

COMPUTER PROGRAM MANUAL  
(SURVEY DATA REDUCTION MANUAL)

# DAT38-4

Version 1.24

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# 1. Introduction

Survey data reduction program DAT38-4 for Geonics EM38-4 ground conductivity meter data operates under MS Windows 10/7, and later. DAT38-4 supports EM38-4 data files which include Global Positioning System (GPS) data recorded directly in the Mesa2, Mesa3 or similar MS Windows 10 based field computer) logger operating under the control of program EM38-4.

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## 1.1 About DAT38-4

The program DAT38-4 is designed to process data collected in the field computer using data acquisition program EM38-4. The program can be used to display, edit, re-calculate inversion, and print data files. Data can be plotted on any printer supported by Windows. There is also an option to create XYZ files that can be used as input for the GEOSOFT or SURFER contouring packages, or any other contour software, if three or more columns are required, then the [X, Y, data1, data2, data3, ...] format is suitable.

This Windows based version of DAT38-4 provides an easy interface and information on the screen. The amount of readings are limited only by the capacity of a computer hard drive. It supports any printer or plotter that is supported by Windows.

EM38-4 readings are arranged in profile lines. Every profile line can consist of unlimited number of readings. Each profile line can contain up to 15 separate profiles: eight Quadrature (Conductivity) and Inphase components for each EM38-4 coil separations 0.5 m, 0.75 m, 0.88 m, and 1.00 m (labeled in the program correspondingly as Coil #1, Coil #2, Coil #3, and Coil #4), two for temperature sensors (Temperature #1, Temperature #2), and three for optional real time or re-calculated inversion results (Thickness, Conductivity for Layer #1, and Conductivity for Layer #2). Note that the Quadrature component is generally referred to as Conductivity in this manual.

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## 1.2 Contents of DAT38-4 Distribution Disk

Program DAT38-4 is supplied on one USB memory module, CD disk, it can be also downloaded from the Geonics web site. USB or CD disk contains following files and directories:

- SetupDAT38-4.exe - setup program for DAT38-4.
- Documentation - directory containing manuals available in PDF format
- SetupEM38-4.exe - setup for data acquisition program for the field computer

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## 1.3 DAT38-4 Software Installation

DAT38-4 uses setup program to load files on your computer. The following section describes the installation process.

To install DAT38-4 insert the DAT38-4 CD disk or USB drive into computer. Exit all Windows applications before installing the program.

In Windows Explorer Browse for the file SetupDAT38-4.exe in the CD folder or in any other location if the file was downloaded (Figure 1.1) and double click to launch the Setup program.

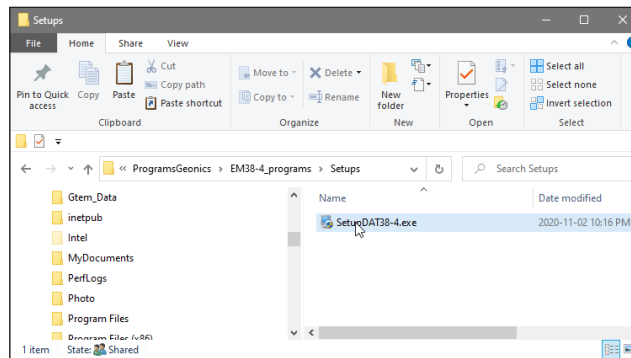


Figure 1.1 Starting setup program

Once the Setup determines your computer configuration the Welcome window opens (Figure 1.2).

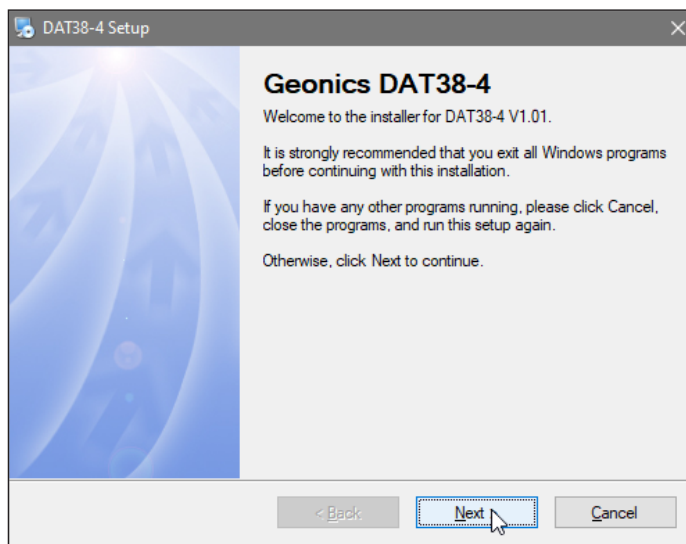


Figure 1.2 Welcome window

Read the text and click the **N**ext button and the Serial Number window opens (Figure 1.3).

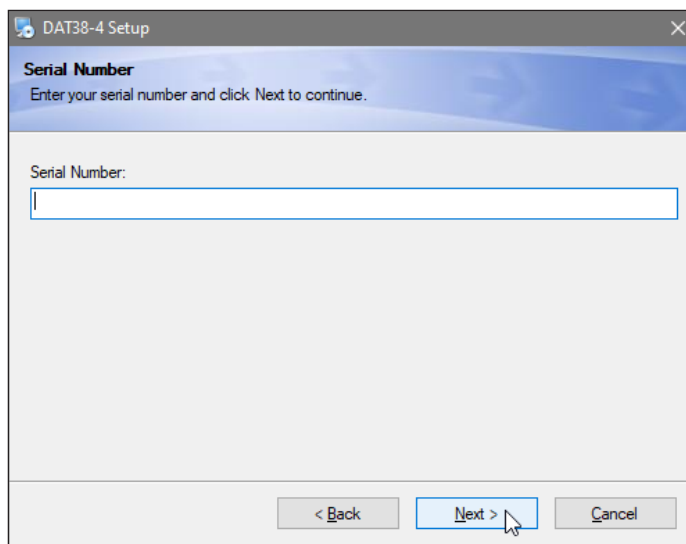


Figure 1.3 Serial Number Entry window

After the serial number is entered the Installation Folder window will appear (Figure 1.4).

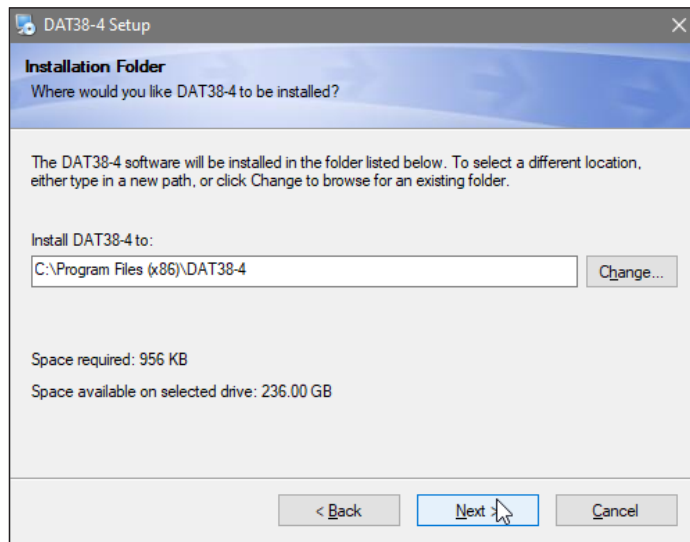


Figure 1.4 Installation directory window

The default directory is C:\Program Files (x86)\DAT38-4. Click the **Next** button to install the program to this directory. If you wish to install DAT38-4 to another directory, click the **Browse** button and the Select Installation Directory window will open (Figure 1.5).

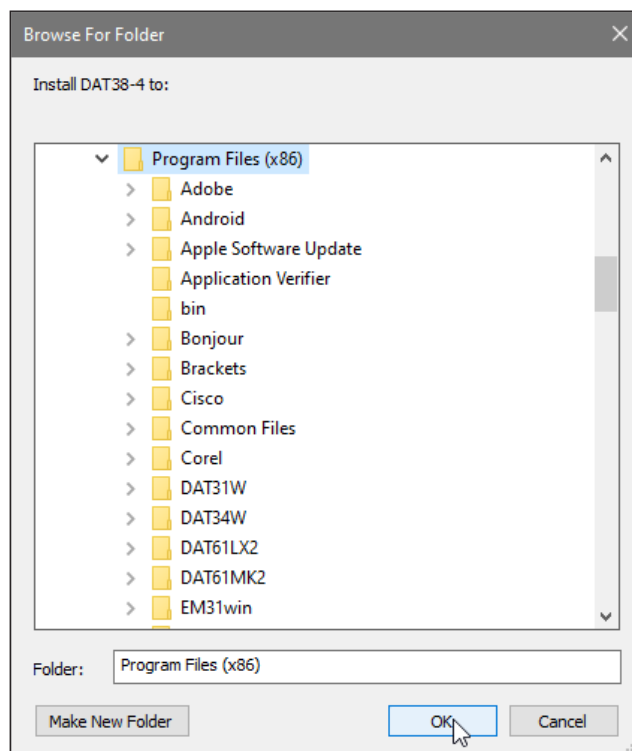


Figure 1.5 Select Shortcut Folder window

Select a target directory and click **OK**. The Select Installation Directory window closes, and the Installation Folder window opens with the selected directory listed. Click the **Next** button. The Select Short cut Folder window opens (Figure 1.6).

The setup program will create a DAT38-4 menu item in the Program menu accessible by clicking **Start**. If you do not want to use the proposed folder, you can either enter a new name, or select an existing folder from the list. Click **Next** and Ready to Install window will follow (Figure 1.7).

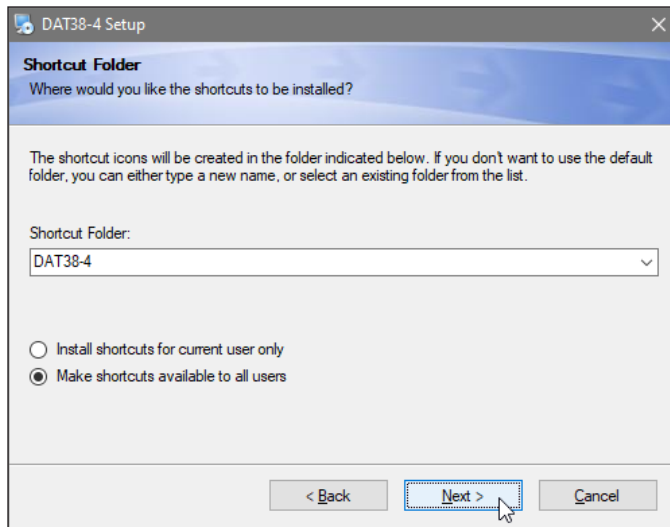


Figure 1.6 Select Shortcut Folder window

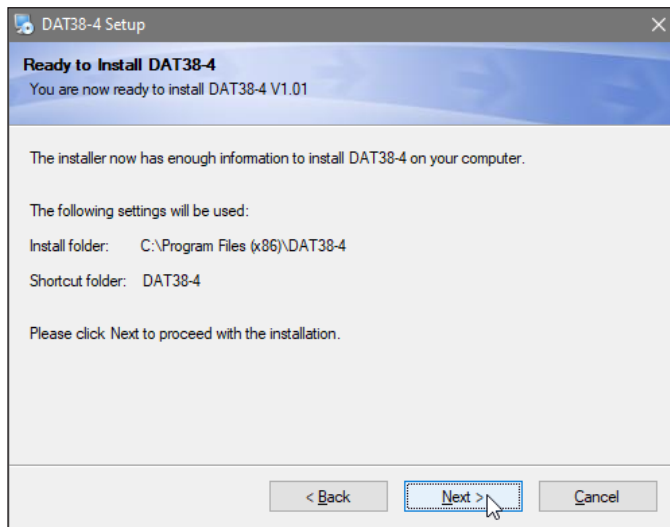


Figure 1.7 Ready to Install window

In case you would like to make any changes before installation, click **Back**. To abort installation click **Cancel**. If you are ready to start installation, click **Finish**. The installation progress bar will appear.

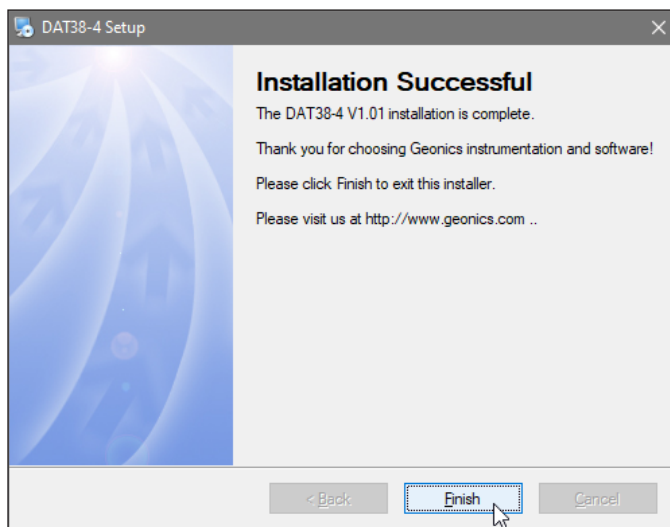


Figure 1.8 Finished window



The Installing Files window with a progress bar displays the percentage of the installation completed. When finished, the End of Installation window will appear (Figure 1.8).

Click **Finish** to end installation. SetupDAT38-4 creates a DAT38-4 program group and places **DAT38-4** and **Uninstall** icons into it. The setup program creates also a **DAT38-4** menu item in the Program menu accessible by clicking **Start**. A reminder to restart the system may be displayed on some systems at the end of the SetupDAT38-4 program.

## 1.4 Data File Transfer

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Data files are saved in the logging computer with extension 384. Transfer of files to desktop PC can be performed with USB memory module, by network, or any other available means. Data files with extension 384 are binary raw data files. These files have to be converted to DAT38-4 format with extension F38 (option “Convert” in DAT38-4). Files in F38 format can be loaded and processed in the DAT38-4.

**Please do not open binary 384 files in a text editor. While it is possible to view these files in text editor, any accidental Save may damage data file. If any binary data file is to be viewed in text editor please make a copy of the file first.**

Also, please retain raw binary files till the end of the project. If any problem will arise binary files in 384 format contain all necessary information that allows to trace potential problem.

## 1.5 Program Overview

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Start the DAT38-4 by double clicking the DAT38-4 icon in the **Start|Programs** menu, in Windows Explorer, or on the desktop shortcut created by the setup procedure. At the start, DAT38-4 occupies 80% of the entire screen (Figure 1.9):

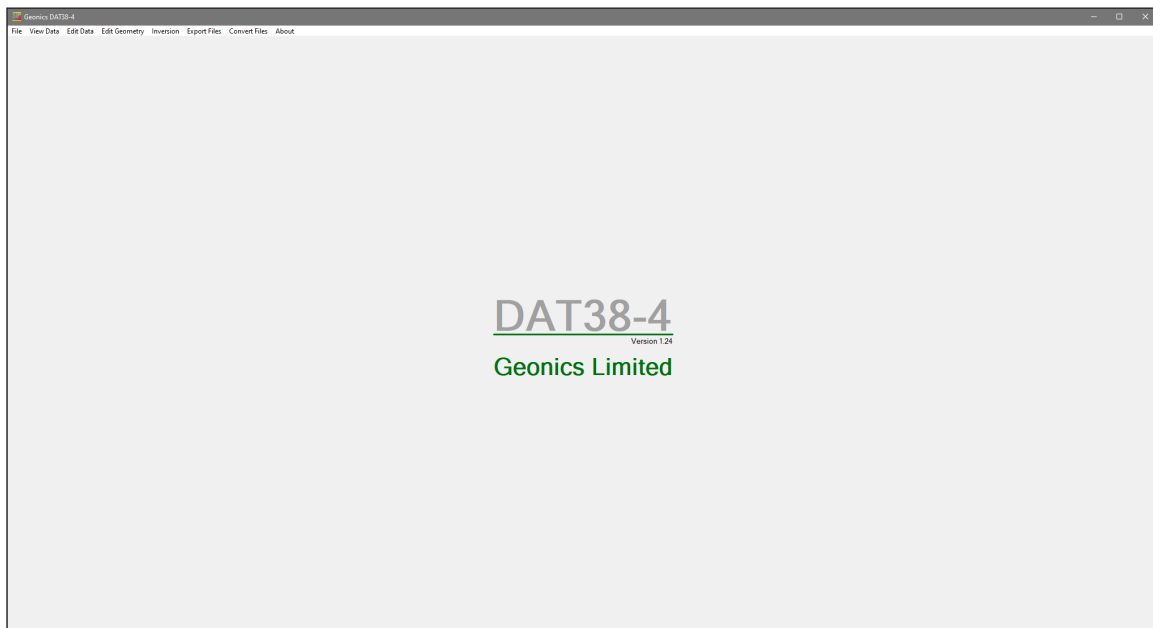


Figure 1.9 DAT38-4 Initial window

The DAT38-4 defaults to 80% of the screen, it can be moved, re-sized, maximized, and by clicking the minimize button allows access to other applications behind DAT38-4. Most menu items are disabled until profile data file (F38) is loaded. At this point, the user can:

- convert a single or multiple raw binary data files (384) to DAT38-4 format F38 with option to have Inphase units ppt or mS/m (regardless of units used during data collection,
- convert multiple raw binary data files (384) to xyz format,
- load data DAT38-4 profile files (.F38 files) and display in form of stacked profiles,
- display the DAT38-4 program version,
- exit the program.

After DAT38-4 profile file (F38) is loaded the program menu expands all menu options become available. The program is a single document interface, in order to display another data file separately use option "Open New Window" and enter new data file using new program instance. Also any number of data files can be add to the displayed data set in the same window (option "Add DAT38-4 Profile File"). The DAT38-4 with displayed profile window has following shape (Figure 1.10).

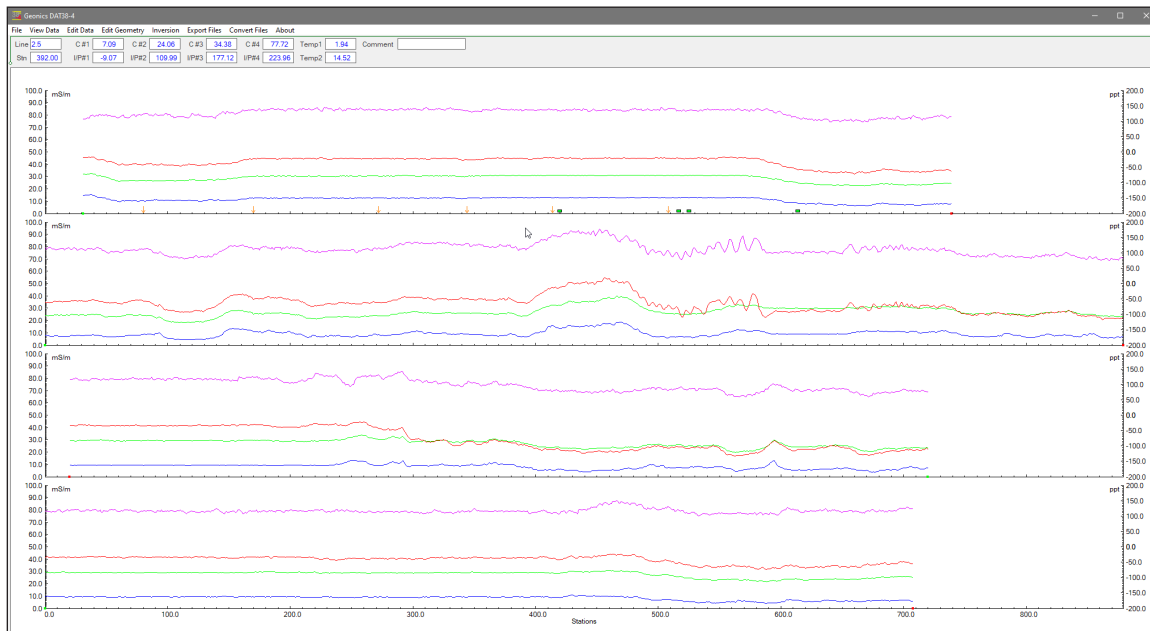


Figure 1.10 DAT38-4 screen after profile file is loaded

At this stage, the user can:

- save, or save as files after editing,
- print profiles on any Windows supported printer,
- manage survey lines: specify selection of survey lines that will be displayed, rename and delete survey lines,
- display profiles with selected parameters (component, coil separation, etc.),
- specify range of values and axes tics, separately for stations and each component,
- display grid lines, separately for each component,
- change colours of lines for each component/coil separation/sensor/combination,
- shift selected data set Up or Down in user specified steps, selection applies to survey lines as well as to any combination of component, coil separation, or other sensor,
- correct possible drift in a data file assuming Drift Control Procedure was used during survey (available in data acquisition program EM38-4 version 1.06 or later),

- edit survey geometry: set line limits, shift survey lines left or right, and position markers and line ends,
- perform inversion using original or edited data set,
- export data set to XYZ file based on grid positioned data (based on survey line names as one coordinate and station numbers as another coordinate),
- export data set to XYZ file based on embedded GPS positions.
- export data set to format of EM4Soil-G inversion program, based on grid or GPS positioned data,
- convert instrument 384 file or multiple 384 files (up 50 files simultaneously) to F38 format,
- convert multiple 384 files (up 50 files simultaneously) to xyz format.



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## 2. Quick Start

This chapter is intended for users who wish to quickly start downloading and editing an EM38-4 survey with the files necessary to collect field data. Detailed information about all functions and capabilities of the program is given in later sections.

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### 2.1 Convert Binary Instrument Files to DAT38-4 Format and XYZ Files

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The data acquisition program EM38-4, operating in the field computer, saves readings in a raw (binary) files format which are given the extension name 384. Transfer raw binary files from the Mesa3 (or other logger) field computer to desktop PC using USB memory module, network, or by other means.

DAT38-4 uses the ASCII format of data files. These files are given the extension name F38. When the binary (raw) data file is transferred from the field computer it must be converted to DAT38-4 (F38) format. A menu called **Convert Files** allows you to convert the raw data files (384) to ASCII files (F38).

To convert 384 files select **Convert Files** in the program menu and then select one of two items: **Convert EM38-4 File (384) to File in DAT38-4 (F38) Format** or **Convert Multiple EM38-4 Files (384) to File in DAT38-4 (F38) Format**. The first item can be used to convert single data file (Figure 2.1) while in the second dialog up to 50 data files with extension 384 can be selected to

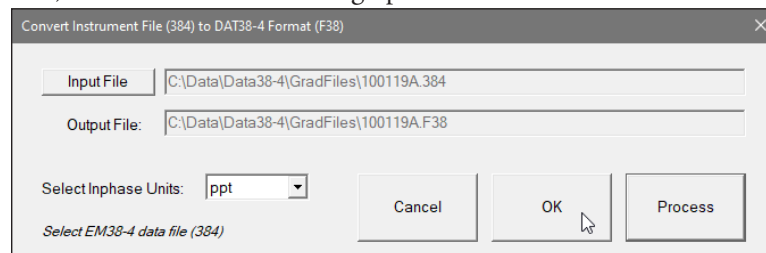


Figure 2.1 Convert EM38-4 Files to F38 Format dialog (Inphase units in ppt)

convert to F38 format after the Process button is clicked on (Figure 2.2). In the latter case files are not named in the dialog, however name of each converted file is displayed during data processing

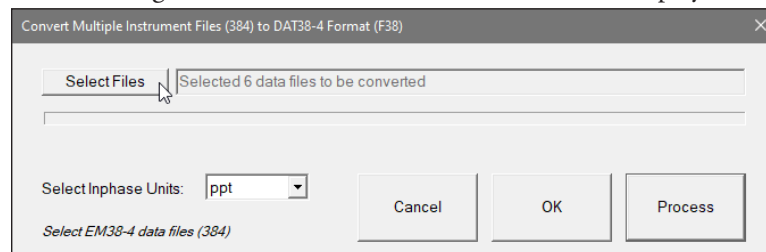


Figure 2.2 Convert Multiple EM38-4 Files to F38 Format dialog (selected Inphase units in ppt)

(Figure 2.3). Conversion to selected Inphase units does not depend on Inphase units used during data collection.

Select the file or list of files (in Multiple Files dialog) to be converted by clicking on the **Select Files** button. An open file window will appear with list of available 384 files. After file or files are selected the **Process** button will be activated. When the **Process** button is clicked selected 384 files are converted to F38 format. These files can be subsequently loaded to the program as a “Profile” file.

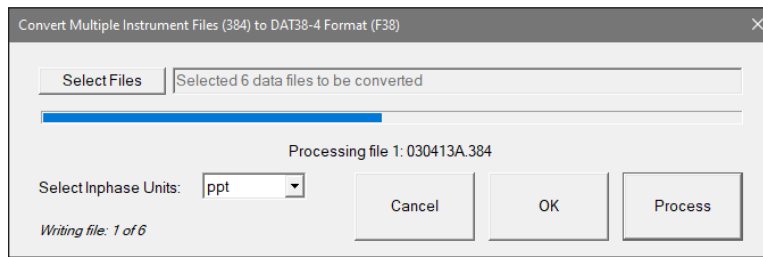


Figure 2.3 Convert Multiple EM38-4 Files to F38 Format dialog during conversion procedure

The third item in the Convert Files menu is **Convert Multiple EM38-4 Files (384) to XYZ File Format**. When this item is executed a dialog shown in Figure 2.4 will be displayed. A detailed description of all parameters in this dialog is provided in the chapter 7 (Export data files to XYZ format). Select files (up to 50 files at a time) to be converted by clicking on the **Select Files** button.

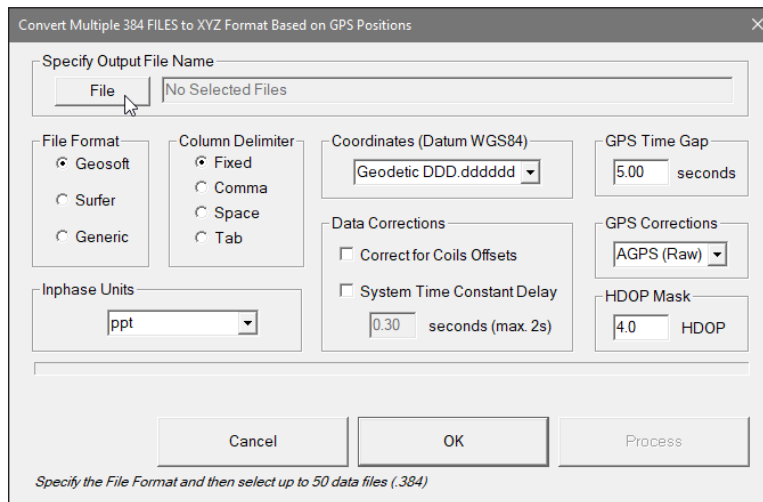


Figure 2.4 Convert Multiple EM38-4 Files to XYZ Format dialog

An open file window will appear with list of available 384 files. After files are selected the **Process** button will be activated. When the **Process** button is clicked selected 384 files are converted to XYZ format. In the latter case files are not named in the dialog, however name of each converted file is displayed during data processing (Figure 2.5). All XYZ files converted using this option contain not processed data, with values that were acquired during filed data collection. This option is provided for a quick conversion of field data to XYZ format.

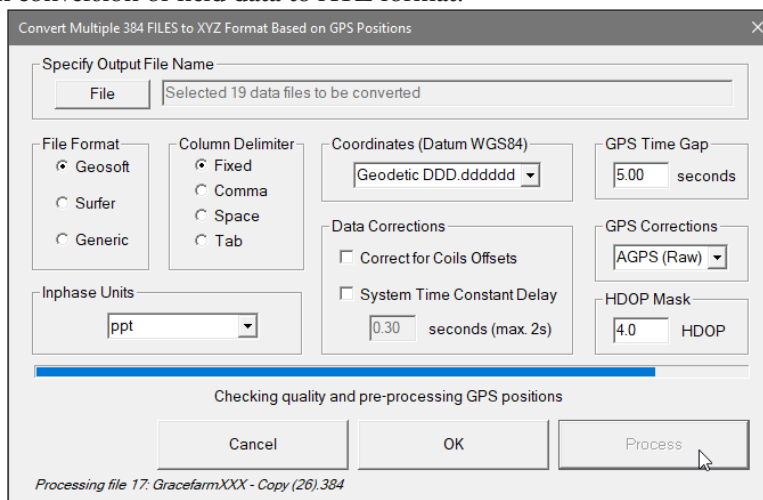


Figure 2.5 Convert Multiple EM38-4 Files to XYZ Format dialog during conversion procedure

## 2.2 Displaying Data as Profiles

### Loading and Displaying Data Files

To display data, select **File | Open Profile File** in the DAT38-4 program menu. The **Select Profile File** window will be displayed (Figure 2.6).

Select a directory and file name and then click on **Open** (you can also simply double click the left mouse button or press **Alt\_O** on the keyboard). The **Select Profile File** window displays available files with the extension name F38.

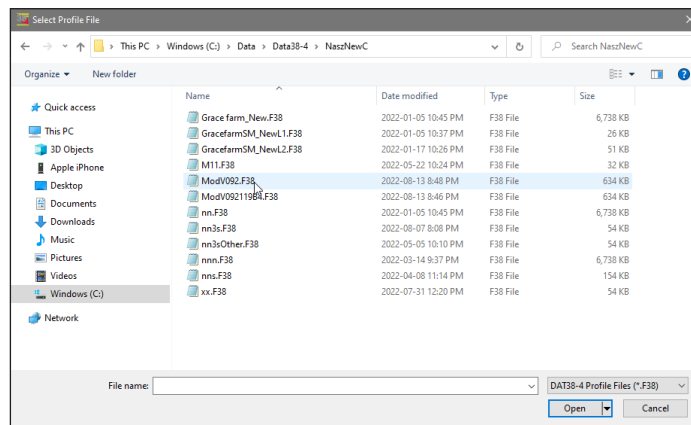


Figure 2.6 Open EM38-4 File window

After the file is loaded, data is displayed in the stacked profile format shown in Figure 2.7. Survey lines are organized in panels, which contain recorded data. In general, each survey line belongs to a separate panel, although, in the case where two or more survey lines have the same line name and same instrument mode, they will be placed in separate panels. A sequence of small windows located below the program menu displays current Line Name, Station, and values of all readings at survey line and station pointed by mouse cursor. Data file name (without extension name) is displayed in the top right corner of the profile plot window.

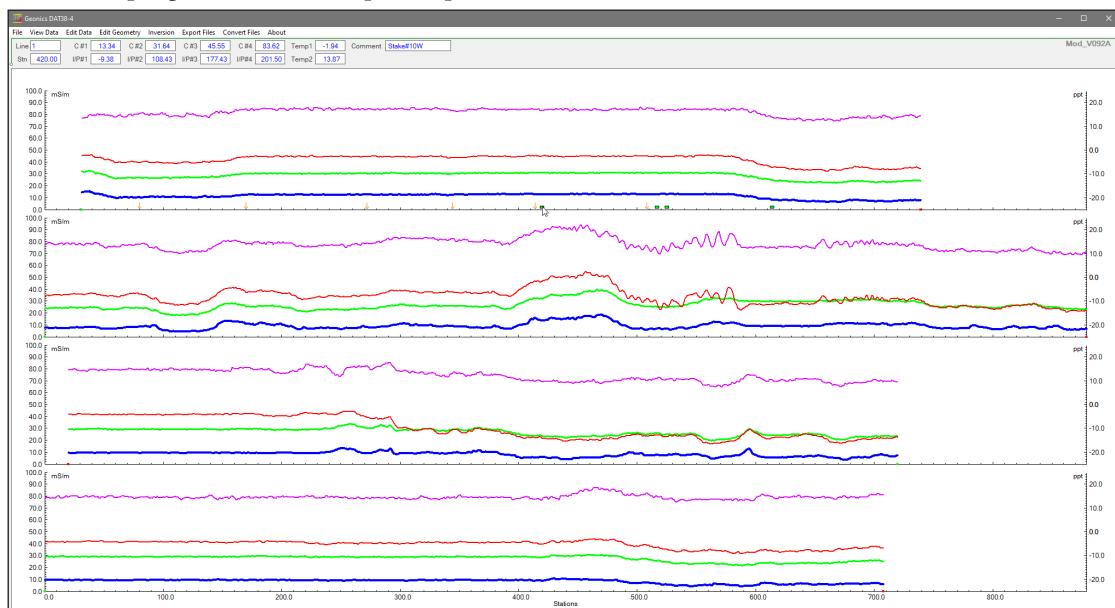


Figure 2.7 DAT38-4 screen with stacked profiles

Each panel will include one or more data types (channels, each channel is combination of component and coil separation, as well as other parameters) as specified in the Select Data Type window. This window can be accessed from the main menu by selecting **Display|Select Data Type**. See Select Data Type section below.

This description of the EM38-4 data types is used through the entire program in several windows. Each data type (channel) is described by an abbreviation:

<b>C #1</b>	-	Conductivity,	Coil Separation <b>0.50</b> m
<b>I/P #1</b>	-	Inphase,	Coil Separation <b>0.50</b> m
<b>C #2</b>	-	Conductivity,	Coil Separation <b>0.75</b> m
<b>I/P #2</b>	-	Inphase,	Coil Separation <b>0.75</b> m
<b>C #3</b>	-	Conductivity,	Coil Separation <b>0.88</b> m
<b>I/P #3</b>	-	Inphase,,	Coil Separation <b>0.88</b> m
<b>C #4</b>	-	Conductivity,	Coil Separation <b>1.00</b> m
<b>I/P #4</b>	-	Inphase,	Coil Separation <b>1.00</b> m
<b>Temp 1</b>	-	Temperature Sensor #1	
<b>Temp 2</b>	-	Temperature Sensor #2	

In addition profiles for inversion results (thickness of the 1st layer, conductivity of layer #1, and conductivity of layer #2) can be plotted if available, however there are no numeric windows for these three parameters.

By default all channels representing Conductivity and Inphase are displayed for all survey lines. The left vertical axis relates to the EM38-4 apparent conductivity (Quad-phase component) and it is labeled in millisiemens per meter (mS/m), while right axis corresponds to the EM38-4 Inphase response and it is labeled in parts per thousands of Primary Field (ppt) or mS/m (depending how file was converted). When Temperature sensors data will be selected additional axis labeled degrees will be drawn. In case Inversion Results will be selected, then Inphase and Temperature selections are disabled and the right Inphase axis will be replaced by axis for Thickness in meters. Inversion Conductivity results will be scaled according to the left Conductivity axis.

## Selecting Survey Lines

When a data file is loaded, all survey lines are profiled. To display a selection of available survey lines select **Display|Select Lines** in the program menu. The Select Survey Lines window is shown in Figure 2.8.

