5.0 Extended Features of VSP

VSP has many extended features that will be discussed in this section. The beginning user may not need these features, but a more experienced user will find them invaluable. These features expand on VSP's core capabilities. They are useful once a user has identified a basic sampling design and now wants to explore variations of the design, explore features of the design that are not part of the initial selection parameters, and add more capability to VSP.

The extended features fall into three categories:

- Features found in Main Menu items: **Tools**, **Options**, and **View**,
- Features found in the Dialog Box for individual sampling designs, e.g., the **Costs Tab**, and the **Data Analysis Tab,** and
- Multiple Areas to be Sampled

5.1 Tools

5.1.1 Largest Unsampled Spot

If VSP has generated a sampling design for a Sample Area and you want to know the largest unsampled area, VSP can display this information. The largest unsampled spot is defined as the largest circle that will fit inside a Sample Area without overlapping a sample point.

In Figure 5.1, we opened the VSP Project File *Example1.vsp* included with the standard VSP installation. From the Main Menu we select **Tools > Largest Unsampled Spot > Find.** A dialog box shown in Figure 5.1 in the insert tells you that VSP will search the Sample Area to find the largest circle that would fit into the unsampled area. The user is given the option of specifying the accuracy of the circle's radius, whether to consider area corners as additional sample points, and whether to allow the spot to overlap the Sample Area. After hitting the **OK** button, VSP searches the Sample Area, and places the spot on the Map, and displays an Information Box that says the radius of this circle is **205.22 ft**. (see Figure 5.2).

Two other displays are available: **Show Size** and **Inside Area.** The **Show Size** displays the Information Box shown in Figure 5.2. **Inside Are**a brings up the Information Box shown in Figure 5.3. It says that 100% of the circle is within the Sample Area. If the option to allow the largest unsampled spot to overlap the Sample Area edges had been selected, there may be situations where the circle extends beyond the boundary of the Sample Area resulting in a percentage less than 100%.

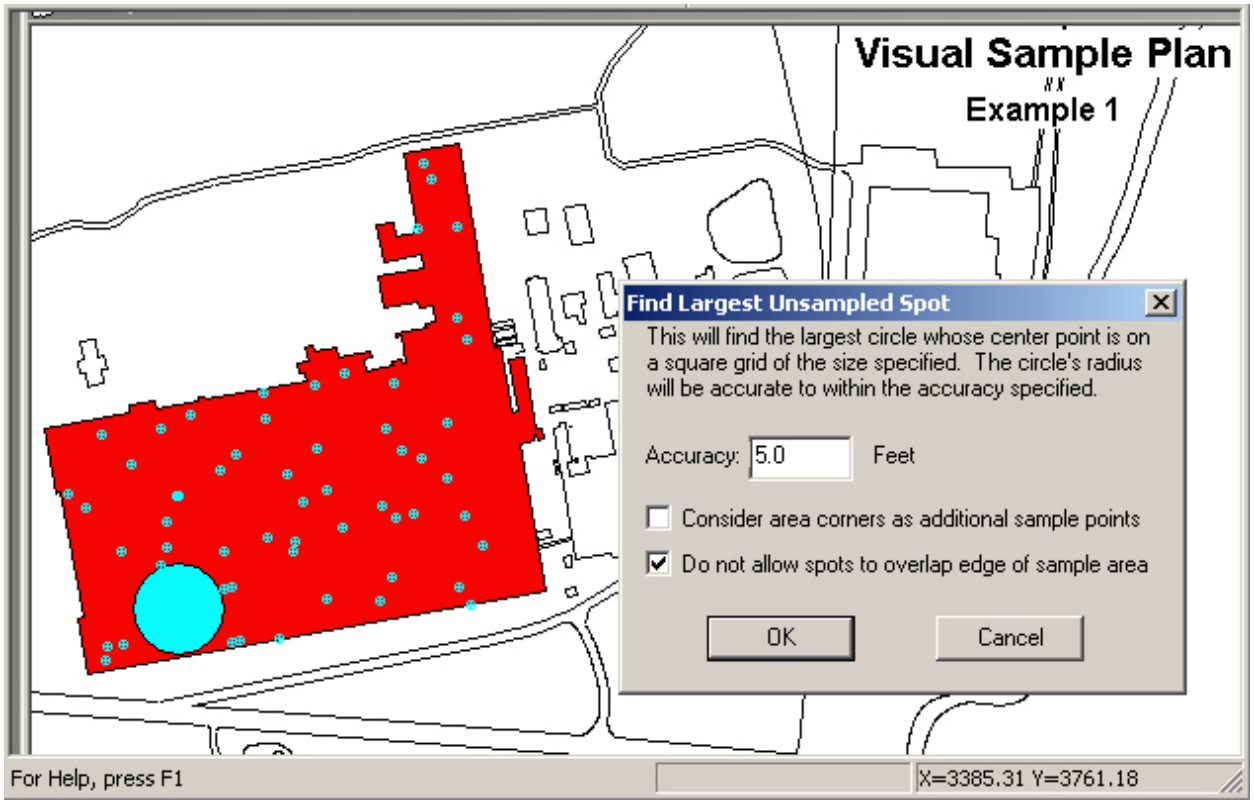


Figure 5.1. Largest Unsampled Spot Displayed on Map

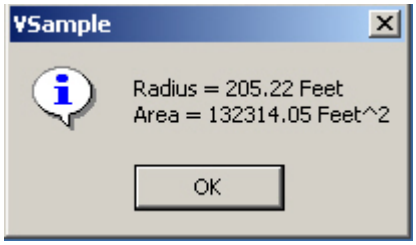


Figure 5.3. Information Box for Largest Circle That Would Fit Within an Unsampled Area

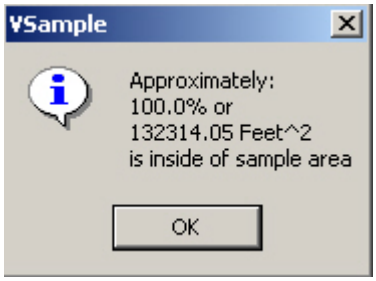


Figure 5.2. Information Box Showing Percentage of Circle Within the Sample Area

5.1.2 Reset Sampling Design

This command clears the current sampling design and removes all samples from the map (including unselected sample areas).

5.1.3 Measure Distance

Use this tool to measure distances on the map. After selecting this command, the cursor will become a ruler. Click on the map or enter a location (x, y) on the keyboard to anchor the first point. A line will be

drawn from the anchor point to the cursor as you move the mouse. The status bar will also indicate the distance from the anchor point to the cursor. After clicking on a second point or entering a second point on the keyboard, a dialog will appear displaying the distance. In Figure 5.4, we see that the distance from the sampling point to the building edge is **547.33 ft**.

Hold the Shift key down to attach either point to an existing point on the map.

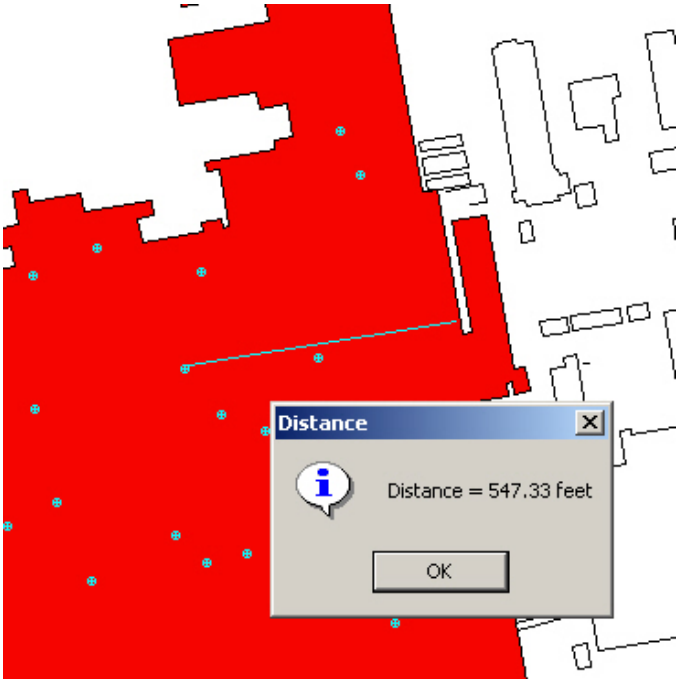


Figure 5.4. Measuring Tool in VSP

5.1.4 Make Sample Labels

Individual samples can have labels and values associated with them. This tool lets the user design the sample label. Selecting **Tools** > **Make Sample Labels** brings up the Dialog Box shown in Figure 5.5. VSP assumes the user will want to assign a unique number to each sample within a Map, so all labels start with "VSP-<NNN>". Other information can be added to the label, such as the Local X Coordinate and Local Y Coordinate as shown in Figure 5.5, by selecting the information variable names on the list and hitting the **Add** button. (The information can also be added by double-clicking on the list item or by typing in the label format edit box.) Once the **OK** button is pushed, the user sees the current set of Sample Labels in Map View.

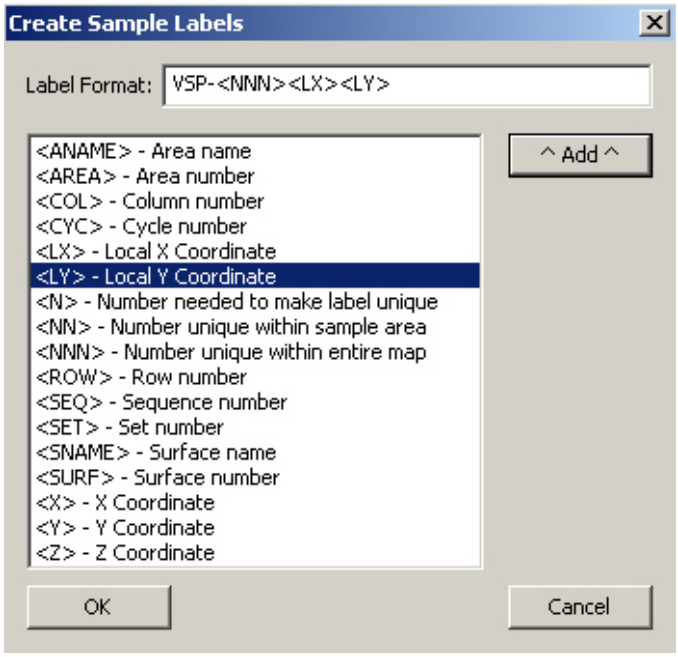


Figure 5.5. Dialog Box for Creating Sample Labels

Sample labels are discussed in Section 2.4

5.2 Options

5.2.1 Random Numbers

VSP allows the user two options when selecting how random numbers are generated. The random numbers are used to pick coordinates for sampling locations when the design calls for either a random-start grid or random placement of all points. The user selects the desired random number generator using **Options** > **Random Numbers** from the Main Menu. The two options are **Pseudo-Random Numbers** and **Quasi-Random Numbers.** The user "toggles" between these two options. This is shown in Figure 5.6. Note that once an option is selected, it remains active until changed. VSP is initialized with the **Pseudo-Random Numbers** option active.

