Generating a 1-D Shear-Wave Velocity (Vs) Profile

– Working with Sample Data ("Vs1DMASW.dat") –

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About the Sample Data Set ("Vs1DMASW.dat")

This sample data set simulates a set of data from an MASW survey to produce a 1-D shear-wave velocity (Vs) profile commonly used to dictate depth variation of stiffness at a fairly confined area. Typical application would be the MASW survey for geotechnical investigation of wind-turbine sites. The data set is an output from a seismic modeling based on the reflectivity method that is also part of the PS software (available under the "Modeling" menu). This data set is used to demonstrate how to produce a 1-D shear-wave velocity (Vs) profile. Because it is an output from PS, the data set is already in PS format, not in SEG-2 format. It consists of eight (8) field records of 24-channel acquisition with a 1-ms sampling interval (dt) and 1024 samples of recording (i.e., recording time, T, is 1.024 sec). These records are modeled with a 2-layer earth model (overburden and bedrock), as shown below. Two different source orientations (i.e., forward and reverse shots) and four different source offsets (X1's) are used to produce eight (8) unique records for the combination of the two variables. This is a common practice to maximize the robustness of data analysis. For example, use of different X1's minimizes any adverse influence from the near-field effects, whereas acquiring data from both ends of the receiver array tends to average out any lateral variation in the subsurface velocity model (e.g., dipping or uneven bedrock surface) so that the analysis can achieve the highest resolution in vertical variation.

Shear-wave velocities of overburden and bedrock were arbitrarily set to 200 m/sec and 1000 m/sec, respectively. Corresponding Poisson's ratios were set to 0.45 and 0.33, respectively. A constant density of 2 gm/cc was used for both overburden and bedrock. The source/receiver (SR) configuration chart displayed below the velocity model shows relative SR location for each record. It shows the receiver array stayed at the same surface location for all eight (8) records, with only the source moving to change offsets (X1's) and orientations. Forward shots refer to those impacts made off the first channel, whereas reverse shots refer to those made off the last (24th) channel. Table 1 summarizes locations of source and receivers for each record in the sample data set.

Other types of sample data are explained in the PS User Guide "Sample Data."

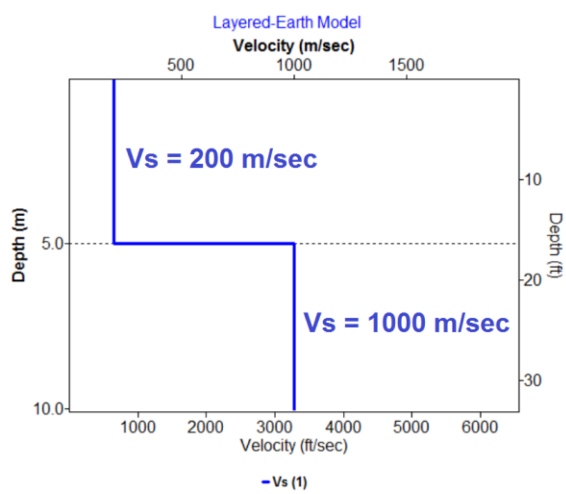
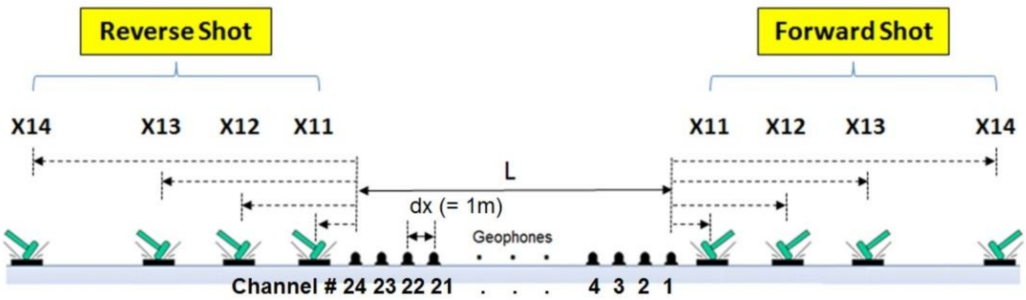


Figure 1. Shear-wave velocity (Vs) model used to generate synthetic data "Vs1DMASW.dat."



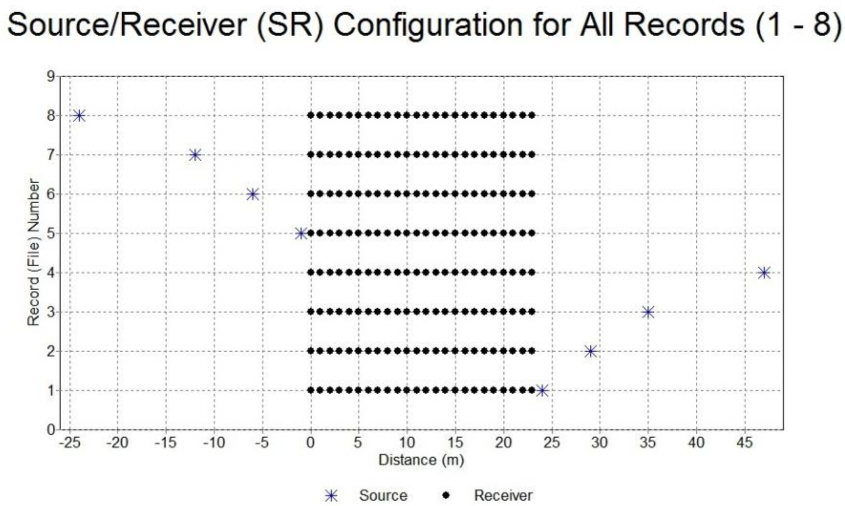


Table: Location and orientation of source and receivers (SR) for each record

File (Record)	Receiver X (m)		Source		
	Channel #24	Channel #1	Offset (m)	X (m)	Orientation
1	0.0	23.0	1.0	**24.0**	**Forward**
2	0.0	23.0	6.0	**29.0**	**Forward**
3	0.0	23.0	12.0	**35.0**	**Forward**
4	0.0	23.0	24.0	**47.0**	**Forward**
5	0.0	23.0	1.0	**-1.0**	**Reverse**
6	0.0	23.0	6.0	**-6.0**	**Reverse**
7	0.0	23.0	12.0	**-12.0**	**Reverse**
8	0.0	23.0	24.0	**-24.0**	**Reverse**

Figure 2. Source and receiver (SR) configuration used to generate model data set "Vs1DMASW.dat."

Data Processing Steps — Overview

By treating this sample data set as a typical field data set from an MASW survey to produce a 1-D shear-wave velocity (Vs) profile, the typical data-processing procedure is demonstrated by following the steps outlined below. The sample data set consists of eight (8) field records in PS format. The only difference in comparison to a real case would be the data format. In a real situation, there would be multiple individual field files ("records") saved in SEG-2 format at the end of a survey; for example, "1.dat", "2.dat", "3.dat", etc. Then, you will have to import (open) all of them at the same time at the beginning of the data-processing flow ("Step 1" below),where they are all combined within the program's internal memory, in the order of file (record) number, to make one file right after they are imported. The sample data set is like the real data set at this point after combining. In this sense, the demonstrated procedure outlined here is virtually identical to a real situation.

Step 1: Source/Receiver (SR) Setup

Relative locations of seismic source and receivers are encoded into the header of each channel's data set ("trace"). The critical parameters of receiver spacing (dx), source offset (X1), movement of source and/or receivers, distance within the survey line of source and receivers, station numbers, etc., are inserted into the proper headers. In reality, these parameters are usually set at the beginning of the survey. If that is the case, then PS will inform it at the beginning of the SR setup so that the user can visually examine the encoded information in a manner similar to the chart displayed in Figure $. If user confirms the displayed setup is correct, then this SR setup is skipped. If user finds the original field data set did not have proper information encoded, then this SR setup is crucial and cannot be skipped.

The sample data set does not have such information encoded. Therefore, you have to input the source/receiver setup before moving to the next step. Output from this step will have the same extension as input seismic data (".DAT") with a post fix of "(SR)" at the end of the file name; for example, "Vs1DMASW(SR).DAT." Explanations about the general use of the SR setup are provided in the PS User Guide "Source-Receiver (SR) Setup."

Step 2: Dispersion Imaging

Once SR setup is complete, the next step is to generate dispersion images; one dispersion image per field record. Because the input seismic data file has eight (8) records, the output dispersion image file will also have 8 images. These dispersion "images" are actually another instance of numerical data similar to seismic data, and different from the ordinary graphical images (e.g., BMP or JPG files). In fact, they have the same numeric data format as used in the seismic data (i.e., PS format) and therefore can be displayed by using the seismic data display module. However, PS has a separate module dedicated for dispersion image displays in the main menu ('Display' → 'Dispersion Data' → 'Dispersion Image').

There are many parameters related to dispersion imaging process, which is basically a wavefield transformation operation that converts seismic wavefields in an offset-time (x-t) domain into those in a phase velocity-frequency (Pv-f) domain. These parameters can influence the quality and size of the image. In most cases, however, the program will set them to the most optimal values through many internal automated analysis steps. Output will have the same extension as input seismic data (".DAT") with a post fix of "(ActiveOT)" at the end of the file name; for example, "Vs1DMASW(SR)(ActiveOT).DAT." Explanations about the general use of this part of the analysis are provided in the PS User Guide "Dispersion Image Generation."

Step 3: Dispersion Curve Extraction

This step extracts and saves the fundamental-mode (M0) dispersion curve from each dispersion image generated from previous step. Although there are eight (8) dispersion images generated, they all originated from the receiver array that stayed at the same surface location. Therefore, it will have little meaning to extract separate M0 curves from each of these images. Even if all separate M0 curves are extracted, it will be very unlikely they will all look identical because each image has slightly different dispersion characteristics dominating over different frequency and phase velocity ranges. This is because they all had different source locations and are therefore influenced to a different extent by near-field effects and lateral subsurface variation. Instead, these images should be stacked to produce one image that has the most accurate dispersion characteristics over the broadest frequency and phase velocity ranges through the constructive interference of coherent dispersion trends, while suppressing inconsistent random noise energy patterns.

Generated dispersion image data [*(ActiveOT).DAT] will be displayed by a dedicated module. Then, the program will ask if you want to stack the images to produce one final image to be used for the extraction of an M0 curve. If 'stacking' is not chosen, then the remaining procedure will be identical to generating a 2-D velocity (Vs) cross section after extraction of all eight M0 curves. In this case, the record number (instead of surface distance) will be used as the horizontal coordinate for the 2-D cross section. However, it is highly recommended that you choose the stacking option until you become fairly well experienced in recognizing complicated dispersion patterns. At that point, you will be able to decide if any of the individual images possess the dispersion pattern superior to that of the stacked image, as is sometimes the case.

Once the stacked image is displayed, then first it will be necessary to visually examine the image and make an interpretation for the M0 trend. This interpretation usually will be simple and easy when there is only one obvious trend of coherent energy, which is often the case in most overburden/bedrock settings (except for "too" shallow bedrock). Once this identification has been made, then you can define the approximate M0 trend by clicking multiple points (e.g., 5-10) along the identified image trend. The program will then draw both lower and upper bound curves within which it will try to extract the most probable M0 curve by examining energy levels at each frequency. You can freely change these curves to refine the zone of examination.

The extracted dispersion curve will be saved as a text file of its own format with an extension of ".DC" with a post fix of the record number within parentheses [e.g., "Output(SR)(ActiveOT)(1).DC"]. There will be only one dispersion curve file (*.DC) saved at the end of this step. General description of this part of analysis can be found in the PS User Guide "Dispersion Curve Extraction (1-D Profile)."

Step 4: Inversion for 1-D Shear-Wave Velocity (Vs) Profile (Automatic 1st Phase)

This step will generate one 1-D (i.e., depth variation) shear-wave velocity (Vs) profile from the input M0 dispersion curve (*.DC) previously saved at the end of the Step 3.

There are many parameters that can influence the reliability of inversion output. Among them is the most important, the maximum depth (Zmax) of output, which is the depth to the half space (i.e., depth to the top of the last layer of infinite thickness, the half space). Zmax is determined by the program based on the minimum (Xmin) and maximum (Xmax) distances of the receiver from the source that were used during the survey. However, you can always modify it, as needed, according to your own experience and knowledge. Other inversion parameters, such as number of layers and searching-algorithm related parameters, are set to default values by the program although they can always be manually changed by the user. During the inversion process, the program will display both measured and modeled dispersion curves to indicate how closely they match for the solution found by the program.

There will at least two (2) output files saved at the end of the inversion process, all in text files but with different extensions; 1-D Vs profile file [*(1DVs).LYR] and its modeled dispersion curve [*(Model).DC]. The processing history of all inversion parameters (for example, number of layers, number of iterations, final match between measured and modeled dispersion curves, etc.) is included in the Vs profile (*.LYR). The Vs profile will show depth variation of shear-wave velocity (Vs) within the maximum investigation depth (Zmax) set during the inversion, whereas the modeled dispersion curve will show the theoretical M0 curve corresponding to the velocity (Vs) profile.

The Vs profile will be displayed automatically at the end of the inversion process. This will be the velocity (Vs) model found automatically by the program without user's intervention, based on its own searching algorithm, and is usually sufficient to dictate the reality. Then, this completes the entire procedure to generate the 1-D Vs profile. General description of this part of the analysis can be found in the PS User Guide "Inversion (1-D Profile)."

