DURHAM GEO SLOPE INDICATOR

M+D Indicator

MDI-2000 Series

United States Patent 7040145

User Manual

Version 1.4.3

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RECORD THE FOLLOWING INFORMATION FOR FUTURE REFERENCE		
TYPE / MODEL	❑ MODEL M+DI-2050 ❑ OTHER MODEL M+DI_____	
UNIT SERIAL NUMBER		
SOFTWARE VERSION	ORIGINAL:	LATEST UPDATE:
PC		
PDA		
DATE PURCHASED		
VENDOR (PURCHASED FROM)	❑ DIRECT FROM DURHAM GEO SLOPE INDICATOR ❑ FROM DISTRIBUTOR (NAME) _____	
OTHER		

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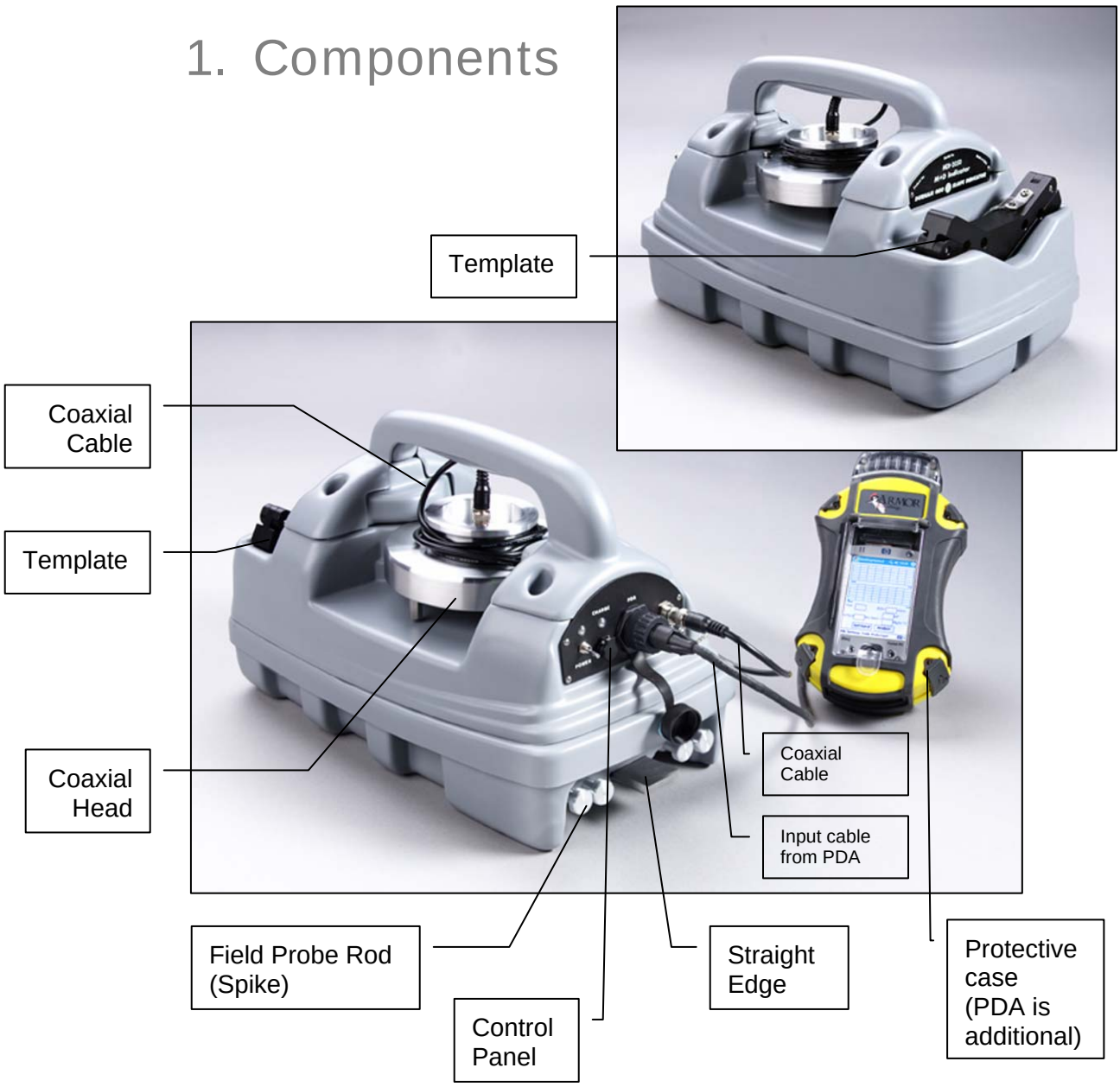
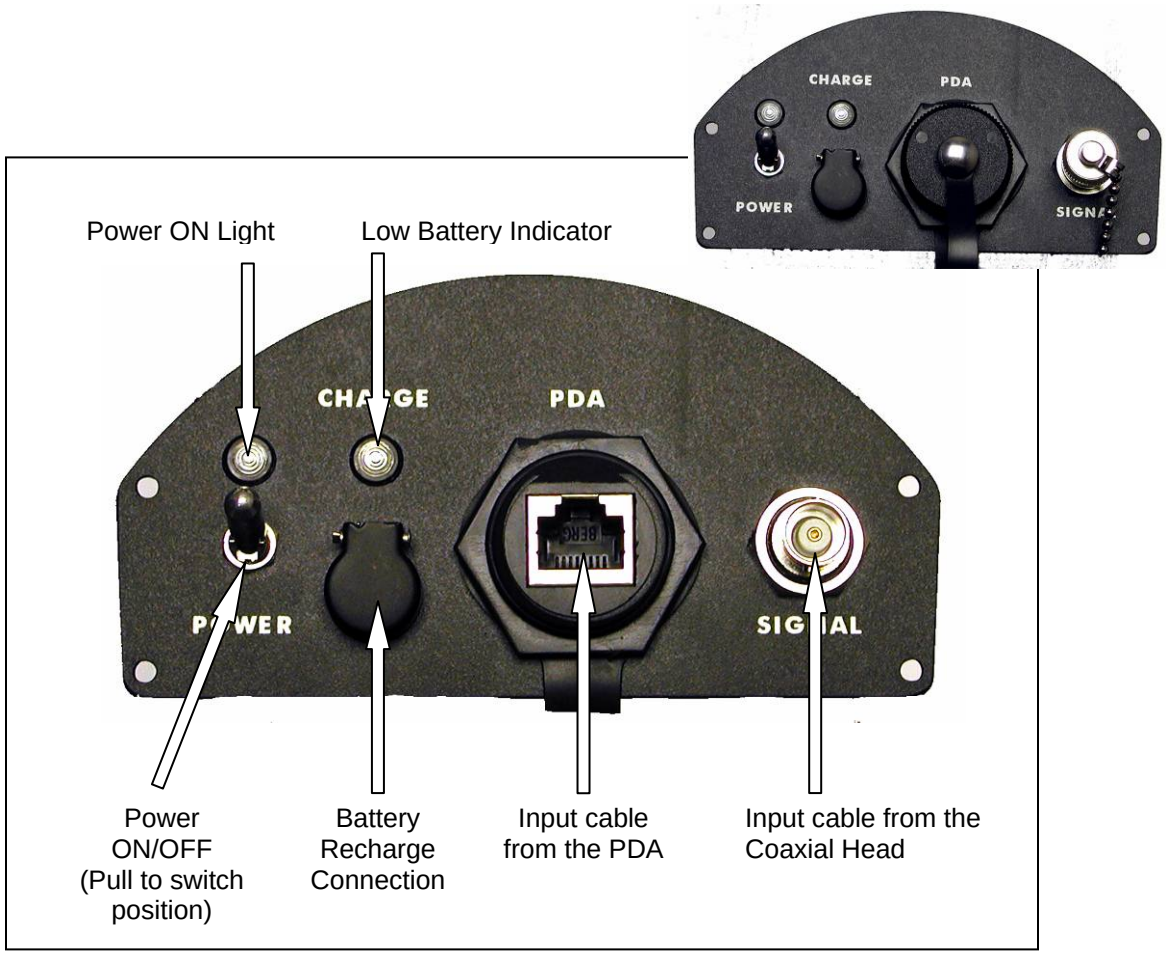
Chapter 1

QUICK OVERVIEW AND USER TIPS

1. Components



2. Control Panel



3. Protective Case for PDA

Note: PDA is not included (The PDA is supplied by the customer).

Note: Consult our web site (www.DGSI.info/mdi) for a list of approved Pocket PCs

4. Software

The MDI-PDA software for this product will run only on specific PDAs (i.e., Pocket PCs running a Windows® operating system). A list of acceptable PDAs is posted on our web site at www.DGSI.info/mdi.

This manual assumes the use of an HP iPAQ Pocket PC running under Windows® Mobile 2003

For software installation, please refer to Chapter 2.

The data files from the PDA version are totally compatible with the ones from the PC version of the software. Either platform can read and operate on files generated by the other platform.

Transfer of files from the PDA to a laptop or desktop is done by simply removing the memory card from the PDA and reading it from the PC with an optional card reader. As an alternate method—not covered in this manual— you may use the ActiveSync® software which was developed and is maintained by Microsoft. ActiveSync® comes with the Pocket PC and is also is available as a free download from the Microsoft web site. With ActiveSync® installed on the laptop or desktop and the PDA connected through a USB port, the PDA appears as another drive on the laptop or desktop. Files may be transferred in both directions from within Windows Explorer or a file transfer folder.

ⓘ USER TIP

Become familiar with the operation of your PDA before you start working with the TDR program.

In developing this manual, we used screen captures from the MDI-PDA software installed on an **HP iPAC Pocket PC Model h2215.** At the time, this was the latest PDA compatible with the software.
Other models and brands may be suitable. Please consult our web site (www.DGSI.info/mdi) for the latest compatibility or contact our Customer Service Dept.

BACK-UP your files after each job and if battery power goes below 30%.

The MDI-PDA saves files and PROGRAMS in volatile memory. If you save your files in volatile memory you could loose all files not on your SD card or in non-volatile memory in the event the PDA looses power and needs a hard boot. See Chapter 2 “Software Installation” on how to safeguard your software.

We recommend you back-up your files on the PDA to the iPAQ File Store folder (if you have an iPAQ Pocket PC) or on the SD (secure Digital) card after each job as well as to a PC or appropriate device for long-term storage. Consult your PDA’s manual for specific instructions.

5. Procedures for One-Step Method

1. Obtain soil constants for the soil to be tested.
2. Turn MDI on.
3. Turn on PDA or laptop.
4. Insure communication between MDI and PDA/Laptop has been made.
5. Start software on PDA.
6. Using Tools/calibration Open the calibration file for the soil to be tested.
7. "Plot" and "Update" calibration file
8. Close calibration screen using "x" in upper right hand corner.
9. Insure you are using "Field Probe" screen.
10. Insert four pins through template -center pin last.
11. Remove template.
12. Place head on pins, make sure you have good contact.
13. "Get Signal" on software.
14. inspect curve to insure good signal.
15. "Analyze" to obtain results.
16. Save results to a safe location on laptop or in non-volatile memory on PDA.

TO OBTAIN ANOTHER SAMPLE IN THE SAME SOIL TYPE: You do not need to reopen the calibration file. It is already applied to the current screen.

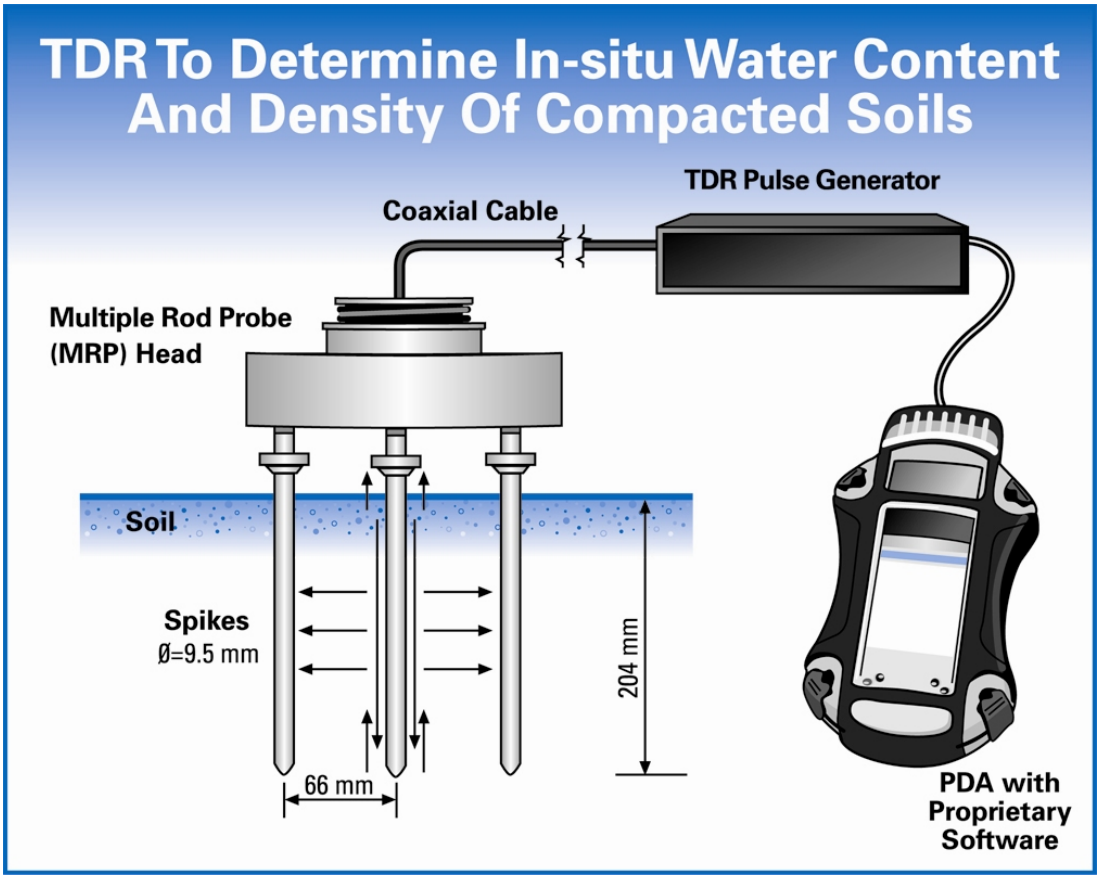
1. Insert four pins through template -center pin last.
2. Remove template.
3. Place head on pins, make sure you have good contact.
4. "Get Signal" on software.
5. Inspect curve to insure good signal.
6. "Analyze" to obtain results.
7. Save results to a safe location on laptop or to a Non Volatile memory location on PDA.

The **Two-Step Method** is explained in Chapter 5.

6. Limitations

- Only for non-frozen soils.
- Not for measuring the density of asphalt or concrete.
- The M+DI has been used successfully for testing base and subbase materials. However, the M+DI may not be appropriate for aggregates or earth-rock mixtures that either interfere with penetration of the probes or have numerous and large void spaces.
- Highly organic (peat, etc.) or highly plastic soils at higher water contents may attenuate the M+DI response signal.

7. Principle of Operation (Summary)



The method for water content and density measurement uses two “coaxial cables” where the “insulating” material between the “coaxial lead” and the

"shield" is soil. Driving four metal spikes into the soil surface in a pattern that simulates a cable creates the first "coaxial cable". The length of the spikes driven into the soil represents the length of the cable. Time Domain Reflectometry (TDR) is used to measure the travel time of an electromagnetic step pulse in this cable. The travel time allows for determining the "apparent dielectric constant" of the soil contained between the spikes. The word "apparent" is used because the dielectric permittivity of soil is complex.

The second "coaxial cable" consists of a soil-filled metal compaction mold with a metal rod driven into the center to act as the center lead. The metal mold forms the "shield." The compaction mold is placed on a non-metallic base to complete the simulation. Again, TDR is used to measure the travel time from which the "apparent dielectric constant" is determined.

Two methods resulted from research programs at Purdue University. The first method developed is called the Two-Step Method. Subsequent development resulted in the Simplified or One-Step Method. Calibration in the laboratory prior to field tests is recommended—but not obligatory—for both Methods for the purpose of obtaining soil constants that will be used in the field measurements. Calibration is conducted in conjunction with a set of standard compaction tests (ASTM D698 or D 1557, A & B), adding only a few simple steps to take TDR measurements in the compaction mold. The laboratory work to develop the soil constants with either method is about the same, but the field effort and time is greatly reduced in the One-Step Method by eliminating the field mold test of the Two-Step Method. Below are the key points of the two methods.

Two-Step Method:

The Two-Step Method consists of measuring the dielectric constant of the soil in-place (Step One) and the soil in a compaction mold (Step Two) with the M+D Indicator.

The dielectric constant of the soil in-place is determined using the M+D Indicator. The soil at the location of the in-situ measurement is then excavated and compacted in a mold. By measurement of the mass of the mold and soil and with the mass and volume of the mold known, the wet density of the soil in the mold is determined. Then, the dielectric constant of the soil in the mold is measured using the same M+D Indicator. The water content of the soil in the mold is determined automatically by the MDI-PDA software using a correlation between the dielectric constant, moisture content and soil density. The correlation requires two soil-related constants. The density of the soil in place is determined by the software from the density of the soil in the mold and the dielectric constants measured in the mold and in-place.

One-Step Method:

The One-Step Method consists of measuring the bulk electrical conductivity in addition to the dielectric constant of the soil in-place with one measurement. Thus, no soil needs to be excavated on site which saves considerable time.

For further details, please consult our web site at **www.DGSI.info/mdi**

8. Operating Tips

Suggestions for getting improved accuracy in field tests:

1. Remove the top inch or so of soil that may have dried or has become wet from recent rainfall before performing field density and water content measurements.
2. Be sure the surface (an area at least 1 ft^2) of the soil being tested is flat and smooth.
3. When running the TDR test, be sure to **drive the center spike last**. This will minimize the forming of gaps adjacent to this spike. If, after removing the template, you see a small gap around the center spike from drift of the spike as a result of driving, fill it in with loose soil or redo the test at another location.
4. When driving spikes into the ground, if any spike is deflected from the vertical (for example, as a result of hitting a rock), all spikes should be removed and the test done at a new location at least 8 in (20 cm) away from the original location.
5. Make sure all spikes are driven to just touch the template. If one of the outside spikes is driven too hard, it will cause the other sides of the template to lift off the soil. This will introduce a source of error into the results because the “length above soil” will be different from that assumed in the data reduction.
6. Check that all spikes penetrate the soil tightly and that there are no air gaps surrounding the spikes because these air gaps will affect the TDR signal.
7. Check the TDR signal for good contact between the Coaxial Head and the spikes (and ring on compaction mold). If the signal does not show the classic shape (see an example in Chapter 3, point 3.16), move the Coaxial Head on the spikes or ring until that shape appears and does not change.
8. Keep all metal parts clean and free of oily films. Use a fine emery cloth or steel wool to remove any corrosion.
9. The proper sequence for turning the M+DI ON is:
    - Connect one end of the coaxial cable to the Coaxial Head and the other to the M+DI control panel.
    - Turn the M+DI ON
    - Allow 30 sec for the TDR device to perform self-calibration.
10. Check that the proper mold volume is entered into the program. The volume should be about 1900 cm^3 if using the 4" x 9" mold and, if using the 4" x 4.58" mold, the volume should be about 943 cm^3.
11. Check the calibration of the field scale against a standard laboratory scale.

12. Measure the spike's (field probe rods') length and check that the proper total length of spikes is entered into the program. Also check that the correct length above soil also is entered into the program.

    Note:

    - The spike (field probe rod) length is about 0.235 m
    - The above-soil clearance is about 0.032 m.
    - The 9" mold probe length is about 0.263 m

13. Discard probe rods as soon as the sides and pointed tips become worn or if they are bent (because this greatly affects the signals).
14. We recommend using molds with a stainless steel body. Common molds—which are made from mild steel and are zinc plated for corrosion protection—may hinder the TDR signal.
15. When performing the 2-step method (field mold), if the soil contains large particles or comes out in clumps, we recommend passing the soil through a ¾" opening sieve to remove the larger particles and break up the clumps before placing the soil in the mold. For this we recommend using the following (available from Durham Geo Slope Indicator):

    - PCF-10500 — 12-in dia. sieve, ¾ in opening
    - PB-120 — 12-in dia. sieve pan, full height
    - P-413 — Brass sieve brush
    - 601594 — Wooden block (2x4x6) (to work the soil through the sieve)

16. Back-up your data!

9. Things to Keep in Mind

- **Coaxial cables are not all the same. Using a coaxial cable with characteristics that differ from those of the cable provided by Durham Geo Slope Indicator will result in erroneous wave forms. Buy replacement coaxial cables only from Durham Geo Slope Indicator.**
- As with any electronic equipment, keep the unit in the shade when it is not in use for long periods and ambient temperatures are above 85°F (30°C).
- Keep all metal parts clean and free of oily films. Use a fine emery cloth or steel wool to remove any corrosion.
- Be careful around extended cables —they are a trip hazard.
- Filed probe rods (spikes) are sharp. Store them in the M+DI case rather than carry them.
- Keep dust covers on when connectors are not attached.
- Weather resistance only. Avoid exposure to water.
- Avoid severe impacts. Handle with care. Transport in a cushioned, protective case.
- Connect coaxial cable only to a DGSI-manufactured Coaxial Head. Never short together the signal output leads.
- Keep cable ends free of dirt and moisture.
- The decreasing battery voltage will not influence the measurements. The battery will turn the system off before the voltage drops low enough to influence the measurements.
- Do not charge the M+DI battery until the charge indicator light turns red. Charging a lithium battery before it is fully discharged shortens its life. Charge the battery for at least eight hours. The battery will shut off incoming current when it becomes fully charged.

Chapter 2

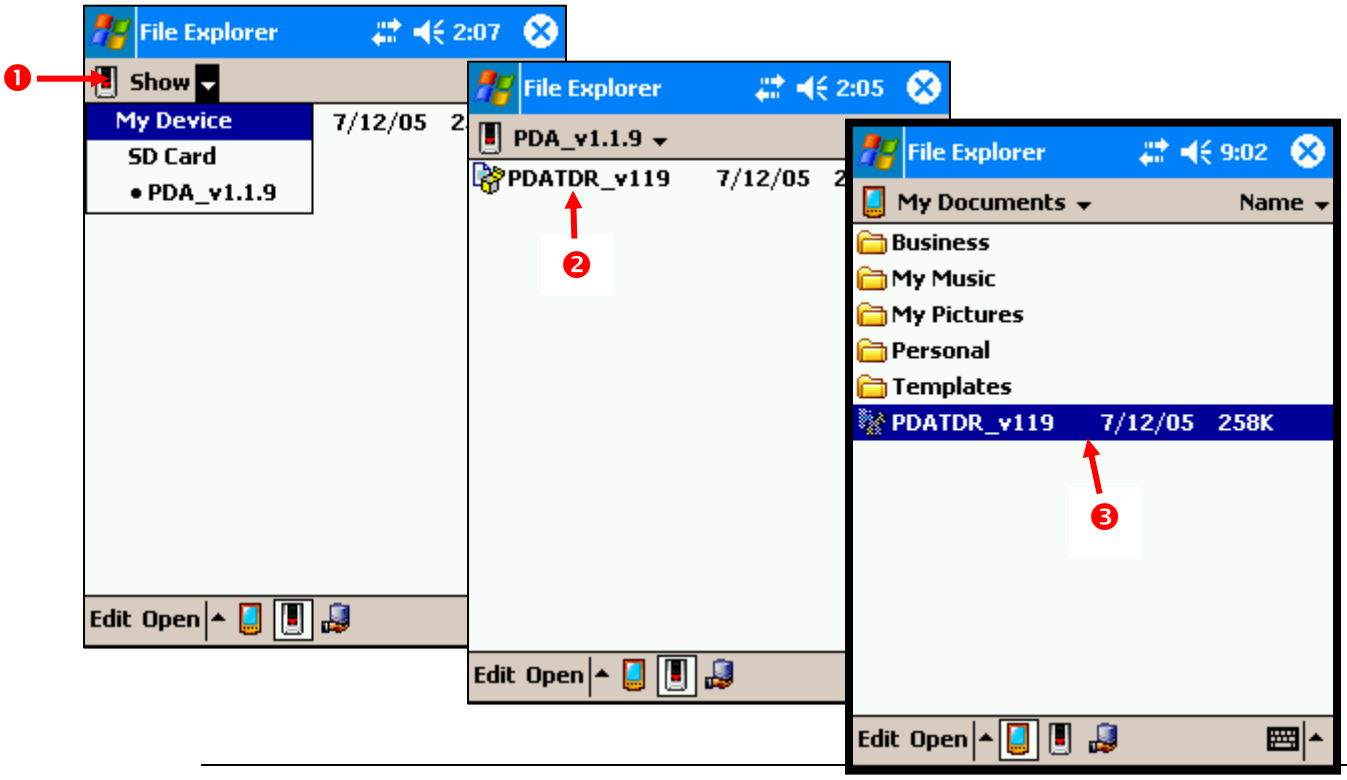
SOFTWARE INSTALLATION

Installing the MDI-PDA software involves two steps: installing the software itself and configuring the PDA's network settings so it can communicate with the M+DI.