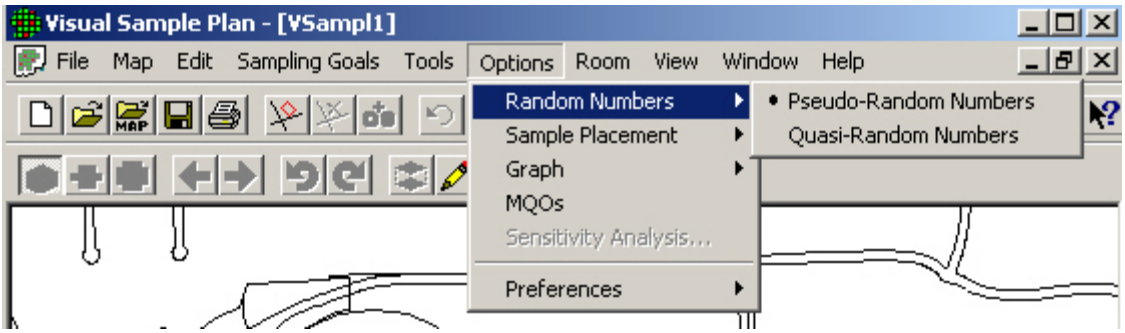


Figure 5.6. Menu for Selecting Type of Random Number Generator

Sampling locations (i.e., the x and y coordinates of the location) chosen with a pseudo-random number generator are not restricted in any way. The first location chosen and the tenth location chosen can be right next to each other or far apart, like throwing darts at a dart board. The locations where the darts hit can be clumped together or spread out, depending on chance.

Quasi-random numbers are generated in pairs. One member of the pair is used for the X coordinate; the other member is used for the Y coordinate. The sequence of paired numbers is generated in such a way that sample points tend to be spread evenly over a sample area. VSP's quasi-random-number generator uses Halton's Sequence. For a discussion of the algorithms used for both the pseudo- and the quasi-random number generator, see *Version 2.0 Visual Sample Plan (VSP) Models and Code Verification* (Gilbert et al. 2002).

If the current sampling design is being added to a study area with existing sampling locations, the quasi--random number generator will have no knowledge of those locations and might by chance put a new sampling location right next to an existing location. See the **Adaptive-Fill** option in Section 5.2.2 to handle the problem of avoiding existing sampling locations.

5.2.2 Sample Placement

The Adaptive-Fill option allows the addition of "random" sampling locations in such a way as to avoid existing sampling locations. Adaptive Fill has to do with the placement of the sampling locations, not the number of samples. The basic idea is to place new sampling locations so as to avoid existing locations and still randomly fill the Sample Area. The current Sampling Design option determines the number of locations.

VSP usually places new sampling locations using the default option, **Options > Sample Placement > Regular Random**. When Regular Random is selected, the sampling locations produced by either of the two random number generators discussed in Section 5.2.1 are placed in the Sample Area without regard to pre-existing samples. In fact, VSP removes all previous sampling locations prior to placing the new set of sampling locations.

When the **Options > Sample Placement > Adaptive-Fill** option is selected, all pre-existing sampling locations are left in place, and new sampling locations are placed in the Sample Area using an algorithm to maximally avoid preexisting sampling locations. The Adaptive-Fill algorithm can be used with either random number generator. The Adaptive-Fill option is shown in Figure 5.7.

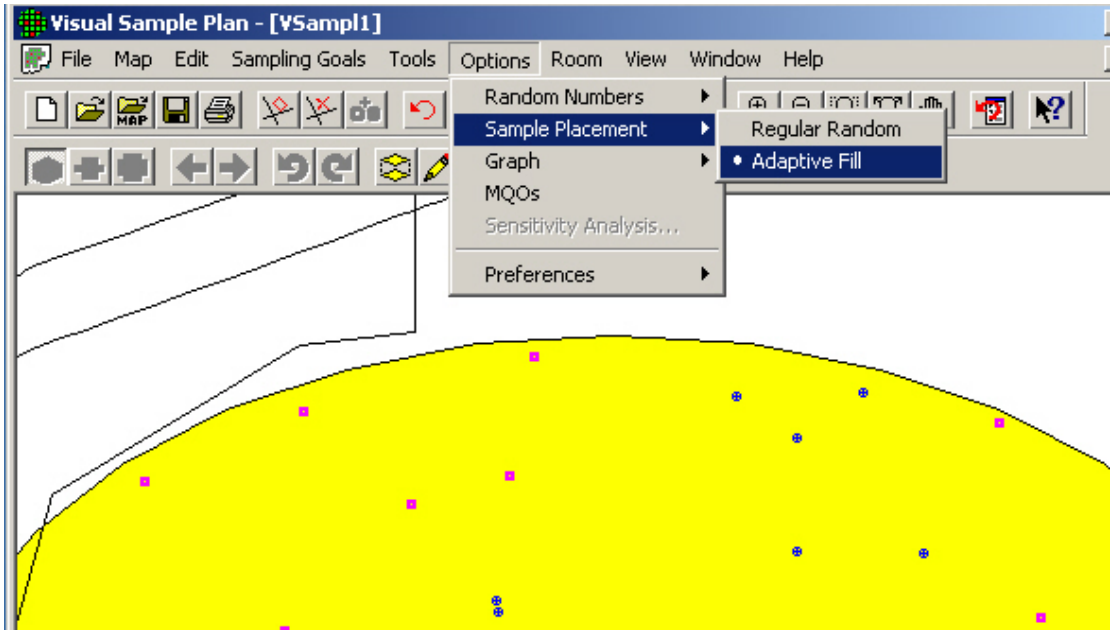


Figure 5.7. Adaptive-Fill Option for Sample Placement (Shown Here with Sample Area from Millsite Map)

Note that in Figure 5.7 the original sampling locations are marked with a circular symbol. In contrast, the Adaptive-Fill sampling locations are marked with a square symbol. If you right-click on a sampling-location symbol, a Sample Information dialog will display the type of sample, the coordinates, and a label input field. The label input field allows a specific sampling location to be given an ID number or remark.

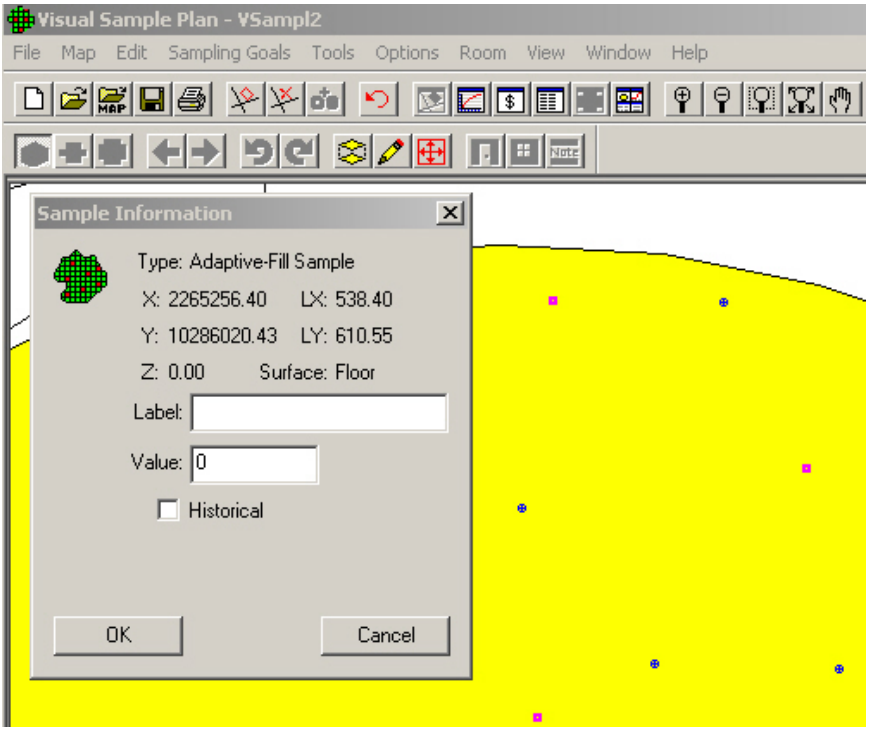


Figure 5.8. Sample Information Window Displayed When the User Right-Clicks on Selected Sample Points on Map

The label information is displayed in the Sample Information dialog, the report view, and the coordinate view. The label is also exported along with other sample information when exported to a text file (see Figure 5.9). See Figure 5.8 for an example of right-clicking on an Adaptive-Fill sampling location.

If the sampling locations are exported to a text file using **Map > Sample Points > Export**, an Adaptive-Fill location will be noted and any label the user might have added will be saved. An example text file is shown in Figure 5.9.

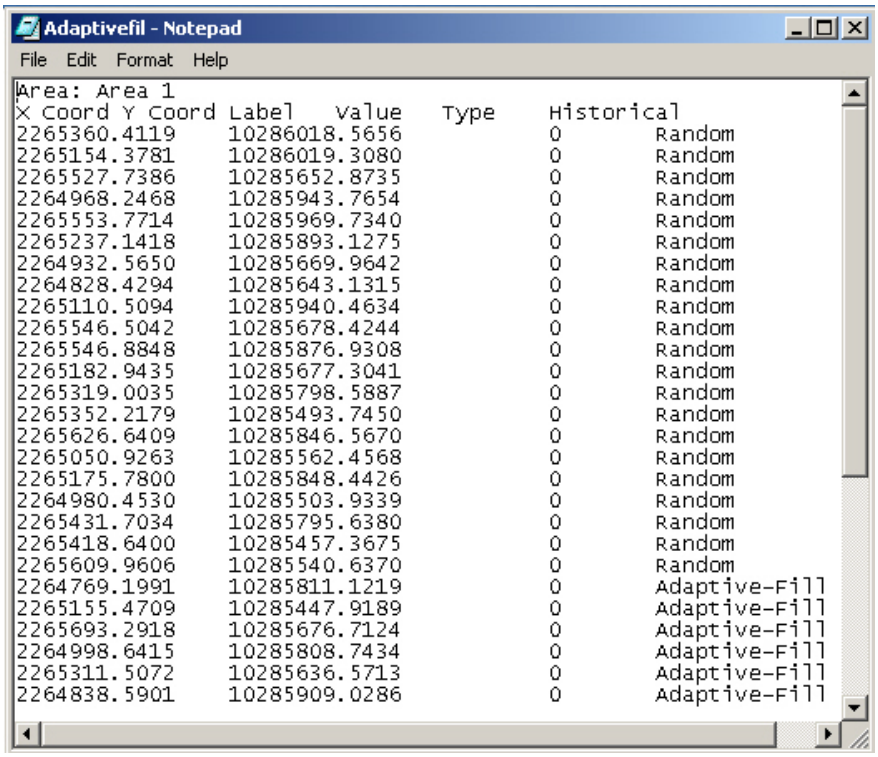


Figure 5.9. Sample Exported Text File of Sampling Locations

5.2.3 Graph

Graphs can be displayed with many different options. Figure 5.10 shows the options that can be selected using **Options > Graph**. Options are selected by clicking the option on or off. Once selected, that option will be in place for all Graphs. Note that we saw these same options in Chapter 4, Figure 4.3, by right-clicking on a Graph. Table 4.2 describes these options in more detail.