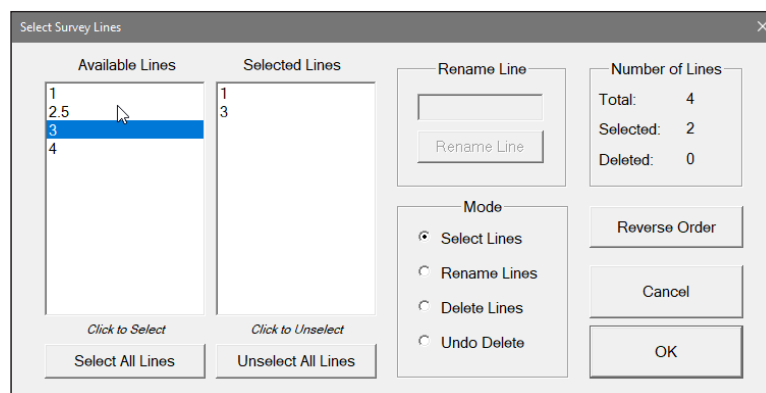


Figure 2.8 Select Survey Lines window

Select and deselect lines to be displayed, by clicking on the line names in list boxes labeled **Available Lines** and **Selected Lines**. Buttons **Select All** and **Unselect All** are also available. All highlighted line names will be profiled on the screen after clicking on the **OK** button.



## Deleting and Renaming Survey Lines

---

The most common initial task in data processing is deleting and renaming survey lines. Both tasks can be accomplished in the **Select Lines** window (Figure 2.8).

To delete a survey line from the loaded set of data, click on the radio button labeled **Delete Lines** located in the section labeled Mode. When the radio button is checked, click on the appropriate line name in the Available Lines list box. The letter **D** will be displayed next to the line name. These lines will not be displayed nor written to the output file during **Save** or **Save As** tasks.

Survey lines also can be renamed in the Select Lines window. Click on the radio button labeled **Rename Lines** and then click on the line name in the Available Lines list box. The highlighted line name will appear in the edit box located in the Rename Line section. Edit the name in the Edit Box and click the **Rename Line** button. The updated name will now be displayed in both line names list boxes.

Please refer to section 3 (Data Display) for a detailed description of the Select Survey Lines window.

**Please note that Deleted and Renamed lines will be valid as long as the program is running. In order to save changes permanently use “Save As” or “Save” option to create a new data file which can be used later by the program. It is recommended that you use “Save As” and keep the original data in not edited form.**

## Selecting Data Types to Display

---

To select the type of data to be displayed select the **Display|Select Data Type** from the program top menu. The Select Data Type window will appear as shown in Figure 2.9.

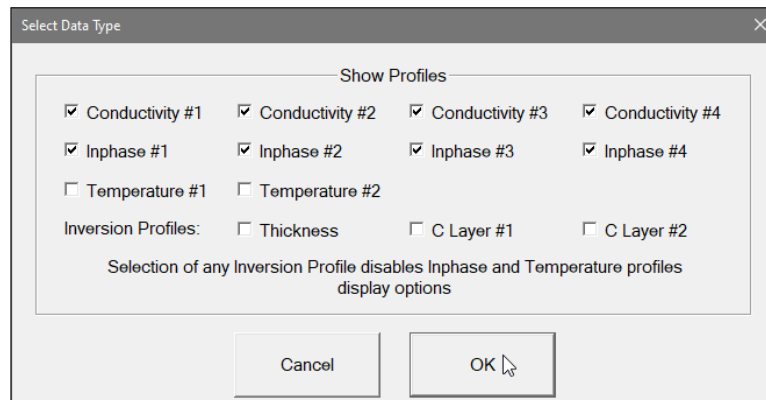


Figure 2.9 Select Data Type window

The Select Data Types window contains check boxes for each type of EM38-4 data. Each Type is described by a label:

<b>Conduct. #1</b>	-	Conductivity,	Coil Separation <b>0.50</b> m
<b>Conduct. #2</b>	-	Conductivity,	Coil Separation <b>0.75</b> m
<b>Conduct. #3</b>	-	Conductivity,	Coil Separation <b>0.88</b> m
<b>Conduct. #4</b>	-	Conductivity,	Coil Separation <b>1.00</b> m
<b>Inphase #1</b>	-	Inphase,	Coil Separation <b>0.50</b> m
<b>Inphase #2</b>	-	Inphase,	Coil Separation <b>0.75</b> m
<b>Inphase #3</b>	-	Inphase,	Coil Separation <b>0.88</b> m
<b>Inphase #4</b>	-	Inphase,	Coil Separation <b>1.00</b> m

- Temperature #1 - Temperature Sensor #1
- Temperature #2 - Temperature Sensor #2
- Thickness - Inversion: Thickness of the first layer
- C. Layer #1 - Inversion: Conductivity of the first layer
- C. Layer #2 - Inversion: Conductivity of the second layer

The Select Data Type dialog lets you select data channels to be displayed as profiles. Inversion Profiles can be visible only if Inversion was applied for the data file. If any of Inversion Profiles is selected then all Inphase and Temperature profiles are disabled automatically.

## Changing Display Parameters

---

To adjust the range of displayed parameters select **Display|Set Display Parameters** in the program menu. The **Set Display Parameters** window is shown in Figure 2.10.

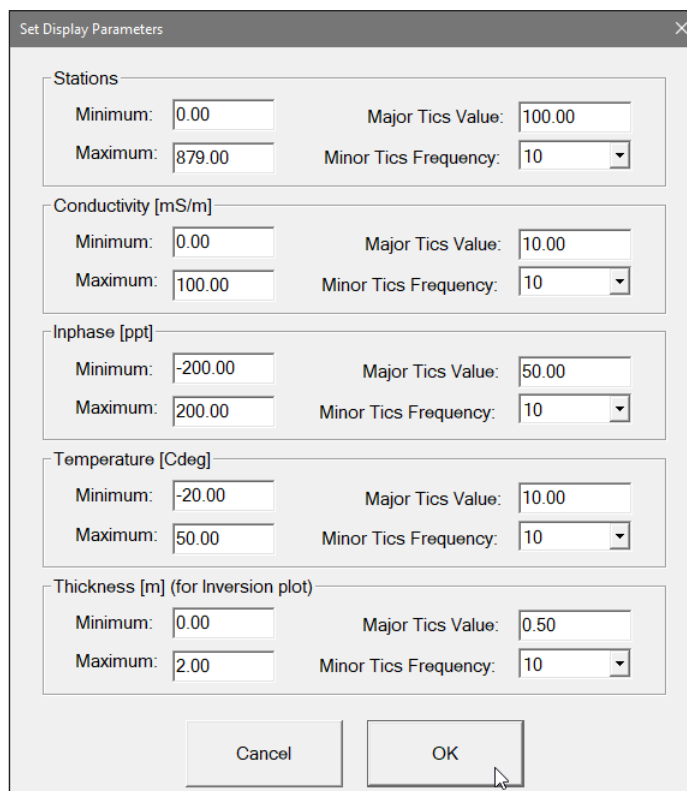


Figure 2.10 Set Display Parameters window

This option allows a range to be set for the length of the line (stations displayed), and the EM38-4 conductivity and Inphase amplitudes, as well as parameters of Temperature and Inversion results if they are selected.

The major axis tick intervals as well as minor tics frequency are also controlled through this window. (Labels and optional grid lines are plotted at the major ticks only.)

## Setting Profiles Graphic Attributes

---

To adjust the range of displayed parameters select **Display|Line Attributes** in the program menu. The **Setup Display Options** dialog is shown in Figure 2.11.

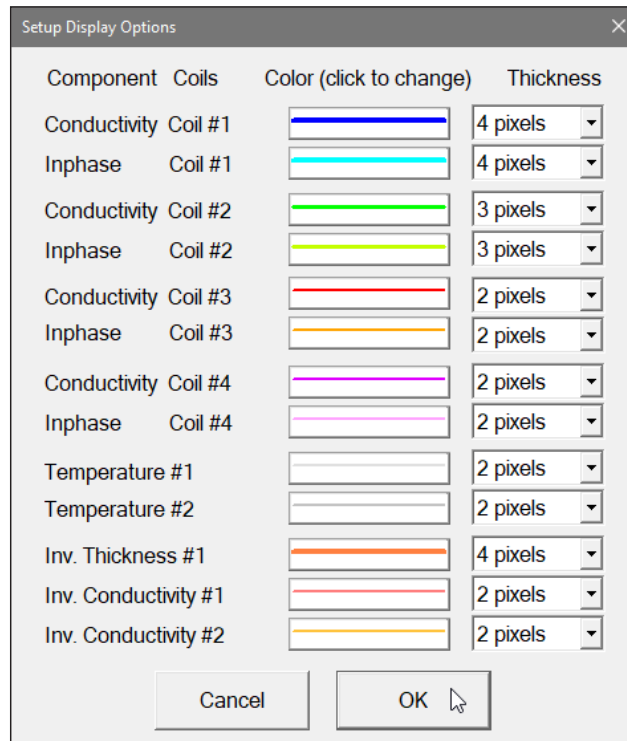


Figure 2.11 Selecting attributes for profiles

To change specific profile color click on the button with a colour line and then click on one of colours listed in the Select Color window. The Colour button will reflect settings (color and thickness).

## 2.3 Editing Data

The Edit Data option allows adjustment of data for entire survey lines, it includes shifting of response level, applying linear shift, as well as smoothing data for selected survey line and component. To display the Edit Data menu select **Edit Data** in the main menu at the top of the screen (Figure 2.12).

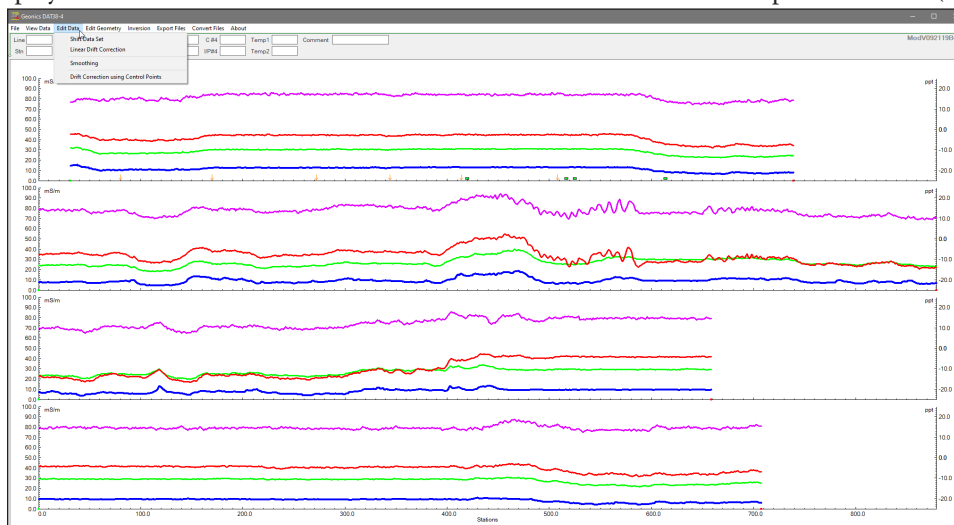


Figure 2.12 Edit Data menu

The Edit Data menu contains four items:

**Shift Data Set** changes level of amplitude for selected survey line and component;

**Linear Drift Correction** can be used to remove possible linear drift effect for selected survey lines and specified component;

**Smoothing** is a tool to smooth data according to select degree of smoothing for selected survey lines and components;

**Drift Correction using Control Points** is a procedure removing possible drift based on drift control points measurements performed during survey (available in the EM38-4 program V1.06 or later).

## 2.4 Editing Survey Geometry

The Edit Geometry option allows adjustment of the profile geometry, including the repositioning of both the start and end stations of each line, shift survey lines, as well as any station marked with the fiducial switch. To display the Edit Geometry menu select **Edit Geometry** in the main menu at the top of the screen (Figure 2.13).

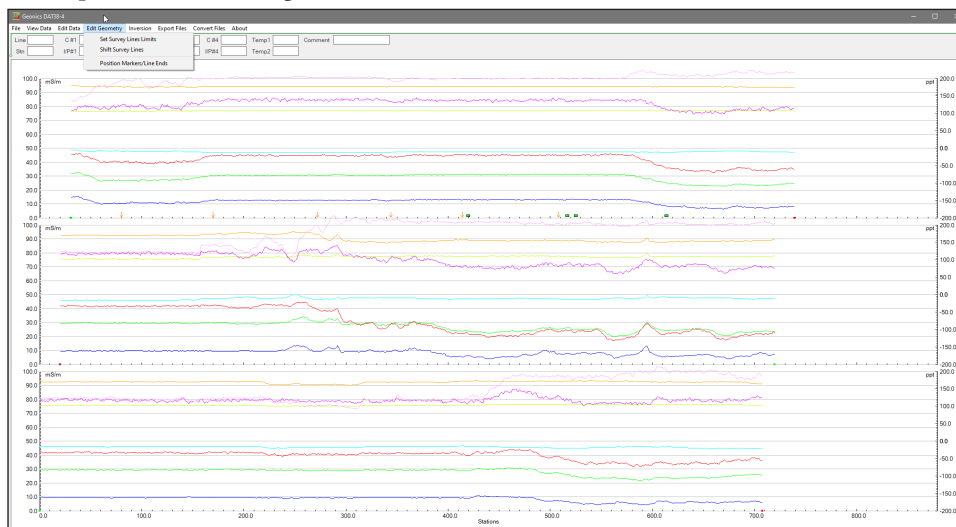


Figure 2.13 Edit Geometry menu

The Edit Geometry menu contains three items:

**Set Line Limits** changes the position of the start and end stations of any selected group of survey lines;

**Shift Survey Lines** can be used to move any selected group of survey lines in either a positive or negative direction along the profile axis;

**Position Markers** is an efficient tool for aligning fiducial markers and the start and end points of survey lines.

A survey that was done without using the fiducial markers will generally not require any editing of data positions. Corrections of common field errors, such as an incorrect start station or line direction, can be made using the **Set Line Limits** or **Shift Survey Lines** option in the Edit Geometry menu shown in Figure 2.13.

**Please note that ends of survey lines can also be easily adjusted by the Position Markers tool even if during the survey fiducial markers were not used. The Start and End stations of each survey line can be edited in the same way as stations tagged by fiducial markers.**

If data was recorded with fiducial markers, the following two step procedure is recommended: Adjust the ends of the survey lines using the **Set Line Limits** options, or by using Position Markers option (see the note above), and then position fiducial markers using the **Position Markers** option.

## 2.5 Inversion

This option is provided to calculate inversion results if the inversion option was not enabled during data collection or to re-calculate inversion in case data is edited, especially when Data Shift or Smooth Data options were used. After the Inversion menu item is clicked the Inversion Setup dialog is displayed (Figure 2.14). The dialog and parameters correspond to the Inversion Setup dialog used in data acquisition program. The main difference is that this dialog allows you to change EM38-4 Height (always in metres). At the same time the dialog displays EM38-4 Height as it was specified during data collection. All parameters listed in the Inversion Setup dialog are described in Chapter 6.

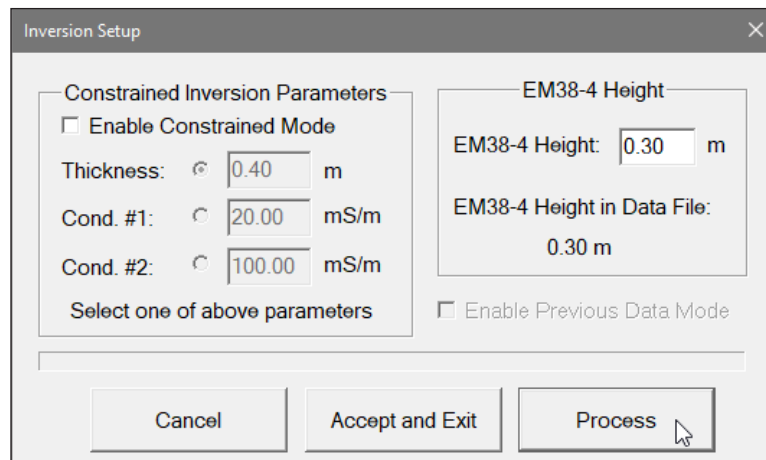


Figure 2.14 Inversion Setup dialog

After the Process button is clicked on the program starts inversion calculations for each data point. A progress bar shows how procedure progresses. The entire procedure depends on the file length, it can take minutes for large data files. After inversion is completed results are drawn with profiles attributes as specified in the Setup Display Options. If previous inversion results are present in data set corresponding profiles are drawn in gray for comparison (Figure 2.15). New inversion values can be accepted (the button Accept and Exit) or cancelled (the button Cancel).

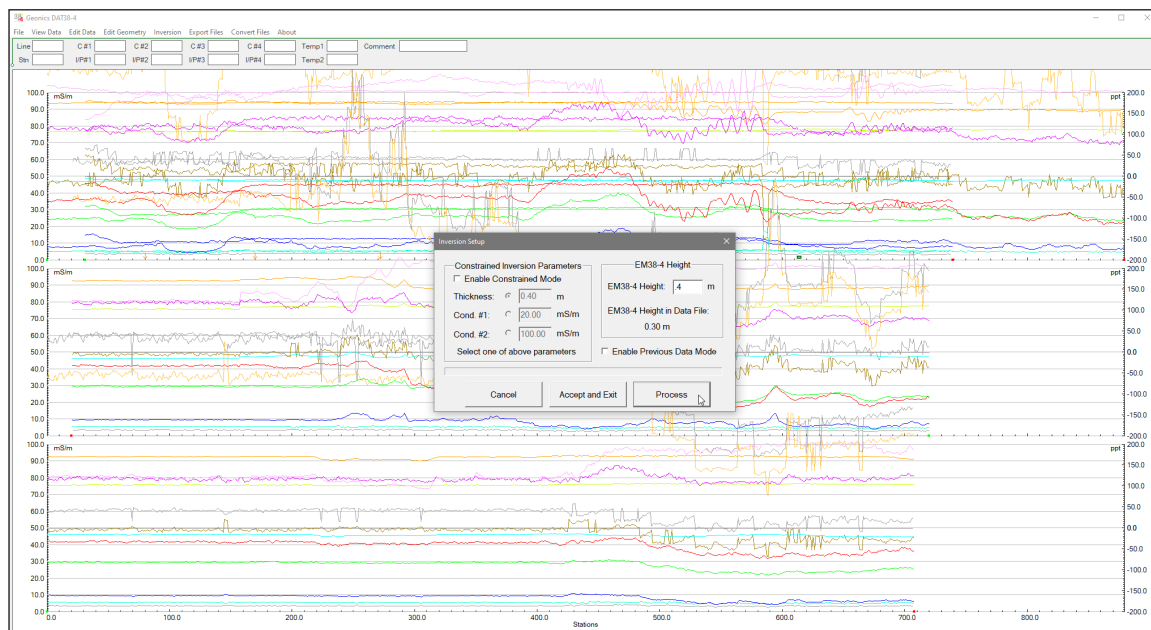


Figure 2.15 Inversion procedure after processing

## 2.6 Export Files

To display Export Options options select **Export Files** in the main menu at the top of the screen. The menu contains four items: Create Grid Based XYZ File, Create GPS Positioned XYZ File, Create Grid Based EM4Soil-G File, and Create GPS Positioned EM4Soil-G File (Figure 2.16). Two first items are used to create standard type of XYZ files for various mapping systems while latter two items are used to create input file for EM4Soil-G inversion program (developed by EMtomo). The EM4Soil file structure is similar to XYZ files, these files have an extension name gxyz.

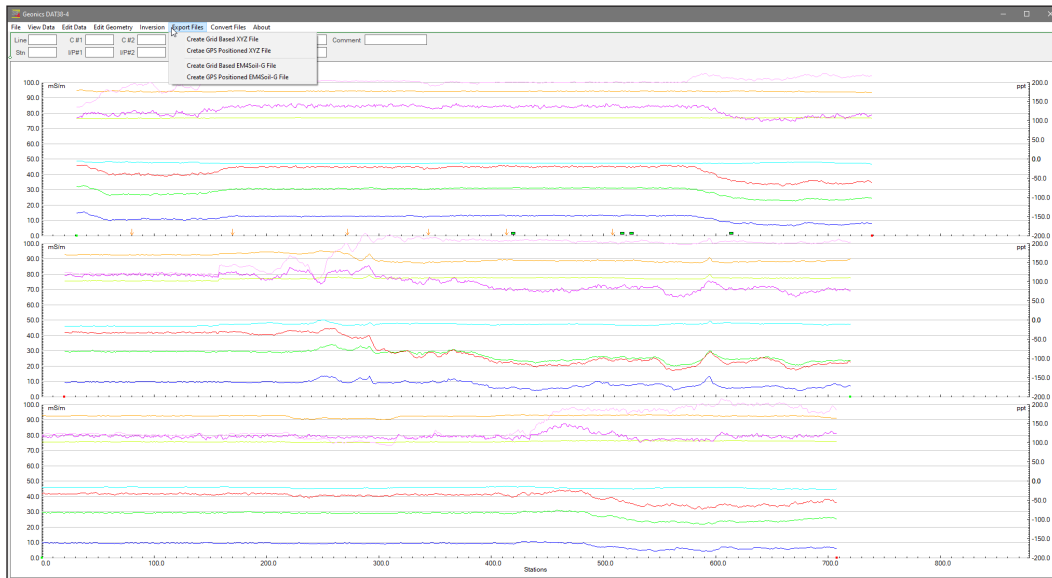


Figure 2.16 2Export Files menu

Both the first and the second options, **Create Grid Based XYZ File** and **Create Grid Based EM4Soil-G File** let you generate files with N-S and W-E configuration of survey lines, when readings are collected along grid that it is layout before the survey. Therefore, it is strongly recommended that data files be organized so that each file contains parallel lines surveyed in one direction, either W-E or N-S. The program assumes that stations along survey lines correspond to one of coordinates (X or Y) and line names indicate another coordinate (X or Y). If line names do not correspond to an appropriate coordinate they can be easily changed by the **Rename** function in the **Select Survey Lines** window. Position of stations (line end points, fiducial markers) along survey lines should be organized using the **Edit Geometry** menu options prior to creating XYZ file.

The second and the fourth Export Files menu items, **Create GPS Positioned XYZ File** and **Create GPS Positioned EM4Soil-G File** can be used only when EM38-4 data is collected together with GPS positioning data. In this method the GPS receiver is connected to the Mesa3 (or other field computer logging EM38-4 readings) serial port and GPS data is recorded in the EM38-4 data file.

### Create Grid Based XYZ File and Create Grid Based EM4Soil-G File

After you select the **Eport Files|Create Grid Based XYZ File** from the profile menu the **Create Grid Based XYZ File** dialog is displayed (Figure 2.17). When item is selected then the **Export EM4Soil-G Format with Grid Layout Based Positions** will appear (Figure 2.18). The latter dialog is much simpler since the EM4Soil-G format has fixed format and content, therefore two parameters must be specified only: File Name and Survey Lines Orientation.

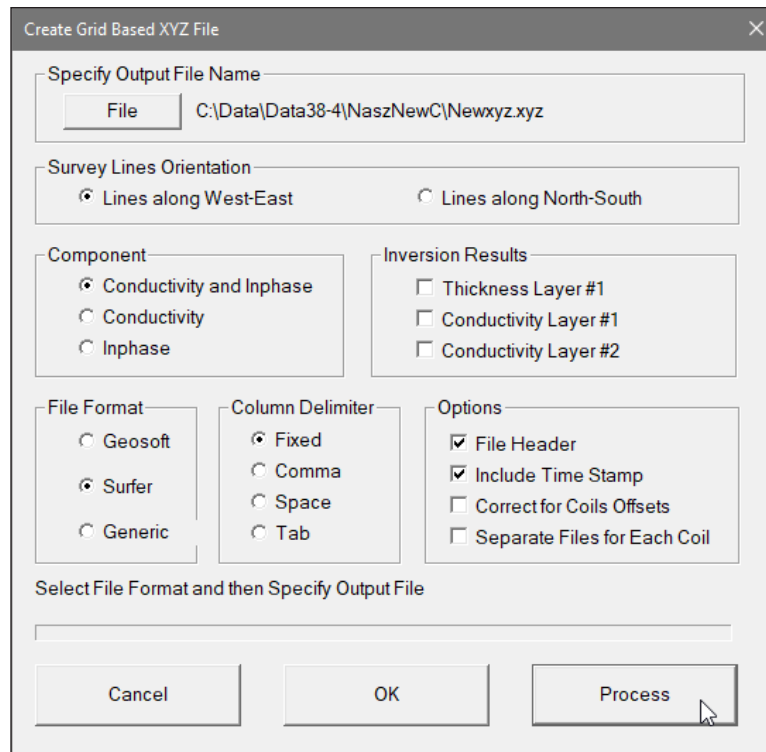


Figure 2.17 Create Grid Based XYZ File dialog

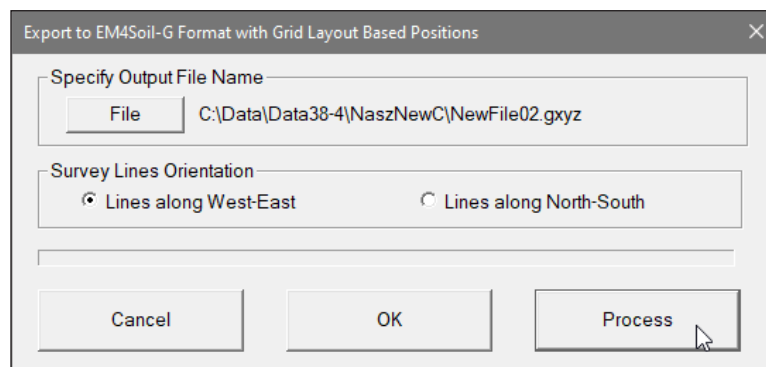


Figure 2.18 Create Grid Based EM4Soil-G File dialog

Several parameters which affect the contents and format of the created XYZ file must be specified. Specifically, these are the Orientation of Survey Lines, the EM38-4 Data Type and other parameters to be written to the file, format of the output file, and the output file name. For each parameter there is only one option for each layout which you select by clicking the appropriate radio or check box button.

### File

When the **File** button is clicked, a Select File Name (for XYZ or GXYZ depending on the dialog) is displayed. The EM38-4 file name with an extension corresponding to the selected output file format (xyz, dat, or asc) is given as a default. After the Output File is specified the **Process** button is activated.

### Select Survey Lines Orientation

The W-E orientation corresponds to a layout where lines are parallel and oriented in the X direction (assuming that the North or Y coordinate points to the top, and that the East or X coordinate points to the right edge of a page). The N-S orientation corresponds to the perpendicular layout, with survey lines oriented in the Y direction.



If W-E orientation is selected, it is assumed that the line name gives the Y (N-S) coordinate and stations are aligned along the X (W-E) axis. If survey lines are parallel and oriented in W-E direction, but line names do not correspond to the Y coordinate, then rename the lines in the Select Lines window. It should be noted that if the line name starts with a number and ends with a letter, e.g. 10N, only the number will be recognized as a Y coordinate.

Description of remaining parameters applies to the Create Grid Based XYZ File option.

### **Component**

To select the EM38-4 data type, component to be written in the output file click the corresponding radio button in sections labeled **Component** (Figures 2.17). Selected components or component are written if file for all four coil separations. Data is always placed in the created XYZ file in the following order: X coordinate, Y coordinate, two or one components for separation #1, then for separation #2, and then similarly for two remaining separations.

### **Inversion Results**

Inversion Results section is enabled and can be written in the file if Inversion mode was enabled during data collection, otherwise this option is disabled. Inversion results always follow components selected in the Component option.

### **File Format**

Indicate the appropriate option for the contouring software to be used. The Generic option will create a multicolumn file without any text strings. This file can be used as an input file for many contouring packages (including Geosoft and Surfer). When Geosoft is selected then file extension name XYZ will be given as a default, and extension names DAT and ASC will be given respectively for Surfer and Generic selections respectively.

### **Column Delimiter**

Select column delimiter that is required by your application. The option Fixed corresponds to fixed field for each column with space or spaces between columns. This format is suitable for most applications and a file created with this selection provides the easiest option if file is to be viewed using any standard text editor.

### **Options**

There are three items listed: File Header, Time Stamp, and Date. File Header occupies one line at the top of file and contains description of each column included in the file. Time Stamp and Date will be written in two columns (or one if any of two selected) that follow instrument readings (and optionally Inversion Results).

### **Create Additional File**

When this option is checked a separate file containing comments only (with associated coordinates and time). In case data set does not contain any comment entry this option is disabled.

When you click on the **Process** button a progress bar, located at the left bottom corner of the window, will indicate the percentage of the created file that has been completed.



## Create GPS Positioned XYZ File and Create GPS Positioned EM4Soil-G File

EM38-4 files positioned with GPS receiver can be exported directly to an XYZ file format by selecting the **Export Files|Create GPS Positioned XYZ File** menu item. The **Create XYZ File Based on GPS Positions** dialog is displayed (Figure 2.19).

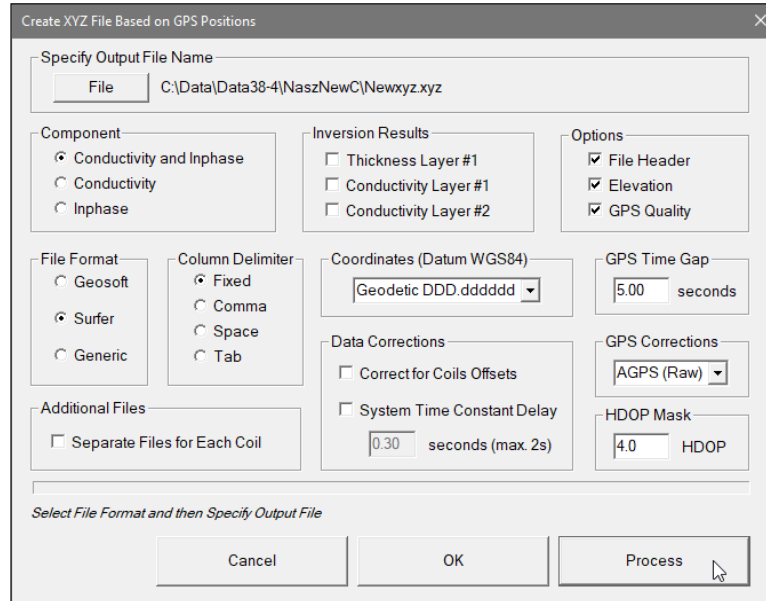


Figure 2.19 Create XYZ File Based on GPS Positions dialog

Similarly, files with GPS receiver records can be exported to EM4Soil-G program format by using menu item **Export Files|Create GPS Positioned EM4Soil-G File**. In this case, a simpler dialog labeled **Export to EM4Soil-G Format with GPS Based Positions** will be displayed (Figure 2.20). In the EM4Soil-G input file, format and content are fixed, therefore coordinates and GPS quality parameters only must be specified.

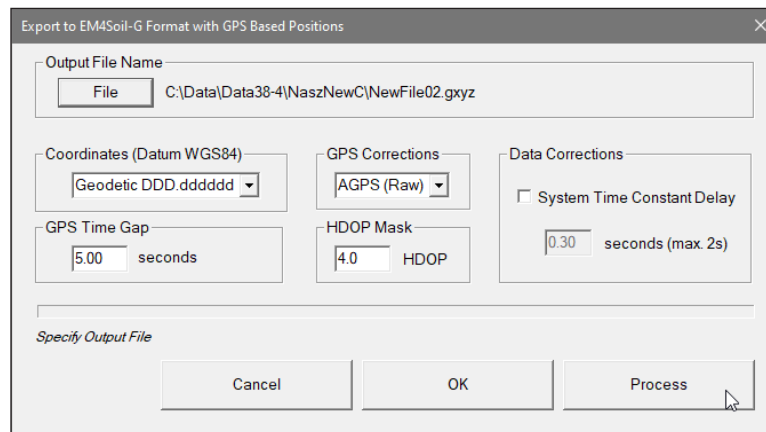


Figure 2.20 Export to EM4Soil-G Format with GPS Based Positions dialog

Before creating the XYZ file the following parameters must to be specified:

### Select Output File Name

Click on the **File** button. The Select XYZ File window is displayed. Select a file name and click the **Save** button. The Select XYZ File window will close and the selected file name will be displayed beside the **File** button in the GPS Positioning window.

When Input and Output files are specified the **Process** button in the Create XYZ File Based on GPS Positions becomes active.

### Select Component

To select the EM38-4 data type, component to be written in the output file click the corresponding radio button in sections labeled **Select Component** (Figures 2.19). Selected components or component are written if file for all four coil separations. Data is always placed in the created XYZ file in the following order: X coordinate, Y coordinate, two or one components for separation #1, then for separation #2, and then similarly for two remaining separations.

### Inversion Results

Inversion Results section is enabled and can be written in the file if Inversion mode was enabled during data collection, otherwise this option is disabled. Inversion results always follow components selected in the Component option.

### Options

There are six items listed: File Header, GPS Quality, Elevation, Time Stamp, Date, Insert Comment (the latter selection is disabled unless comments were used during file collection). File Header occupies two lines at the beginning of file, the first line contains Datum description and the second line contains labels with description of each column included in the file. GPS Quality, Elevation, Time Stamp and Date will be written in columns (in the order as listed in this dialog) that follow instrument readings and selected Inversion Results. The GPS Quality contains parameters in three columns: Quality (degree of differential corrections), number of satellites, and HDOP parameter.

### Additional File

When this option is checked a separate file containing comments only (with associated coordinates and time). In case data set does not contain any comment entry this option is disabled.

### XYZ Format

Indicate the appropriate option for the contouring software to be used. The Generic option will create a multi column file without any text strings. This file can be used as an input file for many contouring packages (including Geosoft and Surfer). A comment indicating column contents and used coordinates will be written at the beginning of file if Header More detailed description is given in the XYZ File Format section.

### Column Delimiter

Select column delimiter that is required by your application. The option Fixed corresponds to fixed field for each column with space or spaces between columns. This format is suitable for most applications and a file created with this selection provides the easiest option if file is to be viewed using any standard text editor.

### Coordinates

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum.

Geodetic coordinates are given in degrees, while UTM coordinates can be generated in meters, feet or US Survey feet.

### **GPS Time Gap**

The **GPS Time Gap** parameter specifies the maximum time during which the EM38-4 data will be linearly interpolated between two GPS positions. Enter this parameter (in seconds) in the edit box labelled GPS Time Gap. In most cases a value 2 to 3 times larger than the GPS acquisition frequency is adequate.

### **GPS Corrections**

Select item in combo box placed in a section labeled **GPS Corrections** to write selected or higher degree of GPS differential corrections.

### **HDOP Mask**

Specify value of HDOP parameter the section labeled **HDOP Mask**. Readings associated with GPS positions that have HDOP values higher than specified will not be written to the file.

### **Correct for Coils Offsets**

When this parameter is checked a correction takes to account varying locations of centres of measurement points for coil separation 0.50 m, 0.75 m, and 0.88 m. While applying this correction program interpolates reading values to reflect differences between center of the instrument (same as separation 1.00 m) and centers for each other separation, based on the direction of system movement and location of TX coil as specified in Program Settings (default, standard TX location is on the front of the instrument).