Step 5: Inversion for 1-D Shear-Wave Velocity (Vs) Profile (Optional 2nd Phase)

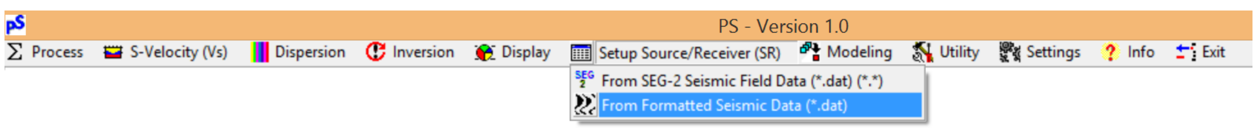
However, it is often beneficial to attempt one or a few more rounds of the inversion process through a manual searching process followed by another automatic inversion process. This can often lead to finding a profile whose M0 curve matches the measured curve even better (i.e., a higher match), or a profile that appears more realistic. This is especially true under two possibilities. First, due to the non-uniqueness of inversion, a property inherent to all types of inversion processes, the Vs profile found automatically by the program may appear very unrealistic (for example, a highly oscillating profile) although its M0 curve matches very closely to the measured one. In this case, it is necessary to manually update the profile until it looks more realistic while maintaining a comparable (or even improved) match between the two M0 curves. Second, due to the possible error at one or more data points in the measured M0 curve (that in turn may be a result of noisy data or analysis error), the inversion process can sometimes generate an unrealistic Vs profile in response to the searching algorithm trying to find a solution that satisfies all data points in the input M0 curve as much as possible. Again, in this case, it will be necessary to manually update the profile, possibly followed by another automatic inversion after the update. Whenever either or both of these two possibilities are suspected, another round of inversion will be necessary that should start with the manual update of the profile by using the computer mouse. The risk of the non-uniqueness issue in inversion will be significantly reduced if the manual update is followed by another execution of the automatic inversion that will use the updated profile as the initial velocity model. Extending the degree of freedom in inversion variables by choosing the 'Variable Depth' option can significantly improve the effectiveness of the new searching process. General description of this part of the analysis can be found in the PS User Guide "Inversion (1-D Profile)."

Processing "Vs1DMASW.dat"

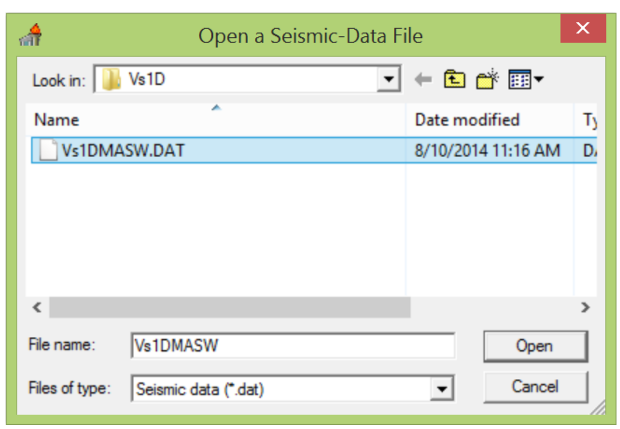
The entire data-processing procedure with the sample data set "Vs1DMASW.DAT" is demonstrated. A yellow arrow  in the figure indicates a mouse click on the selected place, and a red arrow  indicates places and items that need attention.

Step 1: Source/Receiver (SR) Setup

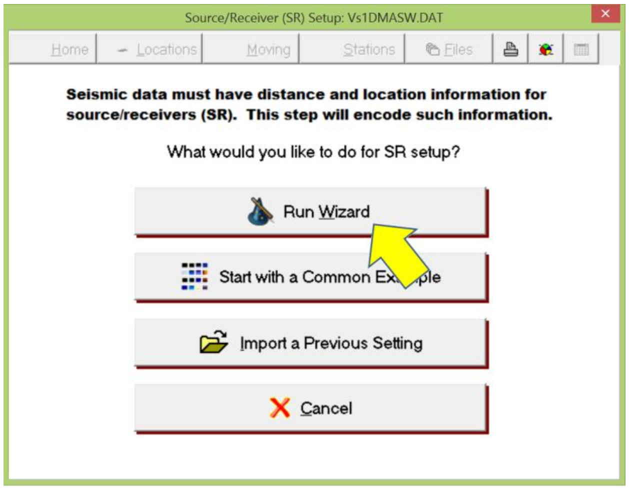
From main menu, "Setup Source/Receiver (SR)" → "From Formatted Seismic Data (*.dat)"



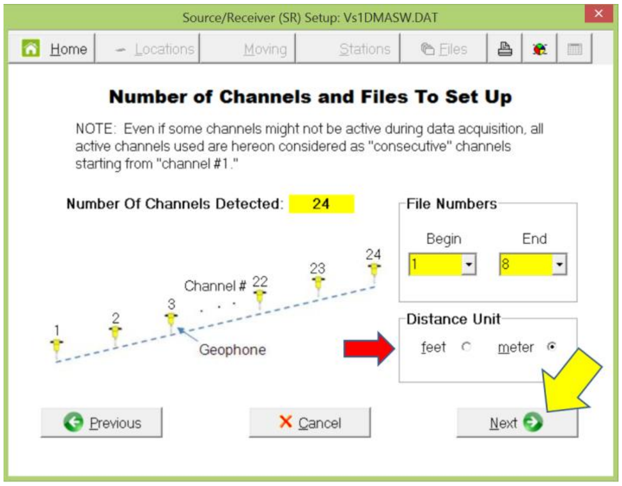
Open " Vs1DMASW.DAT."



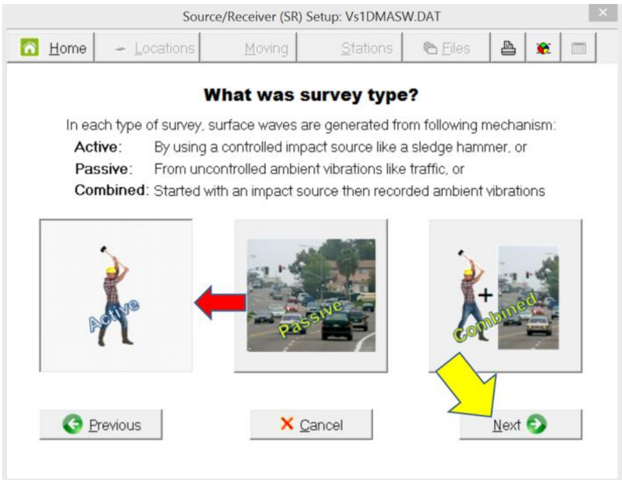
Select and click "Run Wizard" button.



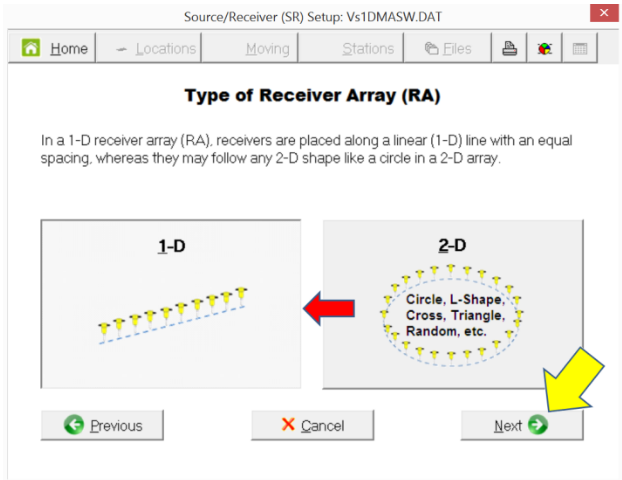
Check and select distance unit ("meter") and then click "Next" button.



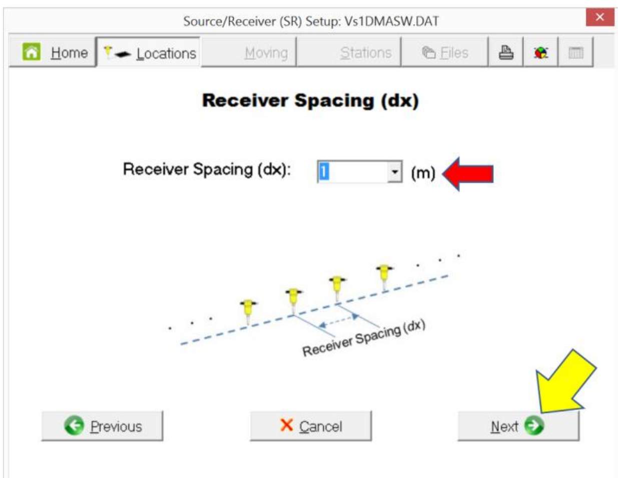
Select "Active" and then click "Next" button.



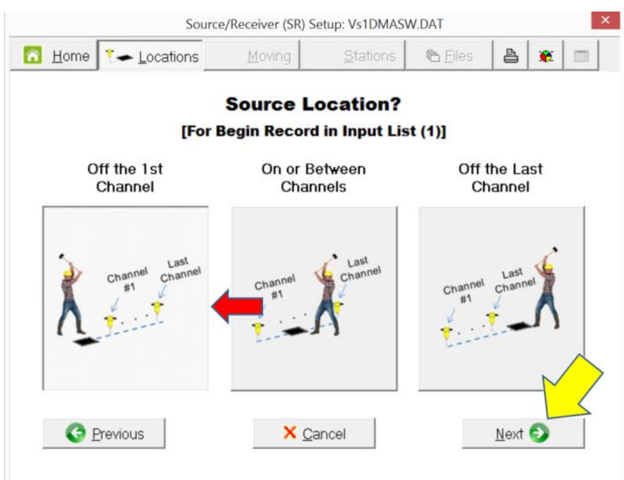
Select "1-D" and then click "Next" button.



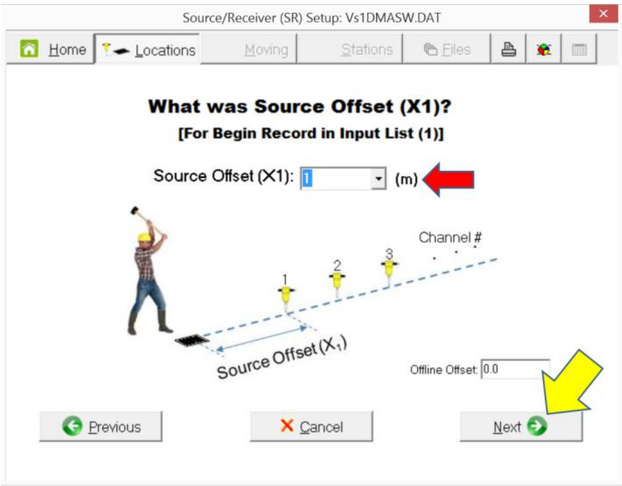
Enter "1.0" for receiver spacing and then click "Next" button.



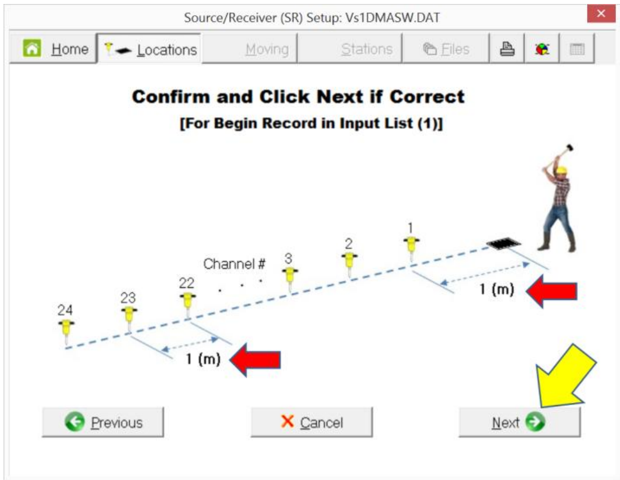
Select "Off the 1st Channel" and then click "Next" button.



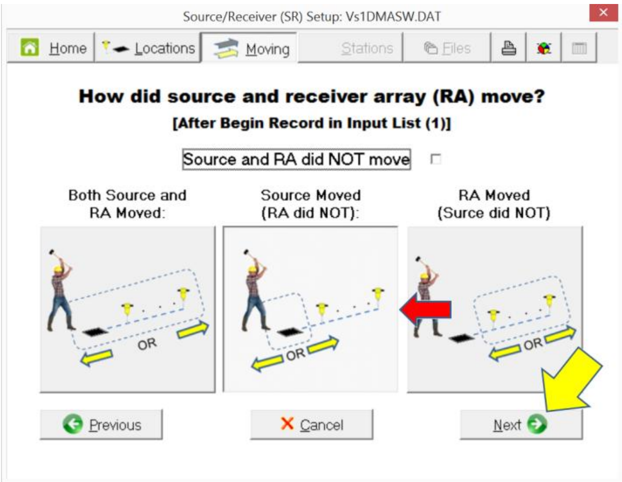
Enter "1.0" for source offset (X1) and then click "Next" button.



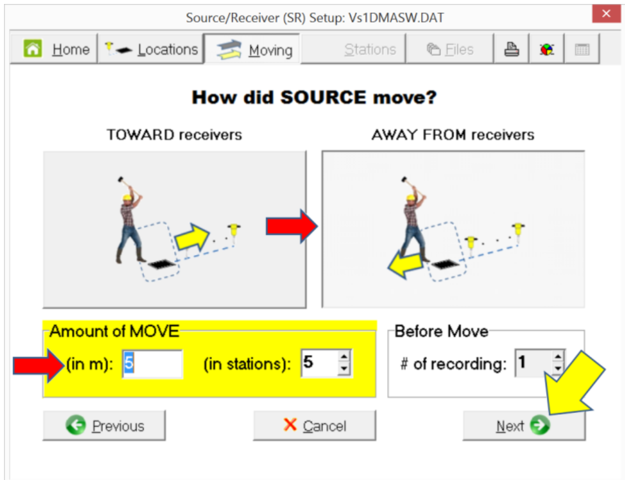
Check and confirm receiver spacing (dx) and source offset (X1). Then, click "Next" button.



Select "Source Moved (RA did NOT)" and then click "Next" button.

