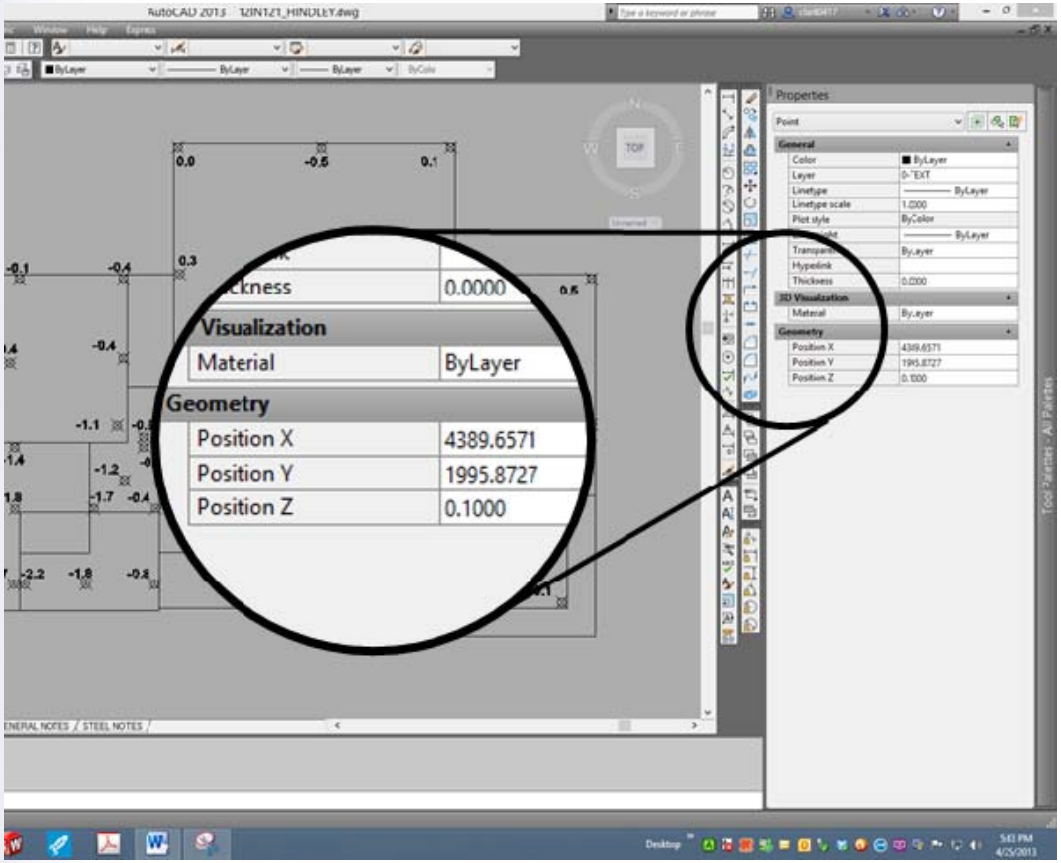
Step 3 continued

- For each elevation point,
- Click on a single point
- **Right click**



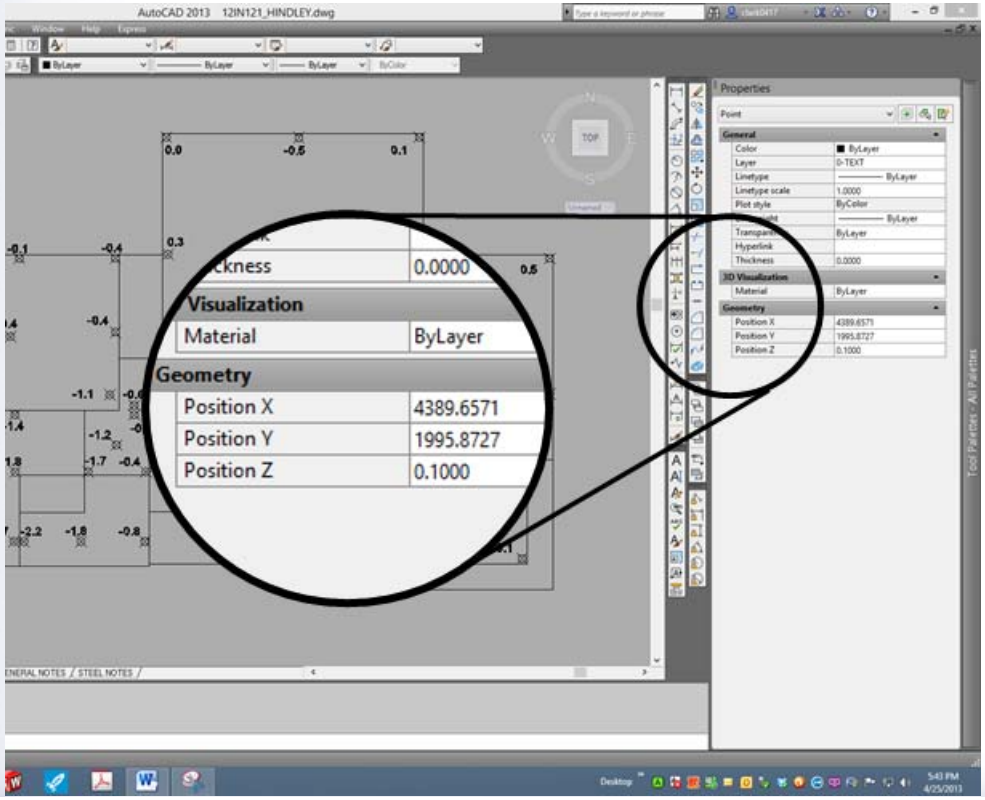
Step 3 continued

- For each elevation point,
- Click on a single point
- Right click
- **Select properties, menu opens**



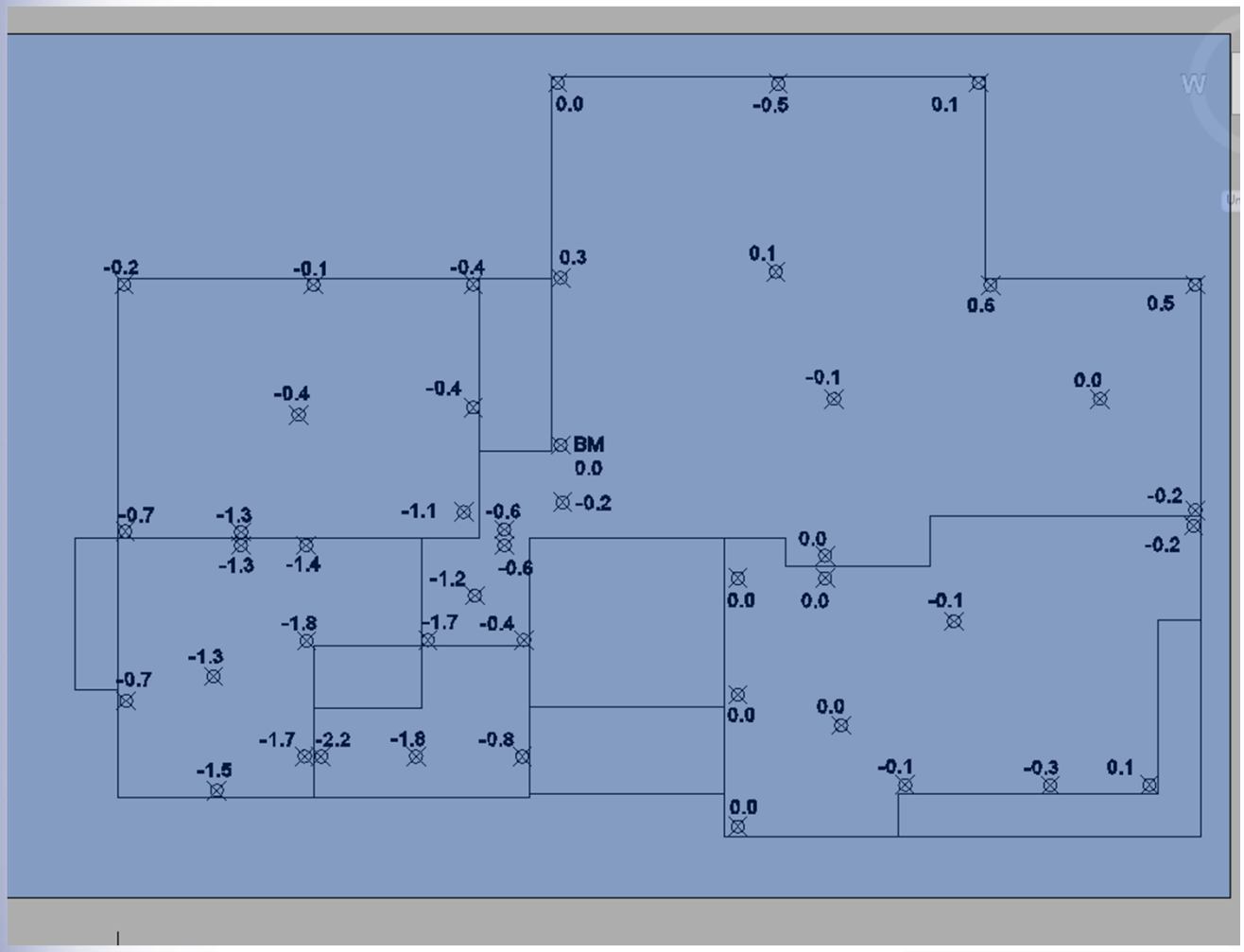
Step 3 continued

- For each elevation point,
- Click on a single point
- Right click
- Select properties, menu opens
- **Edit geometry and record elevation value for "z"**