### **System Time Constant Delay**

Here a correction for time constant delay can be entered. The value of correction for the system (EM38-4 plus GPS receiver) must be determined experimentally. To ignore this option enter zero.

When you click on the **Proceed** button a progress bar, will appear above command buttons and it will indicate the percentage of the created file that has been completed.



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# 3. Loading/Displaying Data

The DAT38-4 requires that files have to be displayed in the form of stacked profiles prior to any editing, reorganizing survey lines, or exporting to grid or GPS based XYZ data file for mapping systems. Files containing EM38-4 readings and displayed in the program as profiles have the extension name F38. These files are described in this section. Conversion of binary raw (384) format to F38 format is described in section 2.1. Format of instrument binary data files (with extension name 384) and DAT38-4 file (with extension name F38) formats are described in Appendix A.

---

## 3.1 Loading Profile Files

---

### Loading Data File

The DAT38-4, when started, has most menu items disabled. After data file (F38) is loaded then all menu items are enabled. To load EM38-4 data file in F38 format select **File|Open Profile File** in the menu (Figure 3.1).

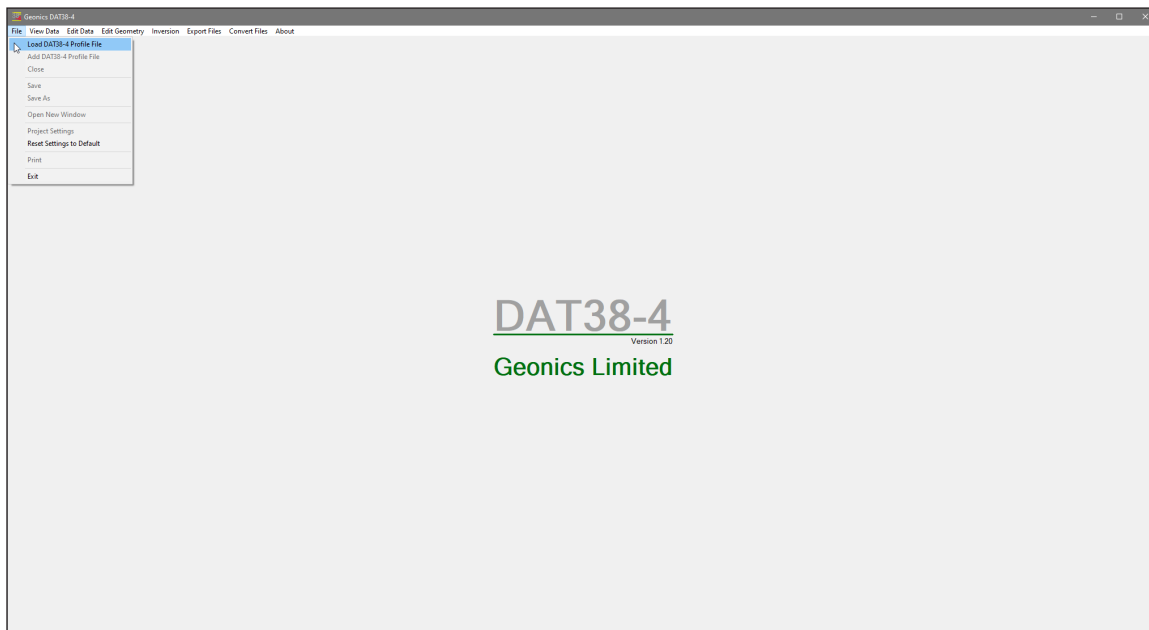


Figure 3.1 DAT38-4 File menu before any data file is loaded

The **Select Profile File** dialog will be displayed (Figure 3.2). Select the directory and file name and then click the **Open** button (or double click the left mouse button, or press **Alt\_O** on the keyboard). Data files in DAT38-4 format have the extension name F38. When a large data file in DAT38-4 format is loaded to the program a progress bar may show the percentage of file loaded.

After a DAT38-4 profile file is loaded, data is displayed in a stacked profile format as shown in Figure 3.3. Survey lines are organized in panels, which contain the recorded readings. In general, each survey line surveyed in one instrument mode appears in a separate panel. In the case where two or more survey lines have the same line name, they still will be placed in separate panels.

In each panel the data type selected for display (see section 3.4 below) are profiled. In the default settings, both components Conductivity and Inphase for all four coil separations are profiled, and

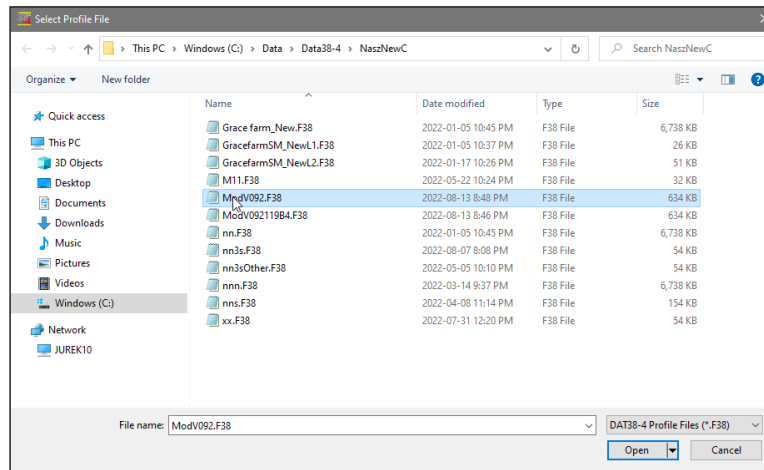


Figure 3.2 Select EM38-4 Profile File dialog

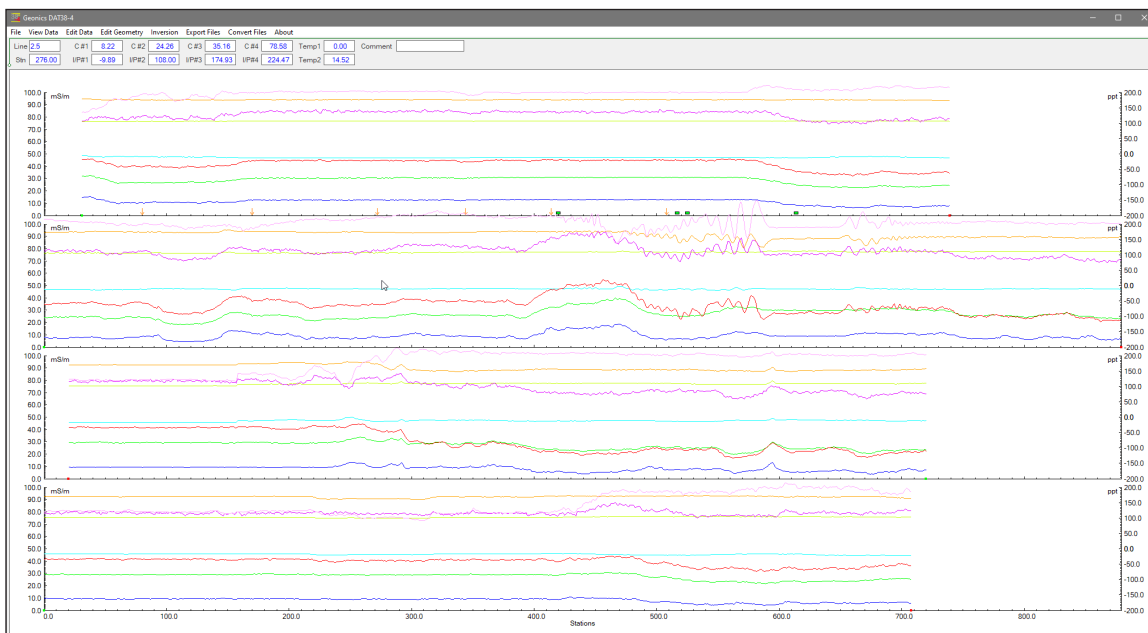


Figure 3.3 DAT38-4 screen with stacked profiles

other sensors and inversion results can be selected. Therefore each panel may contain up to 8 profiles for each survey line. The left vertical axis corresponds to EM38-4 Quad-phase component (conductivity) in milliSiemens/m (mS/m), while the right axis is assigned to EM38-4 Inphase component in parts per thousands (ppt) of Primary Field or in mS/m depending on settings during file conversion (Inphase units can be changed in the Project Settings item of File menu, see below).

If Temperature sensors are selected then additional axis is plotted. When any of Inversion Results is selected then Inphase and Temperature profiles are disabled. Thickness axis (in meters) replaces Inphase axis (on the right) and Conductivity axis (on the left) is used for layers conductivity profiles.

### Loading Additional Data Files to the Same Window

To display another data set in the same window select **File|Add DAT38-4 Profile File** in the menu (Figure 3.4). The Select Profile File dialog will be displayed (Figure 3.2). Select directory and file name and then click the **Open** button (or double click the left mouse button, or press **Alt\_O** on the keyboard).

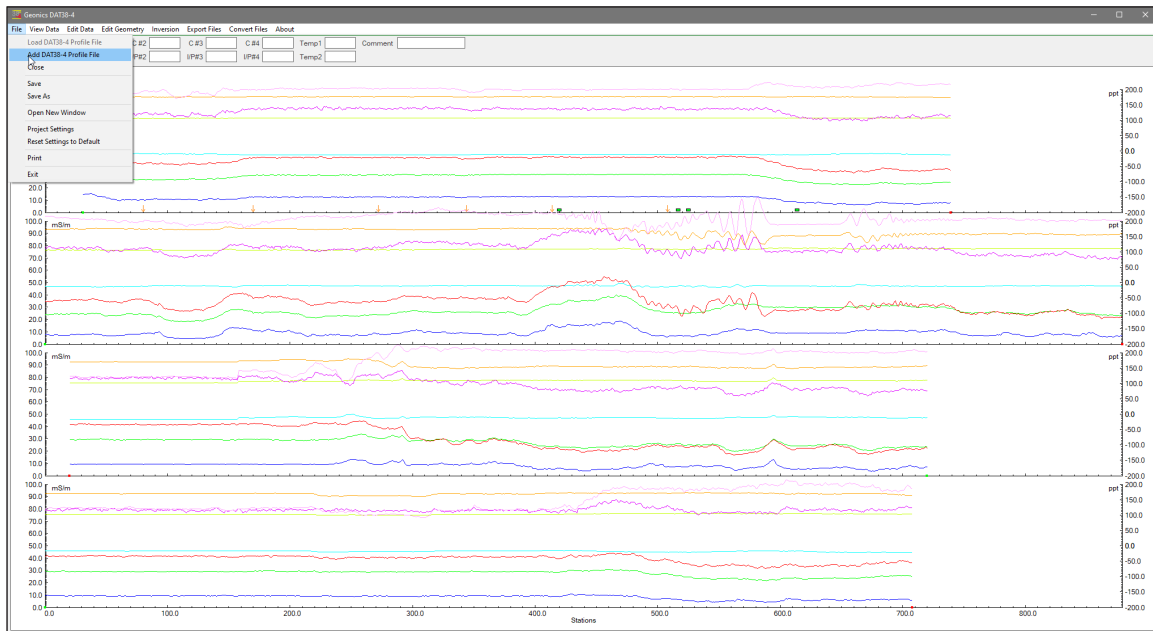


Figure 3.4 Add DAT38-4 Profile File menu

After a new profile file is loaded, data is displayed in a stacked profile format in a new window below previously loaded DAT38-4 file, as shown in Figure 3.5. The data set can be Saved or Saved As allowing you to combine few data file into one data set.

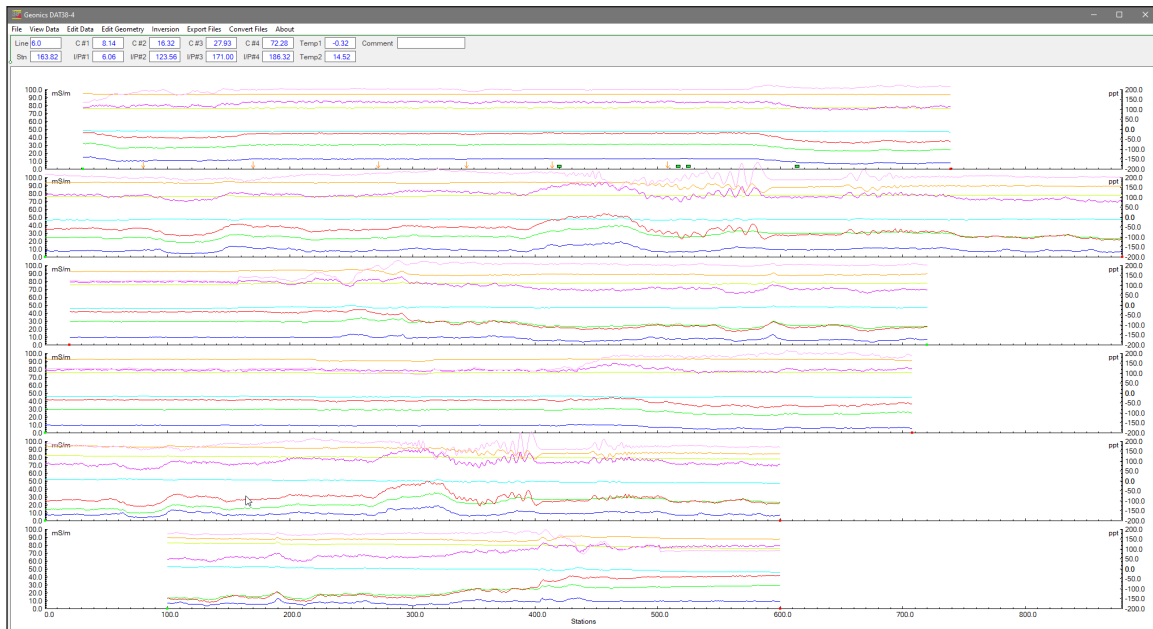


Figure 3.5 DAT38-4 screen after additional file is loaded

### Loading Additional Data Files To Separate Windows

To display another data set (can be exactly same data file) in a separate window select **File|Open New Window** in the menu (Figure 3.6). A new program window will be displayed with a small offset on top of previous DAT38-4 window (Figure 3.7). A new data file can be loaded as described above.

The DAT38-4 is a Single Document Interface. Each data set is displayed in a separate window with its own menu. Windows can be re sized, moved, and arranged in any configuration. This includes multiple entry of the same file name, so the same data set can be displayed in separate windows.

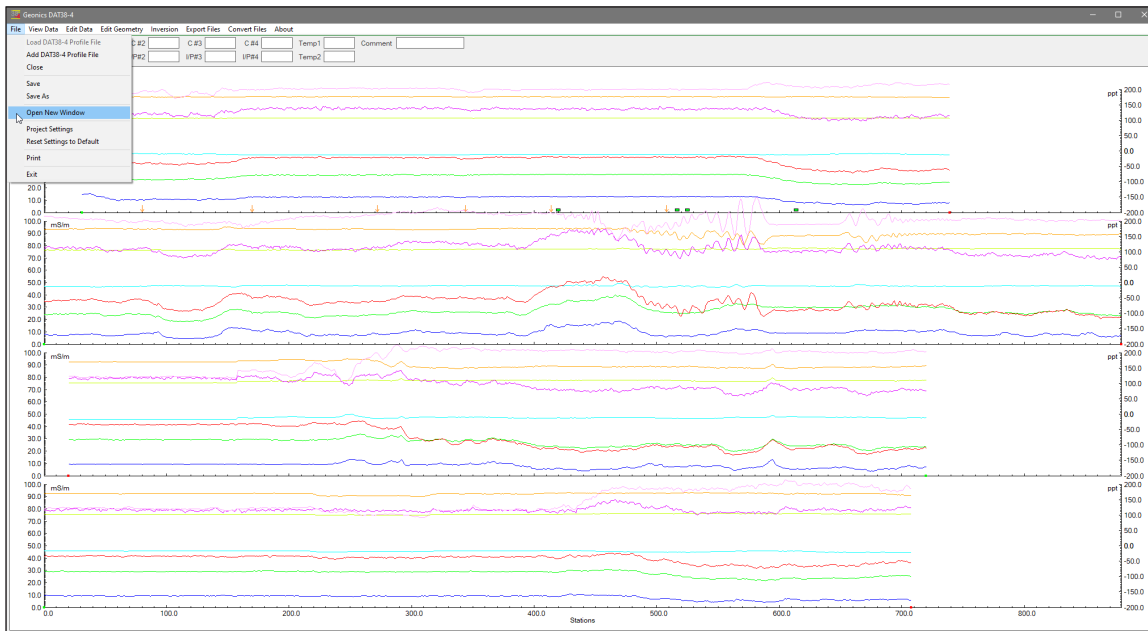


Figure 3.6 DAT38-4 File menu, Open New Window

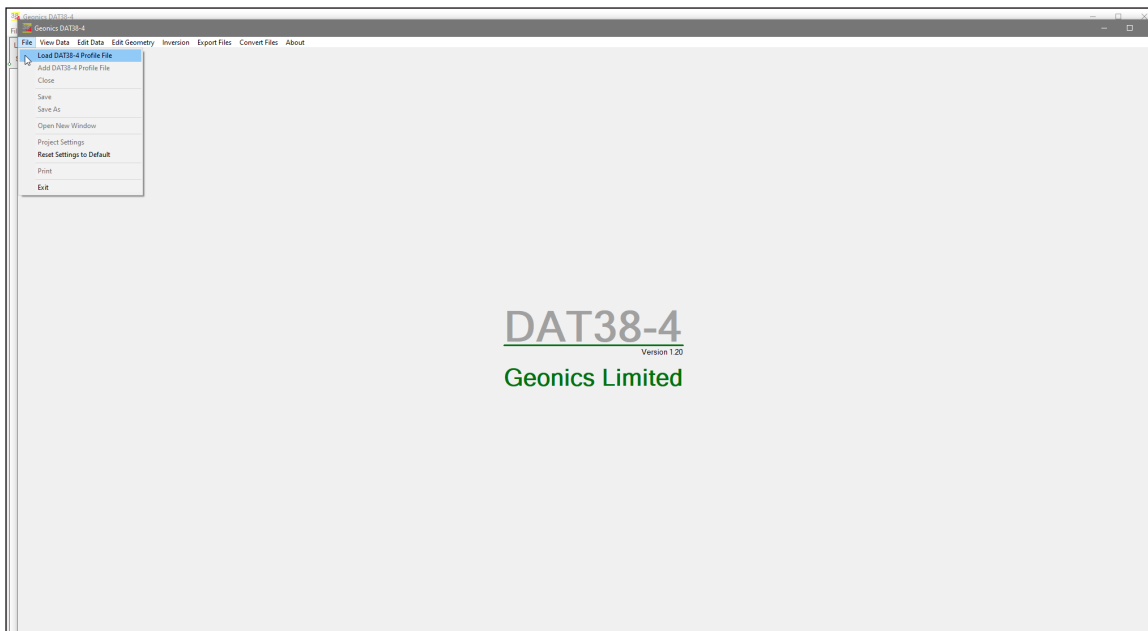


Figure 3.7 New DAT38-4 Program Window on top of previous data set

## 3.2 Closing Profile Window and Saving Data

### Closing Active Window

To close any active window select **File|Close** in the menu (Figure 3.8). This procedure can also be performed by clicking the close button of the active window.

If any data processing was performed on the loaded data set and items not saved using **Save** nor **Save As** functions (see below), a Save Changes dialog will appear as a warning (Figure 3.9).



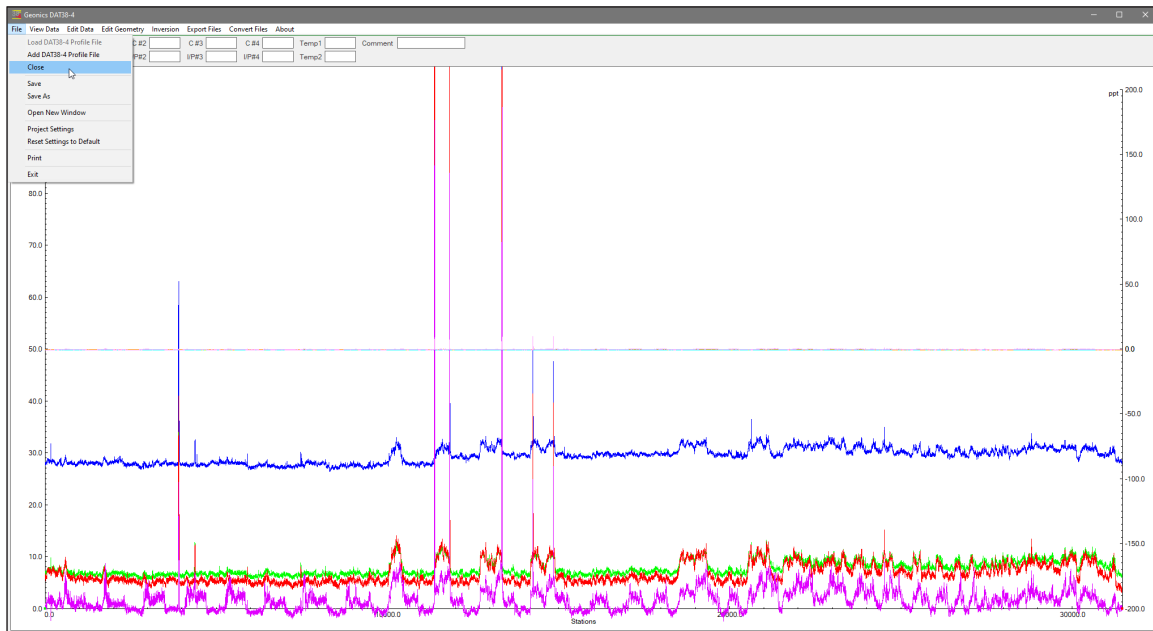


Figure 3.8 DAT38-4 File menu, Close item

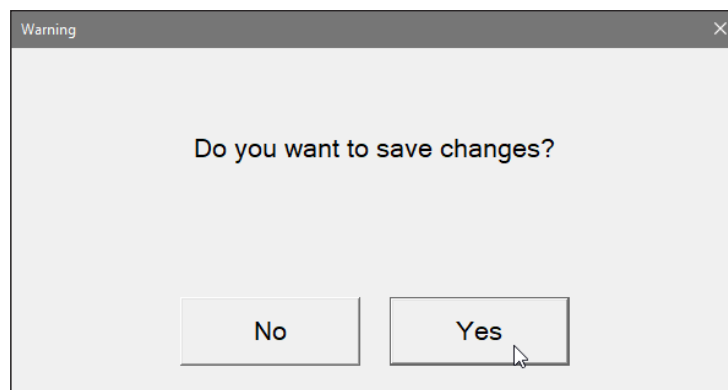


Figure 3.9 Save Changes dialog

## Save Data

---

To save data to the currently opened file select **File|Save** in the menu (Figure 3.8). If several files are open, the caption displayed at the top of the active window will be used as the file name.

**It is recommended that you use the option Save As, to maintain the original data in an unedited form.**

## Save Data to Specified File (Save As)

---

To save data to a different file select **File|Save As** from the top menu (Figure 3.6). The Save As dialog will be displayed (Figure 3.10). Select a directory, specify a file name and then click the **Save** button (or double click the left mouse button, or press **Alt\_S** on the keyboard). Data files created by Save As procedure will have the extension name F38.

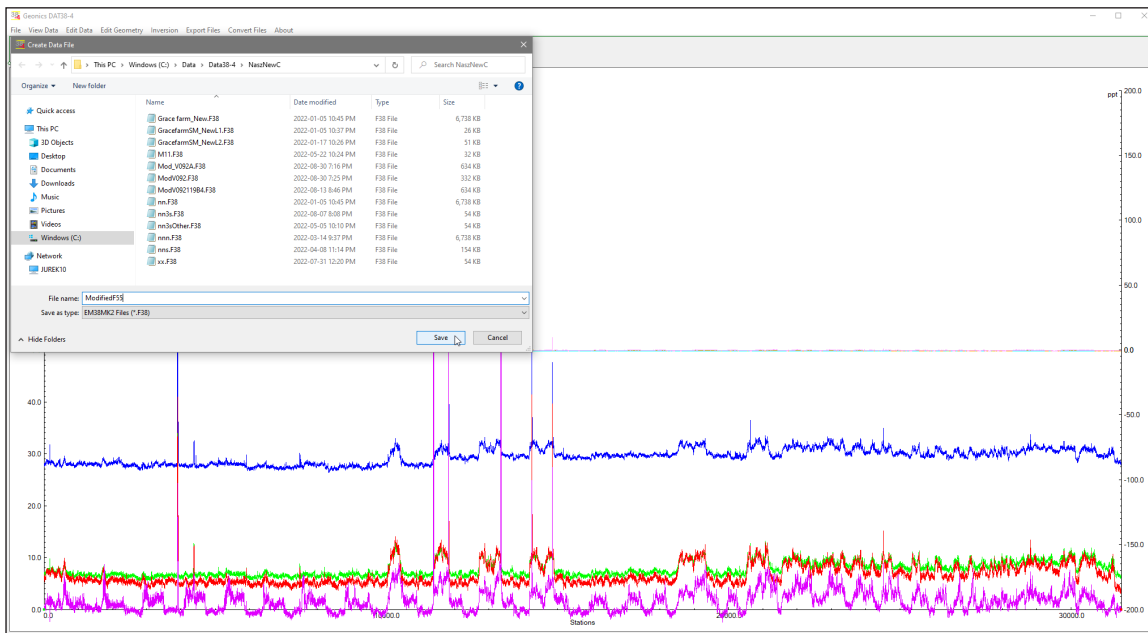


Figure 3.10 DAT38-4 Save As dialog

### 3.3 Project Settings

Some file parameters can be changed in the loaded data set. These are: Distance Units, Inphase Units, EM38-4 Height, and orientation of EM38-4. Click on the **File|Project Settings** menu and the dialog Survey and Data Settings dialog will be displayed (Figure 3.11).

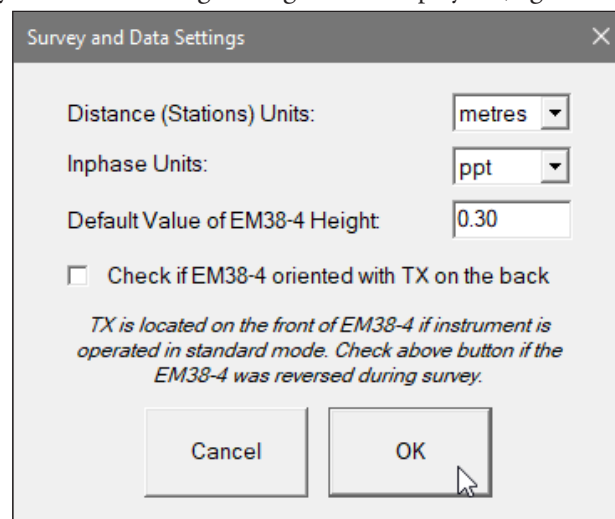


Figure 3.11 Survey and Data Settings dialog

Distance (stations) units are important if grid based xyz files are to be created. They can be changed in the above dialog if other units were selected during data collection be an error.

Inphase units can be changed to mS/m or ppt. The Inphase range for should be adjusted to display properly Inphase profiles in the selected units. Inphase axis will be labeled properly according to the Inphase Units selection.

Default Value of EM38-4 Height is the instrument height as recorded in the data file (usually during data collection). This parameter is used during inversion calculations. The parameter can be updated here if wrong value was entered during data acquisition.

Location of transmitter (TX) antenna is important if Coil Offsets Correction is to be used in while creating XYZ files. In the standard mode TX antenna is located at the front of the EM38-4. If for any reason EM38-4 is used in different orientation and TX antenna is located at the back of the instrument (as related to the direction of movement) then check the button in this dialog.

All changed entered in the Survey and Data Settings are valid till end of the program execution. Use Save or Save As options to save updated parameters permanently.

### 3.4 Reset Parameters to Default

When resetting all parameters to the program default is needed click on the **File|Reset Parameters to Default** menu item. A warning dialog Reset Settings to Default will be displayed as shown in Figure 3.12.

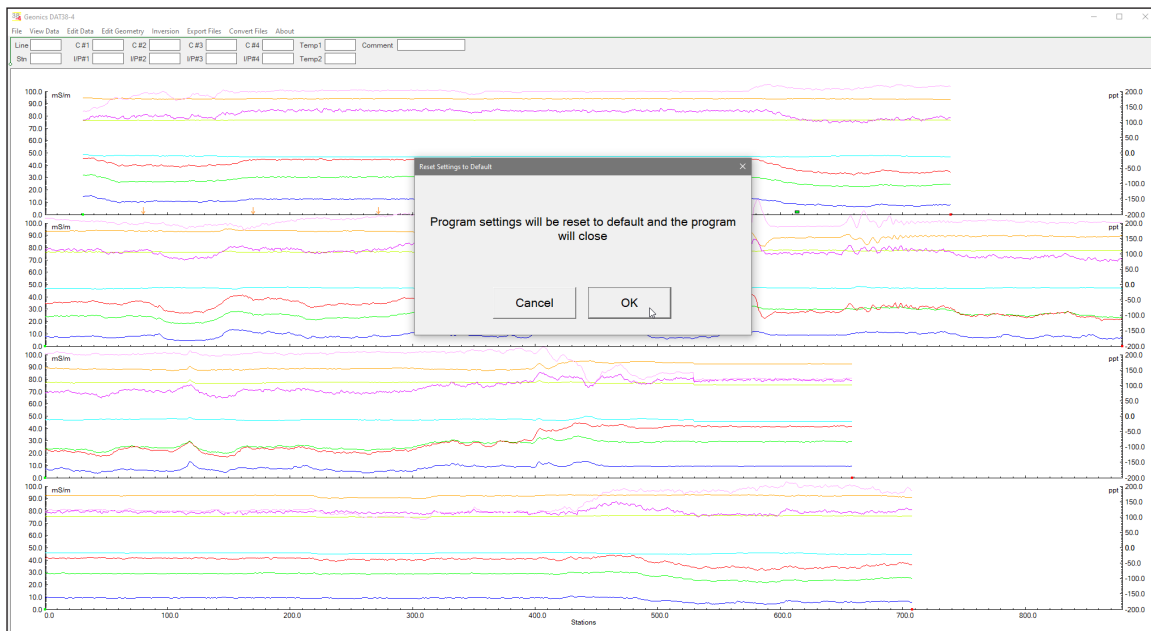


Figure 3.12 Reset Settings to Default dialog

When the OK button is clicked the program will close. At next execution of the program all parameters will have program default values.

### 3.5 Select, Delete and Rename Survey Lines

#### Selecting Survey Lines

When a data file is loaded, all survey lines contained in the file are displayed. To display a selection of survey lines select **View Data|Select Lines** from the program menu (Figure 3.13).

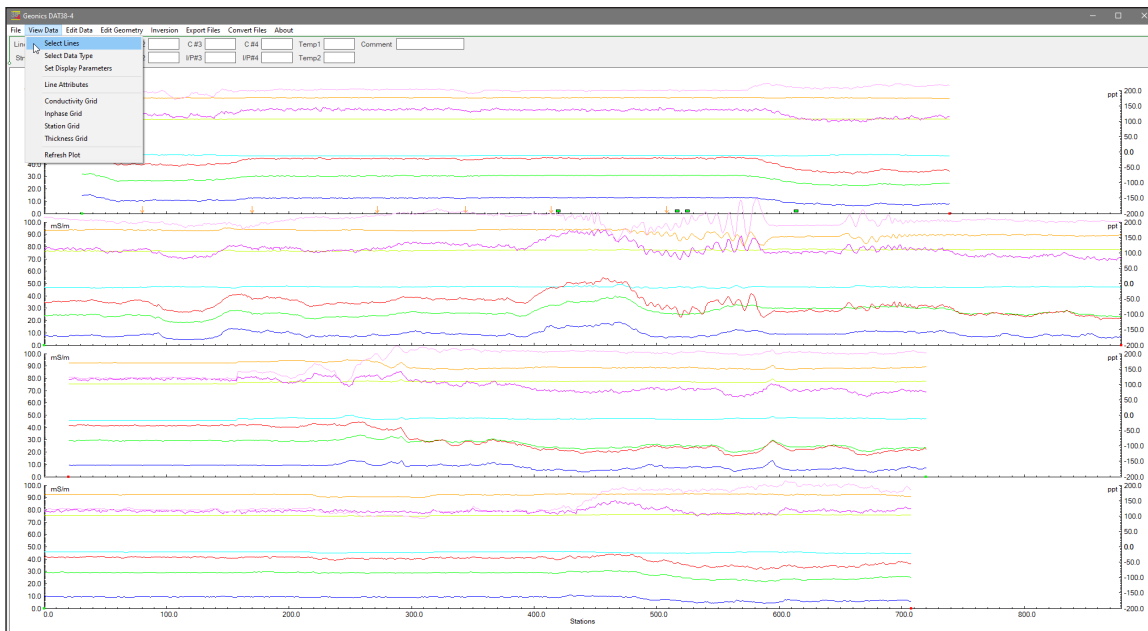


Figure 3.13 DAT38-4 View Data menu

The Select Survey Lines dialog is shown in Figure 3.14. In the top right section the number of available survey lines (Total), the number of currently selected lines (Selected), and the number of deleted lines (Deleted) are displayed.

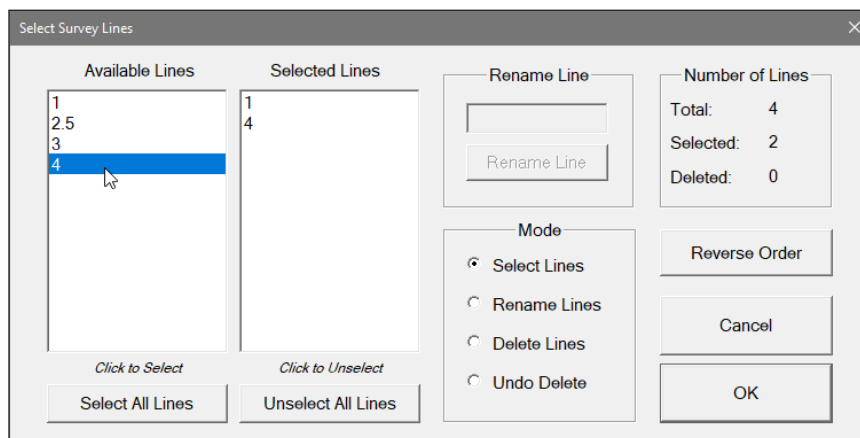


Figure 3.14 Select Survey Lines dialog

The left list box, labeled Available Lines, displays all available lines. The right list box, labeled Selected Lines, shows the lines selected for display. When saving data (**Save** or **Save As** options), data will be saved in the order shown in the Select Lines window.