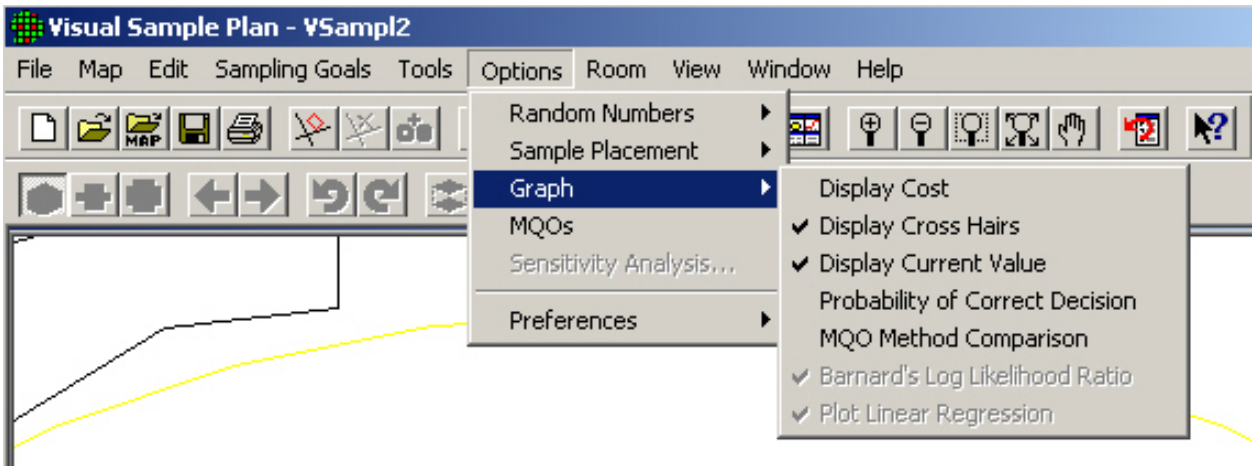


Figure 5.10. Graph Options

5.2.4 Measurement Quality Objectives (MQOs)

The Measurement Quality Objectives (MQO) module in VSP provides a way to extend the sampling design to consider not only the number and placement of samples in the field but also what happens in the measurement or analysis process. After all, it is the final result of the "measured sample value" that gets reported back to the project manager and used in statistical tests to make a decision.

There is a trade-off between taking more samples using a crude (i.e., less precise) measuring device vs. taking fewer samples using a precise measuring device and/or method. This is because total decision error is affected by the total standard deviation of the samples. The total standard deviation includes both sampling variability and analytical measurement variability.

There is also a trade-off between taking more measurements (i.e., replicate measurements) when using these less precise analytical measuring devices and/or methods vs. taking few measurements and using more precise analytical measuring devices and/or methods. The MQO module in VSP lets the user play "what-if" games with various combinations of sampling standard deviation, analytical (i.e., measurement) standard deviation, number of analyses (i.e., replicates) per sample, and number of samples to take. More discussion of this topic and the sample size equations behind the VSP calculations can be found in *Version 2.0 Visual Sample Plan (VSP) Models and Code Verification* (Gilbert et al. 2002).

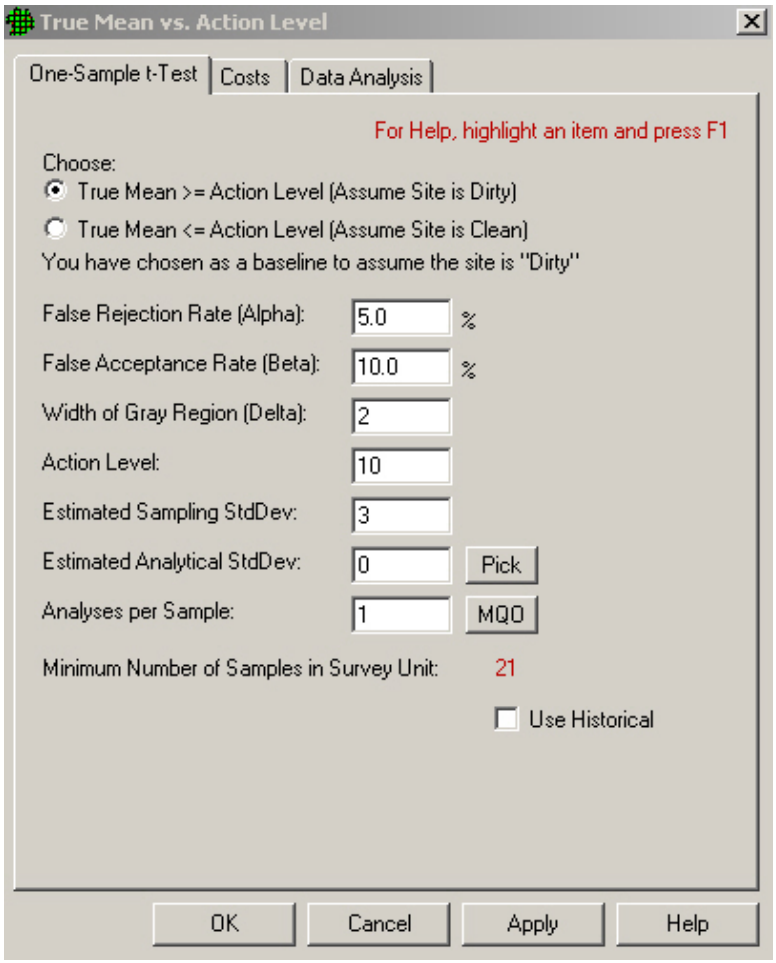


Figure 5.11. MQO Input Dialog Box with Default Values Displayed

The MQO option is selected from the dialog that pops up after a Sampling Design has been selected. The MQO option can also be toggled using **Options > MQOs** from the main menu. In Figure 5.11, we see a dialog box that contains the MQO button (**Sampling Goals > Compare Average to Fixed Threshold**). This dialog box allows you to provide additional inputs, such as the analytical standard deviation and number of analyses per sample. There is also a **Pick** button (not active at this time but planned in future versions of VSP) to provide access to a library of standard analytical methods with their reported analytical standard deviations.

Note that the default values are **0** for the **Estimated Analytical Standard Deviation** and **1** for the **Analyses per Sample.** This means that the user-selected analytical or measurement method does not add a significant component of variability to the total

standard deviation; i.e., the method provides essentially the same numeric value when repeated measurements are made on a sample. Using the input parameter values shown in Figure 5.11 and with these default MQO values, we get n = 21 samples.

Now let's start changing the MQO input values. First, we change the **Estimated Analytical Standard Deviation** to **3.** We still take only one analysis per sample. We see VSP now tells us we need to take **40** field samples to obtain the desired error rates we specified. This is shown in Figure 5.12.

If we take two repeated measurements of each sample **(Analyses per Sample** set to **2),** we see in Figure 5.13 that the number of field samples is now only **31.**

You can try different values in the MQO input boxes and see the effect on the resulting number of field samples.

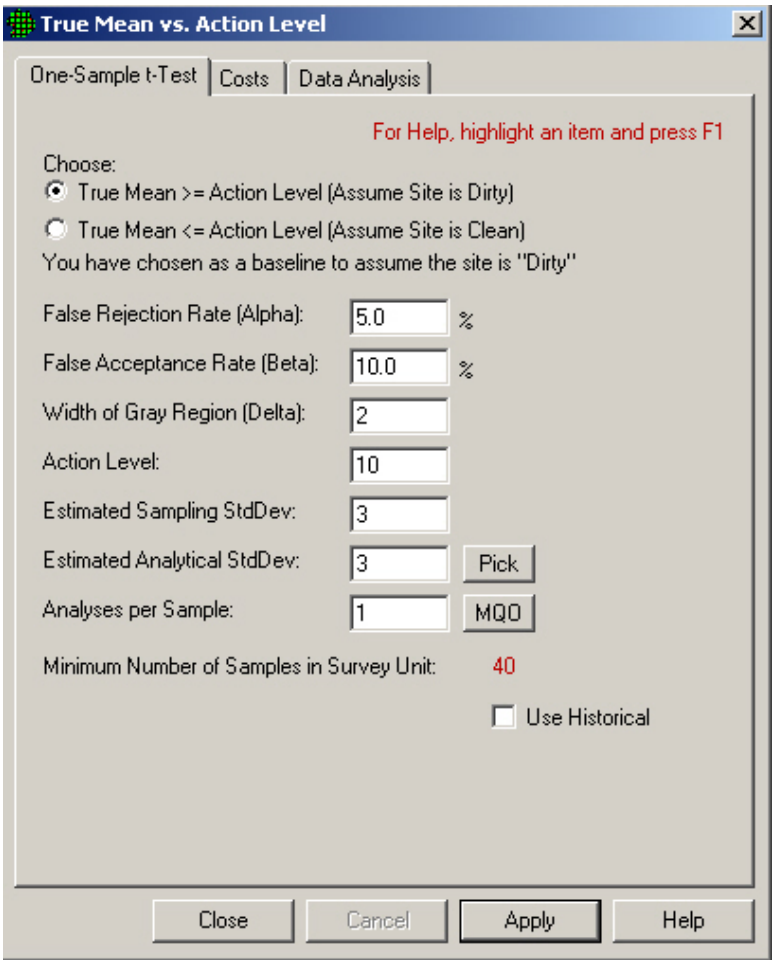


Figure 5.12. MQO Input Dialog Box Showing Positive Value for **Estimated Analytical Standard Deviation** with **1 Analysis per Sample**

When you select the **COSTS** tab at the top of the screen, a new display and set of inputs is shown. This is shown in Figure 5.14. In this dialog box, we can enter costs for **Field Collection** (shown here as **$100** per sample) and **Analytical Cost per Analysis** (shown here as **$400** per analysis). This screen also provides a **Cost Comparison** between two possible options, Analytical Methods A and B. We see the Method A Analytical Standard Deviation of **3** that we entered on the previous screen. We can also enter an Analytical Standard Deviation for Method B. Initially, VSP displays the default values of **0** for Method B as shown in Figure 5.14. VSP displays the comparison for one, two, or three replicate analyses for only Method A because Method B has an analysis cost of $0.00.

