RADIODETECTION®

RD1500™

Ground Penetrating Radar with Ultra Wide Band Antenna

Operation Manual

90/RD1500-OPMAN-ENG/04

SPX®

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Section 1 - Preface

Before you begin

Thank you for your interest in Radiodetection's RD1500 Ground Penetrating Radar system.

Please read this user manual in its entirety before attempting to use the RD1500.

Radiodetection products, including this manual, are under continuous development. The information contained within is accurate at time of publication; however the RD1500, this manual and all its contents are subject to change.

Radiodetection reserves the right to modify the product without notice and some product changes may have taken place after this user manual was published.

Contact your local Radiodetection dealer or visit www.radiodetection.com for the latest information about the RD1500, including this manual, and the rest of the Radiodetection range of products designed for locating buried utilities.

1.1 Important notices

General

This instrument, or family of instruments, will not be permanently damaged by reasonable electrostatic discharge and has been tested in accordance with IEC 801-2. However, in extreme cases temporary malfunction may occur. If this happens, switch off, wait and switch on again. If the instrument still malfunctions, disconnect the power supply for a few seconds before restarting.

Safety

⚠️ WARNING! Failure to comply with safety warnings can cause serious injury or death

CAUTION!: Failure to comply with safety cautions can result in damage to equipment or property

This equipment shall be used only by qualified and trained personnel, and only after fully reading this Operation Manual.

Use the Display Unit only as specified in these operating instructions or the protection provided by the unit may be impaired.

The battery charger/AC adapter must only be connected to a power outlet, which provides a protective earth (ground).

Connect the AC power cord only to designated power sources as marked on the battery charger/AC adapter.

The battery charger/AC adapter is rated for indoors use only.

Do not replace detachable MAINS supply leads for the battery charger/AC adapter with inadequately rated leads.

Do not position the Display Unit such that it is difficult to disconnect the 37-pin GPR connector.

The exterior of this product should be cleaned using a damp cloth.

1.2 Intellectual property

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Section 2 - Introduction

2.1 About this manual

This manual provides utility locating and other professionals with comprehensive operating instructions for the RD1500™ system. Before operating the RD1500 system, it is very important that you read this manual, noting all safety warnings and procedures.

2.2 About the RD1500

The Radiodetection RD1500 is a state of the art Ground Penetrating Radar system.

Designed specifically for utility locating, RD1500 is an advanced Ground Penetrating Radar for the detection of non-conductive pipes and ducts. Using a grid based data collection system, it is possible to build up both horizontal and vertical depth maps. A high resolution screen, on-site analysis tools, and advanced reporting capabilities with WiFi data transfer, allow locate professionals and surveyors to both mark artefacts and to generate and deliver customer field reports while on-site.

2.3 Manual outline

Section 1 includes an overview of safety procedures and notices. Review them before moving on to Section 2 and the rest of this manual

Section 3 provides an overview of the RD1500 system

Section 4 shows how to assemble the RD1500 system

Section 5 describes Getting Started

Section 6 covers the Tools and Setup

Section 7 provides an overview of GPR Concepts

Section 8 introduces Line Scan mode

Section 9 covers Grid Scan mode

Section 10 describes Slice View mode

Section 11 provides a description of the Map View mode

Section 12 shows Capturing Screens and Emailing Mini Reports

Section 13 introduces Transferring Data to a PC

Section 14 is the Troubleshooting section

Section 15 covers Care and Maintenance

Section 16 has the Technical Specifications of the RD1500

Section 17 explains the Warranty

Sections 18 to 23 are the Appendices covering:

Appendix A: Health & Safety Certification

Appendix B: GPR Emissions, Interference and Regulations

Appendix C: Instrument Interference

Appendix D: Safety around Explosive Devices

Appendix E: WiFi Module

Appendix F: Import/Export

2.4 Safety

Read this manual in its entirety before attempting to operate the RD1500. Note all safety notices in the preface and throughout this manual

Follow your company and national safety procedures and or requirements when operating this equipment in any environment or workplace. If you are unsure what policies or procedures apply, contact your company or site's occupational health and safety officer or your local government for more information.

Do not use this equipment if you suspect that any component or accessory is damaged or faulty.

Use authorized accessories only. Incompatible accessories may damage the equipment or give inaccurate readings.

Keep this equipment clean and arrange for regular services with an authorized Radiodetection service center. More information can be found in the Appendix or from your local Radiodetection representative.

Do not attempt to open or dismantle any part of this equipment unless directed specifically by this manual. Doing so may render the equipment faulty and may void the manufacturer's warranty.

2.5 Training

Radiodetection provides training services for most Radiodetection products. Our qualified instructors will train equipment operators or other personnel at your preferred location or at Radiodetection headquarters.

For more information go to www.radiodetection.com or contact your local Radiodetection representative.

Section 3 - System Overview

3.1 Introduction

This manual references embedded software version V1 R4. To see which software version is installed on your system, see **Section 5.4 Swipe Down menu**.

The RD1500 is a complete Ground Penetrating Radar system, offering two modes for acquiring data: Line Scan and Grid Scan. Once the unit is assembled and powered-up, you can start conducting a GPR survey in less than a minute.

Features of the RD1500 include:

- High visibility, touch screen display

- Display depth slices from collected grids, right in the field

- UWB Antenna producing high data quality

- Frequen*See*™, which allows user to selectively view small, medium or large subsurface targets

- Lightweight fibreglass cart frame

- Built-in WiFi capability

- Integrated GPS receiver with optional external GPS for increased positional accuracy for geo-referencing data

- Ability to mark surface flags and subsurface interpretations

- Display your travelled path and targets in Map View

- Seamless export of data to EKKO_Project software for further data analysis

The RD1500 is also available in an Enhanced configuration. The chart below summarizes the differences between the two configurations:

Criteria	RD1500	RD1500 Enhanced
How is data saved?	Screenshots (.JPG)	Screenshots (.JPG) and .GPZ files
How much data can be saved?	• 10 grids • 99 lines • 999 screenshots	9 Projects each with: • 10 grids • 99 lines • 999 screenshots
File organization	Lines and Grids	Projects containing Lines, Grids and Screenshots
Map View	Displays a single line or grid	Shows all lines/grids in a Project
PC-based data display	Any .JPG viewing software	Data can be opened in EKKO_Project

Section 4 - Assembly

4.1 Out of the box

You will find the following components in your RD1500 box. Some of these may already be assembled.

Attach the Cart Handle to Cart Base using the Handle Pins. Ensure the Display Unit Tray is facing the operator.

Attach the GPR Sensor to the Cart using the Sensor Support Straps. Ensure the Sensor is oriented the correct way with the connections toward the back of the Cart. Using the Sensor Support Straps, adjust the height of the Sensor so it is 1-2 cm (½ – ¾ inch) above the ground. The best way to get a uniform Sensor height is to place a couple of sheets of thick cardboard, particle board or Styrofoam on a level surface under the sensor before securing the Sensor Support Straps.
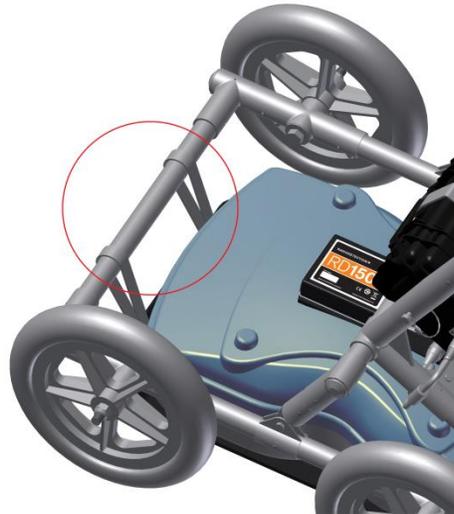
Attach the Display Unit onto the Display Unit Tray on the Cart. The Display unit slides down into the tray, catching on both sides of the mount and is held in place with the pull pin. When a click is heard, the Display Unit is firmly in place. Adjust the angle of the Display Unit by loosening the hand-screws underneath the Display Unit Tray, rotating the Display Unit to the desired angle and tightening the hand-screws. To remove the Display Unit, disconnect all cables, pull out the pull pin and lift the Display Unit up.

Attach the Display Cable to the back of the Display Unit with the jackscrews.

Connect the other end of the cable to the Sensor. Ensure the cable is routed as shown below.

Attach the Odometer and Battery Cables. The Odometer Cable connects to the closest receptacle on the Sensor. Attach the Battery Cable to the Sensor and the Battery. The system is now set up and ready to use.

4.2 External GPS (optional)

The instructions for connecting the GPS, mount and cable are below:

GPS Mount – The GPS mount attaches to the crossbar frame above the battery, using a quick release pin. Please remove the pipe plug first.

With the pole pointing upwards, insert the GPS mount into the opening where the plug was located, and secure it with the quick release pin. This allows the GPS to sit directly over the middle of the GPR sensor. It comes with 5/8-11 UNC-1A threads at the top of the pole, which is standard for many GPS receivers.

GPS Cable

GPS
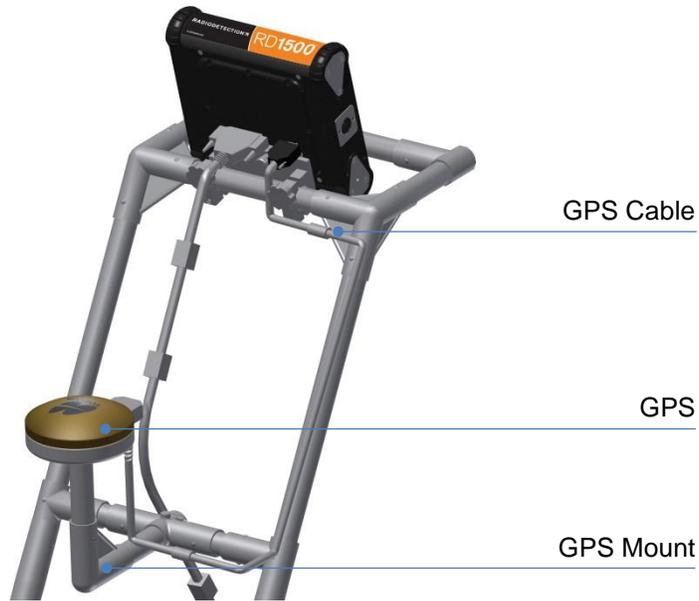
GPS Mount

GPS – If you have purchased the Topcon GPS from Radiodetection, this can be screwed onto the threads at the top of the GPS mount. Connect one end of the GPS cable to the GPS receiver, and the other end to the serial port on the back of the Display Unit. This single cable powers the GPS and receives data from it.

CAUTION! Ensure that the Display Unit is powered down when connecting or disconnecting the GPS cable.

If you choose to connect a 3rd party GPS receiver, you must ensure the following parameters are set for the GPS to communicate with the Display Unit:

- Baud rate = 19200 bps

- Output string = NMEA

- NEMA string must include $##GGA

- Parity = None

- Stop Bits = 1

- Data Bits = 8

CAUTION! The serial port of the Display Unit outputs power (current=1A, voltage=12V). Be very careful if connecting other GPS units to the serial port. Verify the pins on the drawing below.

5 Ground
Power and Signal

Accessory

2 RX (in)

3 TX (out)

4 Accessory Power

Provides a switched, and current-limited positive(+) feed from the system battery.
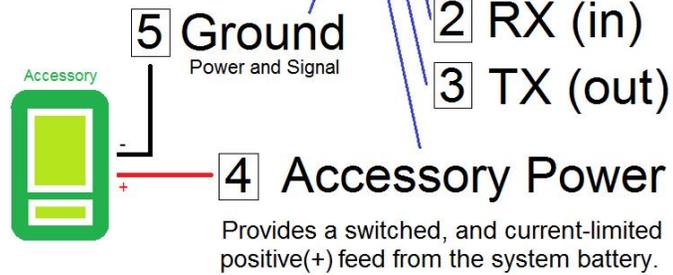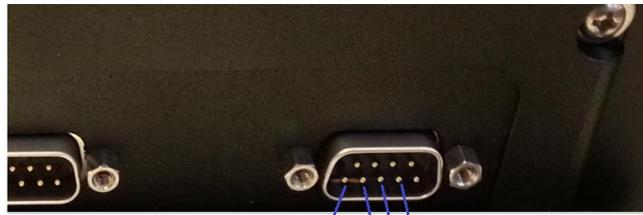
⚠ Care should be taken to ensure that the accessory can handle the supplied power, and that it does not feed power back into the GPR system.

4.3 Fully Assembled

The fully assembled RD1500 will look like the following. Simply reverse the directions above to disassemble for transport.

Section 5 - Getting Started

5.1 Powering up

1. When the battery is first plugged in, the LED goes green for 5 seconds then disappears.

2. To start the system, press the red power button on the display unit. The LED on the front panel will light up red.
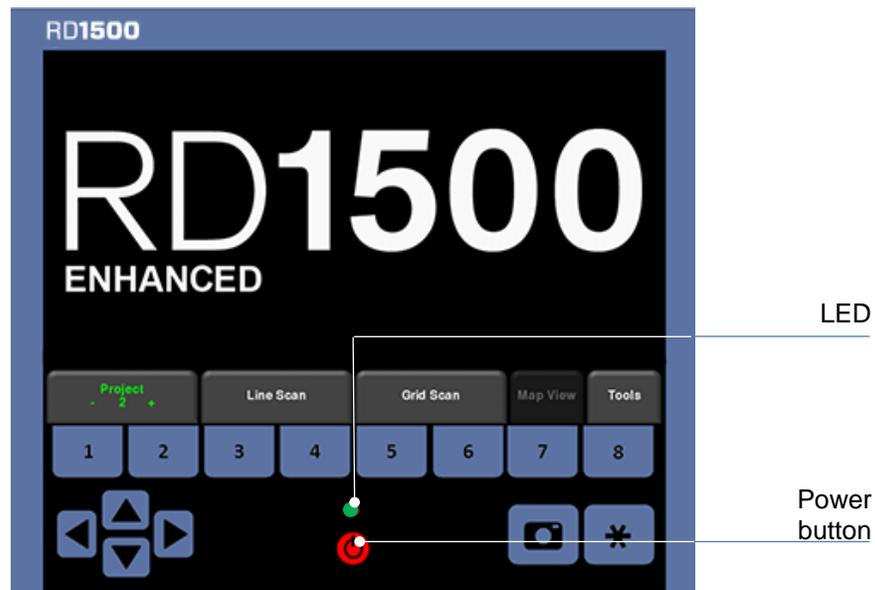
Figure 5-1: Front of Display Unit

Once boot up is complete, the color of the LED will indicate the amount of battery power remaining:

- 100% to 20% = green
- 20% to 10% = orange
- 10% to 0% = red

The first time you turn on the RD1500, you will need to configure the system. A series of screen prompts will allow you to setup the language, units, date & time, and some other options. You will have to do this again anytime you update the embedded software.

Every subsequent time the system boots up, you will see the main screen (Figure 5-2). If you have purchased (or upgraded to) the RD1500 Enhanced system, you will see the main screen shown in Figure 5-3.