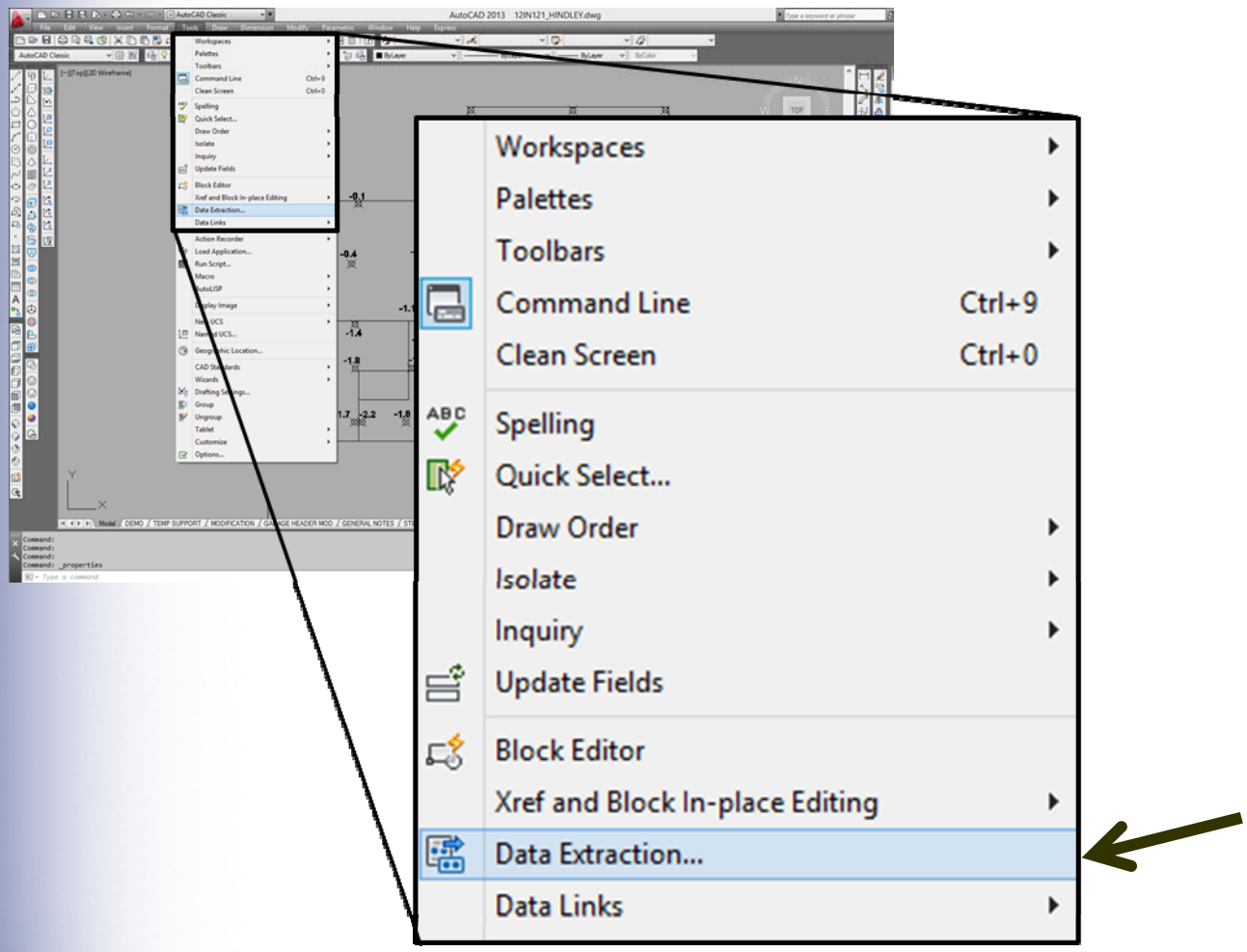
Step 3 continued

- **Completed plot with elevation points and text for values.**



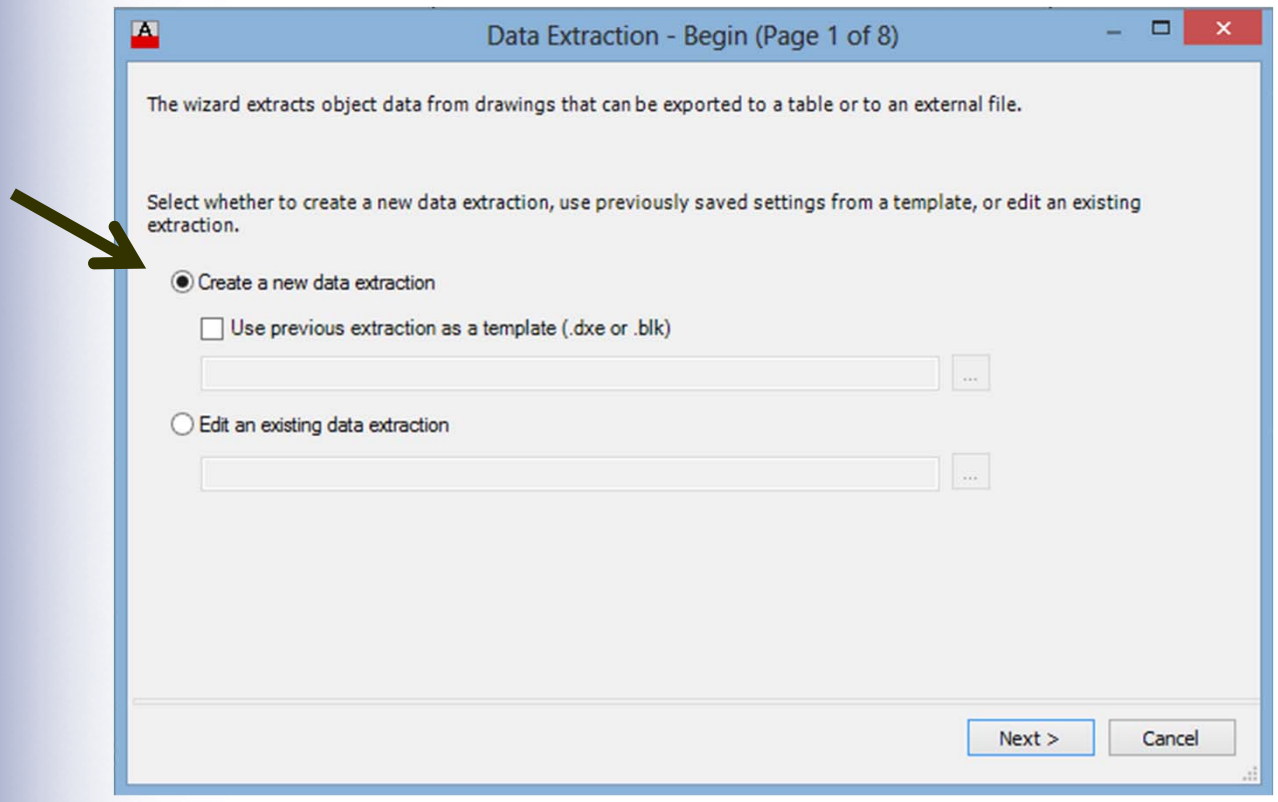
Step 4

- **Data Extraction**
  - **GO TO: Tools> Data Extraction>**



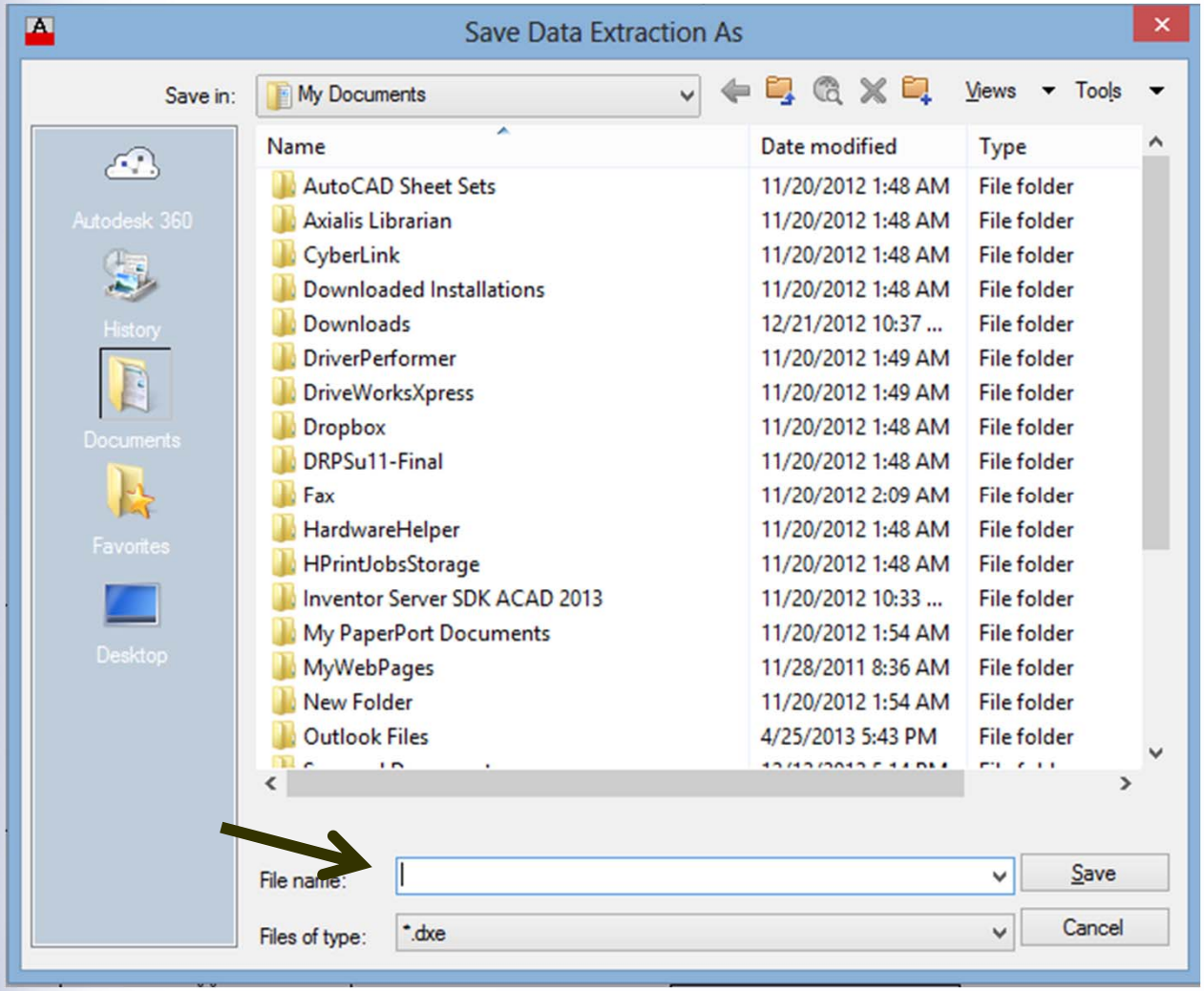
Step 5

- **Select Create a new data extraction**



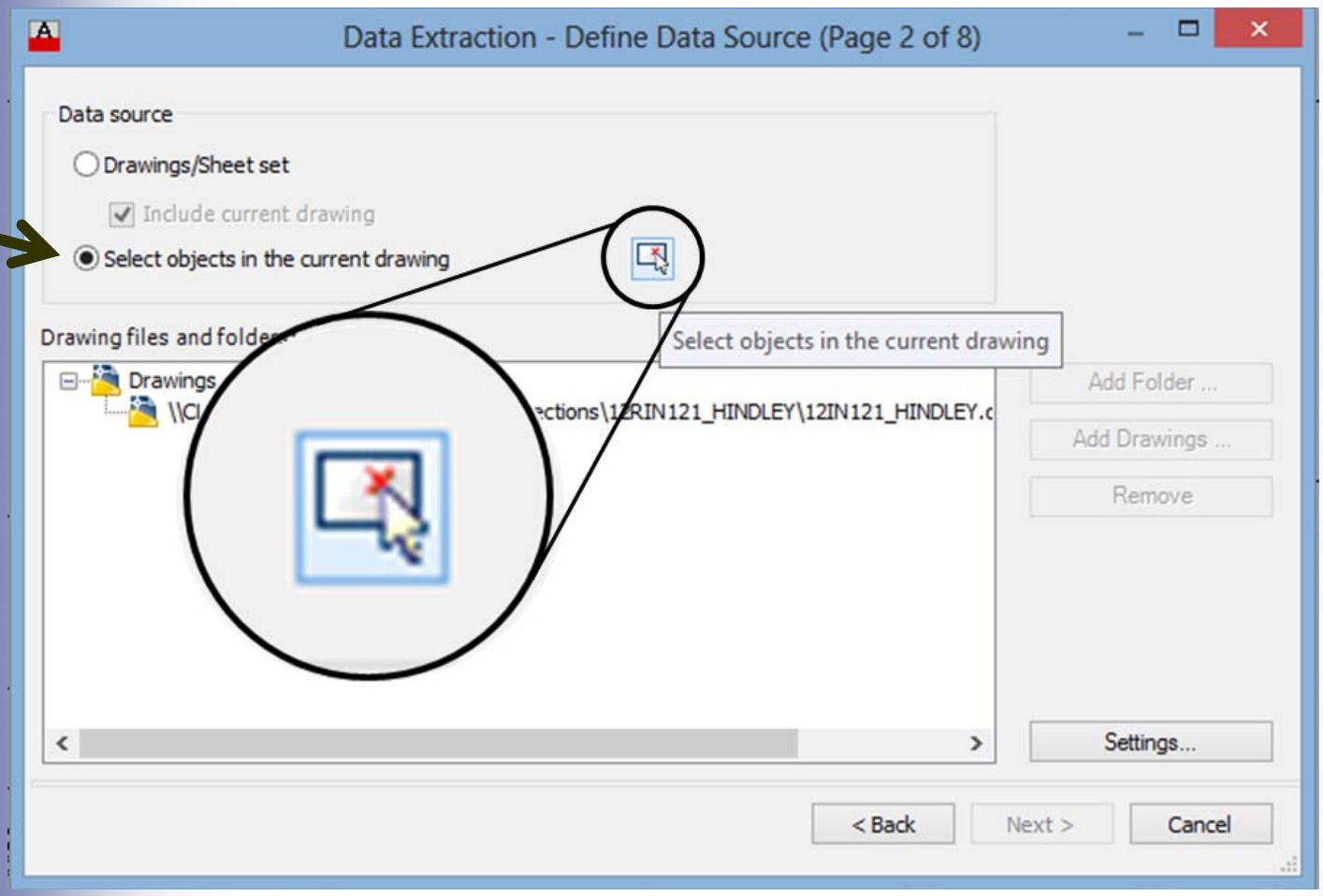
Step 6