Next we show input values for Method B. Here, we enter a **Method B Analytical Standard Deviation** of **4** (somewhat higher than Method A), but with a lower **Cost per Sample** (shown here as **$100).** In Figure 5.15 we see that the Method Comparison is now filled in with the new values. The lowest cost option (Method B with 1 Analysis per Sample) is highlighted in blue.

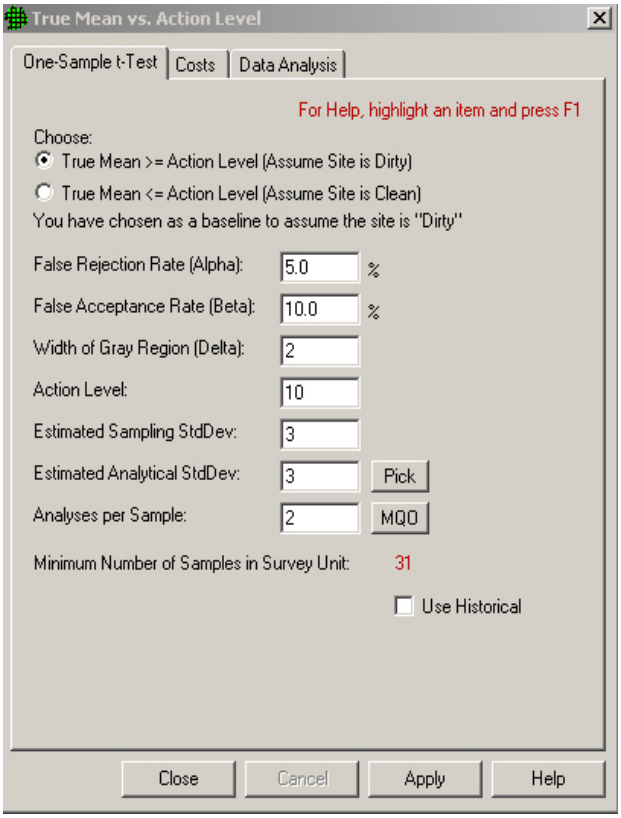


Figure 5.13. MQO Input Dialog Showing Positive Value for **Estimated Analytical Standard Deviation** with **Multiple Analyses per Sample**

A graphical comparison of the analytical methods is shown an overlay on the Decision Performance Curve when **Options > Graph > MQO Method Comparison** is checked. You must go to **View > Graph** to see the chart. Figure 5.16 shows an example.

The yellow circle is placed above the lowest-cost sampling design that meets the objectives. In this case, the circle is above a green bar representing the cost of using sampling design Method B with one analysis per sample.

5.2.5 Sensitivity Analysis

This option accesses the sensitivity analysis parameters on the Report View. The sensitivity

Notice that the lowest cost sampling design for this problem has the most field samples, $n = 55$. This is because Method B has a very low analysis cost of only \$100 vs. the much higher cost for Method A of \$400. Therefore, Method B can reduce the uncertainty in the final decision by allowing many more field samples to be analyzed compared with Method A.

Note also that the sampling design will not automatically change to the Method B case highlighted in blue. If you want a sampling design based on Method B, you must update the **Analytical Cost per Analysis** for Method A to match the Method B cost.

Then return to the **One-Sample t-Test** tab, change the **Estimated Analytical Standard Deviation** value to match the Method B value, and press the **Apply** button to get the Method B-based sampling design.

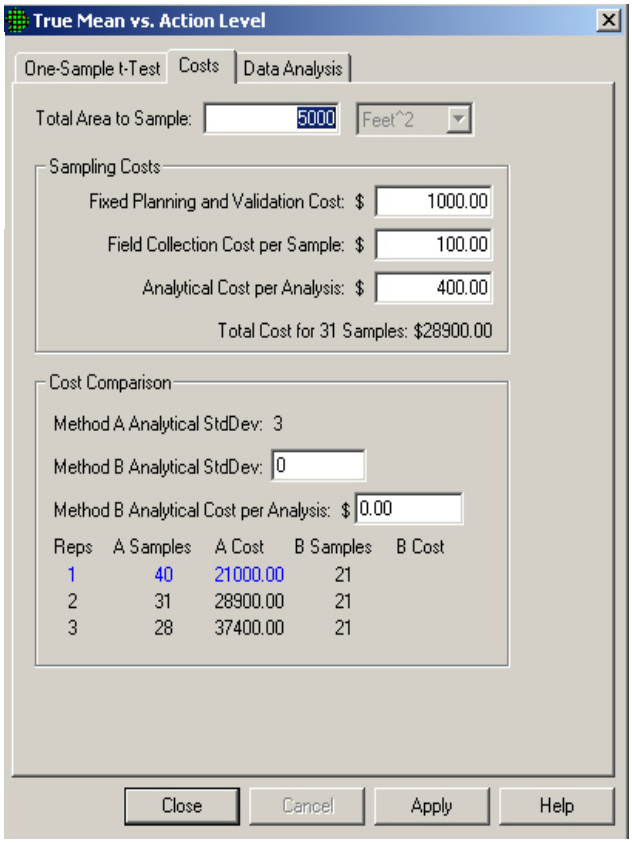


Figure 5.14. Cost Input Dialog Box for MQO Option

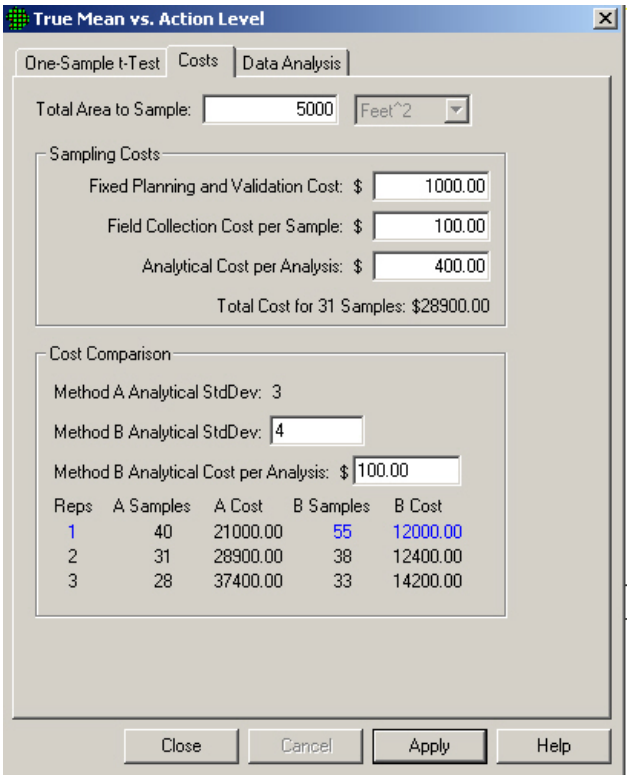


Figure 5.16. Display of **Cost Comparison** for Method A and Method B from MQO Module

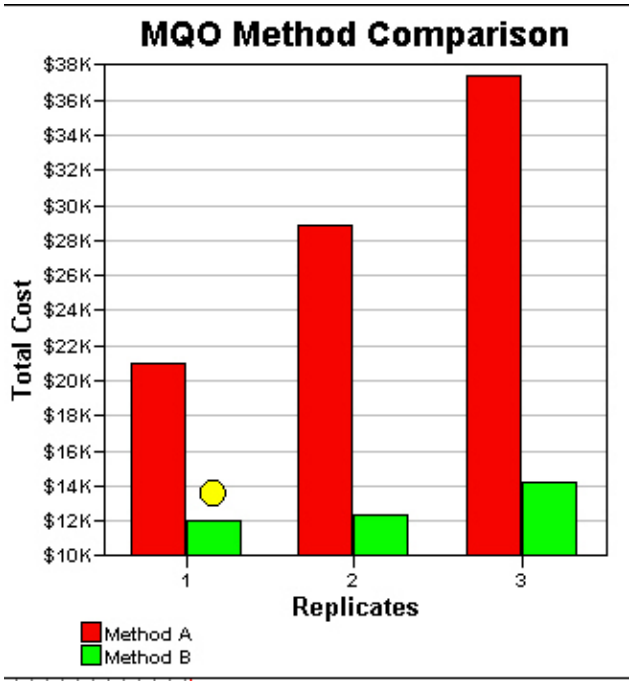


Figure 5.15. MQO Method Comparison Chart

analysis parameters may also be accessed by right-clicking on the Report View itself. The example shown in Figure 5.17 is from the VSP Project File *Example1.vsp*. With **View > Report** selected, scroll down to the section on Sensitivity Analysis. Now select **Options > Sensitivity Analysis**, and the Dialog Box shown in Figure 5.17 is displayed. The user can do sensitivity analysis on up to 4 variables (only 3 are shown here), can select a starting and ending value for each variable, and can specify the number of steps for incrementing the variable. VSP displays the values for each step in Red below the Step window. For this example, in Figure 5.17, we say we want to see the number of samples required at values of the Standard Deviation s= 1.2, and 0.6. For each of these levels, we want to look at three levels of Beta, and three levels of Alpha. VSP calculates sample size for each of these 2 x 3 x 3 = 18 options and displays the values in the Table.

This option is a very powerful tool for looking at "what if" scenarios and determining trade-offs for risk and cost. Tables for Number of Samples, Sampling Cost, or both can be displayed. Figure 5.18 shows 4 of the DQO Parameters being changed, and shows the results of the sensitivity analysis for both number of samples and cost.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying s, β and α and examining the resulting changes in the number of samples. The following table shows the results of this analysis.