3.
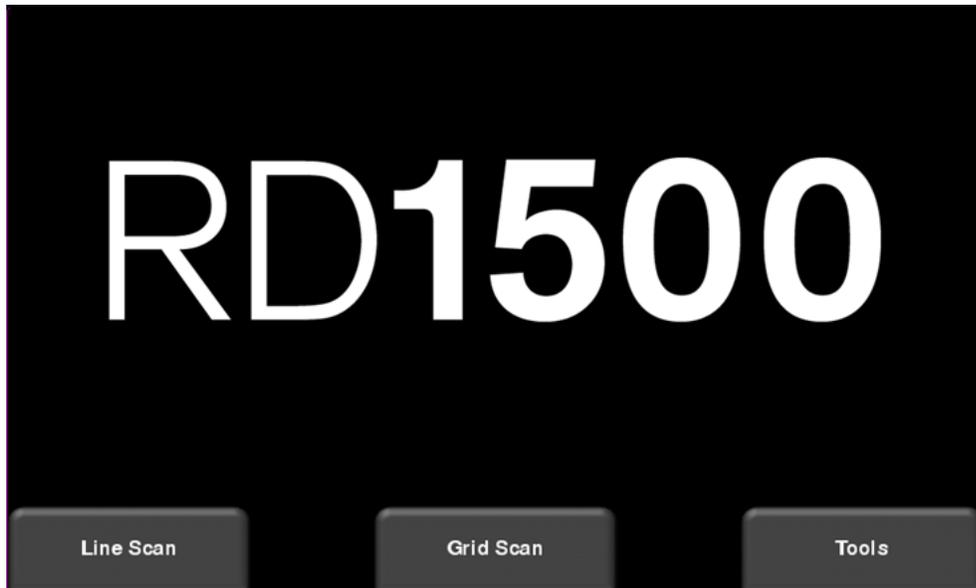
Figure 5-2: Main Screen for RD1500
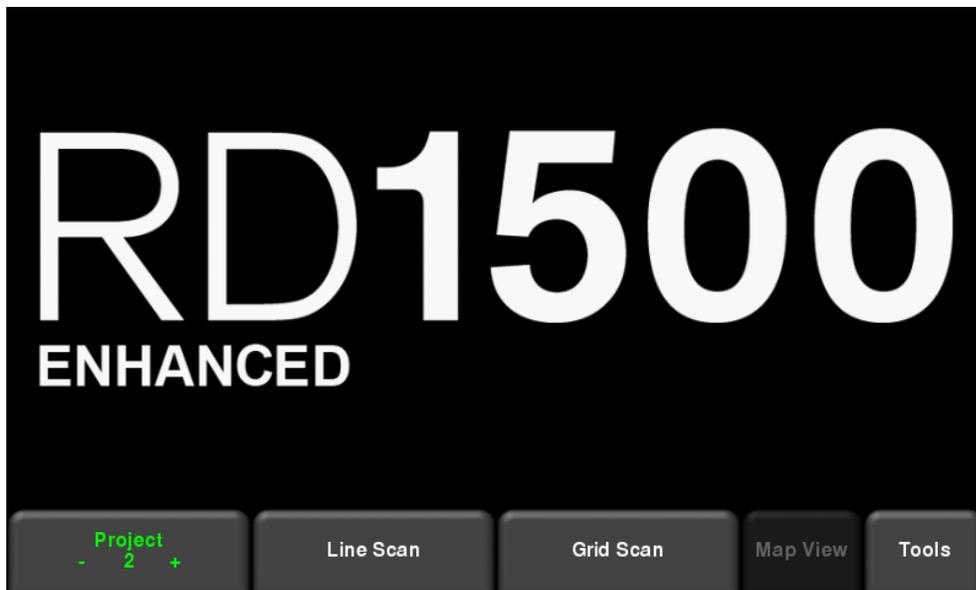
Figure 5-3: Main Screen for RD1500 Enhanced

The differences between the two configurations are described in Section 3. Everything remains the same in the on-board software, except for in the Enhanced system, where the main screen will allow you to organize data into projects. Within each project, you can have a number of lines and/or grids.

From the main menu of the Enhanced system, select the project number to work in. Projects that contain data are in red color, whereas those with no data are in green. As you change projects, the main screen will also display the number of lines and grids collected in each project. These will appear under the Line Scan and Grid Scan buttons respectively.

5.2 Shutting down

4. To power down, press the red power button on the display unit once. A confirmation message will appear; after which you can press **Yes** to proceed. If necessary, a hard shutdown can be done by pressing and holding the red power button until the unit shuts down.

5.3 Interacting with the Display Unit

Data collection is controlled by the Display Unit. The Display Unit has embedded software to set survey parameters and collect, display and store data.

The Display Unit offers touch screen operation, as well as a water-resistant membrane keypad with a number of buttons that can be pressed to perform various tasks. Most operations can be done using either the touch screen or the keypad.

5. Use the following table as a guide to working with the keypad on the Display Unit:

Item	Description
Menu Buttons [1] [2] [3] [4] [5] [6] [7] [8]	The blue buttons labelled 1 to 8 correspond to menu choices that appear on the screen.
4-way directional keypad	Controls Up/Down/Left/Right operations in certain menus.
Camera	Saves a screenshot of line data, grid data or the Map View display.
Asterisk / Special Function	Used for adding Flags during data acquisition, and to quickly enter the No Save mode for Line Scan data collection.

5.4 Swipe Down menu
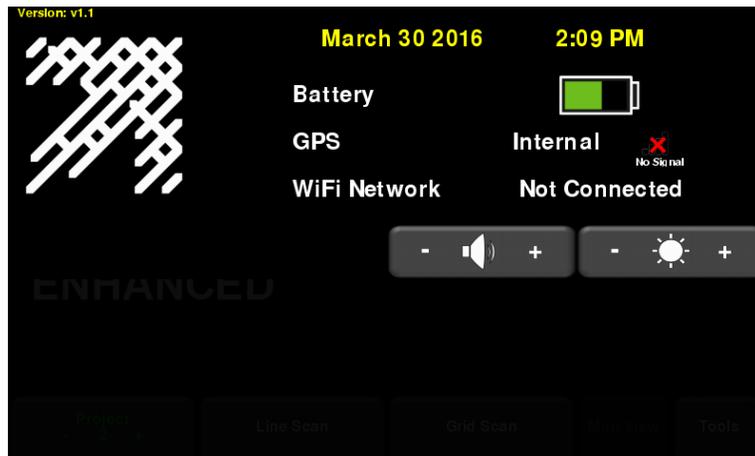
Figure 5-4: Swipe-Down menu

When the Display Unit is powered on (except during data acquisition), you can "swipe" your finger from the top of the screen towards the bottom, to bring up a drop-down menu (Figure 5-4) with the following items:

Date and Time: The current date and time (12-hour clock).

NOTE: The time needs to be changed in areas that observe daylight-savings-time.

Battery: The battery icon displays the amount of power remaining in the battery. If the battery power is getting low, the icon will change color to orange and red to match the LED color on the keypad.

GPS: Shows which GPS is being used (Internal or External) and the signal strength.

WiFi Network: Indicates if the system is connected to a wireless network and, if so, the name of the network. See **WiFi Settings** in **Section 6.2** for details on connecting the system to a wireless network.

Volume: The **Volume +** and **-** buttons are used to increase and decrease speaker volume.

Brightness: The **Brightness +** and **-** buttons are used to increase and decrease the screen brightness. For example, increasing the Brightness setting may improve the visibility of the screen in bright sunlight.

NOTE: Increasing the screen brightness also increases power consumption, thus reducing battery life.

To close the Swipe-Down menu, touch anywhere on the screen below the swipe-down menu.

Section 6 - Tools & Setup

From the main screen shown in Figure 5-2 or Figure 5-3, press **Tools** to enter this sub-menu. Here you can set preferences, adjust system settings, perform system tests and manage files. You will see the screen shown in Figure 6-1:
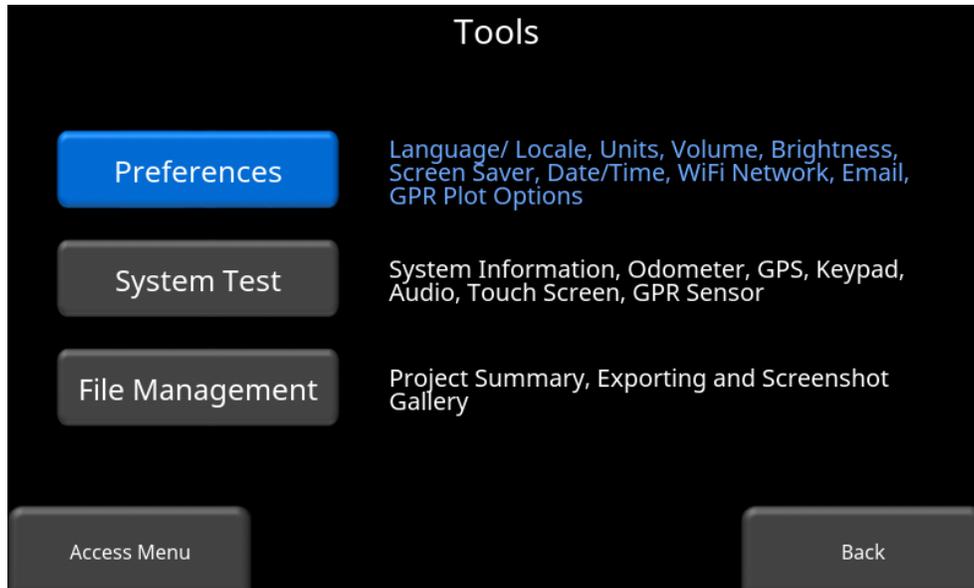
Figure 6-1: Tools menu

6.1 Preferences

Selecting the **Preferences** option will take you to the sub-menu shown in Figure 6-2.
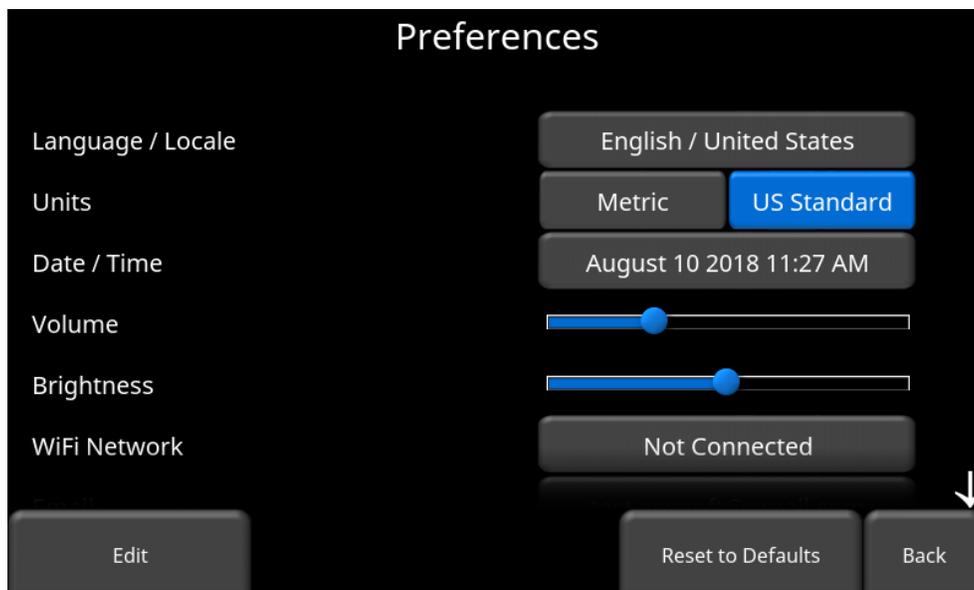
Figure 6-2: Setting Preferences

There are several parameters that can be modified. Touch the screen and swipe up or down to scroll and view additional parameters. To change a value, press the value on the right side of the screen. Alternatively, use the up and down arrows on the 4-way keypad to highlight the desired parameter, then press Edit. Each parameter is described in detail below.

Language

Selecting this option will display the screen in Figure. The current language is displayed; pressing the **+** and **–** buttons on either side of the language will cycle between the languages currently available. Below that, the Country/Region is displayed. Press the **+** and **–** buttons on either side of the displayed Country/Region to alphabetically move to the next or previous country or region.

Alternatively, both Language and Country/Region can be changed by pressing the **+** and **–** buttons on the bottom of the screen. Press **Back** when you are done.
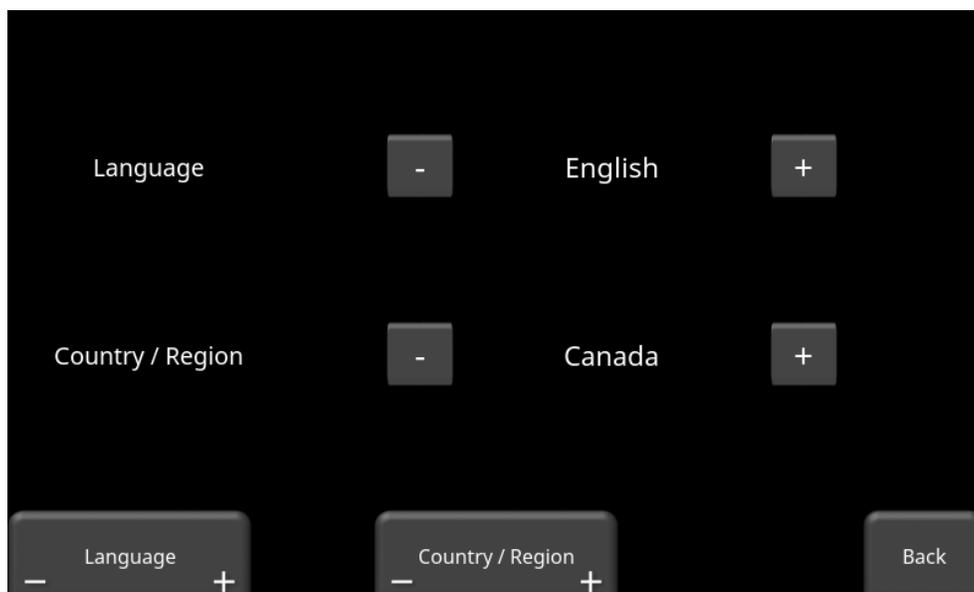
Units

Pressing **Units** will cycle between US Standard and Metric Units.

Date/Time

Selecting this option takes you to a screen where the date and time can be set. The time is manually set, and will not automatically correct for daylight savings time.

Volume

Scroll bar for adjusting the volume of clicks and beeps heard during operation. This can also be changed by using the Swipe Down menu (Section 5.4) any time the system is not collecting data.

Brightness

Scroll bar for adjusting the brightness of the screen. This can also be changed by using the Swipe Down menu (Section 5.4) any time the system is not collecting data.

NOTE: Increasing the screen brightness also increases power consumption, thus reducing battery life.

WiFi Network

Connecting to a wireless network allows you to send a mini-report to someone by e-mail.

This connection can be through a standard WiFi network or through a hotspot on your mobile device while in the field.

NOTE: RD1500 **CANNOT** connect to Public Hotspots (typically restaurants, hotels and airports) that require a web-based login and acceptance of their Terms & Conditions. It also CANNOT connect to unsecured networks (networks that do not require a password).

If you are already connected to a WiFi network, the name of the network is listed beside the WiFi Network field. Selecting **WiFi Settings** takes you to a sub-menu for connecting and configuring WiFi settings.
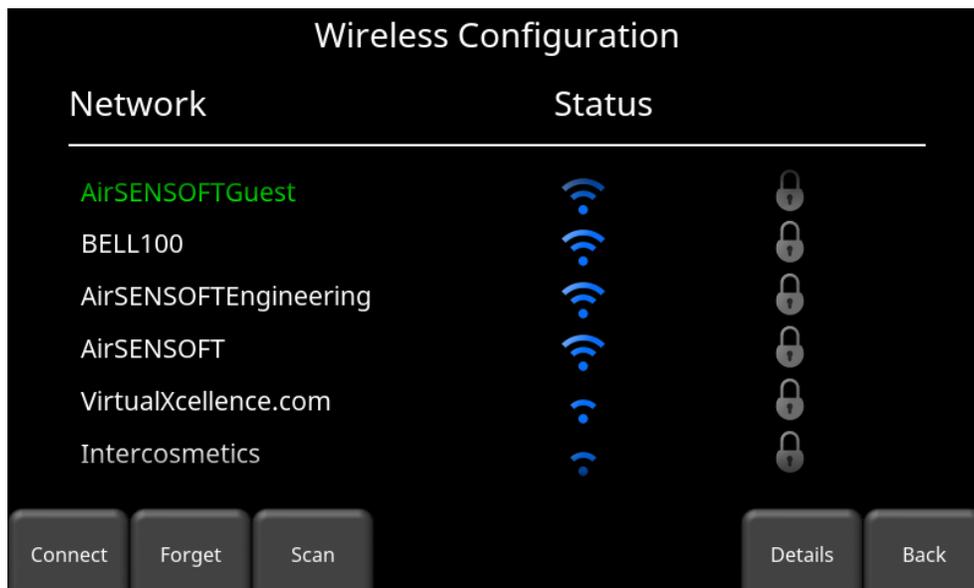
Use the 4-way directional arrows or touchscreen to select the network. The color of the Network Name indicates the status:

- Green = Connected
- Yellow = Not currently connected, but remembered from before when you previously connected and entered a password.
- White = Not connected

o **Connect** – Select the desired network and press Connect.
   If the connection is successful (this can take a minute or so) a screen appears asking for the password for that network. If the network name is yellow (from a previous connection to this

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network), it will not ask for a password because it is a remembered network. Once it connects the Network Name will turn green.

