GeoGraphix®

whitepaper

Title	*How to Build Cross Sections in smartSECTION*
Category	smartSECTION
Author	LMKR GeoGraphix Technical Support Team
Date	August 31, 2012

Building Cross Sections in smartSECTION

The smartSECTION module is a great tool to visualize the stratigraphy and structure of an area. This document reviews the process of making two kinds of cross section that enable you to not only interpret the geology of the study area, but also quickly display the stratal geometries present in the project area. The workflows covered are:

- How to build a projected line of section
- How to build a cross section template
- How to build a well-to-well cross section
- How to pick tops.

How to Build a Projected Line of Section

To start a new cross section:

1. Activate a project in **ProjectExplorer**, and click the **smartSECTION**  icon.
2. Select an **Interpretation**, if you have already saved one; if not, create a new one.
3. Click the **Geologic Model Properties**  tool to toggle the surfaces to be modeled and interpreted in your cross sections.

Note: It is best to choose fewer than 20 surfaces at one time in order to maximize performance.

The first cross section you will learn to build is a “projected” line of section. This kind of cross section is extremely useful to see what the overall geology of an area is, and to be able to quickly pinpoint areas where more interpretations are needed and/or changes need to be made.

To create a projected line of section:

1. From the **Map View** menu, select **Cross Section > Define Projected**. The cursor becomes a cross hair.
2. Click the cursor on the map, and select any two or more points to make a line of section. Right-click and select **End Definition**. A new cross section window is displayed.

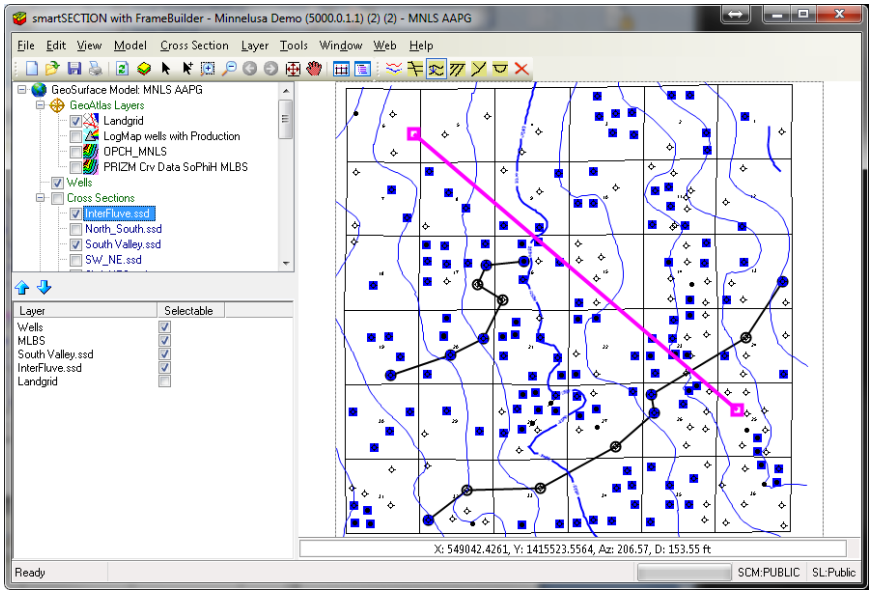

Figure 1: Map View with projected line of section (magenta).

3. Click the **Full Extents** tool to display the entire study area within the window.

4. Use the **Zoom in** tool to see a close-up of your surfaces and the geometric relationship of those surfaces. These surfaces are modeled on all the formation picks made in the surrounding wells. The cross section displays a **True Space** mode by default, which allows you to see how these picks are projected throughout the area, and allows you to observe thickening and thinning relationships. This lets you actually see what the geology is doing between the wells.

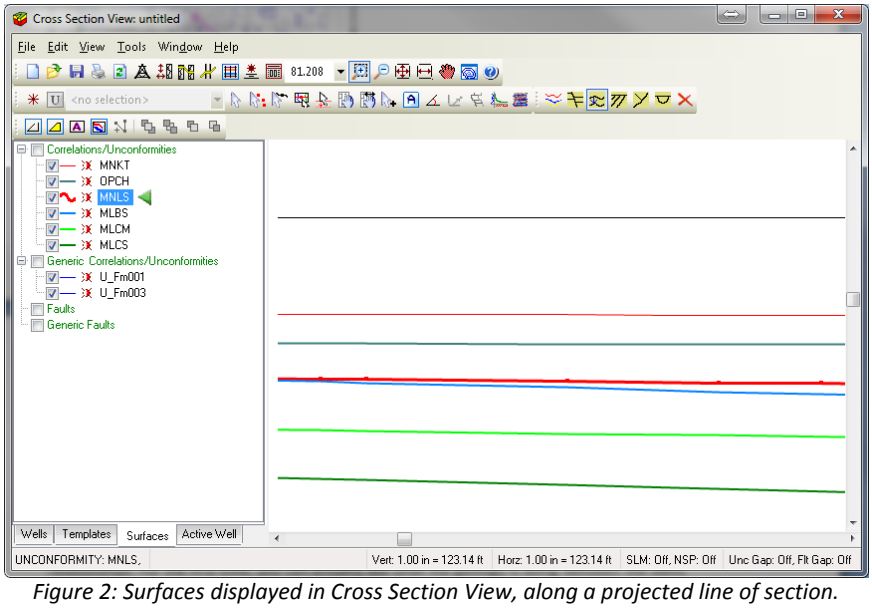

Figure 2: Surfaces displayed in Cross Section View, along a projected line of section.

Before putting wells on the cross section, notice the four tabs at the lower-left side of the **Cross Section View** window. These are the **Wells**, **Templates**, **Surfaces**, and **Active Well** tabs. Each tab, as described below, is useful when making cross sections.

The **Wells** tab lists the wells in the cross section and the location points (either latitude, longitude, or x, y values) used to select the projected line of section. The blue circles, or dots, denote these location points. If wells are loaded into the cross section, a list of unique well IDs is also displayed.

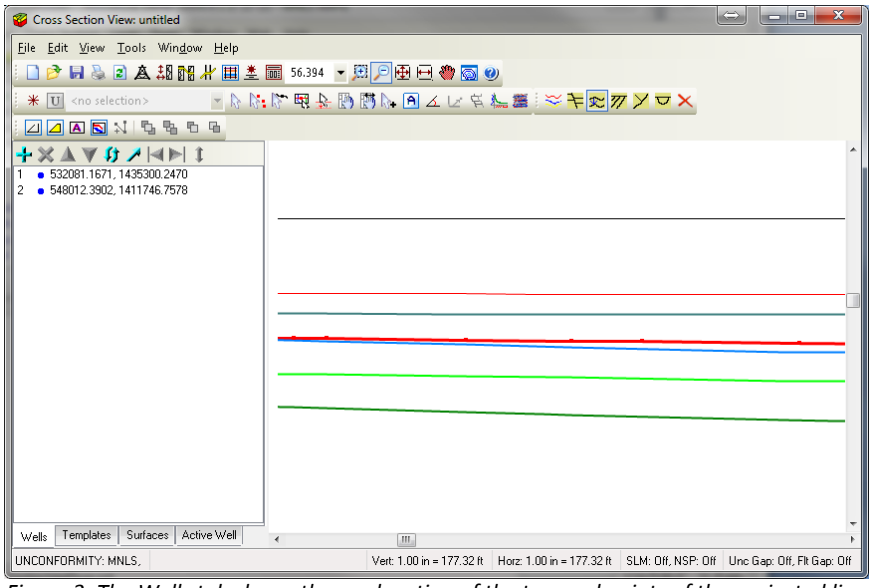

Figure 3: The Wells tab shows the x, y location of the two end points of the projected line of section.