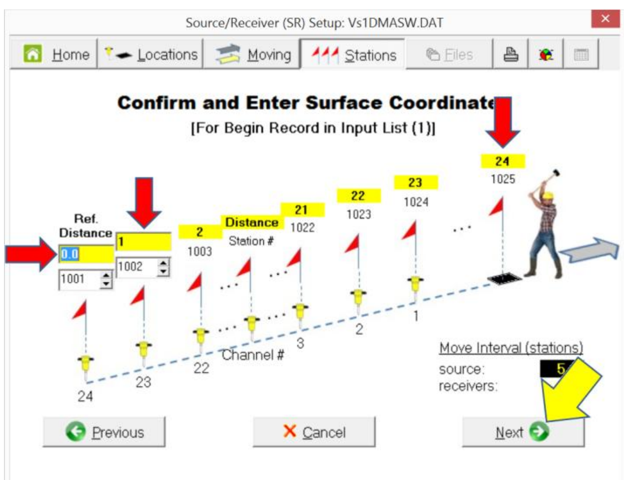


Enter "5" for Move Interval, and then click "Next" button.

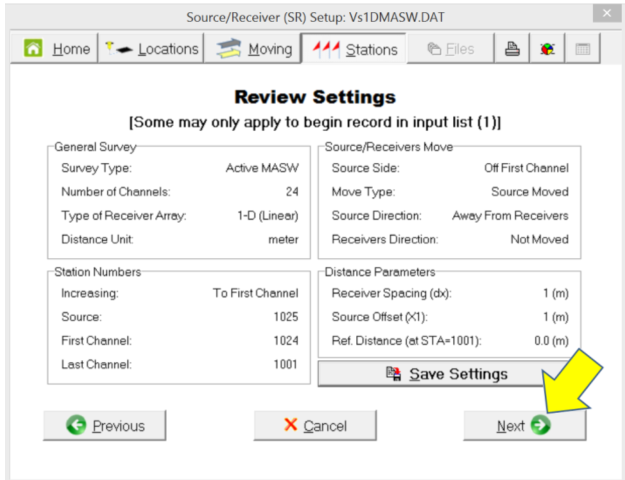


Enter "0.0" for "Ref. Distance" and then "1.0" for next distance.

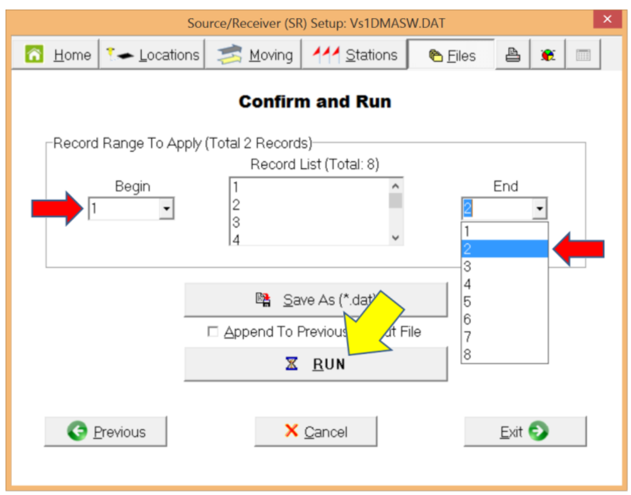
"Ref. Distance" is an arbitrary surface distance coordinate used as a reference point. Therefore, it can be any number. But, the distance for next channel should be offset (+ or -) by one receiver spacing (dx). Enter "1001" and "1002" for the station numbers for the first two channel positions. Then, click "Next" button. These are arbitrary "station" numbers that must be consecutive. The general convention for station numbering is "1001, 1002, etc." for line 1, and "2001, 2002, etc." for line 2, and so on. They can also decrease instead of increase.



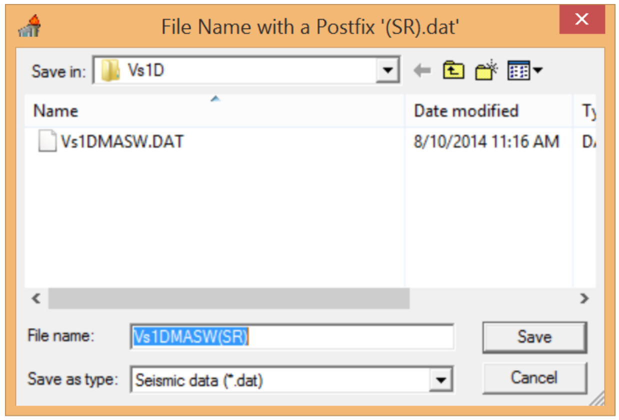
Review and click "Next" button.



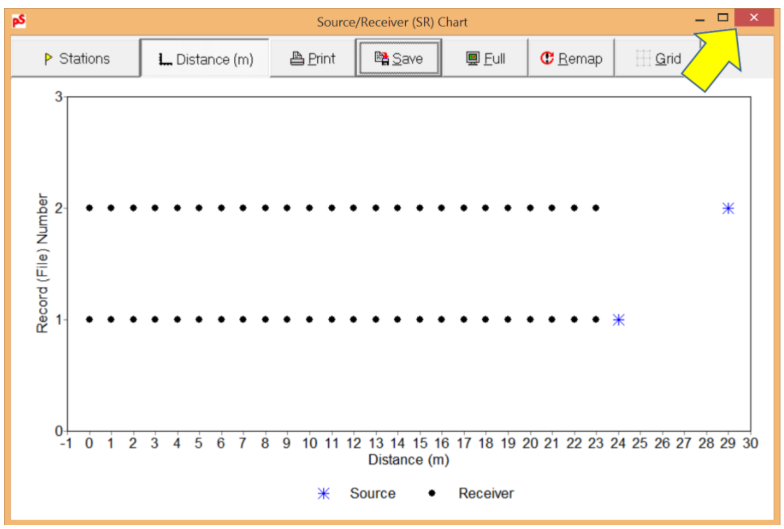
Make sure to specify begin and end record numbers correctly here. The previous specification of moving 5 meters (5dx) is valid only for the next record (2), and therefore the end record number should be '2'. The other records will be handled separately (two records at a time) after completion of these two records. Click "Run" to launch the SR setup process.



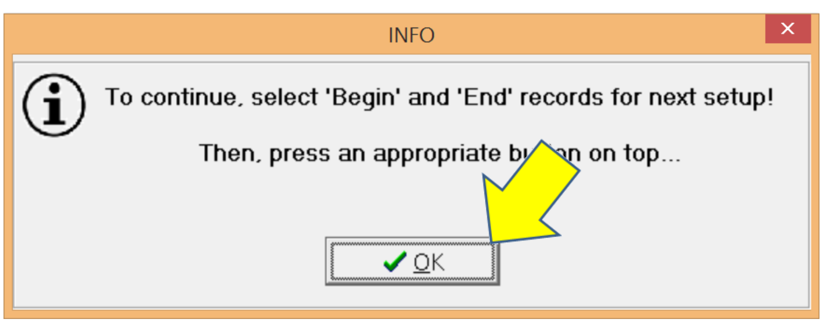
It will ask for output file name first. Default output file name is "Vs1DMASW(SR).DAT."



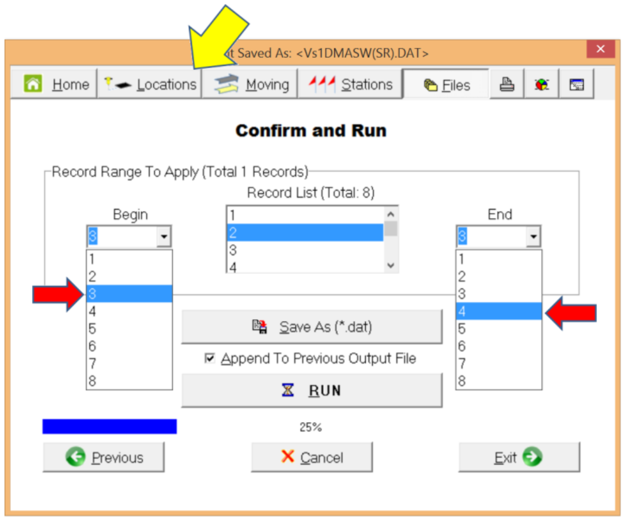
The source/receiver (SR) configuration chart will be displayed that shows relative location of source and receivers for the first two records (1 and 2). The configuration can also be displayed in "Stations" by clicking the button at the top. Close the chart.



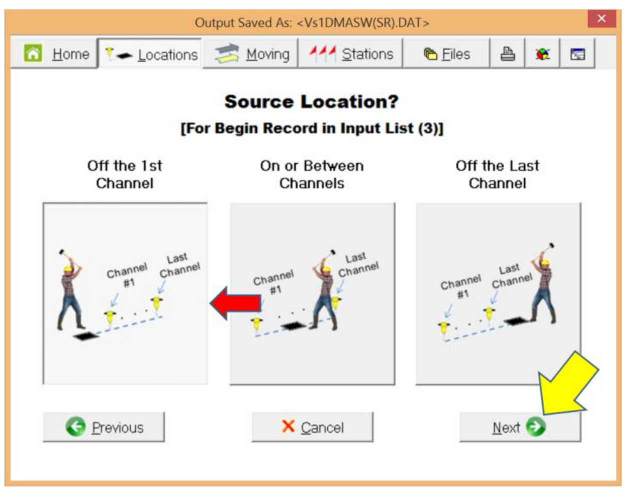
It is now time to set up SR for next two records (3 and 4). The box shown below reminds you of this.



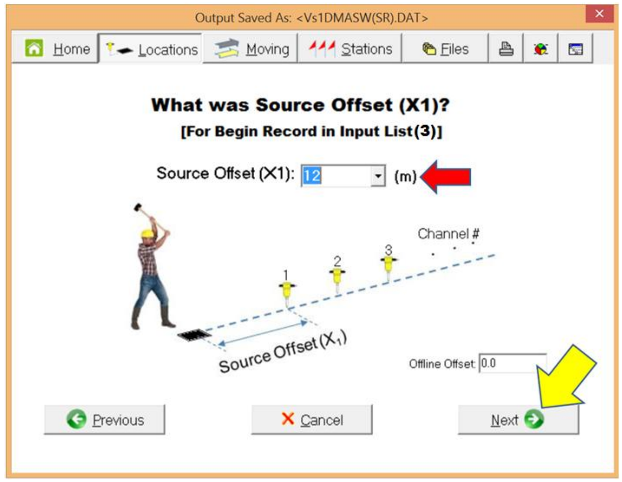
Select '3' and '4' for the begin and end records, respectively. Then, click 'Locations' button at the top.



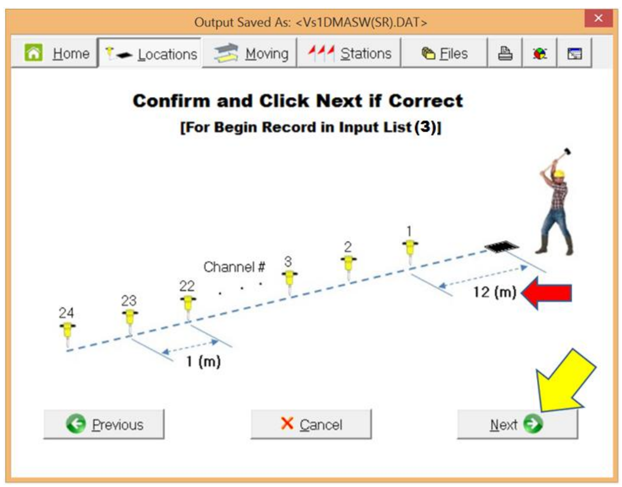
Make sure the "Off the 1st Channel" button is selected and then click "Next" button.



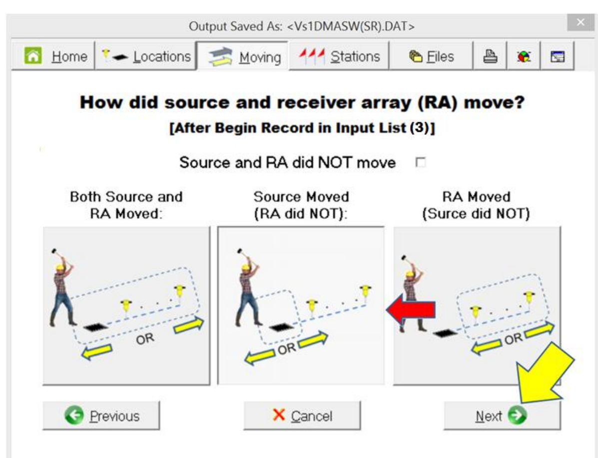
Enter '12' for source offset (X1) and then click 'Next' button.



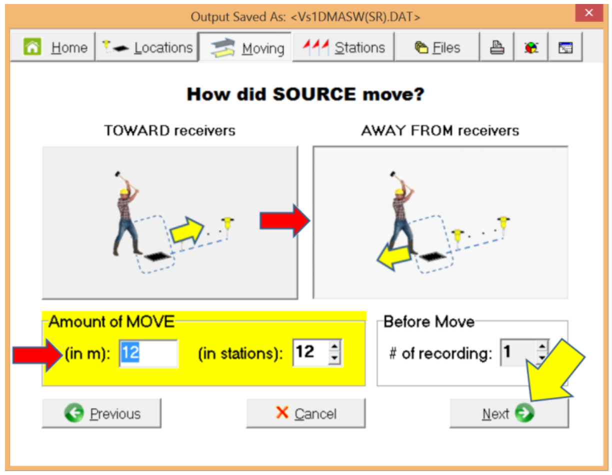
Check and confirm receiver spacing (dx) and source offset (X1). Then, click 'Next' button.



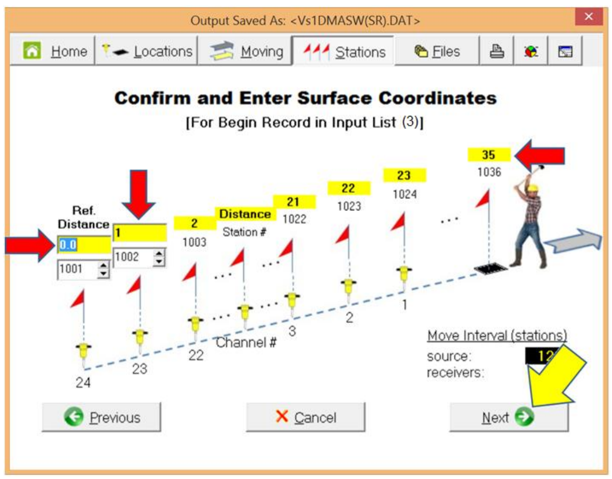
Make sure the 'Source Moved (RA did NOT)' button is selected and then click 'Next' button.