- o **Forget –** Use the Forget button to remove the password for connected or remembered networks (text in green or yellow). Once the 'forget' button is pressed on a selected network it will remove the password and the Network Name will turn white. You will also be disconnected if you are currently connected to that network.
- o **Scan –** Scans for any available networks in the area and displays them in order of strength of signal. You may need to press this button a second time if you don't see the network you are looking for.
- o **Details –** Pressing this button displays the security settings and device addresses related to the selected network.
- o **Back –** Press this button to return to the System Settings screen.

Email

Press **E-mail** to arrive at a sub-menu where you can setup and configure a sending e-mail address. Ensure that this e-mail address already exists. This is the sending account where messages will originate from. All mini-reports received by the recipient will appear to come from this account.

Using Gmail™

The system is already pre-configured to use Gmail as the e-mail provider for the sending account (Figure 6-3):

Outgoing Email Setup

Provider	Gmail
Username	test.sensoft
Password	********

Provider Gmail — +   Username Password   Save   Cancel
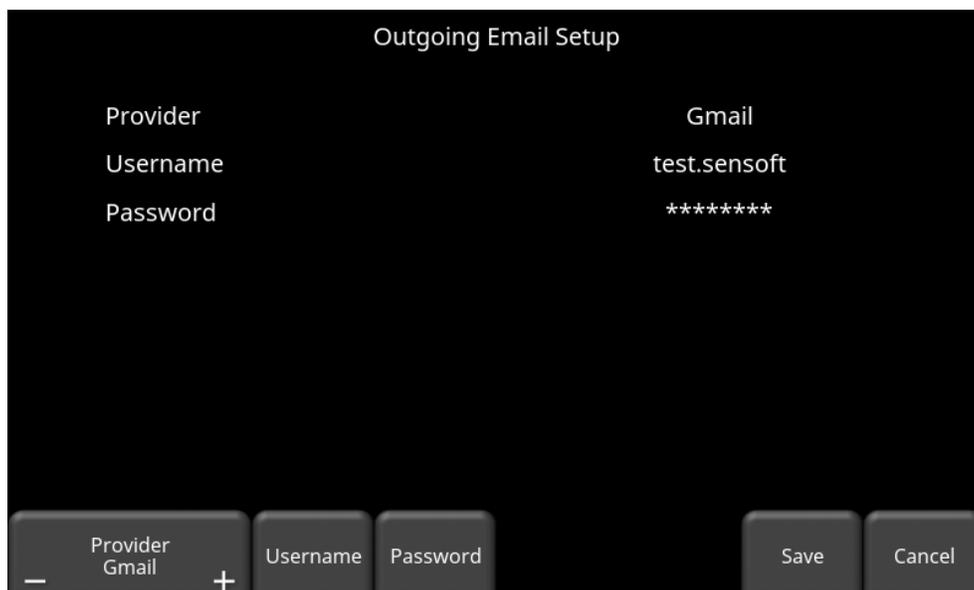
Figure 6-3: Using Gmail as e-mail provider

- • Press **Username** to display a keyboard where you can enter your Gmail user name only; you do **not** need to enter @gmail.com. Then press OK when done (Figure 6-4a)

- Press **Password** to display a keyboard where you can enter your Gmail password. Then press OK when done (Figure 6-4b)

- Press **Save** when both Username and Password have been entered.
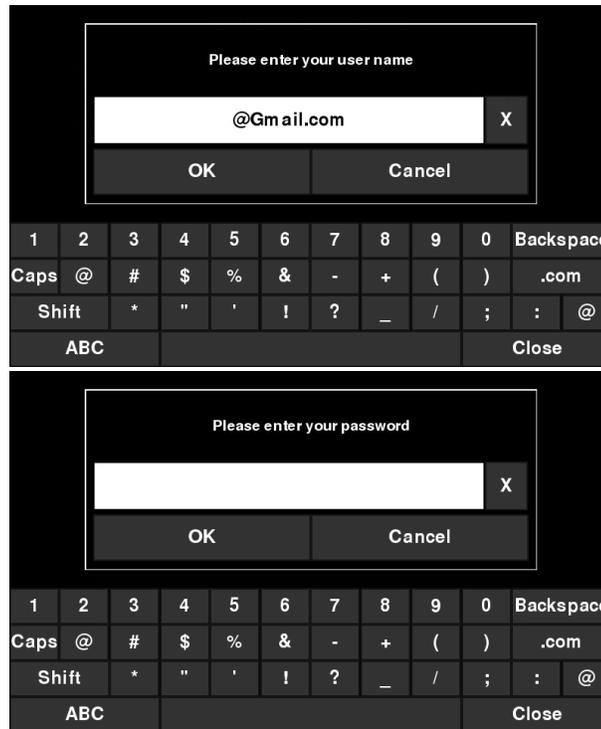
Figure 6-4: Entering e-mail address (a) and password (b) for Gmail

If there are no warning messages, the e-mail address is setup properly and you are ready to e-mail mini-reports from the field. If this does not work, see the Failed Setup section below.

Using Another Provider

NOTE: It is highly recommended to use a Gmail account as the system is pre-configured for this. If you choose to use another provider, you will have to contact that provider if you have any issues with the settings.

To use another e-mail provider, press the **+** and **–** buttons under **Provider** until it says **Custom.** This will display the screen shown in Figure 6-5 allowing you to setup and configure a different e-mail provider:
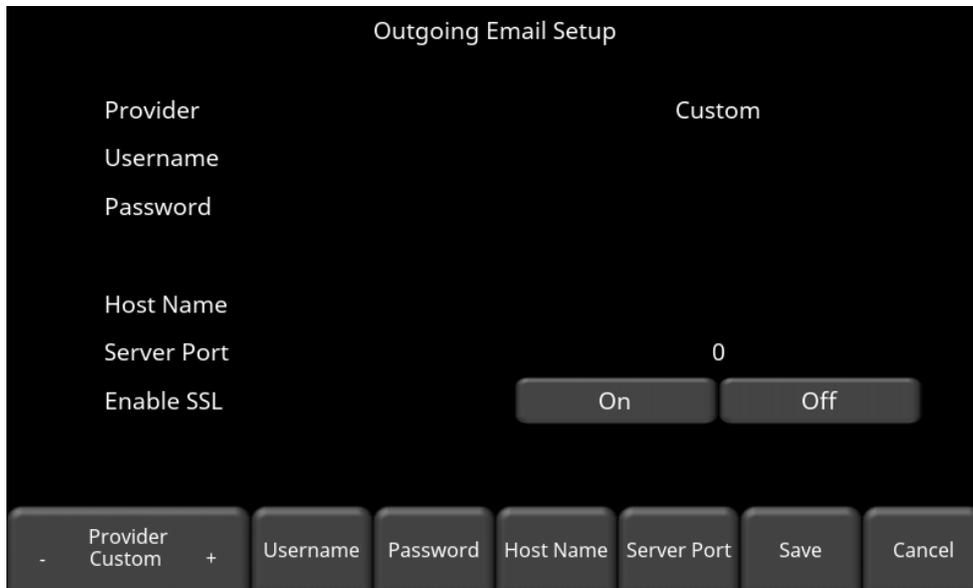
Figure 6-5: Entering e-mail address and password for another e-mail provider

- Press **Username** to display a keyboard where you can enter the <u>complete</u> e-mail address, then press OK when done.

- Press **Password** to display a keyboard where you can enter the password, then press OK when done.

- Press **Host Name** to display a keyboard where you can enter the name of the server address handling the outgoing mail. See chart below for some common e-mail providers. If your provider is not listed, it can usually be found by searching online for "SMTP host name <provider>", where provider is the host name eg. Yahoo or AOL. Press OK when done.

- Press **Server Port** to display a keyboard where you can enter the port number used by the email server. Searching online for host name will usually provide the port number for that e-mail provider. In most cases, it is usually 465 (if SSL is enabled, see next bullet point), or 587. See chart below for some examples. Press OK when done.

- Enable SSL – you can select **On** or **Off** on the display. SSL provides encryption security. Some e-mail providers require this set to ON. This will usually be indicated on the same online search page that was used above. See the chart below for examples.

- Press **Save** when all the information is entered and correct.

Below is the chart for some common e-mail providers:

Provider	Host name	Server Port	Enable SSL
Yahoo	smtp.mail.yahoo.com	465	On
Hotmail/Outlook	smtp.live.com	587	Off
iCloud	smtp.mail.me.com	587	Off
163.com	smtp.163.com	465	On
Yandex	smtp.yandex.com	465	On

If there are no warning messages, the e-mail address is setup properly and you are ready to e-mail mini-reports from the field.

Failed Setup

If setup failed, possible reasons include:

1. Email address or password was entered incorrectly – try re-entering these fields.

2. Hostname, port or SSL setting are incorrect

3. Your email security settings **may need** to be adjusted, which may require you to login to your e-mail account from a PC or mobile device. An example of the Gmail security settings is shown below (current as of writing this manual). For other e-mail providers, you may need to modify the settings accordingly.

   To edit the Gmail security settings, visit https://myaccount.google.com/ and sign into your account. You will then see the screen below. Click on **Connected apps & sites**
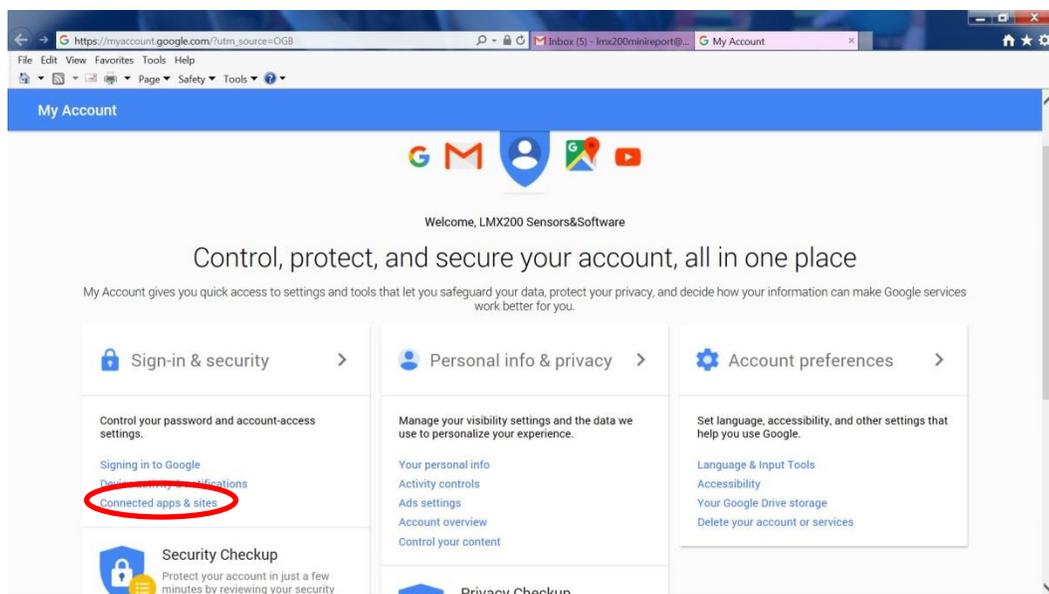
On the page that follows, ensure the setting "Allow less secure apps" is set to ON:
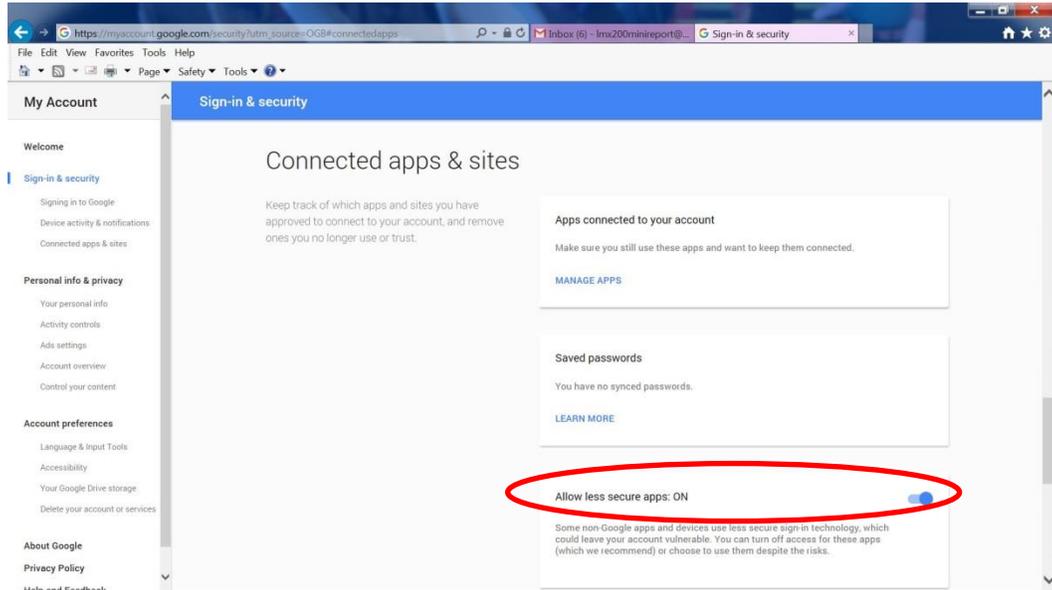
Screen Saver

A screen saver can be setup to turn off the DVL screen after a period of inactivity to save power. The Screen Saver can be set to turn the screen off after 1 minute, 5 minutes or never (OFF setting). Pressing this button cycles between those three options. When the screensaver is activated and the screen shuts off, touch anywhere on the screen to turn it back on again.

GPR Plot Options

Selecting this option will display the screen in Figure 6-6.

Figure 6-6: GPR Line Plot Options

- **Auto-Hide Buttons** - If this is set to ON, then in Line Scan mode, the buttons at the bottom of the screen disappear shortly after data collection begins, effectively enlarging the area for data display. The buttons will re-appear after a couple of seconds whenever the sensor stops moving forward, is in back-up mode or any button is pressed on the keypad.