- Click the [+] sign to select and add wells to the cross section from a list
- Delete wells by clicking the [X]
- Change the order of the wells by selecting the up and down arrows.

The **Template** tab lists the cross section templates. These templates enable you to quickly display all cross sections with a particular layout. The layout of a cross section includes the “look and feel” of the cross section, including the distance between the cross sections, whether the wells are displayed as straight wells or deviated wells, well-related header data, and surfaces with different colors. All these parameters, and much more, can be applied to any cross section by simply double-clicking the template name. Template creation is discussed below.

The **Surfaces** tab displays the list of the surfaces that were toggled on and modeled in the **GeoSurface Model Properties** dialog box, as well as any future new surfaces you choose to create. In this tab, you can select a surface, highlight it on your section, and even change the surface color and thickness by selecting it and then right-clicking and choosing **Display Properties**. You can also toggle the surfaces on and off. This list represents only the surfaces modeled in the **GeoSurface Model Properties** dialog box. If you want to add additional surfaces, you will have to go back to the **GeoSurface Model Properties** dialog box, and toggle additional surfaces on.

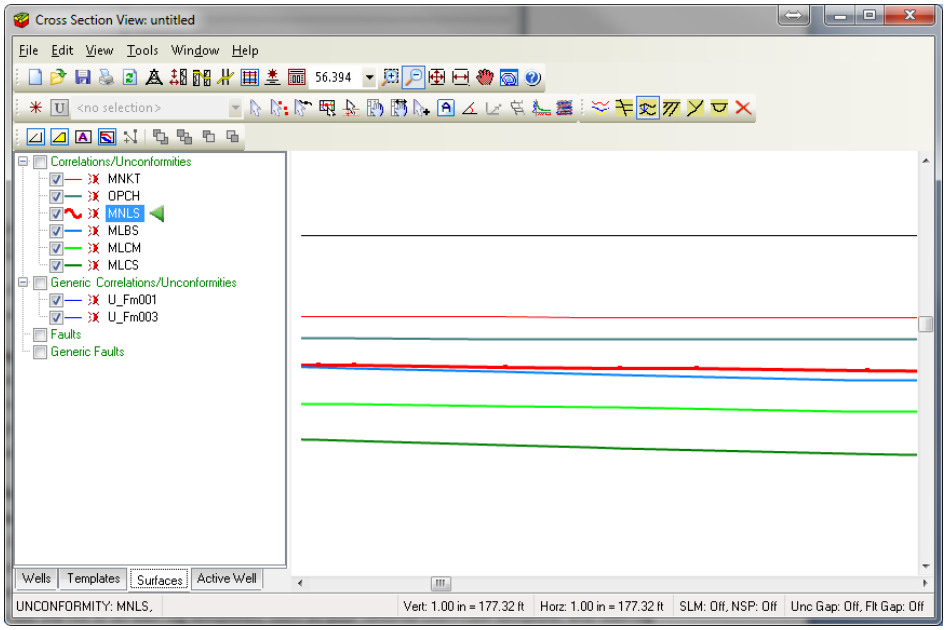

Figure 4: View of Cross Section with the Surfaces tab selected.

The **Active Well** tab enables you to instantly display and view a list of all Prizm well-log templates and raster well-log images available for a selected well. You can select any image, and/or raster well log template you wish to display, in your cross section. This tab is discussed below.

How to Add a Well from the Map View to the Line of Section

1. To add a well to the projected line of section, you must first activate the cross section by clicking the **Cross Section View** window, and then click a well symbol in **Map View**. It will either turn blue, or a drop-down menu will appear with a list of UWI numbers (if there is more than one well in that location, or if there are other objects on the map layer.)

2. If this happens, click the desired **Well ID** to specify which well to select. The well symbol will then turn cyan (blue).

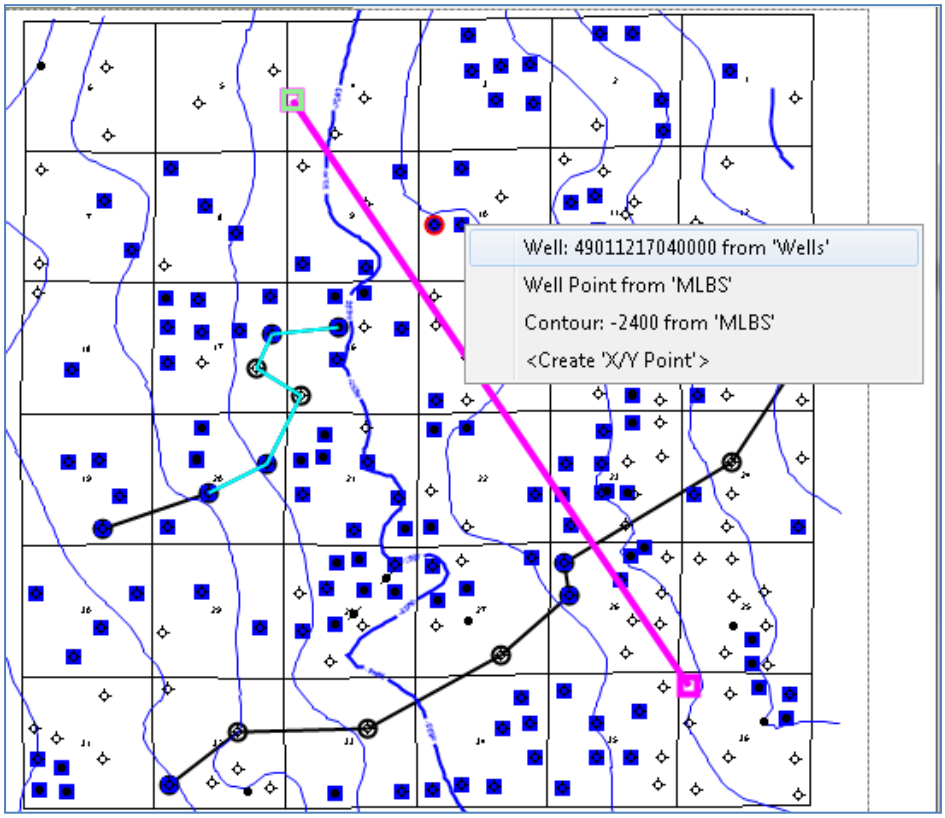

Figure 5: Drop-down menu in Map View showing well ID.

3. Right-click the well symbol, and select it's unique well ID number. The well symbol will turn blue indicating the well is selected. Right-click again and select **Add Well to Active Cross Section** from the shortcut menu.