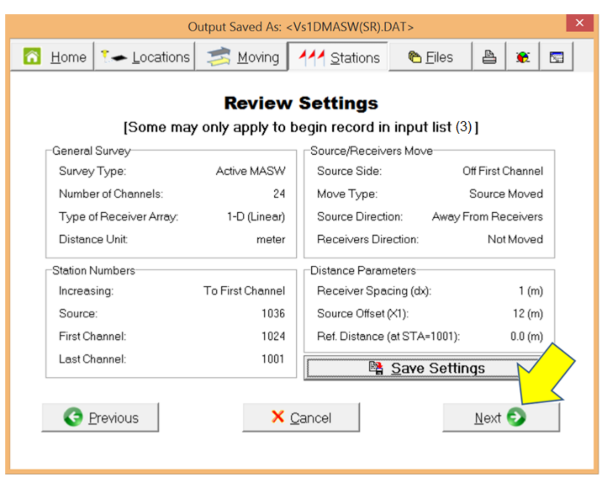
Enter '12' for Move Interval, and then click 'Next' button.



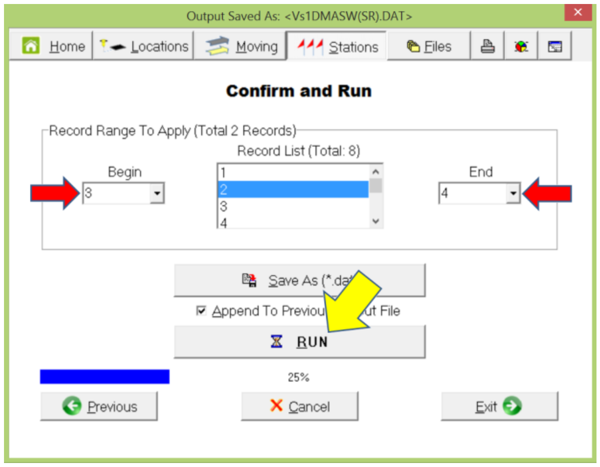
Make sure you use the same convention previously used for distance and station numbering; x = 0.0 m (station number = 1001) at 24th channel, and x = 1.0 m (station number = 1002) at 23rd channel, etc.



Review and click "Next" button.

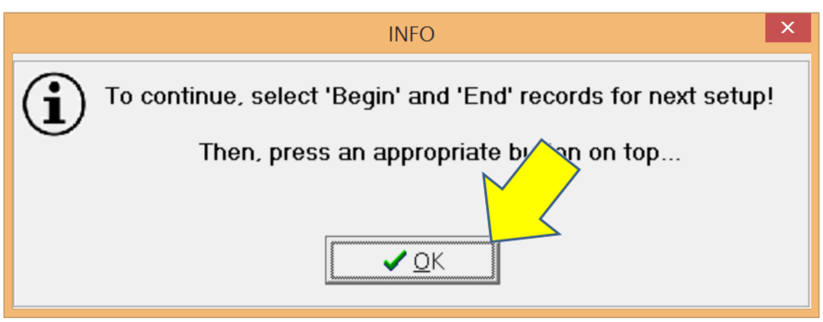


Make sure begin and end records are set to '3' and '4,' respectively. Then, click 'Run' button.

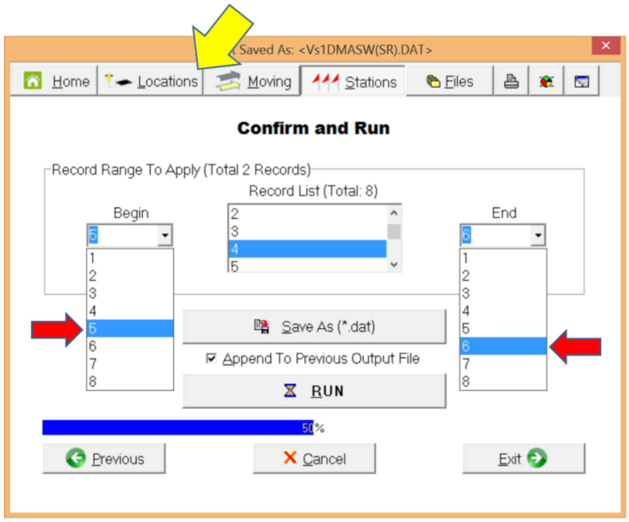


The source/receiver (SR) configuration chart will be displayed, showing the relative location of source and receivers for all records in the output file (1, 2, 3, and 4). Close the chart.

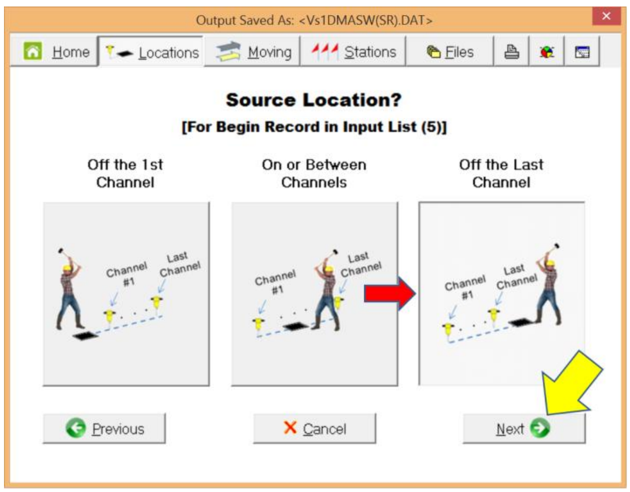
Now, it is time to setup SR for the next two records (5 and 6). The box shown below reminds you of this.



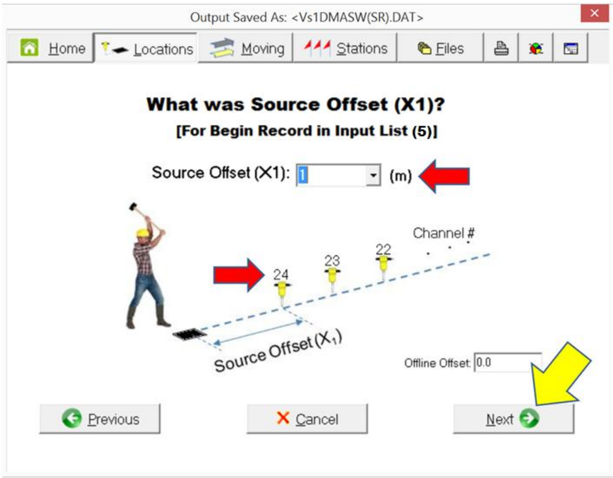
Select '5' and '6' for the begin and end records, respectively. Then, click 'Locations' button on top.



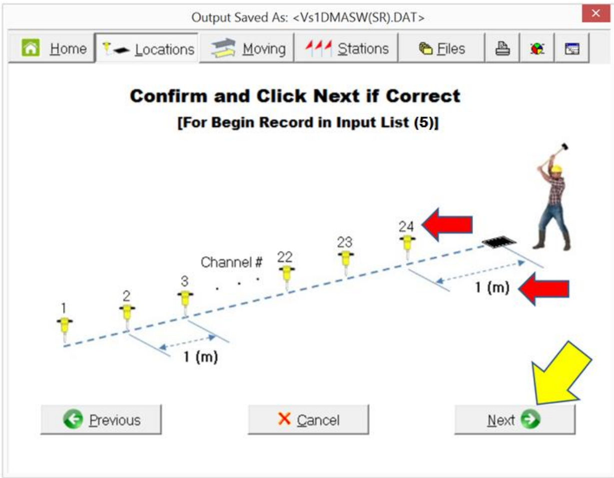
Now, make sure the "Off the Last Channel" button is selected because the two records were acquired with the source on the opposite side of receiver array (i.e., "reverse shots"). Click the "Next" button.



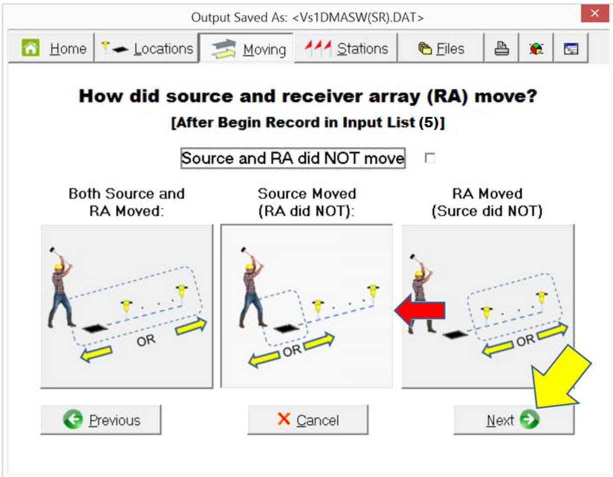
Confirm source location and enter "1" for the source offset (X1). Click "Next" button.



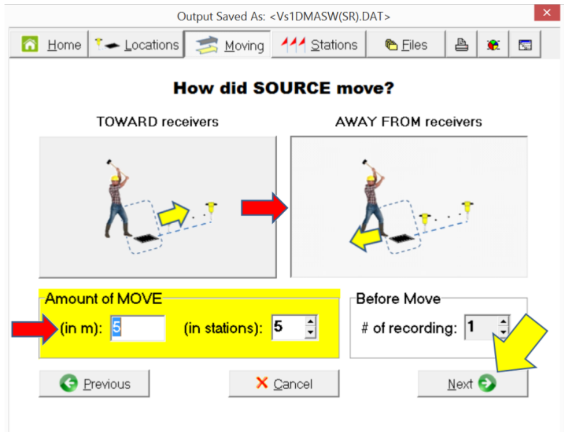
Confirm receiver spacing (dx) and source offset (X1). Click "Next" button.



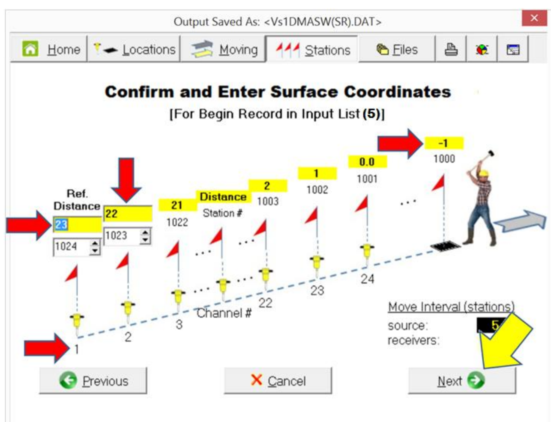
Make sure "Source Moved (RA did NOT)" button is selected. Click "Next" button.



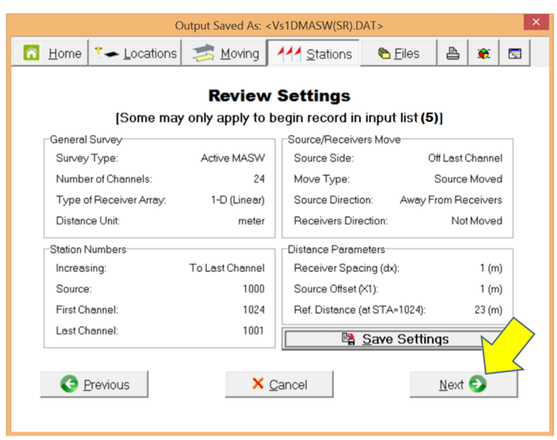
Enter "5" for the move Interval, and then click "Next" button.



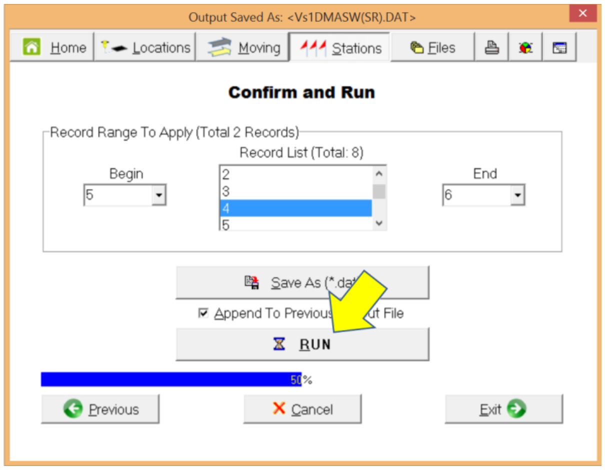
Make sure you use the same convention previously used for distance and station numbering; x = 0.0 m (station number = 1001) at 24th channel, and x = 1.0 m (station number = 1002) at 23rd channel, etc. Now, displayed configuration requires this information to be set for the first two channels (1st and 2nd). Therefore, enter "23" ("1024") and "22" ("1023") for distance (station number) of the first two channels, respectively.



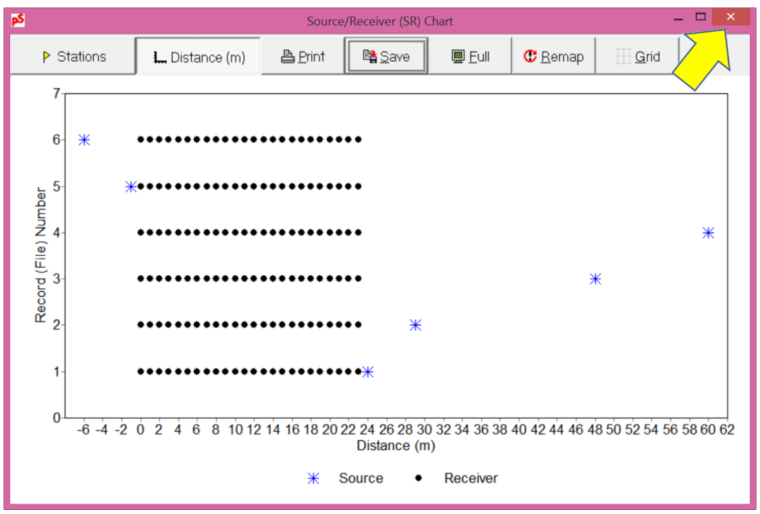
Review and click "Next" button.