1. Software for PDA

1.1 The software for PDA comes on the SD (Secure Digital) or CF (CompactFlash) card supplied with the unit. It consists of one file. Note: The SD Card we supply is locked (write-protected) to protect the data.

1.2 To install the MDI-PDA software, simply insert your SD or CF card in the PDA, open File Explorer and navigate to the SD or CF card (❶).Select the software (❷). Copy the PDATDR_v1.22 to "My Documents". Tap on the software file name (❸) to execute the program and start the installation. Note: the version number for your software may be different from the one shown here.



1.3 For back-up, copy the program file to a safe location on your desktop or network.

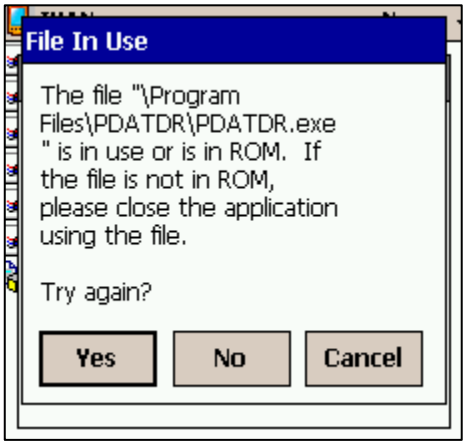
ⓘ USER TIP

If your SD card is not write-protected, or if you are installing the program from another location, be aware that once you execute the file, it will be no longer be useable. If you need to re-install it, copy a fresh file back to the folder, over-writing the older file, and repeat the installation.

1.4 If you are re-installing the program or installing a new version, you will see the message shown on the right. Click OK to continue the installation.

1.5 If you are presented with the "File in Use" error message, it means you have one or more instances of the program running in the background. These must be closed before the installation can start.

In this case, tap NO and close the programs by following step 1.8 and start at point 1.1 (previous page) again.

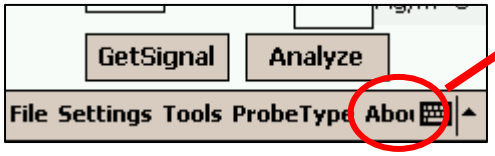


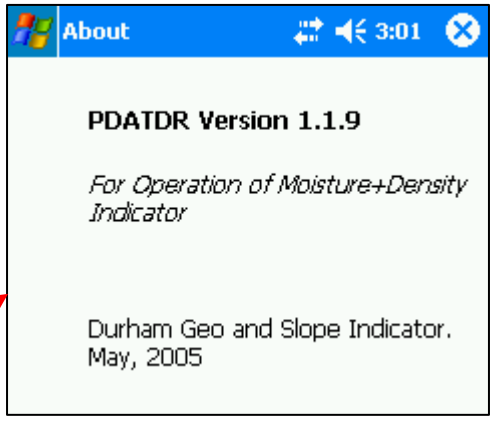
ⓘ USER TIP

The latest version of the software may be downloaded from our web site (www.DGSI.info/mdi)

1.6 Launch the program by going to Start > Program Files and selecting (tapping) the PDATDR program.

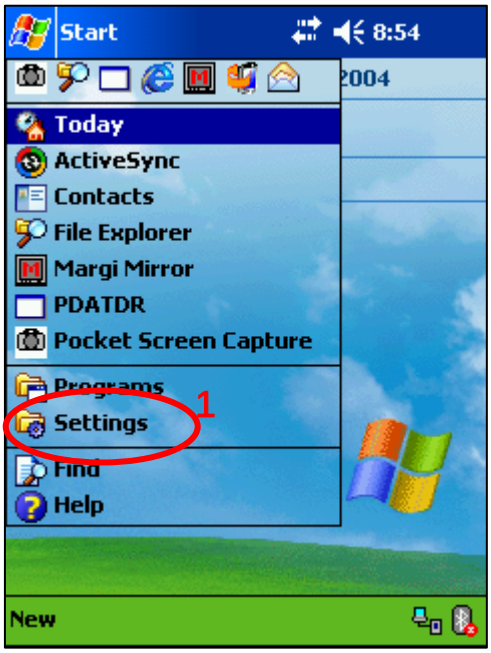
1.7 To check the version of your MDI-PDA program software, start your MDI-PDA software, select either One-Step Method or Two-Step Method (it does not matter which for this purpose). Select **About** and the screen at right will appear.

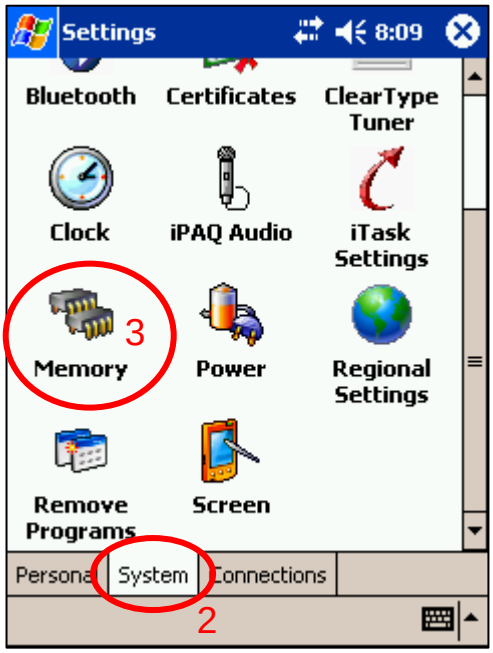


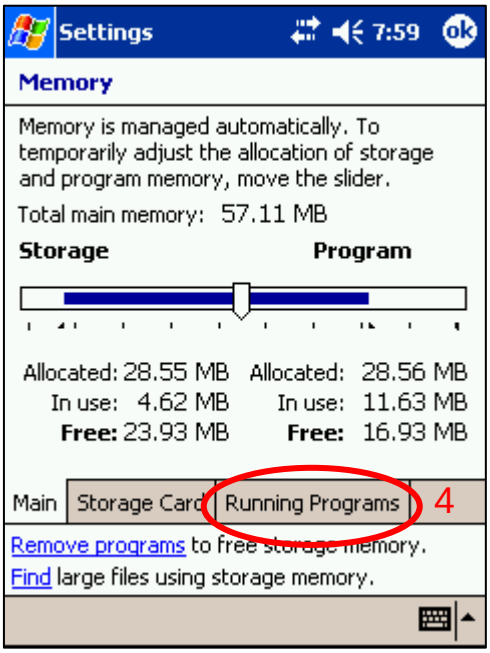


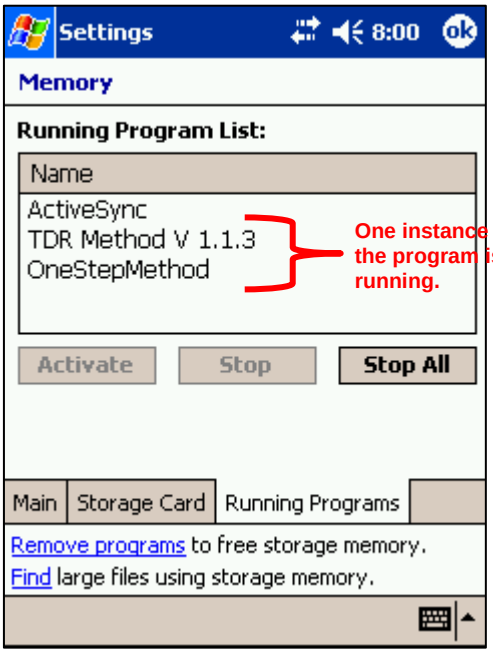
1.8 To close multiple instances of MDI-PDA:

- from the Windows® Main Screen, choose **Settings** (ref 1 on the image below)
- Select the **System** tab (ref 2 on the image below)
- Tap on the Memory icon (ref 3 on the image below)
- Select the **Running Programs** tab (ref 4 on the image below)
- Under the **Running Program List**, select all the programs related to MDI-PDA (they may appear under various names) and tap on **Stop** to close the selected programs.

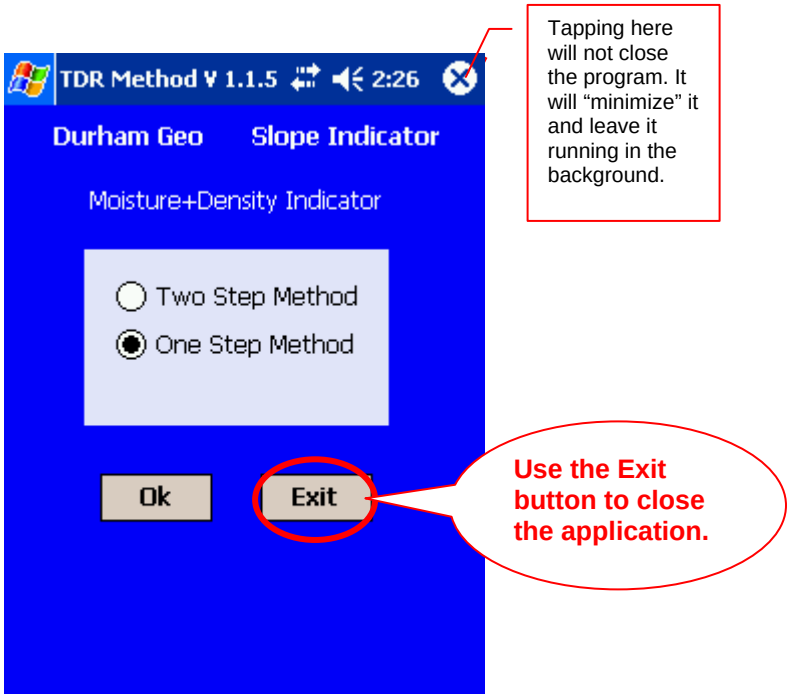








Use the Exit key to close and leave the program. Using the X icon (on the upper right) will close the window but the program will still be running in the background, consuming resources.



2. Ethernet Card Driver Installation.

The 10/100 Ethernet card requires a driver installation. This card will not work with the NE-2000 standard Drivers on H/PCs (Handheld PC).

The required drivers and a PDF instruction sheet are included on the CF (Compact Flash) or SD (Secure Digital) card included with the M+DI. Alternatively you can go to our web site, www.DGSI.info/mdi and select the Download Ethernet Card Driver link.

NOTE: The required driver is dependent on the Windows® Operating System loaded on your H/PC.

To install a driver:

1. Note your operating system: Start/settings/system/about.
2. Using File Explorer, select the CF or SD card, then the folder called “Ethernet Card drivers”.
3. Locate the driver associated with your version of Windows and Socket Ethernet card.

System	Ethernet card	Driver
Windows Mobile 5.0	Socket 10-100	Socket 10-100 Windows 2005.CAB
Windows Mobile 2003	Socket 10-100	Socket 10-100 Windows 2003.CAB
Windows Mobile 5.0	Socket Low Power	Socket Low Power- Windows 2005.CAB
Note: The original Ethernet card: Socket LPE (Low Power) card will need a driver only if you upgrade to Windows Mobile 5.0.		

4. Copy the driver to a folder in “My Documents” on your H/PC.
5. Single-tap the drive cab file and it will install onto your H/PC.
6. For Windows Mobile 5.0: Select (“Start/settings/connections/network adaptors/network cards/”

   For Windows Mobile 2003: Select “Start/settings/connections/network cards/”
7. Select “Work” under “My Network card connects to”.
8. Select “Socket 10-100 Driver”.
9. Use “Server Assigned IP Address”.
10. Select “OK” / “OK” / “OK”.
11. Your Ethernet Card is now ready to use.

Chapter

3

DETERMINING SOIL CONSTANTS

The purpose of the laboratory tests is to obtain soil-specific constants—*a* and *b* in the case of the Two-Step Method and *a, b, c, d, f, g,* for the One-Step Method. A soil-specific calibration test is recommended for applying the One-Step Method, unless sufficient confidence is gained as a result of widely accumulated experience. In this case, empirical constants can be applied.

Calibration is conducted in conjunction with a set of standard compaction tests (ASTM D698 and ASTM D 1557) using a stainless steel 4-in compaction mold with a non-conductive base.

1. Laboratory Procedure (Summary)

- Ambient temperatures and the temperature of the test soil must be within 15 to 25°C (59 to 77°F). Make sure the probe of your digital thermometer is at least 2" into the soil or the atmosphere will influence the readings.
- Obtain a representative sample of soil from the borrow area. Sample to be large enough for at least five compaction specimens (more material may be required if other tests are planned).

Laboratory procedures to obtain soil constants start when you perform compaction tests according to ASTM Compaction Procedures ASTM D698 (A and B Standard) or D1557 (A and B Modified). After wet weight has been acquired,

1. Place mold on non-conductive base (“base MDI Assembly”) for the TDR test
2. Place the center rod guide on the mold.
3. Drive 4-in center rod into mold
4. Remove guide for center rod and place the 4-in mold adapter ring on mold
5. Place M+DI’s MRP head on the mold and take a reading to obtain K_a and EC_b. Check the legs, particularly the center leg, for good contact with the M+DI mold collar.
6. Record EC_b and K_a readings in relationship to the sample being compacted.
7. Save file to a known location as a mold file.
8. Remove mold from base and use sample extruder to remove sample

9. Weigh pan to determine tare mass
10. Take a representative sample from center of sample and place into tray marked with identifying #'s
11. Weigh pan and sample and record
12. Place sample into oven @ 105°C for 8 hrs min.
13. Obtain the water content (per ASTM D 2216)
14. Repeat steps 1 to 20 for each soil specimen.
15. Determine the soil constants using the Moisture content/Dry density in Mgm/cubic meter/K_a and EC_b from each sample by placing them into the calibration form under Tools/calibration.

2. Configure the Software

Before you perform field or lab work for the first time, we recommend configuring your PDA to take the TDR readings and save them properly. If you are using a PC, please refer to Chapter 6 for software instructions.

Software configuration is slightly different depending on the Method (One-Step or Two-Step) you will use. Be sure to choose the correct method because the configuration file created by one method cannot be used in the other method.

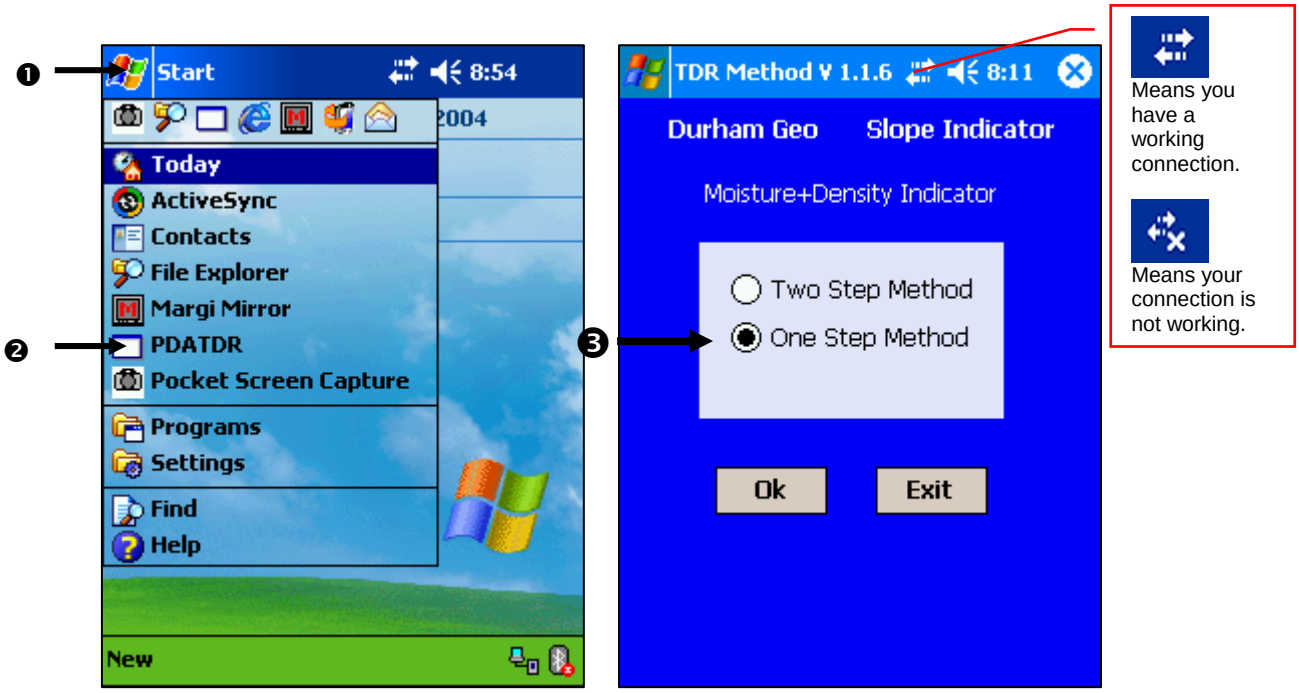
After the soil constants are obtained, the configuration file can be re-saved with these constants.

A configuration file contains specific information for that soil type. It makes this information readily available so the field work is quick and easy. When in the field simply open the configuration file for that job and get signal. The soil constants, probe lengths, and site information will be loaded when you open the config file.

NOTE: The configuration file does not save the test or contain signals from the test. You must save the signal file with analyzed data as a field or mold file.

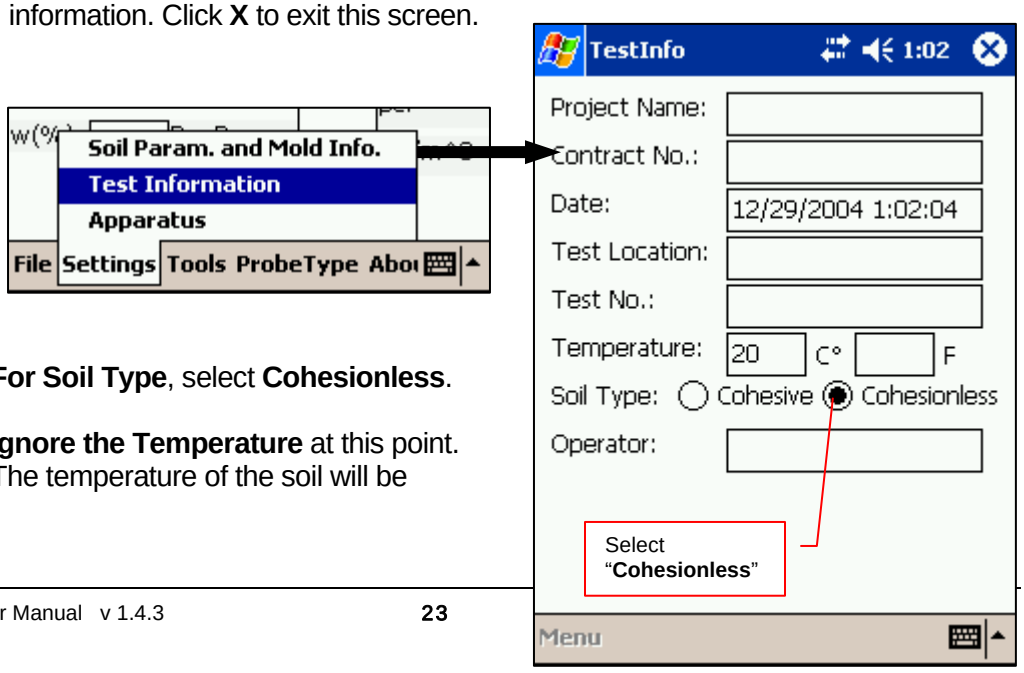
CONFIGURE SOFTWARE FOR ONE-STEP METHOD

1. **Launch the MDI-PDA program on your PDA (1 and 2) and select the One-Step Method (point 3).**



2. **Set up your configuration file.**

   a. From the menu bar, select **Settings > Test Information.** Enter relevant information. Click **X** to exit this screen.

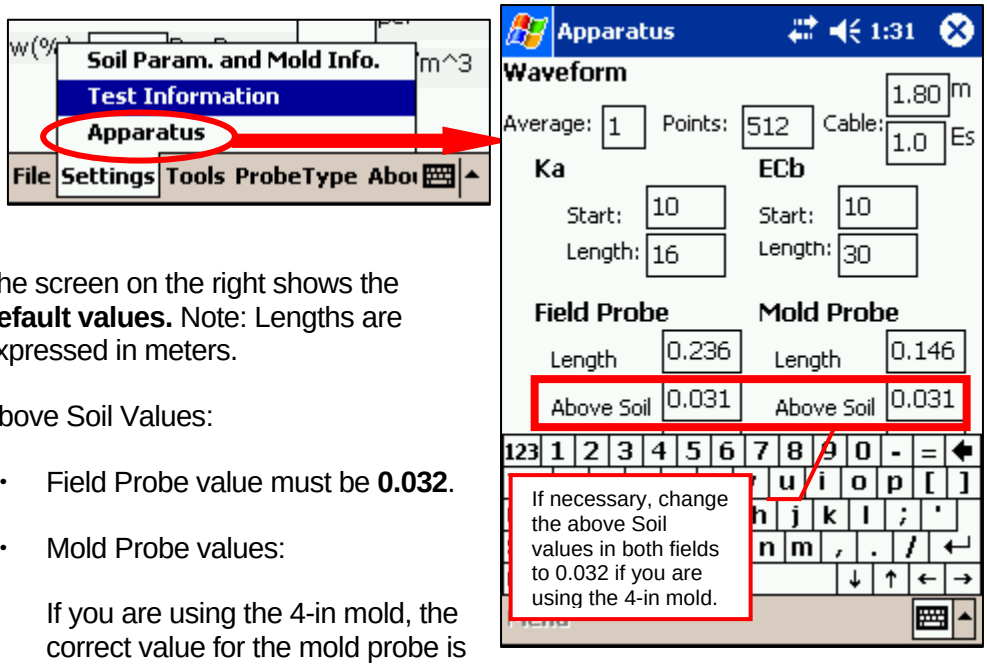


   For Soil Type, select **Cohesionless**.

   Ignore the Temperature at this point. The temperature of the soil will be

measured when performing the test. Leave the default value of 20°C as is.

b. From the menu bar, select **Settings > Apparatus.**



The screen on the right shows the **default values.** Note: Lengths are expressed in meters.

Above Soil Values:

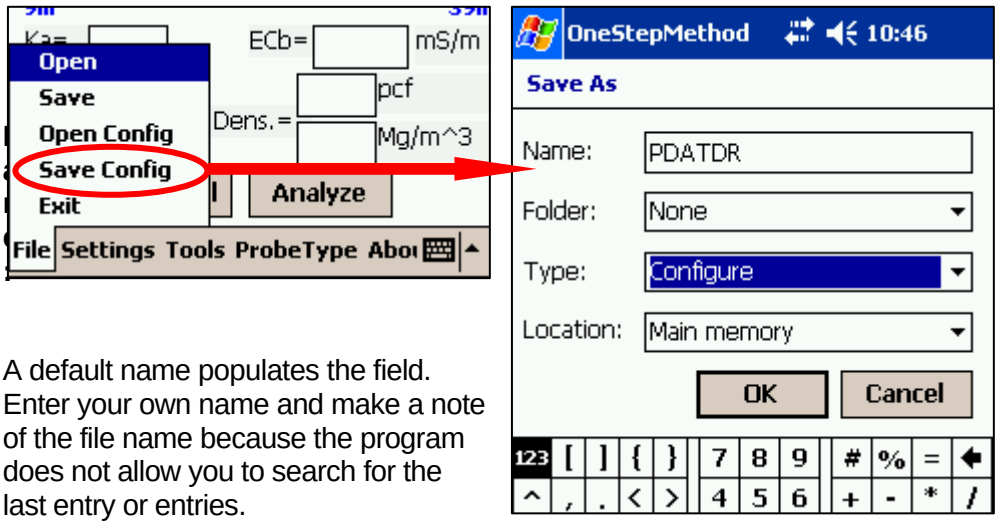
- Field Probe value must be **0.032**.
- Mold Probe values:

  If you are using the 4-in mold, the correct value for the mold probe is 0.032.

Note: If you were using non-standard probes, you would enter all setup parameters here. Example:

.147 M= 4” mold Probe
.032 M= 4” mold above soil
.235 M= 9" probe (Field Spike)
.032 M= Field probe above soil

3. **Save your configuration** by selecting **File > Save Config**.