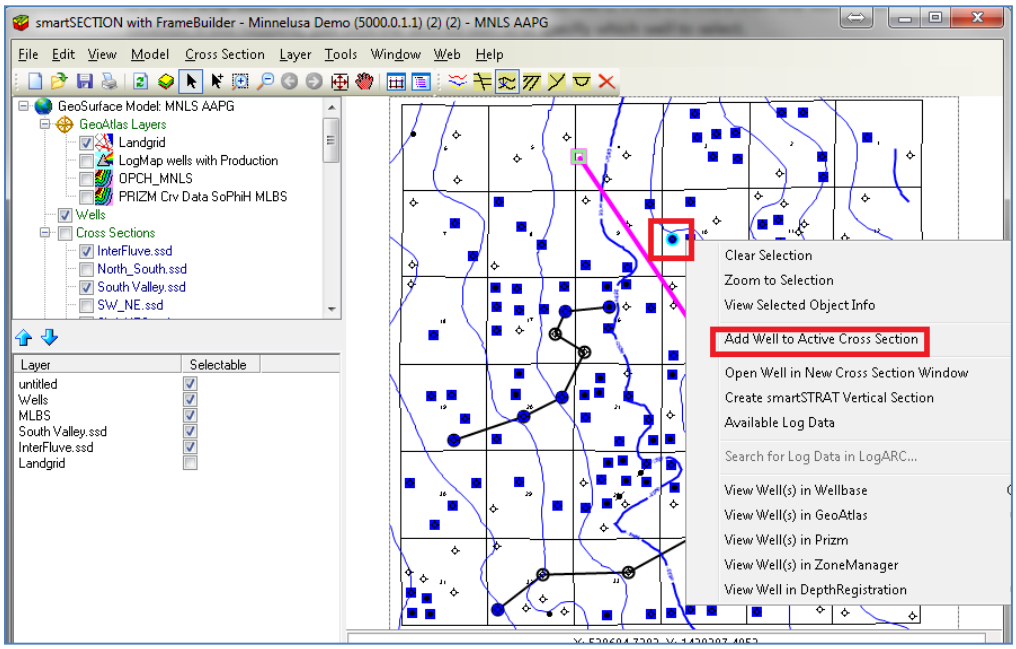

Figure 6: Add Well to Active Cross Section option in Cross Section View window.

Note: A red "stick figure" of the well instantly displays in the line of section.

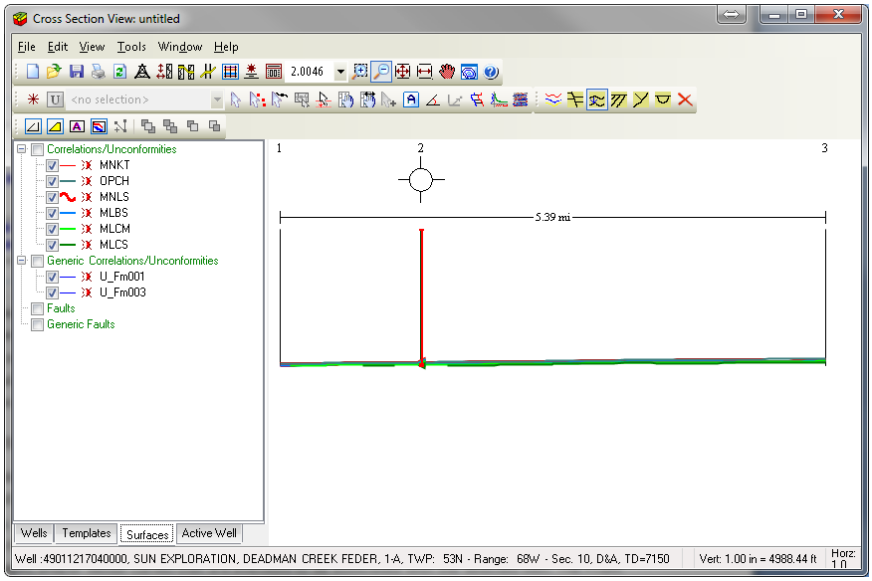

Figure 7: Projected line of section with stick figure of well and display of formation surfaces.

Note: In **Map View**, the well is orthogonally projected into the line of section.

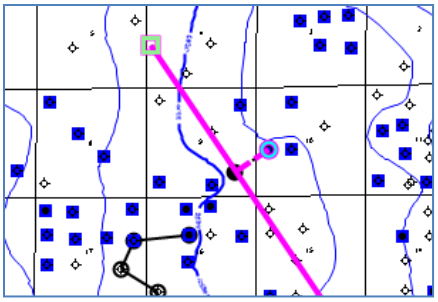

Figure 8: Close-up of Map View image showing well being projected into line of section.

If you know the regional strike and dip of the beds, you can move the point of projection anywhere on the line of section to correctly project the well along strike into your line of section. To do this, select the projection point, note the presence of a cross hair, and move the point up and down along the line of section. The well will automatically re-display on the cross section in the new location.

Choosing a Well Log template to Display the Well Log

When a well is first projected into the cross section, it will project as a stick figure if you do not have a cross section template. To see a list of what well log images and well log templates are available for display:

1. Select the well using the **Select** tool. The well borehole turns red.
2. Select the **Active Well** tab. The **Active Well** tab displays a list of Prizm well-log templates (both raster and vector log templates), raster well-log images, and/or vector curves that are available to be associated with the selected well.
3. Access the PRT list by clicking the plus sign adjacent to **PRT Template**.

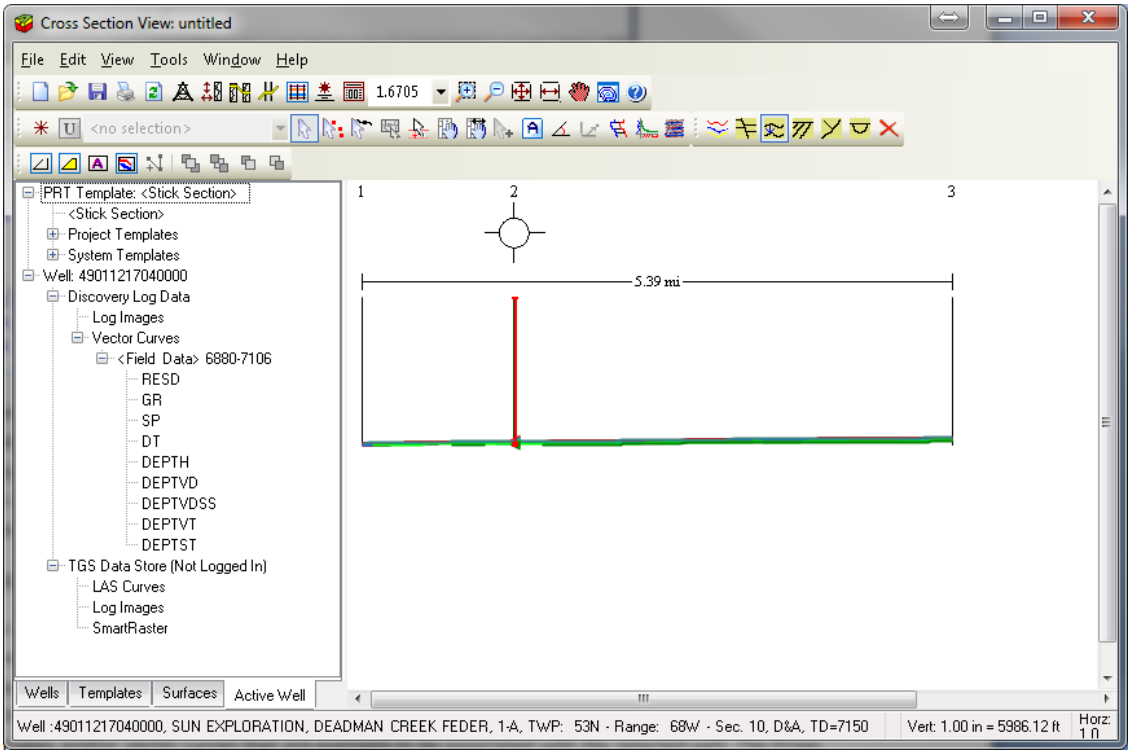

Figure 9: Active Well Tab on the left, displaying different vector log curves associated with the selected well (red).