Number of Samples				
		α=5	**α=10**	**α=15**
s=1.2	**β=15**	261	195	156
	β=20	224	164	128
	β=25	196	139	106
s=0.6	**β=15**	67	50	40
	β=20	57	42	33
	β=25	50	36	27

s = Standard Deviation
β = Beta (%), Probability of mistakenly conclud
α = Alpha (%), Probability of mistakenly conclu

Cost of Sampling

The total cost of the completed sampling progra
others that are based on the number of samples
determined above, the estimated total cost of s
a per sample cost of $500.00. The following tab

COST INFORMAT	
Cost Details	**Per Analy**
Field collection costs	
Analytical costs	$40C
Sum of Field & Analytical costs	

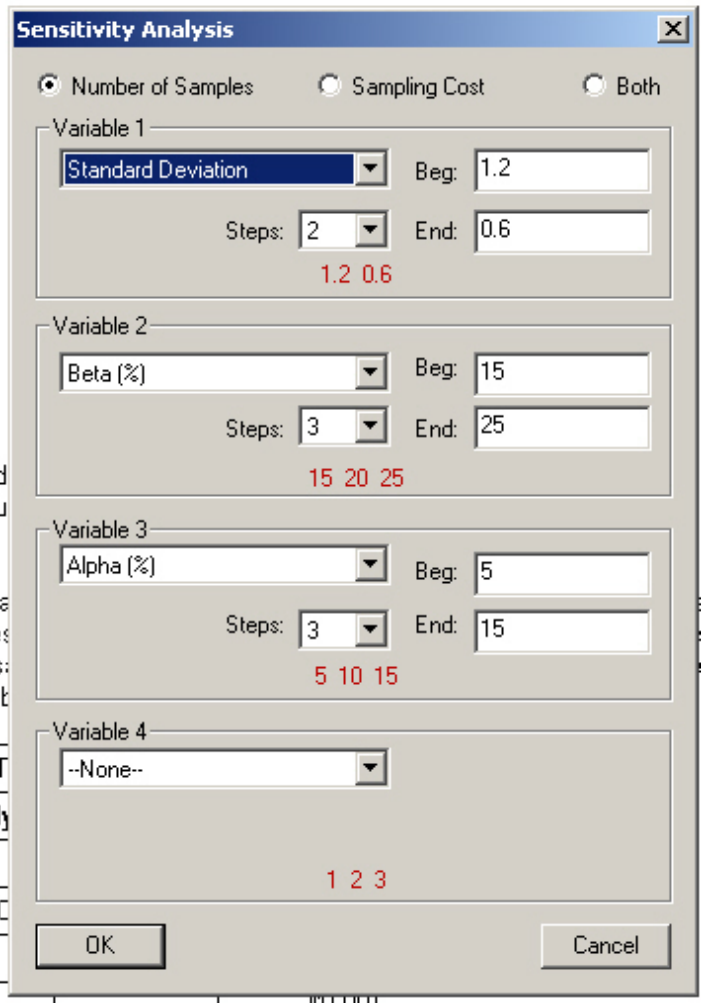
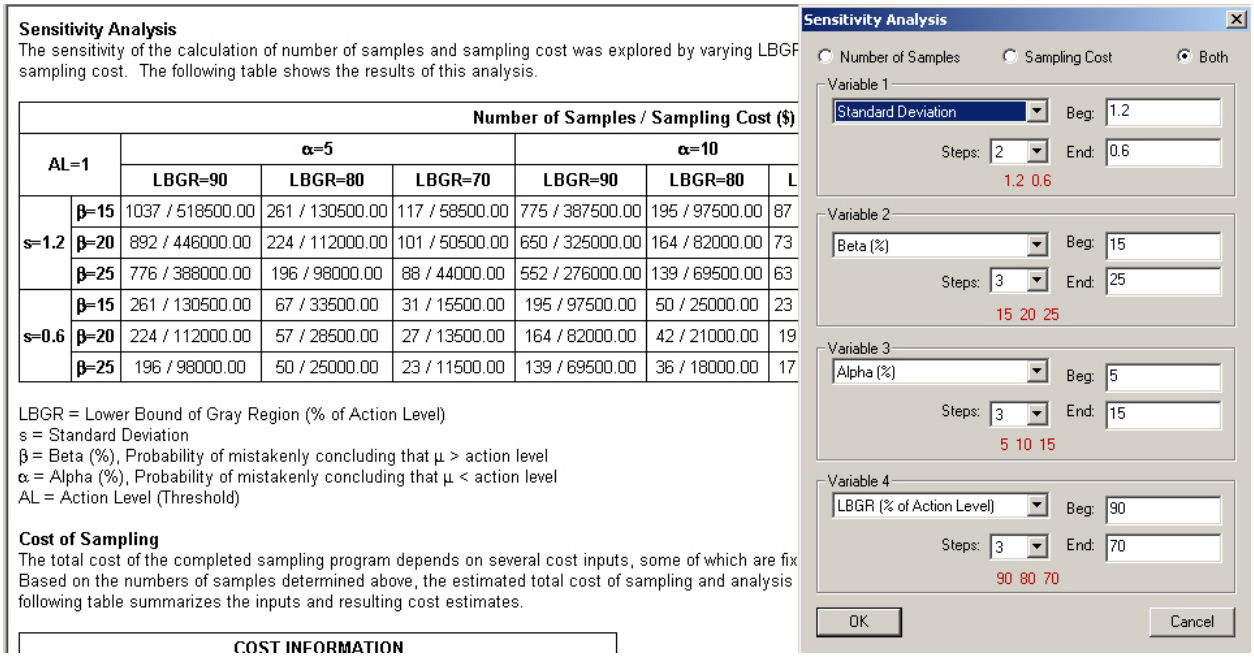


Figure 5.17. Sensitivity Analysis for 3 DQO Input Parameters. Results are shown for Number of Samples, as displayed in a table in Report View.



Sensitivity Analysis

The sensitivity of the calculation of number of samples and sampling cost was explored by varying LBGR sampling cost. The following table shows the results of this analysis.

Number of Samples / Sampling Cost ($)

AL=1		α=5			α=10		
		LBGR=90	LBGR=80	LBGR=70	LBGR=90	LBGR=80	L
s=1.2	β=15	1037 / 518500.00	261 / 130500.00	117 / 58500.00	775 / 387500.00	195 / 97500.00	87
	β=20	892 / 446000.00	224 / 112000.00	101 / 50500.00	650 / 325000.00	164 / 82000.00	73
	β=25	776 / 388000.00	196 / 98000.00	88 / 44000.00	552 / 276000.00	139 / 69500.00	63
s=0.6	β=15	261 / 130500.00	67 / 33500.00	31 / 15500.00	195 / 97500.00	50 / 25000.00	23
	β=20	224 / 112000.00	57 / 28500.00	27 / 13500.00	164 / 82000.00	42 / 21000.00	19
	β=25	196 / 98000.00	50 / 25000.00	23 / 11500.00	139 / 69500.00	36 / 18000.00	17

LBGR = Lower Bound of Gray Region (% of Action Level)
s = Standard Deviation
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fix
Based on the numbers of samples determined above, the estimated total cost of sampling and analysis
following table summarizes the inputs and resulting cost estimates.

COST INFORMATION

Figure 5.18. Sensitivity Analysis for 4 DQO Input Parameters. Results shown for Number of Samples / Sampling Cost ($), as displayed in a table in Report View

5.2.6 Coordinate Digits

Selecting this option (**Options > Coordinate Digits**) brings up a dialog box where the user inputs the number of significant digits (after the decimal point) for displaying the X, Y, and Z coordinates in **View > Coordinates**.

5.2.7 Preferences

Figure 5.19 shows the Preferences available in VSP. Table 5.1 provides a brief description of each Preference. Consult VSP **Help > Help Topics > Menus > Options menu > Preferences** for a more detail discussion of each menu item.

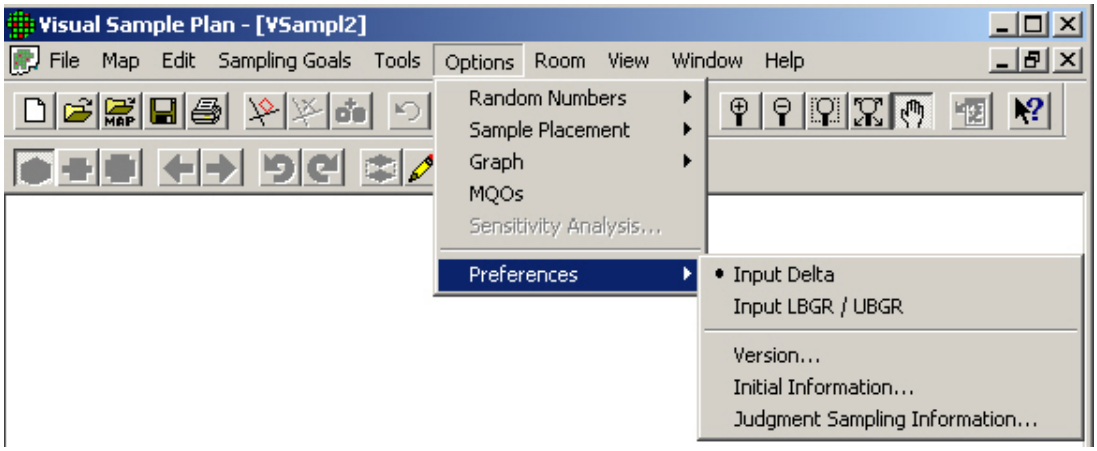


Figure 5.19. Preferences Available in VSP

Table 5.1. Preferences Menu Items

Input Delta	Allows the input of Delta in design dialog boxes
Input LBGR / UBGR	Allows the input of LBGR / UBGR in design dialog boxes.
Version	Changes the sub-version of VSP (which eliminates some of the sampling design choices)
Initial Information	Displays the initial information associated with the chosen sub-version of VSP.
Judgment Sampling Information	Displays informational dialog when judgment sampling is used.

5.3 View Menu

The View Menu offers the user options for how VSP displays information. Table 5.2 gives a brief description of each option. Consult VSP **Help > Help Topics > Menus > View menu** for a more detail discussion of each menu item. Many of these items have been discussed previously in this manual and will be mentioned only briefly here.

Table 5.2. View Menu Items

Main Toolbar	Shows or hides the main toolbar
Map Drawing Toolbar	Shows or hides the toolbar used for drawing on maps.
Ranked Set Toolbar	Shows or hides the toolbar used for ranked set sampling
Room Toolbar	Shows or hides the toolbar used for room manipulation
Status Bar	Shows or hides the status bar.
Labels	Shows or hides the sample labels on the map. Any combination of Labels, Coordinates, Local Coordinates and Values can be displayed.
Background Picture	Shows or hides the background picture.
Transparent Sample Area	Allow background picture to be seen behind sample areas.
Largest Unsampled Spots	Shows or hides the largest unsampled spots.
All Grid Cells	Shows or hides all grid cells used for adaptive cluster sampling
Leading Edge	Shows only the leading edge of an open-type sample area
Map Scale	Shows or hides the coordinate scale on the map.
Map Legend	Shows or hides the map size legend.
Swath Corners	Shows the coordinates at the corners of swaths
Room North Arrow	Shows or hides the north arrow in the room view.
Room Perspective Ceiling	Shows or hides the ceiling in the perspective room view.
Map	Change current project view to map view.
Graph	Change current project view to graph view.
Report	Change current project view to report view.
Coordinates	Change current project view to coordinate view.
Room	Change current project view to room view.
Zoom In	Increase the map view size.
Zoom Out	Decrease the map view size.
Zoom Max	Change map view size to fit window
Zoom Window	Increase map view size to selected area.
Pan	Move the visible portion of the map.