- **Create a file name for the data extraction: Projectname_ELDATA**



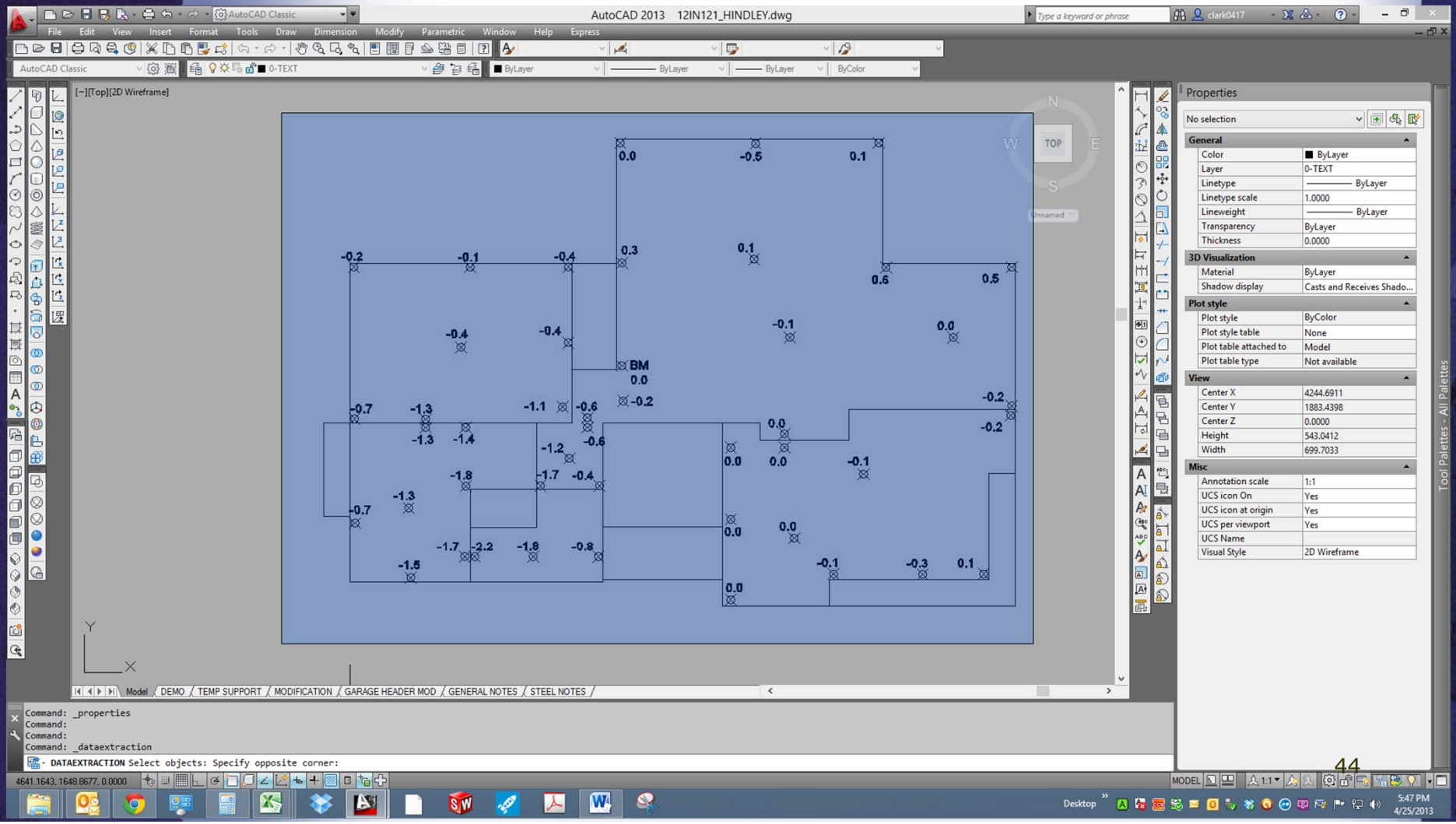
Step 7

- **Select: Select object in drawing**



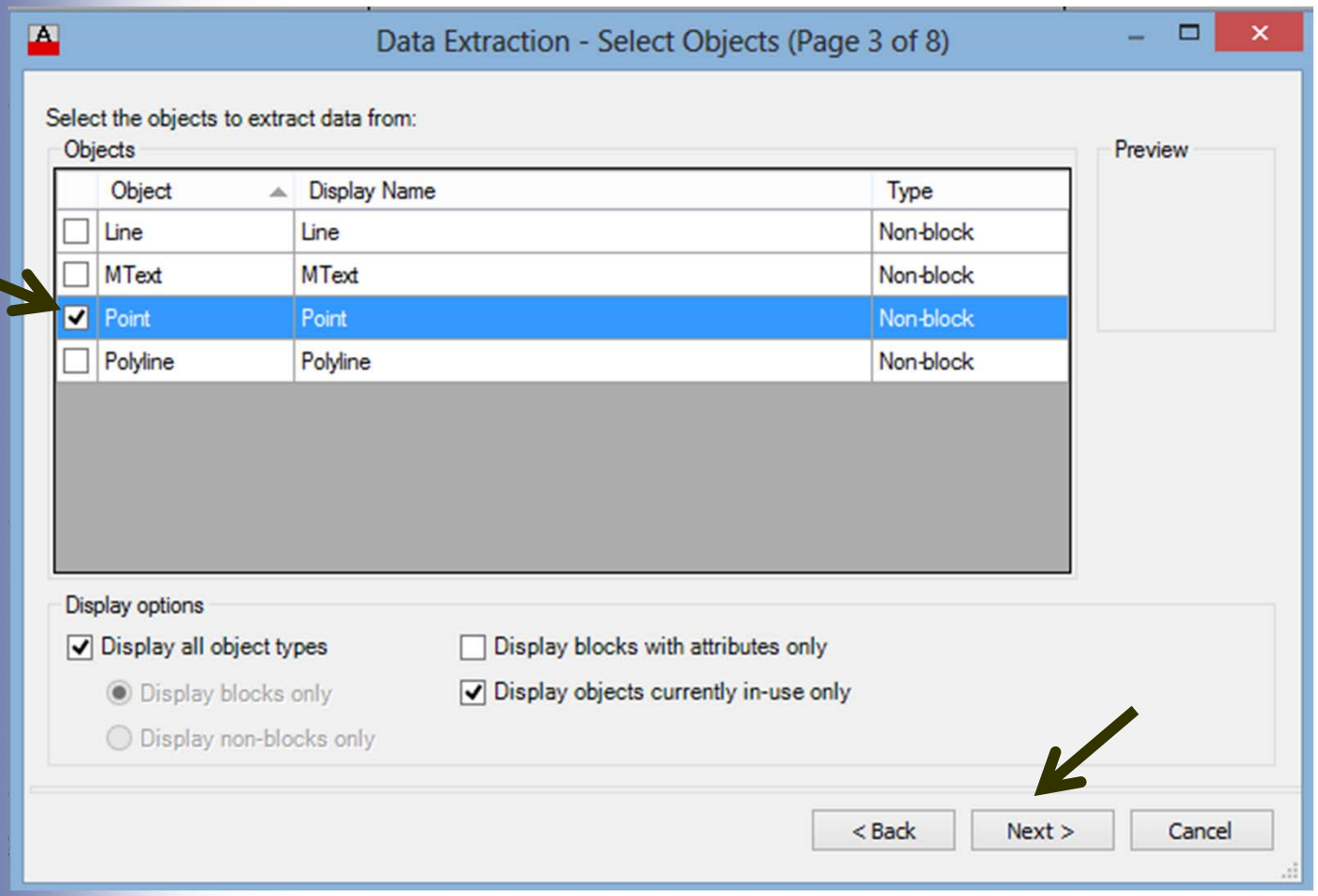
Step 8

- **"Select entire drawing" to select points for contour plots**



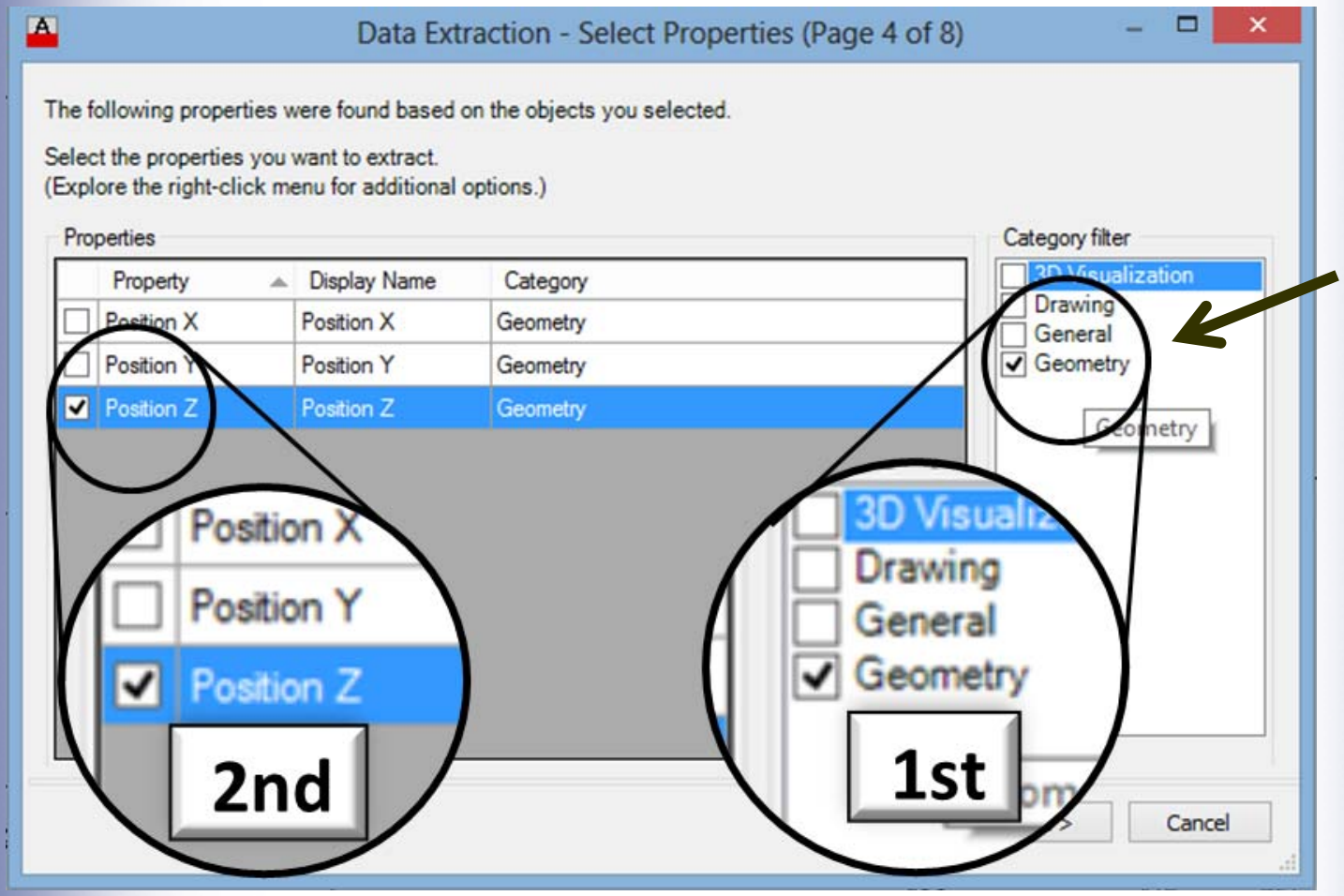
Step 9 Select objects cont.

- Check point box and select next



Step 10