Note: The Prizm templates are in the **Project** folder, and the pre-made raster templates are in the **Systems** folder. After you create and save your own raster templates, those will be placed in the **Project** folder. To display newly created templates in this list, select the **View > Refresh all Views** menu option in the Cross Section window.

4. To select a PRT, or well-log template, click the template name (a vector template in the following example), right-click, and select **Apply as Default Log** template. This will apply the selected template to all wells in the Cross Section. To apply a different template to each well, select **Apply to Active Well** only. The template will be applied to the well, and the log will display.

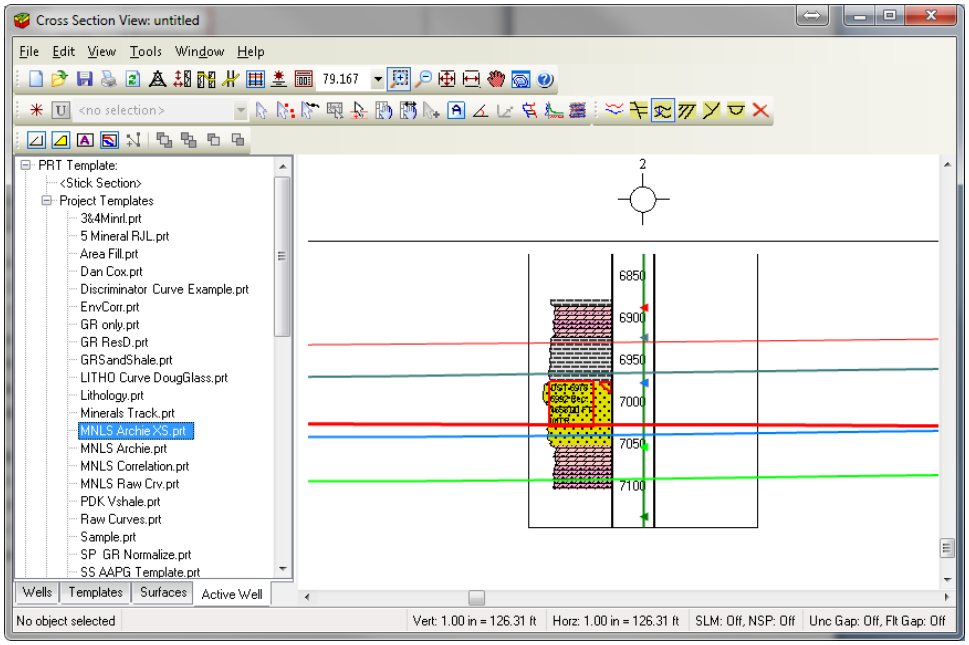

Figure 10: Well log template selected in Active Wells tab and displayed in Cross Section View.

Well log templates can also be selected from the **Wells/Logs** tab, accessed by selecting the **Wells/Logs** tool. To do this:

1. Click the **Wells/Logs** tool to open the **Wells/Logs** tab.

2. Click [Select] to access the available Prizm templates for all the wells, or select a specific well in the **Well List** and then click [Select] to select an alternate template for a specific well.

3. Click [OK]. The new template(s) are displayed.

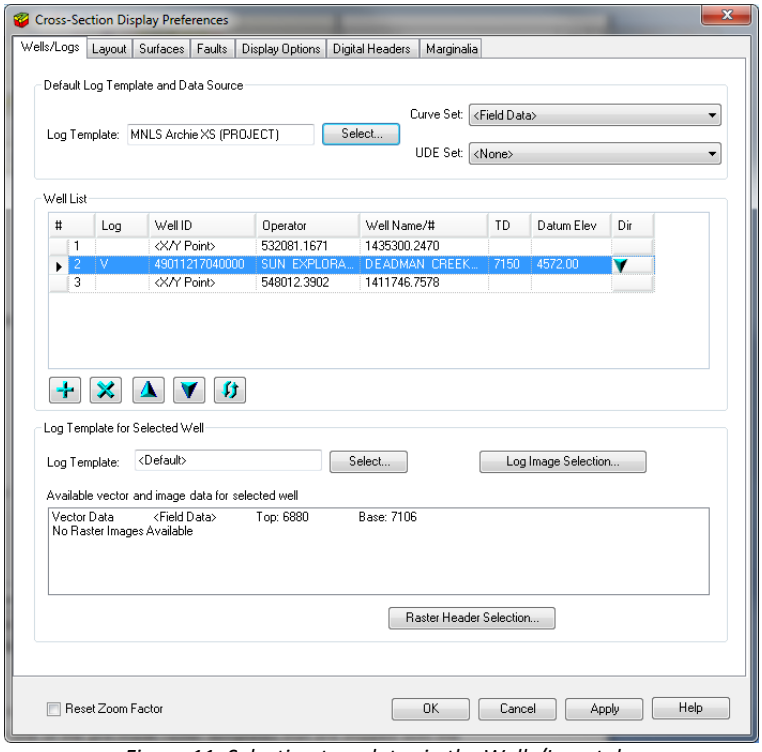

Figure 11: Selecting templates in the Wells/Logs tab.

Note: "Raster" templates originally built for use in **XSection**, will not work in **smartSECTION**. You must use either one of the pre-made raster templates that are shipped with the software, or make a new raster template in Prizm. However, vector logs previously made in Prizm will work.

Using the Display Preferences tabs to Create the "Look and Feel" of a Cross Section Template

After you have selected your wells and displayed your well-log images or vector templates, you can focus on what other display characteristics you wish to see in the cross section. You can save these features to a cross section template. You can then apply the cross section template to display new cross sections. To access the cross section templates, select the **Templates** tab and double-click the desired template.

You can control the following features in your cross section, and make a cross section template:

1. Select the **Wells/Logs** tab to select the "well-log" template to apply to each well. You can also use the **Active Well** tab as discussed above.

2. Select the **Layout** tab to establish features such as the cross sections scales and spacing to be used. In the following image, the **Projected** and **Straight wells in TVD** options are selected in the **Layout** tab. There is a scale of **1 inch = 100 feet**. In addition, you can clip the wells to focus on, and display only a small portion of the entire well log. You also have the option of selecting a **proportionally-spaced** cross section. If you had made a **Well-to-Well** cross section, you would be able to select the **Equally Spaced** option for the horizontal layout of the wells.

Note: This option is not enabled for a projected line of section since a projected cross section, by definition, shows the actual relative position of the wells.

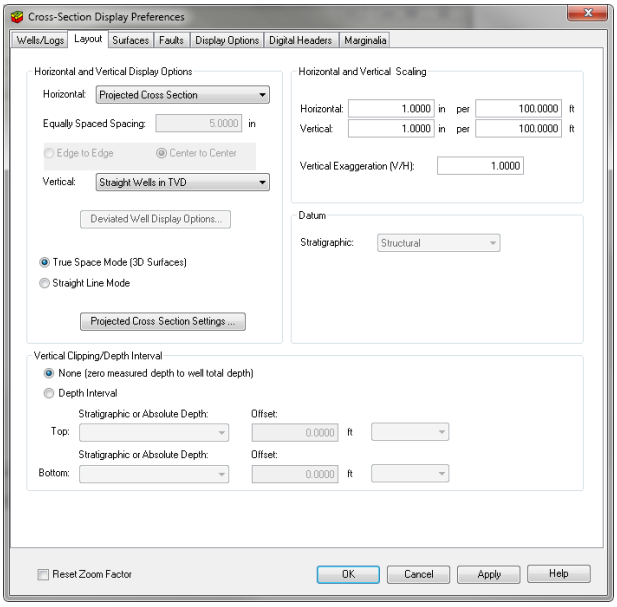

Figure 12: The Layout tab for a projected line of section.