Reset to Defaults

Selecting this option at the bottom of the screen will reset all settings & preferences back to the default settings (Figure 6-7). Pressing this will ask you to confirm the Reset to Defaults. If **Yes** is selected, the next screen will ask if you would like to remove all saved wireless networks and e-mails addresses.
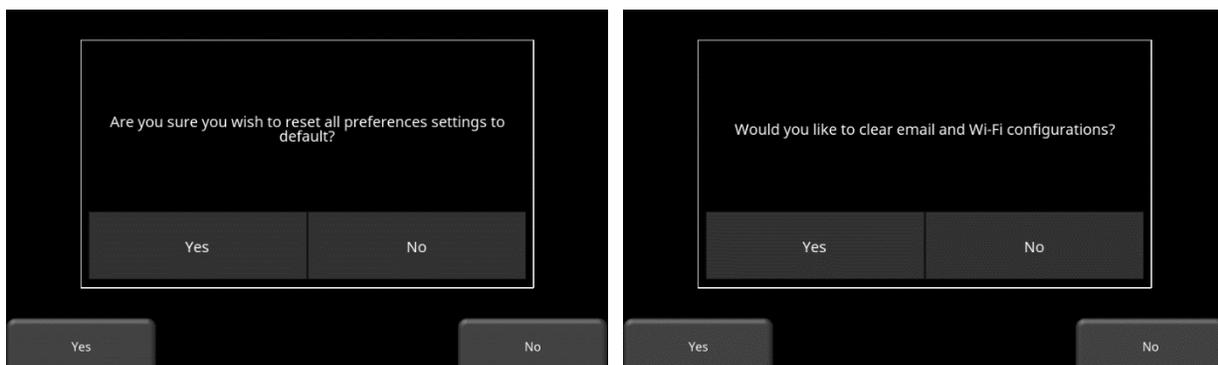
*Figure 6-7: Reset to Defaults, a) Image on left is the first confirmation screen. b) If you press **Yes**, you will see the second confirmation screen on the right asking about deleting e-mails and WiFi settings.*

6.2 File Management

Press **File Management** to enter this sub-menu. From here, the user can view screenshots, export data and delete all data. If you have the regular RD1500, you will see the image in Figure 6-8a. If you have the RD1500 Enhanced system, you will see the image in Figure 6-8b.
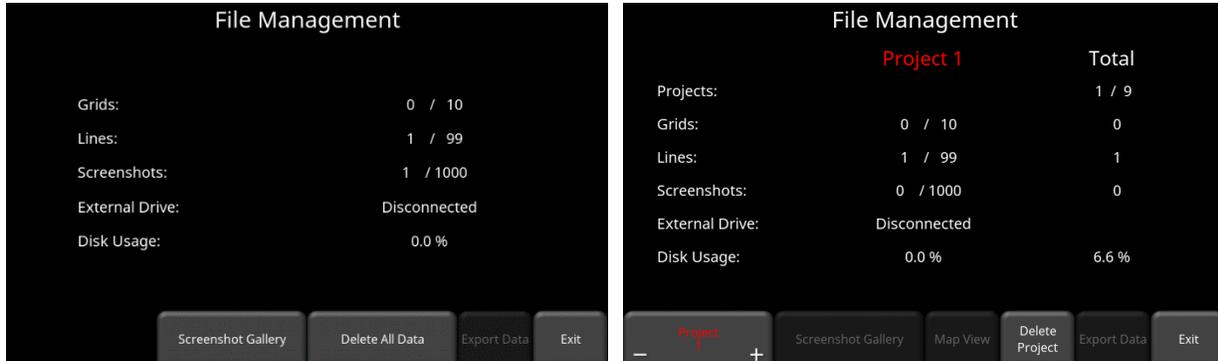
Figure 6-8: a) RD1500 system on left, displays the total number of lines, grids and screenshots saved on the system. b) The RD1500 Enhanced system on the right displays the lines, grids and screenshots for a given project in the middle column. The right column displays the total for each that are saved on the system.

A description of each of the buttons is given below:

Screenshot Gallery

This allows the user to view all screenshots that were saved by pressing the Camera button (see **Section 12.1 Capturing Screens**). The display will show a Tile View of four screenshots per page (Figure 6-9). If there are more than four screenshots saved, swipe the screen to the right and left to view the rest. Alternatively, you can also use the **Left** and **Right** arrow keys on the 4-way directional keypad.
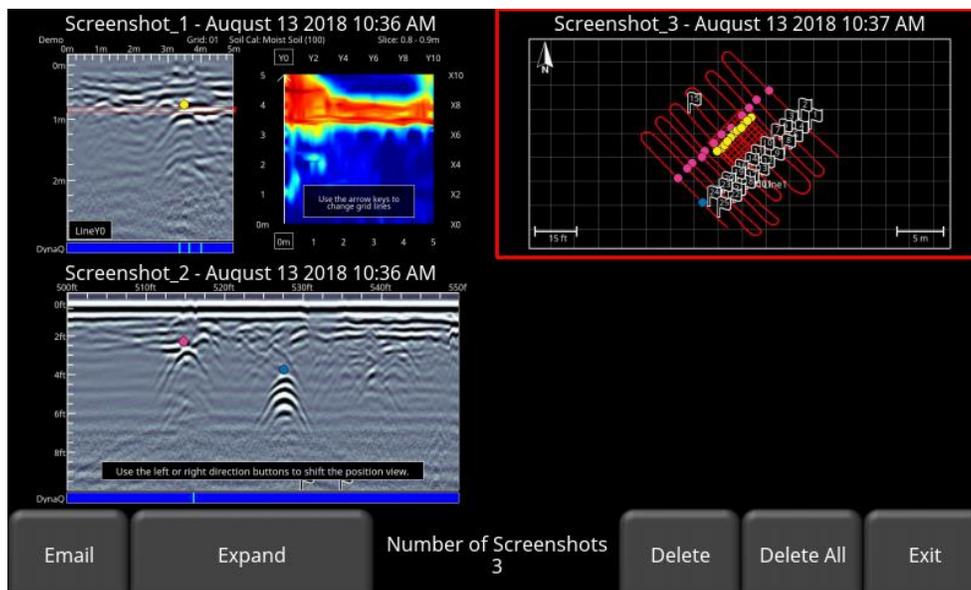
Figure 6-9: Tile View in Screenshot Gallery

From the Tile View, the user has the following options:

- **Email** – Pressing this button will e-mail the selected screenshot (provided you are connected to a wireless network and have set up an account to send from, see **Section 6.2. WiFi Settings** for details). You will be prompted to enter an email address, or you may use the most recent one which will be listed by default.

- **Delete** – Pressing this button will delete the displayed screenshot.

- **Delete All** – pressing this button will delete all screenshots. There will be a confirmation message asking if you are sure. Press **Yes** to proceed.

- **Expand** – Press this button to show the selected screenshot as a full screen image. On the subsequent screen, press **Tile View** to return to the screen that displays four screenshots per page.

Delete All Saved Data

Pressing this will delete *all* data saved on the system. There is a confirmation window asking if you are sure; press **Yes** to continue deleting, press **No** to cancel.

Delete Project (Enhanced system only)

Pressing this will delete the current project number. There is a confirmation window asking if you are sure; press **Yes** to continue deleting, press **No** to cancel.

Map View (Enhanced system only)

Pressing this will display a map view for all the data (lines and grids) in a given Project (Figure 6-10). For collected grids, Map View is enabled if a GPS (internal or external) was on during data collection. However, for lines, Map View will only be enabled if an external GPS was used.

Map View shows the survey path travelled, as well as any flags or interpretations ("interps") added to the data. Map View is fully explained in **Section 11**. While Map View is available in both configurations, the Map View button in File Management is only available in the Enhanced version.
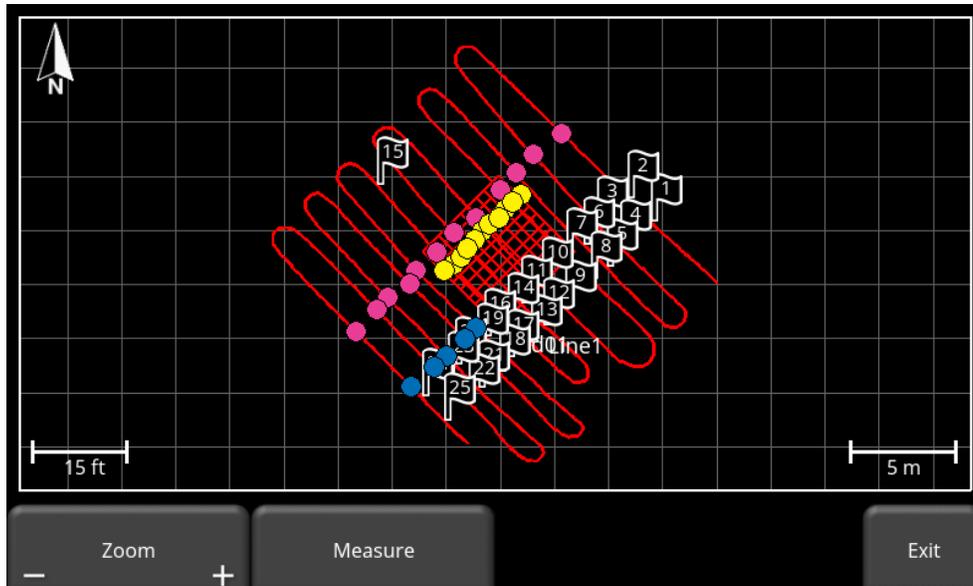
Figure 6-10: Map View showing two grids and a long line with interpretations. Map View is enabled because the data was collected with GPS.

Export Data

Screenshots and data are always saved to the internal memory of the Display Unit. If a USB-drive (memory stick) is inserted into the USB port on the Display Unit, pressing the **Export Data** button will copy all the data files to the USB-drive. If no USB-drive is inserted, this option will not be accessible.

6.3 System Test

The System Test sub-menu (Figure 6-11) allows the user to perform certain tests to ensure proper operation of the system. Select the component to test then press **Start**. After completing a test there is an indication of whether the system passed or failed the test. Each test is described below in more detail.
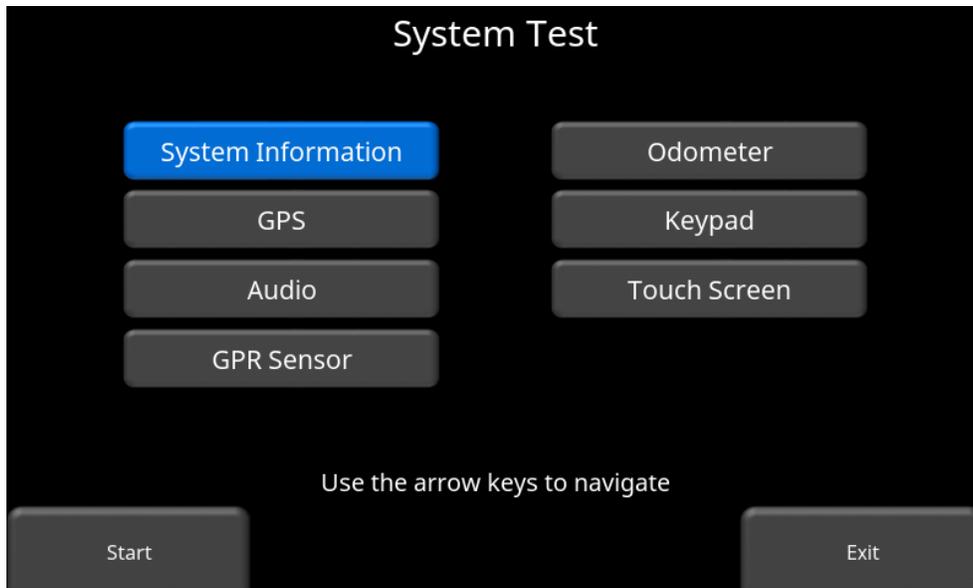
Figure 6-11: System Test menu

System Information

System Information is the only option in System Test, which is not actually a test. Here information such as the version, serial numbers, temperature and battery power is displayed (Figure 6-12). If a USB memory stick is currently inserted, pressing Export will just export these System Log Files.
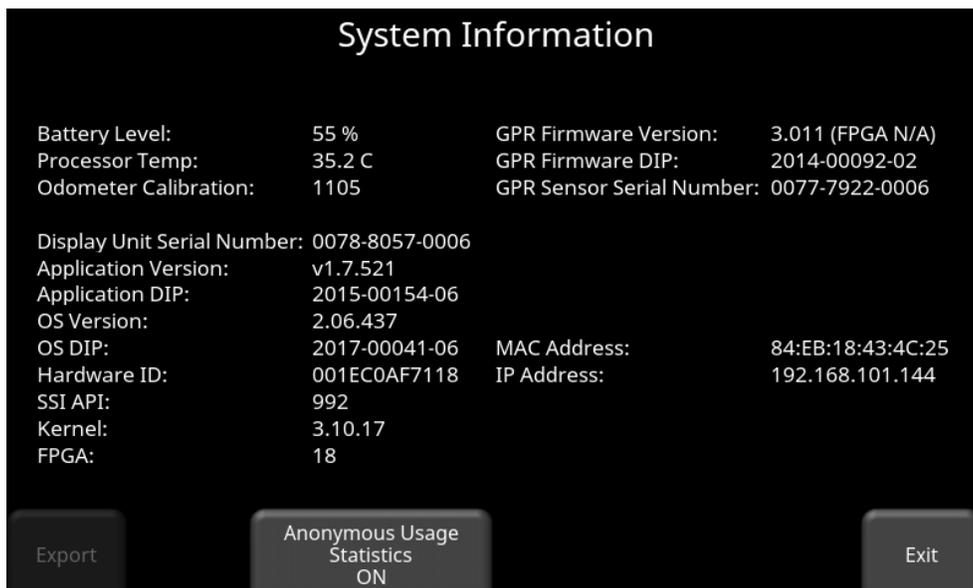
Figure 6-12: System Information

- **Anonymous Usage Statistics** - When this is set to ON and the user is connected to a wireless network, any system malfunctions will trigger an automatic notification to Sensors & Software. This is to help with gathering information about any system irregularities. As the name suggests, the notification is completely anonymous and no personal information is sent.

Keypad Test

The keypad test ensures that all buttons on the membrane keypad are working. Press **Start** to begin the test which requires the user to press each button once, within a 20 second timeframe (Figure 6-13).
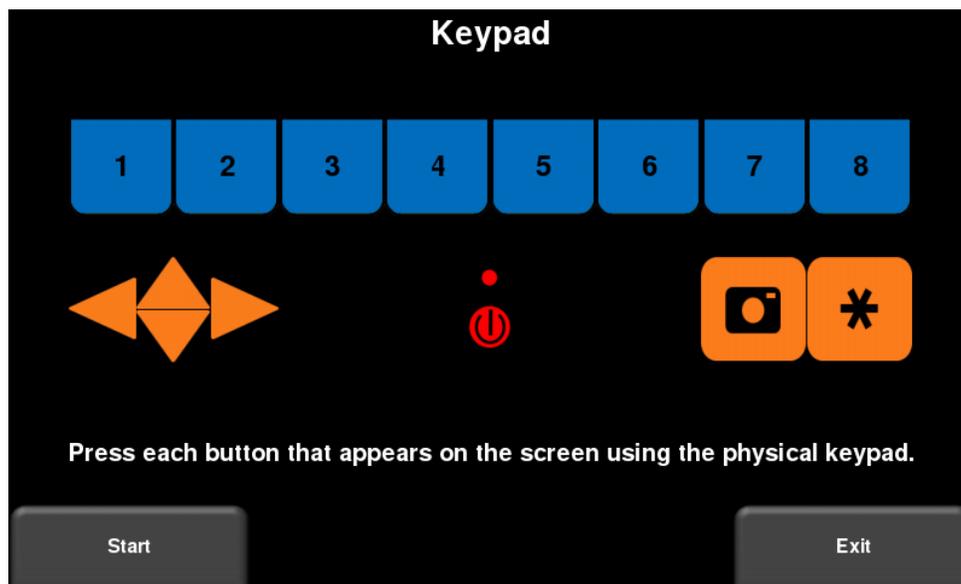
Figure 6-13: Keypad Test

Once that is complete, a short LED test will ensue, which checks for proper operation of the LED.