- **Under Category Filter, uncheck everything except geometry**



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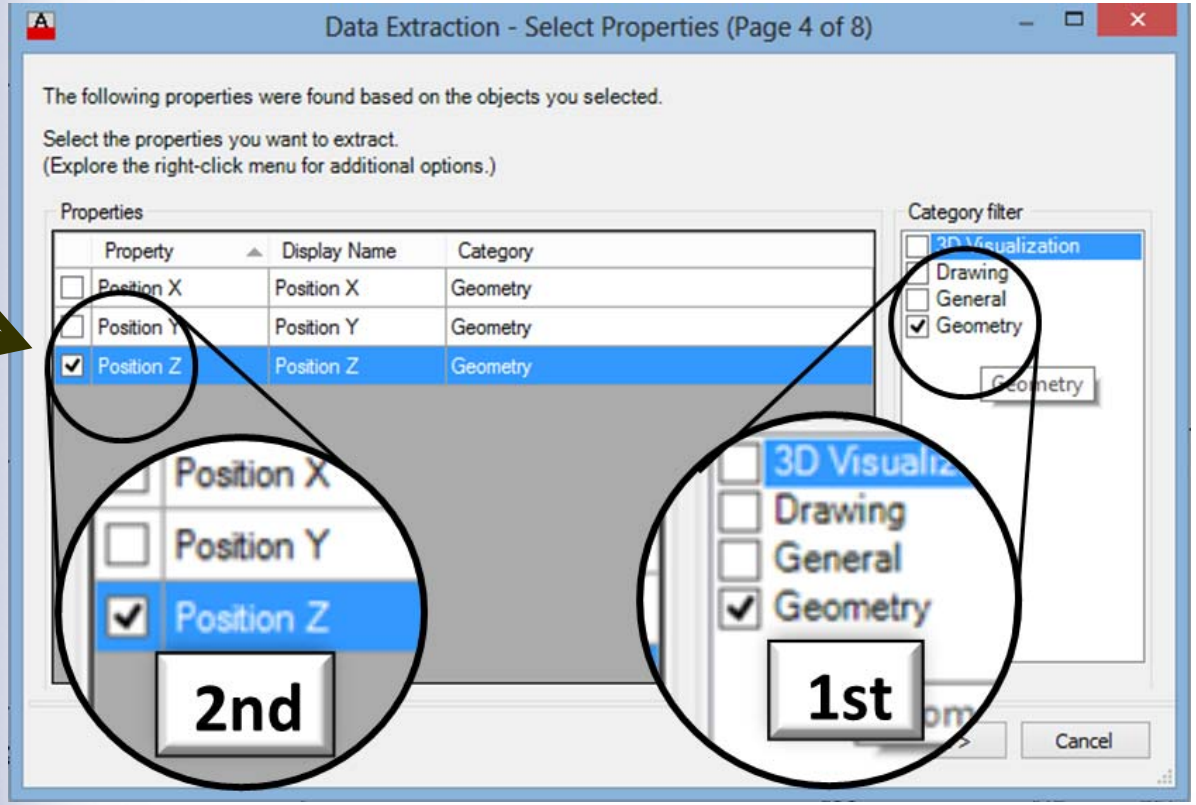
- Under Category Filter, uncheck everything except geometry
- **Under Properties Filter uncheck X and Y position, leaving only Z position checked**



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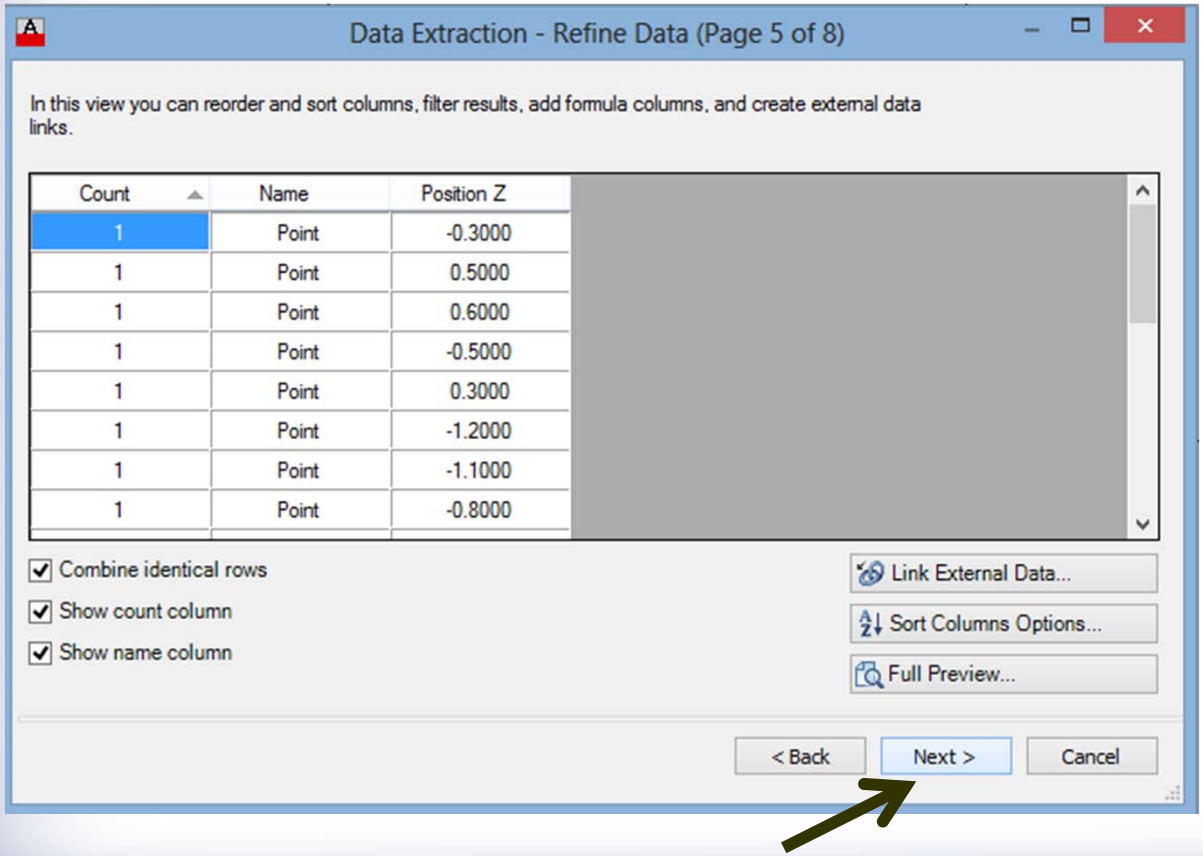
- **Click next**