5.4 The Cost Tab: Setting Up Sampling Costs – Inputs for the General Screen

VSP allows users to enter sampling costs so that the total cost of a sampling program is available. Once a sampling design is selected and the DQO inputs have been entered into one of the dialog boxes, click on the **Costs** tab to enter costs. A sample **Costs** screen is shown in Figure 5.20. The inputs for this example were entered in the Dialog Box shown in Figure 5.11.

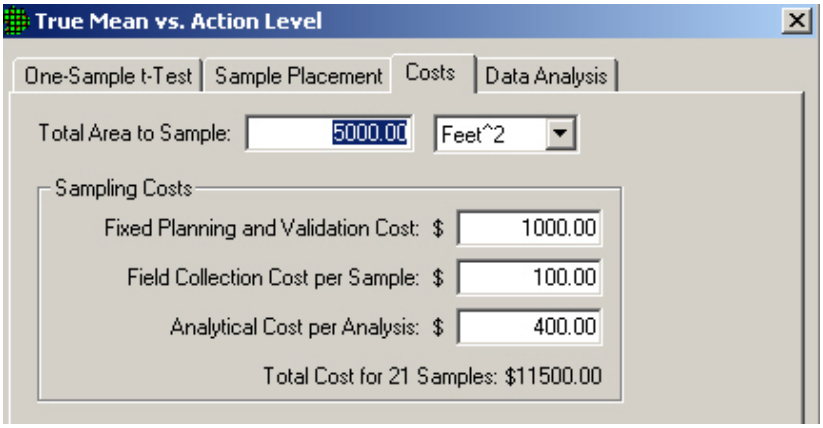


Figure 5.20. Screen for Entering Sampling Costs for a Sampling Design – Accessed through the Cost Tab

VSP enables you to break down costs into the following categories:

- *fixed planning and validation costs* - This is the fixed cost that is incurred, regardless of how many samples are taken. Examples of fixed costs are the cost to mobilize a sampling crew and get the equipment into the field.

- *field collection cost per sample* - This is the per-sample **field collection cost.** Examples of per-unit field costs are the costs paid to technicians to collect the sample and package and transport it.

- *analytical cost per analysis* - This is the cost to analyze a specimen or a sample. As discussed in Section 5.4, you can specify how many repeated analyses you want taken per sample or specimen.

VSP calculates a total cost for the design specified, shown here as $11,500. Total cost is the sum of the fixed cost, shown here as $1,000, plus per-sample field collection cost of $100, plus analytical cost per analysis of $400, multiplied by the number of samples, 21. No duplicate analyses were specified, so the total per-unit cost is $500. Thus, the total sampling cost is $1000 + 21 x $500 = $11,500.

The hot spot sampling goal has some unique cost features. First, total costs are displayed in one of the tables in the **Report View**. Second, you can specify a cost as a design criteria and VSP will calculate the number of samples to meet that goal (see Figure 3.29). This is done by selecting from the main menu **Sampling Goal > Locating a Hot Spot > Systematic Grid Sampling .**

5.5 Multiple Areas to be Sampled

VSP allows the user to select multiple areas as sampling areas. All the examples shown so far involved a single Sample Area. When multiple areas are selected, VSP allocates the samples to the areas in proportion to the area of the respective individual sample areas. For example, if one area is twice as large as the other sample area, it will receive twice as many sample points. This is shown in Figure 5.21.

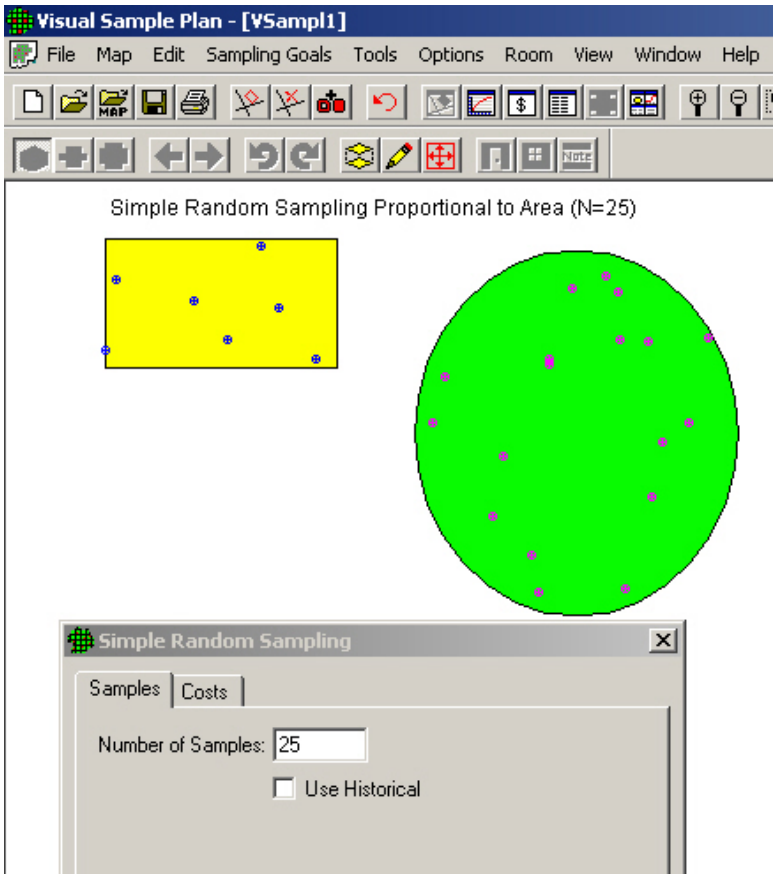


Figure 5.21. Proportional Allocation of Samples to Multiple Sample Areas

In Figure 5.21, we show two sample areas -- a rectangle and a circle. We next assume that a sampling-design algorithm not currently in VSP called for n = 25 samples. Using option **Sampling Goals > Non-statistical sampling approach > Predetermined number of samples > Ordinary sampling,** VSP allocated 7 of the 25 requested samples to the rectangle and 18 to the circle. This is because the circle covers an area approximately three times larger than the rectangle.

Note that when multiple sample areas are drawn on a Map, you can select or deselect sample areas using Main Menu option **Edit** > **Sample Areas** > **Select/Deselect Sample Areas.** Alternatively, you can select or deselect a sample area by clicking on it with the mouse.

The **Change Color** option can be used to change a sample area's color. First, select those sample areas to be given a new color. Then use the **Edit** > **Sample Areas** > **Change Color** sequence and choose the new color for the currently selected sample areas.

Note that when multiple sample areas are selected, VSP-derived sampling requirements assume that the decision criteria and summary statistic of interest (mean, median) apply to the combined sample areas and not to the individual areas.

5.6 Data Analysis

For some sampling goals, VSP allows the user to input the results of a sampling effort and obtain certain basic analyses of the data, including summary statistics, plots of the data, and results of statistical tests performed on the data. VSP provides a statement of the conclusion(s) that can be drawn based on results of the statistical tests. Only selected tests appropriate for the design in question are displayed. The tests included in VSP are standard statistical tests and are included in VSP for the convenience for the user so a separate software package for analyzing results in not needed. The tests and calculations used in VSP have been verified. This verification, along with an extensive discussion of the methods used in VSP, can be found in PNNL reports: *Technical Documentation and Verification for the Buildings Module in the Visual Sample Plan (VSP) Software*, PNNL –15202, June, 2005, and *Version 2.0 Visual Sample Plan (VSP): Models and Code Verification*, PNNL-13991, August 2002. If the user wants to perform more complex tests and analyses, a commercial statistical software package, or freeware such as EPA's

ProUCL (ProUCL Version 3.0 User Guide April 2004, available for download from http://www.epa.gov/nerlesd1/tsc/tsc.htm) should be consulted.

Figure 5.22 shows a Dialog Box that appears when the user selects the **Data Analysis** tab for **Compare Average to Fixed Threshold > Assume data will be normally distributed > Ordinary Sampling.**

In Figure 5.22, we see four options: **Data Entry, Summary Statistics, Tests, and Plots**. **Data Entry** is a user input screen for inputting data values. **Summary Statistics** displays VSP calculations, shown in red, of selected summary statistics of the data input in Data Entry. The **Tests** tab displays the results of computations done within VSP to execute various *tests* and make various *calculations*. The *tests* are of two types:

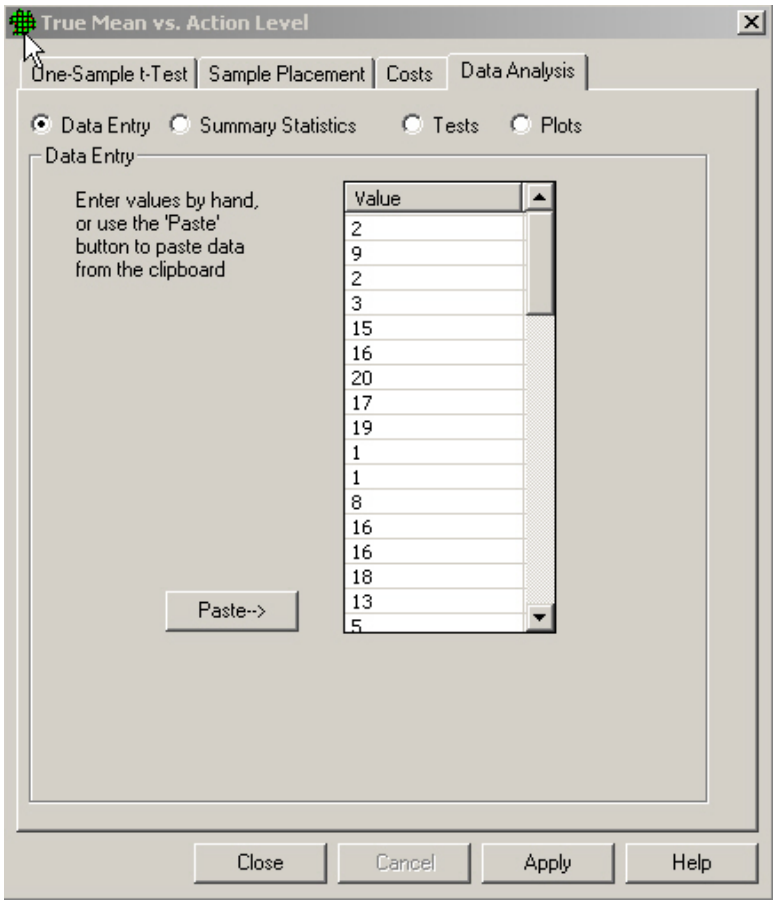


Figure 5.22. Data Analysis Tab for the One-Sample t-Test, Data Entry Dialog Box

- Tests of the assumptions underlying the statistical tests (e.g., the normality assumption for the One Sample t test), and
- Statistical tests to test the Null vs. Alternative Hypothesis for the sampling goal selected

Calculations made by VSP are

- Upper Confidence Limit (parametric and non-parametric) on the Mean and on Percentiles, and
- A count of the number of sample points or grid locations that exceed the Action Level.