Audio

This test ensures that the speaker is operating properly. After starting the test, you should hear a sound with an increasing pitch.
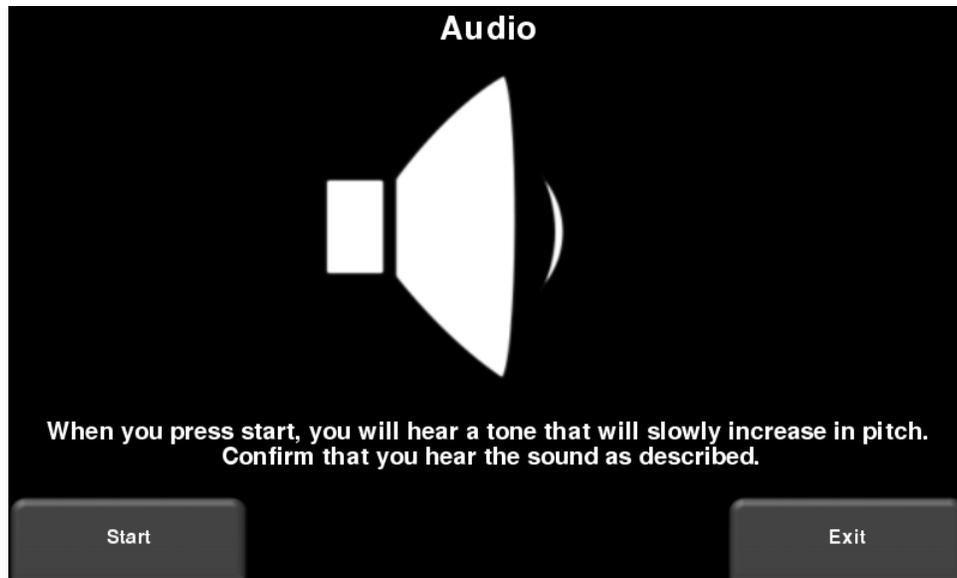
Figure 6-14: Audio Test

Touch Screen

This test checks proper operation of the touch screen (Figure 6-15). It allows you to test the screen (by pressing **Test**) or perform a quick calibration followed by a test (by pressing **Calibrate**). Both involve touching targets on the screen in the allotted time.
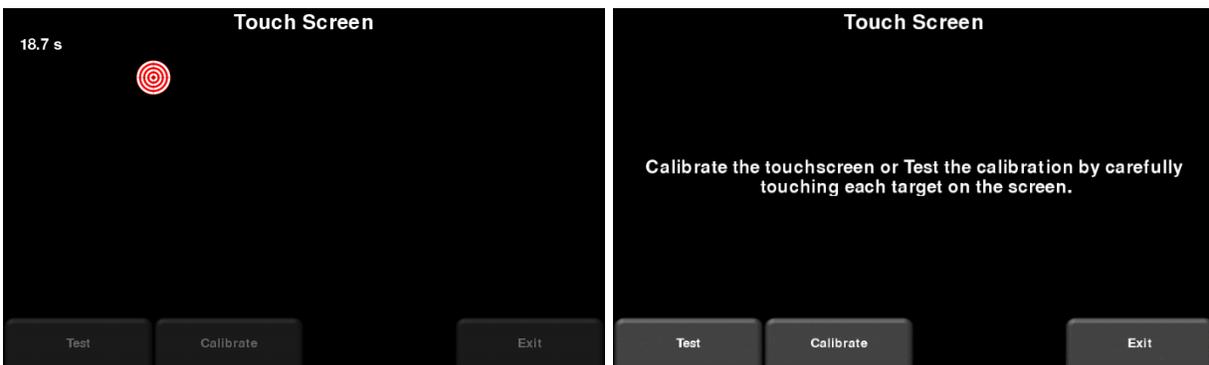
Figure 6-15: Touch Screen test on the left, Touch Screen calibration test on the right

Sensor Test

This test checks proper operation of the GPR sensor, including the amplitude of the pulse. Once the cart is tipped backwards and **Start** is pressed, it will conduct the test (Figure 6-16). If there are any irregularities, the test will indicate failure.
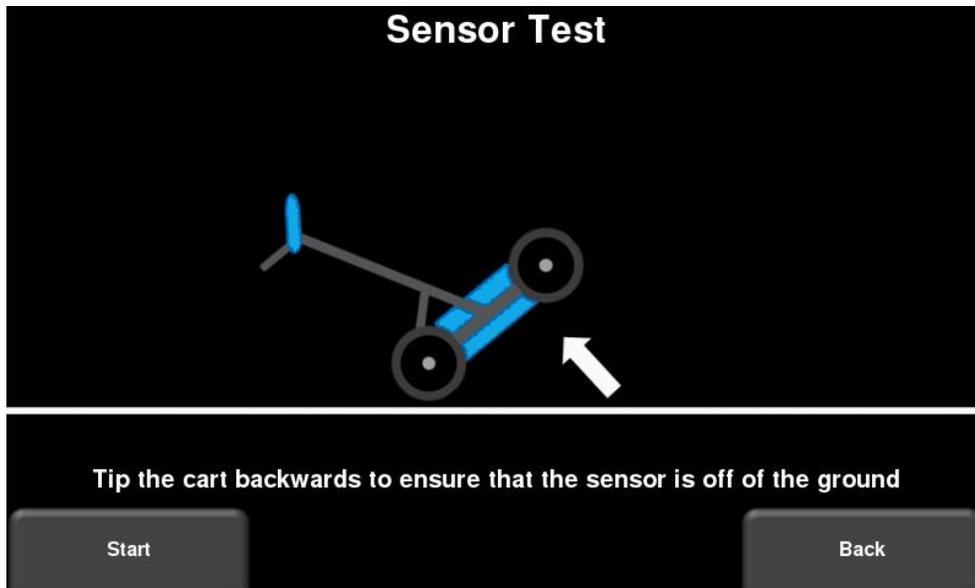
Figure 6-16: Sensor Test

6.4 Odometer Calibration

This test ensures that the odometer is calibrated properly for distance. Even though the odometer is calibrated in the factory, you must calibrate it periodically to ensure accuracy. This is particularly important as the calibration can change with different surface materials.

When selecting this option, you will see the screen in Figure 6-17. The following options exist:
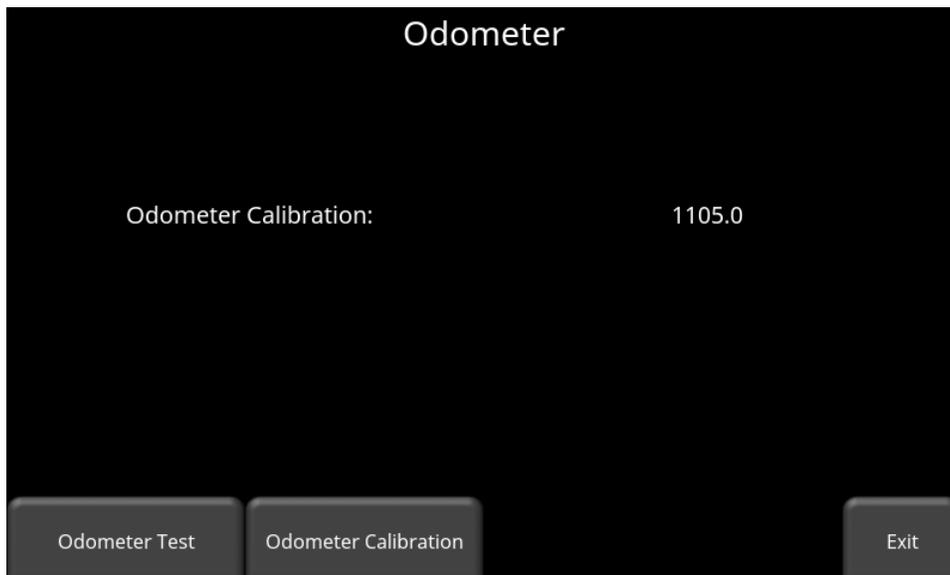
Figure 6-17: Screen displaying current odometer calibration

- **Odometer Test** – This test verifies the odometer is calibrated properly. It involves moving the system a set distance (5m or 10', depending on units used), and comparing the value obtained to a known value. The screen in Figure 6-18 will be displayed once Odometer Test is pressed. Press **Start** to begin and then press **Finish** when you've moved that distance. It will display a pass or fail, along with a percentage difference from the known value (Figure 6-19).
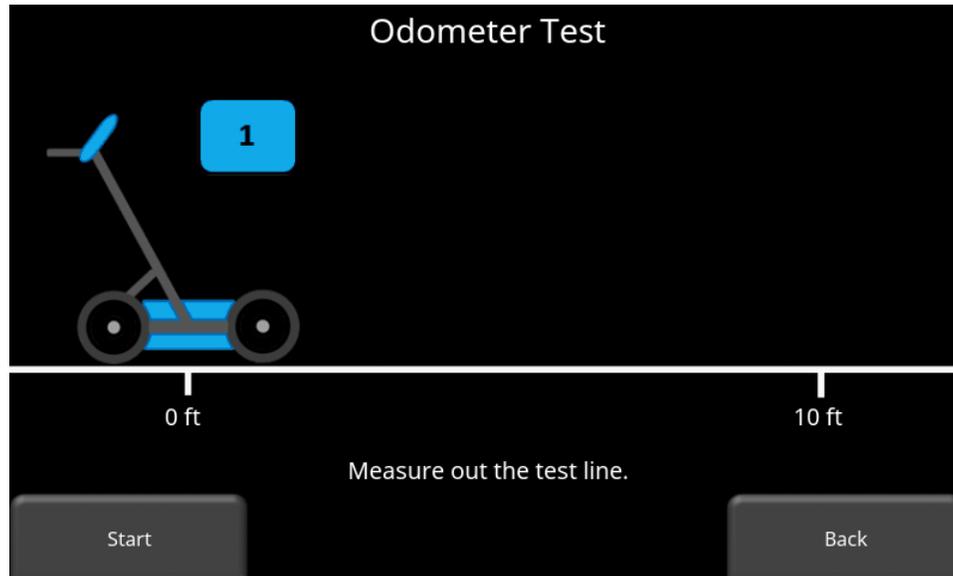
Figure 6-18: Doing an odometer test
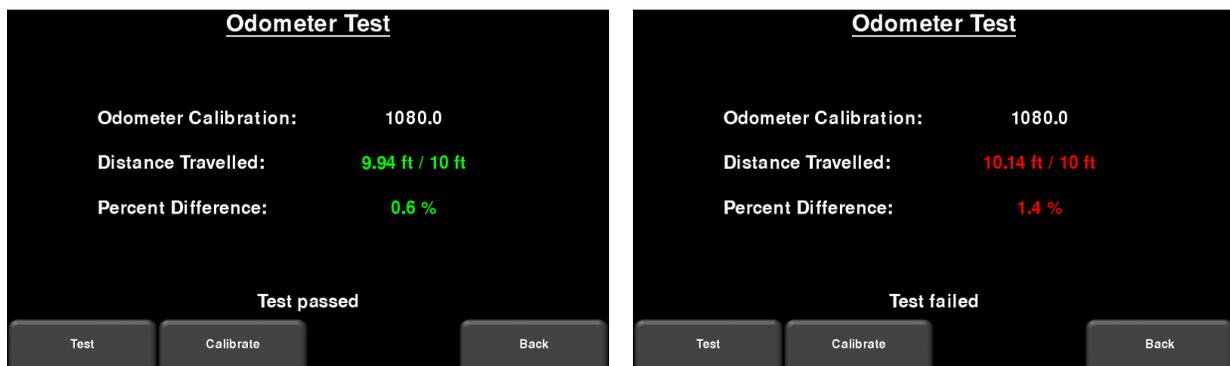
Figure 6-19: Odometer Test passed on left, failed on the right

- **Odometer Calibration** - This option actually calibrates the odometer (Figure 6-20). Choose a set distance from the screen, or select Custom. Then press **Start** and then move the system that exact distance, using a measuring tape or other known distance indicator. Press **Finish** when you have travelled that distance

---
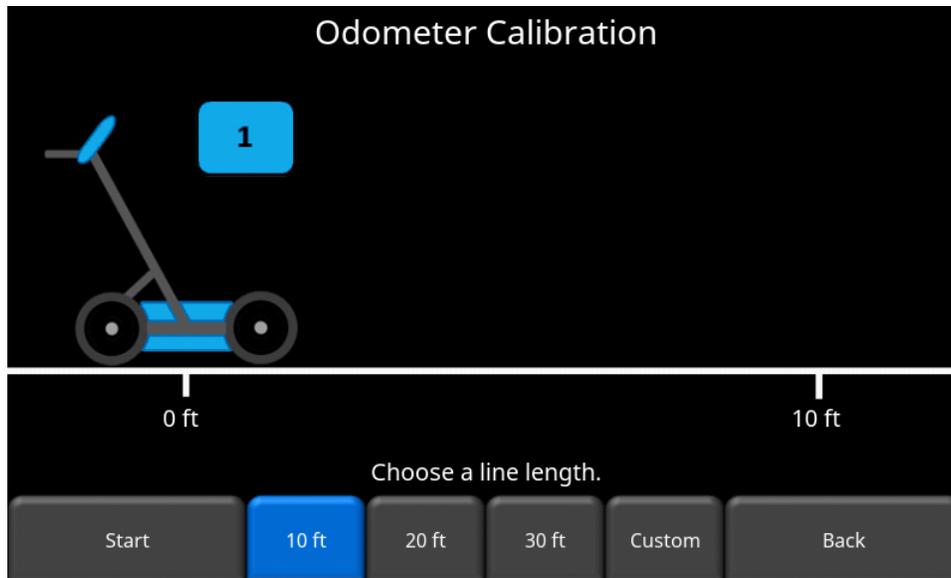
Figure 6-20: Odometer Calibration – select a distance and then press Start

Upon completion, it displays the screen in Figure 6-21 (left image). You can either accept the new value by pressing **Accept**, or revert back to the previous value by pressing **Reject**. If the new value is significantly out of range, the test will fail Figure 6-21 (right image).

The odometer calibration value is stored in the Display Unit. If the Display Unit is changed, or swapped out, you will need to run the Odometer Calibration test again.
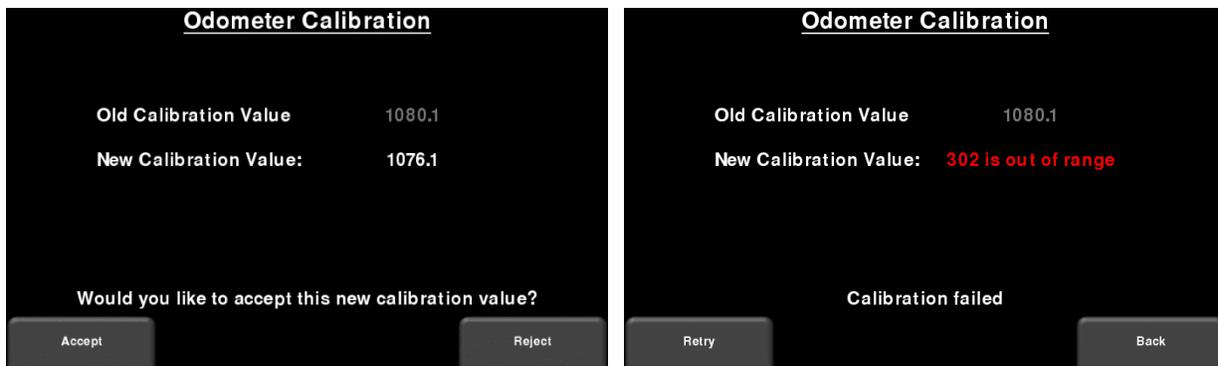
Figure 6-21: Results of Odometer Calibration (L). Image on right shows a failure, as calibration is way out of range

GPS

The GPS test will ensure that the system is communicating properly with the GPS and receiving data (Figure 6-22).

Figure 6-22: GPS Test

The basic position and time information is displayed on the screen. On the screen, the Fix Type notes if there are any corrections being applied, such as DGPS.

Pressing **Strings** will display the raw data strings that are outputted by the GPS (Figure 6-23) as they scroll down the screen. The user may select this option to verify the GPS is outputting the proper NMEA string format.

Figure 6-23: GPS Strings

Pressing **Clear** will clear the strings. Pressing **Info** will return to the main GPS test menu.

Press **GPS Setup** to see the screen in Figure 6-24.
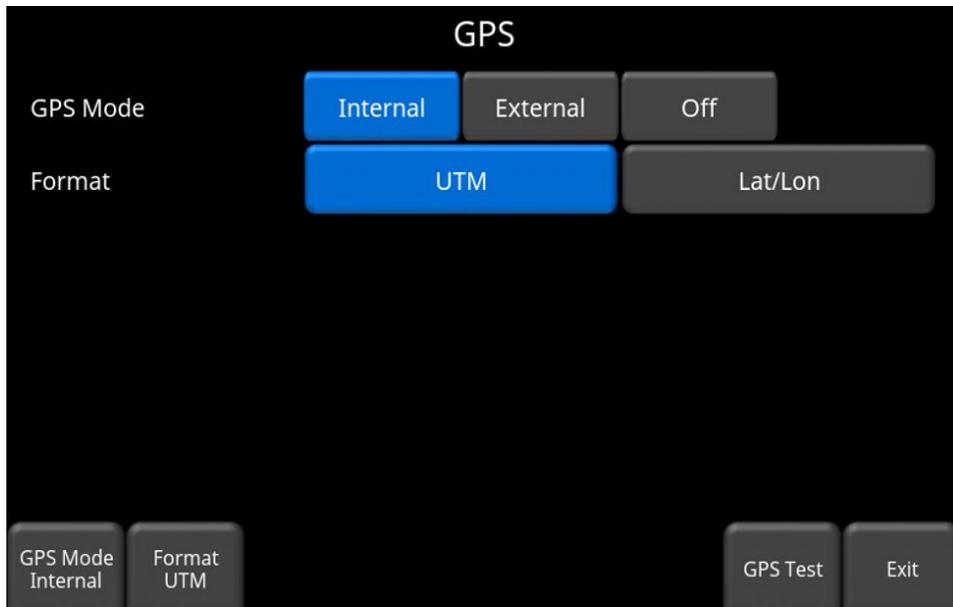
Figure 6-24: GPS Setup screen

The display buttons are explained below:

- ○ **GPS Mode** –you can select whether to use the internal GPS, external GPS or no GPS at all (Off)

- ○ **Format** – GPS units can be either UTM (Universal Transverse Mercator) or Latitude/Longitude coordinates

- ○ **GPS Test** – pressing this will return to the screen in Figure 6-23.