Step 11

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  - Output to external file

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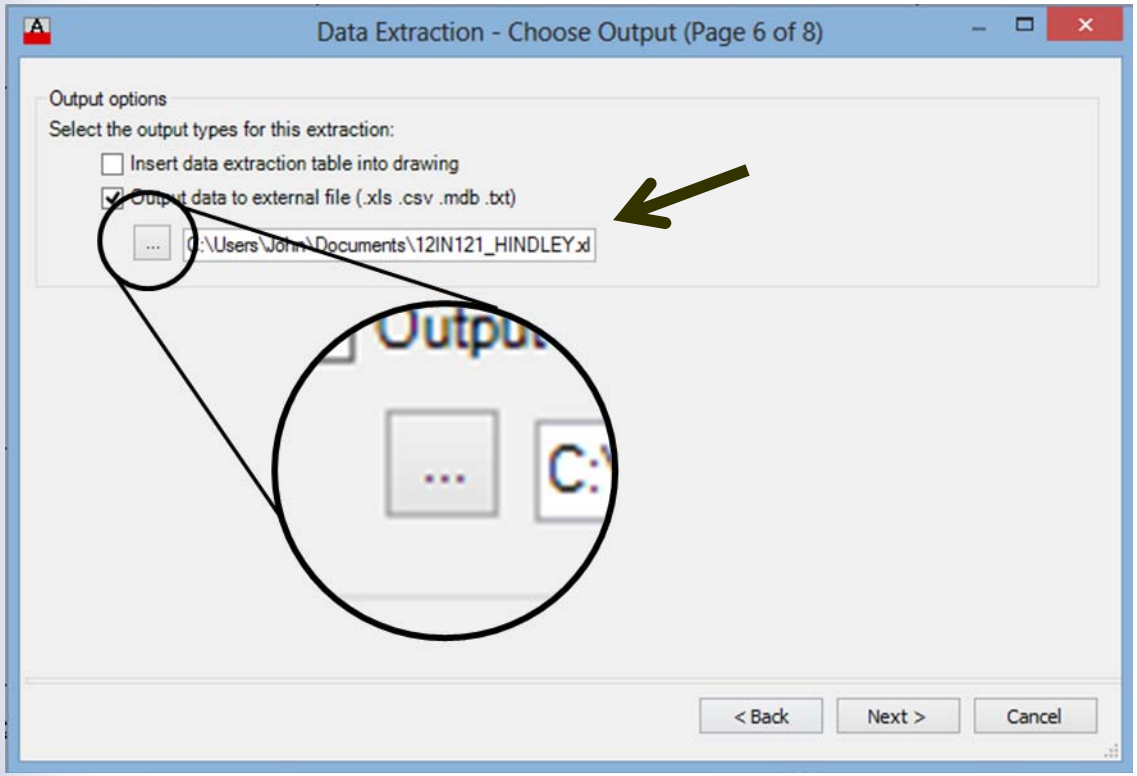
- **Click here to browse**



Step 12

- Data in Excel

Excel Sheet		
436.11	529.89	-0.1
353.7	529.89	0.3
206.11	529.89	-0.4
330.44	406.11	-0.1
290.89	268.89	-1
436.11	189.29	-1
315.11	130.11	-1.5
206.11	130.11	-1.6
552.69	130.1	0
552.89	381.89	-0.2
584.89	529.89	-0.9
709.69	578.1	-0.1
679.5	748.89	0.1
477.25	748.89	0
355.11	748.89	-0.4
330.89	648.89	0
206.11	648.89	-0.6
206.11	406.11	-0.8
206.11	293.11	-1
110.11	268.89	-2.1
18.11	162.08	-3.7
110.11	130.11	-3.3
110.11	18.11	-3.7
248.5	18.11	-2.9
315.11	18.11	-2
436.11	18.11	-1.2
552.69	18.1	-1

Step 13
Paste data into MathCad

- Create a variable for the first data column (usually x values)

$$x := \blacksquare$$

Step 13
Paste data into MathCad

In the red solid box

Right click on the red box and select paste

$x := \blacksquare$

$$x := \begin{pmatrix} 436.11 \\ 353.7 \\ 206.11 \\ 330.44 \\ 290.89 \\ 436.11 \\ 315.11 \\ 206.11 \\ 552.69 \\ 552.89 \\ 584.89 \\ 709.69 \\ 679.5 \\ 477.25 \\ 355.11 \\ 330.89 \\ 206.11 \\ 206.11 \\ 206.11 \\ 110.11 \\ 18.11 \\ 110.11 \\ 110.11 \\ 248.5 \\ 315.11 \\ 436.11 \\ 552.69 \end{pmatrix}$$

Step 13
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- **Add correct units for the vector**
  - **In this case inches**

Input vector

$$x := \begin{pmatrix} 436.11 \\ 353.7 \\ 206.11 \\ 330.44 \\ 290.89 \\ 436.11 \\ 315.11 \\ 206.11 \\ 552.69 \\ 552.89 \\ 584.89 \\ 709.69 \\ 679.5 \\ 477.25 \\ 355.11 \\ 330.89 \\ 206.11 \\ 206.11 \\ 206.11 \\ 110.11 \\ 18.11 \\ 110.11 \\ 110.11 \\ 248.5 \\ 315.11 \\ 436.11 \\ 552.69 \end{pmatrix}$$

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Vector with units

Step 13
Paste data into MathCad

- Add correct units for the vectors
  - In this case inches
- **Use any desired units**

$$x = \begin{pmatrix} 36.3 \\ 29.5 \\ 17.2 \\ 27.5 \\ 24.2 \\ 36.3 \\ 26.3 \\ 17.2 \\ 46.1 \\ 46.1 \\ 48.7 \\ 59.1 \\ 56.6 \\ 39.8 \\ 29.6 \\ 27.6 \\ 17.2 \\ 17.2 \\ 17.2 \\ 9.2 \\ 1.5 \\ 9.2 \\ 9.2 \\ 20.7 \\ 26.3 \\ 36.3 \\ 46.1 \end{pmatrix} \text{ft}$$

Output vector

Units Changed output to feet

Step 13
Paste data into MathCad

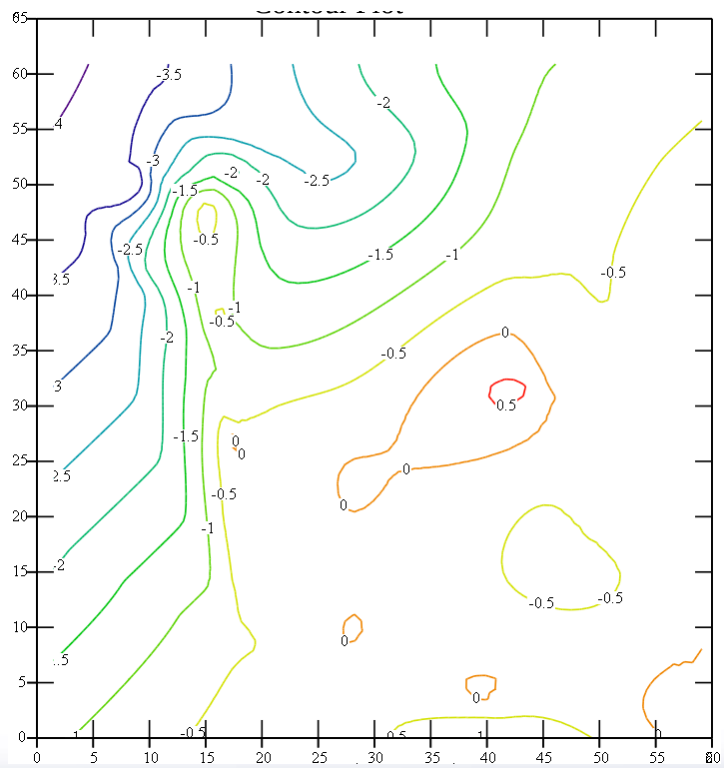
- **Repeat steps for Y and Z vector**

$$x = \begin{pmatrix} 36.34 \\ 29.47 \\ 17.18 \\ 27.54 \\ 24.24 \\ 36.34 \\ 26.26 \\ 17.18 \\ 46.06 \\ 46.07 \\ 48.74 \\ 59.14 \\ 56.62 \\ 39.77 \\ 29.59 \\ 27.57 \\ 17.18 \\ 17.18 \\ 17.18 \\ 9.18 \\ 1.51 \\ 9.18 \\ 9.18 \\ 20.71 \\ 26.26 \\ 36.34 \\ 46.06 \end{pmatrix} ft \quad y = \begin{pmatrix} 44.16 \\ 44.16 \\ 44.16 \\ 33.84 \\ 22.41 \\ 15.77 \\ 10.84 \\ 10.84 \\ 10.84 \\ 31.82 \\ 44.16 \\ 48.17 \\ 62.41 \\ 62.41 \\ 62.41 \\ 54.07 \\ 54.07 \\ 33.84 \\ 24.43 \\ 22.41 \\ 13.51 \\ 10.84 \\ 1.51 \\ 1.51 \\ 1.51 \\ 1.51 \\ 1.51 \end{pmatrix} ft \quad z = \begin{pmatrix} -0.1 \\ 0.3 \\ -0.4 \\ -0.1 \\ -1 \\ -1 \\ -1.5 \\ -1.6 \\ 0 \\ -0.2 \\ -0.9 \\ -0.1 \\ 0.1 \\ 0 \\ -0.4 \\ 0 \\ -0.6 \\ -0.8 \\ -1 \\ -2.1 \\ -3.7 \\ -3.3 \\ -3.7 \\ -2.9 \\ -2 \\ -1.2 \\ -1 \end{pmatrix} in$$