Select (and deselect) lines to be displayed by clicking the line names in the corresponding list box. **Select All Lines/Unselect All Lines** functions are also available. Clicking on the **Reverse Order** button will change sequence of all previously selected survey lines (from top to bottom of the display). All line names shown in the Selected Lines list window will be displayed on the screen after clicking the **OK** button. Figure 3.15 is an example of a screen with two selected survey lines. (The corresponding Select Survey Lines dialog is shown in Figure 3.14.)

The selection of lines has no effect on the execution of **Save**, **Save As**, **Create Grid Based XYZ File**, **Create GPS Based XYZ File** options. Select Lines only affects the current display. Therefore, one or two survey lines can be displayed and examined in detail and then saved with all other (not deleted) survey lines to a new file.

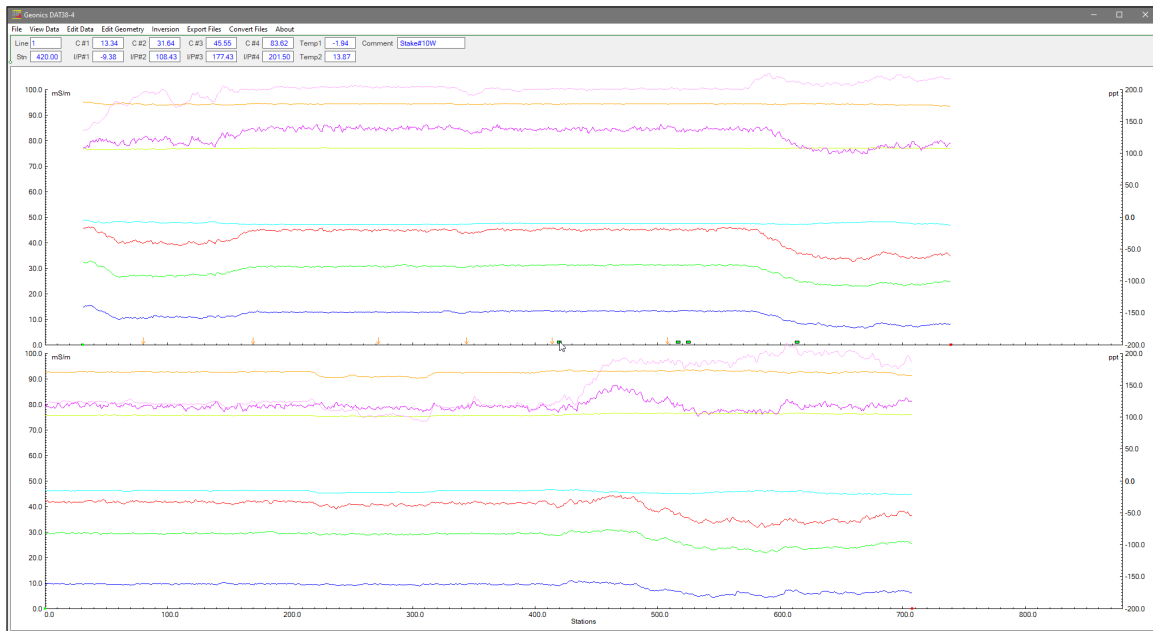


Figure 3.15 DAT38-4 screen with selected survey lines

## Deleting Survey Lines

You can also delete and rename lines with the **Select Lines** window while using Delete and Rename mode (Figure 3.16).

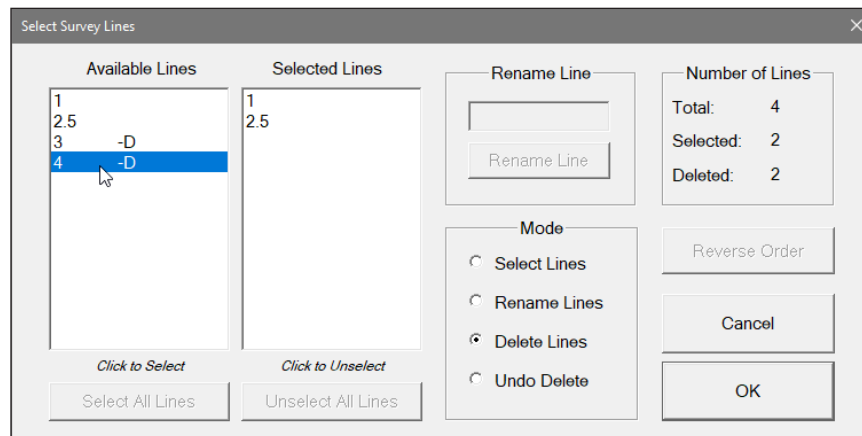


Figure 3.16 Select Survey Lines dialog during Delete Line procedure

To delete a survey line from the loaded set, first click the **Delete** radio button in the section labeled Mode. When the radio button is checked click the appropriate line name in the list box labeled **Available Lines**. The letter **D** will be displayed next to the line name in the Available Lines list (Figure 3.14). These lines will not be displayed nor written to the output file during **Save**, **Save As**, **Create XYZ File** tasks.

Lines can be undeleted as well. To undo previously deleted lines (as long as program is running), first click the **Undo Delete** radio button. When this radio button is marked in the Mode section click the appropriate line name (with letter **D** next to its name) in the list box. The letter **D** will disappear and the survey line can be displayed, edited, and saved.

## Renaming Survey Lines

You can rename survey lines in the Select Lines window as well. Click on the radio button labeled **Rename Lines** in the Mode section and then click on the appropriate line name in the Available Lines list box. The highlighted line name will appear in the Rename Line edit box (Figure 3.17). Edit the name and click the **Rename Line** button. The updated name will now be displayed in the Available Lines list.

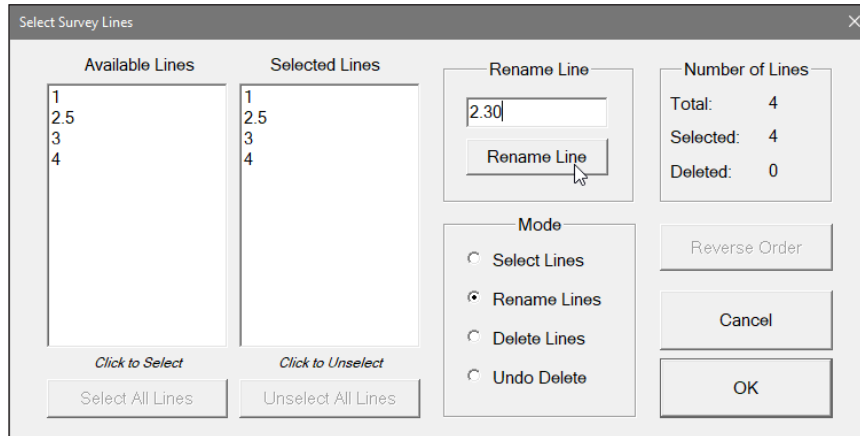


Figure 3.17 Select Lines window during Rename Line procedure

**Deleted and Renamed lines will be valid as long as the program is running. In order to save changes permanently, use the Save As option to create a new data file which can be used later by the program. It is recommended that you use the option Save As in order to maintain the original data in a non edited form.**

## 3.6 Select Data Type

To select the type of data to be displayed select the **View Data|Select Data Type** from the top menu (Figure 3.13). The Select Data Type window will appear as shown in Figure 3.18.

The Select Data Types window contains several check boxes corresponding to each type of EM38-4 component and other available data. Each Data Type is described by following labels:

<b>Conduct. #1</b>	-	Conductivity,	Coil Separation <b>0.50 m</b>
<b>Conduct. #2</b>	-	Conductivity,	Coil Separation <b>0.75 m</b>
<b>Conduct. #3</b>	-	Conductivity,	Coil Separation <b>0.88 m</b>
<b>Conduct. #4</b>	-	Conductivity,	Coil Separation <b>1.00 m</b>
<b>Inphase #1</b>	-	Inphase,	Coil Separation <b>0.50 m</b>
<b>Inphase #2</b>	-	Inphase,	Coil Separation <b>0.75 m</b>
<b>Inphase #3</b>	-	Inphase,	Coil Separation <b>0.88 m</b>
<b>Inphase #4</b>	-	Inphase,	Coil Separation <b>1.00 m</b>
<b>Temperature #1</b>	-	Temperature Sensor #1	
<b>Temperature #2</b>	-	Temperature Sensor #2	
<b>Thickness</b>	-	Inversion: Thickness of the first layer	
<b>C. Layer #1</b>	-	Inversion: Conductivity of the first layer	
<b>C. Layer #2</b>	-	Inversion: Conductivity of the second layer	

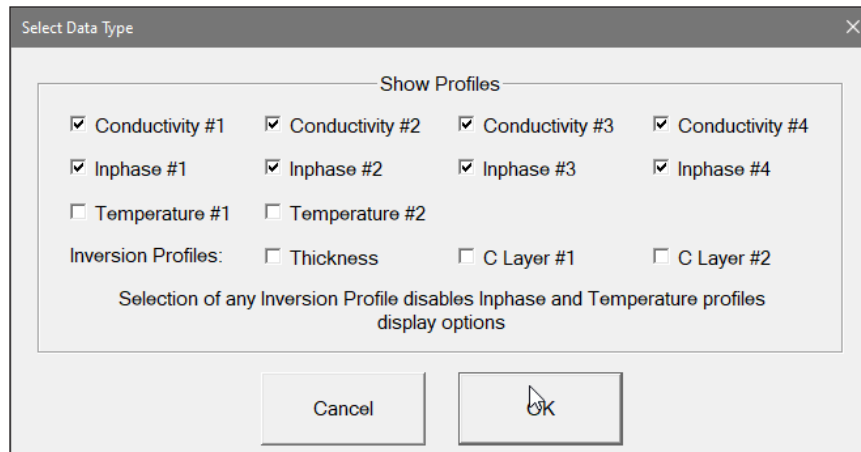


Figure 3.18 Select Data Type window

The Select Data Type dialog lets you select data channels to be displayed as profiles. Inversion Profiles can be plotted only if Inversion procedure was applied during collection of data file. If any parameter of Inversion Results is selected then all Inphase and Temperature profiles are disabled automatically, as illustrated in Figure 3.19. At the same time the Inphase axis (on the right) will be replaced by a Thickness axis labeled in meters. Inversion conductivity values will be plotted with a scale determined by a range shown on the Conductivity axis (on the left).

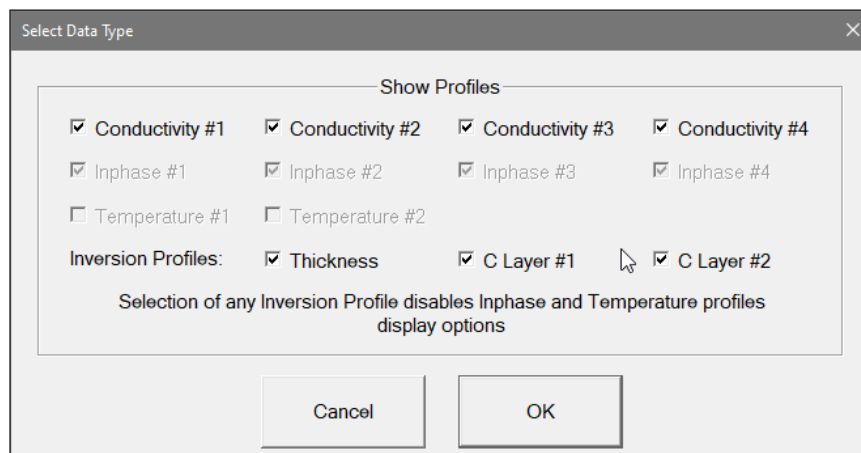


Figure 3.19 Select Data Type dialog with Inversion data selected

After all parameters are selected click the **OK** button located at the bottom of the window. Clicking the **Cancel** button will cancel the selection and the display will not change.

### 3.7 Set Display Parameters

To open the Set Display Parameters dialog (Figure 3.20) select **View Data|Set Display Parameters** from the top menu (Figure 3.13).

This option allows a range to be set for the length of the line (stations displayed), EM38-4 conductivity amplitude (mS/m), Inphase amplitude (ppt or mS/m depending on user choice), as well as Temperature sensor (Celsius degrees) if latter sensors profiles are selected for the profile display.

The major axis tick intervals as well as minor tics frequency are also controlled through this window. Labels and optional grid lines are plotted at the major ticks only.

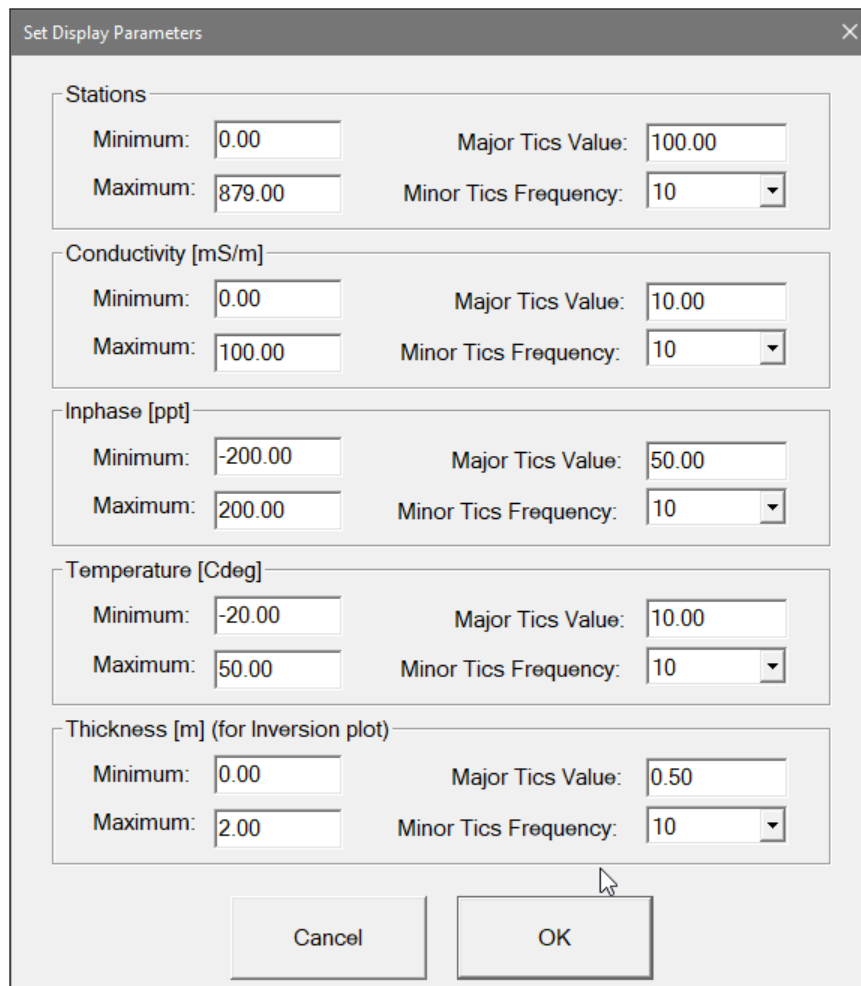


Figure 3.20 Set Display Parameters dialog

After all parameters are set, press the **OK** button and the profile display will be updated according to values specified in above dialog.

## 3.8 Line Attributes

To change the colour and/or thickness of the profile lines of each channel (component/coil separation and other parameters) select **View Data|Line Attribute** from the top menu (Figure 3.13). The **Setup Display Options** dialog is shown in Figure 3.21 (on the left).

Each profile line is of a different type, given by the data type name indicating instrument component (Conductivity and Inphase) for each of four EM38-4 coil separations, other parameters (Temperature 1, Temperature 2), and Inversion Results (Thickness of the first layer, and Conductivity for the first and second layers), see section 3.6 above. The line types labels are displayed in the left column in the dialog. Current colour selections are placed in a column of buttons containing samples of colours for corresponding profile. To change colour of the profile, click on the appropriate button presenting colour sample, a Colour dialog will be displayed (Figure 3.22). Click the desired colour sample and then click on the OK. List of buttons with colour samples will be updated.

To change thickness of profile line click on the corresponding combo box (in a column labeled Thickness) and select line thickness needed line thickness (see Figure 3.21 on the right).



After all attributes are set, click the **OK** button and the profile display will be updated. Line attributes are written to the DAT38-4 configuration file and during future executions of the program these attributes will be used as default settings.

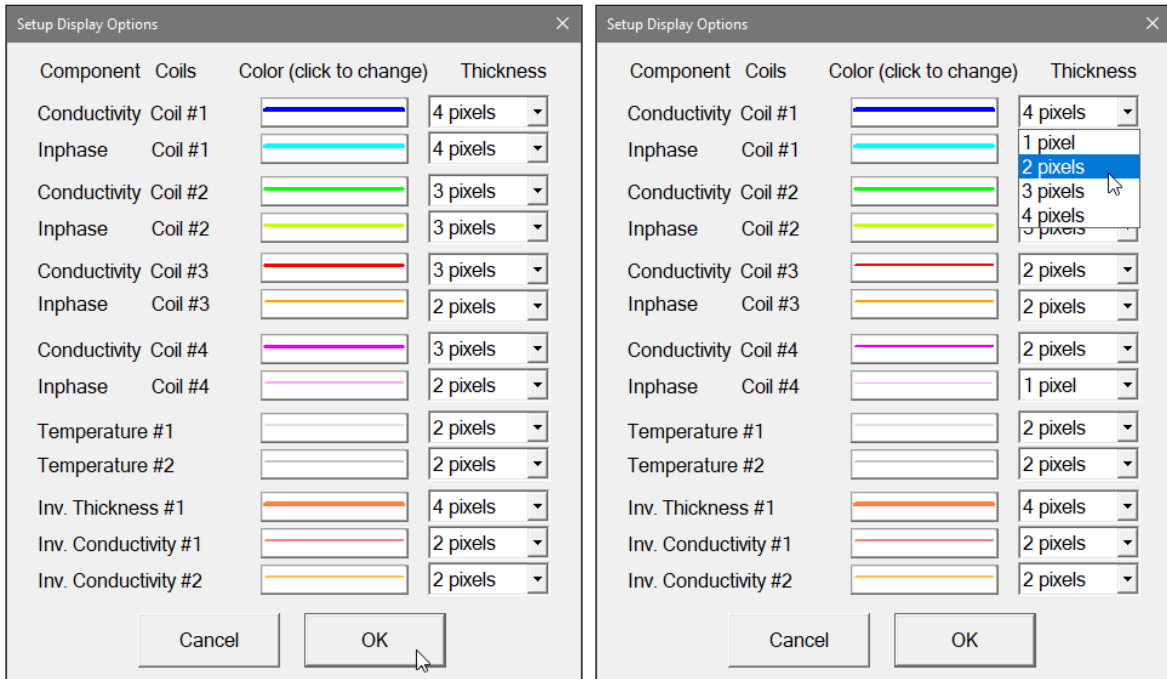


Figure 3.21 Select Display Options dialog and selecting profile line thickness

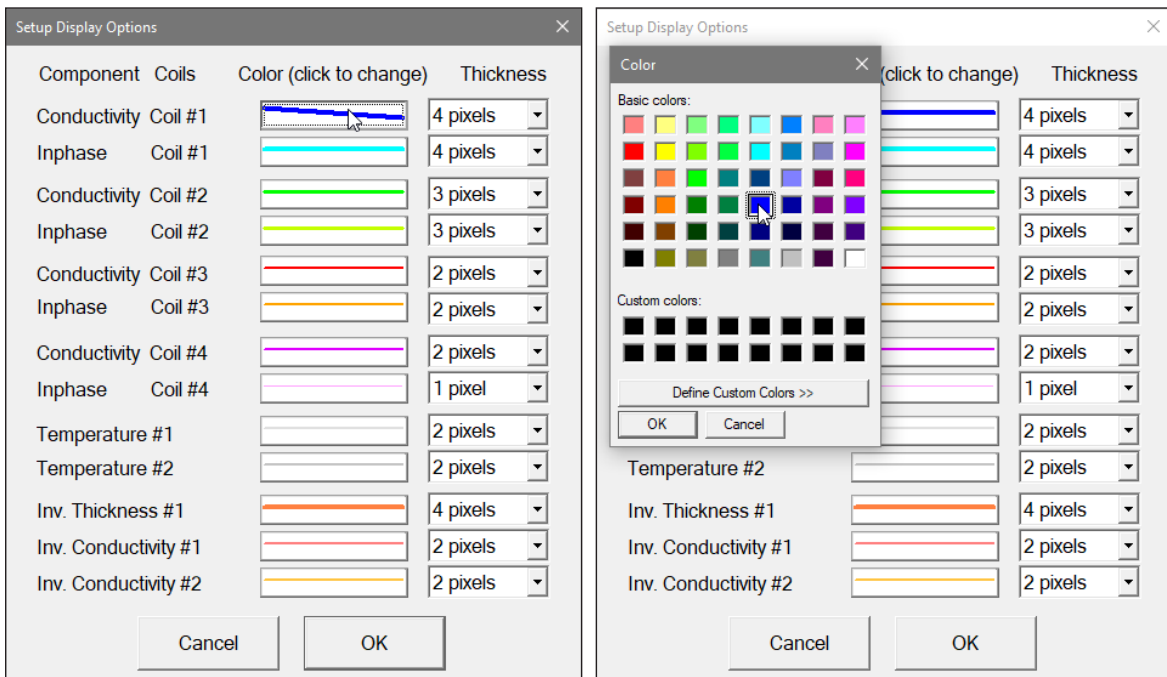


Figure 3.22 Selecting colour for a profile in the Setup Display Options and Color dialogs

## 3.9 Grid Lines

To obtain horizontal and/or vertical lines at major ticks along the axes, select **View Data|Conductivity Grid**, **View Data|Inphase Grid**, **View Data|Station Grid**, **View Data|Temperature Grid**, and **View Data|Thickness Grid** (the latter is for Thickness of the first layer fir inversion results) from the View Data menu. The screen with check marks at View Data menu items and grid lines for Conductivity and Stations is shown in Figure 3.23.

Grid lines are plotted across each panel at corresponding major ticks as light grey lines. These options can be useful in examining the alignment of anomalies which are distributed across more than one survey line, as well as for comparing anomaly amplitudes.

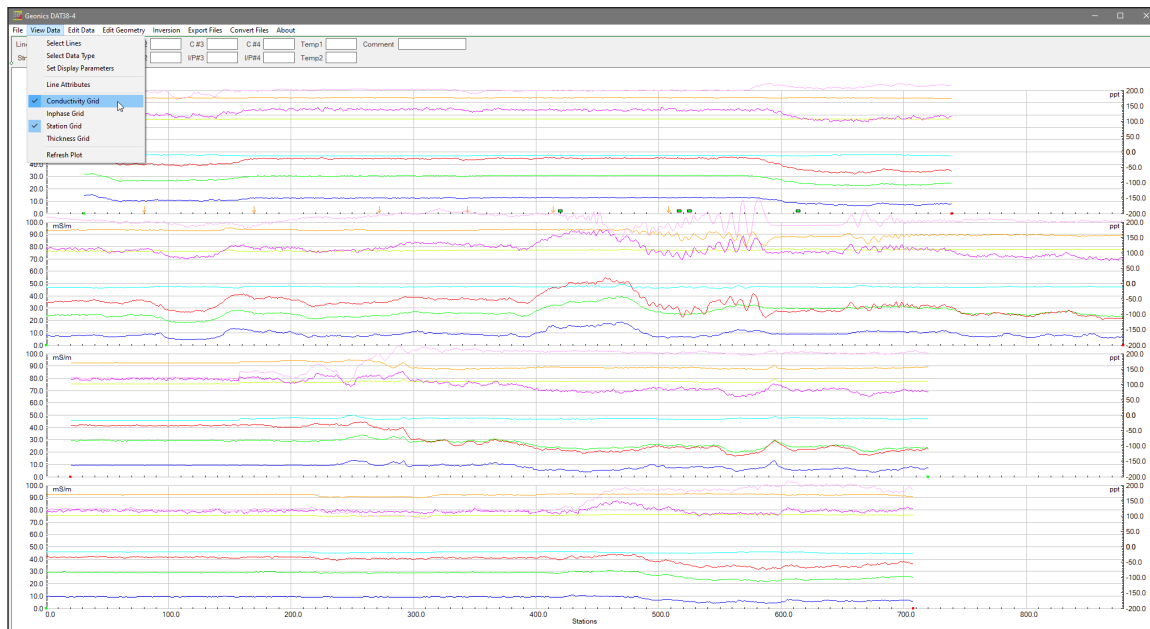


Figure 3.18 DAT38-4 screen with stacked profiles display while grid lines for conductivity and stations are enabled

# 4. Edit Data

To display the Edit Data menu select **Edit Data** from the main menu at the top of the screen (Figure 4.1). The Edit Data menu in the present version of the program contains four items Shift Data Set, Linear Drift Correction, Smoothing Data, and Drift Correction procedure (if drift control points are available).

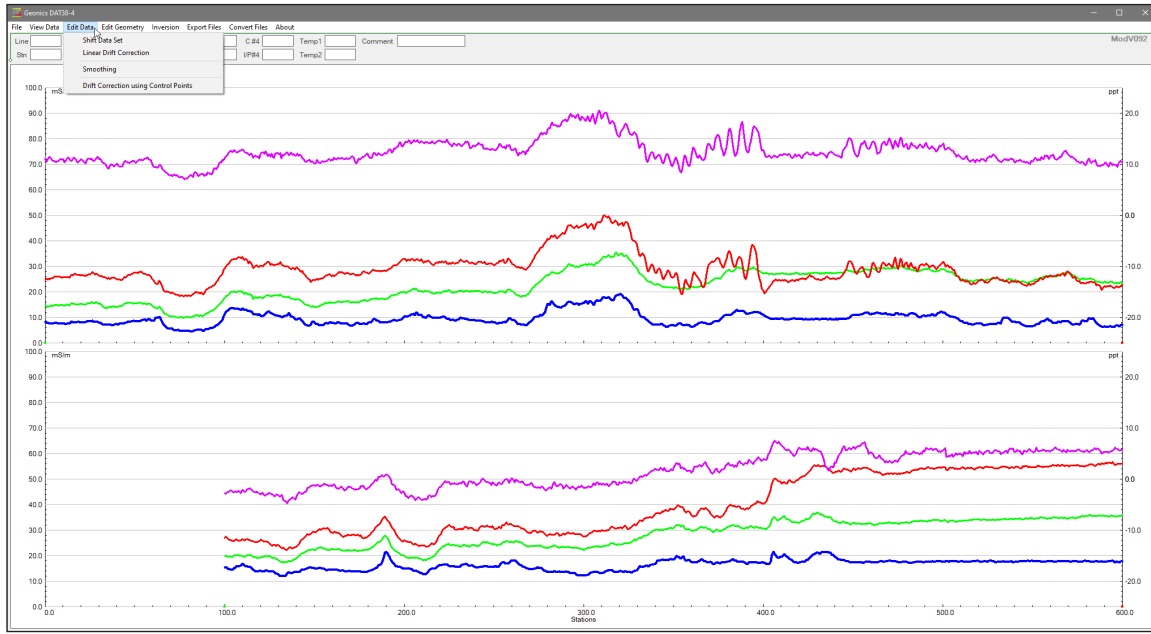


Figure 4.1 DAT38-4 Edit Data menu

## 4.1 Shift Data Set

To display the **Shift Data Set** dialog select **Edit Data|Shift Data Set** from the main menu (Figure 4.1). The dialog that will appear is shown in Figure 4.2.

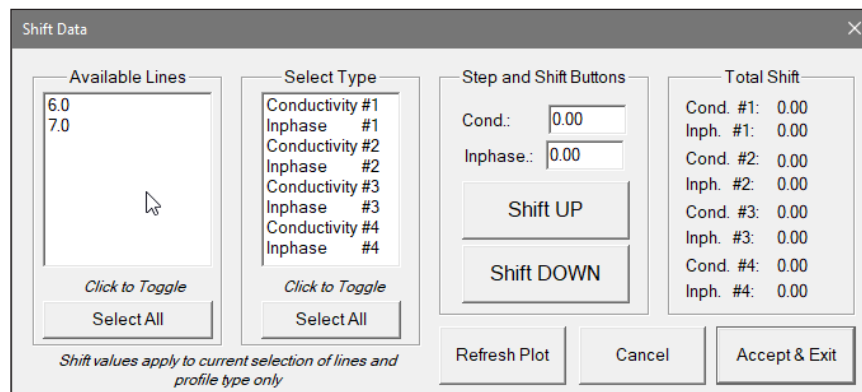


Figure 4.2 Shift Data Set window

The shifting of data function - to increase or decrease the values of all readings that belong to a survey line by a constant amount - can be applied to any number of selected survey lines and to any selected data types of profiles. Survey lines can be selected by clicking on Line Names in the box labeled **Available Lines**, while data types can be chosen by clicking on data types listed in the box labeled **Select Type**. Selected survey lines and data types will be highlighted, see Figure 4.3.

To select all lines and data types click on the **All Lines** button and on the **All Profiles** button to shift data for all survey lines and types listed in the Available Lines and Type of Profile list boxes.

Data is shifted in increments specified in two edit boxes labeled Cond (for Conductivity) and Inphase in the section labeled **Step and Shift**. The increments (steps) for Conductivity and Inphase can be set from the keyboard (after positioning the cursor in the edit box). Increment 0 causes no shift for the data of given component.

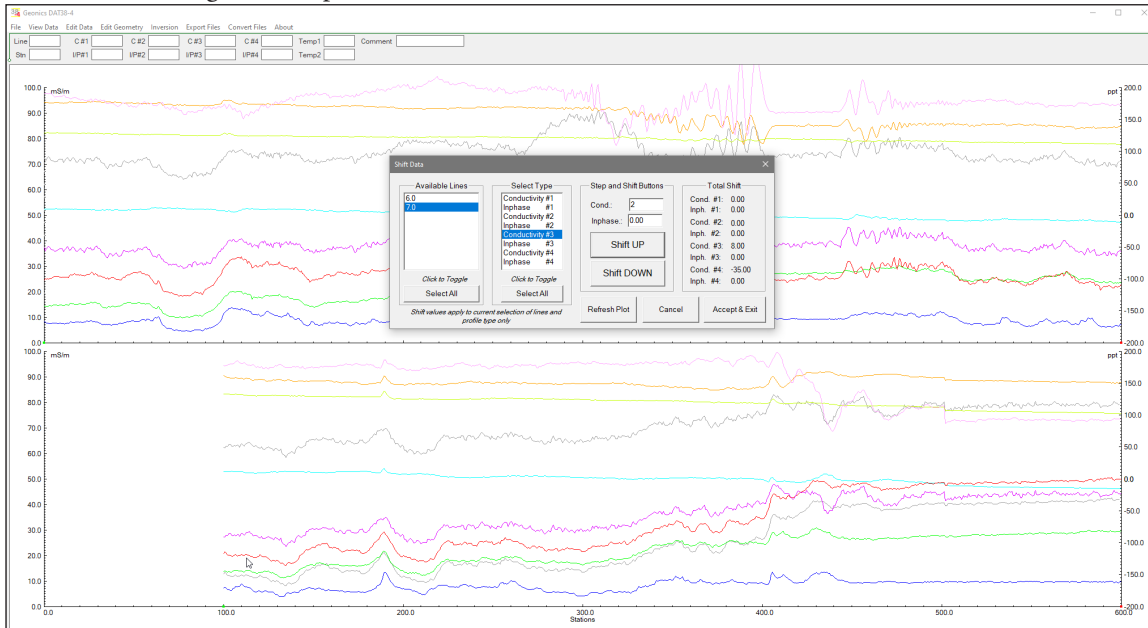


Figure 4.3 DAT38-4 during Shift Data operation

To shift data for the selected survey lines click on the **Shift UP** or **Shift DOWN** button. The total shift will be shown in the display box labeled **Total Shift** and the graphic display (profile view) will be updated in real time. The Shift Data Set window can be moved to a section of the screen where it will be the least obstructive (Figure 4.3). The screen with the shifted readings is shown in Figure 4.3, please compare to Figure 4.1. Original profiles are shown as gray lines for easy comparison of the amount of shift. In case some of profiles or their parts will be deleted by re-drawing shifted profiles click on the **Refresh Plot** button.

To close the Shift Data Set window click on the **Accept & Exit** button. This will temporarily save any changes in the data set. To save changes permanently in the data file use Save or Save As items in the File menu.

## 4.2 Linear Drift Correction

To display the **Linear Drift Correction** dialog select **Edit Data|Linear Drift Correction** from the main menu (Figure 4.1). The window that will appear is shown in Figure 4.4.

In some cases, when elimination of linear drift caused by the site properties or any other possible source is necessary any of two ends of the survey line can be shifted up or down. All readings will be recalculated and plotted on the screen in real time. This procedure can be applied to any number of selected survey lines and to any selected data types (channels). Survey lines can be selected by clicking on Line Names in the box labeled **Available Lines**, while data types can be chosen by clicking on data types listed in the box labeled **Data Type**. Selected survey lines and data types will be highlighted, see Figures 4.4 and 4.5.

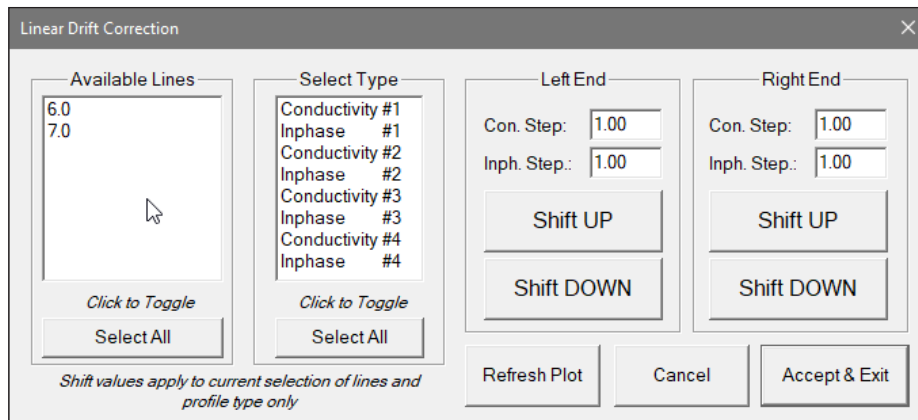


Figure 4.4 Linear Drift Correction dialog

Data is shifted in increments specified in two edit boxes labeled **Step** in two sections labeled **Left End** and **Right End**. The increment (step) can be set from the keyboard (after positioning the cursor in the edit box).

To shift data for the selected survey lines and data types click on the **Shift UP** or **Shift DOWN** button in one of sections corresponding to Left or Right end of lines. The total shift will be shown in the graphic display (profile view) and it will be updated in real time. The Shift Data Set dialog can be moved to a section of the screen where it will be the least obstructive (Figure 4.5). The screen with linearly shifted readings is shown in Figure 4.5 and 4.6 (conductivity and Inphase), please compare to Figure 4.1. Original profiles are plotted as gray lines during shift data procedure for easy comparison of changes.