Section 7 - GPR Concepts

7.1 Theory

Ground Penetrating Radar (GPR) technology uses radio waves to image objects in the subsurface. GPR systems emit high frequency radio wave pulses and detect the echoes that return from objects within the subsurface. Echoes are produced when the target material is different from the host material (eg. PVC pipe in gravel)
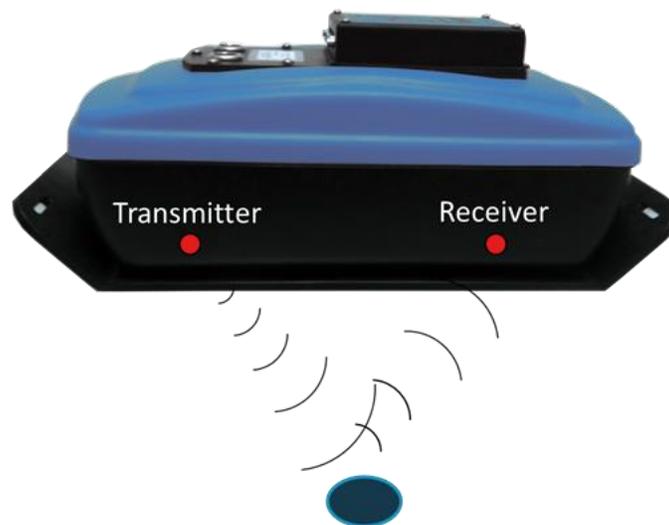
7.2 Hyperbolas

The GPR display shows signal amplitude versus depth (time) and sensor position along a line. This is called a "Line Scan". Since radar energy radiates in a 3D cone shape rather than a thin beam, a **hyperbola** (or inverted U) is the GPR response from a small point target like a pipe, rock, or a tree root. The radar wave hits the object before and after going over it and forms a hyperbolic reflection that can appear on the record even though the object is not directly below the radar:
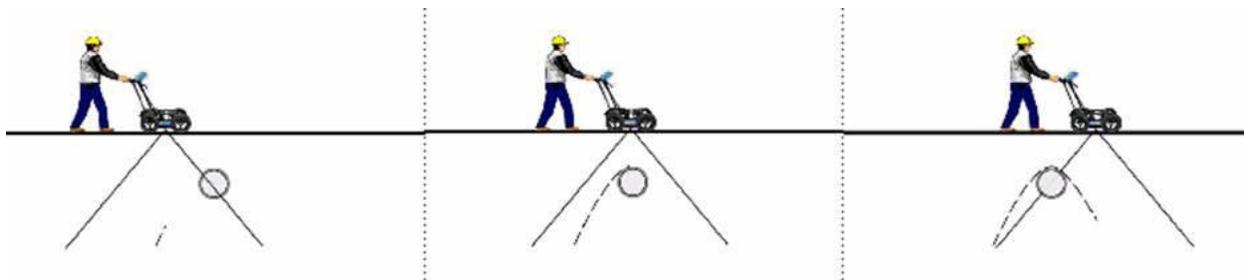
Hyperbolas are best viewed when subsurface targets are crossed perpendicularly or at a 90-degree angle. The actual position of the object is located at the apex of the hyperbola.
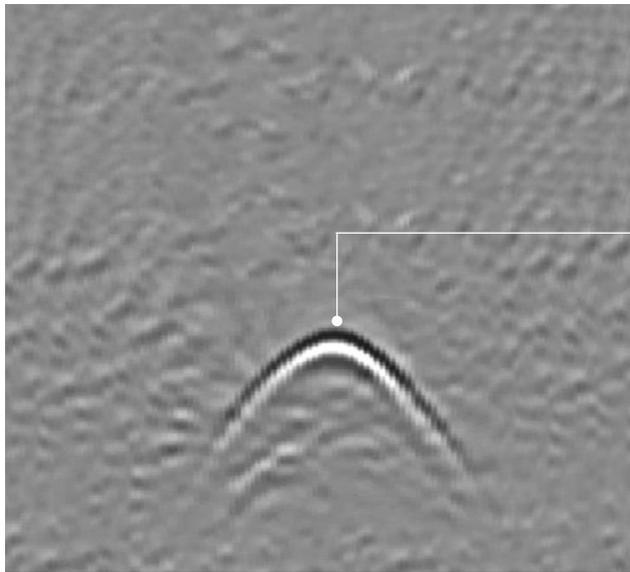
Apex of hyperbola is where the object is located

7.3 Calculating Depth

Ground penetrating radar records the time it takes a radio wave to travel to a target and back; it does not measure the depth to that target directly. Depth to target is calculated based on the velocity with which the wave travels to the target and back.

To calculate depth:

$$D = V \ x \ T/2$$

$$Where \ D \ is \ Depth$$

$$V \ is \ Velocity$$

$$T \ is \ the \ Two-way \ travel \ time$$

For the RD1500, velocity is indicated by the Soil Calibration Value, known as Soil Cal. Once the Soil Cal values are set, the measured depths will be determined accurately (Section 8.6).

7.4 Soil Calibration values

Below is a table of common subsurface materials and their corresponding Soil Cal. This is only a guideline and there is some variation based on the fact that there can be a mixture of different materials in the subsurface. The soil water content has the biggest influence, by far, on Soil Cal values.

Material	Soil Cal
Air	300
Ice	160
Dry Soil	140
Dry Rock	120
Soil	100
Wet Rock	100
Concrete	100
Pavement	100
Wet Soil	65
Water	33

7.5 Air Waves

Some hyperbolas are caused by air wave reflections from objects above ground, such as posts, fences, overhead wires, and trees.

The following image displays how air wave reflections affect data:
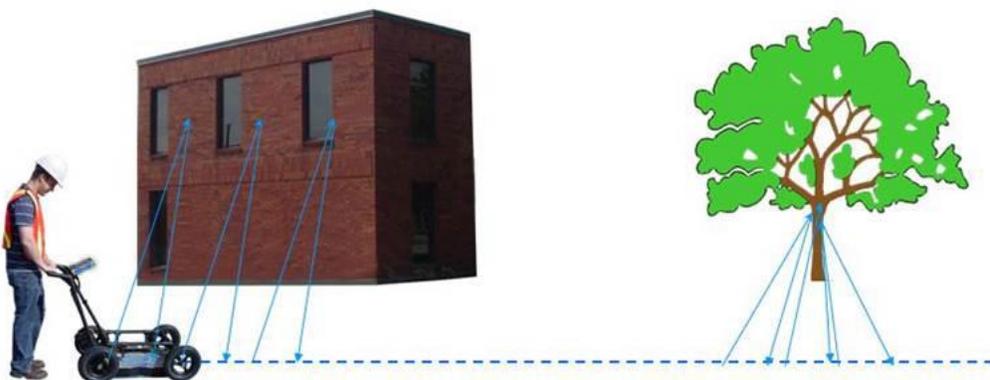
An important part of understanding the data image is learning to recognize these unwanted "air" targets and distinguish them from the targets in the ground. Good field notes are indispensable for helping identify unwanted events on the data.

The best way to identify air reflections is the target hyperbola method. Hyperbolas from above ground objects are wider than objects in the ground and will have a Soil Cal at, or close to, 300.

To learn more, see **Soil Cal** in **Section 8.6**.

Section 8 - Line Scan

Line Scan mode allows the operator to acquire data along a straight line and examine it as a cross-section image. The operator can locate a feature and easily back-up and mark the location of that object on the ground. Line Scan mode can be used to identify the alignment of subsurface features, check for linearity and acquire accurate depth measurements.

If you have the RD1500 Enhanced, ensure you are in the appropriate project before entering this mode.

From the main screen, press the **Line Scan** button; you will see the screen shown in Figure 8-1.
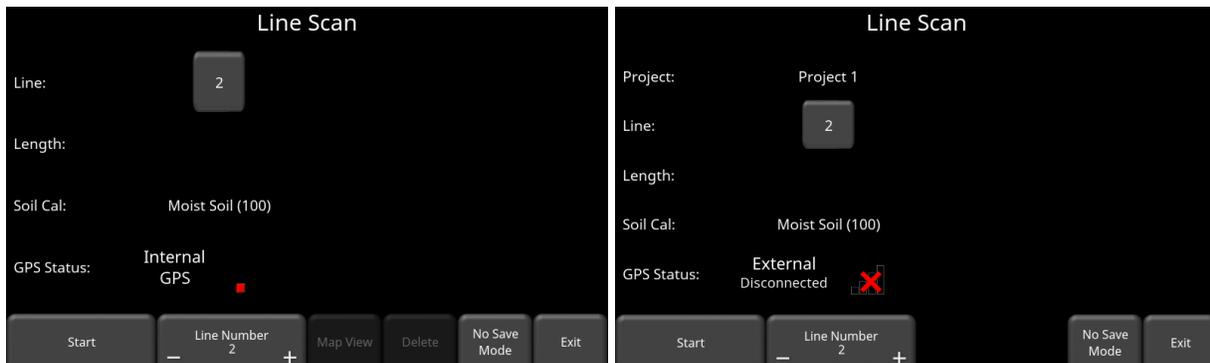
Figure 8-1: (a) RD1500 on left, (b) RD1500 Enhanced on right. The RD1500 has the MapView option on this screen

The GPS Status indicates which GPS is currently selected, as well as the quality of the GPS signal, which is based on the number of satellites that it sees.. The chart below explains what the colours and bars mean:

Indicator Color	# of bars	# of Satellites
Red	1	4
Orange	2	5
Green	3	6,7
Green	4	8,9
Green	5	10+

8.1 Selecting a line

To select the desired line, press the **+** and **-** buttons under **Line Number** on the bottom of the screen. Alternatively, pressing the line number button itself will show the screen in **Error! Reference source not found.**. From here, you can go directly to any line number. If the line number is white, then that line is empty, whereas lines that already contain data are shown in red.

To collect data without saving it, press **No Save Mode**. Any data collected will NOT be saved, but screen shots can still be taken with the **Camera** button. These screen shots get placed in the currently selected project. Two features that are only available in **No Save Mode** (the **Pause** button and the ability to draw arrows) are described in Section 8.6.

If the line number is white (Figure 8-1), Press **Start** to enter data acquisition. All data collected will be saved under this line number.

If the line number is shown in red (Figure 8-2), you will see the data preview on the right side of the screen. If it's a long line, only the last part of the data will be shown. From this screen, you will have the following options available:

- **View** – **press this button to review the currently displayed line**. See Section 6 on Line Scan menu options
- **Delete** – pressing this will delete the line. It will prompt you to confirm before deleting.

When using the RD1500, there is a Map View button at the bottom of the Line Scan screen. The details of the Map View button are explained in Section 9.

When using the RD1500 Enhanced, the Map View button is accessible from the main menu.
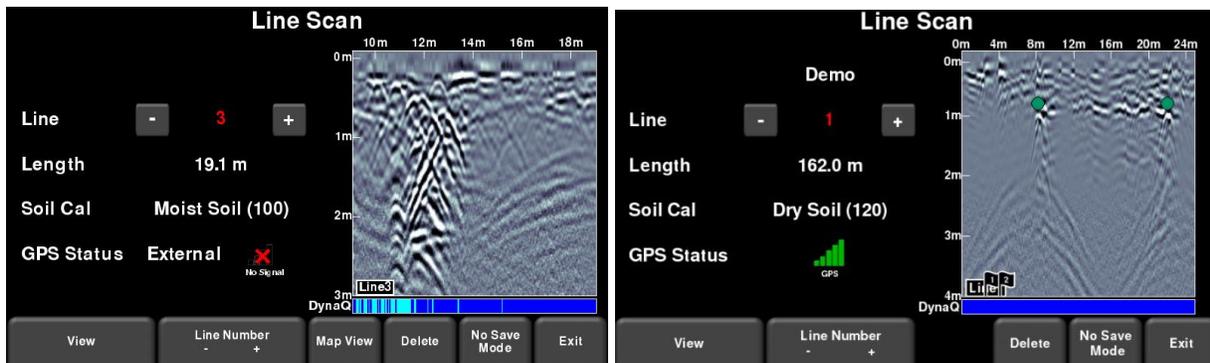
Figure 8-2: Line Scan mode, showing a line that was previously collected (a) RD1500 on left, (b) RD1500 Enhanced on right. The RD1500 has the MapView option on this screen.

8.2 Acquiring Data

Press the **Start** button to begin collecting data. The screen will change to the data acquisition screen. As the system is pushed along a straight line, the GPR data collected scrolls onto the screen from the right and moves to the left (Figure 8-3).

The depth scale along the side of the GPR Line image and the position scale along the top of the image are set to Metric or US Standard units based on the setting in the Preferences menu (6.1).

If **Auto-Hide Buttons** is set to **ON** (Section 6.1), the menu at the bottom of the screen disappears as soon as you start collecting new data, thereby maximizing the data display area. When the user stops, backs up or presses a button on the keypad the menu reappears.
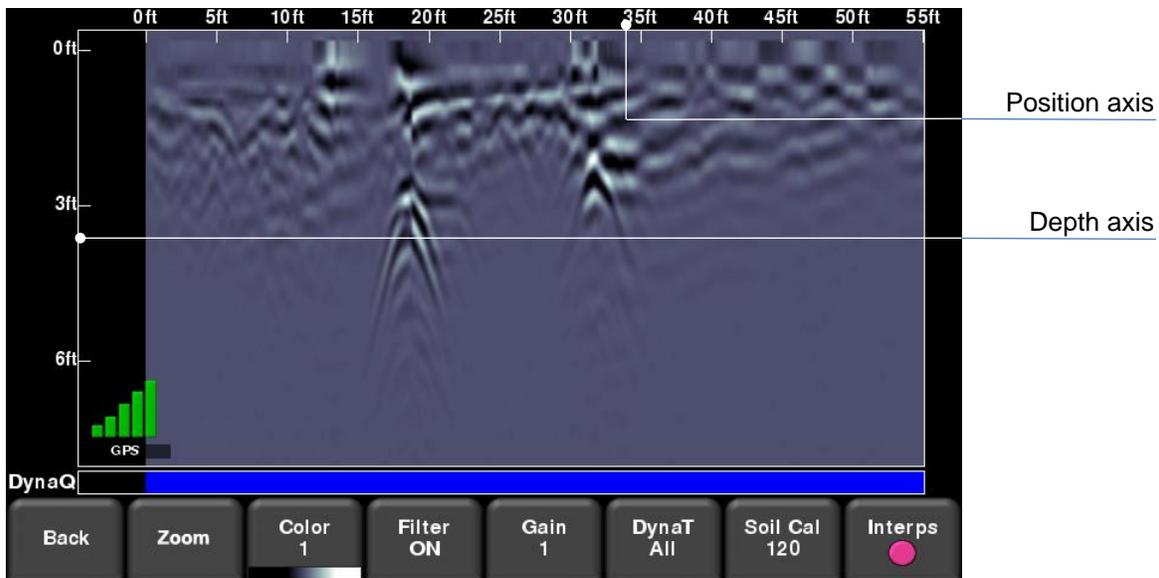
Figure 8-3: Line Scan acquisition mode, showing collected data and axis labels

8.3 DynaQ™

The RD1500 uses DynaQ, an advanced patented technology that adjusts data quality as the system movement speed varies. In most situations, moving the system at a comfortable walking speed generates data of good quality. In situations where target resolution or maximum penetration depth is critical, moving more slowly increases data quality.