Step 14

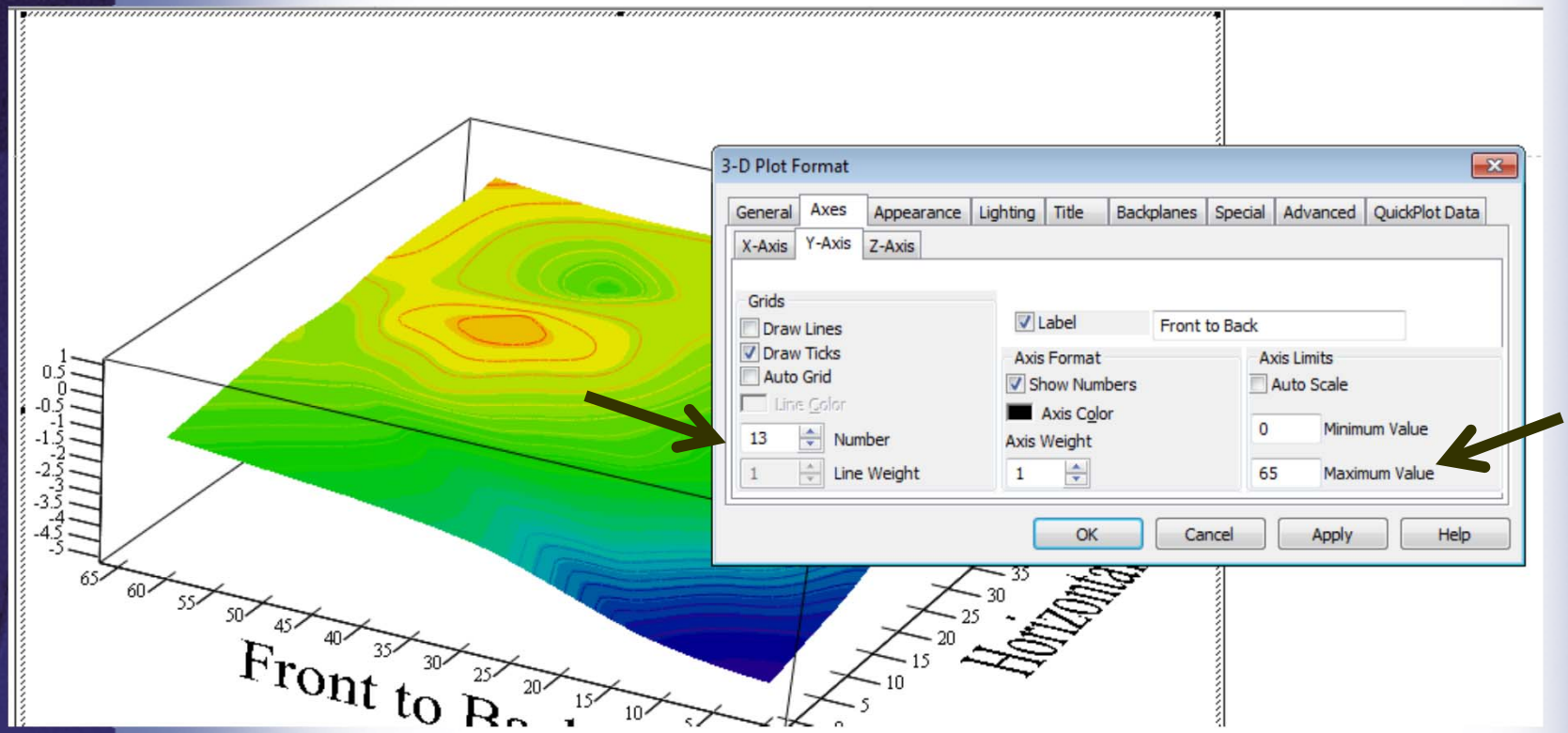
- Data will automatically generate a contour plot, surface plot and polynomial of any selected order (n) data fit plot.
  - Typical order for "n" to use is 1, 2, or 3