A default name populates the field. Enter your own name and make a note of the file name because the program does not allow you to search for the last entry or entries.

Folder: you can choose your own folder. If you leave the selection as **None,** the file will be saved under My Documents and will not be in a designated folder. To create a folder in Windows® 2003, go to My Documents > Edit > New Folder.

Type: must always be "**Configure**"

Location: accept the default of Main Memory if you want your data to reside on the PDA's memory. Select iPAQ File Store or SD card if available. Note: the main memory is volatile and data stored there will be lost if the PDA loses power. The iPAQ File Store and the SD card are non-volatile memories.

NOTE IF USING THE TRIMBLE RECON: all memory is non volatile. You will not loose data if power is lost or the battery is removed for a short time.

When done with this screen, tap on **OK.**

The configuration file does not save signals taken in the field or mold.

The configuration file saves basic information (test information, apparatus setup, and soil coefficients only) and is very useful when going into the field.

ⓘ USER TIP
To make it easier to find your files, create a folder under **My Documents** and give it a project name. Place all files for the project in that folder.
For a given project, the files types to place in the folder are:
• cfg (Configuration file)
• cal (Calibration file)
• cmp, cec (Mold data)
• mrp, mec (Field data)
When searching for configuration files, only the configuration files will be shown.

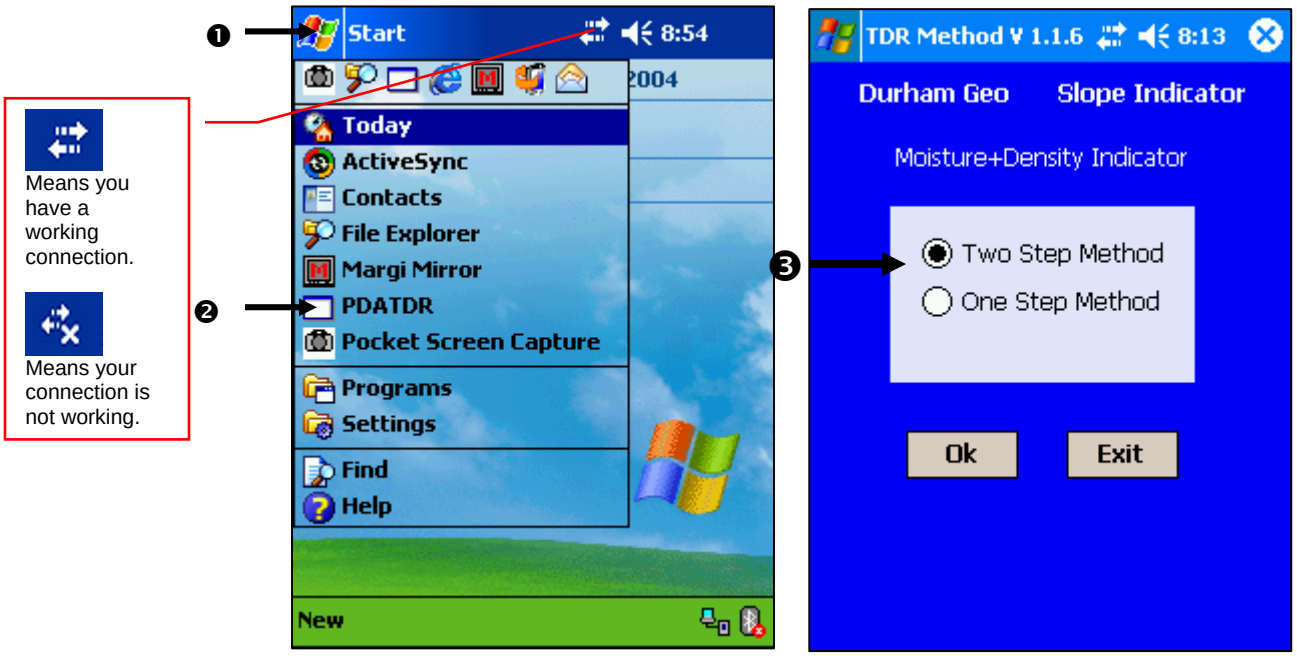
Safeguarding files against drained battery or hardware failure

- The main memory is volatile. Data stored here must be backed up. It will be lost in case of power or hardware failure, or if a hard ("full") reset is required.
- The iPAQ File Store is non-volatile memory so data stored there will not be lost in case of power or hardware failure.
- The SD (Secure Digital) or CF (CompactFlash) card is a non-volatile removable memory and an excellent place to save information.
- NOTE IF USING THE TRIMBLE RECON: all memory is non volatile. You will not loose data if power is lost or the battery is remove for a short time.

We recommend you back-up your files to the iPAQ File Store folder (if you have an iPAQ Pocket PC) or on the SD (secure Digital) card after each job as well as to a PC or appropriate device for long-term storage. Consult your PDA's manual for specific instructions.

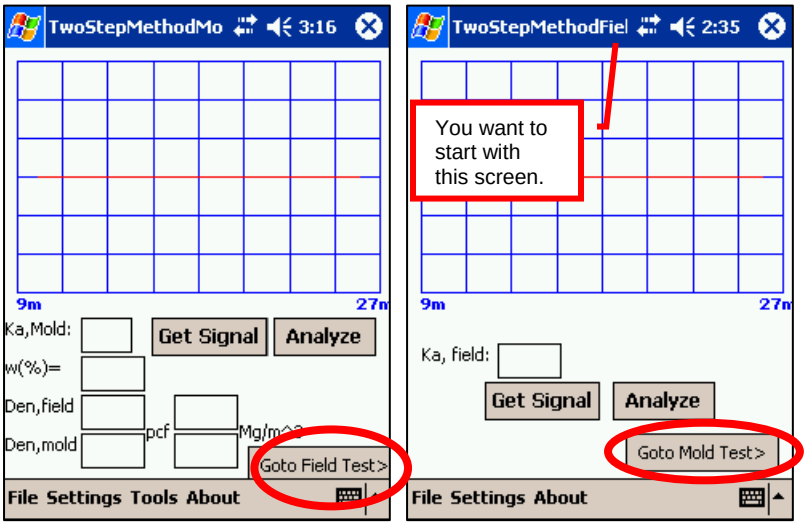
CONFIGURE SOFTWARE FOR TWO-STEP METHOD

1 Launch the MDI-PDA program and select the Two-Step Method.

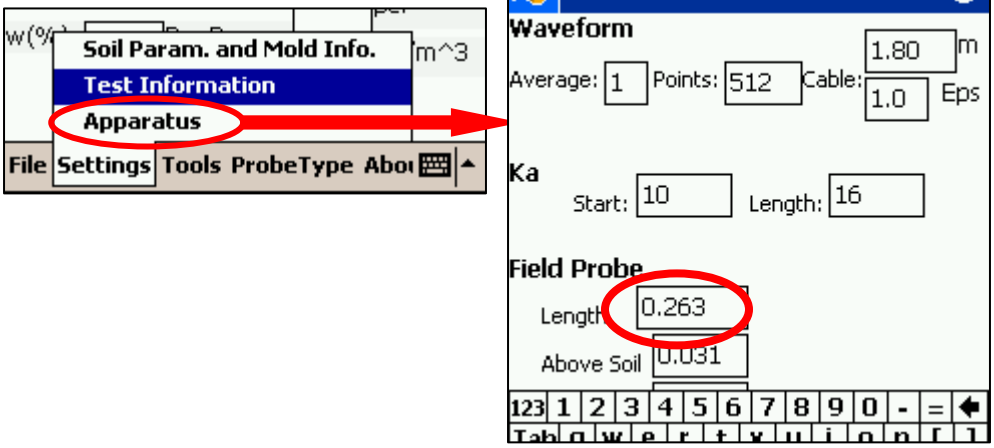


2 There are two separate screens from which to set parameters, one for the field test and one for the mold test. The test information is shared between them. Start by setting the Field Test information and add soil constants. Then, go to the Mold Test screen to set the Apparatus, set Test Information and save the configuration — in that order. These steps are described below.

a. **Set Apparatus.** From the entry screen go to the **TwoStepMethodField** screen. If you are in the TwoStepMethodMold screen select "**Goto Field Test>**" button at the bottom of the screen, right side. You can toggle back and forth between these two screens.



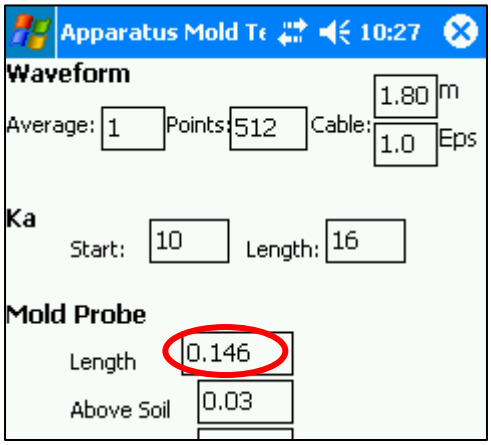
b. From the menu bar in the **TwoStepMethodField screen**, select **Settings > Apparatus.**



c. Tap on the X to exit this screen.

d. Go to the Mold Test Screen by tapping on the **Goto Mold Test>** button.

e. From the menu bar in the **TwoStepMethodField screen**, select **Settings > Apparatus.** You should see the screen shown on the right.

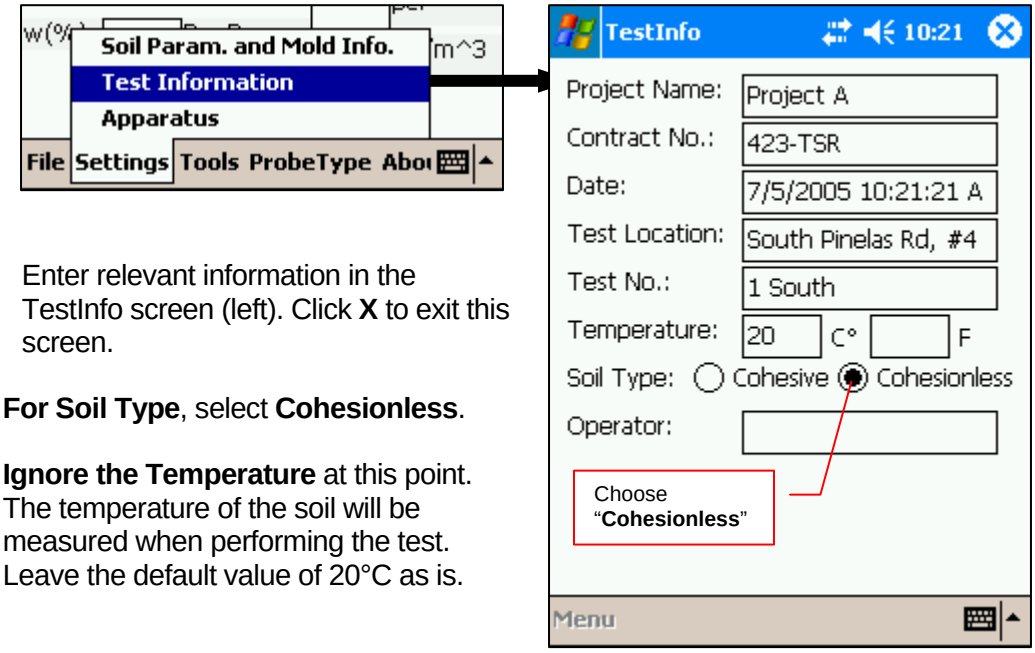


This step is normally not required because all the fields are populated automatically. However, this is where you would change the mold probe length if you were using the 9 in mold in the laboratory (instead of the 4 in mold). If you are using the 9-in mold, the default value for the mold probe would be 0.263 (instead of 0.146).

The screen shot (above, right) shows all the **default values** for the measurements done in the laboratory with the Two-Step Method which assumes a 4-in mold. Lengths are expressed in meters.

f. If you were using non-standard probes (which is not recommended), you would enter their lengths here.

g. From the TwoStepMethodMold screen, select **Settings > Test Information** From the menu bar (below, left)**.**

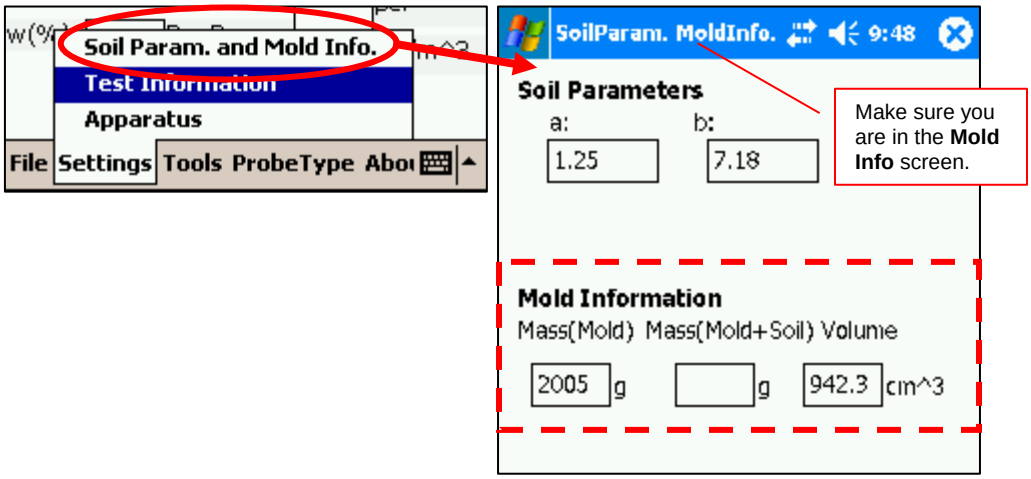


h. Enter relevant information in the TestInfo screen (left). Click **X** to exit this screen.

For Soil Type, select **Cohesionless**.

Ignore the Temperature at this point. The temperature of the soil will be measured when performing the test. Leave the default value of 20°C as is.

i. Select **Settings > Soil Param. and Mold Info.**



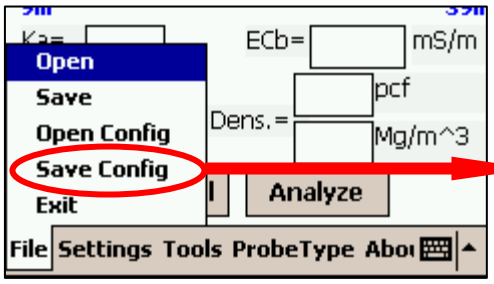
Enter the Mold Information. This requires you to have measured, ahead of time, the mass of the mold (to the nearest gram) and the internal volume of the mold (in cm^3). The mass of the mold with the wet soil will be entered later (see 3.Laboratory Procedure, point 5).

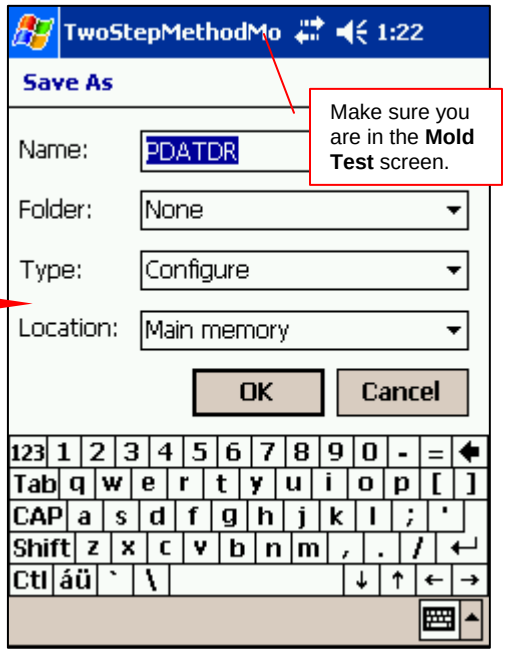
Use ASTM Standard Test Methods for Laboratory Compaction (D698) to obtain the volume of the mold.

If you have no information on the soil and accept an approximation, you can enter 1 and 9 as defaults for *a* and *b* respectively.

ⓘ USER TIP
To open or save a configuration file, you must be in the Mold screen
To set your soil parameters, you must be in the Mold screen

j. Save your configuration by selecting **File > Save Config**.





Name: A default name populates the field. Enter your own name and make a note of the file name because the program does not allow you to search for the last entry or entries. Note: When you select File > Open Config, the program will search and display configuration files only.

Folder: you can choose your own folder. If you leave the selection as **None,** the file will be saved under My Documents and will not be in a designated folder. To create a folder, go to File Explorer > My Documents > Edit > New Folder.

Type: must always be "**Configure**"

Location: accept the default of Main Memory if you want your data to reside on the PDA's memory. Select iPAQ File Store or SD card if available. Note: the main memory is volatile and data stored there will be lost if the PDA loses power. The iPAQ File Store and the SD card are non-volatile memories.

When done with this screen, tap on **OK.**

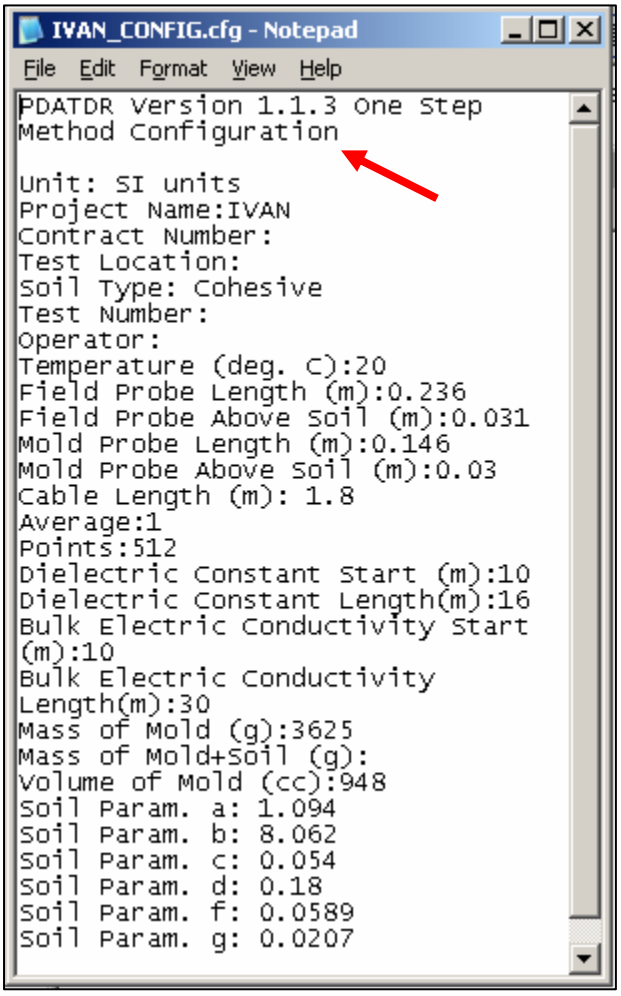
ⓘ USER TIP

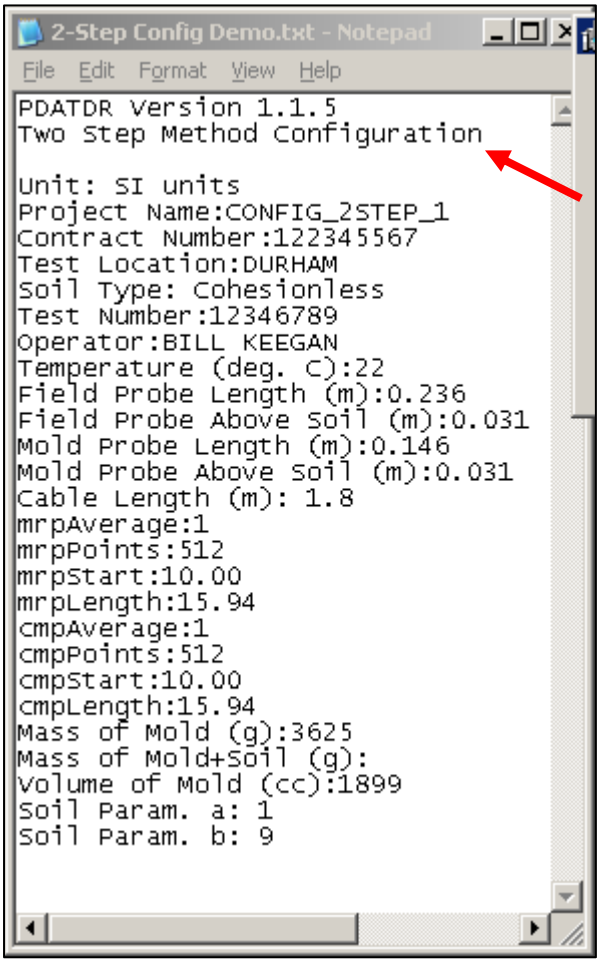
Save and load configuration

Test setting can be saved and then subsequently loaded for convenience. Configuration file is a text file with suffix **.cfg**. It stores project information, test parameters and soil calibration constants only. The Config file does not save mold or field results. An example of the content of a configuration file is shown below.

It is a good practice to create a configuration for each project or soil under test. And then load the configuration by tapping File->Load Configuration.

You may view the information contained in a configuration file by opening it with a text editor such as Notepad. Below are examples for One-Step and Two-Step Configuration files.





3. Laboratory Procedure (Detailed):

Applicable Standards: ASTM D698 (A and B Standard) or D1557 (A and B Modified).

3.1 **Air-dry enough soil** for five compaction specimen.

3.2 **Pass the soil through a sieve**. Use a No. 4 (4.75 mm) for ASTM D698 Method A or D1557 Method A. Use a 3/4-in. (19.0-mm) sieve for ASTM D698 Method C or D, or D1557 Method C.

3.3 **Prepare the soil for five tests** at different water contents which cover the range of moisture content that the M+D Indicator is intended to measure. Use ordinary tap water. Per section 10.2 or 10.3 of ASTM Test Method D698.

3.4 **Compact the soi**l specimen into a 4-in diameter stainless steel mold mounted on a standard steel base (Fig. 2). Use the standard compaction energy designated by section 10.4.1 through 10.4.7 of Test Method D698.

3.5 **Weigh the mold** with the soil (Fig 3) per ASTM D698. This weight will be used for calculating dry density. Record the mass to the nearest gram and enter it in the PDA (Settings > Soil Param. And Mold Info). Note: you can do it later when you use the PDA to take a reading or enter soil data.

3.6 **Attach the mold to the non-conductive base.**

3.7 **Drive the center rod** through the guide and into the soil (Fig. 3). Use a hammer with a brass or hard plastic head to avoid damaging the center rod. (Make sure the center rod is clean before driving it into the soil.)

3.8 After completion of each standard compaction test, remove the center rod guide (Fig.4), clean the shoulder at the top of the mold, place the mold collar on top of the mold and seat the Coaxial Head on the adapter ring (Fig. 5). Rotate the ring and coaxial head back and forth on the mold to ensure good electrical contact.

3.9 **Take TDR readings** (Fig. 6) for each compaction point. The following steps will guide you through the software.

Wear Safety Glasses

Fig. 1: Compact the soil (ASTM D 698).

Fig. 2: Weight the soil specimen and mold to nearest gram (ASTM D 689).

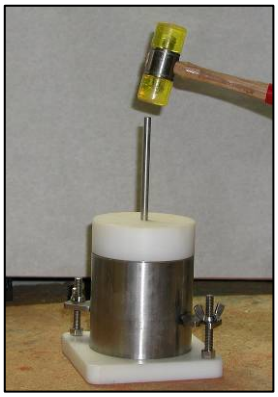


Fig. 3: Drive the center rod.

Figure 4 – Remove the guide for center rod and leave the center rod in place.

Figure 5 – Place the mold collar on the mold. Sit the Coaxial Head on the mold collar. Ensure the contact surfaces are clean (see Fig 7)

Figure 6– Take TDR reading.

Figure 7 – Ensure the electric contact surfaces are clean.

Since conductivity measurement is used for analysis, ensure you have good contact between the adapter ring and mold, Coaxial Head and mold collar. Soil residues on contact surfaces must be removed and the surfaces clean (Fig. 7) before taking measurements.

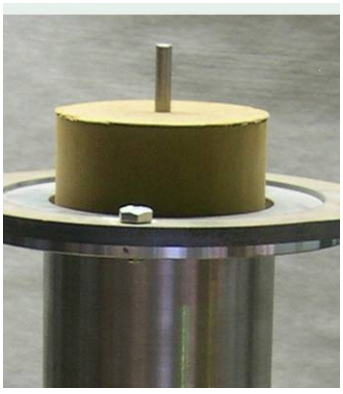


Fig. 8: Extrude the sample

Fig. 9: Removing at least 0.5 kg (1lb).

Fig. 10: Weighing.

Fig. 11: Oven Drying.