As the Line Scan data scrolls on the screen, the DynaQ Index Bar is displayed along the bottom of the screen (Figure 8-3). The color of the bar indicates the quality of the data at that point along the line:

White	=	No Data (too fast!)
Yellow	=	Moderate quality
Light blue	=	Better quality
Dark Blue	=	Highest quality

In general, avoid collecting data at extremely high speeds.

8.4 Back-up Indicator

Line Scan mode incorporates a back-up feature to enable you to accurately locate targets and mark them on the ground. After acquiring some data on the screen, move the system backwards (Figure 8-4a). During back-up mode, there will be two indicators:

- **Position Indicator**: The red vertical line corresponds to the location at the center of the GPR sensor. As you pull the cart backwards, the Position Indicator moves to mark the current

location of the cart in the image and a box appears with the current position, relative to the start of the line, listed as the top number.
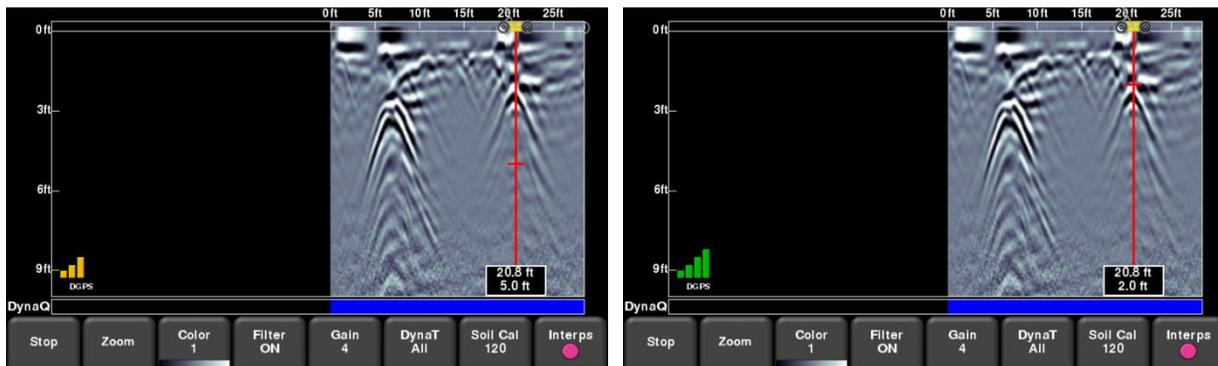
Figure 8-4: a) Back-up Indicator, b) Moving the Depth Indicator to the top of the hyperbola

- **Depth Indicator**: A short red horizontal line corresponds to the current depth value, as shown in the bottom number in the box. To determine the depth of an object, move the indicator up or down by dragging the horizontal line to the desired location (Figure 8-4b). Alternatively, you can also use the **Up** and **Down** arrows on the 4-way directional keypad.

NOTE: Make sure you have done a Soil Cal to ensure depth accuracy (see **Section 8.6**).

To locate a feature, simply roll the system back along the same path until the red vertical line is exactly over the response (usually a hyperbola). You can mark the location of the object on the surface and continue data collection. Once you reach the point where you initially started backing-up, the system will continue acquiring new data.

You can also obtain depth and position information anywhere on the Line Scan by touching the screen and holding for a second. A cross-hair appears where you touched the screen, with a box displaying the position and depth (Figure 8-5). To get the position and depth information about a different point on the screen, simply touch and drag the box or cross-hair to the desired position.
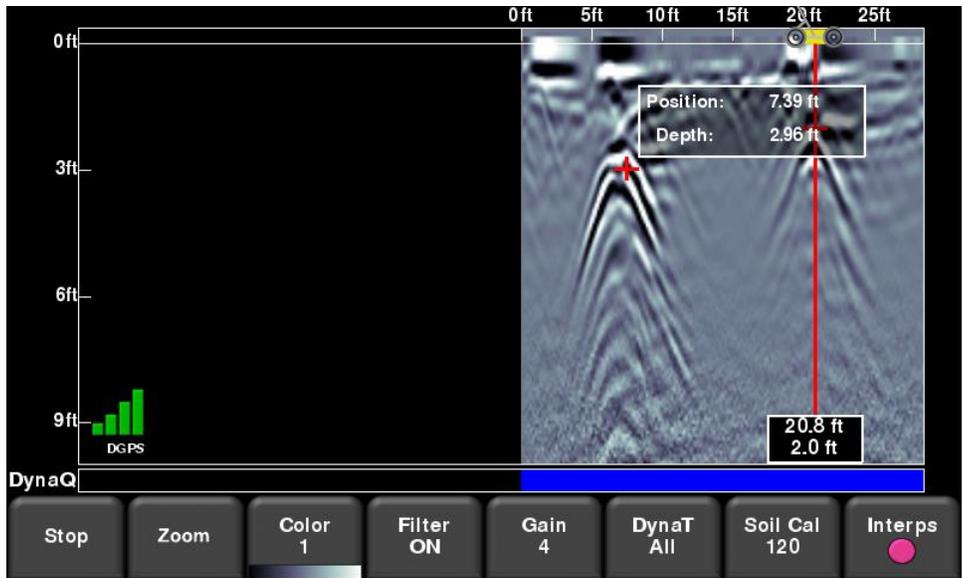
Figure 8-5: Touch screen to get depth and horizontal position at any point

Pressing **Stop** ends the line. This line is saved internally on the system and cannot be added to. Use the Left and Right directional arrow buttons to scroll and view data not currently displayed on the screen.

8.5 Flags

Flags are often inserted to mark noteworthy surface features, such as poles, sidewalks, changes in terrain etc. These markers may help you correlate subsurface targets with above ground features.

Pressing the **asterisk (*)** button on the keypad will insert a flag at your current position, either during forward data acquisition or when backed-up. Flags are sequentially numbered (see Figure 8-6).
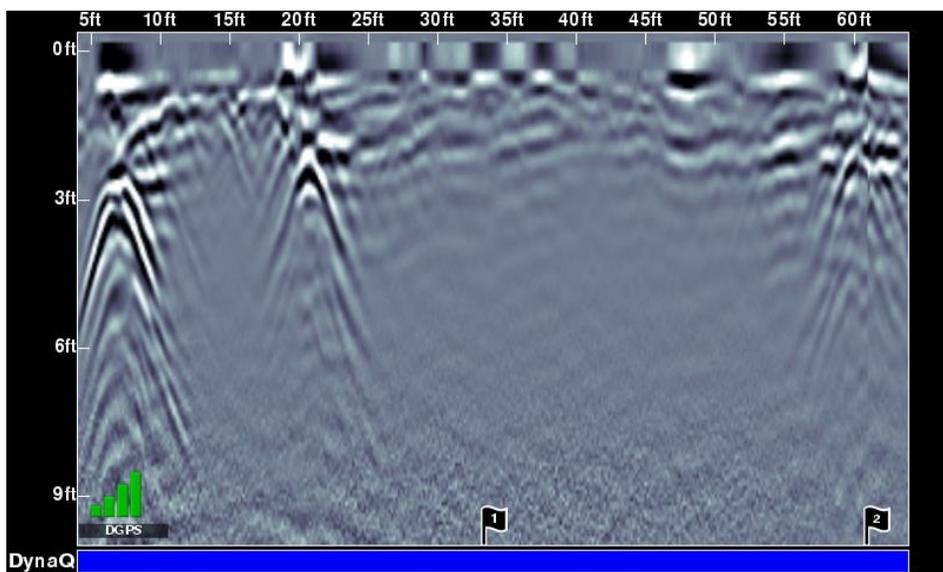
Figure 8-6: Inserting Flags

8.6 Line Scan menu options

All the settings described below change the way the data is viewed on the screen. They do not alter the saved data in any way. These settings can be altered while you are still collecting data, after you have pressed **Stop** or when viewing a previously saved line.

Zoom

This button controls the horizontal and vertical scaling of the displayed GPR data. Pressing the **Zoom** button changes the buttons on the bottom menu, which are explained below:

- **Depth** – Pressing **+** and **-** under the **Depth** button allows you to change the display depth of the data. This is commonly referred to as the depth window. The pre-set values range from 1m to 8m (3' to 25'), see Figure 8-7.

  If the data was collected with a shallower depth, the depth setting can still be increased after the fact, when reviewing the data. In general, it is recommended that you set your displayed depth to 1.5 - 2 times the depth you expect the deepest target to be.

- **Position** – Pressing **+** and **-** under the **Position** button allows you to change the length of data displayed on a single screen. This is also known as horizontal scaling. The pre-set values range from 10m to 30m (25' to 100'), see Figure 8-8.

  One reason for setting this to 30m (100') would be to fit more data on the screen and look for consistency among hyperbolas that were crossed.
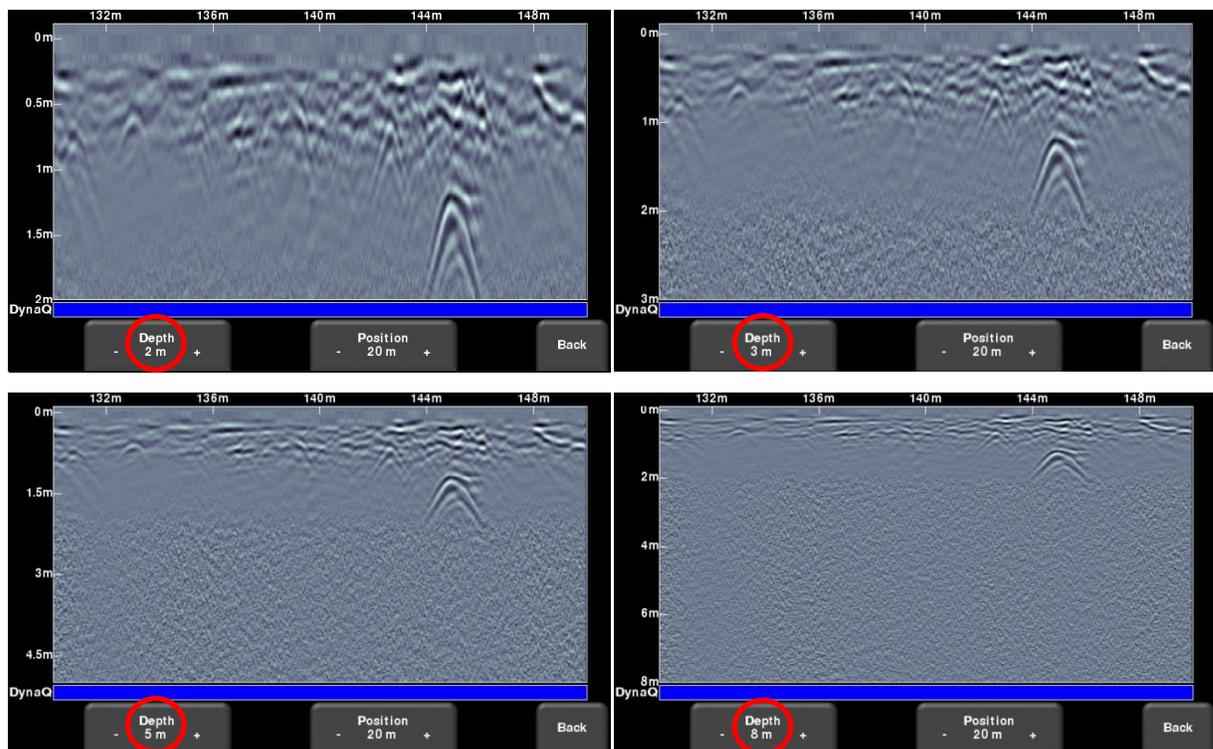
Figure 8-7: Varying displayed depth
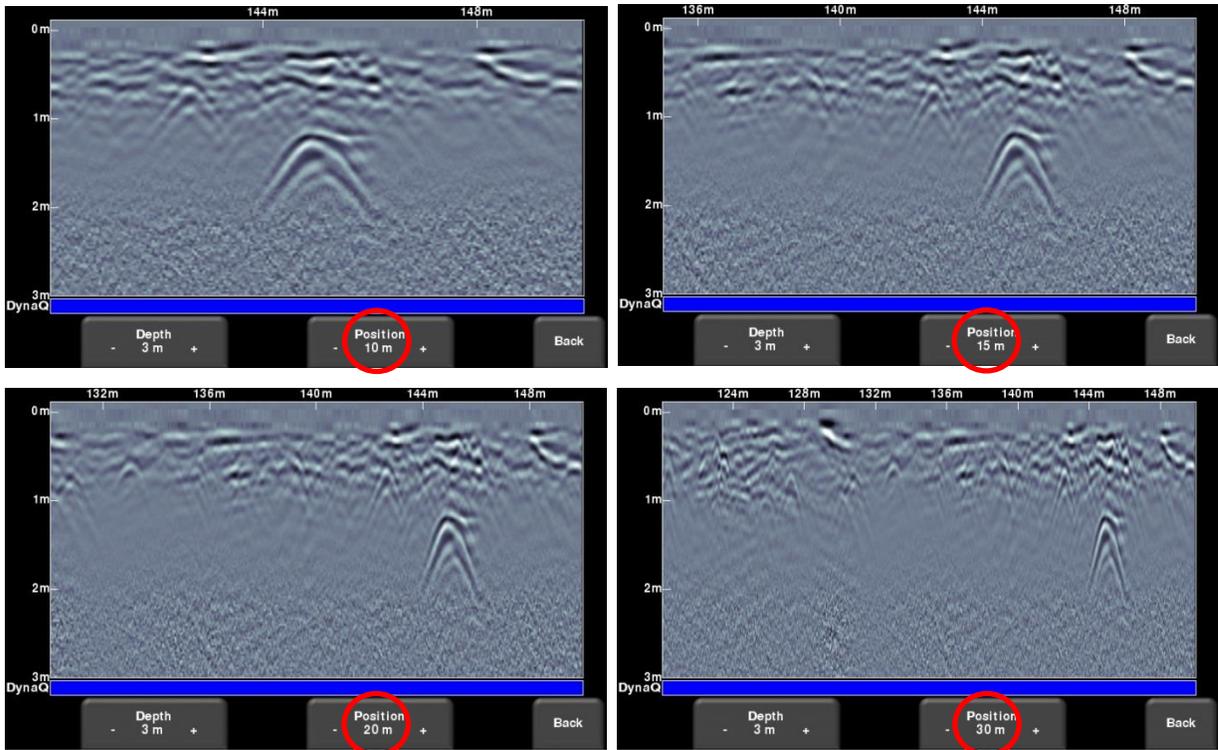
Figure 8-8: Varying position or horizontal scaling