3. Select the **Surfaces** tab, which lists all the surfaces that were selected and modeled in the **GeoSurface Model Properties** tool.

   Note: You can click [Posting Properties] and turn on various annotations to be placed on the formation correlation lines. You can also create color-fills between formation tops. Colors and line thicknesses can also be edited.

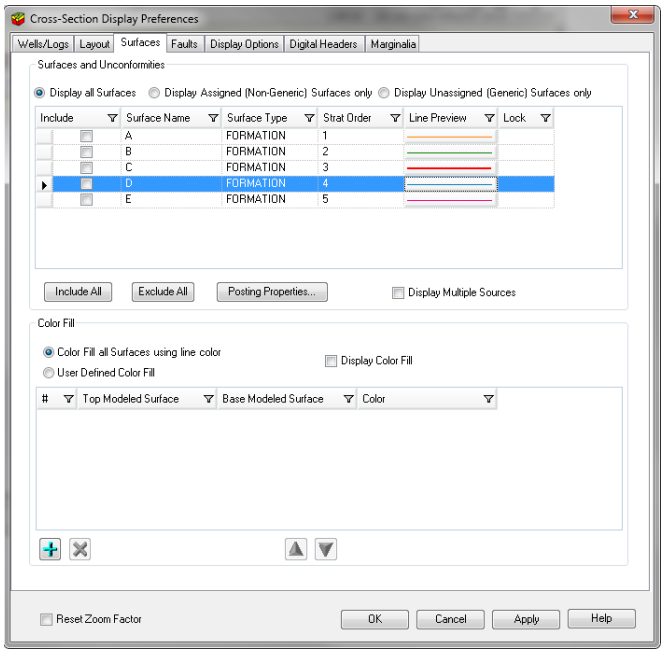

Figure 13: Formations listed in the Surfaces tab.

4. The **Faults** tab is similar to the **Surfaces** tab; however, it enables you to control the colors and postings associated with the faults.

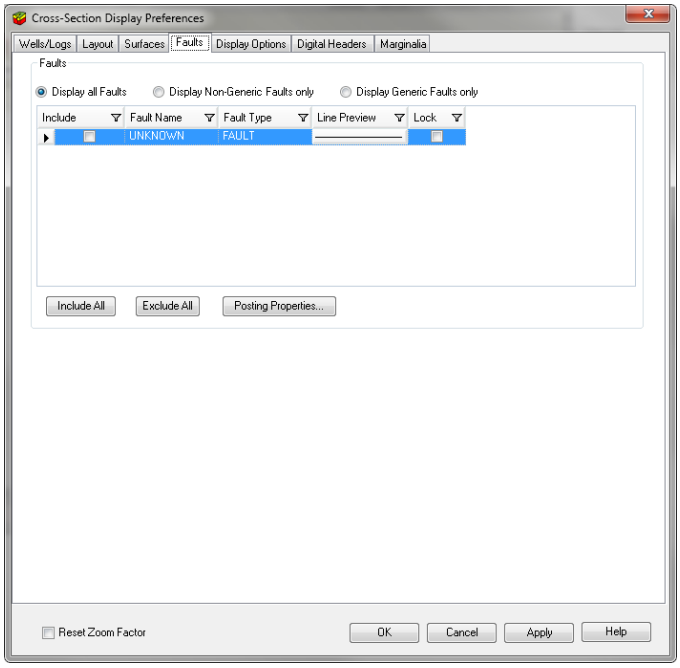

Figure 14: The Display Preferences Faults tab.

5. The **Display Options** tab enables you to display "intervals" that have been picked on a well, and lets you change other items like the grids associated with vector log templates, the color of the borehole, and other display features.

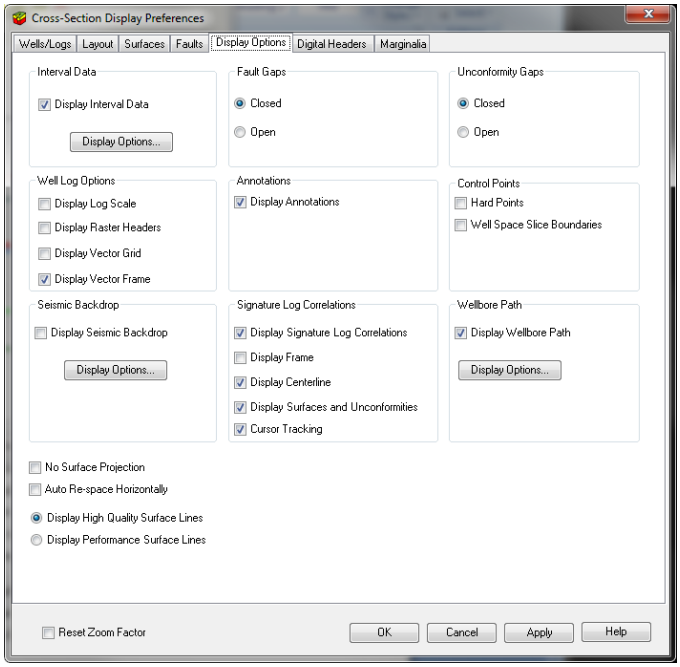

Figure 15: The Display Options tab.

6. The **Digital Headers** tab enables you to specify what well-related annotations are to be placed at the top and or bottom of the well log image. For example, you can choose to post the **Well ID**, and **TD** at the top of the well.

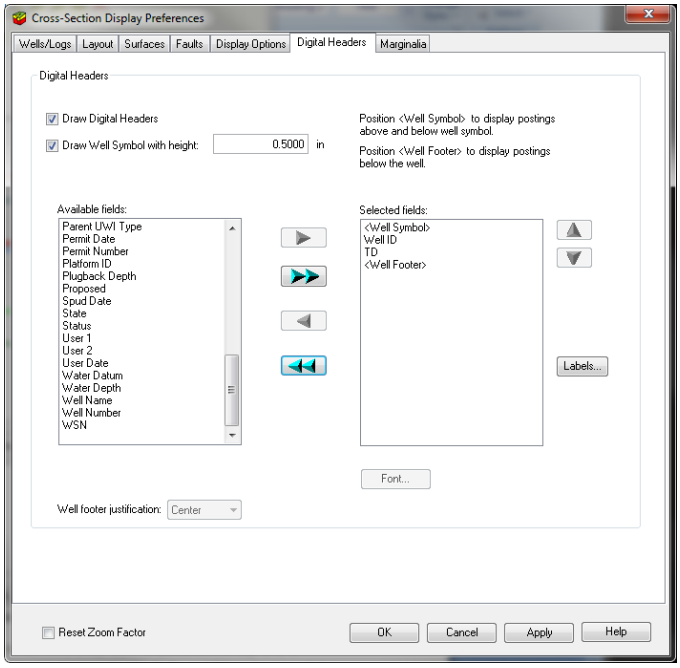

Figure 16: The Digital Headers tab.

7. Finally, the **Marginalia** tab enables you to post vertical and horizontal scales and grids on the overall cross section.

Saving a Cross Section Template

1. After you have determined how you want the cross section to look, by selecting the various options in the **Display Preferences** tabs, click [OK] to apply all the parameters in the various **Display Preferences** tabs.