Output from VSP, and conclusion that VSP determines can be drawn based on the *test* results and *calculations*, are shown in red on the **Tests** screen. The **Plots** tab shows VSP-generated graphical displays of the data.

Not all sampling designs in VSP have the Data Analysis tab – either because analyzing sampling results is not a part of the sampling goal, or because VSP sponsors have not requested the VSP data analysis functionality. For example, **Locating a Hot Spot** does not have a Data Analysis tab because the result of sampling is whether or not there has been a hit at any sampling location, which this doesn't require data analysis. Similarly, **Estimate the Mean > Can assume will be normally distributed > Adaptive Cluster Sampling** does not have a Data Analysis tab because the sampling goal is interactive and does not require a statistical test. Some sampling designs, like Collaborative Sampling, have a **Data** tab for inputting sample results, but not a Data Analysis tab.

For brevity, the Data Analysis for only a few sampling designs will be discussed below. Consult the **Help** function for individual designs for further information.

5.6.1 Data Entry

Data can be entered into VSP in one of two ways: manually or "cut and paste" from another file. To manually enter values, click the mouse in the first line in the input box under **Value**, enter the numeric value for a sampling point, hit **Enter** or **Tab**, and move to the next line for more input. If the data are in another software package such as Excel, use the Windows clipboard to copy the data, then hit **Paste** to get the data into VSP. The data to be pasted into VSP must be one entry per line in the originating source. You can manually add more input values to a set of Pasted values by clicking on the last data value in the input box, hit Enter or Tab, and start entering more data values on the next empty line. You must hit the **OK** or **Apply** button at the bottom of the screen to save your values in a Project file. Figure 5.22 shows 60 values pasted into VSP from an Excel spreadsheet.

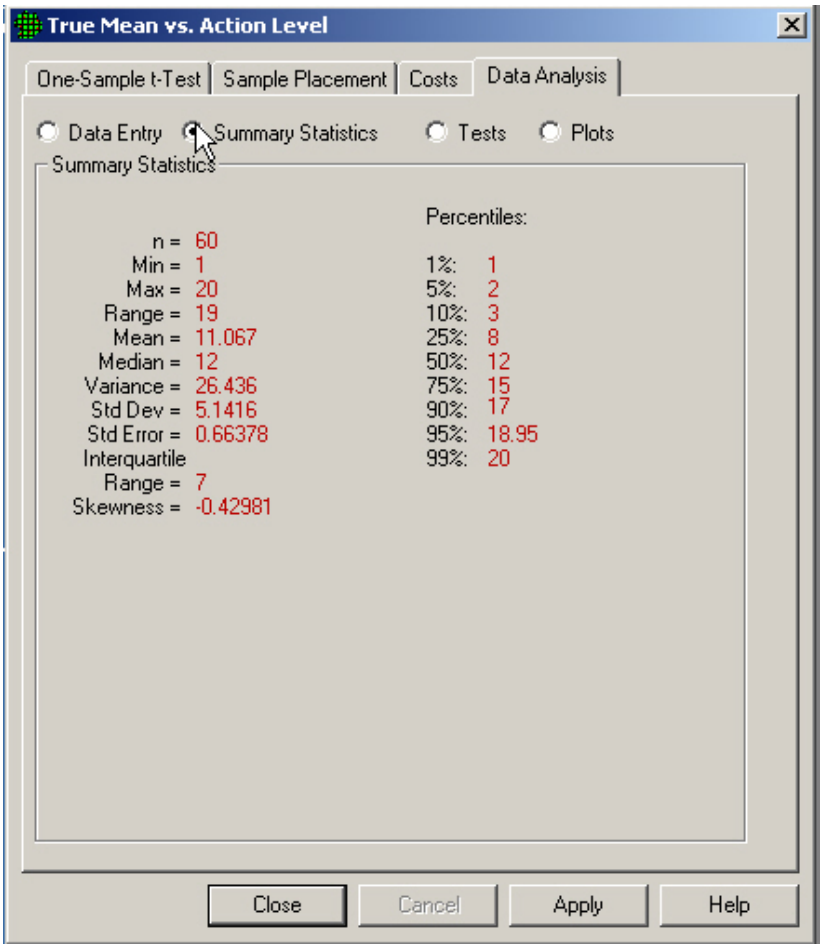


Figure 5.23. Summary Statistics for Data Values Entered on Data Entry Screen

5.6.2 Summary Statistics

Figure 5.23 shows summaries of the data input under Data Entry. The values for the summary statistics are shown in red. The summary statistics, when shown, are the same for all sampling designs.

5.6.3 Tests

The *tests* and *calculations* required by VSP to draw conclusions based on the data input under Data Entry are the core of VSP's data analysis. After telling the VSP user how many samples to take and where to take them, the next most important function of VSP is to tell the user what conclusions can be drawn based on the data. But prior to drawing conclusions, VSP must make sure the assumptions on which the *tests* and *calculations* rely are valid.

The tests in VSP vary by the Sampling Goal selected, and the assumptions made. The tests shown in the screen captures below are an example of the types of tests contained in VSP. Not all data analysis options are shown below.

5.6.3.1 Tests for Sampling Goal: **Compare Average to Fixed Threshold > Assume data will be normally distributed > Ordinary Sampling**

The One-Sample t test is used to test the null hypothesis **True Mean >= Action Level**. However, the t test relies on the assumption that the data are normally distributed. So the first test VSP performs is to test the normality assumption. Two tests are available in VSP for testing for normality:

- Shapiro-Wilk Test (also called W test) when the number of data points do not exceed 50, and
- Lilliefors Test when the number of data points are greater then 50.

Our sample size was n=60, so the Lilliefors test was used. In Figure 5.24a we see the Lilliefors test results indicate we cannot assume normality (i.e., test statistic of .12202 > critical value of .11439 so we reject the assumption of normality).

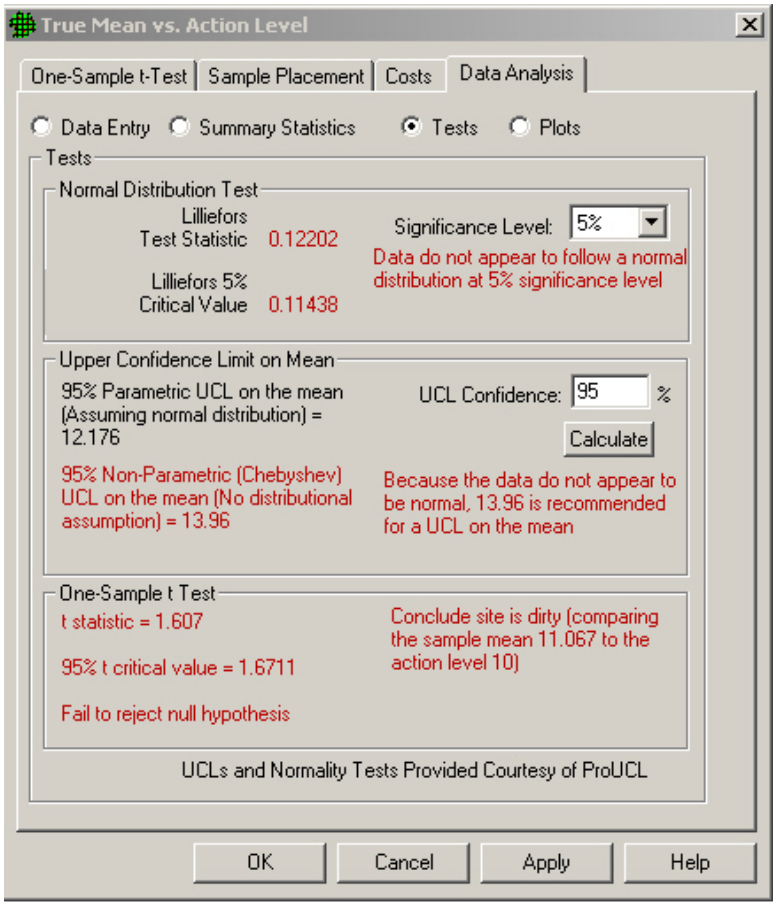


Figure 5.24a. Tests for Comparing the True Mean vs. Action Level

With the normality assumption rejected, we now know we must use a non-parametric test to test the null hypothesis that the **True Mean >=Action Level**. The test we use is to compare the Non-Parametric UCL on the mean to the action level. We see that the Non-Parametric UCL on the mean is **13.96** which is greater than the Action Level of **10**, so we cannot reject the null hypothesis, and we can **conclude the site is dirty.**

5.6.3.2 Tests for Sampling Goal: **Sampling within a Building > Compare measurements to threshold > Ensure most of area is uncontaminated > Upper tolerance limit > Unknown Distribution**

In Figure 5.24b we see the tests VSP executes in order to make confidence statements on a percentile of the population. For example, the goal may be to be able to state with 95% confidence that at least 90% of the values in a population are less than the action level, and therefore the decision unit is contaminated (see Fig 3.47 for a description of the problem). The test is to calculate the Upper Tolerance Limit on the 90th percentile of a population and compare it to the action level. Note: A one-sided upper tolerance limit on the P^{th} percentile is identical to a one-sided upper confidence limit on a P^{th} percentile of the population. The maximum value of a data set is the non-parametric UTL.

In this example, since the sample size was n=60, the Lilliefors test was used. We see that the Lilliefors test rejects that the data are normal, so VSP recommends comparing the nonparametric UTL to the Action Level for deciding whether the unit is contaminated. Since the nonparametric UTL of **20** is greater than the action level of **10,** we **conclude the site is dirty** (i.e., less than 90% of the population is less than the action level of 10). VSP also calculates a parametric UTL of **19.339** but recommends not using it in the test.