Figure 4.5 DAT38-4 during Linear Drift Correction procedure

To close the Linear Drift Correction dialog click on **Accept & Exit**. This will temporarily save any changes in the data set. Permanent saving requires Save or Save As items in File menu.

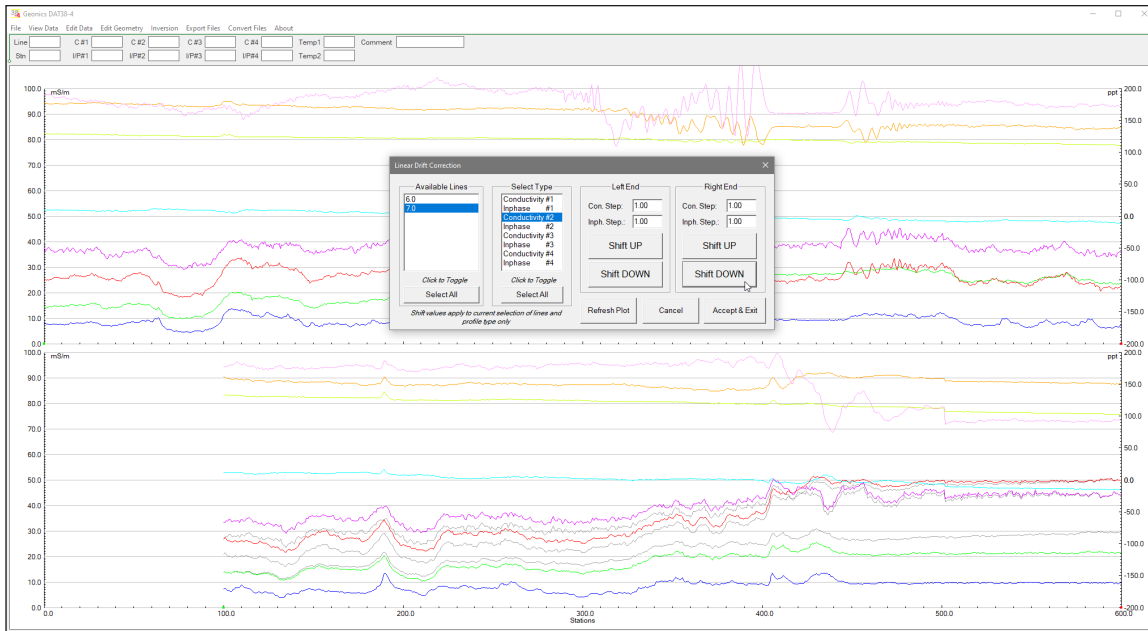


Figure 4.6 DAT38-4 during Linear Drift Correction procedure

### 4.3 Smoothing Data

To display the **Smooth Data** window select **Edit Data|Smooth Data** from the main menu (Figure 4.1). The window that will appear is shown in Figure 4.7

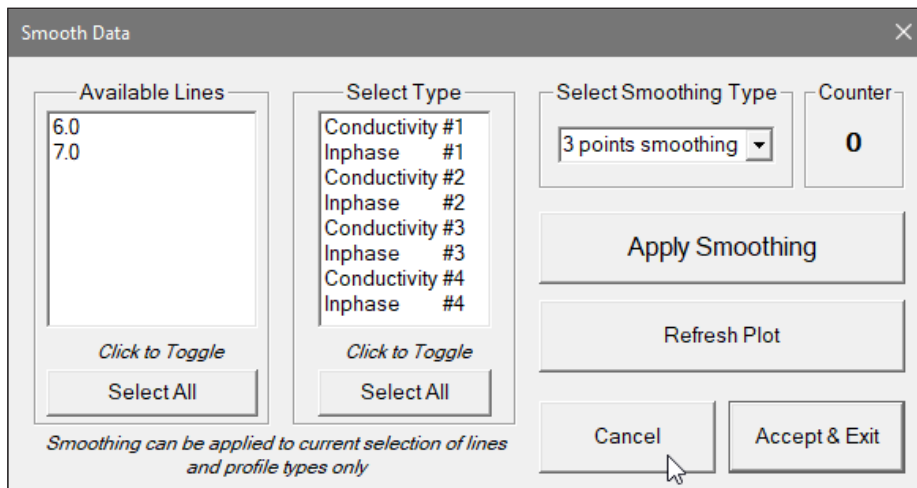


Figure 4.7 Smoothing Data dialog

The smoothing procedure can be applied to any number of selected survey lines and data types. To select lines click on all appropriate lines in the list box labeled Lines and select channels in the Select Type section. Several methods of smoothing are available: 3 point linear smooth, 5 point linear smooth, etc. They are listed and selected using the Select Smooth Routine pull down menu (Figure 4.8).

After the survey lines and the method of smoothing have been selected, press the Apply button to smooth. Smoothing can be applied to a selected set of data several times. The number of smoothing applications is displayed and updated in a section labeled Counter (right top corner of the dialog).

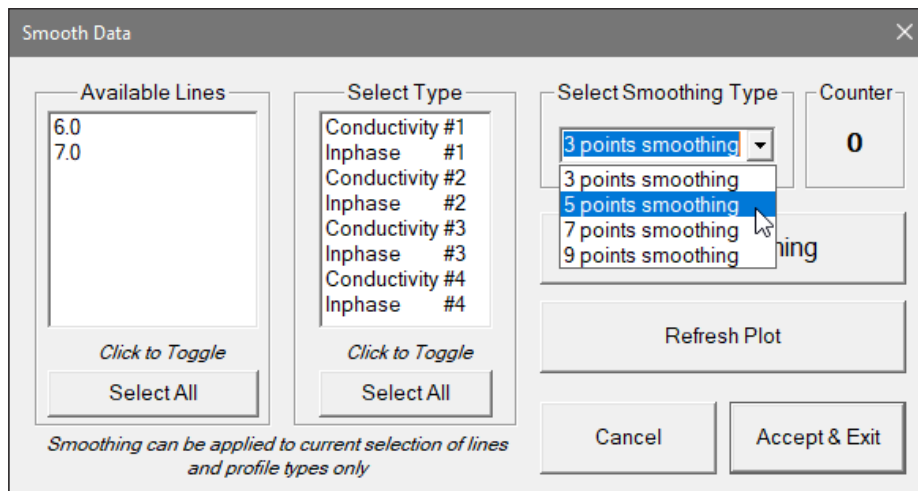


Figure 4.8 Smoothing Data - Available Smooth procedures

The graphic display is updated in real time, with the original curves displayed in grey, as shown in Figure 4.9.

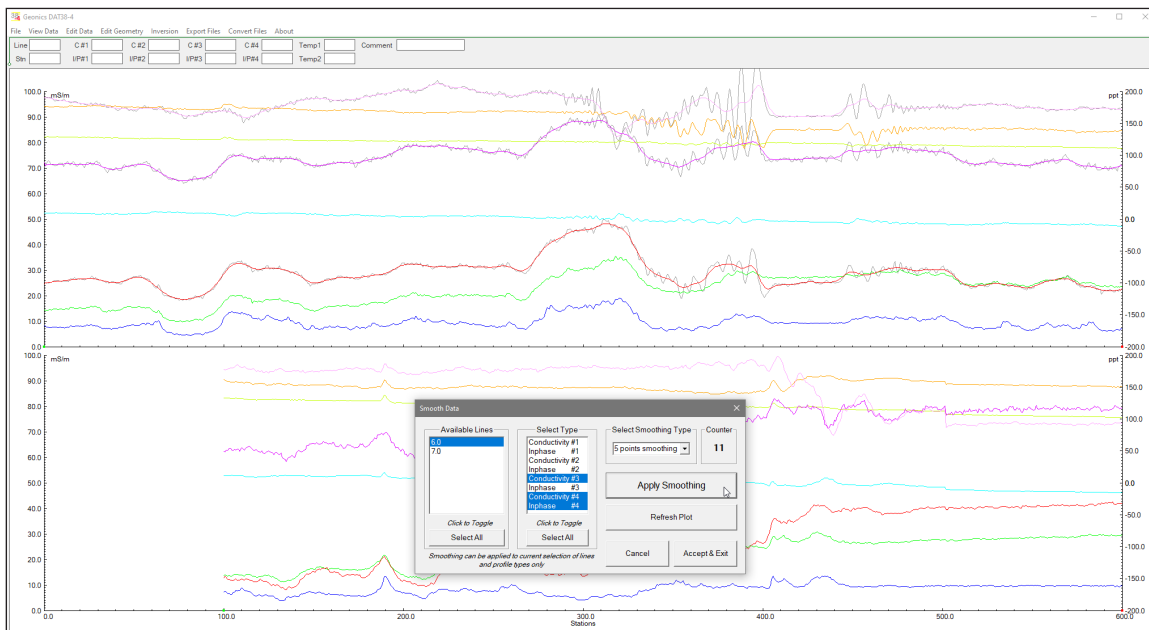


Figure 4.9 DAT38-4 during Smoothing procedure

Method of smoothing and the degree of smoothing depends on the particular data set, objectives, desired method of presentation, etc.

Closing the Smooth Data window using the Accept & Exit button to temporarily save changes in the data set.

Note that changes are saved temporarily in the in the program memory while the window associate with the data set is active. Changes can be saved permanently with the Save or Save As option. (It is recommended to use Save As instead of Save, to preserve the original data.)

The DAT38-4 with smoothed profiles (after the Accept& Exit button was clicked on) is shown in Figure 4.10 (compare with Figures 4.6 and 4.9).

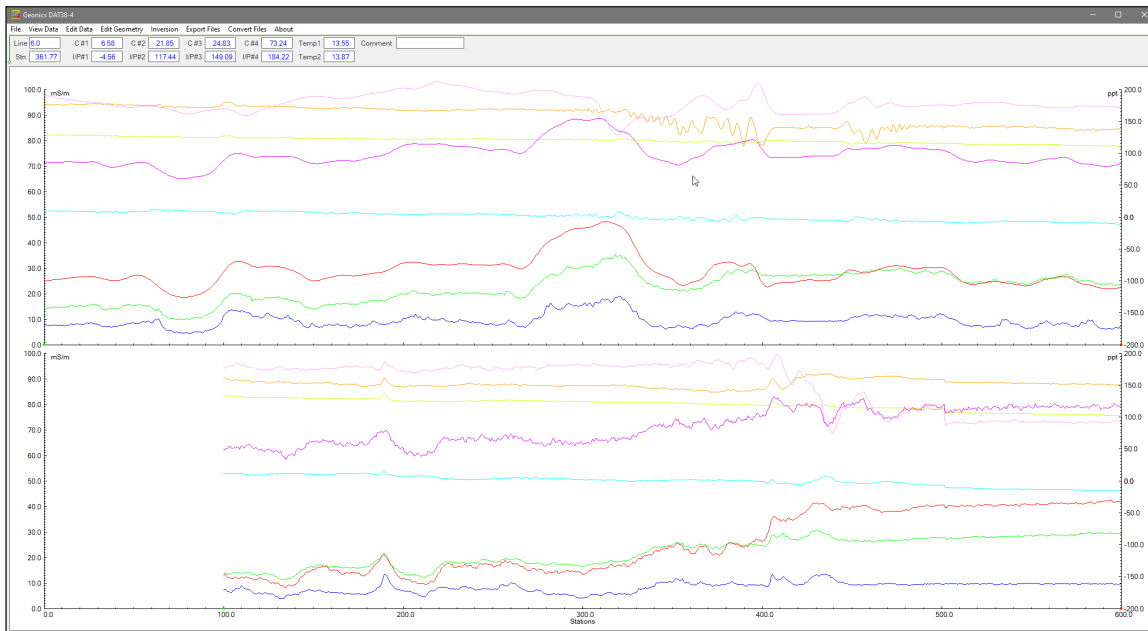


Figure 4.10 DAT38-4 screen with some profiles smoothed (compare with Figure 4.6)

## 4.4 Drift Correction using Control Points

Drift Control Points that are acquired during measurements by the program EM38-4 (version 1.06 or later) are represented by small green arrows at horizontal axis. A survey line shown in Figure 4.11 contains four such green arrows. An example presented in Figure 4.11 represents short stationary measurements with artificially introduced drift, therefore in reality all four conductivity profiles should have near constant value. Drift Control points have been measured four times during this sample survey at the survey start, near stations 1690 and then station 1770, and at the end of the data file. There are visible discontinuities in area of Drift Control points that are caused by unnatural high drift and a fact that the process takes time (about 10 seconds) and logging is not started right away, at the same time profiles are plotted based on stations (not time) providing false impression that signal level changes rapidly between two stations.

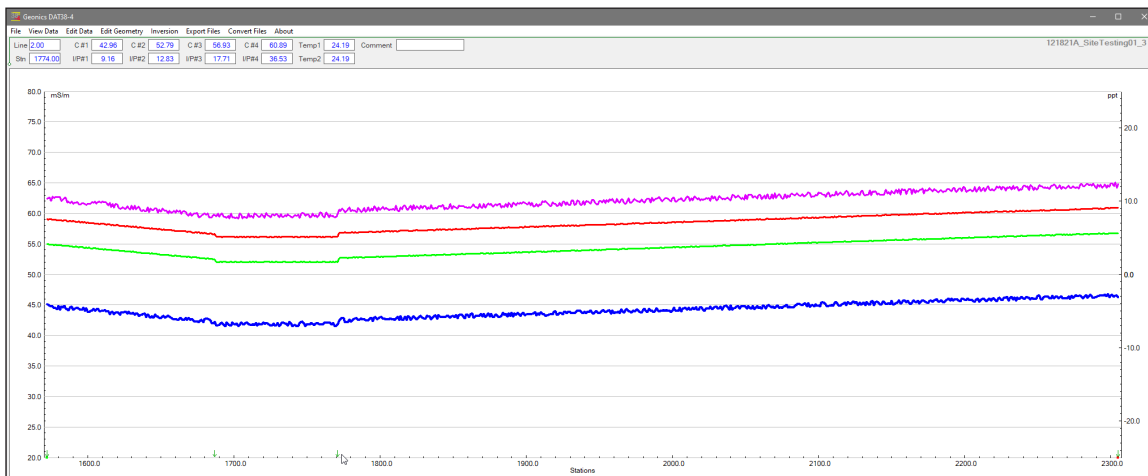


Figure 4.11 DAT38-4 screen with survey line that contains Drift Control Points

The Drift Correction Procedure can be applied only once to each data set. Control Points marked by green arrows indicate that the Drift Correction has not been performed for the displayed data



file, otherwise arrows marking Drift Control points would be displayed as blue arrows (see Figure 4.15 below).

To display the **Drift Correction Based on Control Points** dialog select **Edit Data|Drift Correction using Control Points** from the main menu (Figure 4.12).

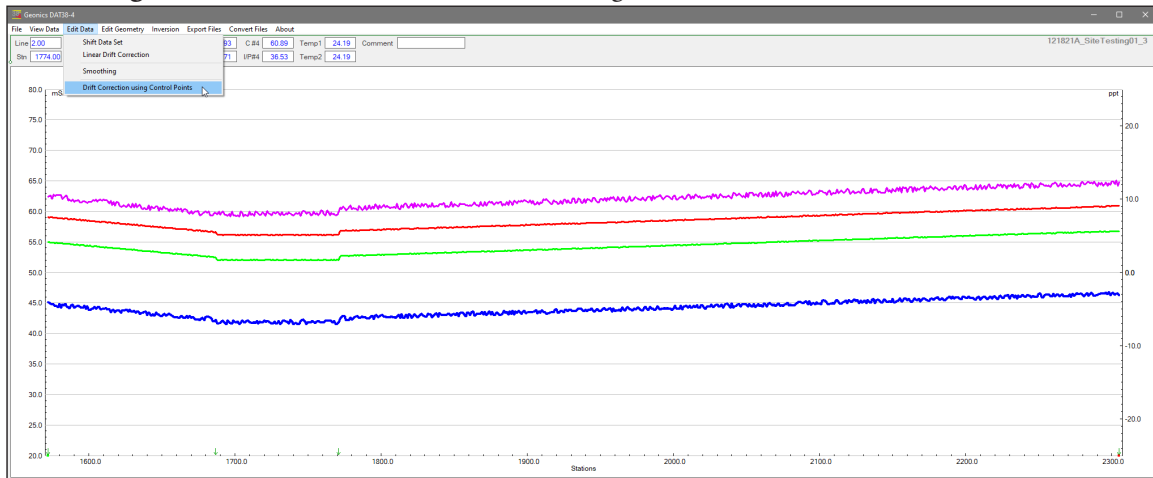


Figure 4.12 DAT38-4 screen with the Drift Correct menu item selected

The Drift Correction Based on Control Points dialog that will appear (shown in Figure 4.13). The dialog provides information about number of Control Points available in the data file and at its bottom displays warning that there is no Undo function for this procedure. However, till data file

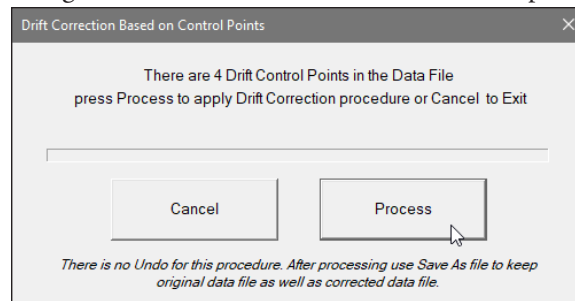


Figure 4.13 Drift Correction... dialog

is Saved changes in the data set are displayed only, they are not permanent. The safest way is to Save As file to have both original and corrected data. After the Process button is clicked calculations start and a progress bar indicates progress of the procedure (Figure 4.14). Duration of calculations depends on the size of data file.

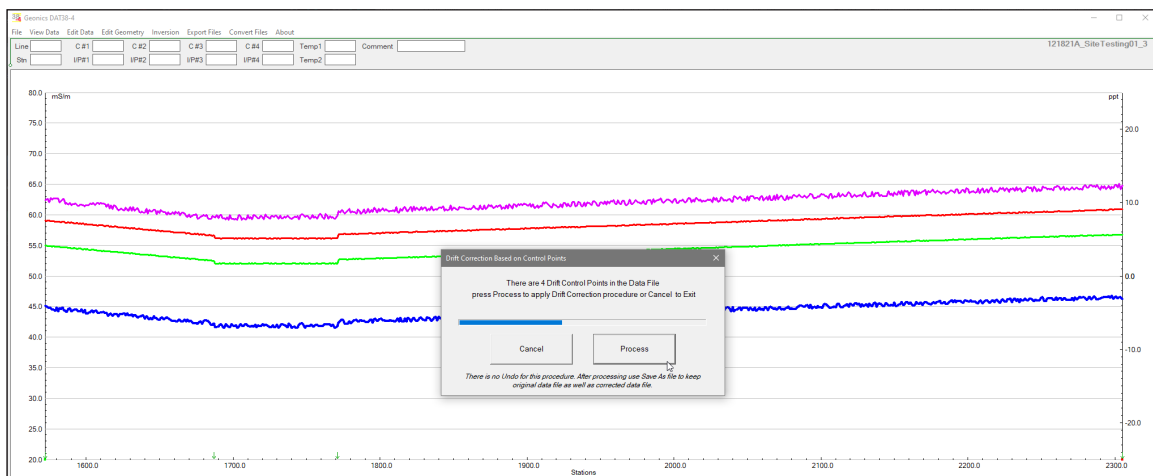


Figure 4.14 DAT38-4 screen during Drift Correction procedure

After the procedure is done, corrected profile plots are re-drawn and Drift Control Points are indicated by blue arrows (Figure 4.15).

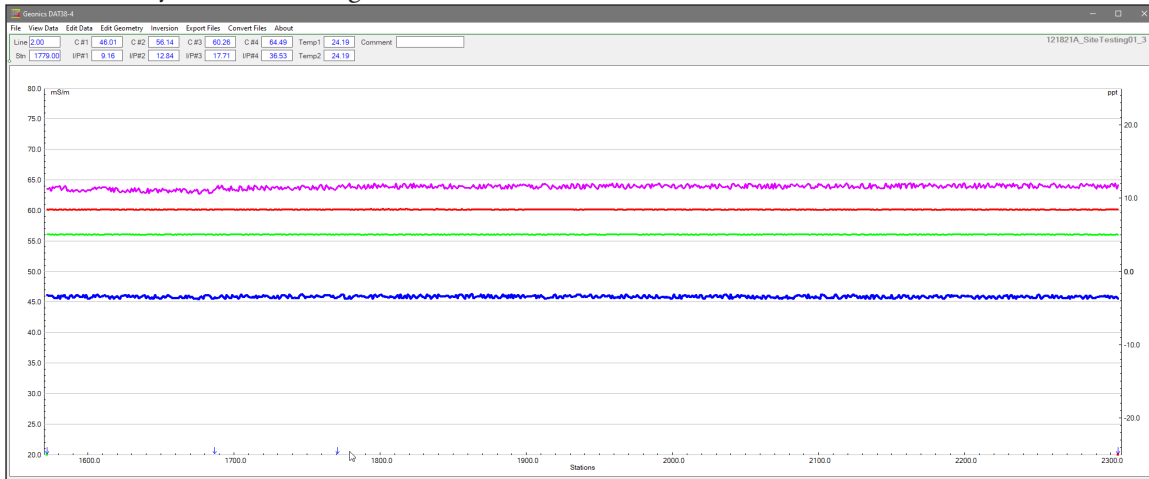


Figure 4.15 DAT38-4 screen with Drift Corrected profiles (compare with Figure 4.11 or 4.12)

If the Drift Correction menu item will be clicked again, a data file with previously drift corrected data will loaded, or whenever Drift Control Points are marked by blue arrows (indicating previously performed drift correction procedure) a following message will appear (Figure 4.16 below).

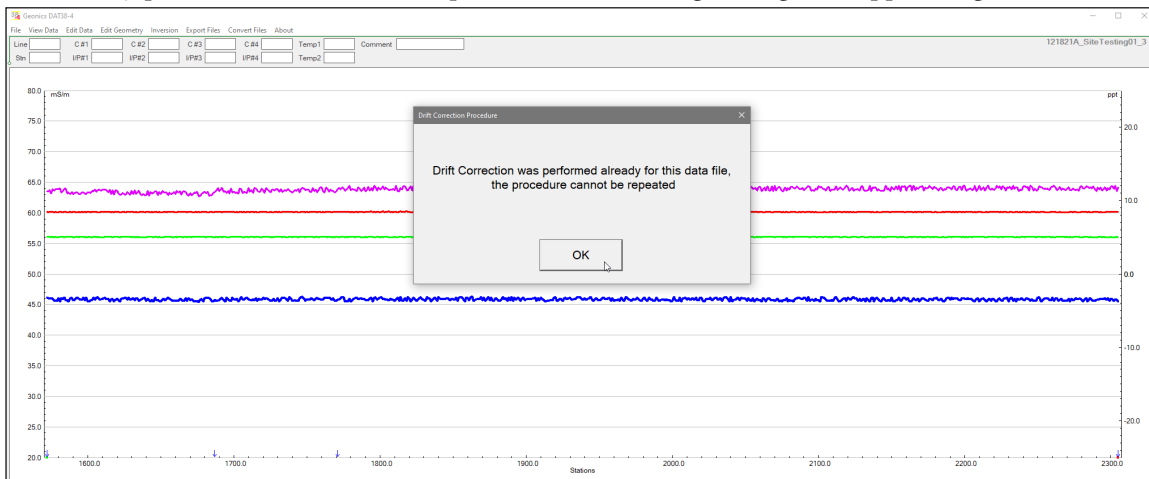


Figure 4.16 DAT38-4 screen with info about previously performed Drift Correction procedure

In case loaded data file contains none or one only Drift Control Point and Drift Correction procedure is attempted a following information message will be displayed, Figure 4.17.

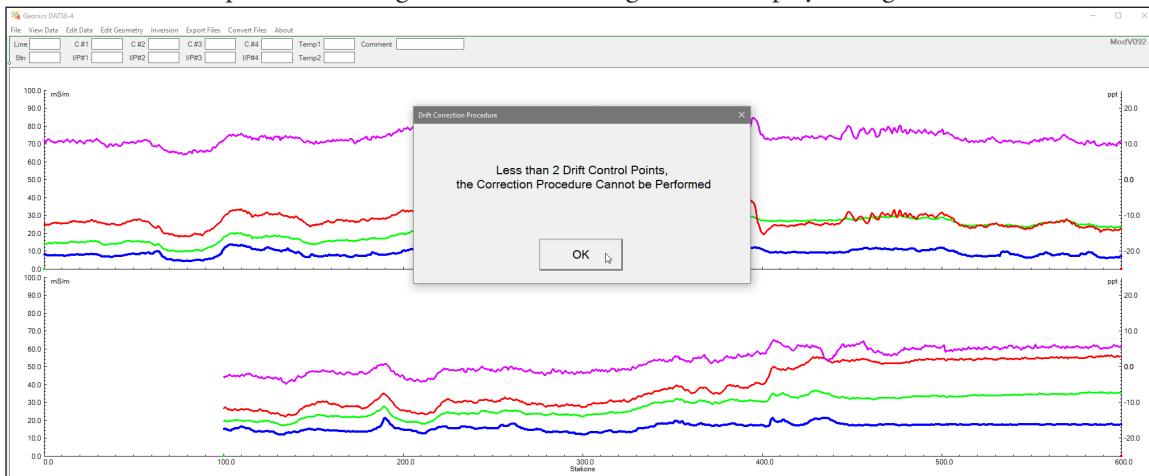


Figure 4.17 Dialog indicating insufficient Drift Control Points to perform Drift Correction

Another case when the Drift Correction procedure cannot be performed is when data set is appended (function Add DAT38-4 Profile File in the File menu). This operation can be applied only to a single data file. If two or more data files are displayed and Drift Correction menu item is clicked a message dialog will appear (Figure 4.18). If data files are to be joined, perform Drift Correction for each data file separately and then use the Add DAT38-4 Profile File function to display files together and/or save them as a single data set.



Figure 4.18 Warning message displayed when more than one data files are loaded and Drift Correction is attempted



# 5. Edit Survey Geometry

The Edit Geometry option allows adjustment of the profile geometry, including the repositioning of both the start and end stations of each line, as well as any station marked with the fiducial switch. To display the Edit Geometry menu select **Edit Geometry** in the main menu at the top of the screen (Figure 5.1).

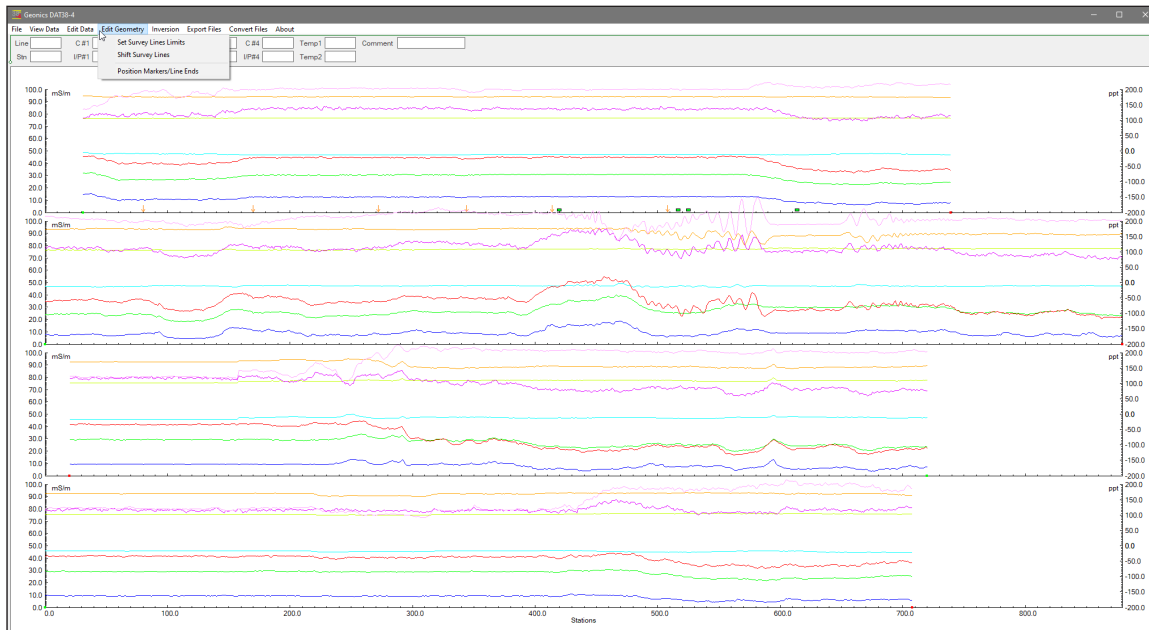


Figure 5.1 DAT38-4 Edit Geometry menu

The Edit Geometry menu contains three items:

- Set Line Limits** changes the position of the start and end stations of any selected group of survey lines;
- Shift Survey Lines** can be used to move any selected group of survey lines in either a positive or negative direction along the profile axis;
- Position Markers/Line Ends** is an efficient tool for aligning fiducial markers as well as the start and end points of survey lines.

## 5.1 Set Line Limits

To display the **Set Line Limits** dialog select **Edit Geometry|Set Line Limits** in the menu (Figure 5.1). The Set Line Limits dialog is shown in Figure 5.2.

You can set line limits (positions of the start and end stations) for any number of selected survey lines at one time. To select lines, use the list box labeled **Select Lines**. The minimum (Left) and maximum (Right) positions of stations are shown in the **Current Line Limits** display box. The Left End corresponds to the minimum station positions on the left side of the screen, while the Right End value corresponds to the maximum positions on the right side for all selected survey lines. New Left and Right positions can be specified in the two edit boxes labeled **Set Lines Selection Limits**. At the start Set Survey Lines Limits lines are not selected by default.

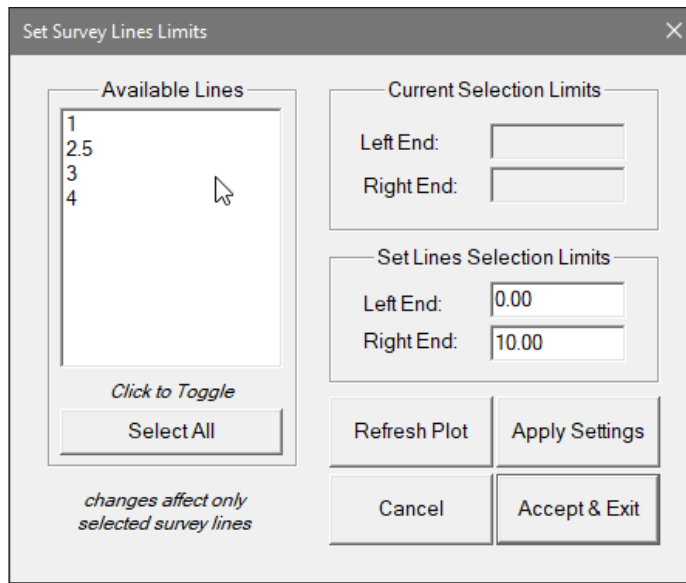


Figure 5.2 Set Line Limits dialog

When any number of lines are selected the Current Selection Limits boxes are filled with minimum and maximum values for ends of selected lines. After new Left End and Right End values can be specified in the Set Line Selection Limits. After you click the **Apply Setting** button, the specified adjustments are completed. The graphic display will be updated in real time (Figure 5.3). The procedure can be repeated for any additional sets of survey lines and settings.

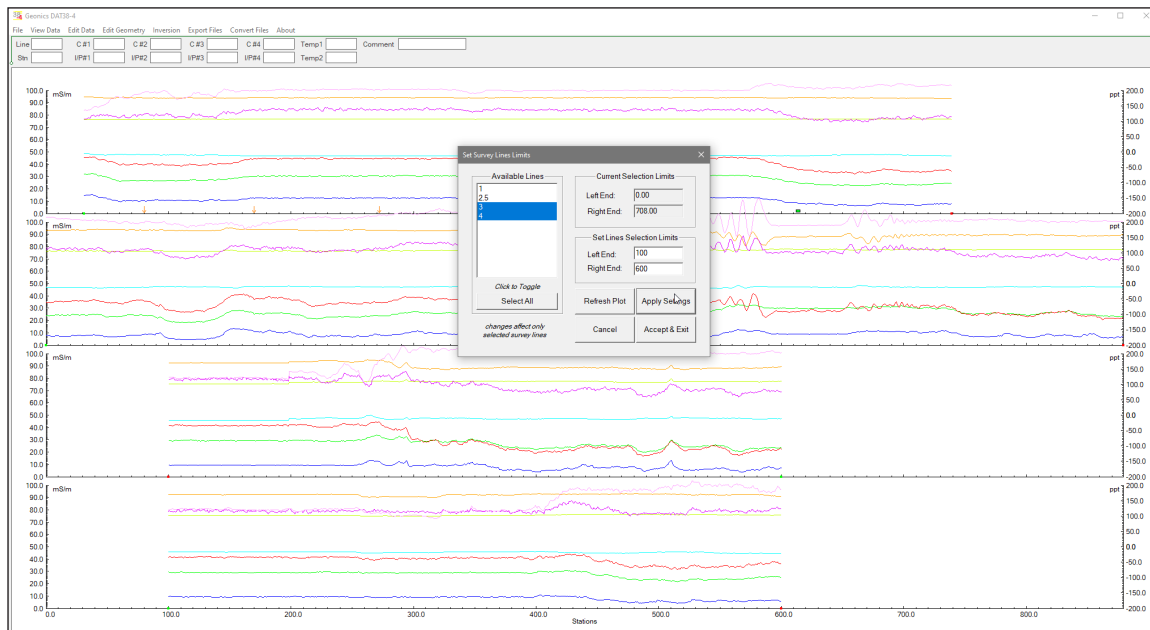


Figure 5.3 Set Line Limits dialog with Lines 3 and 4 repositioned to 100 to 600 (compare with Figure 5.1).

This procedure can be used to reverse direction of survey lines. It is shown in example in Figure 5.4 where lines 3 and 4 have specified new limits (Left End value higher than the Right End).

Example presented in Figure 5.5 shows all available lines adjusted to same range of values.

Above actions are temporary, in order to save new geometry of adjusted survey lines the **Accept & Exit** button must be clicked and then data set must be saved (options Save or Save As). If any change is not satisfactory, click the **Cancel** button to close the Set Line Limits window and return all stations to their original positions.