2. Save the cross section template to include all these features by selecting **File > Save As Template**. The templates will then be automatically listed in the **Templates** tab, in the lower left-hand corner of each cross section window. Label the templates with a name indicative of what you will see and when you will use it. For example, this template is named the "projected straight-hole TVD" template. If you were to go back to the **Layout** tab and select **Deviated WellBore Path**, you could save it as "projected deviated well MD."

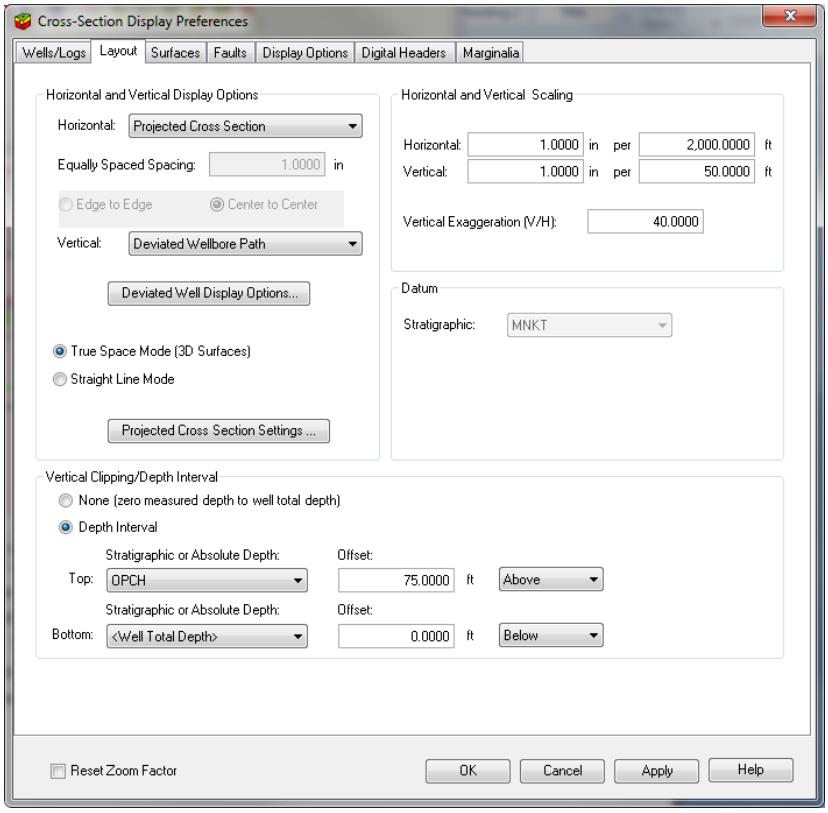

Figure 17: Layout options for a Deviated Well template.

3. The next time you open a new cross section, double-click the desired template in the **Templates** tab and the cross section will contain all the saved attributes from the various tabs.

   Note: This is a tremendous way to save time, so it is well worth the effort to save templates as you create new displays.

Building a Well-to-Well Cross Section

To build a classic well-to-well cross section:

1. Return to the **smartSECTION Map View** window and select **Cross Section > Well to Well**.

2. Click the symbol for each well that you want to include in the cross section. A magenta-colored line is drawn from one well to the next. If there are multiple wells, and/or map objects at the site of the well symbol, a small menu will open and list the well IDs for the symbol.

3. Click on the name of the well you wish to include, and then click the blue well symbol.

4. When you reach the last well, double-click it or right-click it and select **End Definition**. A new cross section window is displayed.

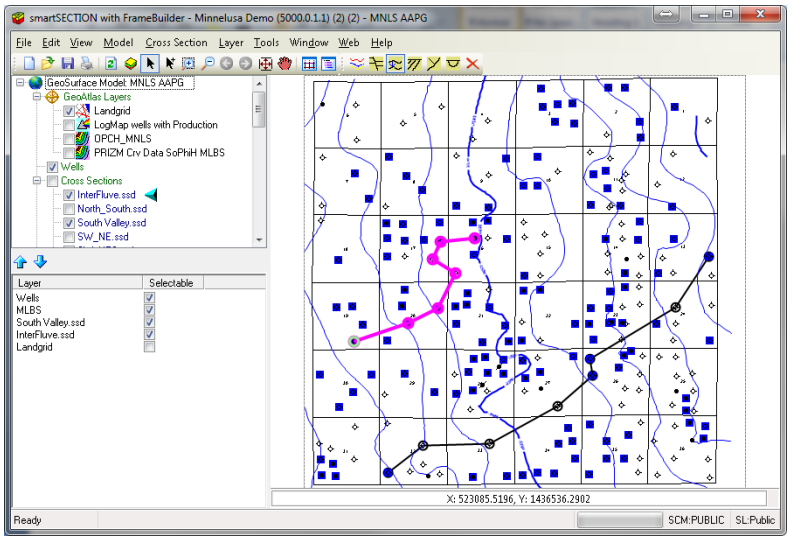

Figure 18: Map View with well-to-well line of section.

5. Select the **Layout** tab. The **Horizontal** option, in the **Horizontal and Vertical Display Options** group, has been set as **Equally Spaced Wells**. It is best to place the wells **Edge to Edge**, at about 0.5 to 1 inch apart, to display them right next to each other. This lets you compare the curves easily. You can name this template “well-to-well equally spaced” or even “ideal correlation template.”

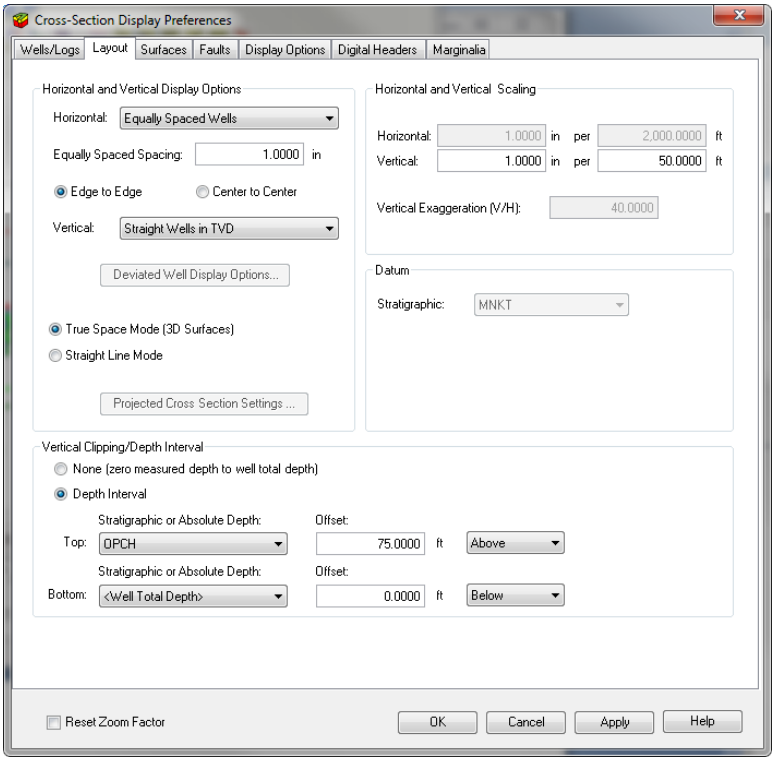

Figure 19: Layout tab depicting parameters for a well-to-well cross section.