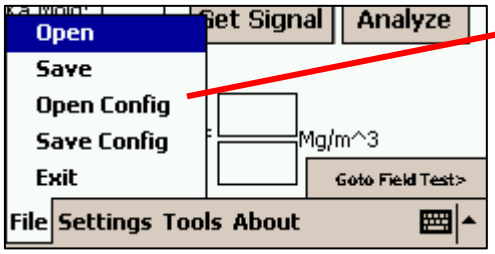
3.10 If you have not already done so, open the MDI-PDA in the chosen mode of operation, ie., One-Step Method or Two-Step Method. Be sure to choose the correct method because the configuration file created by one method cannot be used in the other method.

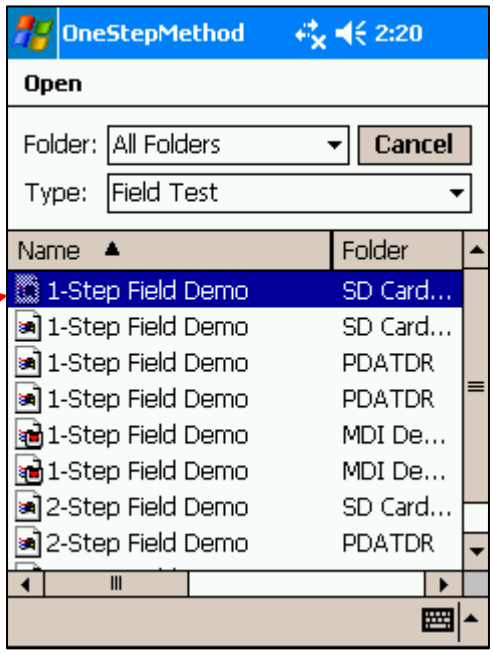
➲ **For the One-Step Method follow 3.7 to 3.19**

➲ **For the Two-Step Method, follow 3.20 to 3.32**

ONE STEP METHOD

3.11 **Open the configuration file**. From the main menu, select **Open > Open Config** and select the relevant configuration file for this soil. This will "load" the soil parameters and permit the waveform analysis.





ⓘ USER TIP

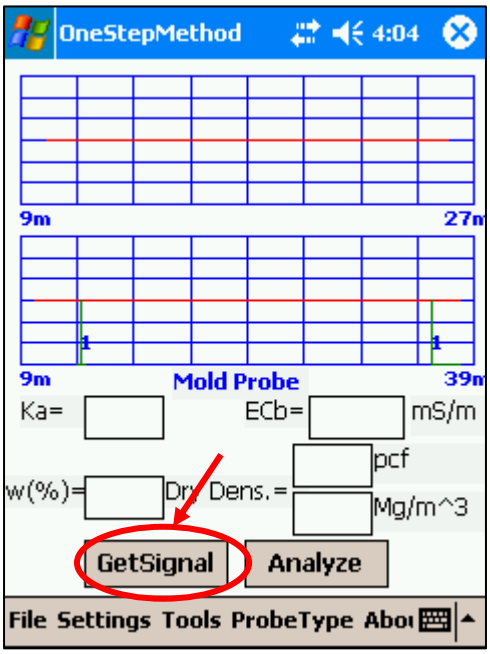
There is no need to load the Config file for each test. Once the first test is saved, the information contained in the Config file will remain active until the program is closed or a different Config file or a different test is opened.

The only information that needs updating is Test Info and File Name.

3.12 After selecting the configuration file, you will see a screen similar to the one shown on the right.

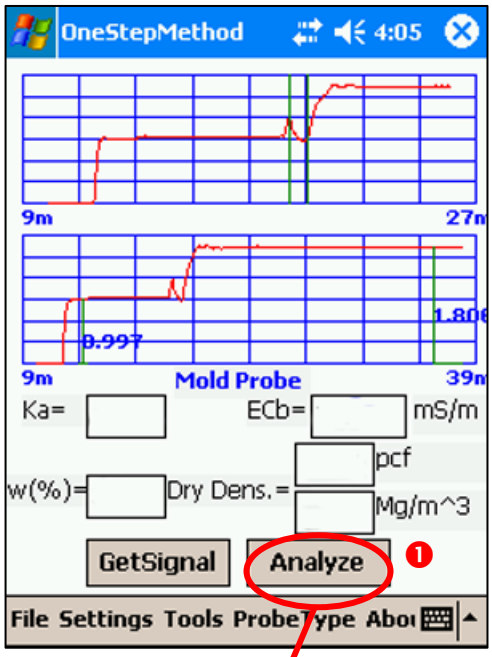
3.13 Select **Probe Type > Mold Probe**

3.14 **Take a TDR Reading** by tapping the **GetSignal** button (screen capture on the right). This will obtain the waveforms similar to the ones shown on the next image.



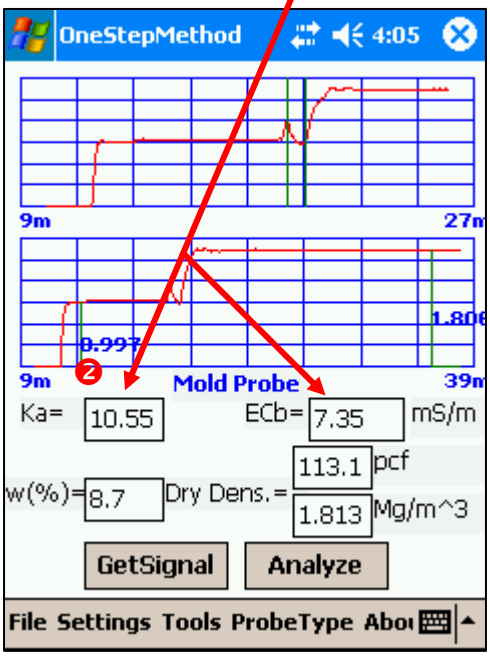
3.15 Observe the wave form. If it does not have the typical shape, there may be a poor electrical contact. Rotating the Coaxial Head slightly to may give a suitable signal.

3.16 Tap on **Analyze** to obtain the dielectric constant ($K_{a,\,Mold}$) and EC_b. Values appear in the corresponding fields. Values will appear in the other fields but they are meaningless at this point — until you enter soil test data (soil-specific constants) and plot the data (point 3.19).



ⓘ USER TIP
Monitor the value of $K_{a,\,Mold}$. Acceptable ranges are:
• 3 - 5 for sand
• 16 -17 for sandy silts
• 30 – 60 for clay
If you have a value smaller than 2, there may be something wrong with the electric signal (check contacts). Check the legs, particularly the center leg, for good contact with the center rod.

We recommend you take two consecutive measurements. After taking the first reading, and saving it, rotate the head slightly to improve contact with the mold collar. Take a second reading to verify results. Consecutive readings should be nearly identical. If they are not, check all connections and contact surfaces between the probe head and the adapter ring. Note: the second measurement may be slightly higher than the first one because electrical charges from the previous reading(s) may still be stored in the soil.



3.17 Make sure you **save your readings** (files) every time you take one and record the K_a and EC_b values manually, typically in your test record sheet (see sample in Appendix).

3.18 **After taking the readings**, the soil in the mold is removed from the mold (Fig. 8), a portion of the sample obtain and is weighed (Fig. 10), and placed in an oven (Fig. 11) to obtain oven-dry water content according to ASTM D 2216.

3.19 **<u>Repeat steps 3.4 through 3.18 for each soil specimen.</u>**

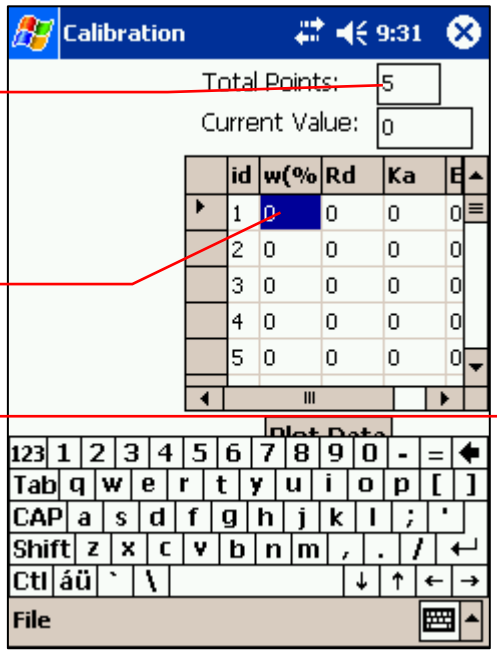
3.20 Enter calibration data. After the soil has been oven dried and you have calculated the water content, you can now enter the soil test data in the software. From the program menu bar at the bottom of the screen, select **Tools** > **Calibration**

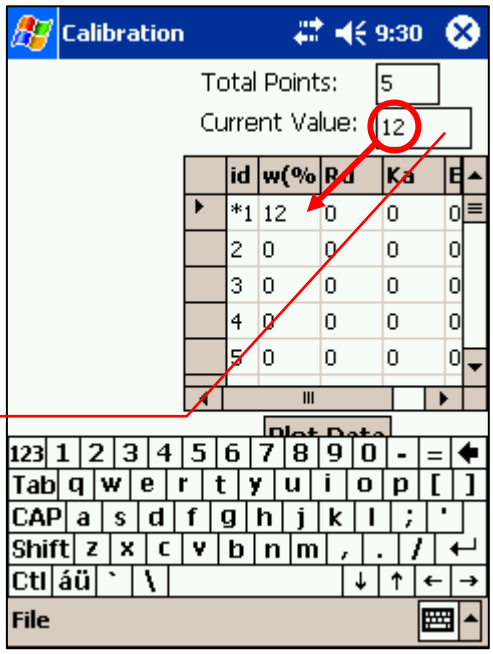
Follow the three steps indicated on the left side of the images.

1 – Enter the number of points from your Proctor test (for example:5)

2 – Tap the cell for which you want to enter a value.

3 – Enter the value from the laboratory tests in the **Current Value** field and it will appear automatically in the selected cell of the data grid.



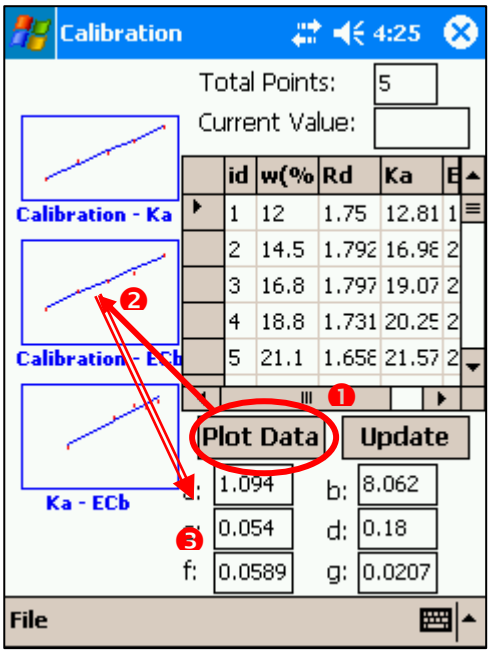


Columns headings in the data grid are:

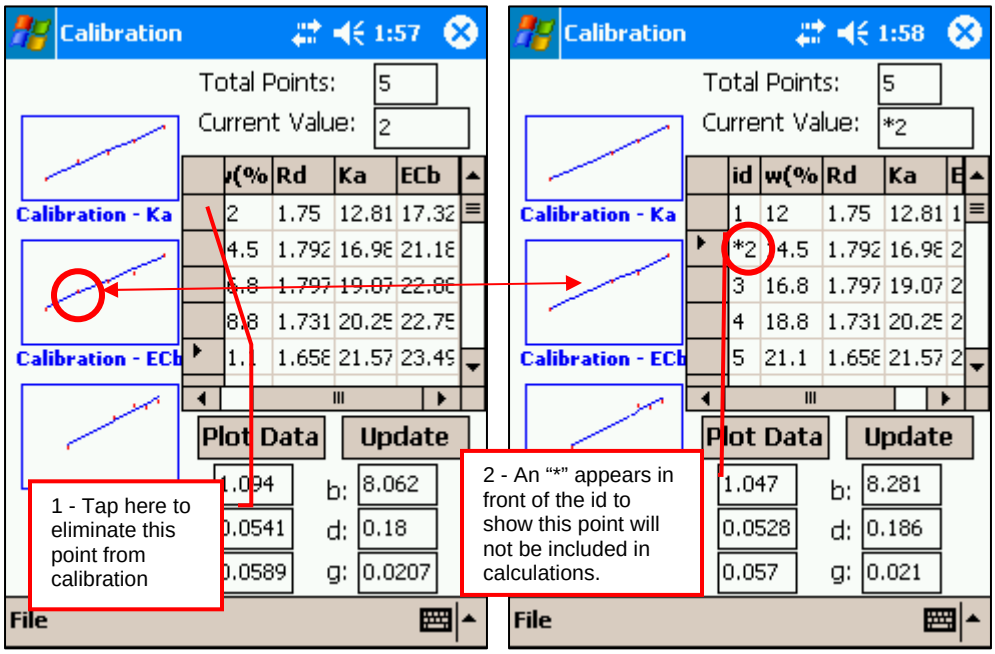
id data point reference
w(%) soil water content
Rd dry density in Mg/m³
Ka Dielectric constant
ECb Electric conductivity (mS/m)

Note:
Megagrams/m³ x 62.42796 = Pounds/ft³
Pounds/ft³ x 0.01601846 = Megagrams/m³

3.21 Plot Data. After test data for all points are entered in the table, tap on **Plot Data** (right). This will produce the three calibration curves that appear on the left of the screen and from which the six calibration constants (*a, b, c, d, f, g*) are derived and shown.



A bad data point in the plots to the left of the screen can be visualized and removed by tapping on the corresponding row header cell. An asterisk (*) sign indicates that the data in this line will removed from the calibration analysis (Image below, left). Calibration can be recalculated by tapping ***Plot Data***. The removed data point can be restored by tapping the corresponding row header cell again (and the "*" will not be removed).



When you are satisfied with the plot, tap the "**Update**" button. This will associate the constants with the Field and Mold files currently open.

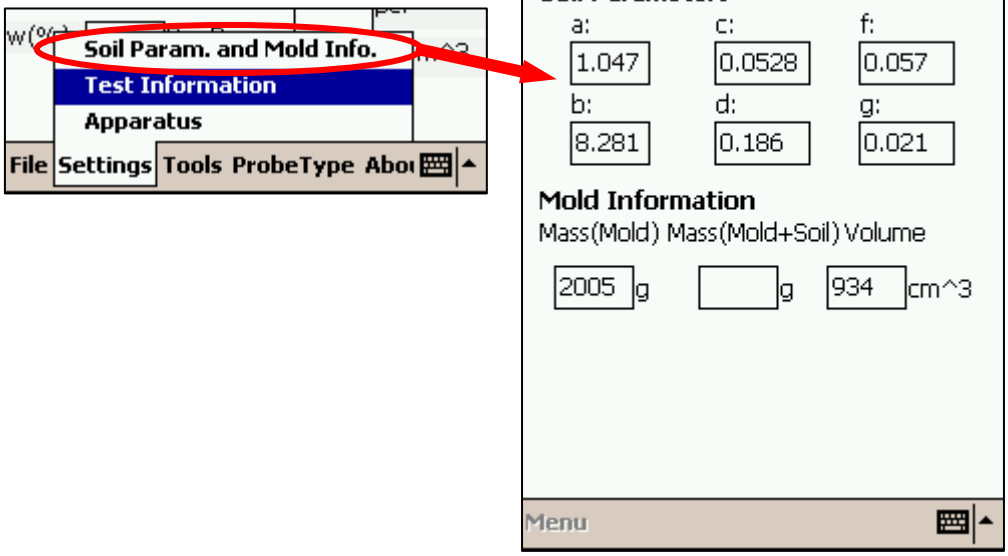
Always save the Calibration file. To save the file, go to File > save calibration.

Select the X to close the current screen.

Always save the Calibration file. To save the file, go to **Settings > Save Config**.

The **Soil Parameters** (for example, soil constants *a* and *b* in the case of the Two-Step Method, or the six constants in the case of the One-Step Method shown above) are now part of the configuration file for this test but **ARE NOT SAVED** at this point.

3.22 Go to **SoilParam. And Mold Info** and ensure the values have been updated. When you exit the screen, the information will be linked to the current file but is not saved to the configuration file.



3.23 **Save the Config file**. (File > Save Config). This will save the Test Info, Apparatus, Soil Param for this soil. When you go to the field and open this file, the calibration and apparatus information will be attached.

3.24 **Save Measurement Results**. The TDR signals and measurement results can be saved by tapping **File > Save and selecting the relevant folder.** The data will be saved using two data files, one with suffix **.mrp** (for K_a) and the other with a suffix **.mec** (for EC_b).

Stored data can be read from the memory by choosing **File > Open**.

TWO-STEP METHOD

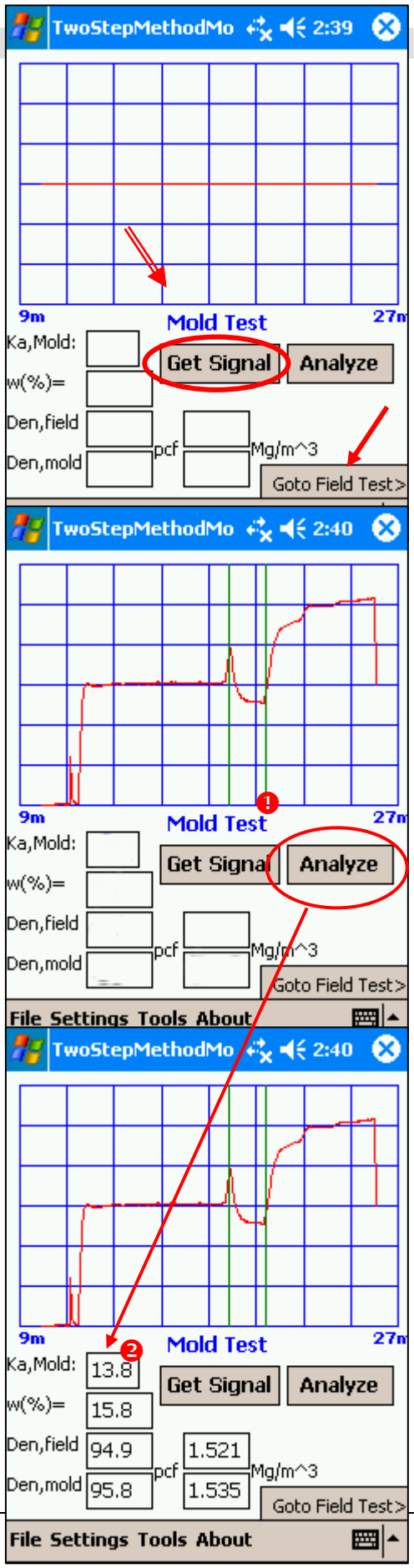
3.25 After selecting the Two-Step Method from the Home screen, you will see screen looking like the one on the right. Make sure the screen indicates "**TwoStepMethodMold**" as the title. If it shows "Field Test", tap on the button on the lower right (referenced by the red arrow on the image). This button allows you to toggle between Field and Mold tests.

3.26 Open the configuration file that was previously set up (see the section titled "Configure Software for Two-Step Method")

3.27 **Take a TDR Reading** by tapping the **GetSignal** button. This will obtain the waveforms shown on the next image.

3.28 Observe the wave form. If it does not have the typical shape, there may be a poor electrical contact. Rotating the Coaxial Head slightly to may give a suitable signal. Check the Center Rod for good contact.

3.29 Tap **Analyze** to obtain the dielectric constant ($K_{a,\,Mold}$). Values appear in the corresponding fields. Values will appear in the other fields but they are meaningless at this point — until you enter soil constants and plot the data (point 3.20).



ⓘ USER TIP
Monitor the value of $K_{a,\,Mold}$. Acceptable ranges are:
• 3 - 5 for sand
• 16 -17 for sandy silts
• 30 – 60 for clay
If you have a value lesser than 2, there may be something wrong with the electric signal (check contacts). Check the legs, in particular the center leg, for good contact with the M+DI mold collar.

We recommend you take two consecutive measurements. After taking the first reading, save the file. Then, rotate the head slightly to improve contact with the mold collar. Take a second reading to verify results. Consecutive readings should be nearly identical (<1% difference). If they are not, check all connections and contact surfaces between the probe head and the adapter ring. Note: the second measurement may be slightly higher than the first one because electrical charges from the previous reading(s) may have been stored in the soil.

3.30 Make sure you **save your readings** (files) every time you take a measurement and record the K_a value manually, typically in your test record sheet (see sample in Appendix).

3.31 **After taking the readings and saving them (File >Save)**, the soil in the mold is removed from the mold (Fig. 9), a portion of the sample obtain and is weighed (Fig. 10), and placed in an oven (Fig. 11) to obtain oven-dry water content according to ASTM D2216.

3.32 **<u>For each soil specimen, repeat step 3.2 to 3.10 followed by 3.21 to 3.27.</u>**

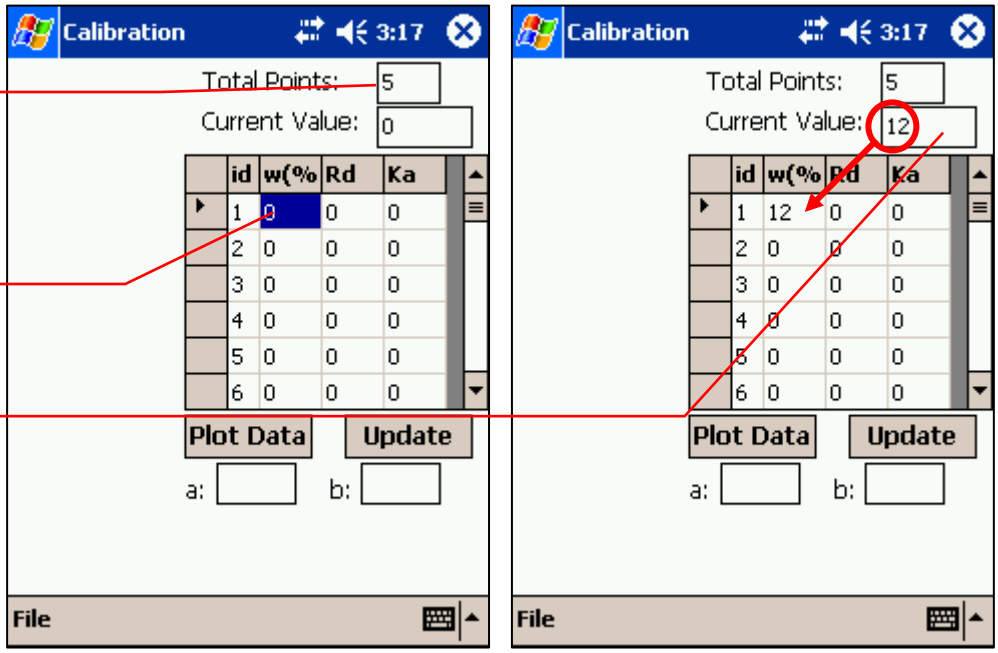
3.33 **Enter** soil **test data.** After the soil has been oven dried and you have calculated the water content, you can now enter you soil test data in the software. From the program menu bar at the bottom of the screen, select **Tools** > **Calibration**

3.34 **Enter soil test data.** Follow the three steps indicated on the left side below.

1 – Enter the number of points from your Proctor test (for example:5)

2 – Tap the cell for which you want to enter a value.

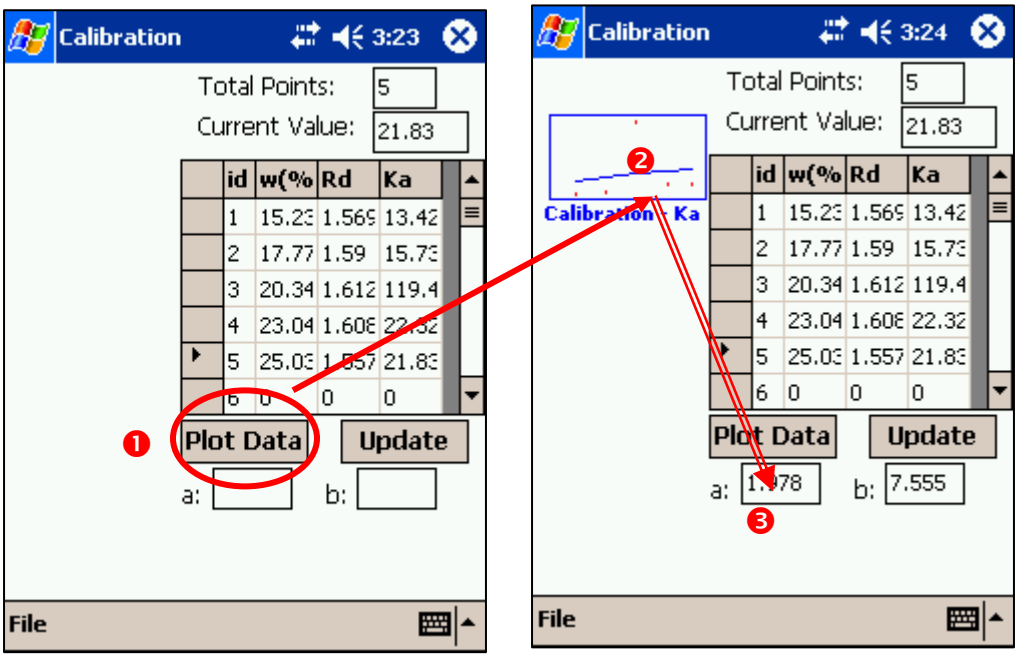
3 – Enter the value from the laboratory tests in the **Current Value** field and it will appear automatically in the selected cell of the data grid.