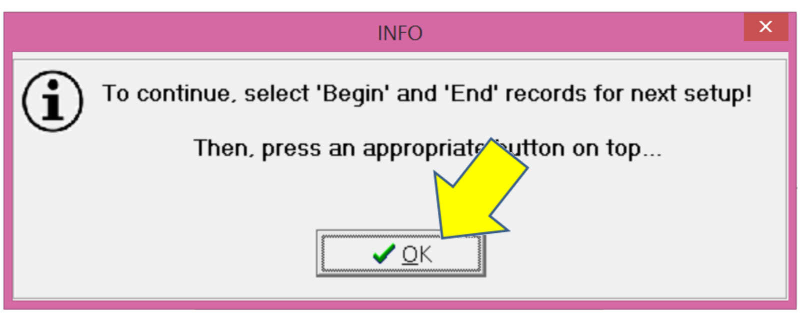
Make sure begin and end records are set to '5' and '6,' respectively. Then, click 'Run' button.



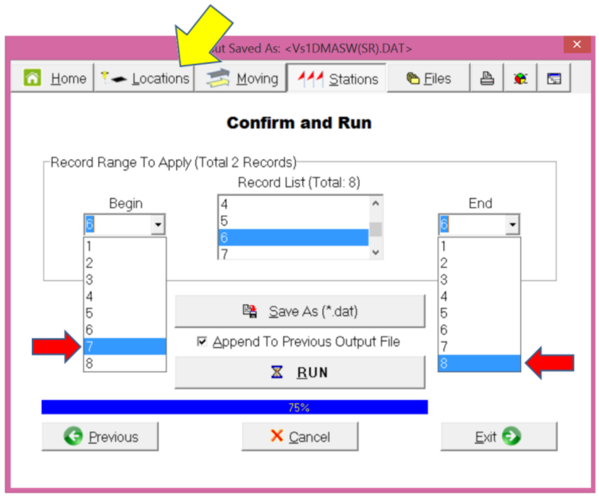
The source/receiver (SR) configuration chart will be displayed showing relative location of source and receivers for all records saved in the output file (1, 2, 3, 4, 5, and 6). Make sure the last two records (5 and 6) have the source located at a negative distance because they are "reverse" shots. Close the chart.



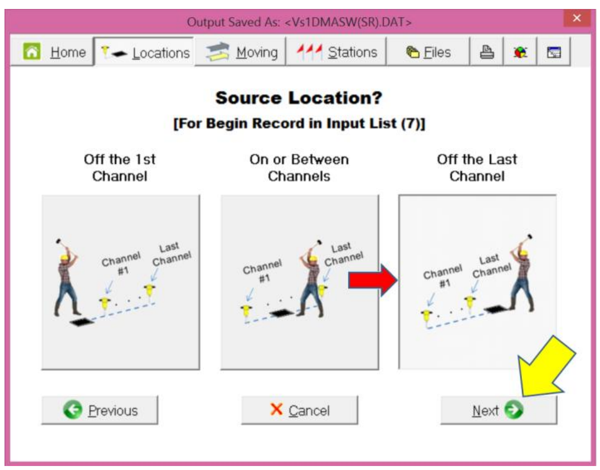
Now, it is time to setup SR for the last two records (7 and 8). The box shown below reminds you of this.



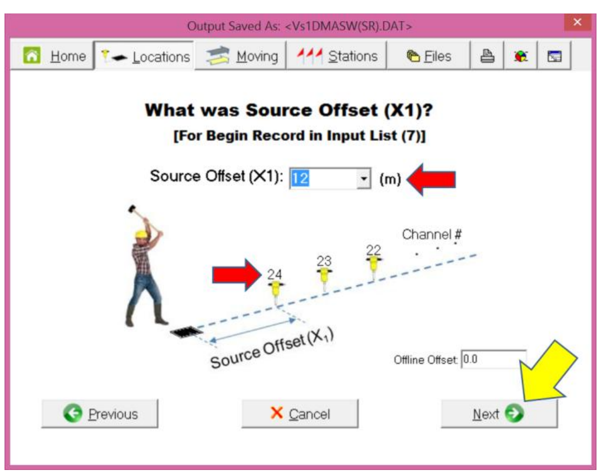
Select '7' and '8' for the begin and end records, respectively. Then, click 'Locations' button on top.



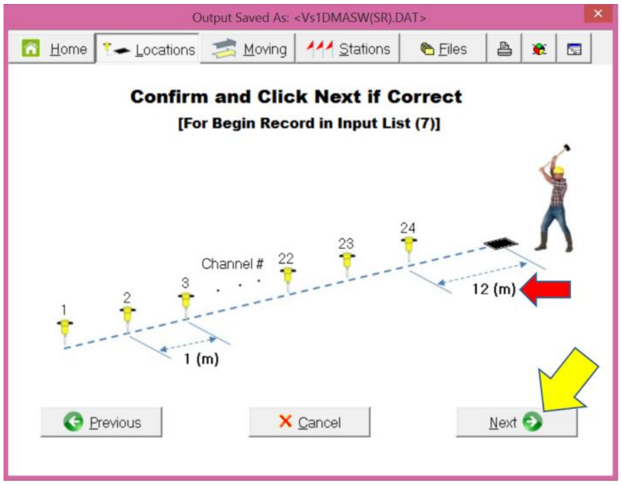
Make sure "Off the Last Channel" button is selected. Click "Next" button.



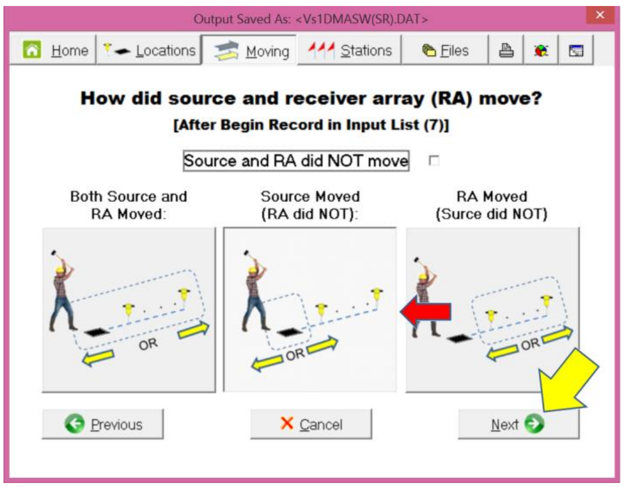
Confirm source location and enter "12" for the source offset (X1). Click "Next" button.



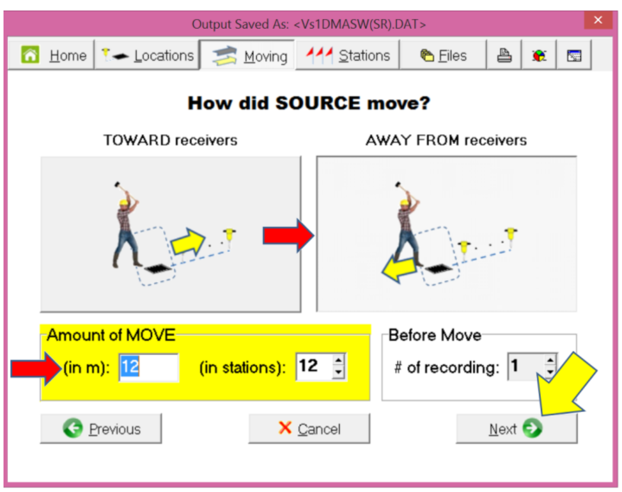
Confirm receiver spacing (dx) and source offset (X1). Click "Next" button.



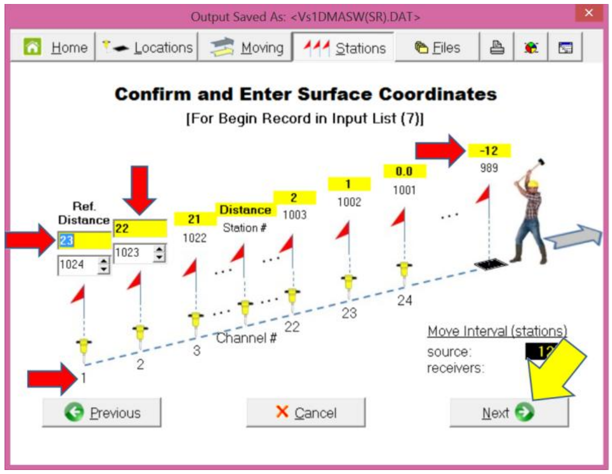
Make sure "Source Moved (RA did NOT)" button is selected. Click "Next" button.



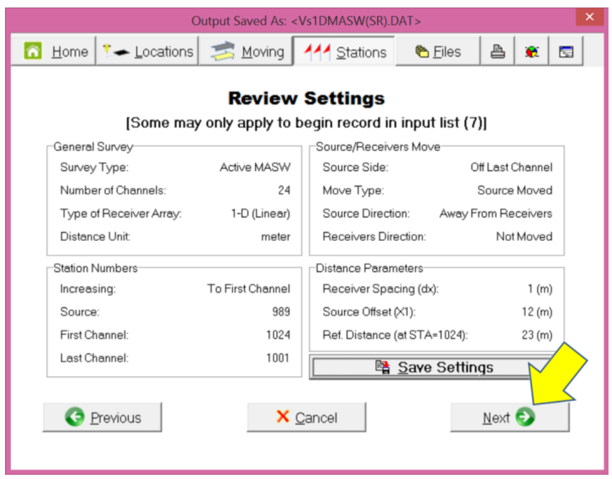
Enter "12" for the move Interval, and then click "Next" button.



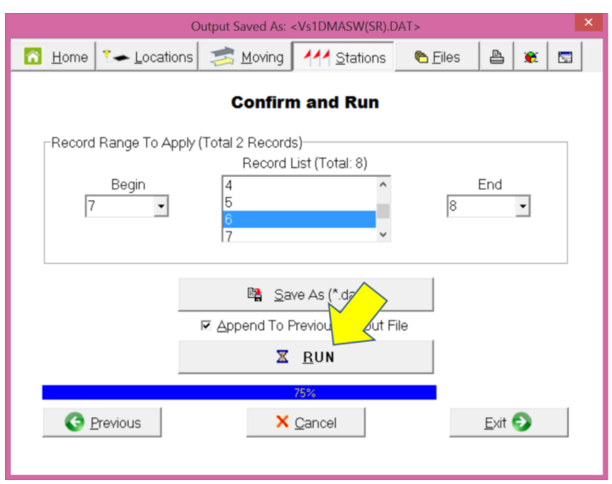
Make sure you use the same convention previously used for distance and station numbering; x = 23 m (station number = 1024) at 24th channel, and x = 22 m (station number = 1023) at 23rd channel, etc.



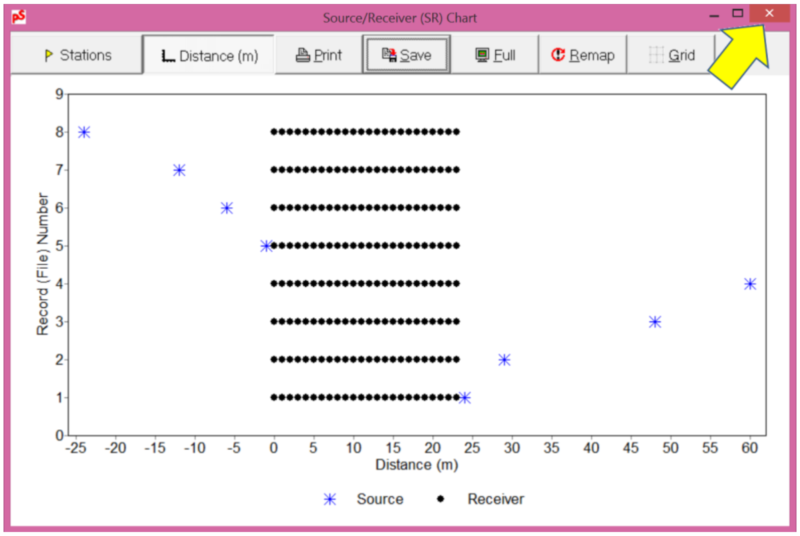
Review and click "Next" button.



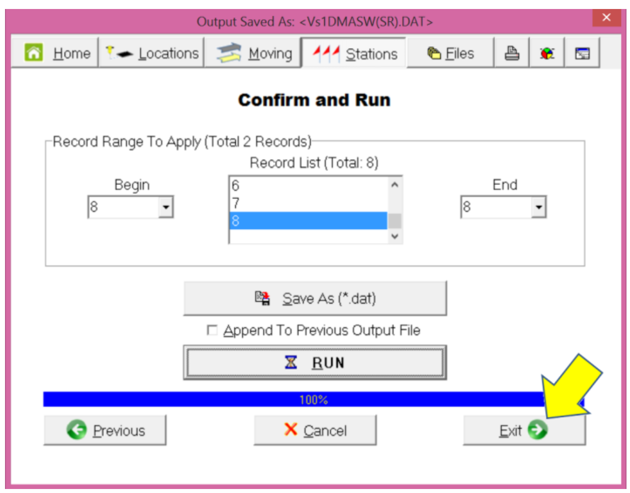
Make sure begin and end records are set to '7' and '8,' respectively. Then, click 'Run' button.



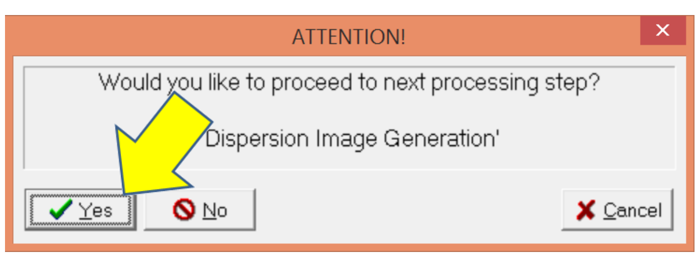
The source/receiver (SR) configuration chart will be displayed showing the relative location of source and receivers for all records saved in the output file (1 - 8). Close the chart.