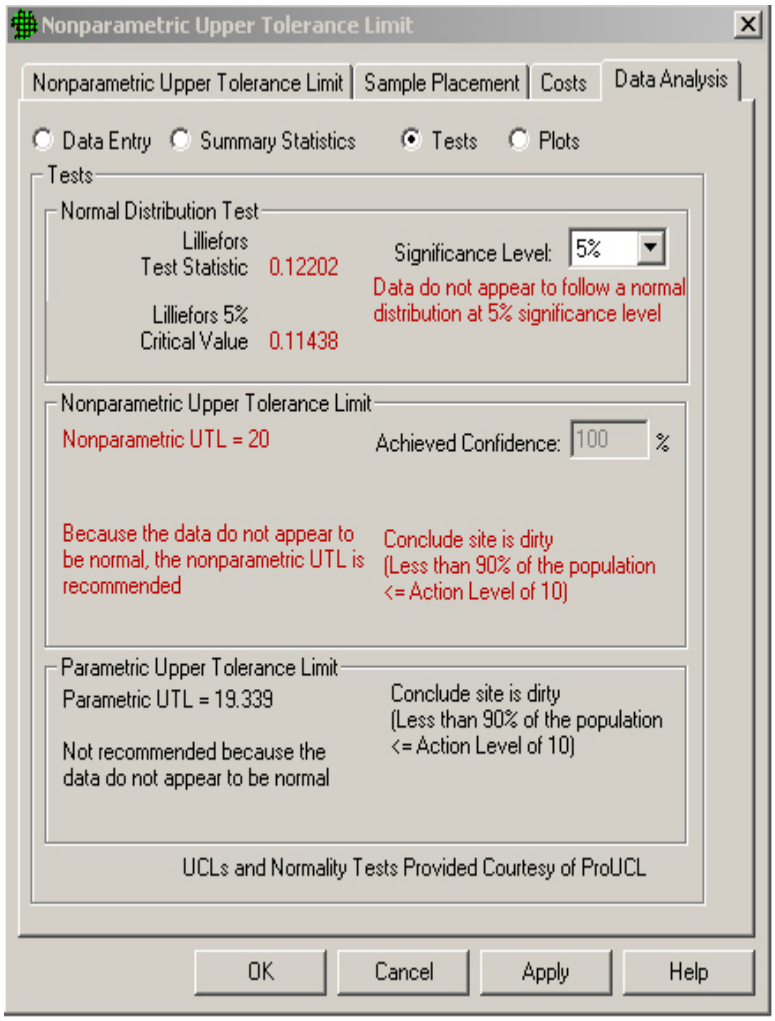


Figure 5.24b. Tests for Making Confidence Statements on a Percentile of a Population

5.6.4 Plots

The final option under Data Analysis is the graphical display of the data. VSP provides three graphical summaries of the data: histogram, box-and-whiskers plot, and quantile-quantile plot (also called the Q-Q plot, or the probability plot). The pull down menu is used to select one of the three plots. The graphical displays provide information on the spread of the data, and can also be used to give a visual assessment of the normality assumption.

5.6.4.1 Histogram

Figure 5.25 shows a histogram of the data. The red line shows the shape of the histogram if the data were normally distributed. Consistent with the results of the Lilliefors Test, the data do not appear to be normally distributed.

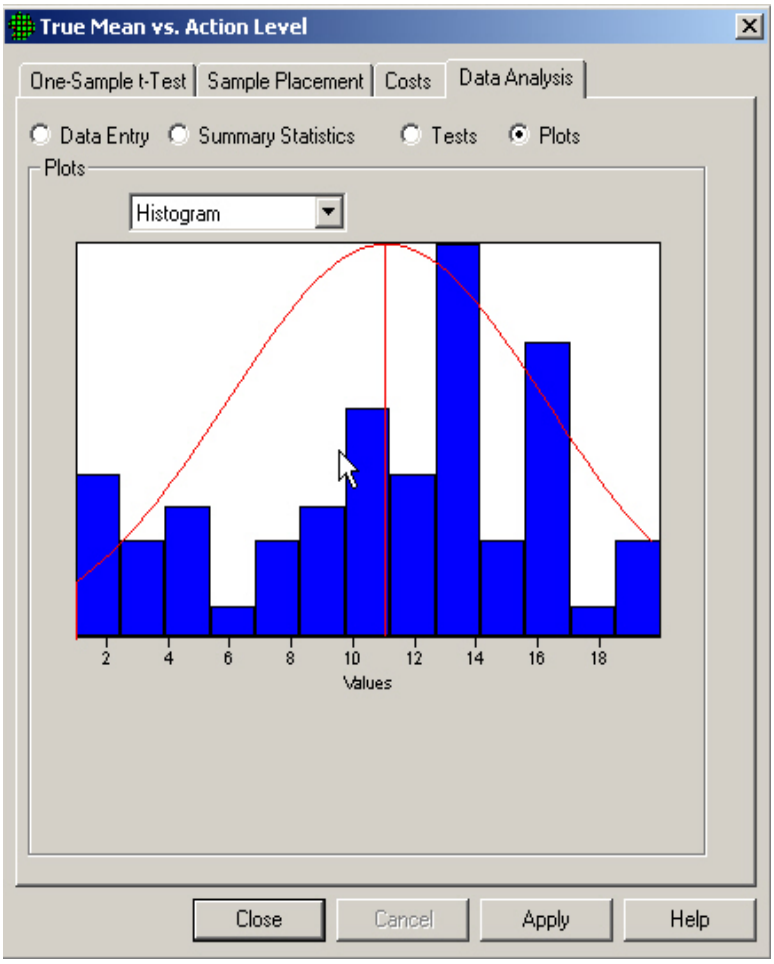


Figure 5.25. Histogram of the Data

5.6.4.2 Box-and-Whiskers Plot

Figure 5.26 shows a Box-and-Whiskers plot of the data. The Box-and-Whiskers plot is composed of a central "box" divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the data (i.e., the 50th percentile). The two ends of the box represent the 25th and 75th percentiles of the data, also called the lower and upper quartiles of the data set. The sample mean is shown as a red "+". The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile – lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. If the data are normally distributed, the box and whiskers appear symmetrical, with the median midway between the ends of the box (i.e., the 25th and 75th percentiles), and the mean is equal to the median. The plot in Figure 5.26 is not symmetrical, consistent with the non-normality conclusion discussed above.

5.6.4.3 Quantile-Quantile (Q-Q) Plot

The Q-Q plot graphs the quantiles of a set of data against the quantiles of a specific distribution. We show here the normal distribution Q-Q plot. The red line shows quantiles of a normal distribution plotted against quantiles of a normal distribution – i.e., a straight line. If the graph of data plotted against quantiles of a normal distribution (shown as blue x's) fall along the linear line, the data appear to be normally distributed. In Figure 5.27 the tails of the data deviate from the red line, indicating the data are not normally distributed.

For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

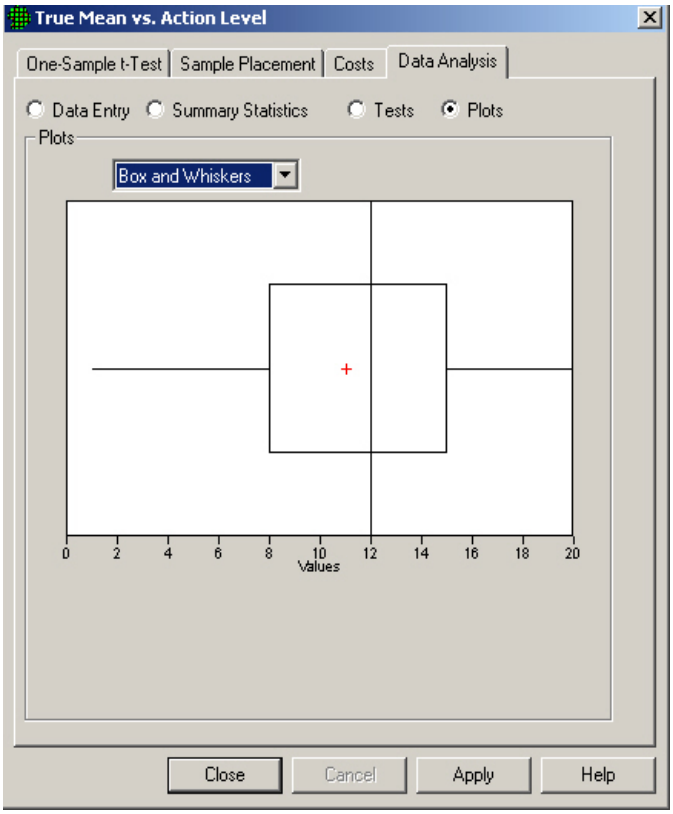


Figure 5.26. Box-and-Whiskers Plot

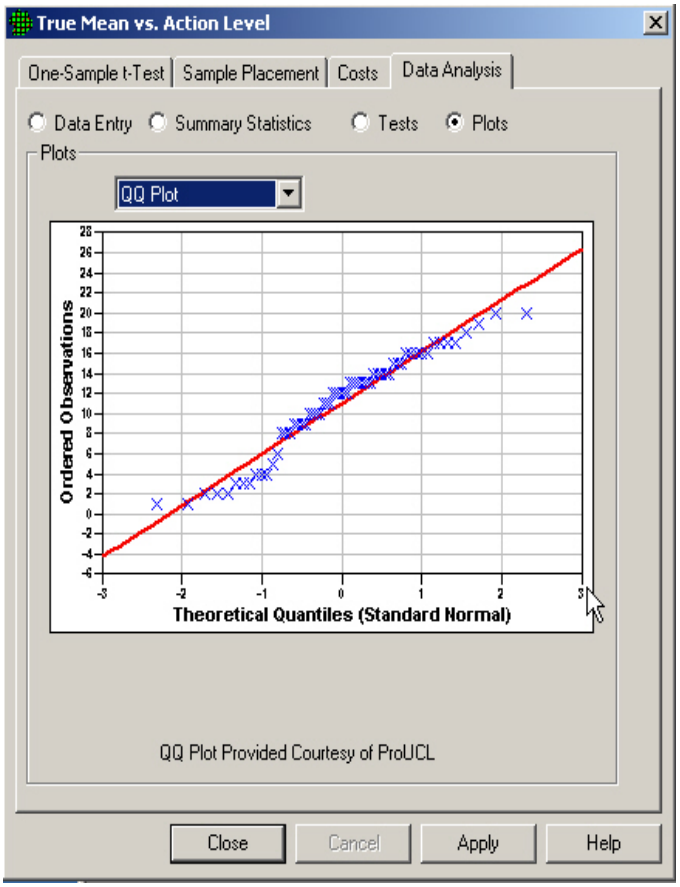


Figure 5.27. Quantile-Quantile (or Q-Q) Plot