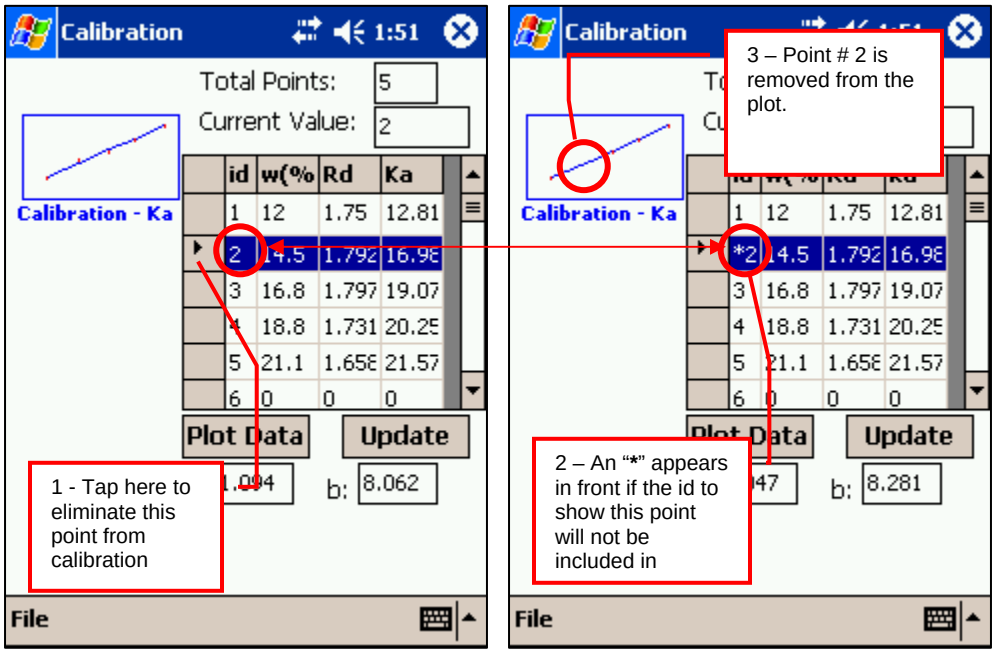
Column headings in the data grid are:

id	data point reference	**Rd**	dry density in Mg/m³ **(Megagrams/m³ = Pounds/ft³ x 0.01601846)**
w(%)	soil water content	**Ka**	Dielectric constant

3.35 Plot Data. After test data for all points are entered in the table, tap on **Plot Data**. This will produce the calibration curves that appear on the left side of the screen and from which the two soil constants (*a, b*) are derived and shown.



Bad data point can be visualized and removed by tapping on the corresponding row header cell. An asterisk (*) sign indicates that data in this line is removed from calibration analysis (Image below, left). Calibration can be recalculated by tapping ***Plot Data***. The removed data point can be restored by tapping the corresponding row header cell again (and the "*" will be removed) followed by **Plot Data**, and the point will be included in calculations.



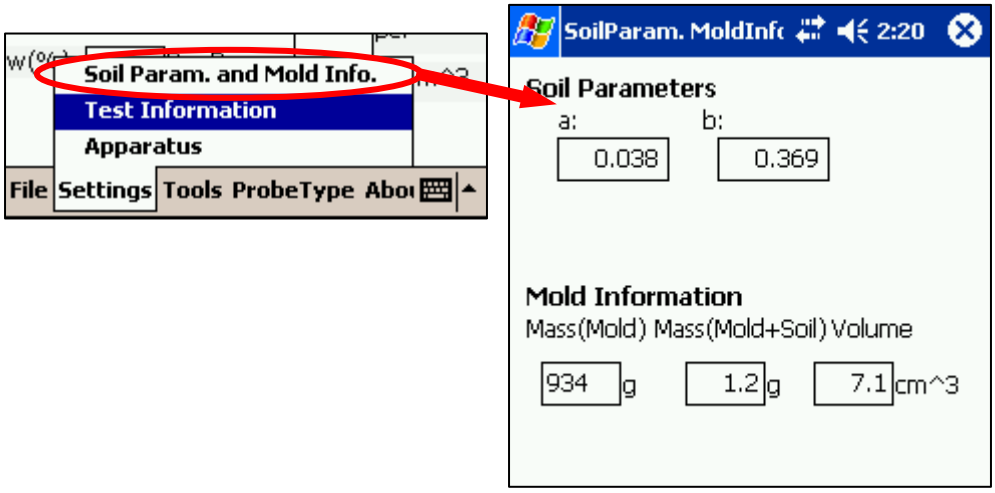
When you are satisfied with the plot, tap the "**Update**" button. This will associate the constants with the Field and Mold files currently open.

Always save the Calibration file. To save the file, go to File > save calibration.

Select the X to close the current screen.

The **Soil Parameters** (for example, soil constants *a* and *b* in the case of the Two-Step Method, or the six constants in the case of the One-Step Method shown above) are now part of the file for this test but **ARE NOT SAVED** at this point.

3.36 Save the Soil Parameters. Go to **SoilParam. And Mold Info**. When you exit the screen, the information will be linked to the current file but the information is not yet saved.



3.37 Save the Config file. (File > Save Config). This will save the Test Info, Apparatus, Soil Param for this soil. So when you go to the field and open this file, the soil constants and apparatus parameters will be attached.

3.38 Save Measurement Results. The TDR signals and measurement results can be saved by tapping **File > Save and selecting the relevant folder.** The data will be saved to a data file with suffix **.mrp** (for K_a).

Stored data can be read from the memory by choosing **File > Open**.

Chapter 4

ONE-STEP METHOD

The One-Step Method consists of measuring the bulk electrical conductivity in addition to measuring the dielectric constant of the soil in-place. Thus, no soil needs to be excavated on site which saves considerable time compared to the Two-Step Method. The One-Step Method requires obtaining soil-specific constants in the laboratory (explained in Chapter 3), prior to taking measurements in the field. The constants will be used in the field measurements.

For further information, see:

ASTM D 6780 — Standard Test Method for Water Content and Density of Soil in Place by Time Domain Reflectometry (TDR)

Concepts and the theory details of the Two-Step Method may be found on our web site, www.DGSI.info/mdi

Field Testing Procedure

The field testing procedure and test apparatus for the One-Step Method are similar to those specified by ASTM D 6780 for the Two-Step Method, but omits the steps of removing the soil, compacting it in the mold, and running a second TDR test on the soil in the mold. In summary, the process includes:

1. **Prepare the soil** surface by leveling an area approximately 300 mm by 300 mm (12 in by 12 in) (Fig. 13). If the soil surface has been exposed for some time such that it is dried out or wet from a recent rain, it is suggested that the top 25 mm (1 in) of soil be removed and the fresh surface leveled for the purpose of conducting the test. The leveled surface should be free of voids. If some exist, they should be filled with soil and smoothed. Likewise, remove any visible organic material.

Fig. 13: Smooth the soil surface

Wear Safety Glasses

Fig 14: Drive the outer field probe rods first.

Fig 15: Drive the field center rod last.

Fig 16: Remove the template by prying it open. Probes are exposed.

Fig. 17: Field probe rods after removing the template.

Fig. 18: The MRP Head is placed on top of the probes.

Fig. 19: Take a TDR measurement.

2. **Place the template** on the leveled soil surface. Be sure the template is closed and the pin is in place. Place the template in the center of the prepared surface. Be sure that it has full contact with the soil surface. If it does not, remove it and further smooth the surface so that full contact is made when the template is replaced.

3. **Drive the four spikes** through the template and into the soil as shown in Fig. 14. Use a hammer to drive the spikes through the outer three holes of the template as shown in Fig. 14. After the outer three spikes are driven to touch the template, drive the center spike (Fig 15). All field probe rods must be touching the template.

If a probe rod hits a large particle that causes the rod to deviate from vertical, or if the rod cannot be driven without the risk of deforming it, remove all rods and start the procedure once again in a new location at least 0.2 m (8 in) away from the original one.

Do not overdrive the spikes as this will damage the template and cause it to lose contact with the soil surface. (It is very important that the center spike be driven last so that it minimizes the air gaps between the spike and the soil surrounding it.)

4. **Remove the template** by taking the locking pin out and spread the template apart to clear the field probe rods as shown in Fig. 16. Then remove the template and set it aside. Leave the four probe rods in place (Fig. 17).

5. **Place the MRP Head on the heads of the probe rods** (Fig. 18). Brush any soil from the heads of the probe rods, wipe contact surfaces with a clean cloth and place the MRP Head on the rods such that each rod on the MRP Head makes good contact with the corresponding probe rod head. It is advisable to slide or rotate the MRP Head a small amount to facilitate good contact. Note: the quality of the TDR signal will depend on the cleanliness of the contact surfaces.

6. **Connect the Coaxial Head** to the M+D indicator with the coaxial cable provided. Be sure the BNC connectors are clean and free of dust or debris before making the connections. (In routine testing, the Coaxial Head may remain connected to the M+D Indicator continuously between tests. However, it should be placed on a clean surface near the M+D Indicator to minimize the chances of having the cable getting caught on something and placing undue stress on the connectors.)

7. If the PDA (or computer) and M+D indicator are not already connected, do so now.

8. Turn the M+D I on and start the **MDI-PDA** program on your PDA.

From the PDA main screen, select the MDI-PDA program (Fig 20 (A), steps1 and 2). Once the program window appears, select "**One Step Method**" for this procedure and click **OK**.

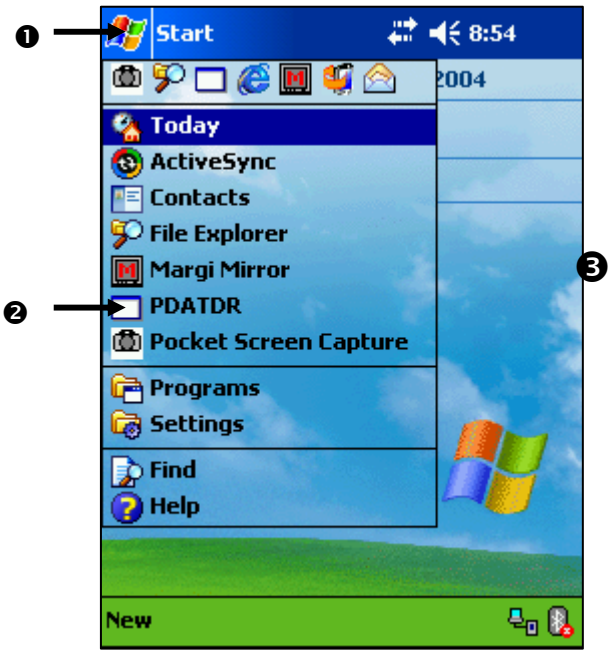


Fig 20 (A)

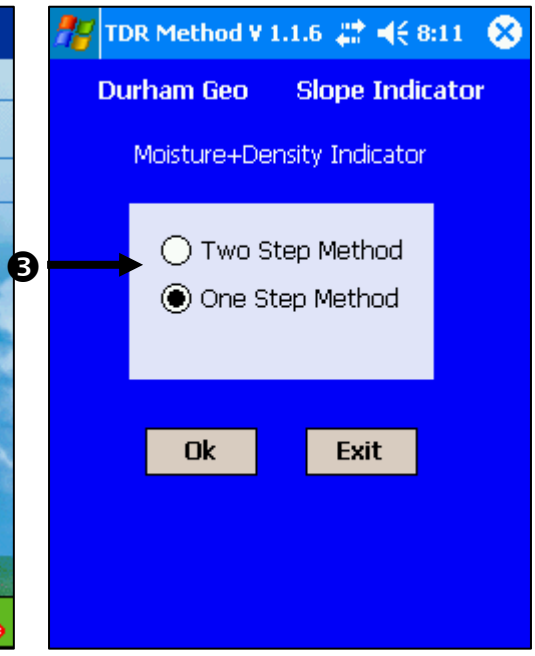
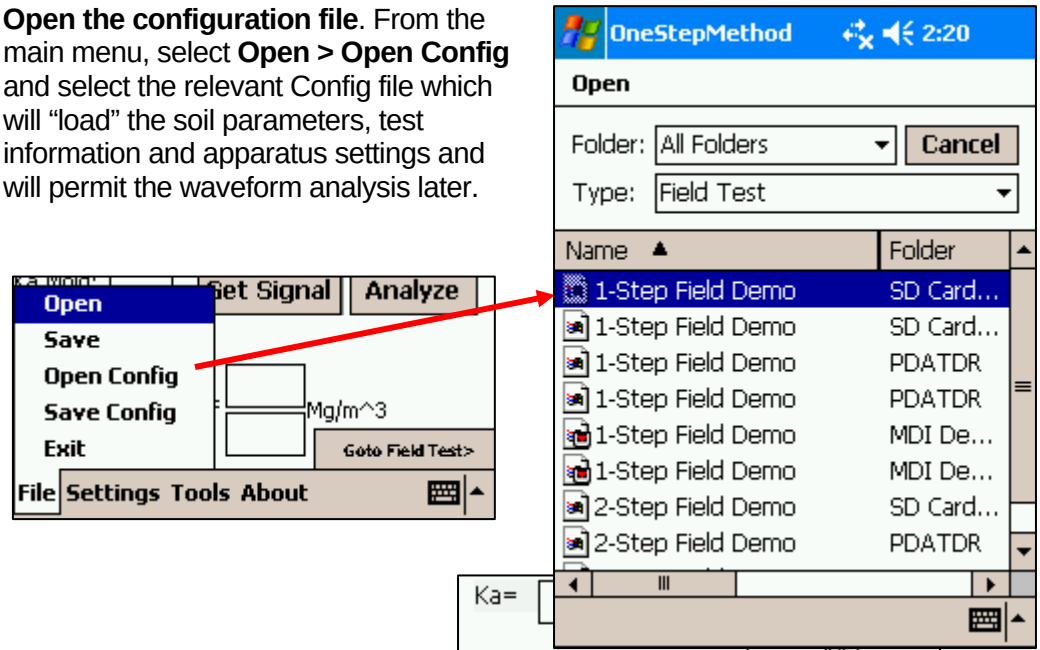


Fig 20 (B)

9. **Open the configuration file**. From the main menu, select **Open > Open Config** and select the relevant Config file which will "load" the soil parameters, test information and apparatus settings and will permit the waveform analysis later.



10. **Select Probe Type > Field Probe.** This loads the proper field probe length for the measurement.

11. **Take a TDR Reading** by tapping the **GetSignal** button (Fig. 21). This will obtain the waveforms (Fig 22).

12. **Observe the wave forms**. If they do not have the typical shape, there may be poor electric contact. Rotating the Coaxial Head slightly might give a suitable signal.

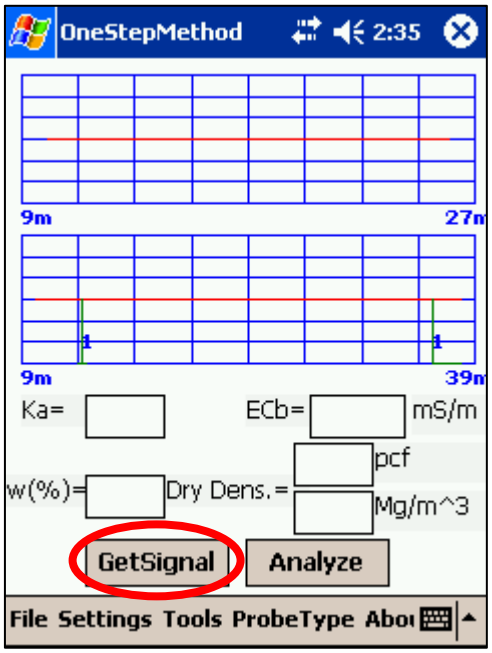


Fig. 21: Obtain Waveform

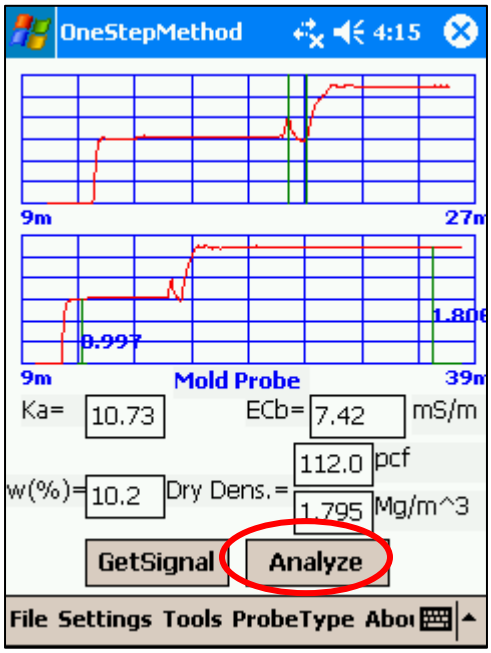
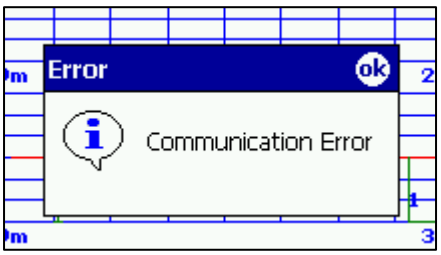


Fig. 22: Analyze waveform.



Note: the program will check automatically the connection between the PDA (or PC) with the TDR Module in the M+DI. If there is a problem with the connection, an error message dialog appears saying: "**Communication Error**". If this occurs, please check and make sure the M+DI is turned on and the battery is sufficiently charged. Ensure the communications cable between the PDA and M+DI is properly connected. After correcting these problems, tap on "**Get Signal**". After the waveform appears on the screen, tap on **Analysis** (Fig 22) to analyze the waveform and obtain the water content and dry density which will appear at the bottom of the same screen. If problems persist with communications, perform a soft boot on the PDA. If that does not solve the problem, please contact Durham Geo Slope Indicator.

The water content and dry density will not be valid until the soil test data has been entered and soil-specific constants have been obtained.

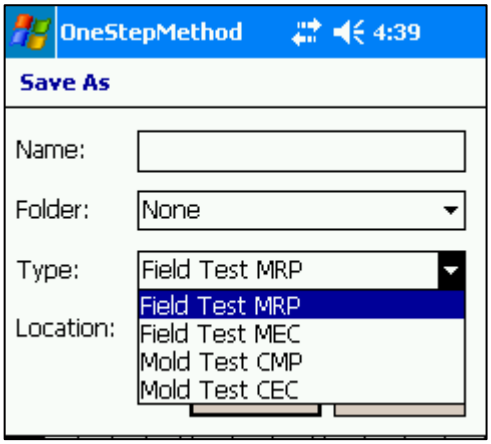
If the soil temperature is likely to be outside the range of 15 to 25ºC (59 to 77ºF), insert a metal thermometer at least 2 inches in the soil, wait for the temperature to stabilize and record the temperature in ºC. Enter the value in the Test Info screen before selecting Analyze (or enter it now and select **Analyze** once again to recalculate with the proper correction factor.

USER TIP

You may take a TDR measurement first and obtain the soil constants later. Bear in mind the software can calculate the water content and dry density only after the six soil constants are known. In certain cases, these may be assumed.

13. **Save your file.** Go to **File > Save** which will present the screen shown on the right.

    Make sure you select the correct **Type** of test because this will determine the file extension (suffix). In the case of a field test, select either **Field Test MRP** or Field Test MEC (it makes no difference).

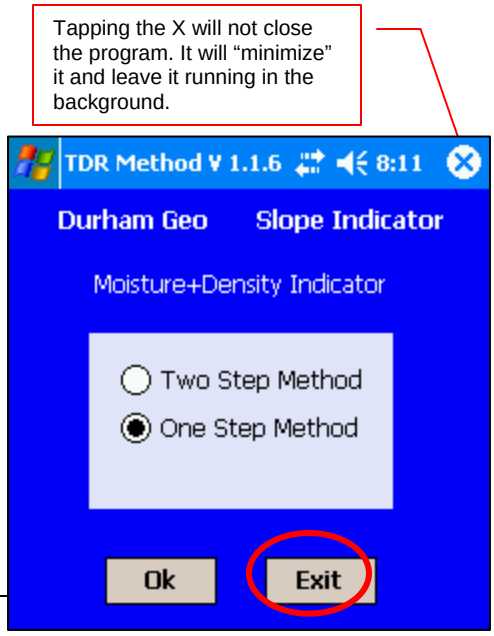


USER TIP

Create a folder for each project in File Explorer prior to the test. It is easier than trying to do it from this screen.

14. **Take the next measurements** on the same soil. If you have multiple measurements to make on a site, and if you may safely assume that the soil characteristics are unchanged, you may take subsequent TDR measurements by repeating the above field steps.

15. **Exit the program**. When you are finished, close and exit the program by tapping on the **Exit** button. If you select the X icon on the top right of the screen, the screen will disappear but the program will still be running in the background and if you start the MDI-PDA again from the main menu, it will open another instance of the program



and both will be running in parallel and neither will be able to communicate with the M+DI.

BACK-UP your files daily and if battery power goes below 30%.

Because the MDI-PDA saves files in a volatile memory, you will loose all data and the MDI-PDA program in the event the PDA's battery power is very low or if the PDA performs a hard boot.

We recommend you back-up your files on the PDA to the iPAQ File Store or on the SD (Secure Digital) card, both of which are non-volatile memories, after each job as well as to a PC or appropriate device for long-term storage.

NOTE: The Trimble Recon PDA does not have a back-up feature. When using the Recon, all data files are in non-volatile memory so backing up is not necessary.

After the Test

2.1 Archiving Data

When testing is completed, we recommend that the saved data files be backed up on a Secure Digital or CompactFlash card as soon as possible. Each field test will have two files associated with it:

- one file with extension **mrp** for the K_a signal
- one file with extension **mec** for the EC_b signal.

When returning to the office after testing, it is recommended that the data then be transferred to an office computer and saved along with the files associated with the project and/or in a master file of TDR data. The latter file will allow for future retrieval of this information for incorporation into a database that could be helpful with future testing.

2.2 Recalling Data Files

Data files can be copied back to the PDA and used to re-display results or re-calculate the apparent dielectric constants, water contents, and dry density for a given test. It is even possible to use different soil constants if needed.

Data may also be retrieved with any word processor program (such as Notepad, Wordpad, MS Word) because all files are in ASCII format. When opening one of these files, it may be necessary to select the “All Files” option of your word processor or spreadsheet.

All items are labeled and their units given. The file also contains all of the data points associated with the TDR curve that was displayed on the screen at the time of the test. Examples of a data files are given in Chapter 6 under File Types

Chapter 5

TWO-STEP METHOD

The Two-Step Method consists of measuring the dielectric constant of the soil in-place (Step One) and the same soil in a compaction mold (Step Two) in the field with the M+D Indicator.

Overview: The dielectric constant of the soil in-place is determined using the M+D Indicator. The soil at the location of the in-situ measurement is then excavated and compacted in a mold. By measurement of the mass of the mold with soil and with the mass and volume of the mold known, the wet density of the soil in the mold is determined. Then, the dielectric constant of the soil in the mold is measured using the same M+D Indicator. The water content of the soil in the mold is determined using a correlation between the dielectric constant, moisture content and soil density. The correlation requires two constants that are somewhat soil specific. It is assumed that the water content of the soil in place is the same as the water content in the mold. The density of the soil in place is determined from the density of the soil in the mold and the dielectric constants measured in the mold and in place.

ⓘ USER TIP
You must have these values:
• Mold Mass (g)
• Mold with Soil Mass (g)
• Mold Volume (cm^3)

For further information, see:

ASTM D6780 — Standard Test Method for Water Content and Density of Soil in Place by Time Domain Reflectometry (TDR)

Concepts and the theory details of the Two-Step Method may be found on our web site, www.DurhamGeo.com

1. Step One — Test In Situ

Step One is essentially the same as the field test in the One-Step Method except the software selections are different.