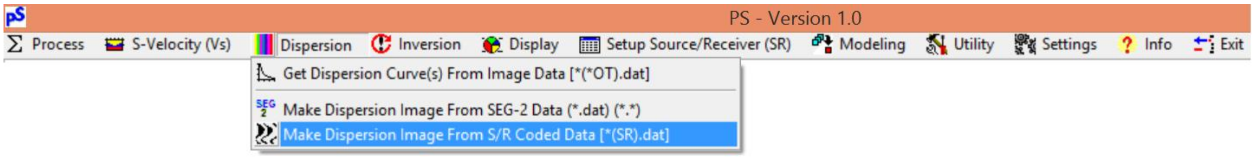
Now, SR setup is complete. Click "Next" button.



Click "Yes" to move to next step, "Dispersion Image Generation" (Step 2). The output file saved previously ["Vs1DMASW(SR).DAT"] will be automatically transferred to next step.



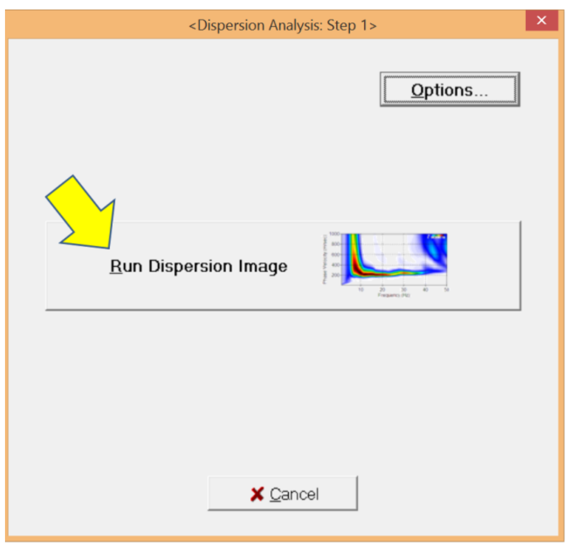
In case you need to manually import the SR-encoded file [*(SR).dat] to generate dispersion images, you can do so by going to "Dispersion" in the main menu, and then selecting "Make Dispersion Image From S/R Coded Data [*(SR).dat]" as shown below.



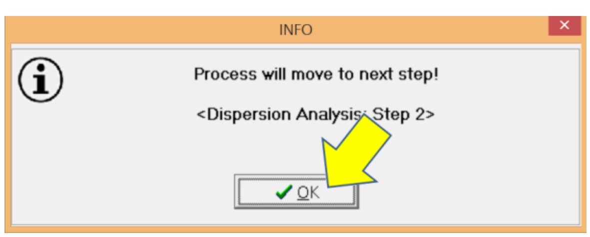
Step 2: Dispersion Imaging

The following dialog will be displayed at the beginning of this step. Although there are many control parameters that can be accessed by clicking the "Options..." button at the top, it is usually sufficient to proceed with default values determined by the program based on its own wavefield detection algorithm. Detailed description about this part of the analysis is provided in the PS User Guide "Dispersion Image Generation."

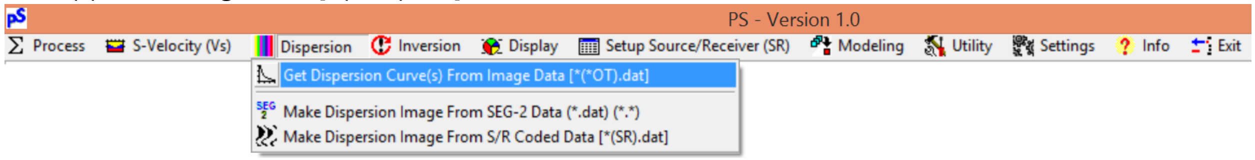
Click "Run Dispersion Image" to launch the process.



Once the process is complete, the output file of dispersion image data will be saved as "Vs1DMASW(ActiveOT).dat" and will be automatically transferred to next step (Step 3: Dispersion Curve Extraction) when you click "OK" button.

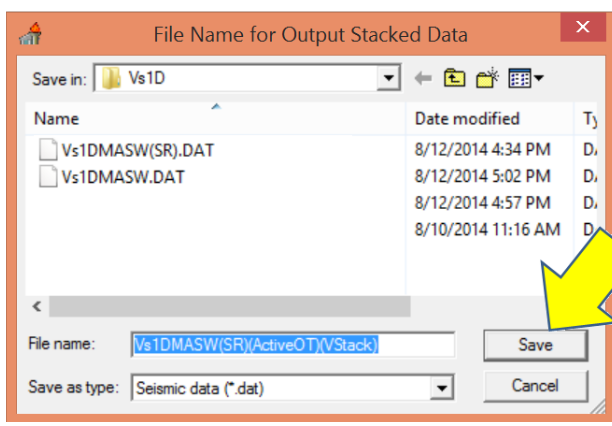


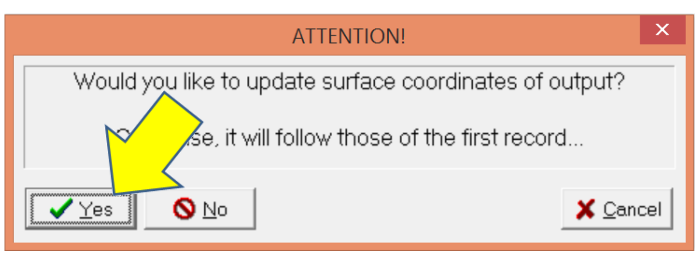
In case you need to manually import the dispersion image file [*(ActiveOT).dat] to extract dispersion curves, you can do so by going to "Dispersion" in the main menu, and then selecting "Get Dispersion Curve(s) From Image Data [*(*OT).dat] as shown below.



Step 3: Dispersion Curve Extraction

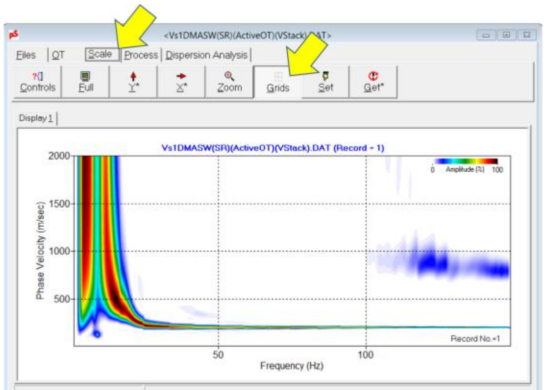
This step extracts and saves the fundamental-mode (M0) dispersion curve from the dispersion image generated in the previous step. Although there are eight (8) dispersion images generated, they all originated from the receiver array that stayed at the same surface location. Therefore at the beginning of this step, the program will ask to stack all of them to make one stacked image. Click "Yes" and specify the output file name for the stacked image [*(ActiveOT)(VStack).dat]. Another dialog will ask how you want to handle the surface coordinate information of the stacked image such as source offset and locations. Click "Yes" to properly update them (i.e., average them). Description of this part of the analysis is presented in the PS User Guide "Dispersion Curve Extraction (1-D Profile)."

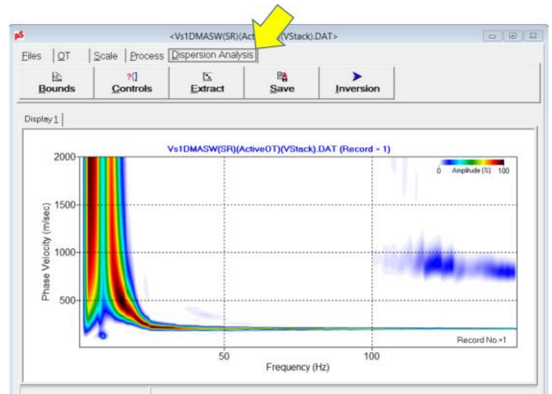




A chart showing the stacked dispersion image will be displayed with "Dispersion Analysis" tab chosen in the top tool panel. (This tab will not be available when this chart is used only for display purposes.) There are five (5) buttons in the tab arranged in the order of common use. Before proceeding to extract the fundamental-mode (M0) dispersion curve, first it will be necessary to make a proper interpretation of the displayed image. For that, it will be useful to draw grid lines on the image. Select "Scale" tab on the top tool panel and then select the "Grids" button. The image shows a coherent dispersion trend starting at about 15 Hz (almost appearing as a vertical streak) that rapidly becomes an asymptotic trend at frequencies higher than about 30 Hz. The vertical streak near the vertical axis is a computational artifact generated from the 2-D wavefield transformation that may or may not become significant depending on the spectral characteristics of surface waves as well as acquisition geometries. There is another weak asymptotic trend occurring at frequencies higher than about 120 Hz with a phase velocity approaching about 1000 m/sec. This type of pseudo-asymptotic trend occurring at relatively high frequencies (e.g., > 100 Hz) is usually associated with shear-wave refraction from the bedrock surface. The theory indicates the upper bound of this trend (~1000 m/sec) can be used as an approximation of the bedrock Vs. Then, it sets the upper bound in picking the M0 curve along the vertical trend near 15 Hz. Considering the theoretical relationship that phase velocity (Vphs) of surface wave is slightly less than Vs (e.g., Vphs ≈ 0.93Vs), the highest Vphs in the picked M0 curve should not exceed ~9300 m/sec.

Then, choose the "Dispersion Analysis" tab to come back to the process mode.

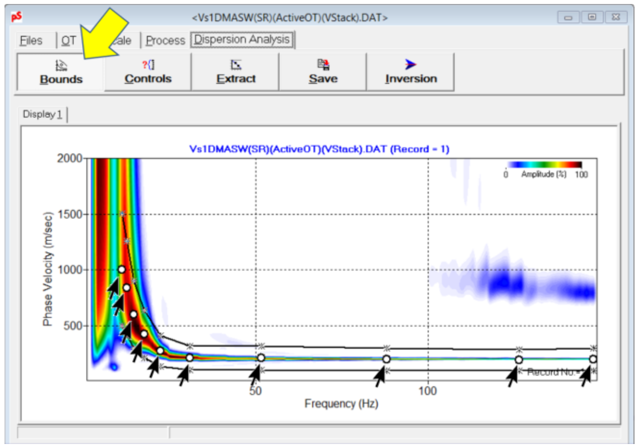




Detailed description of this part of the analysis is provided in the PS User Guide "[Dispersion Curve Extraction (1-D Profile)](#)."

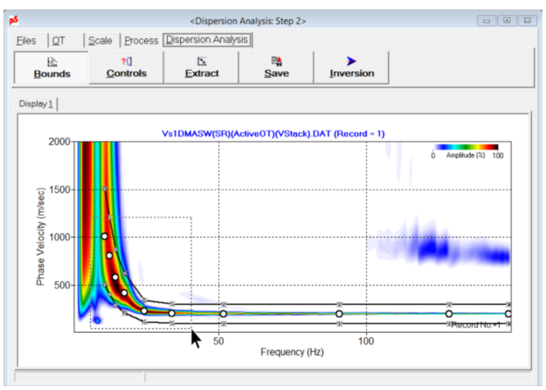
Step 3-1: Bounds

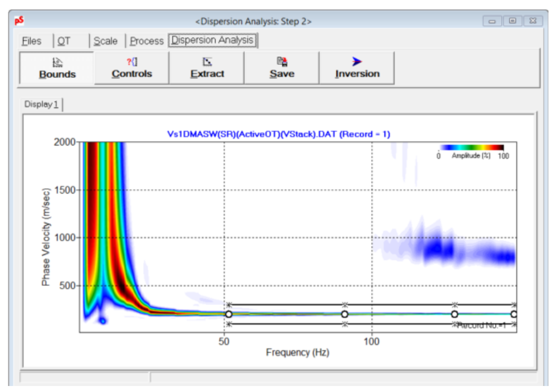
This is the step to set lower and upper bounds of phase velocities for the fundamental-mode dispersion curve to extract. Select the "Bounds" button and then click along the M0 trend to add reference points ("circles") with lower and upper bounds ("asterisks").



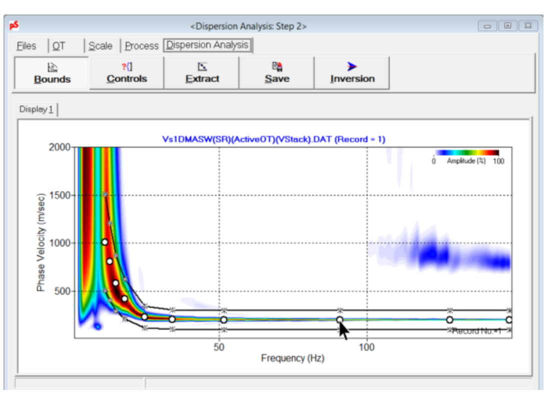
<Deleting Reference Points>

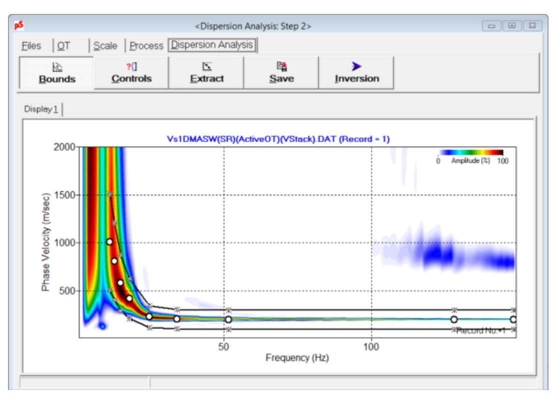
Drag and draw a zone to delete multiple points as illustrated below.





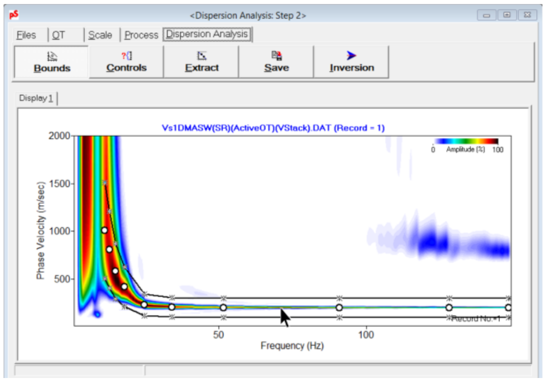
Or, click individual point to delete one by one as illustrated below.