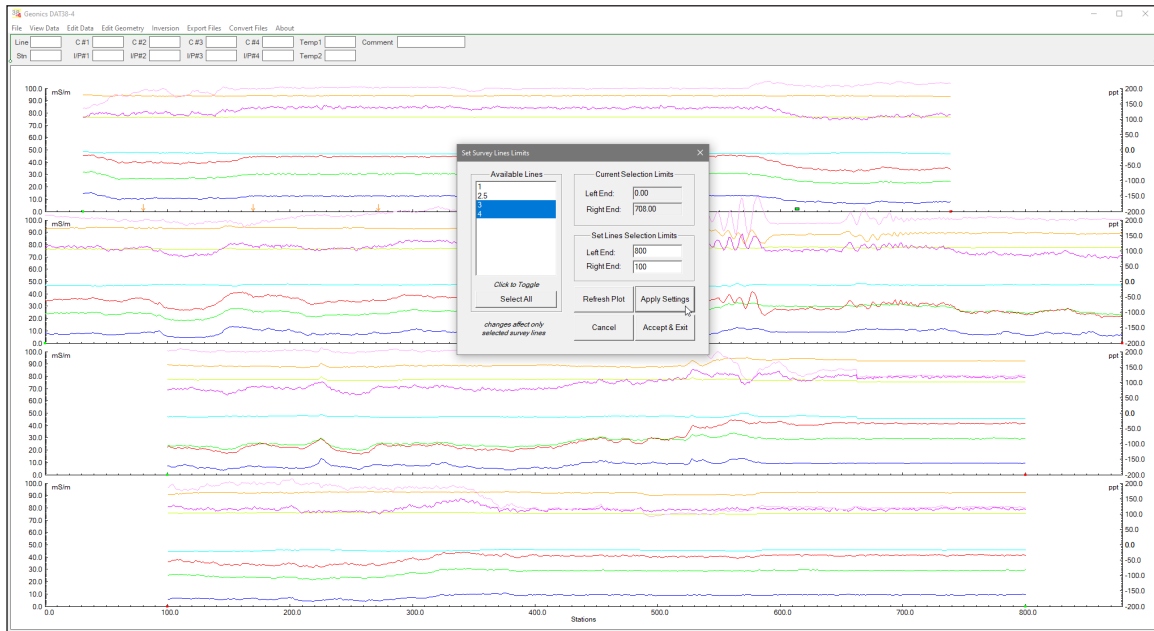


Figure 5.4 DAT38-4 profile display with reversed lines 3 and 4 (compare with Figures 5.1 and Figure 5.3)



Figure 5.5 DAT38-4 profile display after action in Set Line Limits has been applied to all available survey lines.

## 5.2 Shift Survey Lines

To display the **Shift Survey Lines** window select **Edit Geometry|Shift Survey Lines** from the main menu (Figure 5.1). The window is shown in Figure 5.6.

This option lets you shift any number of selected survey lines, left or right, along the profile axis. The survey lines can be selected from the list box labeled **Available Lines**. The information on current positions of the end points of the current line is shown in the display box labeled **Current Position**.

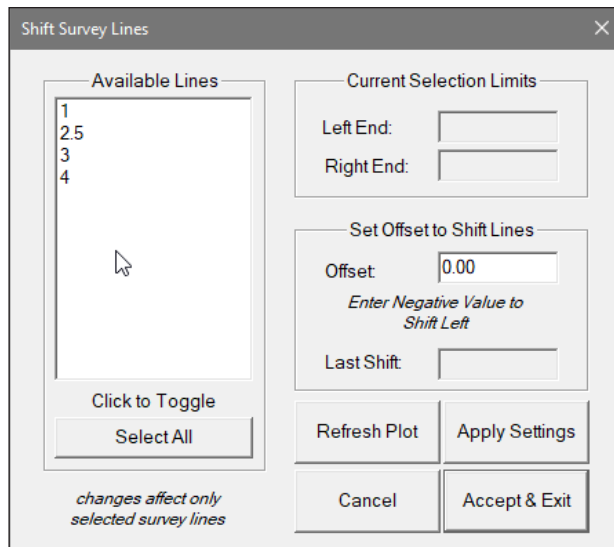


Figure 5.6 Shift Survey Lines dialog

The shift increment (step) can be entered in the edit box labeled **Set Offset to Shift Lines**. If the step is positive, the selected lines will be shifted to the right, with the station numbers increasing accordingly. A negative step will shift survey lines to the left, with station numbers decreasing accordingly. The lengths of the survey lines and spacing between stations will not change.

After the step is entered, click on the **Apply Offset** button to shift the selected lines. The graphic display will be adjusted in real time. An example is shown in Figures 5.7 and 5.8 where lines 3 and 4 are selected (Figure 5.7) and then they are shifted 100 stations to the right, entered shift is 100 (Figure 5.8).

To end this operation, click on **OK**: the Shift Survey Lines dialog will close, and all changes will be applied.

If any change is not satisfactory, click the **Cancel** button to close the Shift Survey Lines window and return all stations to their original positions.

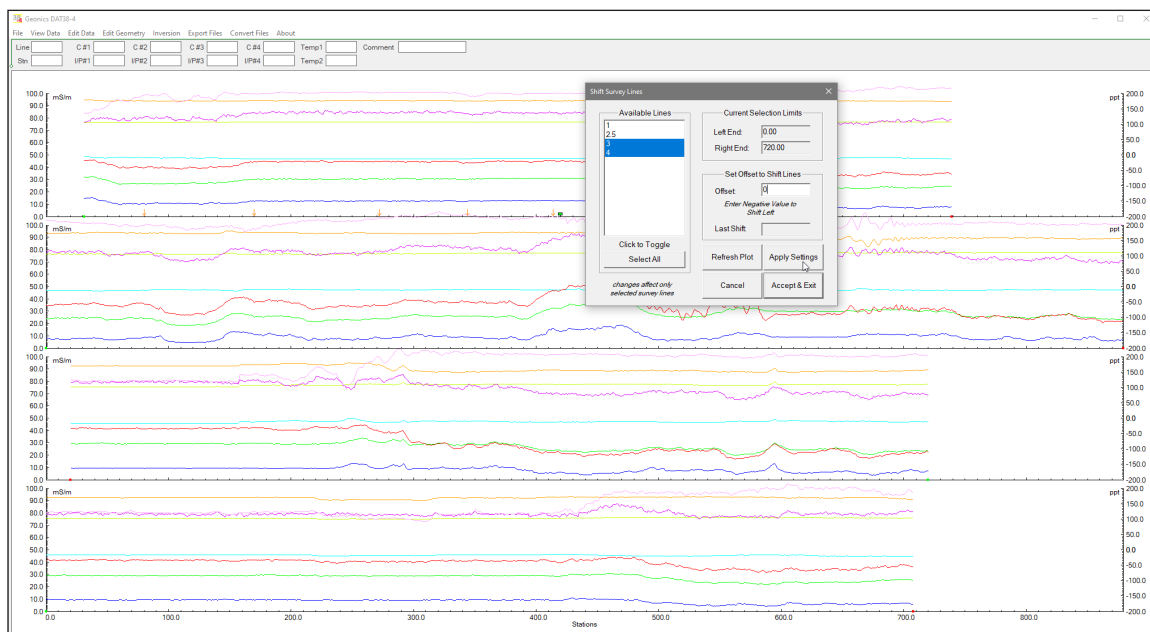


Figure 5.7 DAT38-4 profile display before Shift of survey lines is applied



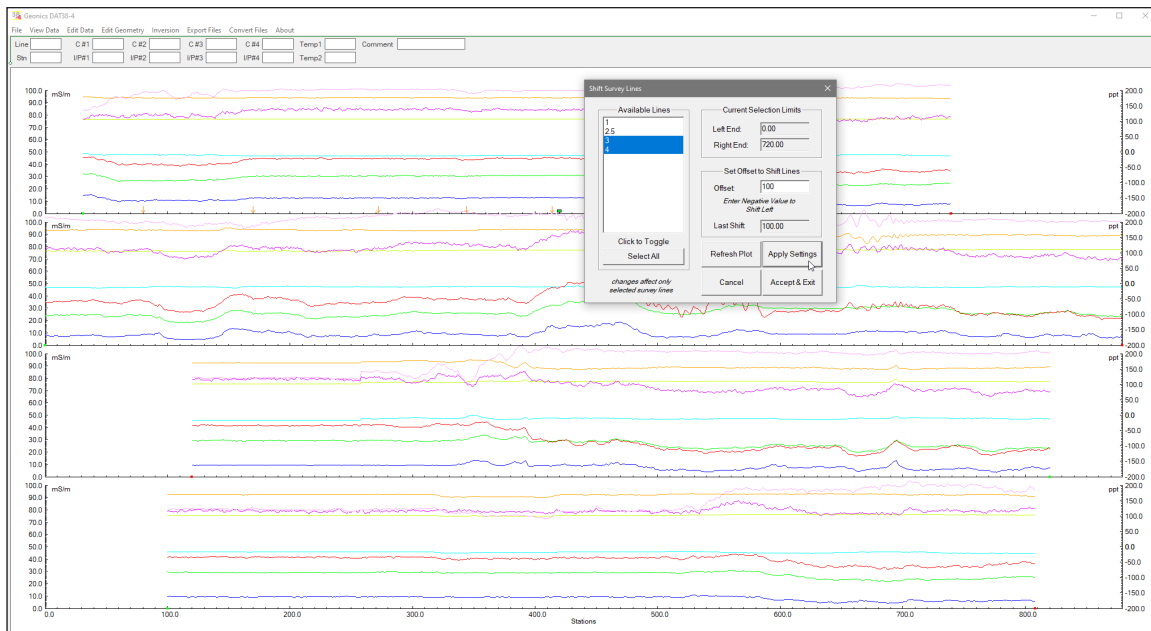


Figure 5.8 DAT38-4 profile display after Shift of 100 stations has been applied to last two survey lines (lines 3 and 4)

### 5.3 Position Markers/Line Ends

To display the **Position Markers** dialog select **Edit Geometry**|**Position Markers/Line Ends** from the main menu (Figure 5.1). The Position Markers window is shown in Figure 5.9.

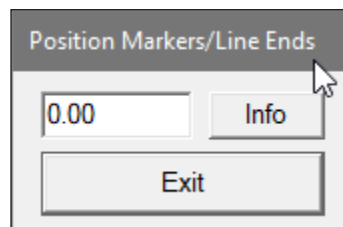


Figure 5.9 Position Marker dialog

This option allows you to reposition fiducial points that were marked by pressing fiducial marker while logging. You can adjust a selected marker, and also change start and end stations.

If the **Info** button is clicked a window with related help information will be displayed (Figure 5.10).

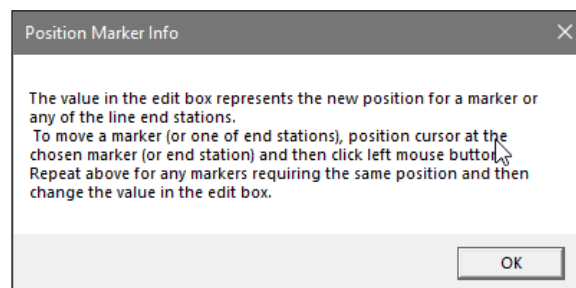


Figure 5.10 Position Marker Info message box

The Position Marker window is simple and small in order to allow a maximum view for the profiles. An unlabeled edit box is provided for entry of the position to where the marker or the start/end sta-

tion will be repositioned. After station value is specified click on the Marker (orange arrow) or any end station to be adjusted. Mouse can be clicked on in vicinity of Marker or end station, program will search for the nearest Marker/End station.

Figure 5.11 shows example where mouse cursor is pointed near Marker at station 80 while value in Position Marker dialog is specified as 100. After the mouse is clicked this Marker is immediately

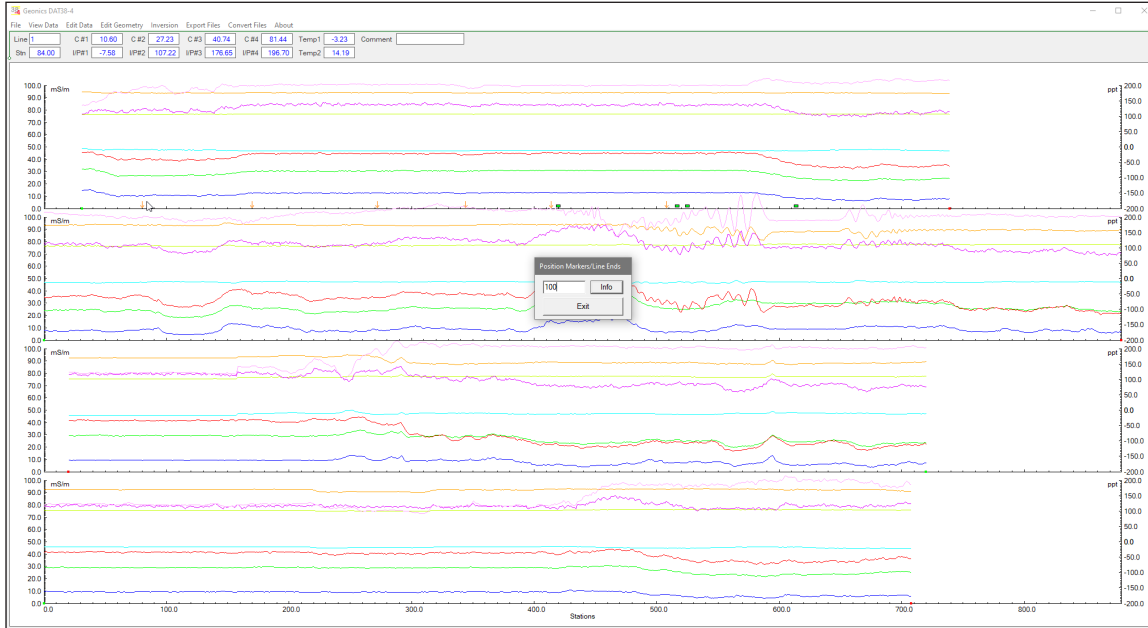


Figure 5.11 DAT38-4 profile display while positioning cursor at Marker to be moved

moved to station 100 (Figure 5.12). All spacing between stations is adjusted between neighbouring markers or line ends. The procedure can be repeated on any other line if reposition is to be the same.

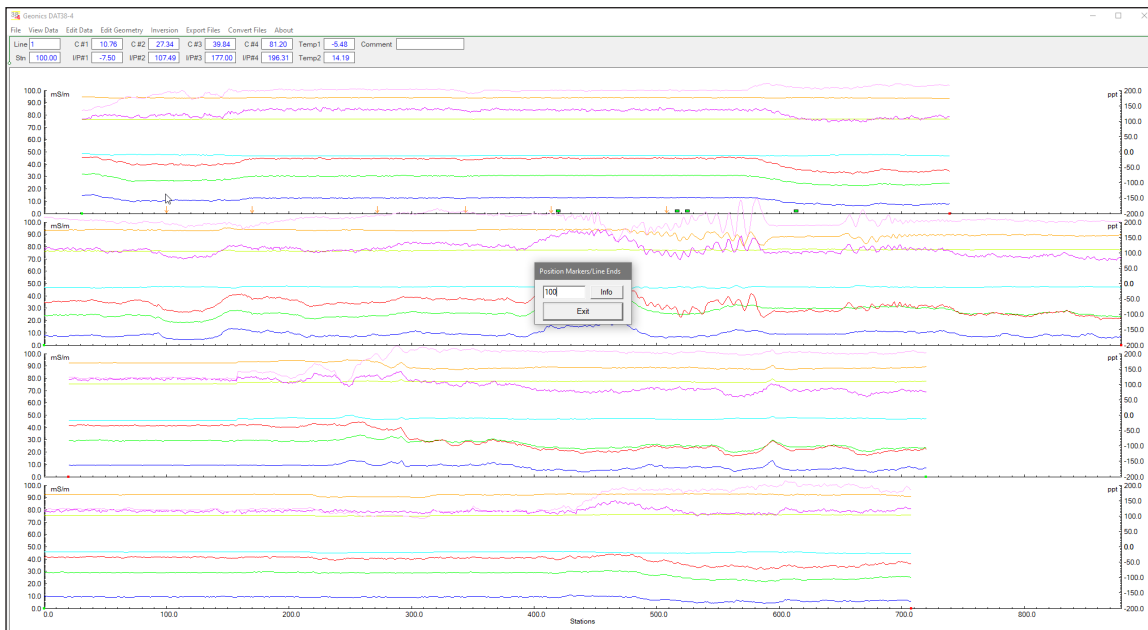


Figure 5.12 DAT38-4 profile display after the Marker is repositioned to station 100

To close the Position Marker dialog click on the Exit button located at the bottom of the dialog.

This procedure has no Undo action, therefore it might be worth to make a copy of the original data file prior to adjusting markers and line ends using this option.

# 6. Inversion

The inversion procedure in the DAT38-4 uses exactly the same function and calculations as provided in the data acquisition program EM38-4. Therefore, this option is provided to calculate inversion results for following cases:

1. When the inversion option was not enabled during data collection.
2. To re-calculate inversion in case data is edited, especially when Data Shift or Smooth Data options were used to modify data set.
3. When wrong instrument height was entered during logging by mistake.
4. To test several inversion with variations of Constrain Parameters

After the Inversion menu item is clicked the Inversion Setup dialog is displayed (Figure 6.1). In case the display contained Inphase profiles, they are replaced by inversion profiles and the right axis

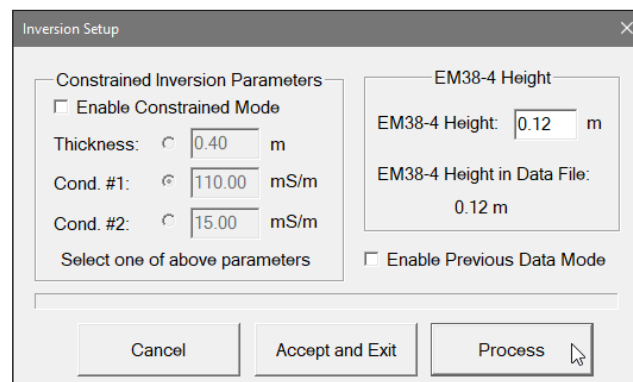


Figure 6.1 Inversion Setup dialog

displays scale in meters (for Thickness) automatically (Figure 6.2). The dialog and parameters are similar to the Inversion Setup dialog used in data acquisition program. The main difference is that this dialog allows you to change EM38-4 Height (always in metres). At the same time the dialog displays EM38-4 Height as it was specified during data collection (or set in Project Settings option).

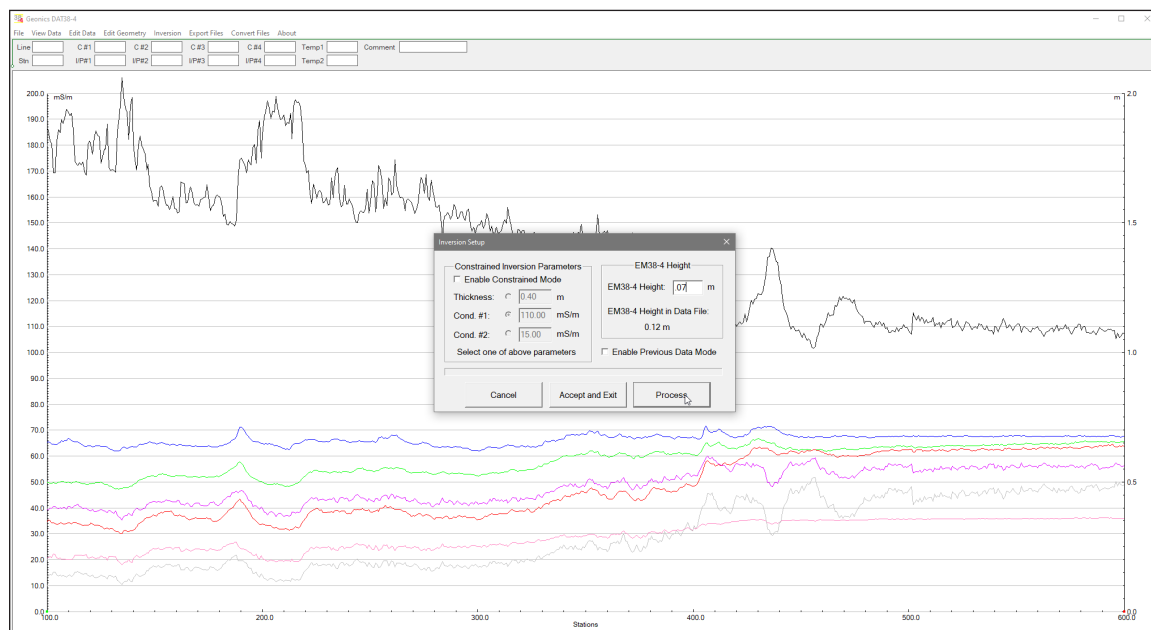


Figure 6.2 Inversion Setup dialog with updated EM38-4 height and displayed results of original inversion

An example of re-calculating inversion with updated instrument height is shown in Figures 6.2, 6.3 and 6.4. Figure 6.1 shows the updated dialog and profiles of Conductivity for four coil separations as well as available inversion results.

After the Process button is clicked on the program starts inversion calculations for each data point. The dialog progress bar shows how procedure progresses, Figure 6.3.

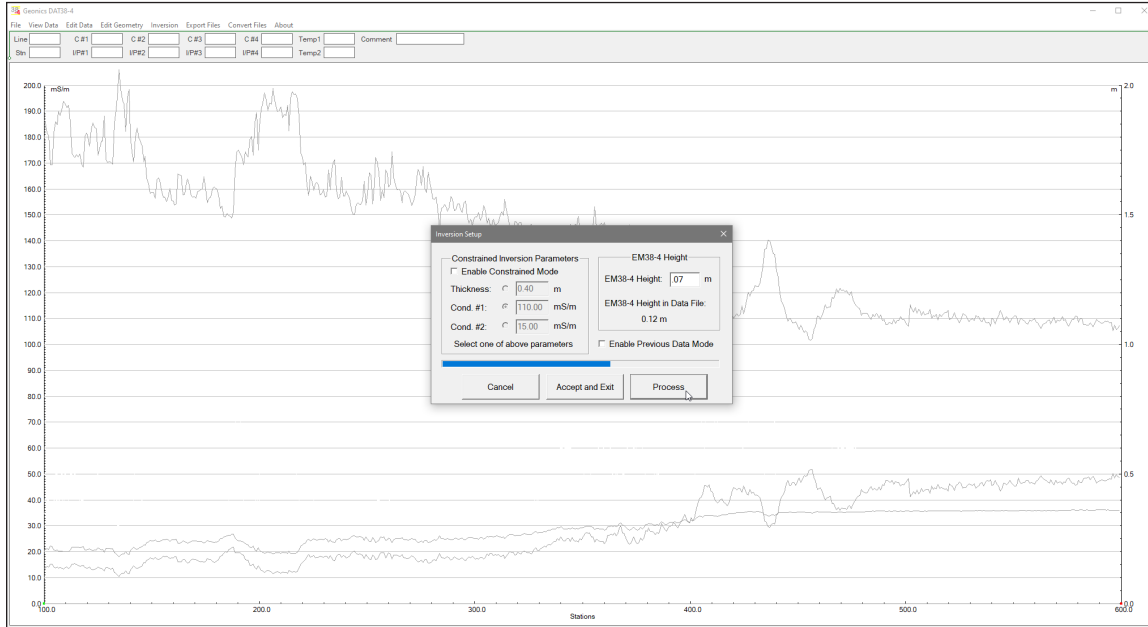


Figure 6.3 The program screen during processing inversion

The entire procedure depends on the file length, it can take several minutes for large data sets. After inversion is completed results are drawn with profiles attributes as specified in the Setup Display Options. If previous inversion results are available in the processed data file then corresponding original profiles are drawn in gray for comparison (Figure 6.4).



Figure 6.4 The DAT38-4 Inversion Setup dialog and display of profiles after calculations are completed.

New inversion values can be accepted by clicking on the button labeled **Accept and Exit** or results can be cancelled by the **Cancel** button. When the Cancel button is pressed new profiles disappear

and gray lines indicating original profiles are plotted with selected colours. Otherwise, when results are accepted original profiles displayed as gray lines disappear and profile with new values remain on the screen. In the latter case data file must be Saved or Saved As if new calculated values are to be written in data file.

When the Constrain Inversion Parameters button is clicked on then one of parameters can be fixed at specified value (Figure 6.5). The inversion procedure can be executed the same way as described above. After inversion is completed new values can be accepted or cancelled (Figure 6.6). Please note that in Figure 6.6 the new profile for Thickness is drawn as a horizontal line at 0.35 m since it is fixed parameter.

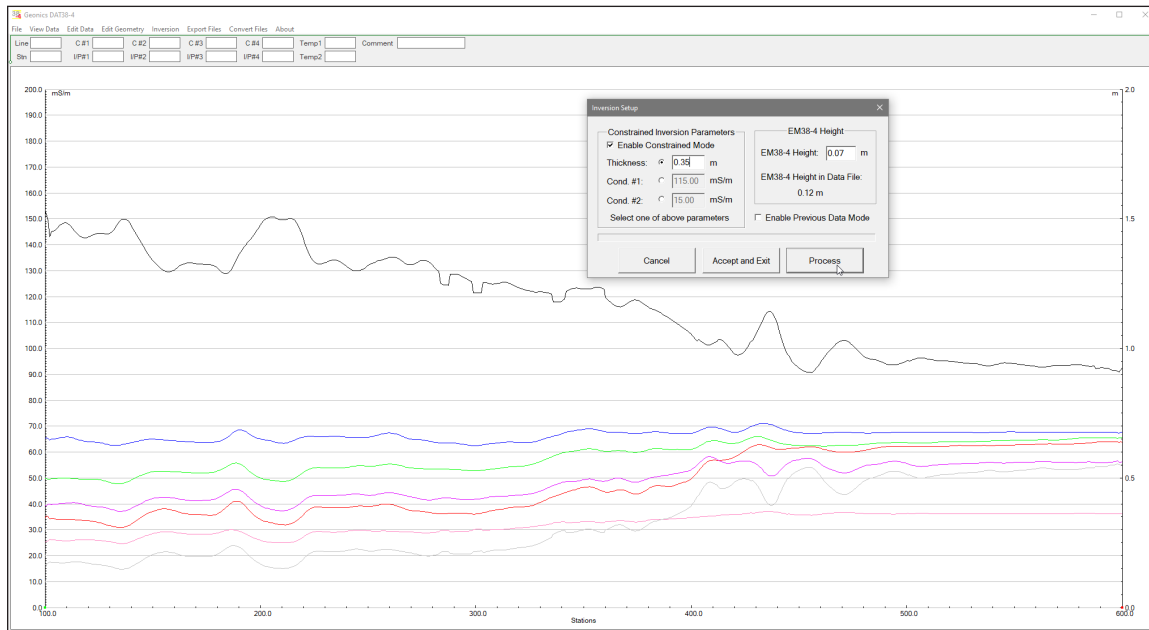


Figure 6.5 The DAT38-4 Inversion Setup dialog with constrained value for Thickness.

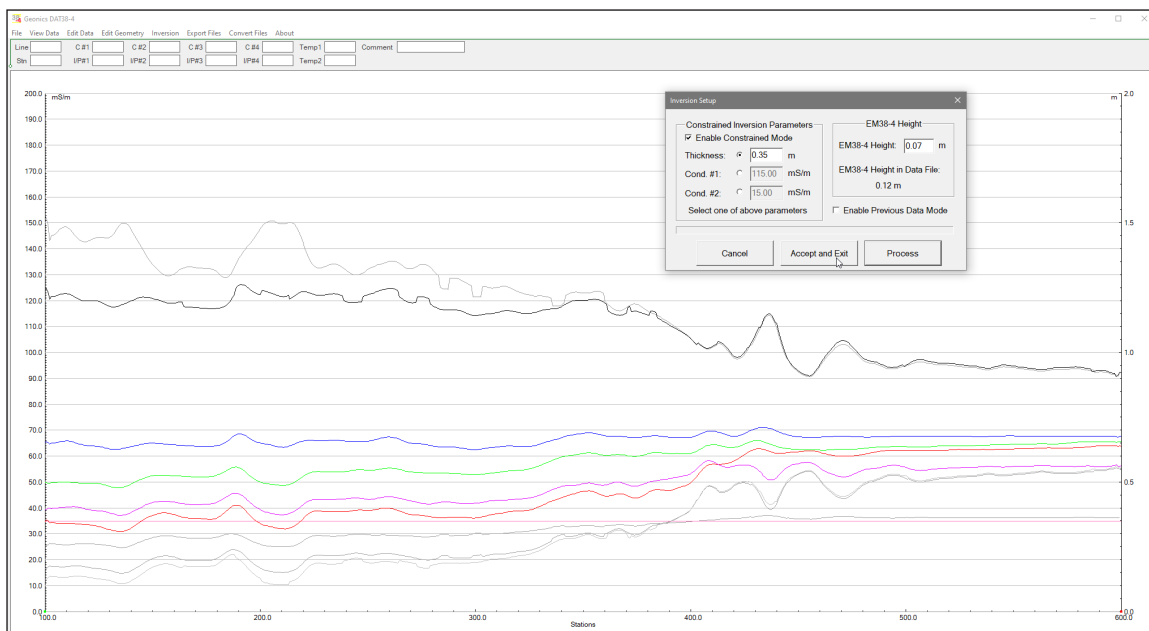


Figure 6.6 The DAT38-4 Inversion procedure completed, compare with above Figure 6.5.

Another parameter in the Inversion Setup dialog is shown as a check button labeled Enable Previous Data Mode. When this mode is enabled then previous data model is used for calculating following neighboring station. Exception is the first station in each survey line that is calculated in the standard mode (it is not affected by the last station of the previous survey line). Examples of inversion with enabled Previous Data Mode are shown in Figures 6.7 and 6.8.

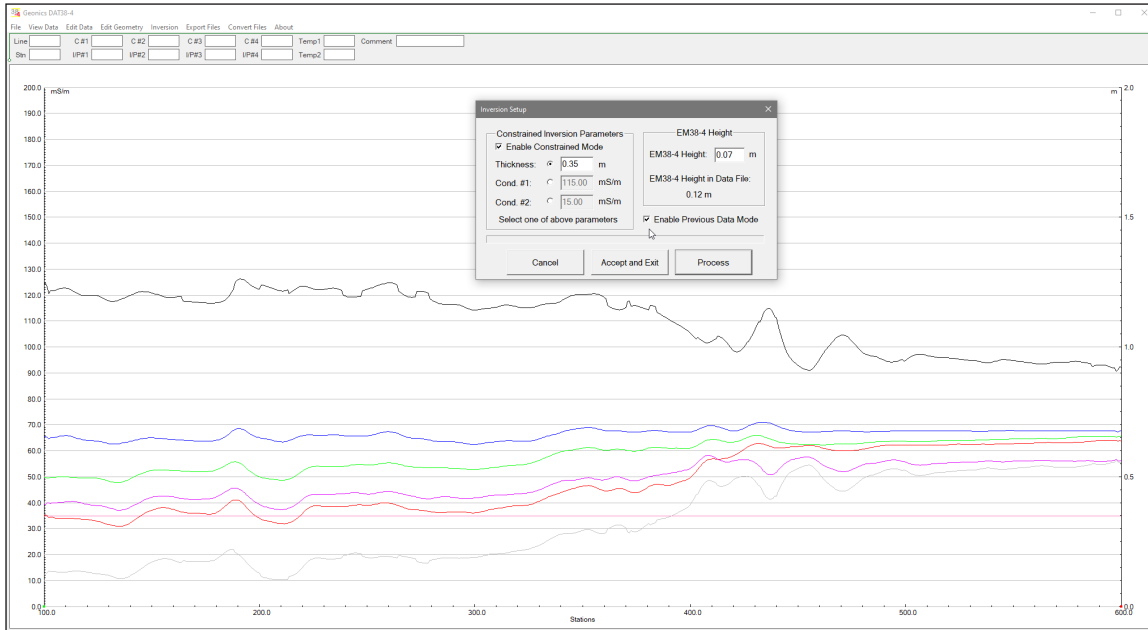


Figure 6.7 The DAT38-4 Inversion Setup dialog with enable Previous Data Mode.

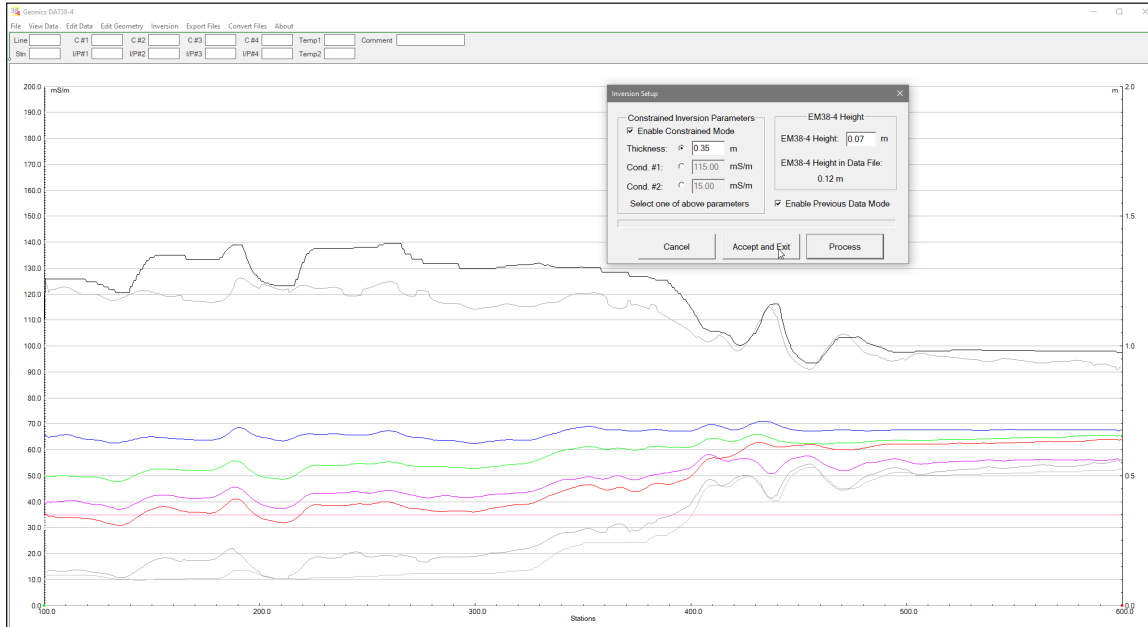


Figure 6.8 The DAT38-4 after Inversion procedure with enabled Previous Data Mode option is completed.

# 7. Export Files

The **Export Files** option lets you create a two dimensional (XYZ type) files that can be used as input files for various contouring and mapping systems as well as export data sets in format accepted by the inversion program EM4Soil-G. The created ASCII file contains three or more columns: X, Y, Z1, Z2 etc. (where Z1 corresponds to e.g. conductivity in mS/m, depending on the Create XYZ File settings). Files exported for the EM4Soil-G format are similar to XYZ files, however there are less options available since this format requires fixed file structure. All data must be entered in the **Load DAT38-4 Profile File** menu prior to running this option.

To display all available items of the menu select **Export Files** in the main menu at the top of the screen (Figure 7.1). The menu contains four options: Create Grid Based XYZ File, Create GPS Positioned XYZ File, Create Grid Based EM4Soil-G File, and Create GPS Positioned EM4Soil-G File.