ⓘ USER TIP
Software Configuration
We recommend setting your configuration and test information files prior to heading to the field. It's easier to do in the office and saves time on the field.
You must have for this test your
• Calibration (.cal) file which is the configuration file with the constants attached.
• Mold mass
• Mold volume

In summary, the process includes:

1.1 **Prepare the soil surface** by leveling an area approximately 300 mm by 300 mm (12 in by 12 in) (Fig. 13). If the soil surface has been exposed for some time such that it is dried out or wet from a recent rain, it is suggested that the top 25 mm (1 in) of soil be removed and the fresh surface leveled for the purpose of conducting the test. The leveled surface should be free of voids. If some exist, they should be filled with soil and smoothed. Likewise, remove any apparent organic material.

Fig. 13: Smooth the soil surface

Wear Safety

Fig 14: Drive the outer field probe rods first.

Fig 15: Drive the field center rod last.

Fig 16: Remove the template by prying it open. Probes are exposed.

Fig. 17: Field probe rods after removing the template.

Fig. 18: The MRP Head is placed on top of the probes.

Fig. 19: Take a TDR measurement.

1.2 **Place the template** on a leveled soil surface. Be sure the template is closed and the pin is in place. Place the template in the center of the prepared surface. Be sure that it has full contact with the soil surface. If it does not, remove it and smooth the surface again so that full contact is made between the template and the soil.

1.3 **Drive the four field probe rods** trough the template and into the soil with a hammer as shown in Fig. 14. Use the brass hammer to drive the probe rods through the outer three holes of the template as shown in Fig. 14. The probe rods may be driven one at a time or may be driven together. After the outer three probe rods are driven to touch the template, drive the center probe rod (Fig 15). All field probe rods must be touching the template.

There must be no air gap between a field probe rod and the surrounding soil or the returning signal may be affected. This is particularly important for the center probe.

If a probe rod hits a large particle that causes the rod to deviate from vertical, or if the rod cannot be driven without the risk of deforming it, remove all rods and start the procedure once again in a new location at least 0.2 m (8 in) away from the original one.

Do not overdrive the spikes as this will damage the template and cause it to lose contact with the soil surface. (It is very important that the center spike be driven last because it will minimize the air gaps between the spike and the soil surrounding it.)

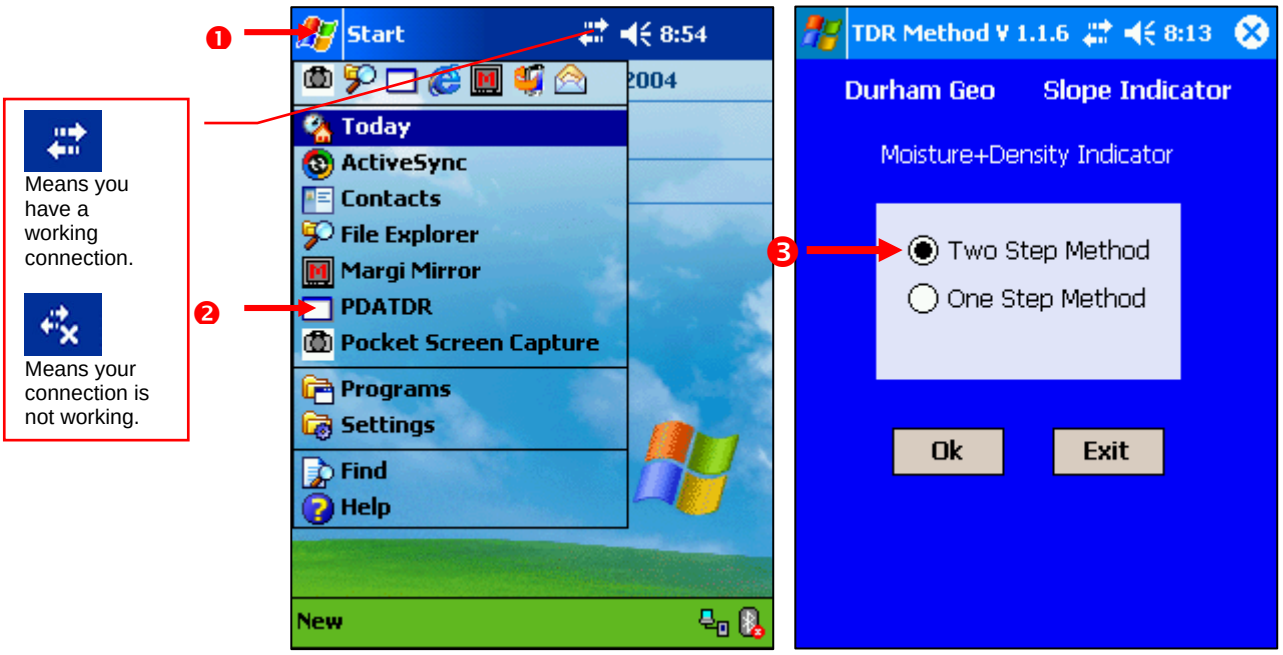
1.4 **Remove the template** by taking the locking pin out and spreading the template apart carefully to clear the field probe rods (Fig. 16) and make sure to not disturb the probe rods in the soil (moving the probes creates air voids which affect the TDR signal). Then remove the template and set it aside. Leave the four probe rods in place (Fig. 17).

1.5 **Place the MRP Head on heads of the probe rods** (Fig. 18). Brush any soil from the heads of the probe rods, wipe contact surfaces with a clean cloth and place the MRP Head on the rods such that each rod on MRP Head makes good contact with the corresponding probe rod head. It is advisable to slide or rotate the MRP Head a small amount to facilitate good contact. Note: the quality of the TDR signal depends on the good contact between the head and probe rods.

1.6 **Connect the Coaxial Head to the M+D indicator** with the coaxial cable provided. Be sure the BNC connectors are clean and free of dust or debris before making the connections. (In routine testing, the Coaxial Head may remain connected to the M+D Indicator continuously between tests. However, it should be placed on a clean surface near the M+D Indicator to minimize the chances of having the cable getting caught on something and putting undue stress on the connectors.)

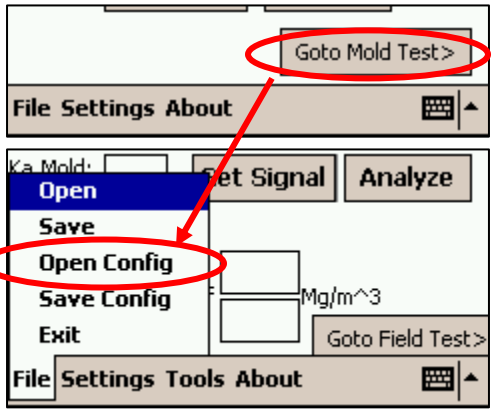
1.7 If the PDA and M+D indicator are not already connected, do so now.

1.8 **Turn the M+D I ON** and start the MDI-PDA program on your PDA.



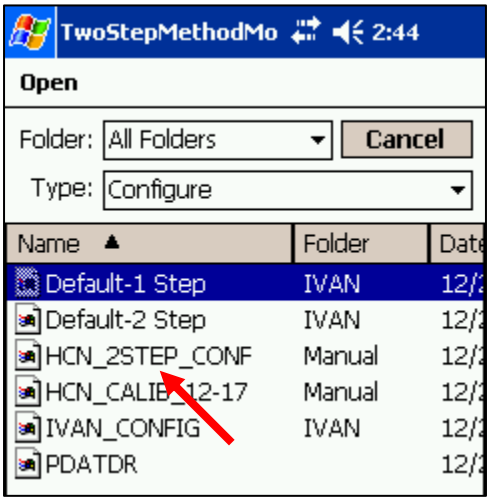
1.9 From the PDA main screen, select the MDI-PDA program (above, steps 1 and 2). Once the program window appears, select "**Two Step Method**" (above, step 3) for this procedure and click OK.

1.10 **Open the relevant configuration file.** This may be done (i.e., is accessible) only from the Mold Test window. So, select Goto Mold Test>, then File > Open Config.



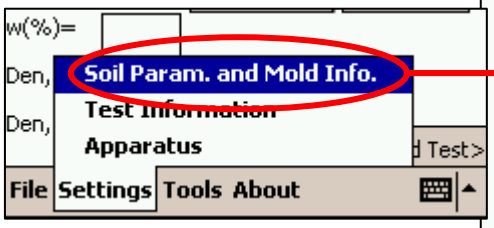
Select the relevant configuration file for this soil. This will "load" the soil parameters and permit the waveform analysis later.

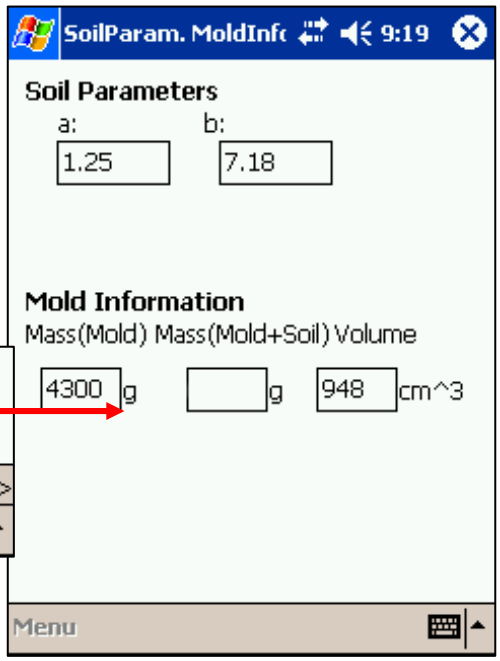
In our illustration (image on the right) we will select the HCN_2STEP_CONF which is clearly identifiable by its name. It is helpful to have a meaningful file naming scheme to be able to quickly recognize the desired files.



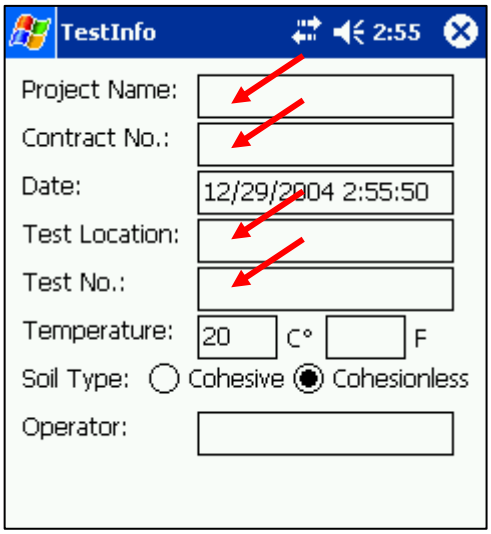
1.11 Check Soil Parameters and Mold Information.

Go to **Settings > Soil Param. And Mold Info**. Check your soil parameters and make sure the mold information has been entered.





1.12 Enter Test Information. This is the same screen discussed in Chapter 3, Section 2- Configure the Software.



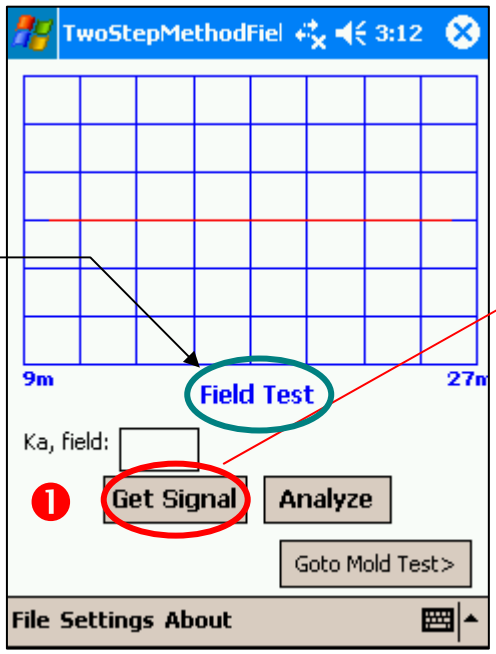
1.13 Go to the Field Test window (Goto Field Test>).

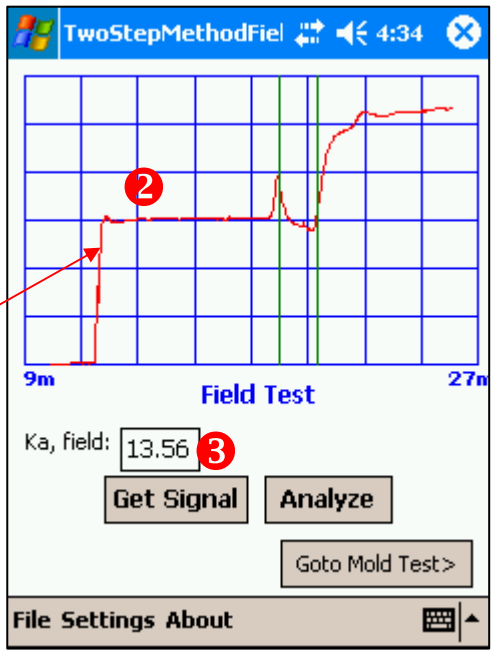
You should see the screen shown below, left.

1.14 Take a TDR Reading by tapping the **Get Signal** button (image below, left, 1). This will obtain the waveform (image below, right, 2). Observe the wave forms. A waveform similar to that shown below, right, should appear on the screen. If the waveform does not have the characteristic rise associated with the reflection from the end of the "soil cable," try moving the Coaxial Head on the ring collar and then tap on the Get Signal button again.

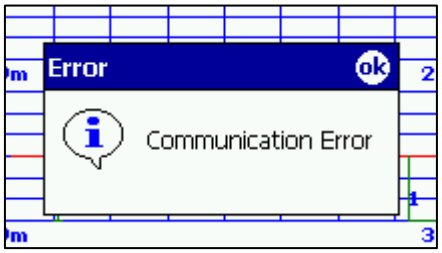
Note: The value—if any—shown in the K_a field is invalid (meaningless) until you tap on "Analyze" (point 1.17)

This confirms you are in the **Test** screen





Note: the program automatically checks the connection between the PDA with the TDR Module in the M+DI. If there is a problem with this connection, an error message dialog appears saying: "Communication Error". If this occurs, please check and make sure the M+DI is turned on and the battery is sufficiently charged, verify that the communications

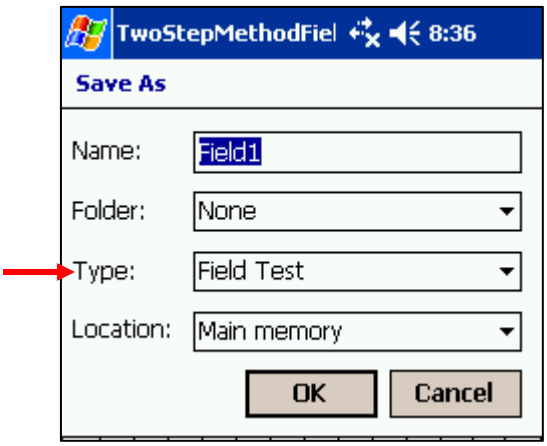


cable between the PDA and M+DI is properly connected. Try again after correcting any problems. If problem persist, please contact Durham Geo Slope Indicator.

1.15 **Analyze the waveform** by tapping on **Analyze**. This will place a correct value in the K_a field.

The water content and dry density will be calculated and known only after the test in the compaction mold has been performed.

1.16 **Save your file.** Go to **File > Save** which will present the screen shown on the right.



USER TIP

Create a folder for each project in File Explorer prior to the test. It is easier than trying to do it from this screen.

USER TIP

There is no need to exit the program at this point. You can let the PDA go dormant. When you wake it up, it will open at the correct place and show the Field Test screen again.

When you save another file, the name will only need to be modified to indicate the next test location.

1.17 Remove the Coaxial Head from the probe rods and place it on the M+DI.

2. Step Two — Test In Mold

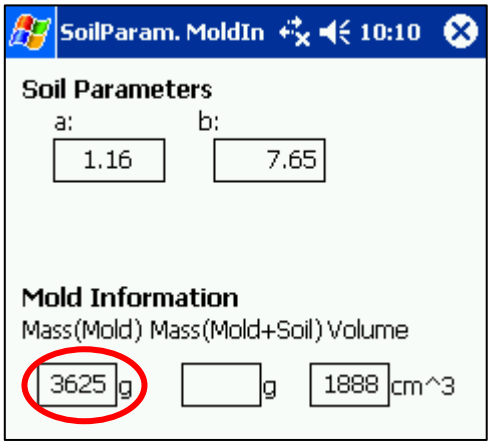
2.1 **Remove the four field probe rods** (spikes) from the soil with the special puller (optional hammer with built-in extractor).

2.2 **Determine the mass of the clean and empty compaction mold.** Place the electronic scale on a flat surface and level it (bring the bull's eye bubble into the center by adjusting the support legs of the scale). Make sure the scale is turned on and that it reads zero when nothing is on it. Place the clean compaction mold on the electronic scale and note its mass in grams.

> ⓘ USER TIP
>
> You don't need to weigh the same mold every time you perform the test unless the mold has been altered or is a different one.

2.3 **Enter the value** in the software. Go to Mold Test and open **Settings > Soil Param. And Mold Info**. Enter the mass in grams in the Mass (Mold) box.

If you have not done so before, enter the value for the volume of the mold. (The nominal value of the volume of the 9-in tall TDR mold is **1888 cm^3** (0.06667 ft^3), which is twice that of the standard compaction mold.)

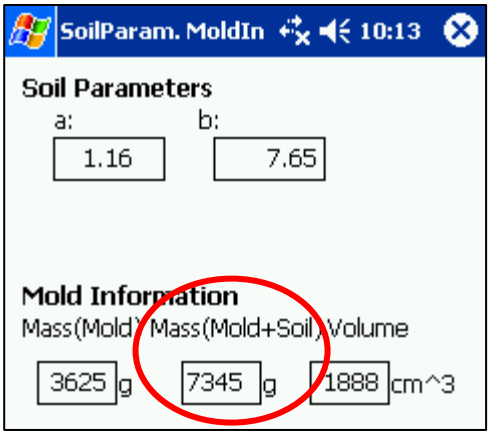


2.4 **Excavate the soil from the location of the in situ test**. Remove the soil from the between the holes left by the outer field probe rods and to a depth corresponding to the rod penetration. Use a hand auger, spade shovel or power drill with an auger bit or other suitable digging implement to excavate the soil.

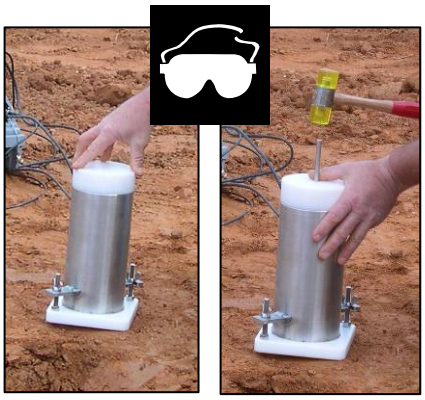
2.5 Compact the soil into the pre-weighed compaction mold. Place the soil into the 9-in cylindrical mold (*near left*) in 6 uniform lifts applying 25 blows per lift using the 5.5 lb hammer (*far right*). Soil should be taken uniformly over the entire depth of in-place measurement and placed directly and quickly into the cylindrical mold to minimize moisture loss. Remove the mold collar and strike the surface level with the straight edge after compaction. Remove any spilled soil from around the exterior of the base plate with the brush.

Note: Do this step quickly to avoid loosing moisture.

2.6 Determine the mass of the soil-filled compaction mold. With the mold collar removed, place the soil-filled compaction mold on the electronic scale and note its mass in grams to the nearest gram. Enter the value into Mass (Mold+Soil) box.



2.7 Place the center rod guide onto the top of the compaction mold (*left*) and make sure that it is fully seated. Introduce the Center Rod into the hole located in the template and drive the rod into the compaction mold with the hard-rubber- or brass-headed hammer[1] (*right*) until the top of the central rod is flush with the top of the template.



[1] *The purpose of using the hard-rubber or brass hammer is to reduce the possibility of peening the end of the central rod, which would make it difficult to remove the template without pulling the rod out. If this occurs, gently file the sides of the pin top, check to see that it passes through the center rod guide.*

2.8 **Remove the center rod guide** without disturbing the central probe rod.

2.9 **Place the CMP collar on the mold** (*left* and *center*) once again and then place the Coaxial Head on the collar (*right*). Make sure the contact surfaces are very clean. Ensure the Center Rod on the Coaxial Head makes good contact with the Center Rod. It is advisable to slide or rotate the Coaxial Head a small amount to facilitate good contact.

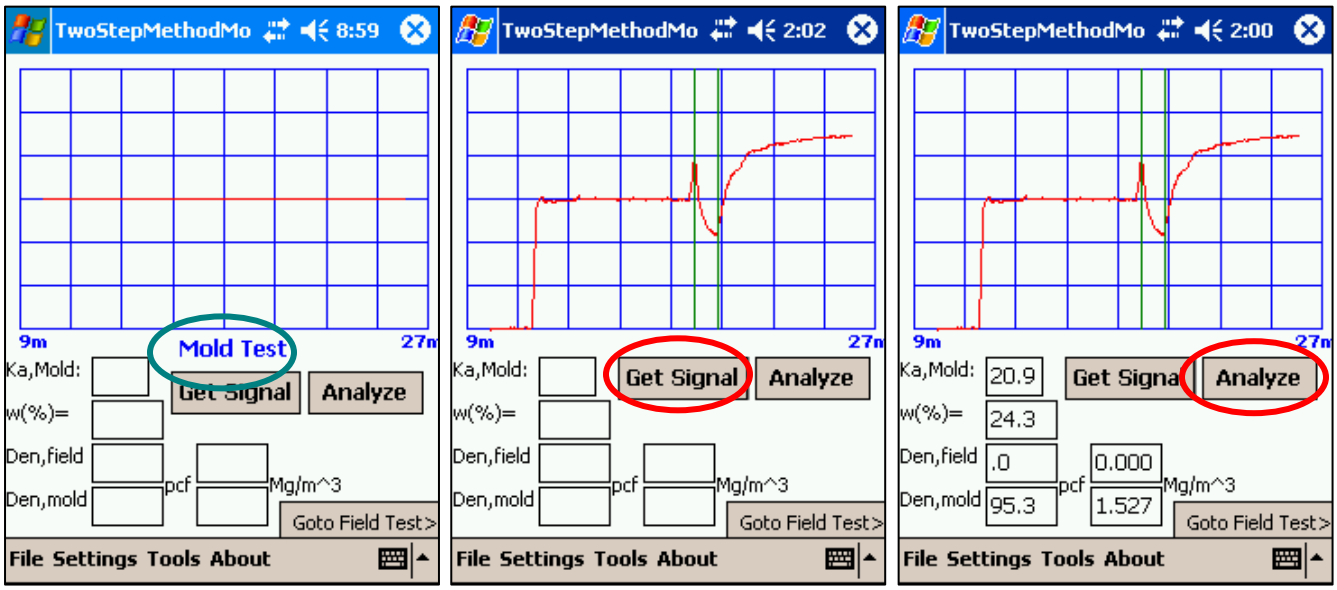
This allows measuring the dielectric constant, $K_{a,\ mold}$ of the soil in the compaction mold.



2.10 Connect the Coaxial Head to the M+DI with the coaxial cable provided—if this was not already connected. Be sure the BNC connectors are clean and free of dust or debris before making the connections. (In routine testing, the Coaxial Head may remain connected to the M+DI continuously between tests. However, it should be placed on the M+DI to minimize the chances the cable getting scrapped or kinked, or caught on something which will put undue stress on the connectors.)

2.11 **Take a TDR Measurement in Compaction Mold.** (Make sure the M+DI is turned ON and allow at least 30 sec for the unit to boot up.)

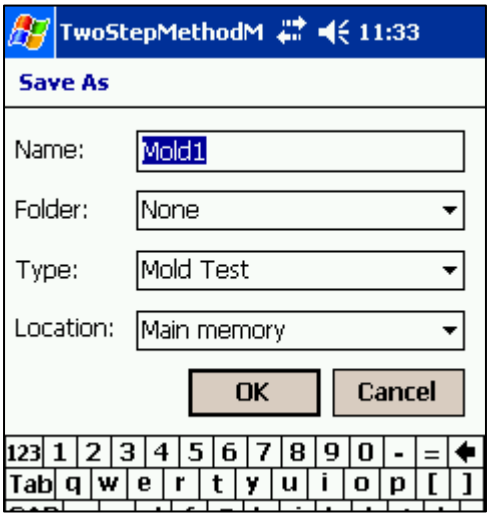
- Bring up the **Mold Test** screen as shown below, left.
- Select **Get Signal** which brings in a signal be similar to the image below, center
- Select **Analyse** which populates all the fields as shown below, right.