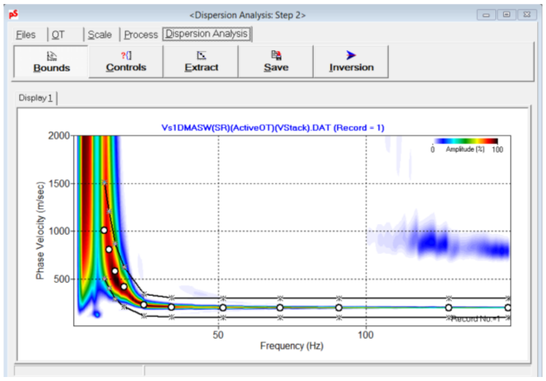




<Adding Reference Points>

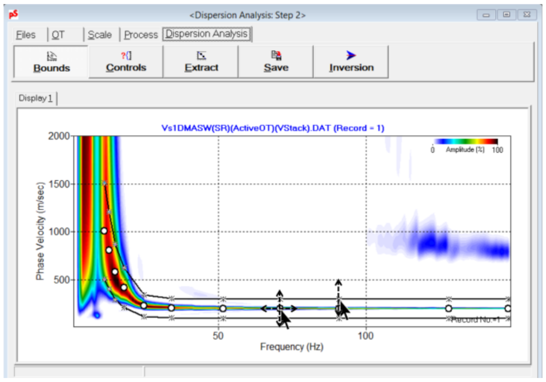
Reference points can be added anytime while the "Bounds" button is selected by clicking any place on the image as illustrated below.





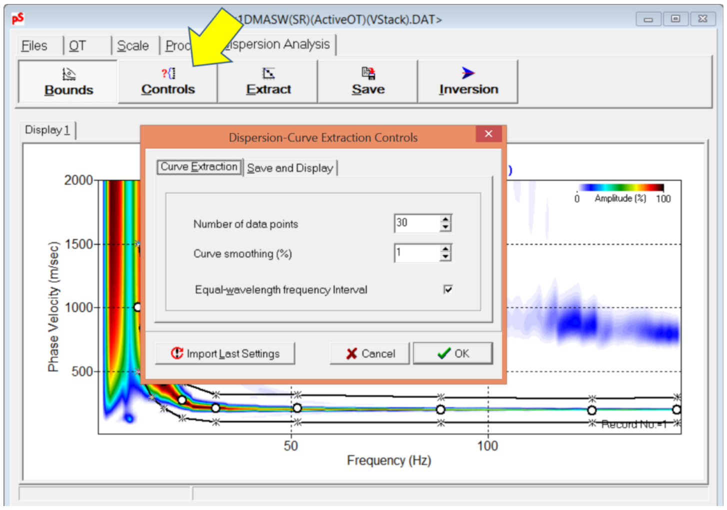
<Moving Reference and Bounds Points>

Reference points can be moved freely (up and down, left and right), whereas bounds points can be moved up and down only at the fixed horizontal location of the corresponding reference point.



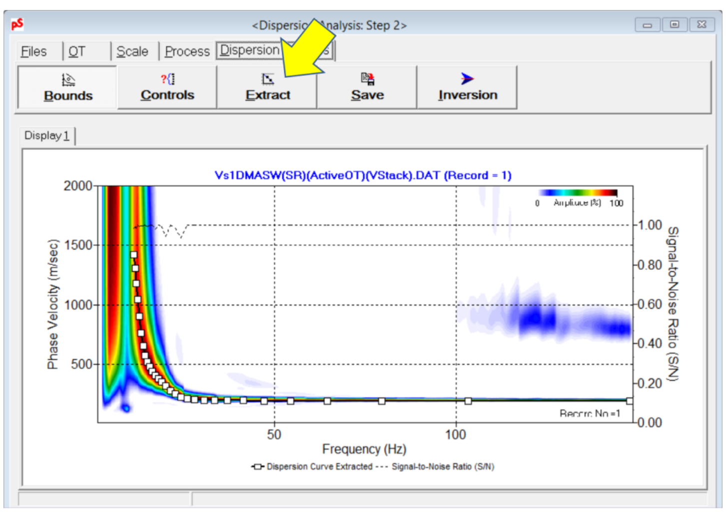
Step 3-2: Controls

Parameters related to the extracted dispersion curve can be controlled. Click "Controls" button to show the dialog of control parameters. Default values are usually sufficient.



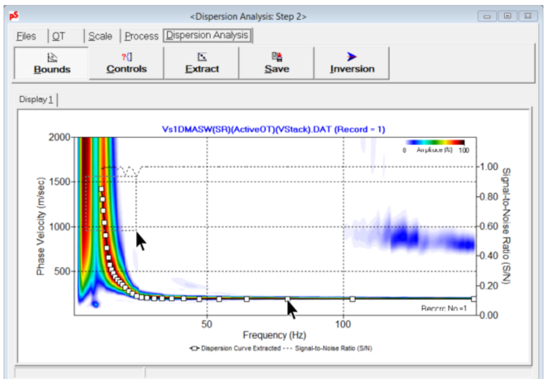
Step 3-3: Extract

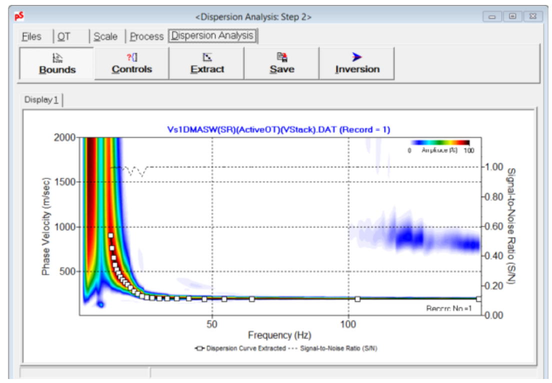
This step will extract the curve by picking data points of maximum amplitude at each frequency in the dispersion image. Click "Extract" button to display the extracted curve on top of the image.



<Editing Extracted Curve — Deleting Points>

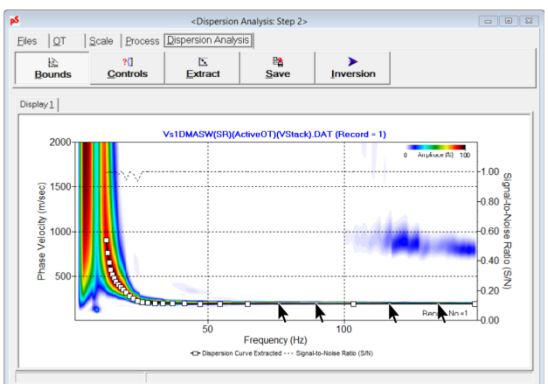
Drag and draw a zone to delete multiple points, or click individual points to delete one by one as illustrated below.

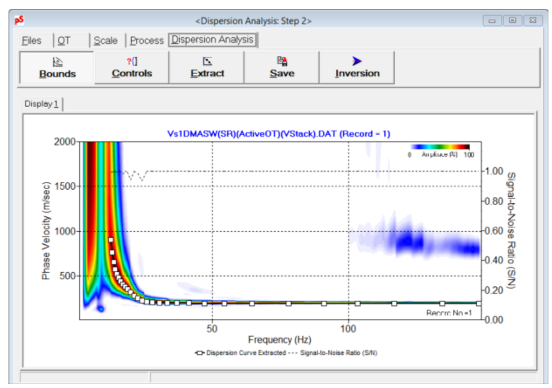




<Editing Extracted Curve — Adding Points>

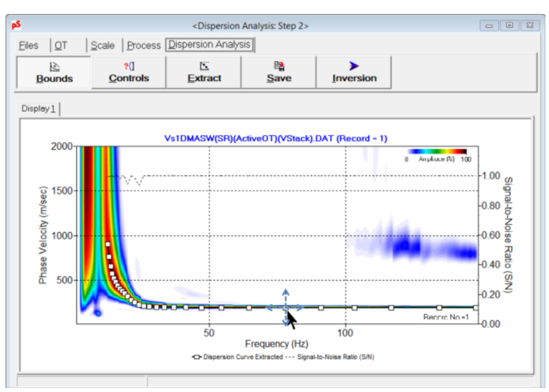
Click anyplace on the M0 trend to add points one by one as illustrated below. Corresponding points for SN will also be added by detecting the energy at the clicked points.





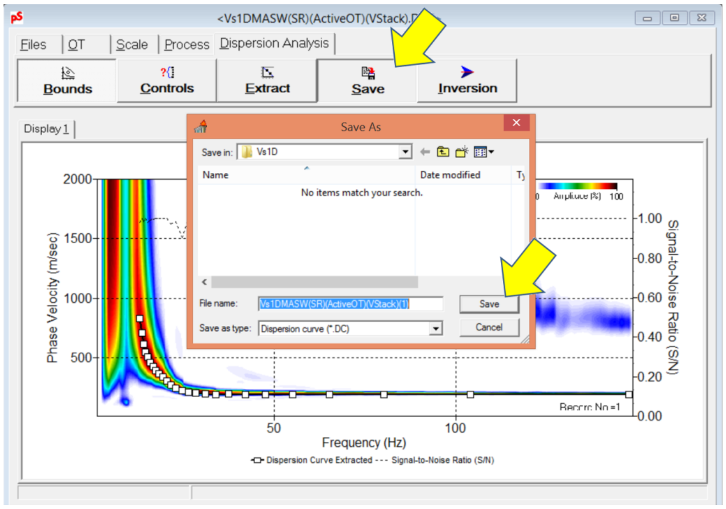
<Moving Data Points>

Data points in the extracted curve can be moved freely (up and down, left and right) as illustrated below.

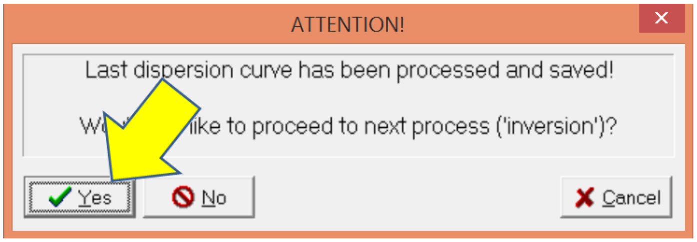


Step 3-4: Save

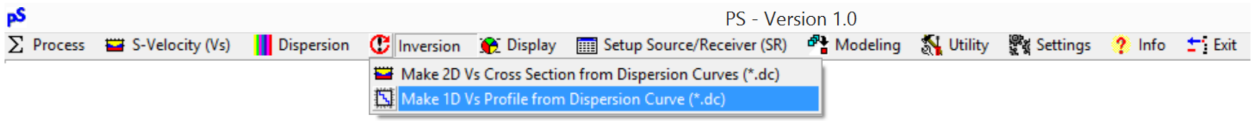
Click "Save" button to save extracted curve (*.DC). The default file name will have the record number attached at the end of output file name [e.g., *(1).DC].



The program will then ask you to proceed to the last step ("Step 4"). The previously saved M0 curve (*.DC) will be automatically transferred.



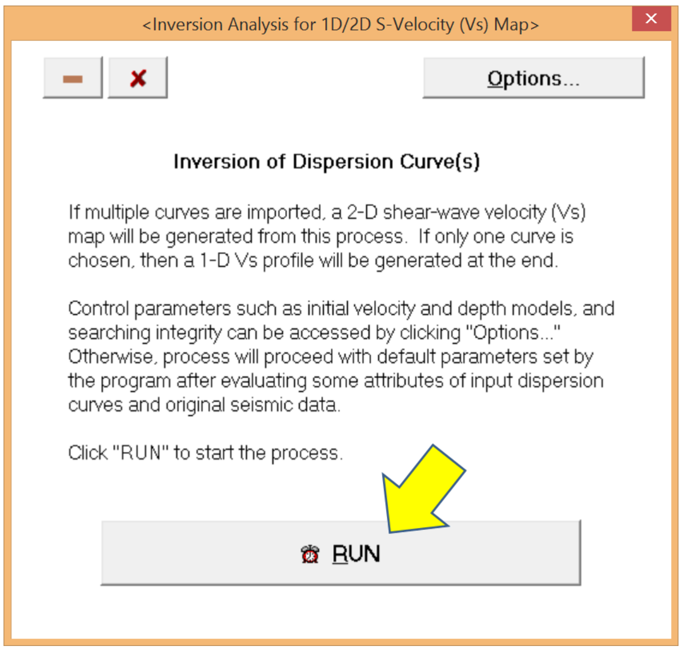
In case you need to manually import this dispersion curve, you can do so by going to "Inversion" in the main menu and then selecting "Make 1D Vs Profile from Dispersion Curve (*.dc)" as shown below.



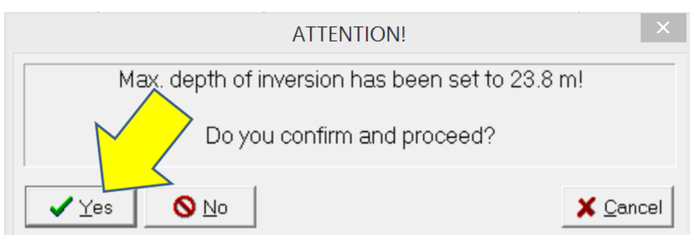
Step 4: Inversion (Automatic 1st Phase)

The following dialog will be displayed at the beginning of this step. Although there are many control parameters that can be accessed by clicking the "Options..." button at the top, it is usually sufficient to proceed with default values determined by the program based on the range of wavelengths in the input dispersion curve and also on the offset range used during data acquisition. For detailed information about this part of the analysis, refer to the PS User Guide "Inversion (1-D Profile)."