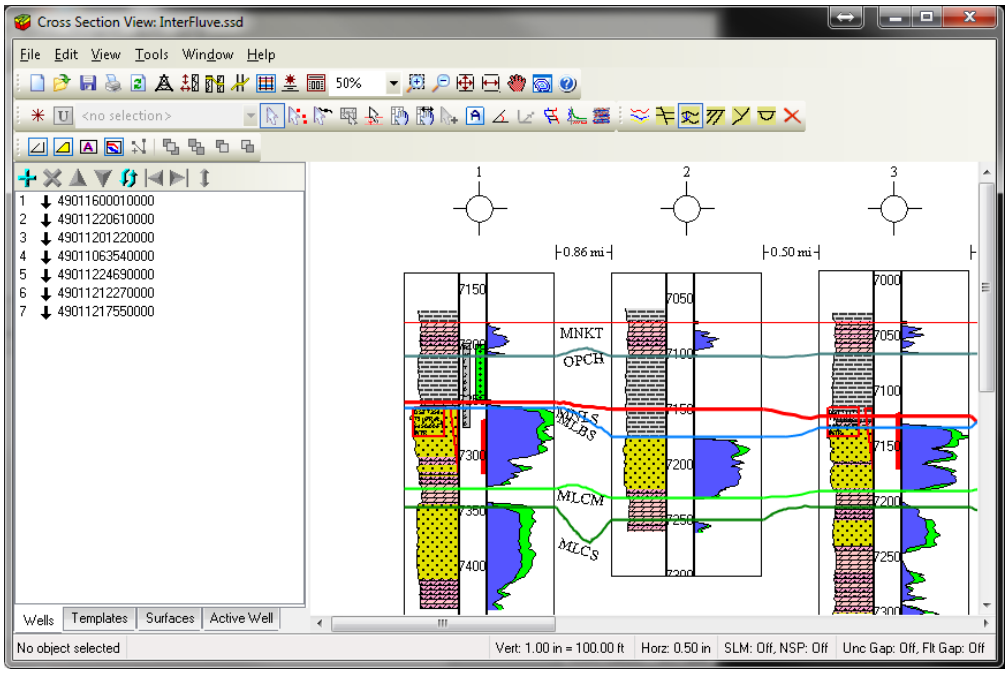

Figure 20: Example of well-to-well, equally spaced cross section with vector log templates.

Note: You can also select the **Layout** tab, and select the **Proportionally Spaced** option. This displays the wells in their correct spatial relationship.

Observing the Differences between Projected and Well-to-Well Cross Sections

There are a few notable differences between a "projected line of section" and a "well-to-well" cross section. On a projected line of section, when you display your surfaces, and select one of the surfaces with the **Select**  tool, you will note a small color-filled or hollow, sideways triangle on the well log image. A solid triangle means that there was a pick made on that well. This is the pick or formation top that is stored in **WellBase**. This pick was either interpreted by the geologist, or imported from some external source. A hollow triangle represents where the surface is estimated (by the smartSECTION 3D geologic model) to intersect the well at the well's location.

If the well is far away from the line of section, and the stratigraphy is not layer cake, the surface associated with the triangle picks will not intersect the equivalent location of that pick on the well. Instead, the surface will be either down-dip or up-dip from the pick on the line of section. The triangle-shaped symbol is a reminder to the geologist that the pick is not on the line of section, but rather picked at the site of the well; the well may be close or far away. The closer the well is to the line of section, the closer the depth of the surface will be to the pick. Just because the pick does not coincide with the surface's position, this does not indicate that the surface or the pick is incorrect.

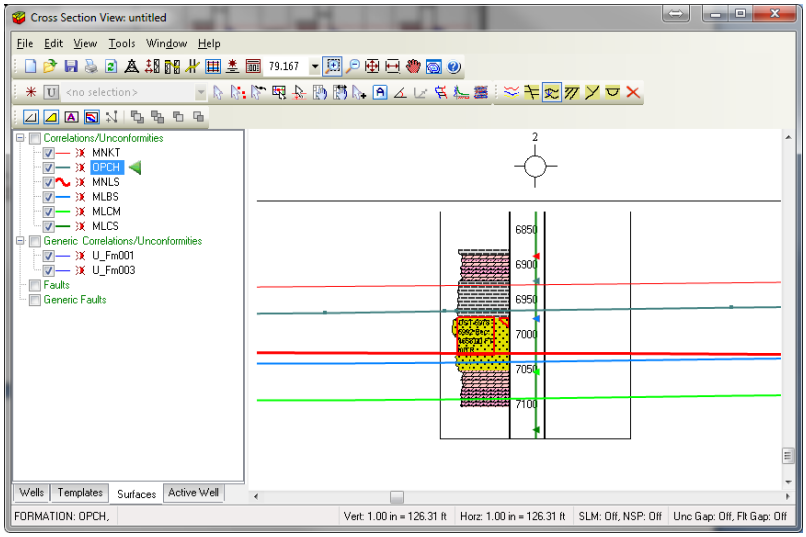

Figure 21: Projected cross section, showing example of the sideways triangular-shaped picks on the wellbore (green line). Picks are not coincident with the position of the surfaces, in the line of section. This indicates that the well is projected at quite a distance, or there is significant dip in the stratal geometry of the area.

In contrast, a cross section that is defined as a well-to-well cross section will display a solid or hollow square at the well site, intersecting the well's borehole (green line). This square represents the formation pick made on the well log itself. A square means the well-log image is on a well-to-well cross section, meaning the cross section is going through the actual site of the wellbore. The square will either be hollow (meaning it is an estimated location made by the 3D model) or solid (meaning the pick was made by the geologist). In the case of the well-to-well cross section, the pick and the surface will always be superimposed since the pick and the surface are in the same location. It is on the well-to-well cross sections that you can always feel safe picking your formation tops, as they will automatically be stored in **WellBase**.

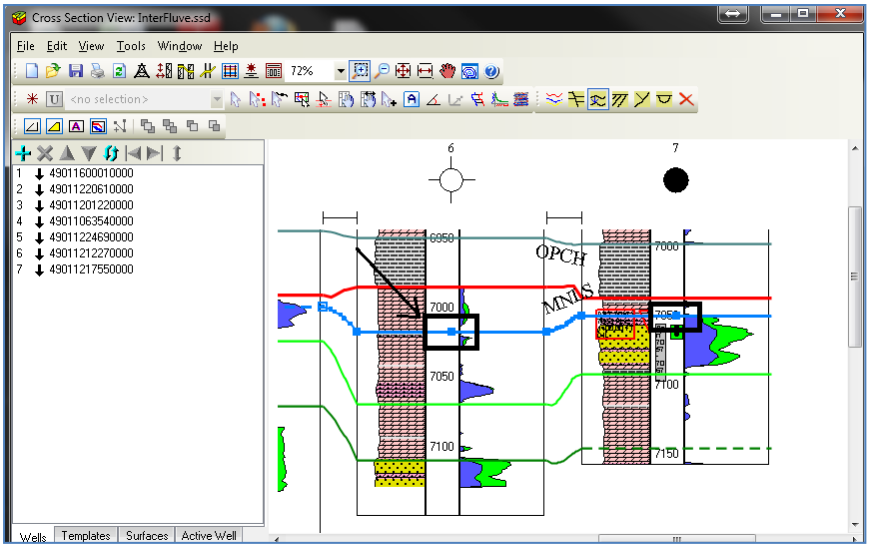

Figure 22: Well-to-well cross section depicting solid squares that show the position of the formation pick at the site of the well. Notice the formation surface goes through the well pick.