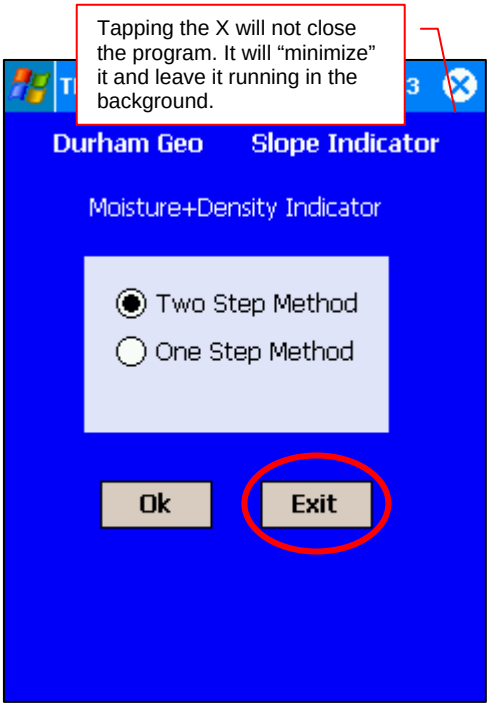
If the soil temperature is likely to be outside the range of 15 to 25ºC (59 to 77ºF), insert a metal thermometer at least two inches in the soil, wait for the temperature to stabilize and record the temperature in ºC. Enter the value in the Test Info screen before selecting Analyze (or enter it now and select **Analyze** once again to recalculate with the proper correction factor.

2.12 **Save your test file.** Go to **File > Save** to bring the screen shown on the right and enter the desired information.

2.13 Click OK to save the file.



2.14 Exit the program. When you are finished, close and exit the program by tapping on the Exit button. If you select the X icon on the top right of the screen, the screen will disappear but the program will still be running in the background and if you start the MDI-PDA again, it will open another instance of the program and both will be running in parallel and neither will communicate with the M+DI.



BACK-UP your files daily and if battery power goes below 30%.

Because the MDI-PDA saves files in a volatile memory, you will loose all data and the MDI-PDA program in the event the PDA's battery power is very low or if the PDA performs a hard boot.

We recommend you back-up your files on the PDA to the iPAQ File Store or on the SD (Secure Digital) card, both of which are non-volatile memories, after each job as well as to a PC or appropriate device for long-term storage.

REFERENCE VALUES TO ENTER
Field Probe (Spike)* Length: 0.237 m
9-in Mold* Volume: 1899 cm^3
Mass of clean new mold*: 3625 g
9-in Center Rod* Length: 0.263 m
** for equipment provided with the Standard M+D Indicator*

3. After the Test

2.3 Archiving Data

When testing is completed, we recommend that the saved data files be backed up on a Secure Digital card. Each test will have two files associated with it; one with extension **mrp** for the in situ test and the other with extension **cmp** for the test in the mold.

When returning to the office after testing, it is recommended that the data then be transferred to an office computer and saved along with the files associated with the project and/or in a master file of TDR data. The latter file will allow for future retrieval of this information for incorporation into a database that could be helpful with future testing.

2.4 Recalling Data Files

Naturally, data files can be copied back to the PDA to be retrieved and to display results or re-calculate the apparent dielectric constants, water contents, and density for given data, but with different values of *a* and *b*. However, data may also be retrieved with any word processor or spreadsheet program because the data is stored in simple ASCII format. When opening one of these files, it may be necessary to select the “All Files” option of your word processor or spreadsheet.

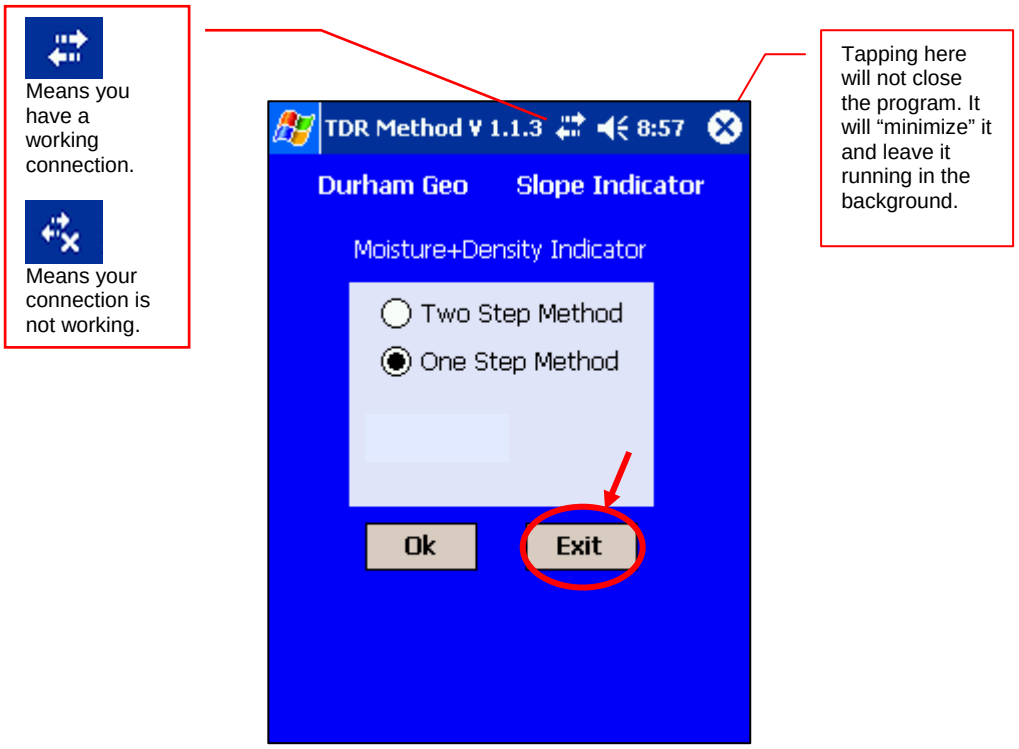
All items are labeled and their units given. The file also contains all of the data points associated with the TDR curve that was displayed on the screen at the time of the test. Examples of a data files are given in Chapter 6 under File Types.

Chapter 6

SOFTWARE – Advanced Info

1. MDI-PDA Home Screen

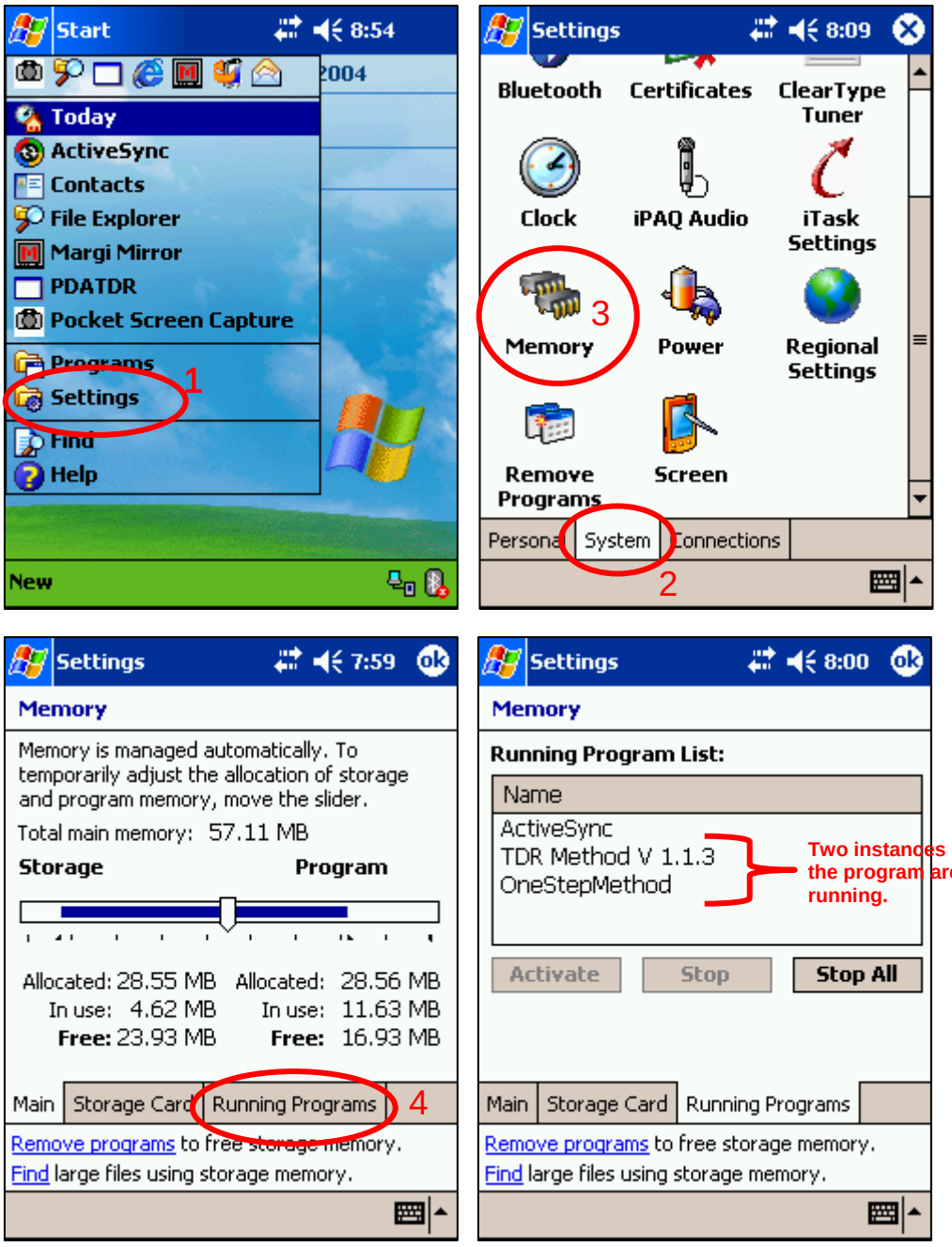
The PDA software has one program with both the One-Step and the Two-Step Method as options chosen from the first screen.



Use the **Exit** key to close and leave the program. Using the **X** icon (on the upper right) will close the window but the program will still be running in the background, consuming resources.

2. To see the programs currently running on your PDA

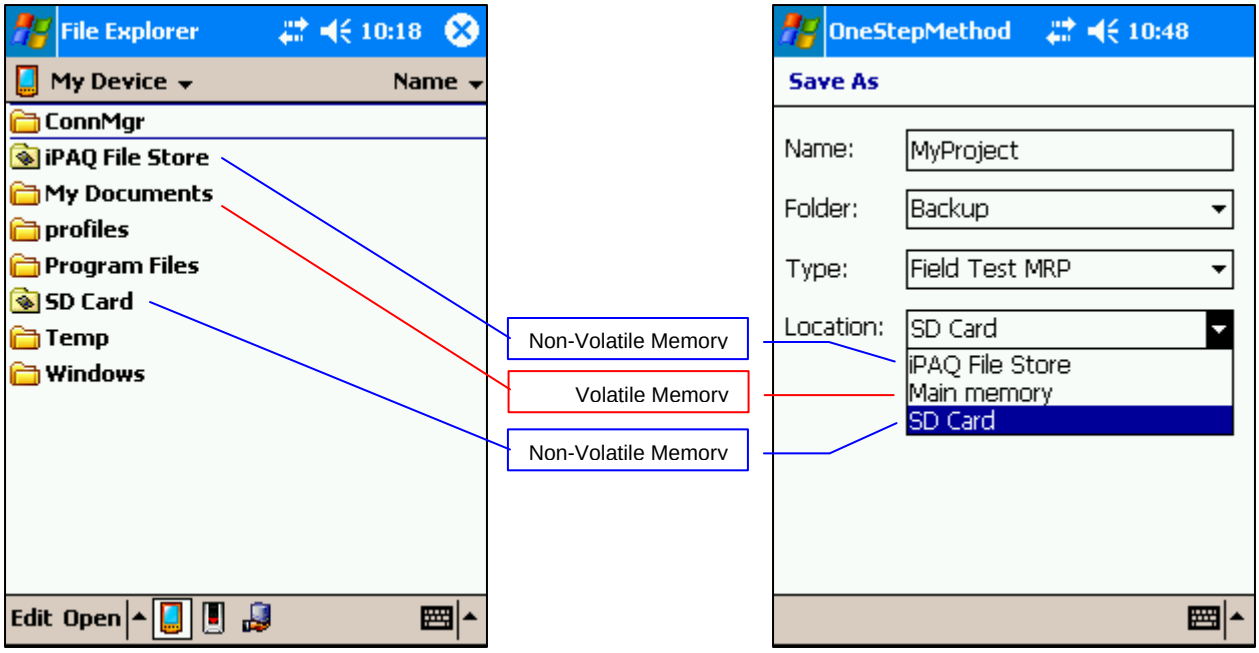
From the main PDA screen go to Settings > System > Running Program. In the **program list, close all instances of the MDI-PDA that are running.**



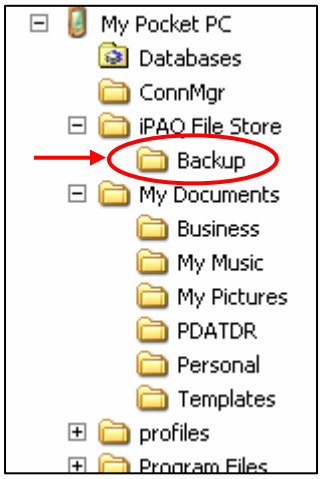
3. Saving Data

1. **Battery drain.** A Pocket PC does not have a hard drive so the ROM, or Read Only Memory, chip stores the operating system and pre-installed software while the RAM, or Random Access Memory, chip stores data and programs that you input once you've purchased the Pocket PC. RAM requires constant power to maintain its data. Because RAM memory chips must draw a little power when a Pocket PC is turned off, the battery is slowly being drained even when a Pocket PC is sitting on a shelf. This is why the battery drains completely after long periods without use. If the battery is drained and the RAM chip no longer has power, the data stored there is lost. The only way to avoid this data loss is to keep your Pocket PC's battery at some state of charge at all times. If you know you're not going to be using your Pocket PC for a period of days or weeks, just charge it every few days or leave it connected to the AC adapter. You can also perform frequent backups using the IPaq backup program so that you'll be able to restore your Pocket PC quickly should a hard reset occur.

2. **Learn how to safely store your data on your Pocket PC** by consulting your PDA's User Manual. The safest locations are in non-volatile memories as indicated below. The SD Card folder is a practical location because it allows you to transfer the data easily to a desktop PC equipped with an appropriate card reader.



3. **Back-up.** We recommend backing up your files to the iPAQ File Store folder on your iPAQ Pocket PC or on the SD (secure Digital) card after each job. This will hold them in ROM and save them if you perform a full reset of your iPAQ Pocket PC. Consult your PDA's manual for specific instructions. In addition, we recommend saving the work files to a PC or appropriate device for long-term storage.



ⓘ USER TIPS
Create a folder for each project in File Explorer prior to the test. It is easier than trying to do it from within a MDI-PDA program screen.
Each Project Folder should contain all relevant files to make it easy to find the desired files.
If you have several locations within a given project, and your measurements/calculations are based on the same configuration file, store all the files in the same folder and give a slightly different name for each measurement point. Likewise, you might consider including a water content reference in your laboratory mold measurements.
Example: JobX_LocA_6% JobX_LocA_8% JobX_LocA_10% JobX_LocB_6% JobX_LocB_8% JobX_LocB_8% JobX_LocB_8% JobX_LocB_10%

4. Menu Tree

ONE-STEP METHOD

File
↳ Open
Save
Open Config
Save Config
Exit

Settings
↳ Soil Param. and Mold Info.
Test Information
Apparatus

Tools
↳ Calibration

Probe Type
↳ Field Probe
Mold Probe

About

TWO-STEP METHOD

Mold Test

File
↳ Open
Save
Open Config
Save Config
Exit

Settings
↳ Soil Param. and Mold Info.
Test Information
Apparatus

Tools
↳ Calibration

About

Field Test

File
↳ Open
Save
Exit

Settings
↳ Test Information
Apparatus

About

5. Menu Tree

The MDI-PDA program uses text files with various extensions as detailed below. Normally, you would not need to work with these files outside of the MDI-PDA program.

However, if you wish to know their content for troubleshooting or other purposes, the examples below will show you what the files contain. Please refrain from editing these files outside the MDI-PDA software and trying to work with the modified files from within MDI-PDA because any formatting change—such as a simple blank space—will render the file useless.

The files used by the MDI-PDA software have the following extensions and purpose:

	File Type (suffix)							
	MRP	**CMP**	**CAL**	**CFG**	**MRP**	**MEC**	**CMP**	**CEC**
Two-Step Method								
Mold Test		✓	✓	✓				
Field Test	✓		✓	✓				
One-Step Method								
Mold			✓	✓			✓	✓
Field			✓	✓	✓	✓		

In other words:

MRP: Two-Step (Field Test)
CMP: Two-Step (Mold Test)
MRP & MEC: One-Step (Field Test)
CMP & CEC: One-Step (Mold Test)
CFG: Configuration file
CAL: Calibration file

Knowing these will help you select the desired files with greater ease.

These are text files which cannot be opened in the PDA outside of the MDI-PDA program. However, you can copy them to your PC and open them with a program such as Notepad, MS Word.

Sample Content for various types of files produced by the MDI-PDA software.

Example: MRP_2 Step_Field file

InSitu MRP output file by MDI-PDA
Version 1.1.4
SI units

Project Name: 2 Step Field
Contract Number: 122345567
Test Location: DURHAM
Soil Type: Cohesionless
Test Number: 12346789
Operator: BILL KEEGAN
Date: 12/16/2004
Time: 9:54 AM
Temperature (deg. C): 22
Field Probe Length (m): 0.236
Field Probe Above Soil (m): 0.031
Cable Length (m): 1.8
Average: 1
Points: 512
Start (m): 10
Length (m): 15.937
Probe Beginning (m): 19.54
Probe End (m): 21.22
Field Apparent Dielectric Constant: 16.79
-1.005
-1.008
-1.005
-1.003
-1.003
-1.001
-1.003
-1.003
-1.003
-1.001

512 data points (rows)

Example: CMP_2 Step_Mold file

Mold CMP output file by MDI-PDA
Version 1.1.4
SI units

Project Name: Mold_2 Step
Contract Number: 122345567
Test Location: DURHAM
Soil Type: Cohesionless
Test Number: 12346789
Operator: BILL KEEGAN
Date: 12/20/2004
Time: 5:19 PM
Temperature (deg. C): 22
Mold Probe Length (m): 0.263
Mold Probe Above Soil (m): 0.031
Cable Length (m): 1.80
Average: 1
Points: 512
Start (m): 10.00
Length (m): 15.937
Probe Beginning (m): 19.579
Probe End (m): 21.536
Mold Apparent Dielectric Constant: 17.792
Mass of Mold (g): 3625
Mass of Mold+Soil (g): 7245
Volume of Mold (cc): 1899
Soil Param. a: 1.094
Soil Param. b: 8.062
water content (%): 19.4
Dry Dens. Mold (pcf): 96.8
Dry Dens. Field (pcf): 99.6
-1.004
-1.004
-1.005
1.006
-1.003
-1.003
-1.003
-1.001
-1.001

512 data points (rows)

	-1.003
Example: MRP_1 Step_field File	**Example: MEC_1 Step_Field_Output file**
InSitu MRP output file by MDI-PDA Version 1.1.4 SI units Project Name: simplified Field Contract Number: 12345 Test Location: Atlanta Soil Type: Cohesionless Test Number: 23 Operator: BILL KEEGAN Date: 12/16/2004 Time: 11:52 AM Temperature (deg. C): 19 Field Probe Length (m): .236 Field Probe Above Soil (m): 0.031 Cable Length (m): 1.8 Average: 1 Points: 512 Start (m): 10 Length (m): 15.937 Probe Beginning (m): 19.296 Probe End (m): 20.988 Field Apparent Dielectric Constant: 17.04 - **512 data points (rows)** 1.004 -1.003 -1.003 -1.003 -1.001 -1	InSitu MRP output file by MDI-PDA Version 1.1.4 SI units Project Name: Simplified Field Output Contract Number: 12345 Test Location: Atlanta Soil Type: Cohesionless Test Number: 23 Operator: BILL KEEGAN Date: 12/16/2004 Time: 11:52 AM Temperature (deg. C): 19 Field Probe Length (m): .236 Field Probe Above Soil (m): 0.031 Cable Length (m): 1.8 Average: 1 Points: 512 Start (m): 10 Length (m): 30 Source Voltage(V): 1.974 Final Voltage(V): 0.996 Bulk Electric Conductivity(mS/m): 39.00 Soil Constant a: 1.16 Soil Constant b: 7.65 Soil Constant c: .0404 Soil Constant d: .182 Soil Constant f: .0440 Soil Constant g: .0189 Soil water content (%) : 13.9 Soil dry density (Mg/m^3): 1.860 Soil dry density (pcf): 116.0 - **512 data points (rows)** 0.991 -0.993 -0.993 -0.995 -0.996 -1 -1.001

Example: CFG_2 step Configuration file	Example: CAL Calibration file
MDI-PDA Version 1.1.4 Two Step Method Configuration Unit: SI units Project Name:CONFIG_2STEP_1 Contract Number:1 Test Location:DURHAM Soil Type: Cohesionless Test Number:1 Operator:BILL KEEGAN Temperature (deg. C):22 Field Probe Length (m):0.236 Field Probe Above Soil (m):0.031 Mold Probe Length (m):0.263 Mold Probe Above Soil (m):0.031 Cable Length (m): 1.8 mrpAverage:1 mrpPoints:512 mrpStart:10.00 mrpLength:16.00 cmpAverage:1 cmpPoints:512 cmpStart:10.00 cmpLength:16.00 Mass of Mold (g):3625 Mass of Mold+Soil (g): Volume of Mold (cc):1899 Soil Param. a: 1.0 Soil Param. b: 9.0	5 12 1.75 12.81 17.32 14.5 1.792 16.98 21.18 16.8 1.797 19.07 22.88 18.8 1.731 20.25 22.75 21.1 1.658 21.57 23.49 1.094 8.062 0.054 0.18 0.0589 0.0207

6. Soft and Hard Reset

If the PDA's screen "locks up" (becomes non-responsive), a soft reset (reboot) should solve the problem. If it does not, and the PDA is still "locked up" or "frozen", a hard boot will be necessary but you will loose all information in volatile memory.

Refer to the operator manual of your Pocket PC to understand the meaning and consequences of these operations and when/how to perform them.

In the case of a hard ("full") reset of an iPAQ Pocket PC, follow the procedures below to reinstall the MDI-PDA software.

1. After the hard reset, turn the PDA ON. This will reinstall all operating software, but will not reinstall the MDI-PDA software or reinstall files in the memory.

2. Reinstall the back up files using iPAQ Backup Restore.

If the PDA still does not function properly continue with the steps below.

3. Using "File Explorer", move all files and data to the iPAQ file Store. The iPAQ file store is non Volatile memory and will not be lost in a hard boot.

4. Perform a hard boot as indicated in the PDA's manual.

5. When turned on, the PDA will reinstall all operating software but will not reinstall the MDI-PDA software or reinstall files in the memory.

6. Installing the M+DI software: on your PDA, find the file **MDI-PDA_PPC.ARM4.cab** and tap it with your stylus. This will install the program.

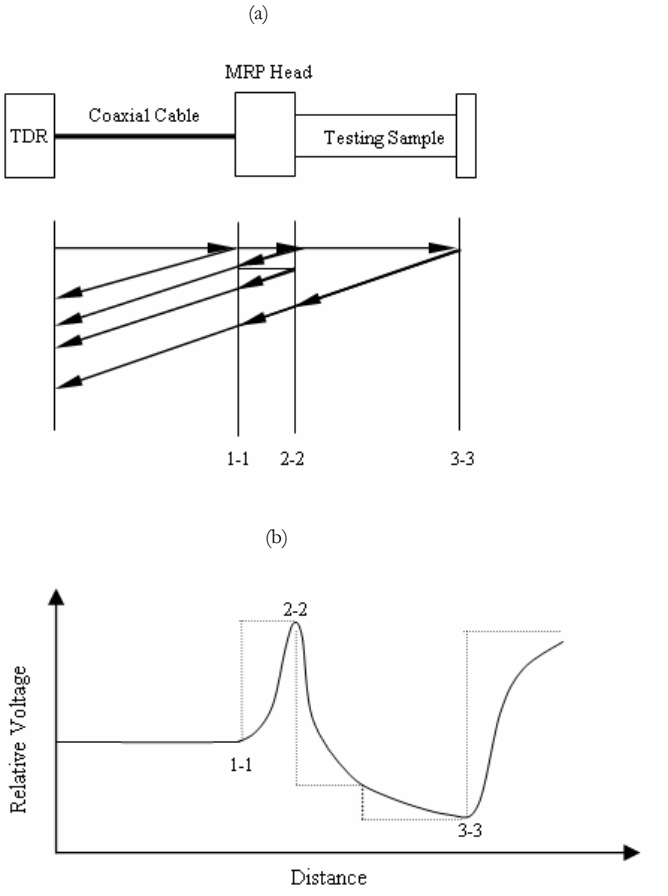
7. You will now need to reconfigure your Ethernet card. See Chapter 2, point 2 on page 20.