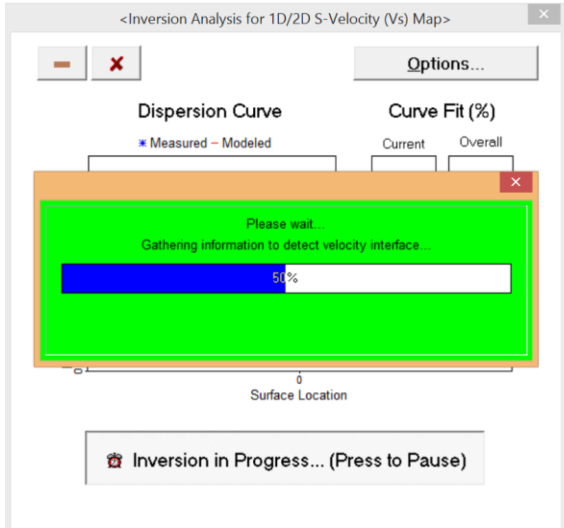
Click "Run" to launch the process.



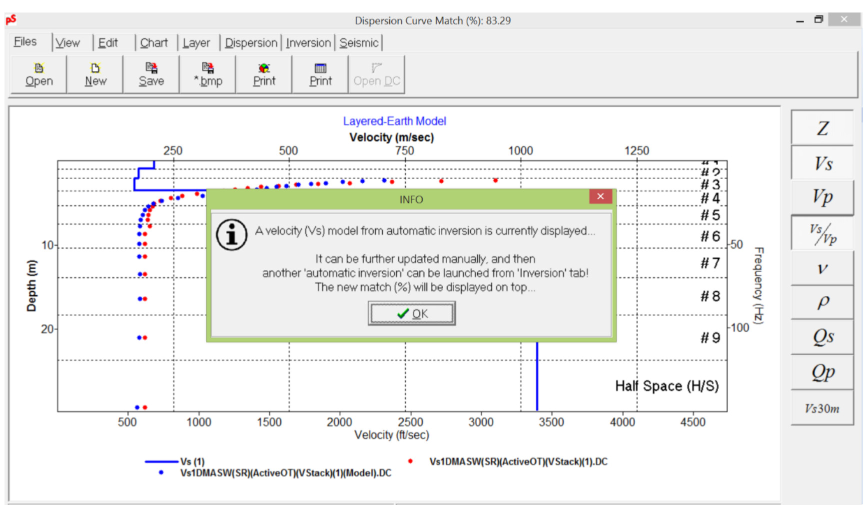
The following dialog will be displayed to confirm the maximum depth (Zmax) of the inversion that is originally determined by the program based on the average offset range used during data acquisition. This is one of the most important parameters in inversion process, directly related to the resolution of the final 1-D shear-wave velocity (Vs) profile. If you click "No", the program will display the relevant tab where you can adjust Zmax as well as other parameters. Otherwise, click "Yes."



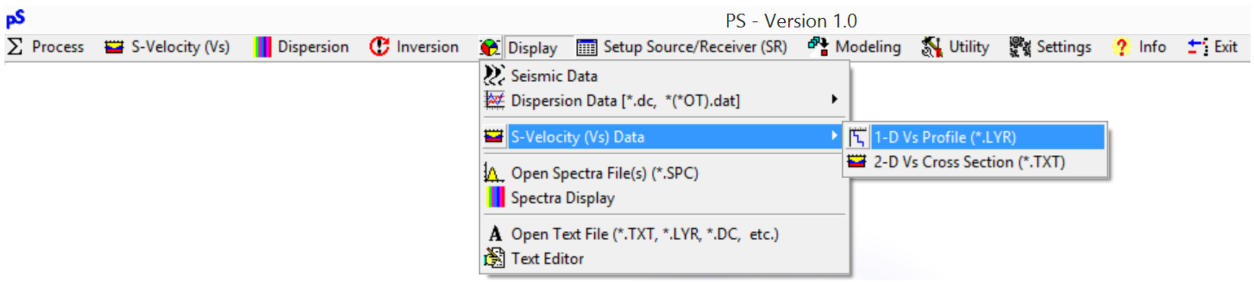
First, the process to determine the depth to the velocity (Vs) interface will take place. This is the depth where the most abrupt change in velocity occurs. This process is termed in the control diagram as "Bedrock Detection." The program then starts the process to search for detailed velocity variations.



The 1-D Vs profile, saved as a layered-earth model [*(1DVs).LYR], will be displayed automatically at the end of the inversion process in the dedicated module as shown below. The two dispersion curves of measured and modeled M0 curves are also displayed to indicate the match between them with one of the two vertical axes of the chart represent frequency of the curve. The match (%) is indicated in the title bar of the display window. It is the velocity (Vs) model found automatically by the program without user's intervention based on its own searching algorithm, and is usually sufficient to dictate the reality. This completes the entire procedure to generate a 1-D Vs profile.



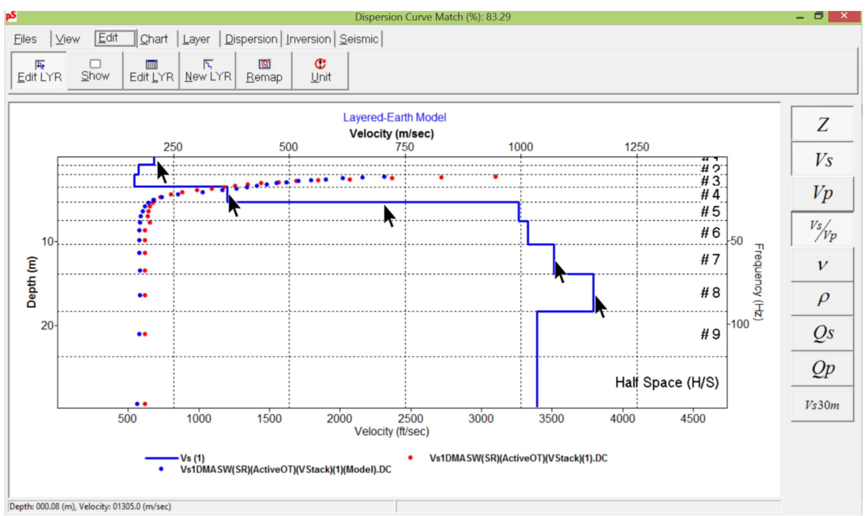
In case you need to display this output file [*(1DVs).LYR], you can do so by going to "Display" → "S-Velocity (Vs) Data" → "1-D Vs Profile (*.LYR)" under the main menu as illustrated below.



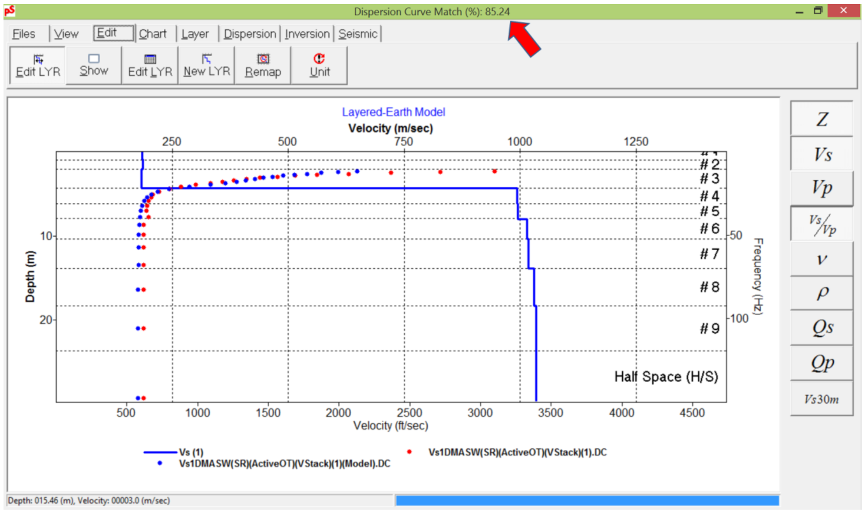
Step 5: Inversion (Optional 2nd Phase)

However, it is often beneficial to attempt one or more passes of the inversion process through a manual searching process followed by another automatic inversion process. This can often lead to finding a profile whose M0 curve matches the measured curve even better and/or a profile that appears more realistic. The module displaying the inversion output of the 1-D Vs profile has all the functions ready for this purpose. For example, the individual layer can be changed in its velocity and thickness by the click-and-drag motion of mouse toward either horizontal (velocity) or vertical (thickness) direction. If you do so, the displayed model dispersion curve [*(Model).DC] will be updated accordingly, with the new match (%) indicated in the title bar of the display window. For detailed information about this part of the analysis, refer to the PS User Guide "Inversion (1-D Profile)."

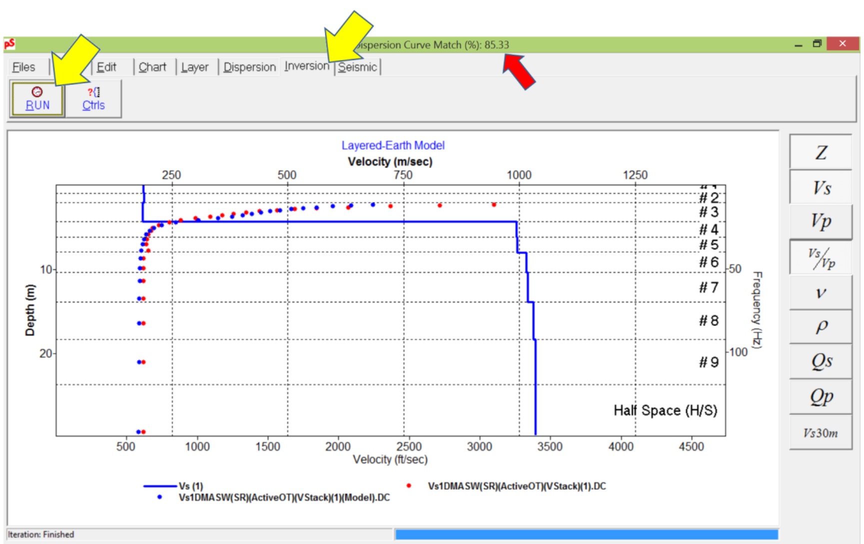
The example below illustrates that several layers are changed in velocity (Vs) by using the click-and-drag motions of the mouse so that the overall profile may look more realistic.



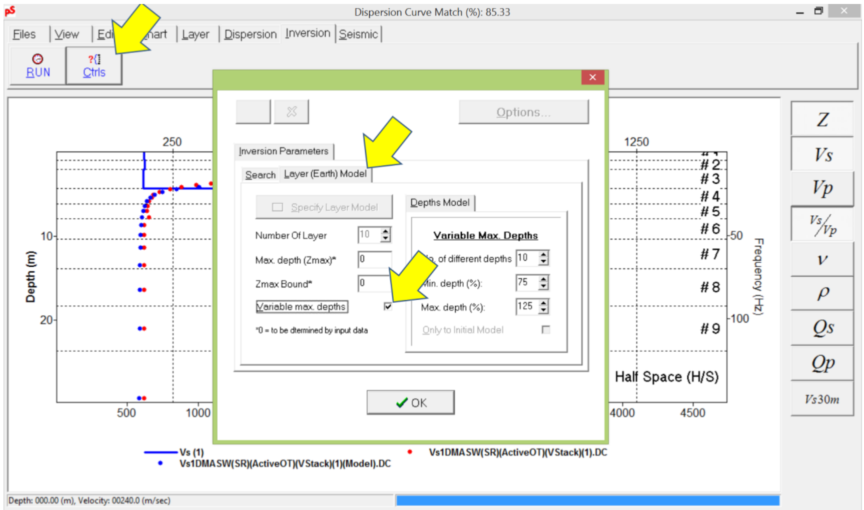
The window title bar shows the match improved, indicating that the manual update was successful.



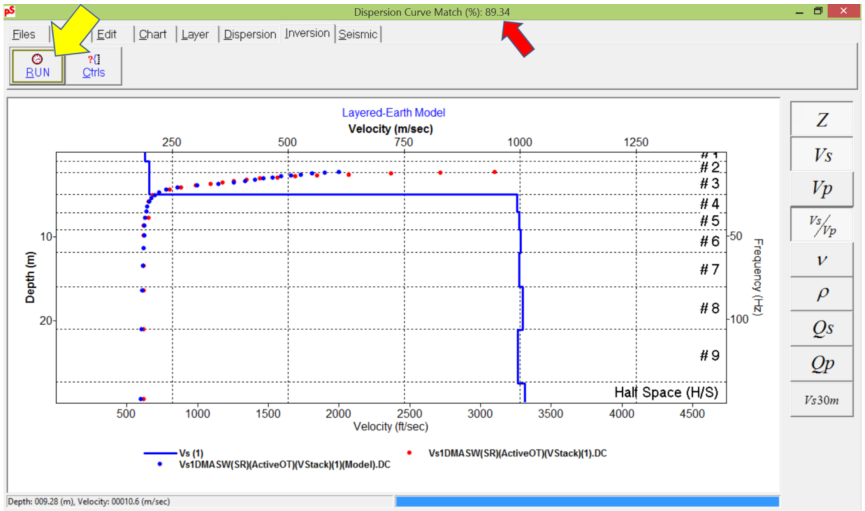
Now, because the "initial" velocity model has been slightly updated, another automatic inversion may find a "further improved" velocity profile. So, it is now suggested to run it again by selecting the "Inversion" tab on the menu panel, and then clicking the "RUN" button as illustrated below. The new match (85.33 %) now shows a little improvement. This is usually the case if the new automatic inversion process could not find another model significantly different from the current one that maintains comparable or an improved match in M0 curves.



It is also worthwhile to try to introduce another degree of freedom in the process by choosing the option of "Variable max. depths" as illustrated below. PS will then execute the automatic inversion process for as many different depth models as selected (e.g., 10) that are created by either contracting (< 100 %) or stretching (> 100%) the current velocity model. The example illustrated below indicates that the process will examine ten (10) different initial models within 75% - 125% of the current velocity model. From the search with all these different models, the program will show at the end the model that has the best (i.e., highest) match.



Click the "Run" button to perform this "Variable max. depths" inversion. After a while, the final solution of a velocity model will be displayed. The example below indicates the match improved noticeably from 85.33% to 89.34%. Above all, the profile looks quite realistic.



Now may be the time to save it as the final solution.