Figure 7.1 DAT38-4 Export Files menu

The first option, **Create Grid Based XYZ File** lets you generate files with N-S and W-E configuration of survey lines, when readings are collected along grids that are laid out before the survey. Therefore, it is strongly recommended that data files be organized so that each file contains parallel lines surveyed in one direction, either W-E or S-N. The program assumes that stations along survey lines correspond to one of coordinates (X or Y) and line names indicate another coordinate (X or Y). If line names do not correspond to an appropriate coordinate they can be easily changed by the **Rename** function in the **Select Survey Lines** window. Position of stations (line end points, fiducial markers) along survey lines should be organized using the **Edit Geometry** function prior to creating XYZ file.

The second 2D Layout menu item, **Create GPS Positioned XYZ File** can be used only when EM38-4 data is collected together with GPS positioning data. In this method the GPS receiver is connected to the Mesa3 (or other field computer logging EM38-4 data) serial port and GPS data is collected in the EM38-4 data file. This method can be used with virtually any GPS receiver that can stream a **GGA** message (standard NMEA-0183 data string). The program is using GPS positions as received from employed GPS receiver, therefore differentially corrected positions (DGSP or any RTK system) provide better accuracy. When Create GPS Positioned XYZ File option is used, the DAT38-4 positions EM38-4 readings based

on simultaneously recorded GPS data and time stamps associated with EM38-4 and GPS records. A GPS positioned survey does not require the use of the survey lines feature, however it is strongly recommended that while conducting project with a GPS, the survey is organized along parallel, or semi parallel lines if possible. Also, entry of line numbers may be helpful to locate specific area in case a portion of survey is to be repeated. At the same time a data set organized in survey lines can be displayed as stacked profiles, even if profiles are not perfectly organized it is easier to note some features on several lines instead of viewing one very long line.

Two remaining menu items, **Create Grid Based EM4Soil-G File** and **Create GPS Positioned EM4Soil-G File** that export EM38-4 data to EM4Soil-G format are very similar to described above export to XYZ files. Main difference is that EM4Soil-G program uses extension name .gxyz and that corresponding dialogs have less parameters due to more structured use of data files in the EM4Soil-G program.

All above four items are described in detail in following paragraphs.

## 7.1 Create Grid Based XYZ File

After you select the **Export Files|Create Grid Based XYZ File** from the profile menu the Create Grid Based XYZ File window is displayed (Figure 7.2).

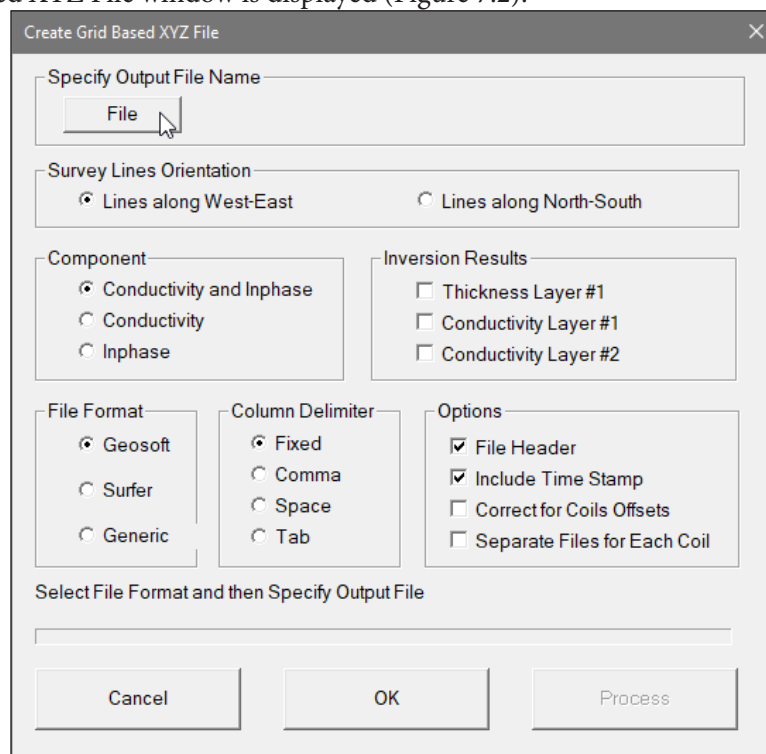


Figure 7.2 Create Grid Based XYZ File window

Several parameters which affect the contents and format of the created XYZ file must be specified. Specifically, these are the Orientation of Survey Lines, the EM38-4 Data Type and other parameters to be written to the file, format of the output file, and the output file name. Each parameter that will affect XYZ file format can be selected by clicking appropriate radio or check box button.

### Output File

When the **Output File** button is clicked, a Select XYZ File Name window is displayed. The EM38-4 file name with an extension corresponding to the selected output file format (xyz, dat, or asc) is given as a default (Figure 7.3).



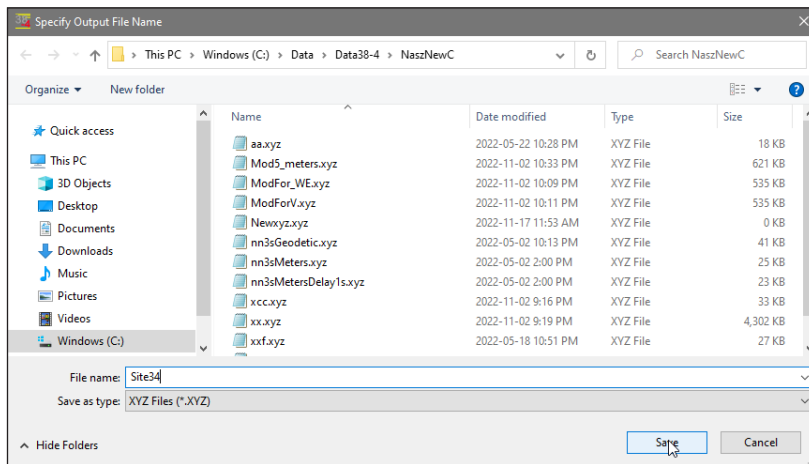


Figure 7.3 Select XYZ File Name window

Specify new file name or select existing one and click the **Save** button. If the specified file exists on the hard disk a warning message will be displayed.

The Select XYZ File Name window will close and the selected file name will be displayed at the bottom of the Create Grid Based XYZ File window. At the same time the **Process** button is activated (Figure 7.4).

### Orientation of Survey Lines

Choose one of two orientations of survey lines. The **Lines along West-East** (W-E) orientation corresponds to a layout where lines are parallel and oriented in the X direction (assuming that the North or Y coordinate points to the top, and that the East or X coordinate points to the right edge of a page). The **Lines along North-South** (N-S) orientation corresponds to the perpendicular layout, with survey lines oriented in the Y direction.

If W-E orientation is selected, it is assumed that the line name gives the Y (N-S) coordinate and stations are aligned along the X (W-E) axis. If survey lines are parallel and oriented in W-E direction, but line names do not correspond to the Y coordinate, then rename the lines in the Select Lines window. It should be noted that if the line name starts with a number and ends with a letter, e.g. 10N, only the number will be recognized as a Y coordinate.

If the N-S orientation is selected, the line name corresponds to the X (W-E) coordinate and stations are aligned along the Y (N-S) axis. Again, if survey lines are parallel and oriented in N-S direction, but line names do not correspond to the X coordinate, then rename the lines in the Select Lines window. It should be noted that if the line name starts with a number and ends with a letter, e.g. 10A, only the number will be recognized as an X coordinate.

Please note that the program does not recognize letters as an indication of positive or negative coordinates. Stations and line names should be clearly named with negative sign (for example -10) if they correspond to negative side of X or Y coordinate.

### Component

To select the EM38-4 data type, component to be written in the output file click the corresponding radio button in section labeled **Component** (Figure 7.2). Selected components or component are written if file for all four coil separations. Data is always placed in the created XYZ file in the following order: X coordinate, Y coordinate, two (Conductivity and Inphase) or one components for separation #1 (Conductivity or Inphase), then the same for separation #2 and two remaining separations #3 and #4. Therefore, coordinates

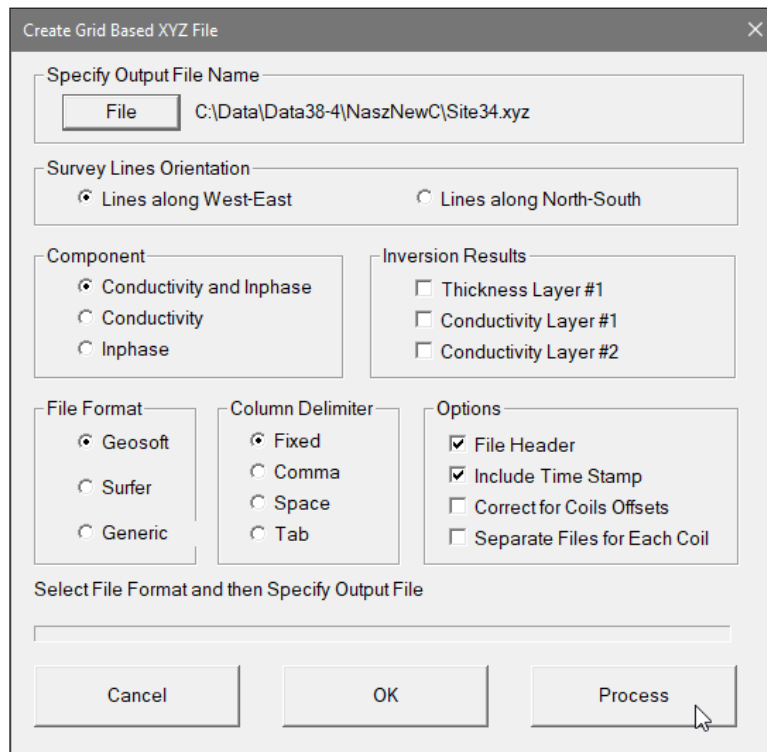


Figure 7.4 Create Grid Based XYZ File dialog after Output File Name is specified

and two or one components for each of four coil separations are mandatory in XYZ file, while parameters listed in sections **Inversion Results** and **Options** are optional.

### Inversion Results

Options listed in the **Inversion Results** section are enabled and can be written to XYZ file only if inversion result are present in the data file. In other words, when inversion option was enabled during data collection or it was processed later during data processing, otherwise this option is disabled (see Figure 7.5). Inversion results always follow components selected in the Component option and follow order Thickness of first layer (in meters), and Conductivity (in mS/m) for layer #1 and #2.

### File Format

Indicate the appropriate option for the contouring software to be used. The Generic option will create a multi column file without any text strings. This file can be used as an input file for many contouring packages (including Geosoft and Surfer). When Geosoft is selected then file extension name XYZ will be given as a default and a tag for each survey line will be written in the created file. Extension names DAT and XYZ will be given respectively for Surfer and Generic selections respectively. Surfer and Generic are basically same formats with different file extension names.

### Column Delimiter

Select column delimiter that is required by your application. The option Fixed corresponds to fixed field for each column with space or spaces between columns. This format is suitable for most applications and a file created with this selection provides the easiest

option if file is to be viewed using any standard text editor. Remaining options include columns delimiter: Comma, Space (single), and Tab.

## Options

There are four items listed: File Header, Include Time Stamp, Correct for Coils Offsets, and Separate Files for Each Coil.

File Header occupies one or two lines at the top of file and contains description of each column included in the file.

Time Stamp will be placed in the last column of the file.

Correct for Coils Offsets option enables interpolation of readings for coils #1, #2, #3 (separated by 0.5 m, 0.75 m, and 0.88 m) that sport small offsets from the center of the center of EM38-4 (and coil 1.0 m). Interpolation results in all coils readings to be related to the one point, center of the EM38-4.

Separate Files for Each Coil option enables the program to create separate xyz file for each coil separation.

When all parameters are properly set the output XYZ file can be created. After you click on the **Create XYZ File** button a progress bar, located at the bottom of the window, will indicate the percentage of the created file that has been completed (Figure 7.5). After the file is created a label indicating selected file name will change and it will display that operation is completed.

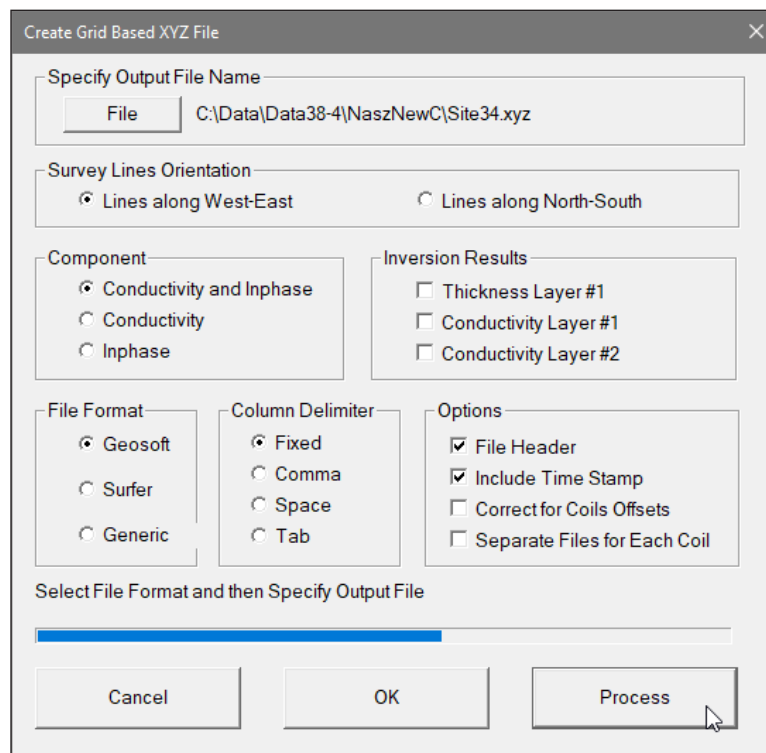


Figure 7.5 Create Grid Based XYZ File dialog during creating output file

Files created by this portion of the program can be viewed in any text editor or by mapping programs. The displayed image will show the spatial layout of lines (along W-E) and stations to scale, based on the station coordinates written to the created file (Figure 7.6).

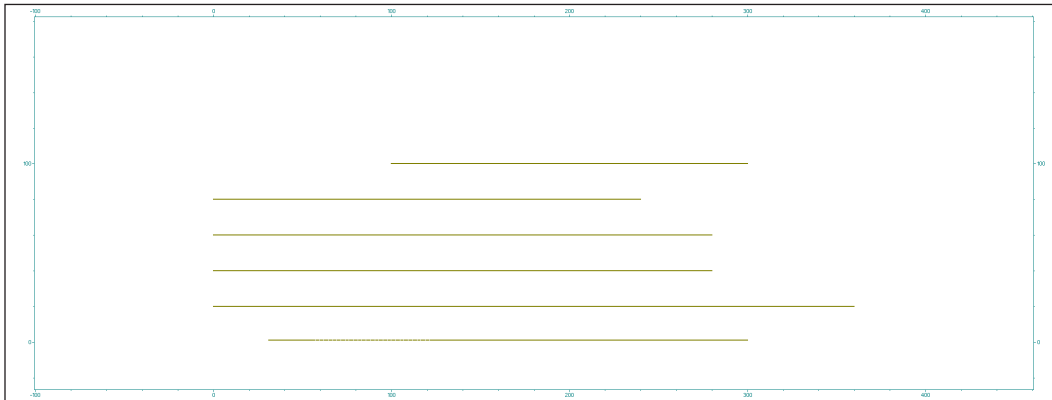


Figure 7.6 Layout of stations after an XYZ file is created

## 7.2 Create GPS Based XYZ File

This option of the DAT38-4 program can be used when the GPS receiver is connected to the EM38-4 logger serial port and GPS data is recorder in the EM38-4 data file. The EM38-4 data can be positioned directly to an XYZ file format by selecting the **Export Files|Create GPS Positioned XYZ File** menu option. The Create XYZ File Based on GPS Positions dialog is displayed (Figure 7.7).

Figure 7.7 Create XYZ File Based on GPS Positions dialog

Before creating the XYZ file several parameters must be specified. These are XYZ file name, the format of coordinates in the output file, and several parameters associated with GPS signal.

**File** (Output File)

Click on the **File** button. The Select XYZ File window is displayed (Figure 7.8).

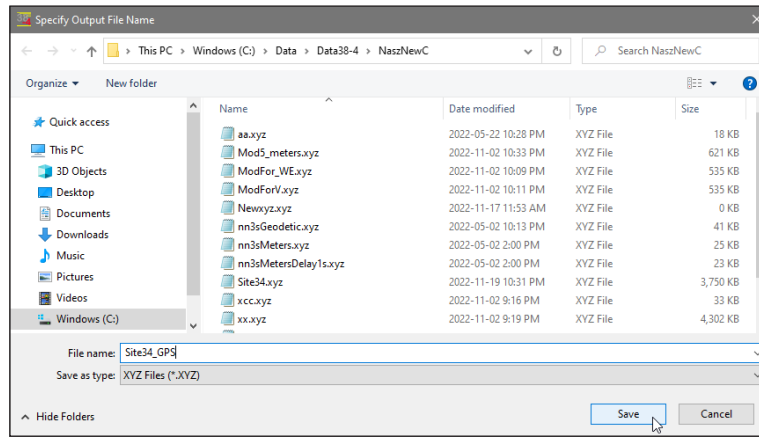


Figure 7.8 Select XYZ File dialog

The XYZ file name extension default will be determined by the selected output file format (xyz, dat, or asc) in XYZ File Format section. The XYZ File Format option must be selected before clicking on the **File** button.

Specify or select a file name and click the **Save** button. The Select XYZ File window will close and the selected file name will be displayed beside the **File** button in the Create XYZ File Based on GPS Positions window.

When Output Files is specified the **Proceed** button in the Create XYZ File Based on GPS Positions becomes active and name of selected file is displayed in the window associated with the **File** button (Figure 7.9).

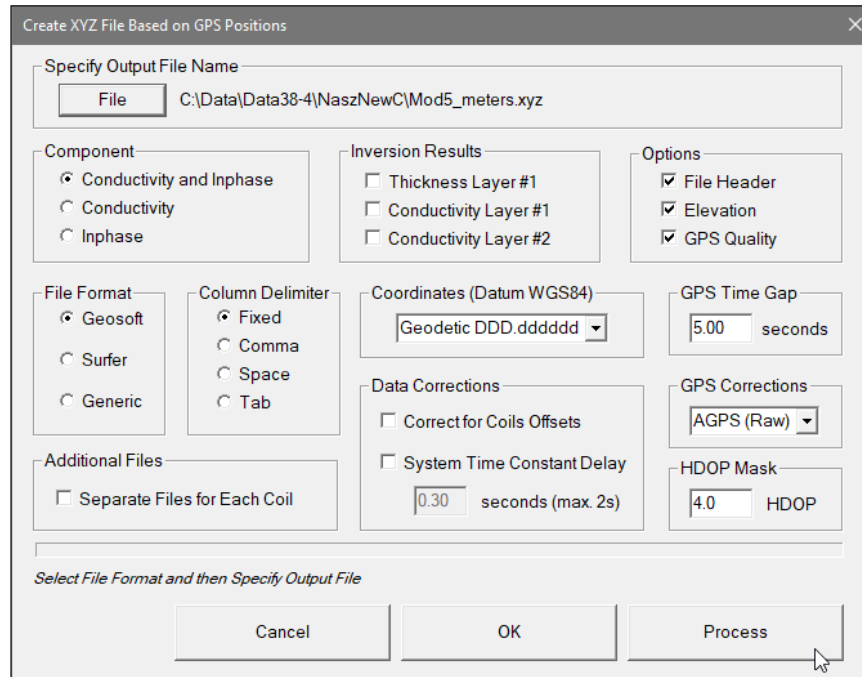


Figure 7.9 Create XYZ File Based on GPS Positions dialog after Output File name is specified

### Select Component

To select the EM38-4 component to be written in the output file click the corresponding radio button in section labeled **Component** (Figure 7.10). Selected components or component are written if file for all four coil separations. Data is always placed in the created XYZ file in the following order: X coordinate, Y coordinate, two (Conductivity and Inphase) or one components for separation #1 (Conductivity or Inphase), then the

same for separation #2 and two remaining separations #3 and #4. Therefore, coordinates and two or one components for each of four coil separations are mandatory in XYZ file, while parameters listed in sections **Inversion Results** and **Options** are optional.

### **Inversion Results**

Options listed in the **Inversion Results** section are enabled and can be written to XYZ file only if inversion result are present in the data file. In other words, when inversion option was enabled during data collection or it was used later during data processing, otherwise this option is disabled (see Figure 7.10). Inversion results always follow components selected in the Component option and follow order Thickness of first layer (in meters), and Conductivity (in mS/m) for layer #1 and # 2.

### **Options**

A two line comment indicating selected datum and column contents will be written at the beginning of file if Header Description is selected in the Options section.

Remaining parameters GPS Quality (includes three parameters in separate columns: degree of differential corrections, number of satellites, and HDOP parameter), Elevation, and Time Stamp will be placed in the last columns of the file assuming it has been selected in the **Options** section. These optional parameters are placed in the order indicated in Options section.

### **Additional Files**

When this option is checked four separate files for each of EM38-4 coil separations will be created.

### **File Format**

Indicate the appropriate option for the contouring software to be used. The Generic option will create a multi column file without any text strings. This file can be used as an input file for many contouring packages (including Geosoft and Surfer). This parameter will also determine a default file extension name during specifying XYZ file name. The program will provide extension file names XYZ for formats Geosoft and Generic, and DAT for the Surfer format. When the Geosoft format is selected then a tag for each survey line will be written in the created file.

### **Column Delimiter**

Select column delimiter that is required by your application. The option Fixed corresponds to fixed field for each column with space or spaces between columns. This format is suitable for most applications and a file created with this selection provides the easiest option if file is to be viewed using any standard text editor. Remaining column delimiters are Comma, Space (single), and Tab.

### **Coordinates (Datum WGS84)**

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum.

Geodetic coordinates are given in degrees. They can be written in format DD.DDDDDDDD. UTM coordinates can be generated in meters, feet or US Survey feet. To select Geodetic or UTM (and units) coordinates click one of the item listed in the combo box labeled Coordinates (Datum WGS84), see Figure 7.10.

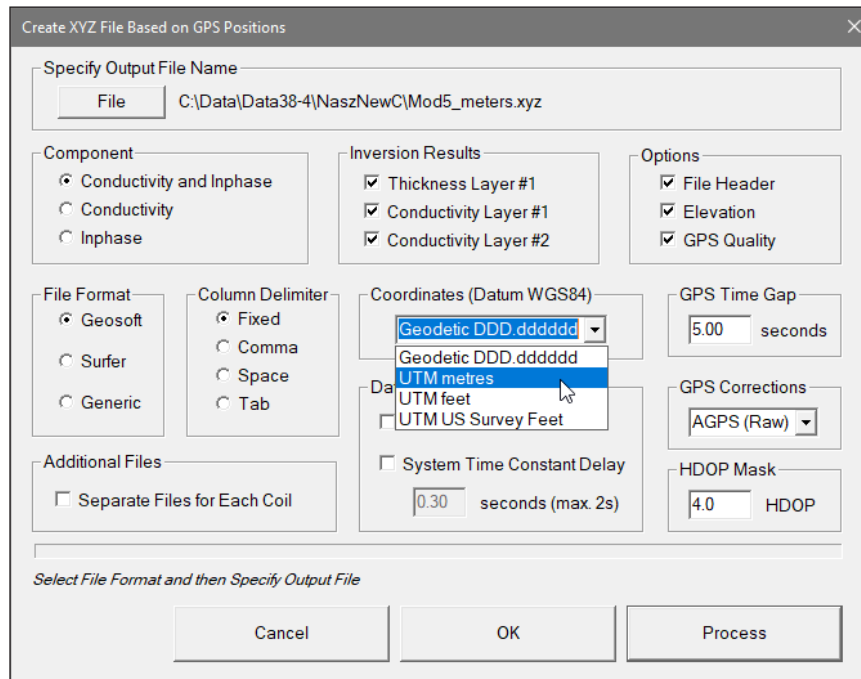


Figure 7.10 Selecting Coordinates in Create XYZ File Based on GPS Positions window

### GPS Time Gap

The **GPS Time Gap** parameter specifies the maximum time during which the EM38-4 data will be linearly interpolated between two GPS positions. Enter this parameter (in seconds) in the edit box labelled GPS Time Gap. In most cases a value 2 to 5 times larger than the GPS receiver update rate is adequate

### GPS Corrections

Select item in combo box placed in a section labeled **GPS Corrections** to write selected or higher degree of GPS differential corrections. Selection includes: 1 AGPS (Raw), 2

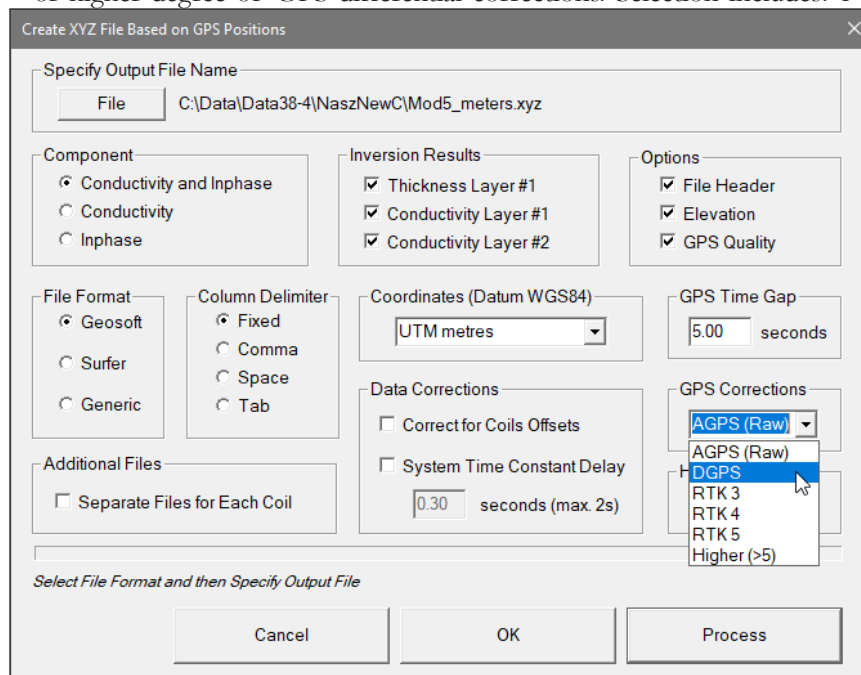


Figure 7.11 Selecting GPS Corrections in Create XYZ File Based on GPS Positions window



Differential (DGPS), 3 RTK (RTK-3), 4 RTK (RTK-4), 5 RTK (RTK-5), and 6 Higher (>5), see Figure 7.11. The latter option covers future RTK options as well as WAAS option that is indicated by Quality Indicator 8. The specified parameter indicates the lowest acceptable degree of corrections. For example, if Raw is selected then all GPS positions will be accepted by the program (obviously with the exception of NO FIX that has Quality Indicator = 0), and if DGPS (Quality Indicator=2) is selected than all positions with Quality Indicator = 1 (Raw) will be ignored by the program filter and DGPS and higher degree of corrections will be accepted.

### **HDOP Mask**

Specify value of HDOP parameter the section labeled **HDOP Mask**. Readings associated with GPS positions that have HDOP values higher than specified will not be written to the file.

### **Data Corrections**

This section contains two parameters: Correction for Coils Offsets and System Time Constant Delay.

#### **Correction for Coils Offsets**

Correct for Coils Offsets option enables interpolation of readings for coils #1, #2, #3 (separated by 0.5 m, 0.75 m, and 0.88 m) that sport small offsets from the center of the center of EM38-4 (and coil 1.0 m). Interpolation results in all coils readings to be related to the one point, center of the EM38-4. The program calculates corrections based on the TX coil position, by default the EM38-4 is positioned with the TX on the front. This parameter can be changed in the Project Settings (the File menu item).

#### **System Time Constant Delay (System Latency)**

This option allows for the system time constant delay correction. While the EM38-4 time constant is known the time constant of the combined EM38-4 and GPS receiver system is a function of these two devices. The best method to determine the time delay is to survey a few lines (in two directions) with varying speeds over the same small metallic target. When displaying the image the anomaly associated with the sample target may be slightly displaced or extended in size on neighboring lines. After the correct time constant for the system is determined the anomaly should be at the same location for each survey line. The alternative, possibly easier method to determine the time constant of the system is to survey a known buried pipe or any other linear feature (reinforced concrete curb, parking divider, etc.). After the proper time constant delay correction is applied the linear anomaly associated with the pipe should be free of any “hearing bone” effect.

Since the image of two dimensional data can be displayed in a mapping system (after gridding) the procedure can be time consuming, however it only needs to be done once for a given GPS receiver and EM38-4.

In order to apply the correction the generated XYZ file must have Time Stamp option selected in the Options section.

Time Delay must be entered in seconds, default is 0 seconds what indicates that the option is disabled.

After all parameters are specified and you click on the **Proceed** button a progress bar, will appear above command buttons and it will indicate the percentage of the created file that has been completed (Figure 7.12).



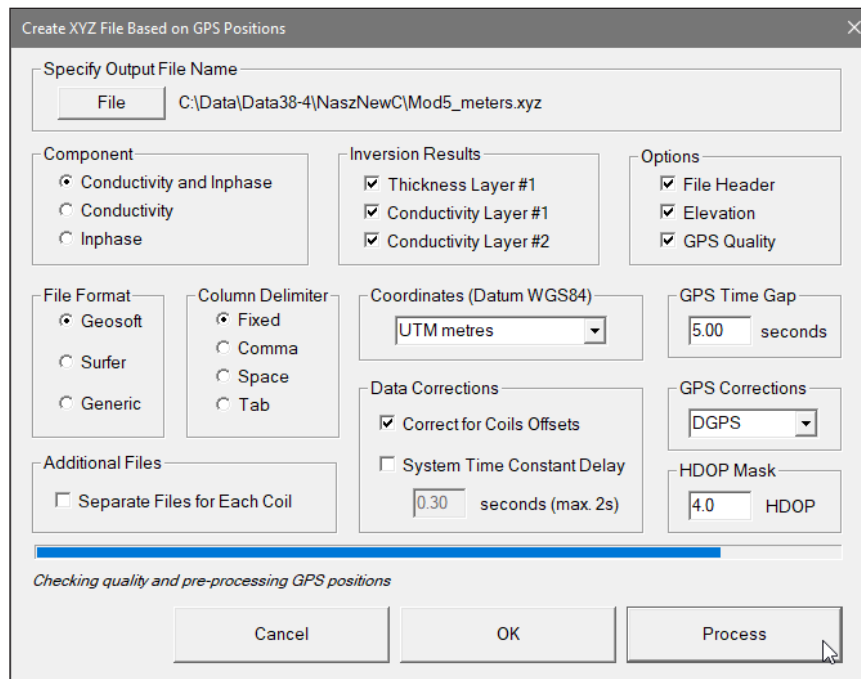


Figure 7.12 Create XYZ File Based on GPS Positions dialog during creating output file

Files created by this portion of the program can be viewed in any text editor or by mapping programs.

### 7.3 Create Grid Based EM4Soil-G File

After you select the **Export Files|Create Grid Based XYZ File** from the profile menu the **Export to EM4Soil-G Format with Grid Layout Based Positions** dialog is displayed (Figure 7.13).

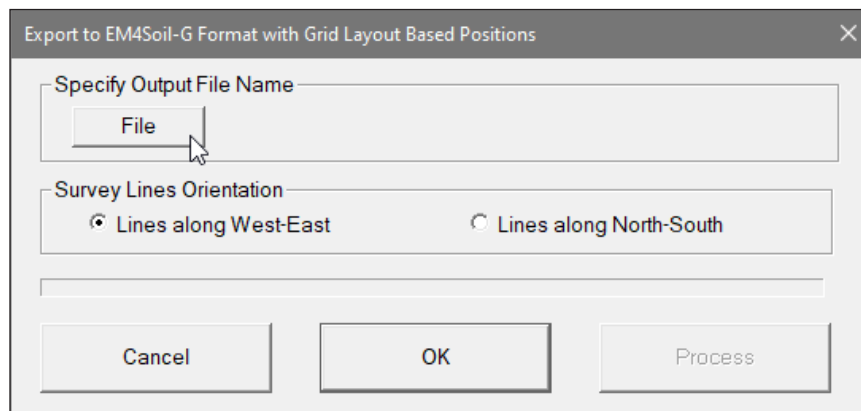


Figure 7.13 Export to EM4Soil-G Format with Grid Layout... dialog

Two parameters, specifically Output File name and the Orientation of Survey Lines must be specified in this dialog.

#### File

When the **File** button is clicked, a **Select EM4Soil-G File Name** window is displayed (Figure 7.14).

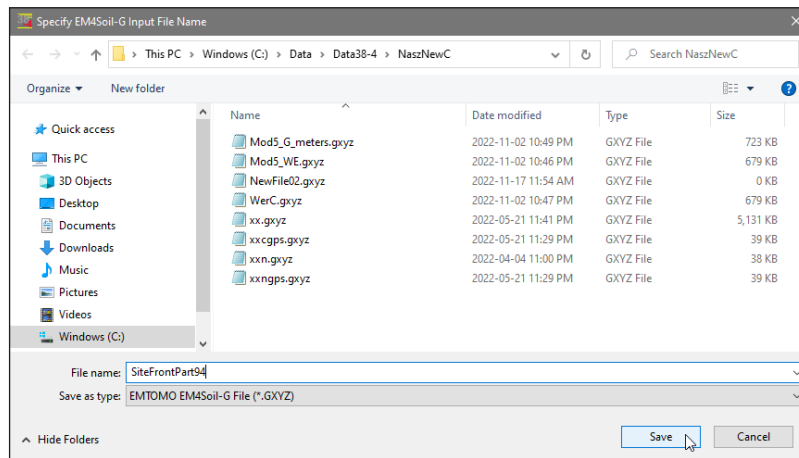


Figure 7.14 Select EM4Soil-G File Name dialog

Specify new file name or select existing one and click the **Save** button. If the specified file exists on the hard disk a warning message will be displayed.

The Select EM4Soil-G File Name window will close and the selected file name will be displayed at the bottom of the Create Grid Based XYZ File window. At the same time the **Process** button is activated (Figure 7.15).

### Orientation of Survey Lines

Choose one of two orientations of survey lines. The **Lines along West-East (W-E)** orientation corresponds to a layout where lines are parallel and oriented in the X direction (assuming that the North or Y coordinate points to the top, and that the East or X coordinate points to the right edge of a page). The **Lines along North-South (N-S)** orientation corresponds to the perpendicular layout, with survey lines oriented in the Y direction.

If W-E orientation is selected, it is assumed that the line name gives the Y (N-S) coordinate and stations are aligned along the X (W-E) axis. If survey lines are parallel and oriented in W-E direction, but line names do not correspond to the Y coordinate, then rename the lines in the Select Lines window. It should be noted that if the line name starts with a number and ends with a letter, e.g. 10N, only the number will be recognized as a Y coordinate.