8. Your MDI-PDA software should now work with the M+DI.

ⓘ USER TIP
Back Up Your Files Regularly to Non-Volatile Memory
We recommend backing up your files to the iPAQ File Store folder on your iPAQ Pocket PC or, if it is inserted, on the SD (Secure Digital) card after each job. This will hold them in ROM and save them if you perform a full reset of your iPAQ Pocket PC. Consult your PDA's manual for specific instructions. In addition, we recommend saving the work files to a PC or appropriate device for long-term storage.

7. Evaluating the Waveform

7.1 Waveform Principle. Referring to the figure on the right, as the signal reaches the head assembly, a reflection takes place as indicated by a voltage increase (1-1). After passing through the head assembly, another reflection occurs due to the impedance mismatch of the air/material interface (2-2), which causes an abrupt voltage drop in the TDR signal. This results in the first peak of the TDR signal. Following the reflection, voltage continues to decrease until the wave front encounters another impedance mismatch when the signal reaches the tapered end of the probe, another reflected signal (3-3).



7.2 Waveform Variations with soil type. The TDR waveform will vary with the soil type. To illustrate this, Fig 1 shows the signals from three materials (Ottawa Sans, ML Silt and CL Clay) superimposed. You can see how the signal is attenuated after the first inflection point. For certain fine-textured soils such as fat clay at high waters, the second inflection point (*arrow*) of the waveform is often poorly defined because the electrical energy is dissipated by high values of conductivity associated with the wet clay.

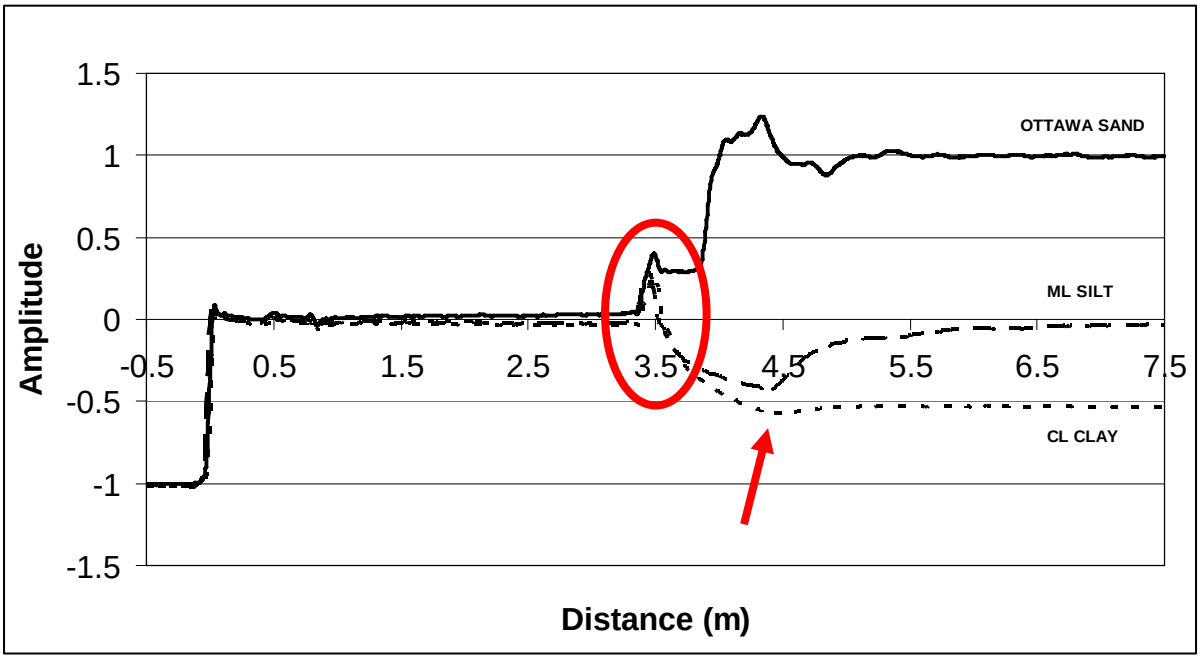


Fig. 1 Typical waveforms for three different materials are superimposed to show how the waveform may vary.

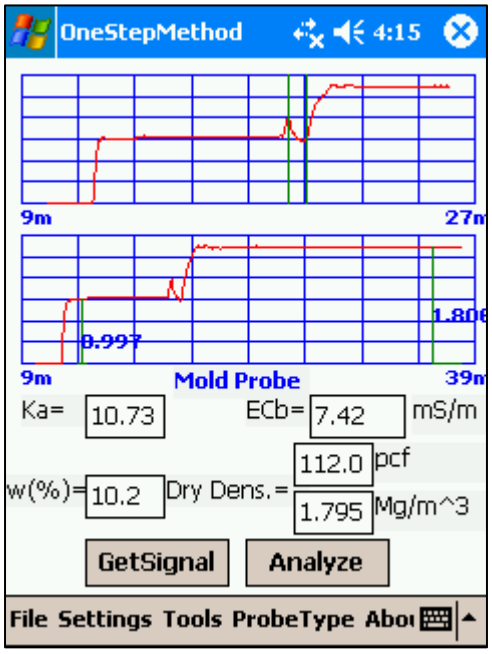


Fig. 2 Typical waveform for sandy silt

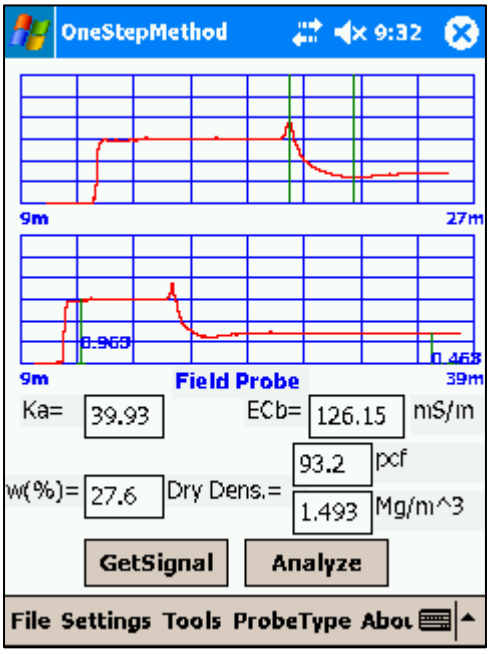


Fig 3. Typical waveform for CH clay.

7.3 Waveform Variations with Water Content. The TDR waveform will also vary with water content (Fig. 4) and the software will take these into account. However, these differences will not be readily apparent on the PDA screen because of the screen size and resolution..

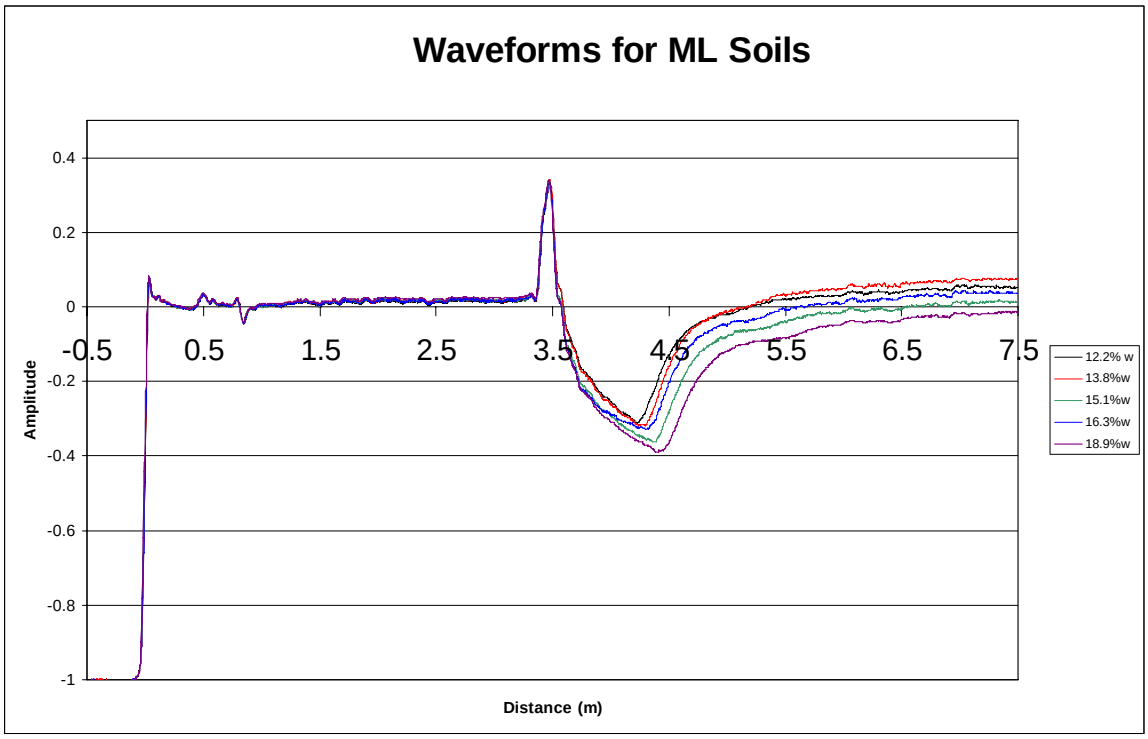


Fig. 4 TDR Waveforms for Silt (ML) at Various Water Contents.

Chapter 7

CARE AND MAINTENANCE

1. Do not charge the M+DI battery until the charge indicator light turns red. Charging a lithium battery before it is fully discharged shortens its life. Charge the battery for at least eight hours. The battery will shut off incoming current when it becomes fully charged.

2. The charger requires a 15 V (dc), 1 A source to charge the unit. (The center terminal of the DC jack connector is positive).

3. **Keep the coaxial cable free from sharp bends, twists and kinks**. The physical integrity of the outer skin of the cable is very important. Replace the cable if it has any cuts or major scrapes. The signal should appear “noisy” on the screen if the cable is damaged.

4. Coaxial cables are not all the same. Using a coaxial cable with characteristics that differ from those of the cable provided by Durham Geo Slope Indicator will result in erroneous wave forms. Buy replacement coaxial cables only from Durham Geo Slope Indicator.

5. TDR connectors and the Ethernet connectors must be kept clean. A small paint brush or tooth brush, or a can of compressed air are handy.

6. Keep all metal parts clean and free of oily films. Use a fine emery cloth or steel wool to remove any corrosion.

7. Water dripping on the Base Unit may enter the shell from the pocket holding the template. Water may seep into the bottom tray of the unit and exit through drain holes. Make sure those drain holes on the bottom of the unit are kept open and are not clogged.

8. The pointed tip of the spikes and the Center Rod must kept relatively sharp. Use a file to smooth burrs. Bent spikes cannot be used.

9. The spikes and straight edge must be cleaned before they are stowed away.

Chapter 8

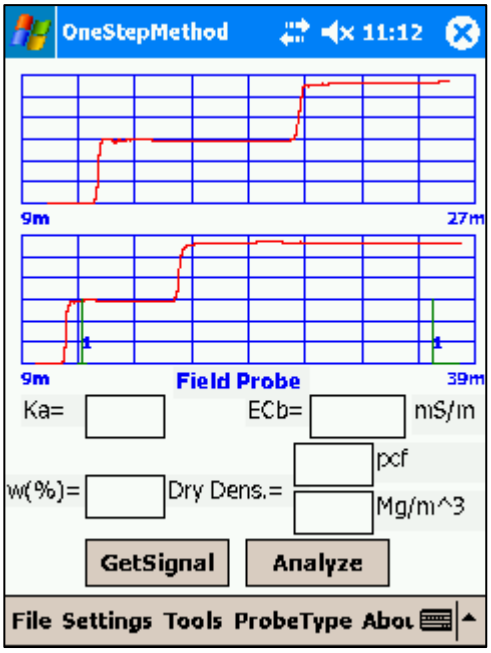
TROUBLESHOOTING

This chart is to aid the user in troubleshooting problems that may occur. If problems persist or need assistance, please contact us.

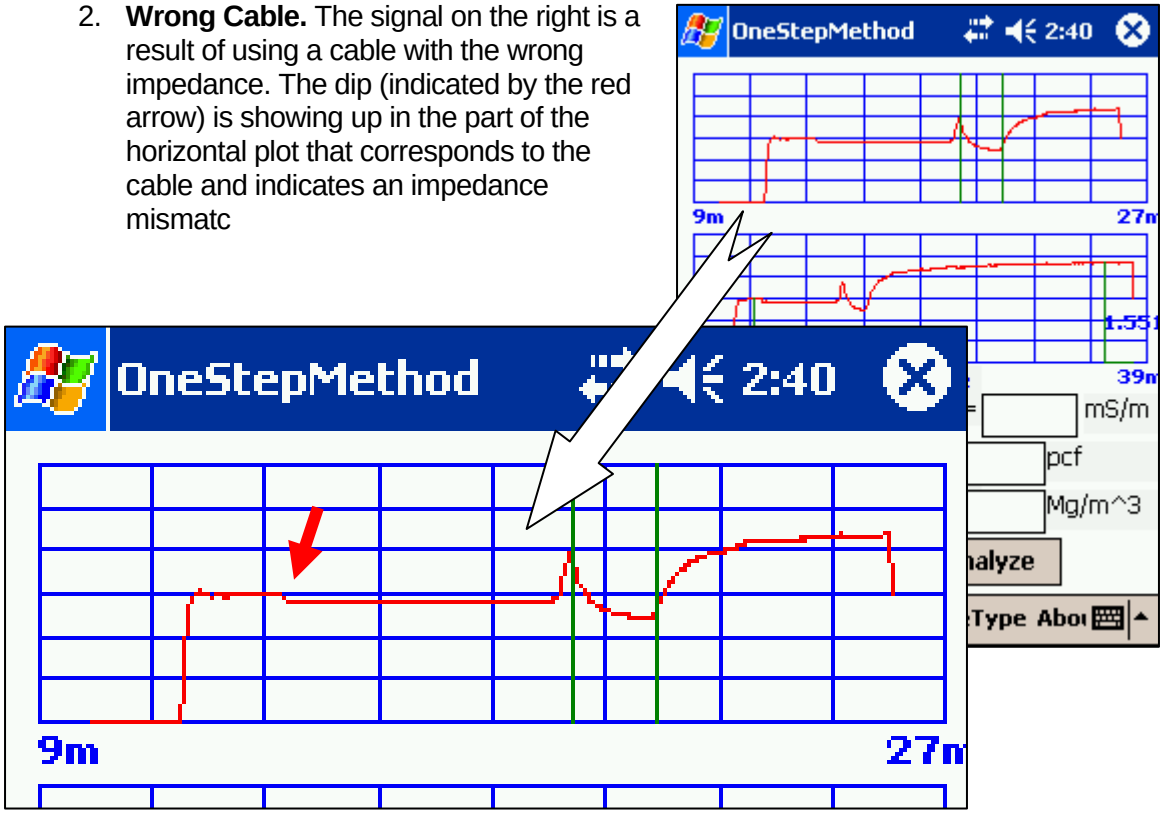
☎ Factory Phone: 1-800-837-0864 ☎

Problem	Cause	Solution
TDR results not as expected	Damaged coaxial cable	If the cable has any cuts or large scrapes, or if it is severely bent or twisted, or if the central pin at the connector ends are damaged, replace the cable.
	Replacement coaxial cable not from DGSI.	Coaxial cables are not all the same. Using a coaxial cable with characteristics that differ from those of the cable provided by DGSI will result in erroneous wave forms. Buy replacement coaxial cables only from DGSI.

1. **NO SIGNAL to the probes.** A square signal such as the one shown at right is an indication that a signal is transmitted to the head but not all the way to the probes. Check the contact between the coaxial head and the spikes.



2. **Wrong Cable.** The signal on the right is a result of using a cable with the wrong impedance. The dip (indicated by the red arrow) is showing up in the part of the horizontal plot that corresponds to the cable and indicates an impedance mismatc



Chapter 9

LIMITED WARRANTY

The M+DI is guaranteed against defective materials and workmanship for a period of one year from the date of shipment. We will repair or replace such items as may prove defective at our option. Under no condition will we allow labor charges or other expenses to repair defective merchandise without our approval. Durham Geo makes no other warranties of any kind or nature and all implied warranties or merchantability or fitness for a particular purpose which exceeds the previously stated obligation are expressly excluded. We accept no responsibility for damage or abuse to apparatus due to improper installation or operation. We accept no responsibility for and will not pay for any lost profits incidental, consequential or special damages.

For a complete warranty disclosure, please refer to the printed statement on the back of any Durham Geo Slope Indicator original invoice,

- ➔ call **1-800-837-0864** (toll free) or +1 (770) 465-7557
- ➔ e-mail **info@durhamgeo.com**

Chapter 10

ANNEX

- Verification by Direct Methods.
- Field Record of Compacted Fill by the Two-Step Method
- Data Sheet for Determination *a* and *b* Values
- Sample Spreadsheet for Compaction Test

Verification by Direct Methods.

Soil water content and dry density are indices most often used for controlling earthwork compaction quality. Presently two methodologies are used to measure these indices – direct or indirect methods. Direct methods of measuring density and obtaining material for water content determination include the sand cone method (ASTM D 1556), the drive tube method (ASTM D 2937) and to a lesser extent, the rubber balloon method (ASTM D 2167).

The reference method for water content determination is oven drying material for 24 hours at 105°C ± 5°C as prescribed in ASTM D 2216. Expedient water content methods are available (such as microwave, direct heat and calcium carbide); however, the user is reminded that these fast, convenient methods must be validated by the oven dried method.

Indirect methods for measuring dry density and water content include the MDI procedures described in this manual and various nuclear gauge devices. It is our recommendation that when using the MDI (or any other indirect method) that one or more direct methods cited above be used sufficiently to validate the results. This validation is best done at the beginning and at regular intervals for major earthwork projects or periodically for smaller projects especially when encountering new geological settings. The user is cautioned that using direct methods can result in wide variation of results or even erroneous results because the methods are highly dependent upon user experience and skill level and equipment calibration. Some will elect to use the nuclear gauge as the reference device which uses one method for determining the density and another method for water content. The water content determination by a nuclear gauge is a back scatter method with 50% or more of the indicated value resulting from the upper 2 to 3-in of material. In addition certain minerals in the soil can create false readings by a nuclear gauge. If the user relies on the nuclear gauge as the referenced device, we recommend that the gauge wet density be recorded and excavate a representative sample of the material beneath the gauge for subsequent water content determination by D2216. This will permit computation of the associated dry density for comparison.

Field Record of Compacted Fill by the Two-Step Method

Project: _____ Contract No.: _____

Operator: _____ Date: _____

M+D Indicator Model: _____ Serial Nr.: _____

Description of Field Material Condition:
Source of Material: On-Site Location:_____ Off-Site Location:_____

Type of Construction Equipment Used:_____

Test No. Location

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

Test No.	1	2	3	4	5	6
Grade/Elevation						
TDR File Name						
Percent Moisture						
Dry Density (pcf)						
Maximum Lab Dry Density						
% Compaction						
Required Compaction						

Notes: _____

Data Sheet for Determination *a* and *b* Values

Operator's Name: _____ Test Date: _____

Sample Description: _____

Mold Information:

Mass of Mold+Base (g):_____

Diameter of Mold (cm): _____

Height of Mold (cm): _____

Volume of Mold (cm^3): _____

Probe Information:

Total Length of Probe (cm): _____

Length of Probe Above Soil (cm):_____

Net Length of Probe (cm): _____

Experiment Record:

COMPACTION AND TDR MEASUREMENT

Test No.	Target Water Content(%)	K_a	Mass of Mold+Soil (g)	Wet Density (g/cm^3)
1				
2				
3				
4				
5				

WATER CONTENT DETERMINATION

Test No.	Target Water Content(%)	Can No.	Mass of Can (g)	Mass of Can+ Wet Soil (g)	Mass of Can+ Dry Soil (g)	Mass of Dry Soil (g)	Mass of Water (g)	Water Content (%)
1								
2								
3								
4								
5								

Determination of *a* and *b* Values

1	2	3	4	5
Test No.	K_a	Dry Density, ρ_d (g/cm^3)	Water Content (%)	$\sqrt{K_a} \cdot \frac{\rho_w}{\rho_d}$
1				
2				
3				
4				
5				

Plot Column 4 versus Column 5. Fit points with a straight line. Get *a* from intercept at zero water content and get *b* from slope of line.

Sample Spreadsheet for Compaction Test

If the form illustrated below can be of help to you, you can download the full and latest version as an **MS Excel spreadsheet** from www.DurhamGeo.com/mdi .

Compaction Test

Date:

Project:

Material Description:

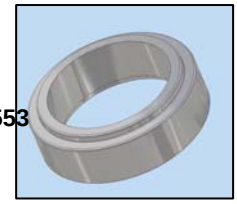
Air Dried Bulk Sample			Sp Gravity:		Test or est.:	test
Tare No.		T1	Mold No.			
Tare + Air dried soil	g		Avg Mold Dia		inch	
Tare + Oven dried soil	g		Avg Length		inch	
Wt of tare	g		Mold vol	0.0	cu in	
Weight of water	g	0.0	Mold Vol	0.0000	cu ft	
Water Content of air dried	%	#DIV/0!	Mold weight		g	
Desired water content	%					
Est. Dry Density	pcf					
Weight of air dried soil	g	0.0	0.0	0.0	0.0	0.0
Desired wet weight	g	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Weight of water to add	g	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Compacted Specimen		1	2	3	4	5
Mold plus wet soil	g					
Mold weight	g	0.0	0.0	0.0	0.0	0.0
Wet Soil Weight	g	0.0	0.0	0.0	0.0	0.0
Dry Soil weight	g	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Water Content Determination						
Tare No.						
Tare + wet soil	g					
Tare + dry soil	g					
water mass	g	0.0	0.0	0.0	0.0	0.0
Tare mass	g					
Dry Soil weight	g	0.0	0.0	0.0	0.0	0.0
Water content	%	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Wet Unit weight	pcf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Dry Unit weight	pcf	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Dry Unit weight	Mg/cm^3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Dielectric Constant, Ka						
Bulk Electric Conductivity, Ecb	mS/m					

Compaction Molds for M+DI

Assemblies and Parts Listed in the Calibration Accessories Kit MD-2100

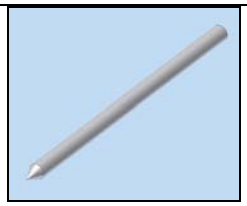
601742 — *4x4-in Mold, Stainless Steel Body, non-conductive base.*

601744 — *4x9-in Mold, Stainless Steel Body, non-conductive base.*



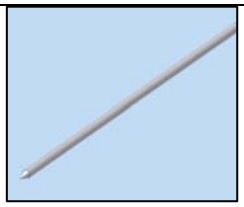
601709 — *Ring Collar, CMP, MDI*

Will fit on either the 4- or 9-in molds (601742 or 601744)



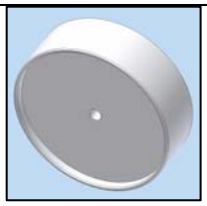
601548 — *4" Center Rod, CMP, MDI*

Use in conjunction with 601290



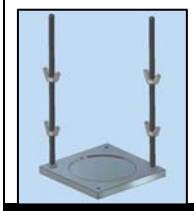
601291 — *9" Center Rod, CMP, MDI*

Use in conjunction with 601290



601290 — *Guide Template, CMP, MDI*

Use in conjunction with either 4" or 9" Center Rod (601548 or 601291)



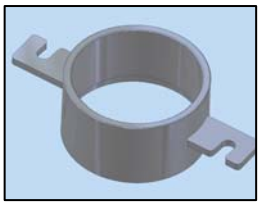
601552 — *Steel Base w/ Long Threaded Rods.*

Will accommodate the 9-in mold (601450) or 4-in mold (601551) plus the std 4-in mold collar (S-32011)

Additional Assemblies and Parts

601451 — *4x9-in MDI Mold, non-conductive base.*

601551 — *4 x 4 in Stainless Steel Mold Body*



S-32011 — *Std 4–in Mold Collar*