Contour Plot



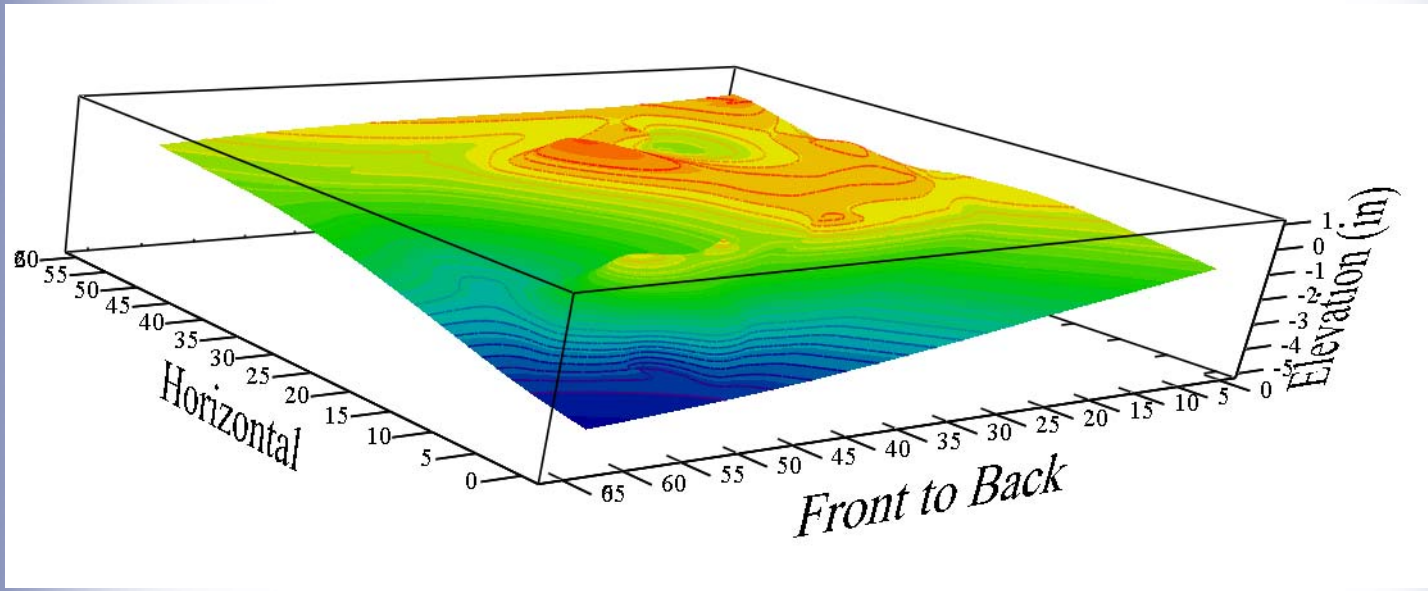
Step 14 continued

- You will probably have to adjust X and Y scale



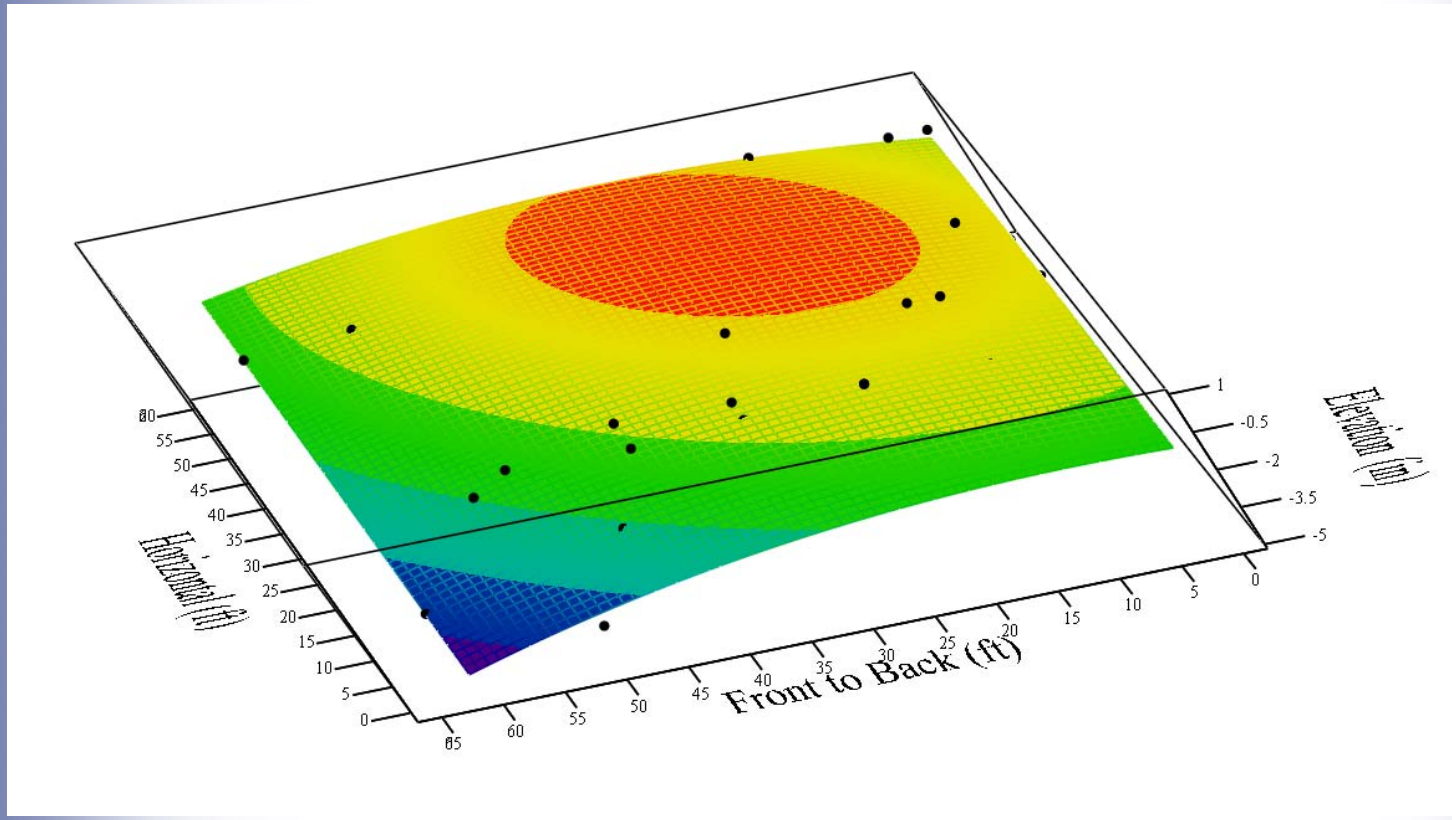
Raw Data Plot

Surface plot



These views can be rotated

Polynomial Plot

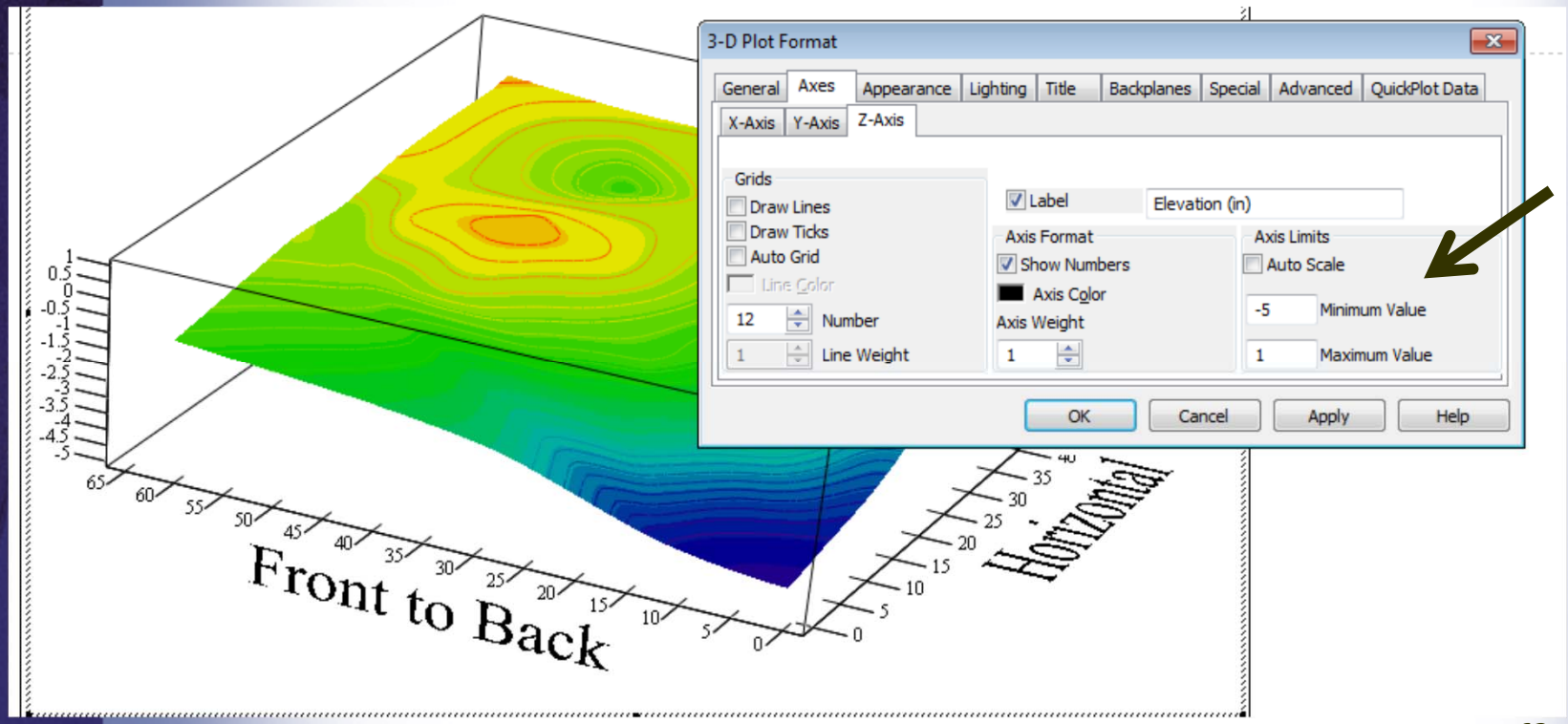


These views can be rotated

Step 15

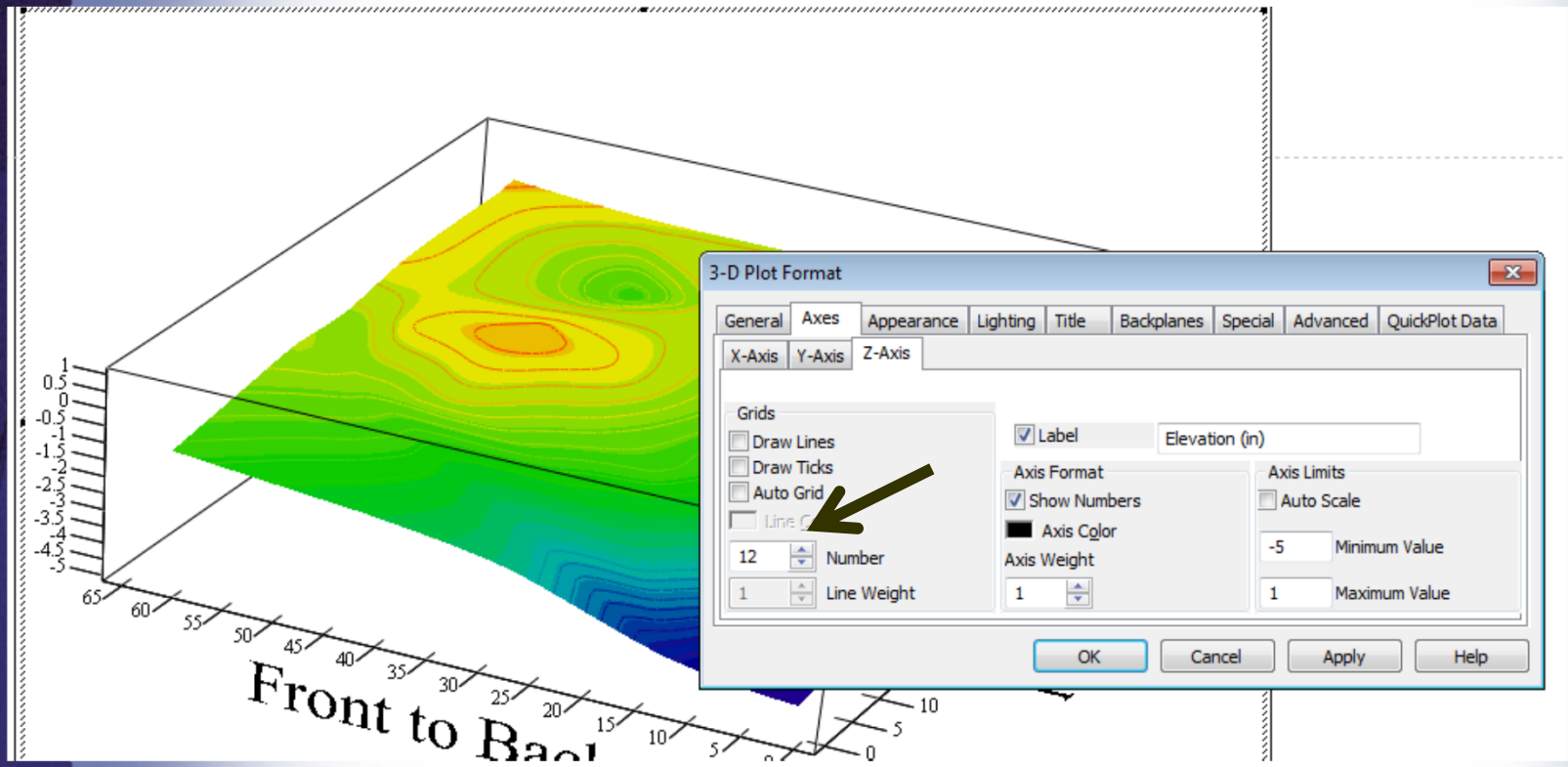
- Adjust scales as required for each plot. For surface plots the Z scale will also have to be adjusted

eg: If min elev= -4 ¾ in and max elev= 0.9 in, select say -5 to 1.0 and so on



Step 15 continued

- Select number of spaces for convenient vertical scale
  - In this case 6” or 12”



Step 16

- Iterate on the polynomial order, usually 2nd or 3rd order is ok. Do not use higher than 4th order.

Polynomial Surface Data Fit

$n := 2$

$M := \text{augment}\left(\frac{x}{ft}, \frac{y}{ft}\right)$

$R_1 := \text{regress}\left(M, \frac{z'}{in}, n\right)$

$$R_1 = \begin{pmatrix} 3 \\ 3 \\ 2 \\ -0.00099 \\ -0.00062 \\ 0.09792 \\ -5.2337 \\ 0.13151 \\ -0.00099 \end{pmatrix}$$

$m_1 := 64$ $\quad m_2 := 64$

$f(x,y) := \text{interp}\left[R_1, M, \frac{z}{in}, \begin{pmatrix} x \\ y \end{pmatrix}\right]$

$f(m_1, m_2) = -1.213$

$F := \text{CreateMesh}\left(f, \min\left(\frac{x}{ft}\right), \max\left(\frac{x}{ft}\right), \min\left(\frac{y}{ft}\right), \max\left(\frac{y}{ft}\right), m_1, m_2\right)$

$n := 3$

$M := \text{augment}\left(\frac{x}{ft}, \frac{y}{ft}\right)$

$R_1 := \text{regress}\left(M, \frac{z'}{in}, n\right)$

$$R_1 = \begin{pmatrix} 3 \\ 3 \\ 3 \\ 0.00004 \\ 0 \\ -0.00209 \\ 0.15787 \\ -0.00194 \\ -0.00003 \\ -6.22967 \\ 0.23392 \\ -0.00486 \\ 0.00005 \end{pmatrix}$$