How to Pick a Formation Top and Extend the Formation's Surface across the Study Area

smartSECTION enables you to quickly and easily pick formation tops. It is best to pick tops, for the reasons cited above, on "well-to-well' cross sections. This way you are assured of automatically storing that top in the **WellBase Formations** tab, and of picking the top at the true site of the well, namely on the well log borehole position.

To pick an existing formation top:

1. Select the **Surfaces** tab in the cross section, and select the specific formation top to be picked. A green arrow will display next to the formation name, and the surface will become active in the cross section. A square will appear on the formation pick on each well already interpreted. In the example below, the **OPCH** formation is selected in the **Surfaces** tab. Note the green square on well #3, coincident with the green **OPCH** surface line.

2. After the surface is selected, select the **Add Surface Points**  tool. The cursor will change into the **PICKER** tool. Click the cursor at the desired spot on the un-interpreted well. A new formation pick will be added to that well, and the surface will be projected.

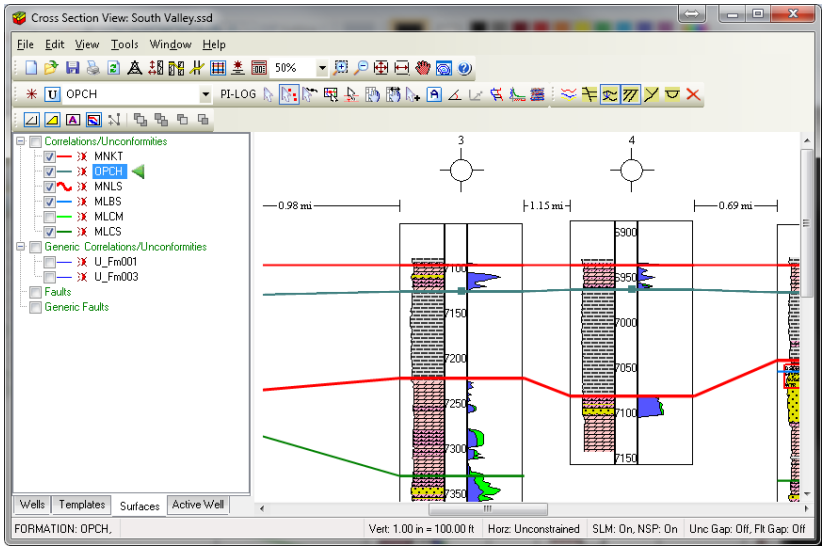

Figure 23: Note the green arrow pointing to the OPCH formation, and the solid square where the OPCH (dark green) surface intersects the well bores. The green arrow and the squares on the green line indicate the OPCH surface is active and ready to be picked.

3. To move or delete the surface, press the <Tab> key to exit "picking" mode and enter "select" mode. In "select" mode you can select the surface and move it up or down, or select the pick and delete it by pressing <Delete>. To proceed with the next correlation, you can press <Tab> again, re-enter the "picking" mode, or click the **Add Surface Points** tool again. The <Tab> key is more efficient and creates a smoother workflow.

   Note: You can select the surface, and press <Spacebar> to hang the wells stratigraphically, or press <Ctrl> + <Spacebar> to hang the cross section structurally.

4. You can also easily move the well logs closer to each other for better correlation by clicking a well and dragging it, or by using the **Log Slipping** tool to move the well log up and down with relation to the well next to it.

Display Modes

There are three display modes you can use to display new and old surfaces: **True Space Mode**, **Straight-Line Mode**, and **No Surface Projection**. You can access these by right-clicking anywhere on the cross section, and then selecting **Draw Modes**.

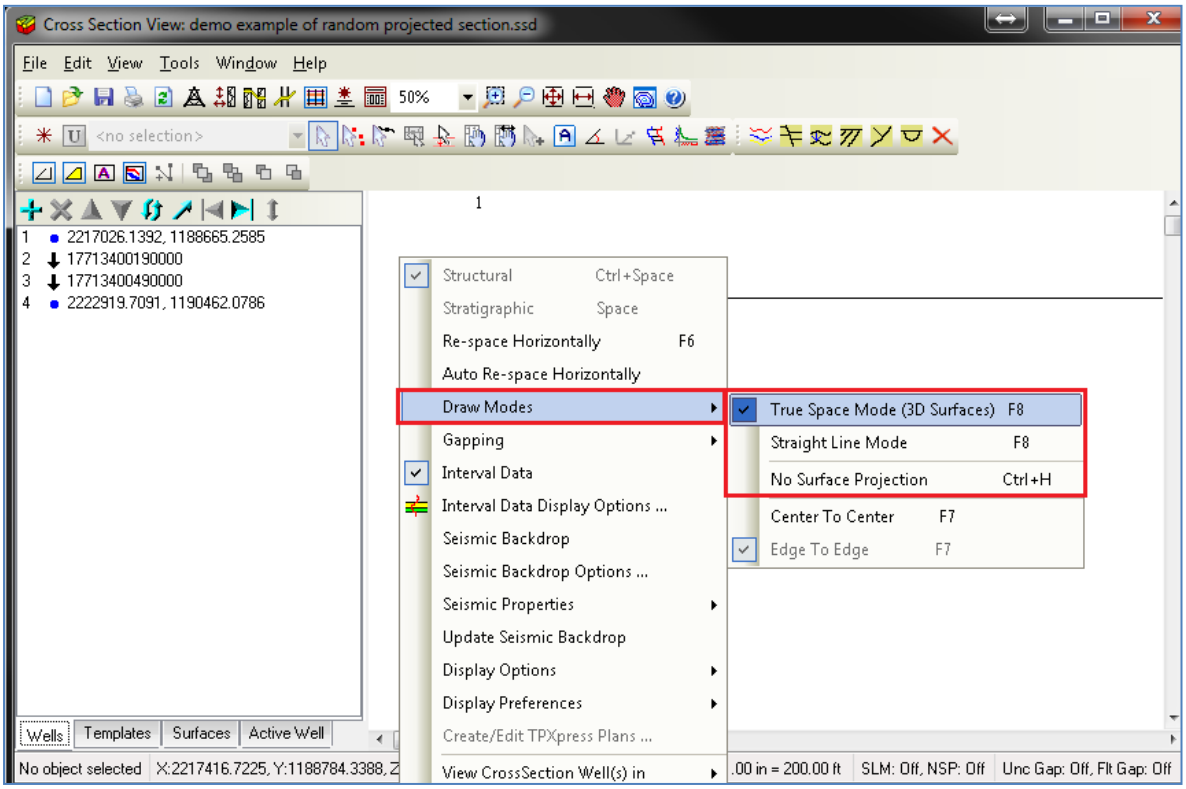

Figure 24: How to access various "Draw Modes".

- If you want a traditional straight line to connect the picks on the wells, select **Straight-Line Mode**.
- However, if you want to see the real stratal geometries between the wells, based on the information from the surrounding well picks, select **True Space Mode**. For most users, it is easiest to correlate in **Straight Line Mode**, but after they make their correlations they like to return to **True Space Mode** to see the true stratigraphy of the region.
- If you are in a projected line of section, you must project your surfaces to see them.
- However, if you are simply correlating your surfaces and only wish to see your picks and no projected lines, estimating the position of that surface on the next well, select the **Draw Modes > No Surface Projection** option. That will only show lines connecting your picks.
- Please note there is a separate white paper on all the details of these three modes. It is highly recommend you read that document to fully understand when each is appropriate to use.

Conclusion

This document covers all the early phases of building cross sections in smartSECTION, and enables you to establish the basics of correlation. Many additional tools are available for the display and interpretation of faults, channels, unconformities, and other geological displays.