If the N-S orientation is selected, the line name corresponds to the X (W-E) coordinate and stations are aligned along the Y (N-S) axis. Again, if survey lines are parallel and

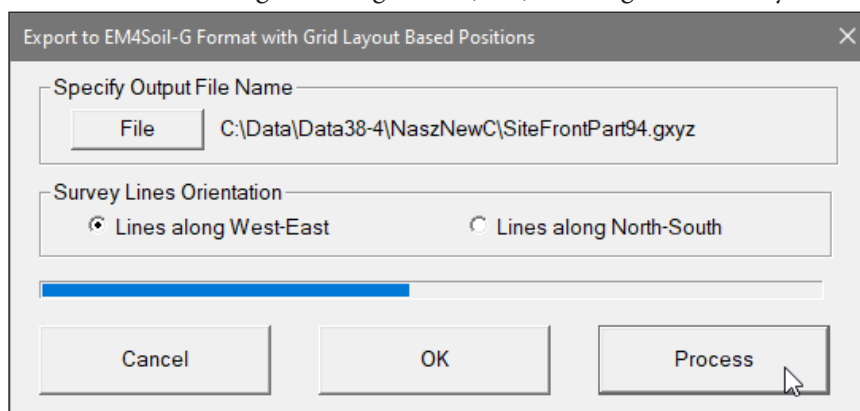


Figure 7.15 Export to EM4Soil-G Format with Grid Layout... dialog during creating gxyz file

oriented in N-S direction, but line names do not correspond to the X coordinate, then rename the lines in the Select Lines window. It should be noted that if the line name starts with a number and ends with a letter, e.g. 10A, only the number will be recognized as an X coordinate.

Please note that the program does not recognize letters as an indication of positive or negative coordinates. Stations and line names should be clearly named with negative sign (for example -10) if they correspond to negative side of X or Y coordinate.

When all parameters are properly set the output XYZ file can be created. After you click on the **Create XYZ File** button a progress bar, located at the bottom of the window, will indicate the percentage of the created file that has been completed (Figure 7.15). After the file is created a label indicating selected file name will change and it will display that operation is completed.

Files created by this portion of the program can be viewed in any text editor or by the EM4Soil-G program.

## 7.4 Create GPS Based EM4Soil-G File

This option of the DAT38-4 program can be used when the GPS receiver is connected to the EM38-4 logger serial port and GPS data is recorder in the EM38-4 data file. The EM38-4 data can be positioned directly in EM4Soil-G file format (with file extension name GXYZ) by selecting the **Export Files|Create GPS Positioned EM4Soil-G File** menu option. The **Export to EM4Soil-G Format with GPS Based Positions** dialog will be displayed (Figure 7.16).

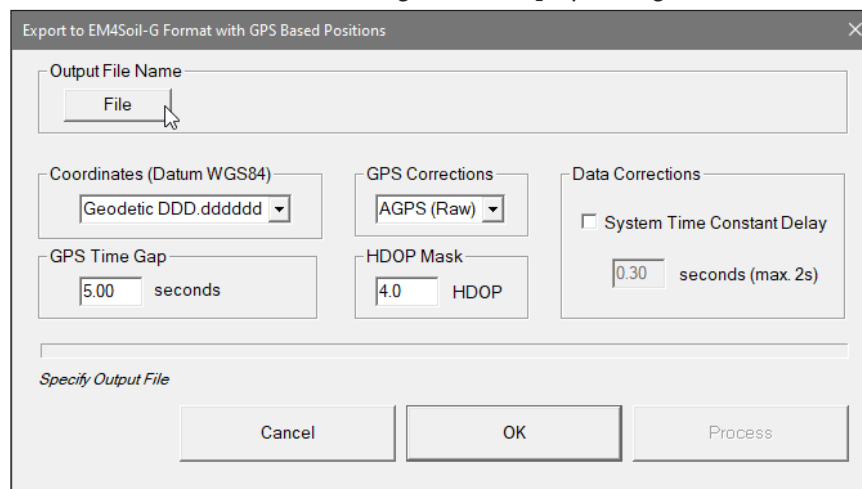


Figure 7.16 *Export to EM4Soil-G Format with GPS Based Positions dialog*

Before creating the GXYZ file some parameters must be specified. These are GXYZ file name, format of coordinates, and several parameters associated with GPS signal.

### **File** (Output File)

Click on the **File** button. The Select GXYZ File window is displayed (Figure 7.17).

Specify or select a file name and click the **Save** button and the Select GXYZ File window will close. When Output Files name is specified the **Proceed** button in the Export to EM4Soil-G Format with GPS Based Positions dialog becomes active and name of selected file is displayed in the window associated with the **File** button (Figure 7.18).

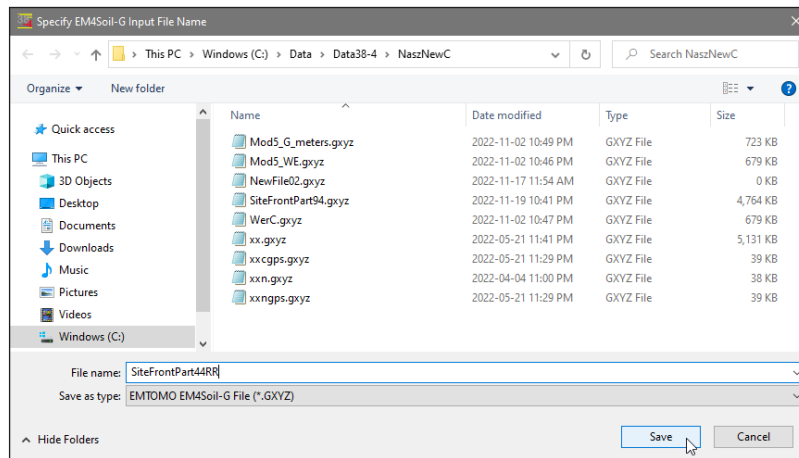


Figure 7.17 Select EM4Soil-G File Name dialog

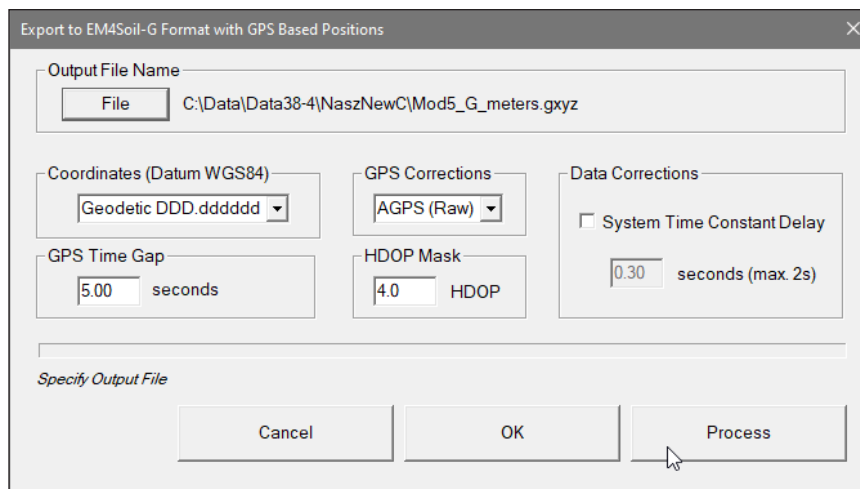


Figure 7.18 Export to EM4Soil-G Format with GPS Based Positions dialog after the export file name is specified

### Coordinates (Datum WGS84)

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum.

Geodetic coordinates are given in degrees. They can be written in format DD.DDDDDDDD. UTM coordinates can be generated in meters, feet or US Survey feet. To select Geodetic or UTM (and units) coordinates click one of the item listed in the combo box labeled Coordinates (Datum WGS84), see Figure 7.19.

### GPS Time Gap

The **GPS Time Gap** parameter specifies the maximum time during which the EM38-4 data will be linearly interpolated between two GPS positions. Enter this parameter (in seconds) in the edit box labelled GPS Time Gap. In most cases a value 2 to 5 times larger than the GPS receiver update rate is adequate

### GPS Corrections

Select item in combo box placed in a section labeled **GPS Corrections** to write selected or higher degree of GPS differential corrections. Selection includes: 1 AGPS (Raw), 2

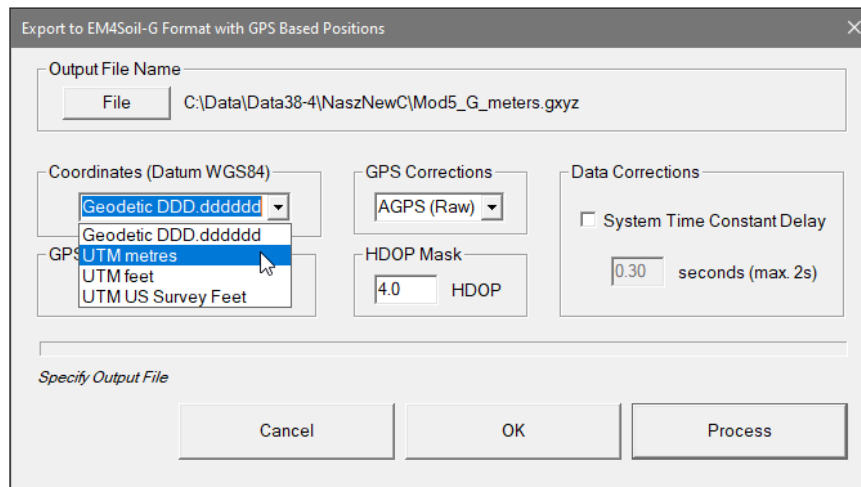


Figure 7.19 Selecting Coordinates in the Export to EM4Soil-G Format with GPS Based Positions dialog

Differential (DGPS), 3 RTK (RTK-3), 4 RTK (RTK-4), 5 RTK (RTK-5), and 6 Higher (>5), see Figure 7.20. The latter option covers future RTK options as well as WAAS option that is indicated by Quality Indicator 8. The specified parameter indicates the lowest acceptable degree of corrections. For example, if Raw is selected then all GPS positions will be accepted by the program (obviously with the exception of NO FIX that has Quality Indicator = 0), and if DGPS (Quality Indicator=2) is selected than all positions with Quality Indicator = 1 (Raw) will be ignored by the program filter and DGPS and higher degree of corrections will be accepted.

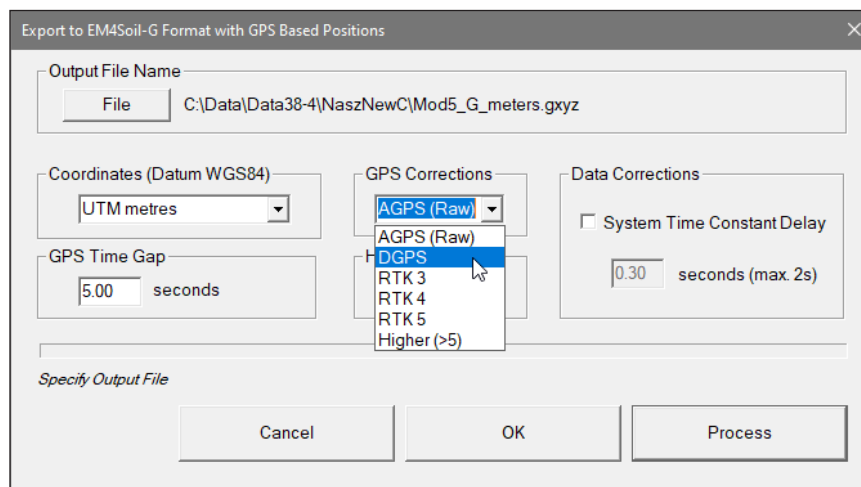


Figure 7.20 Selecting GPS Corrections in the Export to EM4Soil-G Format with GPS Based Positions dialog

### HDOP Mask

Specify value of HDOP parameter the section labeled **HDOP Mask**. Readings associated with GPS positions that have HDOP values higher than specified will not be written to the file.

### Data Corrections

This section contains two parameters: Correction for Coils Offsets and System Time Constant Delay.

### System Time Constant Delay (System Latency)

This option allows for the system time constant delay correction. While the EM38-4 time constant is known the time constant of the combined EM38-4 and GPS receiver system is a function of these two devices. The best method to determine the time delay is to survey a few lines (in two directions) with varying speeds over the same small metallic target. When displaying the image the anomaly associated with the sample target may be slightly displaced or extended in size on neighboring lines. After the correct time constant for the system is determined the anomaly should be at the same location for each survey line. The alternative, possibly easier method to determine the time constant of the system is to survey a known buried pipe or any other linear feature (reinforced concrete curb, parking divider, etc.). After the proper time constant delay correction is applied the linear anomaly associated with the pipe should be free of any “hearing bone” effect. Since the image of two dimensional data can be displayed in a mapping system (after gridding) the procedure can be time consuming, however it only needs to be done once for a given GPS receiver and EM38-4.

In order to apply the correction the generated XYZ file must have Time Stamp option selected in the Options section.

Time Delay must be entered in seconds, default is 0 seconds what indicates that the option is disabled.

After all parameters are specified and you click on the **Proceed** button a progress bar, will appear above command buttons and it will indicate the percentage of the created file that has been completed (Figure 7.21).

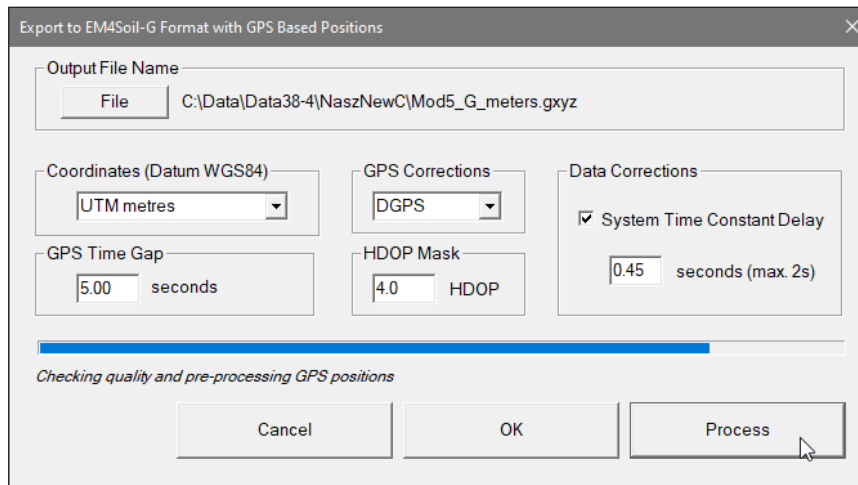


Figure 7.21 *Export to EM4Soil-G Format with GPS Based Positions dialog during creating gxyz file*

Files created by this portion of the program can be used as input files to the EM4Soil-G inversion program by EmTomo.

# Appendix A

## A.1 Description of Data File in EM38-4 (384) Format

Each record contains 48 characters, including line feed at the end of each record.

### Header of the file (contains two records starting with characters E and H)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
E M 3 8 - 4				W 1 0 0		Survey Type	UT	IN	IM	IN	IN	IP	IN	IV	IA													CT	10																		
H	File Name (9 characters)					Update Rate [Hz]		EM38-4 Height [m]				IV	AV													10																					

- EM38-4 - identification of program file
- W100 - version number (1.00)
- Survey Type - GPS (if GPS Input Enabled) or GRD (grid)
- UT - unit type (0 = meters, 1 = feet)
- IM - Survey mode (0 = Auto, fixed)
- IP - Selected Inphase units (0 = ppt, 1 = mS/m)
- IV - Inversion (0= disabled, 2= enabled, 1= not used in this version)
- IA - Inversion averaging index (0 = 1, 1 = 5, 2 = 10, 3 = 15, 4 = 20)
- AV - Number of samples for Inversion Averaging (same as above)
- CT - type of logging computer (=1 fixed)
- IN - not used (0 - fixed)
- CT - type of logging computer (=1 fixed)
- File Name - file name, maximum 9 characters
- Update Rate - Auto Mode, number of readings per second
- EM38-4 Height - Height of EM38-4 above ground (for inversion IV=2)
- 10 - Line Feed character

### Header at the start of survey line (four records starting with L, B, A, Z)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
L	Line Name																				10																										
B	Start Station (Format F11.2)																				10																										
A	Dir	Station Increment (Format F11.2)																				10																									
Z	D	D	M	M	Y	Y	Y	Y	H	H	:	M	M	:	S	S													10																		
O 1	Calibration for Q/P Coil 0.50m				Former Cal. for Q/P Coil 0.50m																10																										
O 2	Calibration for Q/P Coil 0.75m				Former Cal. for Q/P Coil 0.75m																10																										
... and similar records starting with O (from O1 to OS, total 28 records), described below																																															
O S	Cal.Carrier Air I/P Coil 0.88m				Cal.Carrier Vehicle I/P Coil 0.88m																10																										

- Line Name - Line Name, maximum 8 characters
  - Start Station- Start Station for the Line, format F11.2
  - Dir - Direction of the Line (E, W, N, or S)
  - Station Inc. - Station Increment, format F11.3
  - Date - Date when Line was created, format DD-MM-YYYY
  - Time - Real Time when Line was created, format HH:MM:SS
- each Line header (4 records L, B, A, Z) is followed by 28 records starting with O (from O1 to OS) associated with the latest calibration that are described below:

- O1 - Calibration factor - conductivity 0.50 m coils (current and former)
- O2 - Calibration factor - conductivity 0.75 m coils (current and former)
- O3 - Calibration factor - conductivity 1.00 m coils (current and former)
- O4 - Calibration factor - conductivity 0.88 m coils (current and former)
- O5 - Calibration factor - Inphase 0.50 m, (current and former)
- O6 - Calibration factor - Inphase 0.75 m, (current and former)
- O7 - Calibration factor - Inphase 1.00 m, (current and former)
- O8 - Calibration factor - Inphase 0.88 m, (current and former)
- O9 - Calibration factor - Inphase 0.50 m, (current and former, H mode)
- OA - Calibration factor - Inphase 0.75 m, (current and former, H mode)
- OB - Calibration factor - Inphase 1.00 m, (current and former, H mode)
- OC - Calibration factor - Inphase 0.88 m, (current and former, H mode)
- OD - Carrier Calibration factor - conductivity 0.50 m coils (current and former)
- OE - Carrier Calibration factor - conductivity 0.75 m coils (current and former)
- OF - Carrier Calibration factor - conductivity 1.00 m coils (current and former)
- OG - Carrier Calibration factor - conductivity 0.88 m coils (current and former)
- OH - Carrier Calibration factor - Inphase 0.50 m coils (current and former)
- OI - Carrier Calibration factor - Inphase 0.75 m coils (current and former)
- OJ - Carrier Calibration factor - Inphase 1.00 m coils (current and former)
- OK - Carrier Calibration factor - Inphase 0.88 m coils (current and former)
- OL - Carrier Calibration value - conductivity 0.50 m coils (in air, at vehicle, not)
- OM - Carrier Calibration value - conductivity 0.75 m coils (in air, at vehicle)
- ON - Carrier Calibration value - conductivity 1.00 m coils (in air, at vehicle)
- OO - Carrier Calibration value - conductivity 0.88 m coils (in air, at vehicle)
- OP - Carrier Calibration value - Inphase 0.50 m coils (in air, at vehicle)
- OQ - Carrier Calibration value - Inphase 0.75 m coils (in air, at vehicle)
- OR - Carrier Calibration value - Inphase 1.00 m coils (in air, at vehicle)
- OS - Carrier Calibration value - Inphase 0.88 m coils (in air, at vehicle)
- 10 - Line Feed character (ends each above record)

*(more detailed information about Calibration factors is provided below, under the Calibration subtitle).*

### Timer Relation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
*	Computer Time (Format HH:MM:SS.sss)																																				Time Stamp in ms (up to 10 digits)										10

Indicates relation between computer clock and the program timer. This record links timer in milliseconds and computer time (local time) in format HH:MM:SS.sss. This record is written to the file each time a new new line is entered.

### Reading

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
T	Gn	1h 1l	2h 2l	3h 3l	4h 4l	5h 5l	6h 6l	7h 7l	8h 8l	9h 9l	10h 10l	11h 11l	12h 12l	13h 13l	14h 14l	15h 15l	16h 16l	17b											Time Stamp in ms (up to 10 digits)										10								

- T - indicator T, t, or 2
- T - first reading at the EM38-4 (default for Auto mode)
- Gn - information byte, one character parameter,  
the ASCII number of this character indicates following:



Bit	Decimal	Value and Meaning	
7	128	0	<i>not used</i>
6	64	0	<i>not used</i>
5	32	0	<i>not used</i>
4	16	0	<i>not used</i>
3	8	0	<i>not used</i>
2	4	0	<i>not used</i>
1	2	Marker	= 1 <i>no marker</i> = 0 <i>trigger pressed</i>
0	1	0	<i>not used</i>

1h	-	higher byte of the 2's complement Hex number of Channel 1
1l	-	lower byte of Channel 1
2h	-	higher byte of the 2's complement Hex number of Channel 2
2l	-	lower byte of Channel 2
3h	-	higher byte of the 2's complement Hex number of Channel 3
3l	-	lower byte of Channel 3
4h	-	higher byte of the 2's complement Hex number of Channel 4
4l	-	lower byte of Channel 4
5h	-	higher byte of the 2's complement Hex number of Channel 5
5l	-	lower byte of Channel 5
6h	-	higher byte of the 2's complement Hex number of Channel 6
6l	-	lower byte of Channel 6
7h	-	higher byte of the 2's complement Hex number of Channel 7
7l	-	lower byte of Channel 7
8h	-	higher byte of the 2's complement Hex number of Channel 8
8l	-	lower byte of Channel 8
9h	-	higher byte of the 2's complement Hex number of Channel 9
9l	-	lower byte of Channel 9
10h	-	higher byte of the 2's complement Hex number of Channel 10
10l	-	lower byte of Channel 10
11h	-	higher byte of the 2's complement Hex number of Channel 11
11l	-	lower byte of Channel 11
12h	-	higher byte of the 2's complement Hex number of Channel 12
12l	-	lower byte of Channel 12
13h	-	higher byte of the 2's complement Hex number of Channel 13
13l	-	lower byte of Channel 13
14h	-	higher byte of the 2's complement Hex number of Channel 14
14l	-	lower byte of Channel 14
15h	-	higher byte of the 2's complement Hex number of Channel 15
15l	-	lower byte of Channel 15
16h	-	higher byte of the 2's complement Hex number of Channel 16
16l	-	lower byte of Channel 16
17b	-	one byte (one character) Channel 17
Time Stamp	-	time in ms from the Windows start (resets every 49.7 days). The time in milliseconds can be linked with the computer local time by using Times in line started by * (see Timer Relation).
10	-	Line Feed character

#### Channel Information

- Channel 1 - Conductivity for coil separation 1.00 m
- Channel 2 - Inphase for coil separation 1.00 m
- Channel 3 - Conductivity for coil separation 0.88 m
- Channel 4 - Inphase for coil separation .88 m
- Channel 5 - Conductivity for coil separation 0.50 m
- Channel 6 - Inphase for coil separation .50 m
- Channel 7 - Conductivity for coil separation 0.75 m
- Channel 8 - Inphase for coil separation 0.75 m
- Channel 9 - Not used
- Channel 10 - Not used
- Channel 11 - Temperature #1
- Channel 12 - Temperature #2
- Channel 13 - Real Time Inversion: Thickness of the first layer (optional)
- Channel 14 - Real Time Inversion: Conductivity of the first layer (optional)
- Channel 15 - Real Time Inversion: Conductivity of the second layer (optional)
- Channel 16 - Real Time Inversion: RMSE value (optional)
- Channel 17 - Real Time Inversion: Number of iterations (optional)

#### Conductivity Conversion

Use Channels 1, 3, 5, and 7 according to following formulas to obtain Conductivity readings in mS/m.

$$\text{Reading (Conductivity 0.50 m)} = (\text{Channel}_5 \times 5 / 1024 - 160) \times 8 + \text{O1} - \text{OD}$$

$$\text{Reading (Conductivity 0.75 m)} = (\text{Channel}_7 \times 5 / 1024 - 160) \times 8 + \text{O2} - \text{OE}$$

$$\text{Reading (Conductivity 0.88 m)} = (\text{Channel}_3 \times 5 / 1024 - 160) \times 8 + \text{O4} - \text{OG}$$

$$\text{Reading (Conductivity 1.00 m)} = (\text{Channel}_1 \times 5 / 1024 - 160) \times 8 + \text{O3} - \text{OF}$$

If Calibration is not to be included then O5 to O8 and OH to OK can be omitted.

#### Inphase Conversion

- there are four possible scenarios depending on Inphase units used during data collection (see parameter IP in file header) and Inphase units needed after conversion

Use Channels 6, 8, 4, and 2 according to following formulas:

when Inphase units ppt were used during data collection (parameter IP=0)

to obtain Inphase readings in ppt.

$$\text{Reading (I/P 0.50 m)} = (\text{Channel}_6 \times 5 / 1024 - 160) \times 8 \times 0.00716 - \text{O5} - \text{OH}$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel}_8 \times 5 / 1024 - 160) \times 8 \times 0.0161 - \text{O6} - \text{OI}$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel}_4 \times 5 / 1024 - 160) \times 8 \times 0.0222 - \text{O8} - \text{OK}$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel}_2 \times 5 / 1024 - 160) \times 8 \times 0.0286 - \text{O7} - \text{OJ}$$

to obtain Inphase readings in mS/m

$$\text{Reading (I/P 0.50 m)} = (\text{Channel}_6 \times 5 / 1024 - 160) \times 8 - (\text{O5} + \text{OH}) / 0.00716$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel}_8 \times 5 / 1024 - 160) \times 8 - (\text{O6} + \text{OI}) / 0.0161$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel}_4 \times 5 / 1024 - 160) \times 8 - (\text{O8} + \text{OK}) / 0.0222$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel}_2 \times 5 / 1024 - 160) \times 8 - (\text{O7} + \text{OJ}) / 0.0286$$

when Inphase units mS/m were used during data collection (parameter IP=1)

to obtain Inphase readings in ppt.

$$\text{Reading (I/P 0.50 m)} = (\text{Channel\_6} \times 5 / 1024 - 160) \times 8 - \text{O5} - \text{OH}) \times 0.00716$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel\_8} \times 5 / 1024 - 160) \times 8 - \text{O6} - \text{OI}) \times 0.0161$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel\_4} \times 5 / 1024 - 160) \times 8 - \text{O8} - \text{OK}) \times 0.0222$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel\_2} \times 5 / 1024 - 160) \times 8 - \text{O7} - \text{OJ}) \times 0.0286$$

to obtain Inphase readings in mS/m

$$\text{Reading (I/P 0.50 m)} = (\text{Channel\_6} \times 5 / 1024 - 160) \times 8 - \text{O5} - \text{OH}$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel\_8} \times 5 / 1024 - 160) \times 8 - \text{O6} - \text{OI}$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel\_4} \times 5 / 1024 - 160) \times 8 - \text{O8} - \text{OK}$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel\_2} \times 5 / 1024 - 160) \times 8 - \text{O7} - \text{OJ}$$

If Calibration is not to be included then O5 to O8 and OH to OK can be omitted.

### Temperature Conversion

Use Channels 11 and 12 according to following formulas to obtain Temperature readings in Celsius degrees.

$$\text{Temperature \#1} = (\text{Channel\_11} - 31) / 3.1 - 40.0$$

$$\text{Temperature \#2} = (\text{Channel\_12} - 31) / 3.1 - 40.0$$

### Inversion Conversion

Following formulas are to be applied only if real time inversion was performed during data collection. It is indicated by the **IV** parameter in the file header.

If the real time inversion was not performed (IV=0) corresponding bytes for Channels 13 to 17 are filled by Spaces.

$$\text{Thickness Layer \#1 [metre]} = \text{Channel\_13} / 1000$$

$$\text{Conductivity Layer \#1 [mS/m]} = \text{Channel\_14} / 100$$

$$\text{Conductivity Layer \#2 [mS/m]} = \text{Channel\_15} / 100$$

$$\text{RMSE Value} = \text{Channel\_16} / 100$$

$$\text{Number of Iterations} = \text{Channel\_17}$$

(channel 17 it is one byte, ASCII number of corresponding character indicates number of iterations)

### Comment

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
C	Comment (max. 11 characters)																																				Time Stamp in ms (up to 10 digits)										10

### New Station

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
S	New Station (Format 11.2)																																				Time Stamp in ms (up to 10 digits)										10

## Calibration

Calibration values are always recorded as a block of 28 records, each record represents values for different component/coil separation as well as calibration object (instrument and carrier, if used). When Calibration is performed during data logging then record for each component/coil separation/dipole mode and carrier calibration contains two factors. Except of last 8 factors (OL to OS), the first value corresponds to the current calibration and the second, following value shows former calibration factor.

Calibration values indicated by labels **O9** to **OC** and **OL** to **OS** are provided for diagnostic purposes only, they are not used in conversion formulas.

If calibration procedure was performed at any stage of survey then calibration factors should be applied to all following EM38-4 readings, until next calibration is performed.

Calibration values placed in each Line Header repeat the latest calibration set of values. If Calibration procedure was not performed during the survey, factors may contain values from a former data files or all values are zeros, according to program settings.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

O 1	Calibration for Q/P Coil 0.50m	Former Cal. for Q/P Coil 0.50m	10
O 2	Calibration for Q/P Coil 0.75m	Former Cal. for Q/P Coil 0.75m	10

... and similar records starting with **O** (from **O1** to **OS**, total 28 records), described below

O S	Cal.Carrier Air I/P Coil 0.88m	Cal.Carrier Vehicle I/P Coil 0.88m	10
-----	--------------------------------	------------------------------------	----

- O1 - Calibration factor - conductivity 0.50 m coils (current and former)
- O2 - Calibration factor - conductivity 0.75 m coils (current and former)
- O3 - Calibration factor - conductivity 1.00 m coils (current and former)
- O4 - Calibration factor - conductivity 0.88 m coils (current and former)
- O5 - Calibration factor - Inphase 0.50 m, (current and former)
- O6 - Calibration factor - Inphase 0.75 m, (current and former)
- O7 - Calibration factor - Inphase 1.00 m, (current and former)
- O8 - Calibration factor - Inphase 0.88 m, (current and former)
- O9 - Calibration factor - Inphase 0.50 m, (current and former, H mode)
- OA - Calibration factor - Inphase 0.75 m, (current and former, H mode)
- OB - Calibration factor - Inphase 1.00 m, (current and former, H mode)
- OC - Calibration factor - Inphase 0.88 m, (current and former, H mode)
- OD - Carrier Calibration factor - conductivity 0.50 m coils (current and former)
- OE - Carrier Calibration factor - conductivity 0.75 m coils (current and former)
- OF - Carrier Calibration factor - conductivity 1.00 m coils (current and former)
- OG - Carrier Calibration factor - conductivity 0.88 m coils (current and former)
- OH - Carrier Calibration factor - Inphase 0.50 m coils (current and former)
- OI - Carrier Calibration factor - Inphase 0.75 m coils (current and former)
- OJ - Carrier Calibration factor - Inphase 1.00 m coils (current and former)
- OK - Carrier Calibration factor - Inphase 0.88 m coils (current and former)
- OL - Carrier Calibration value - conductivity 0.50 m coils (in air, at vehicle)
- OM - Carrier Calibration value - conductivity 0.75 m coils (in air, at vehicle)
- ON - Carrier Calibration value - conductivity 1.00 m coils (in air, at vehicle)
- OO - Carrier Calibration value - conductivity 0.88 m coils (in air, at vehicle)
- OP - Carrier Calibration value - Inphase 0.50 m coils (in air, at vehicle)
- OQ - Carrier Calibration value - Inphase 0.75 m coils (in air, at vehicle)
- OR - Carrier Calibration value - Inphase 1.00 m coils (in air, at vehicle)
- OS - Carrier Calibration value - Inphase 0.88 m coils (in air, at vehicle)
- 10 - Line Feed character (ends each above record)



## A.2 Example of Data File in EM38-4 (384) Format

The EM38-4 data file records are saved in binary format, therefore the file may have different shape when displayed or printed, depending on particular video or printer settings.

```

EM38-4 W101GPS000010121          1
H Gralowcar 5.000 0.470
L1
B          0.00
AS          1.000
Z02112020 15:59:34
O1          1.321          5.853
O2          1.883          4.279
O3          7.280          11.021
O4         -30.033         -27.777
O5          -2.072         -2.635
O6          -1.415         -1.334
O7          8.288          7.583
O8          1.361          1.475
O9          -0.047          0.027
OA          0.140          0.027
OB          0.092          0.076
OC          0.125         -0.019
OD          -2.820          0.000
OE          8.951          0.000
OF          5.275          0.000
OG         17.764          0.000
OH          0.587          0.000
OI          1.404          0.000
OJ          4.507          0.000
OK          2.800          0.000
OL          0.000          0.000
OM          0.000          0.000
ON          0.000          0.000
OO          0.000          0.000
OP          0.000          0.000
OQ          0.000          0.000
OR          0.000          0.000
OS          0.000          0.000
*15:59:34.267                    74474515
X$STARTED                        74582296
T  Î«[...h'7,]g% f~x  Å  Å p \ _ zDA  74582390
T  Î«|...d'7,^g# i~0  Æ  Æ d ê _ Pp _  74582593
T  Î«r...[',fg& e~x  Å  Æ h » _ iJ² _  74582781
T  Î«h...c':,dg b~0  Å  Æ n ~ _ vD/_  74582984
@$PGGA,154919.00,4314.3667005,N,08030.4043676
#,W,2,14,1.0,266.371,M,-35.220,M,12.0,0138*4F
!                                74583015
@$PGSA,M,3,10,13,15,18,20,23,24,,,,,1.8,1.0,
#1.5,1*24
!                                74583015
T  Î«e...b';,eg j~Û  Å  Æ n $ _ wD@  74583171
T  Î«w...c'? ,cg a~0  Å  Æ a Î _ i9ð _  74583375
T  Î«p...g';,dg b~0  Å  Æ S * ^3=  74583578
T  Î«z...l'>,eg j~Î  Å  Æ X Î _ i/V  74583765
T  Î«p...v'=,gg d~Î  Å  Æ Z ß _ o.¡  74583968
@$PGGA,154920.00,4314.3666975,N,08030.4043633
#,W,2,14,1.0,266.351,M,-35.220,M,13.0,0138*48
!                                74584031
@$PGSA,M,3,10,13,15,18,20,23,24,,,,,1.8,1.0,
#1.5,1*24
!                                74584031
T  Î«t...n'<,\g b~Í  Å  Æ Z } _ n/a  74584171
T  Î«m...l'C,cg g~Ê  Å  Å U Î _ a3>  74584359
T  Î«h...g'? ,cg d~Î  Å  Æ f _ u6i _  74584546
.....

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