$m_1 := 64$ $\quad m_2 := 64$

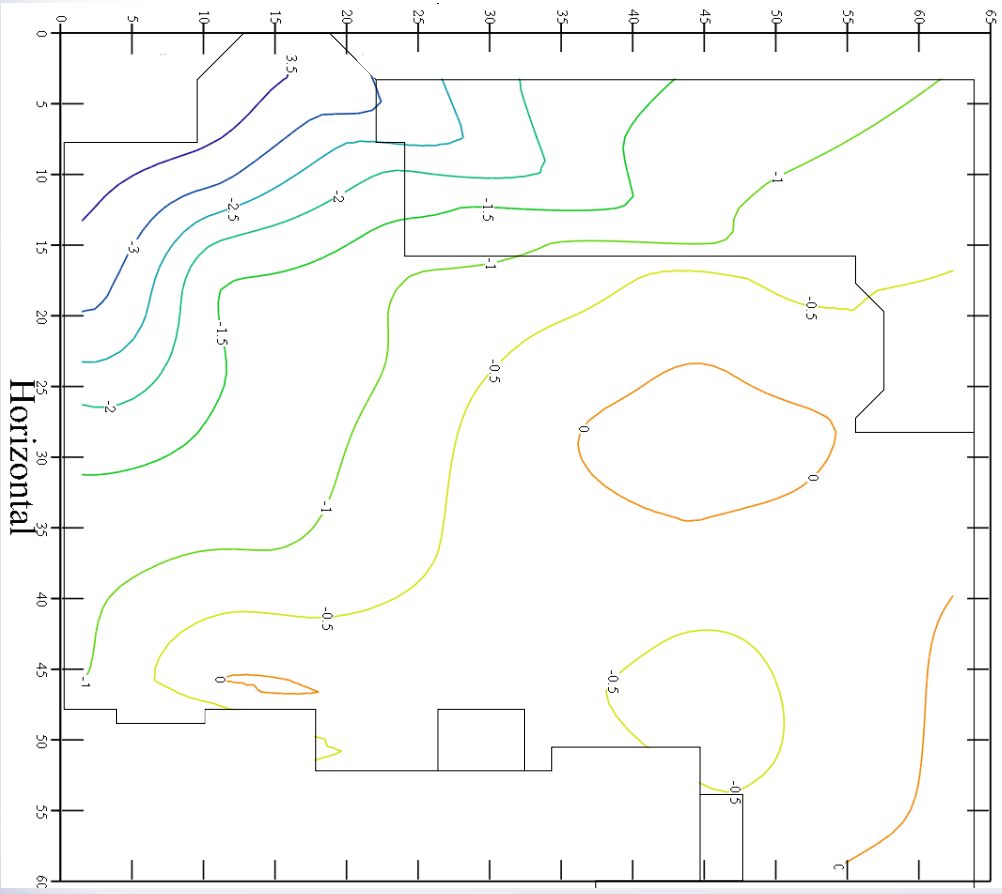
$f(x,y) := \text{interp}\left[R_1, M, \frac{z}{in}, \begin{pmatrix} x \\ y \end{pmatrix}\right]$

$f(m_1, m_2) = -0.078$

$F := \text{CreateMesh}\left(f, \min\left(\frac{x}{ft}\right), \max\left(\frac{x}{ft}\right), \min\left(\frac{y}{ft}\right), \max\left(\frac{y}{ft}\right), m_1, m_2\right)$

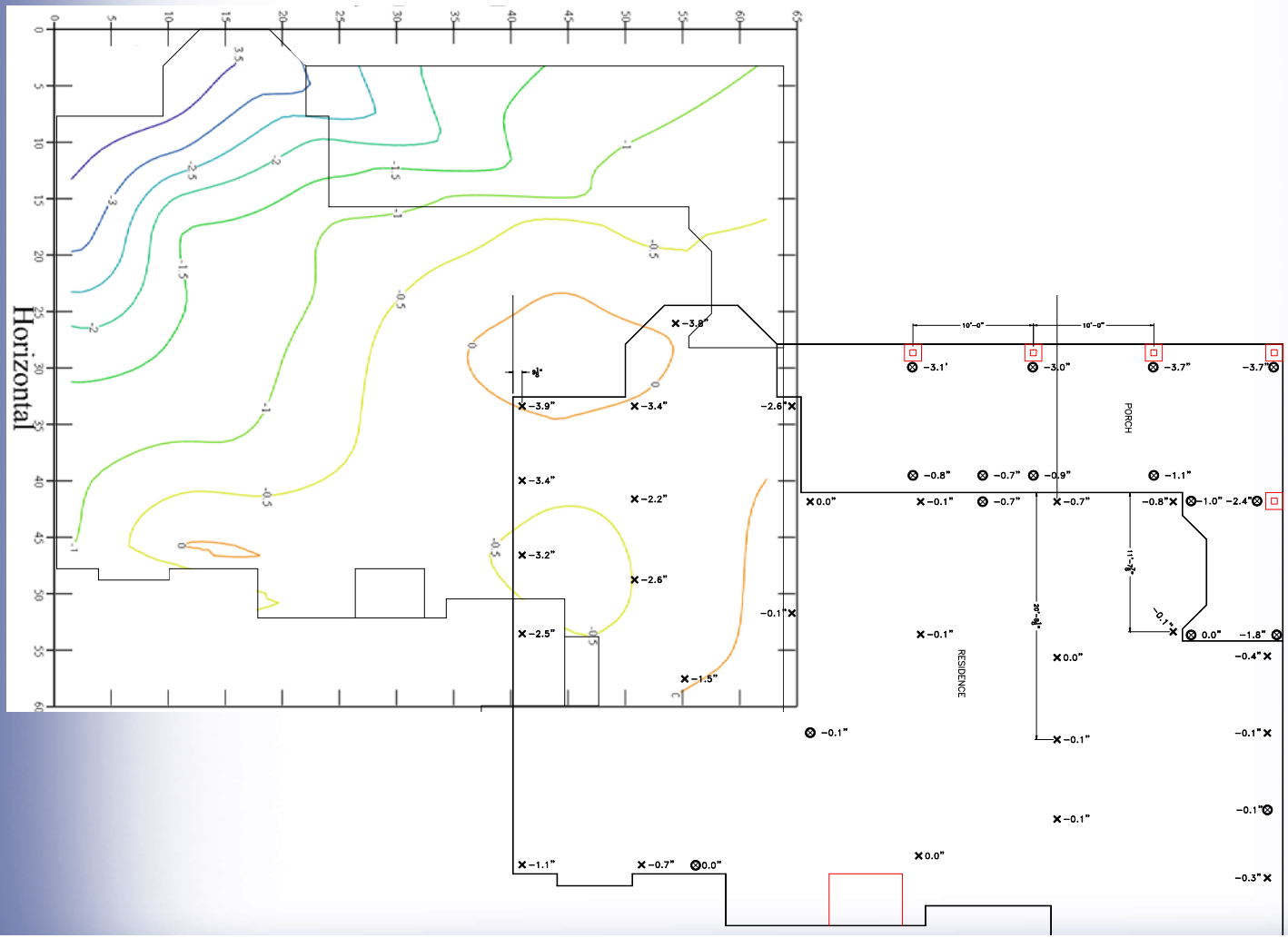
Step 17

- Once the contour plot is set,
  - Copy and Paste floor plan into excel
    - Zoom in on the floor plan and select all desired members
  - Copy and paste contour plot into excel



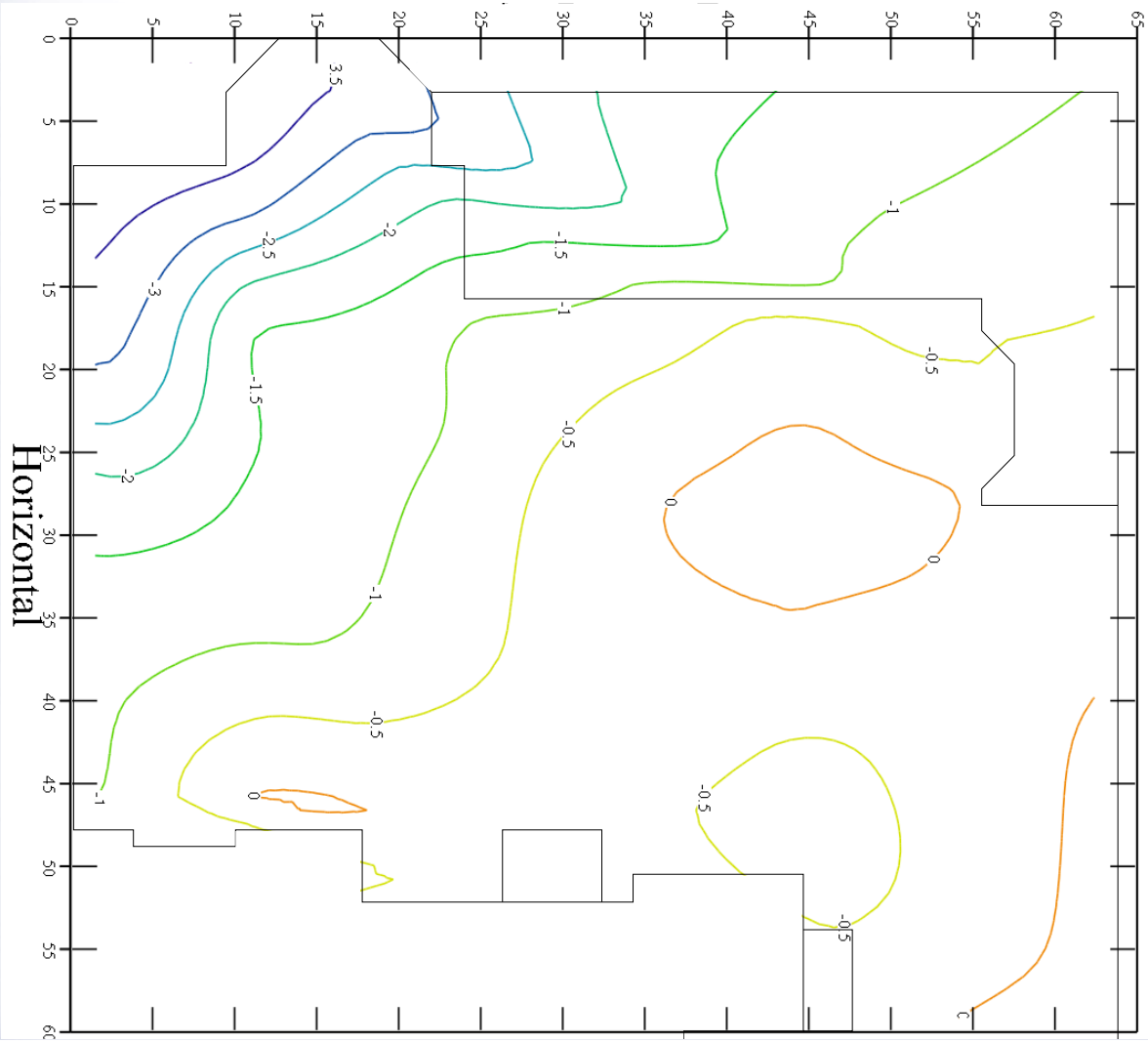
Step 18

- Send the contour plot to the back and the floor plan to the front



Step 19

- Align the plots so that the contour plot is aligned with the floor plan



Step 20

- Areas of the contour that are outside the floor plan can be filled by pasting white filled areas using excel drawing tools, or group pictures and edit in “Paint” what ever is easiest

Step 21

- Select all areas of the final plot and group them

Step 22

- Copy and paste the finished plot to your report document as required

MathCAD Sheet

This MathCAD sheet can be obtained free from www.structuralanalysismcad.com by providing three documented appropriate references (engineers, architects, scientists, CAD technicians, contractors etc.) who are not members of FPA.