Color

Pressing **Color** changes the color palette for the GPR Lines. There are 8 different color palette options. The image is automatically re-displayed as the color palette changes. A few sample color palettes are shown in Figure 8-9.
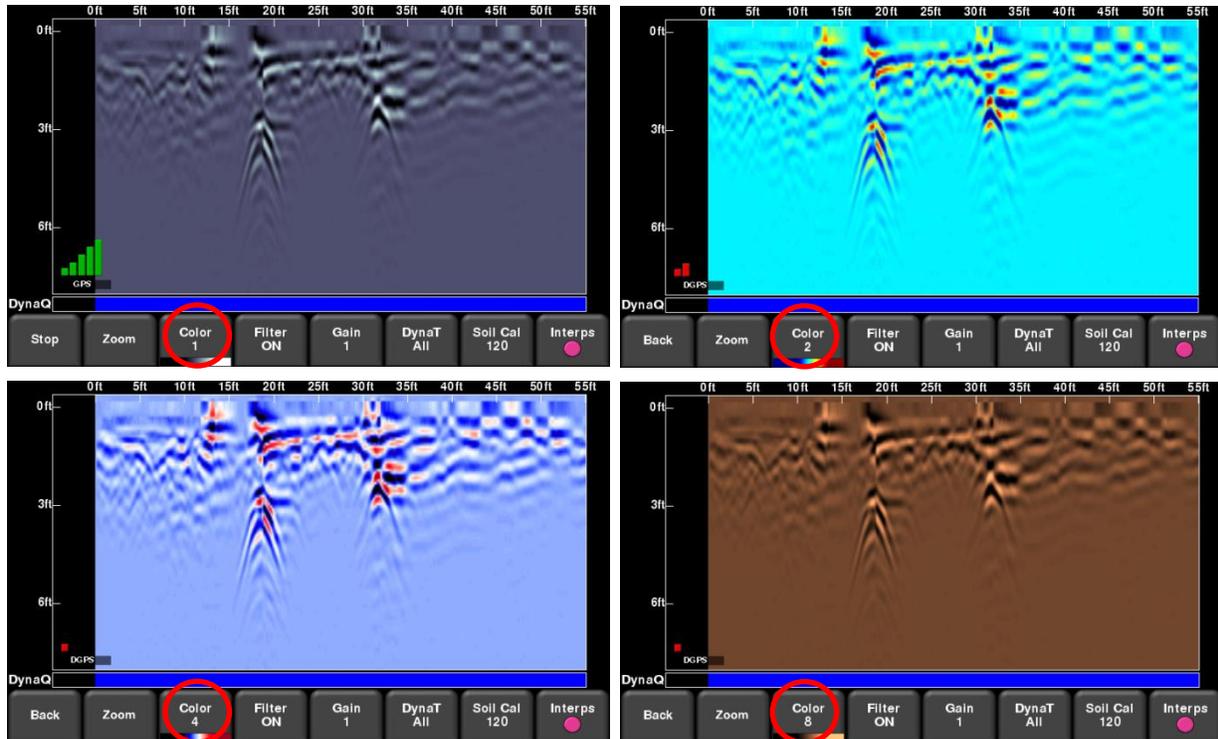
Figure 8-9: Changing Color palettes

Filter

When the filter is **ON**, flat-lying responses in the data are filtered out so that hyperbolic responses from objects are enhanced (Figure 8-10). Filtering also helps identify shallow targets that might be masked by the strong signals at the top of the image. However, it will also filter out other flat-lying responses, such as soil boundaries, so be careful when using this option if your target is flat. The filter is set to **ON** by default.
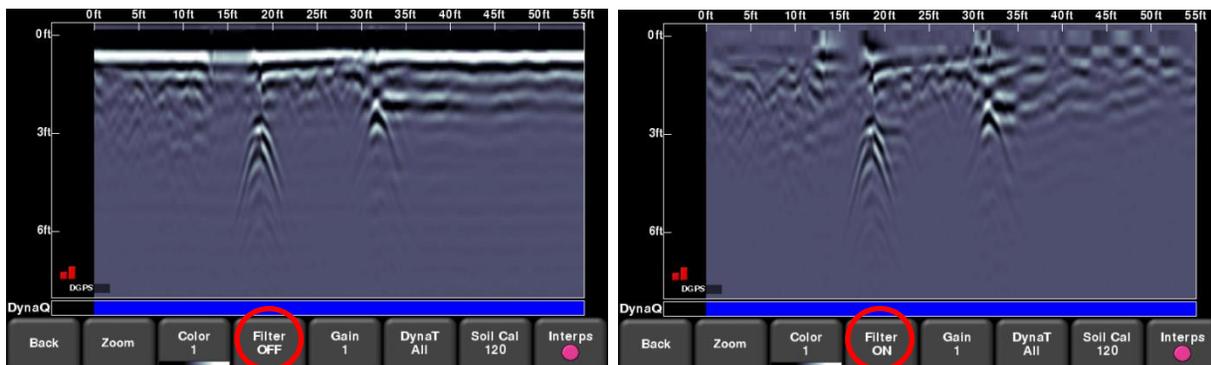
*Figure 8-10: Left image shows **Filter OFF**, while the right shows the same data with the **Filter ON**.*

Gain

Since the material being scanned absorbs the GPR signal, deeper targets return weaker signals. Gain acts like an audio volume control, amplifying signals and making deeper targets appear stronger in the image. Gain values vary from 1 to 9 where 1 means a minimal amplification has been applied and 9 means that maximum amplification has been applied. Pressing this button increments the gain; once you reach 9 it cycles back to 1.

Avoid over-gaining the data as it can make interpretation difficult (Figure 8-11). In general, soils that are more electrically conductive (eg. clays) will require a higher gain compared to soils that are less electrically conductive (eg. sand).
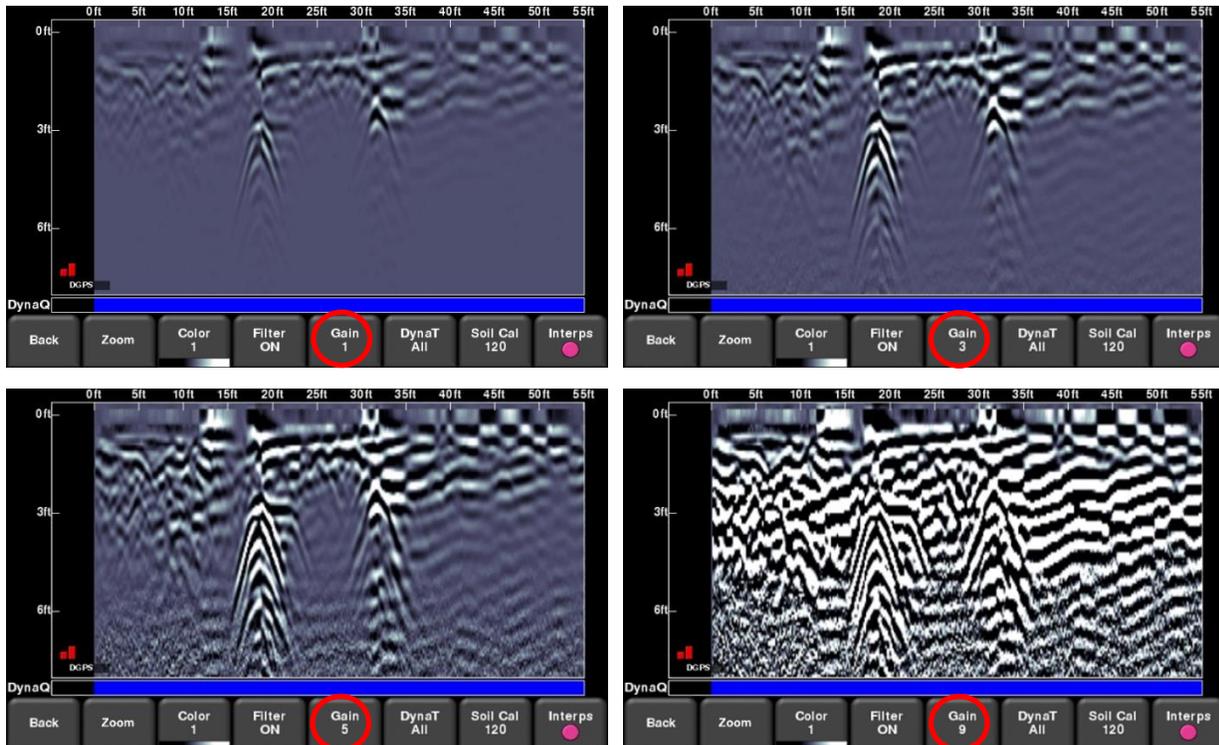
Figure 8-11: Varying the Gain

Frequen*See*™

Frequen*See*™ is a feature that can selectively enhance small, medium or large size targets for easier viewing and detection. Pressing **Frequen*See*** (shown as **DynaT** in some models) cycles between the options: **All**, **Small**, **Medium** and **Large**. Each option allows the user to enhance part of the ultra-wide band (UWB) spectrum to focus on those desired features.

Selecting **Small** will show more of the smaller hyperbolas and more detail, whereas **Large** will focus more on the larger targets with better depth penetration. Selecting **All** will show a combination of small, medium and large targets.
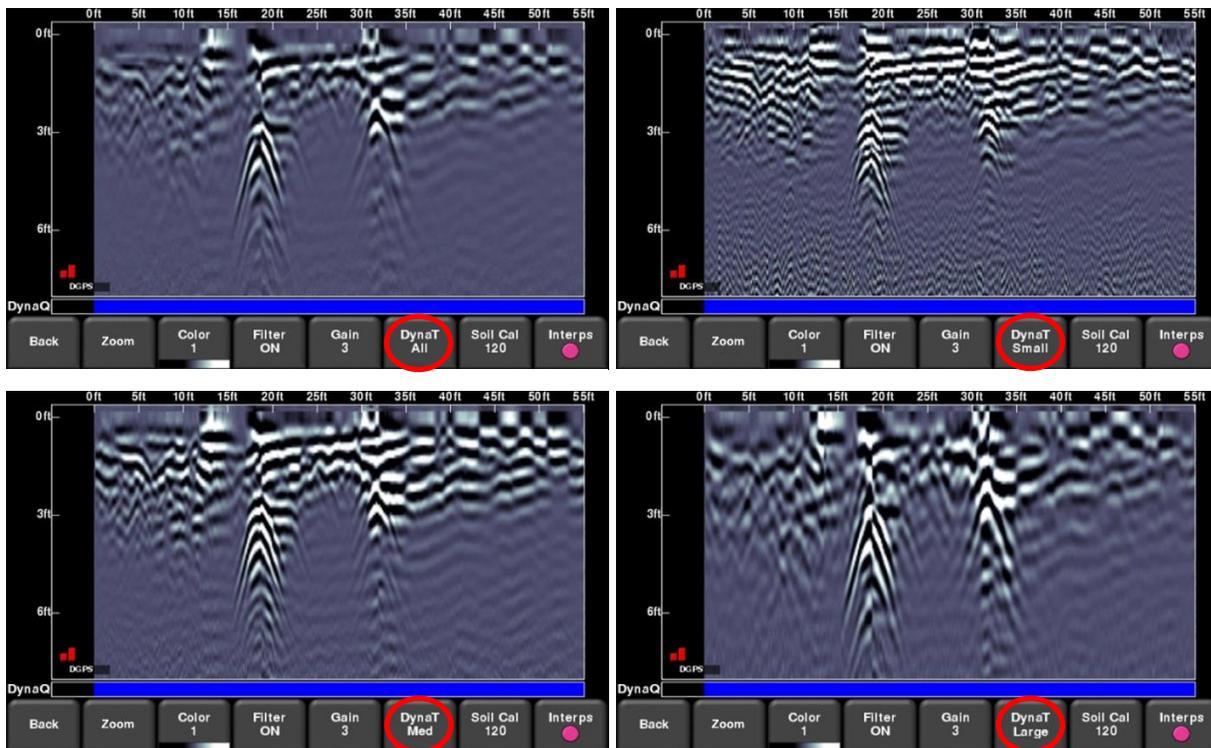
*Figure 8-12: FrequenSee™ settings: a) Top left shows **All**. b) Top right set to **Small** targets. c) Bottom left set to **Medium** targets. d) Bottom right set to **Large** targets*

Soil Cal

Soil calibration (also known as velocity) is a parameter used to ensure that measured depths are accurate. The best way to ensure this is by using the hyperbola-fitting method, since it is based on data collected in the area.

Crossing linear targets like pipes or cables at a 90-degree angle produces a hyperbola suitable for soil type calibration. The Soil Cal value obtained will be used to compute a depth estimate of a target.

NOTE: These depths will be *incorrect* if the soil type is calibrated on a target hyperbola produced at an oblique angle, rather than 90 degrees.

Once you have a hyperbola on the screen from a subsurface target, press **Soil Cal**. The menu at the bottom of the screen will change, giving you the option of either specifying a Soil Type or adjusting the Soil Cal using the hyperbola-fitting method (Figure 8-13). These options are explained below:

- **Soil Types** – If there are no targets to calibrate to, and you know the type of soil, press this button to vary between the following mediums (with the pre-set Soil Cal value shown in brackets):
  - very wet soil (60)
  - wet soil (80)

- o moist soil (100)
- o dry soil (120)
- o very dry soil (150)
- o air (300)

If you do have a suitable hyperbola on the screen from a subsurface target, press:

- **Soil Cal** – allows you to use hyperbola-fitting to determine a more accurate Soil Cal. The options are slightly different, depending whether or not you are in backup mode.

  If the backup indicator is on the screen when you press Soil Cal, then you can only adjust the vertical position of the horizontal scroll bar, since it is presumed you have backed-up so that the RD1500 is right over the hyperbola in question. The scroll bar can be moved up and down by touching the screen and dragging it, or by using the up and down keypad arrows until it lines up with the top of the hyperbola in question (Figure 8-13).
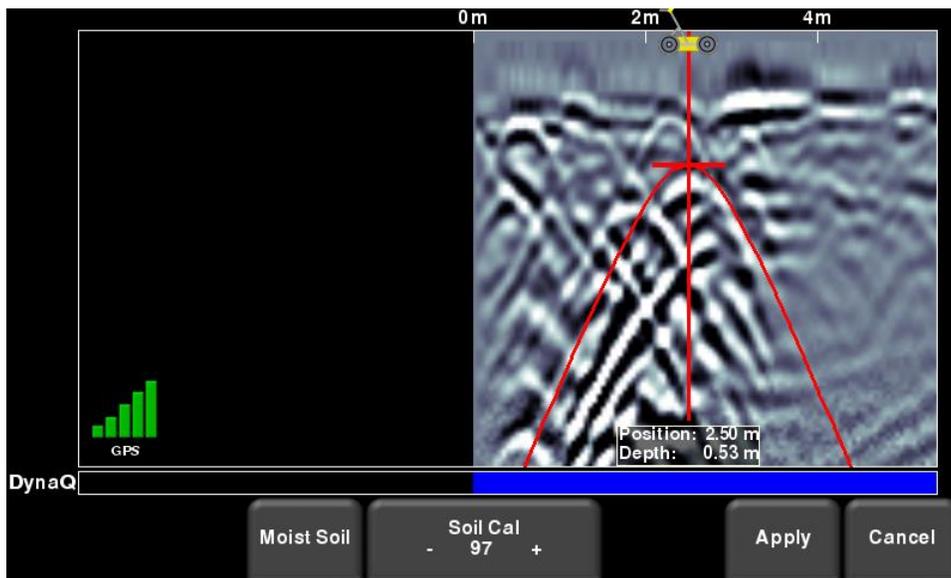
Figure 8-13: Adjusting Soil Cal while in backup mode

  Alternatively, if you press Soil Cal while you are collecting data or have pressed Stop, you will see a red hyperbola in the middle of the screen. Drag the hyperbola until it lies over a real hyperbola from the ground (Figure 8-14). You can use the 4-way keypad arrows to fine tune the movements.
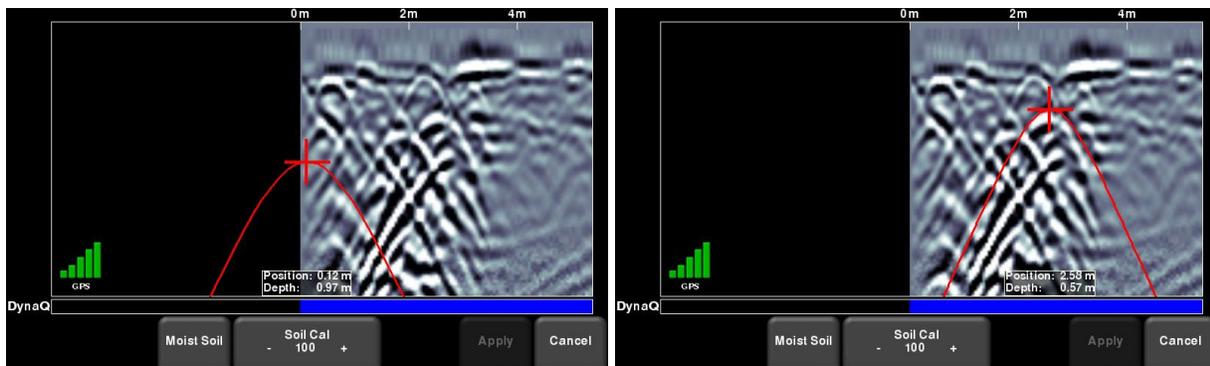
Figure 8-14: Adjusting Soil Cal, without backing up

For either scenario above, once the red hyperbola is properly positioned, you can now use the **+** and **–** buttons on the **Soil Cal** button to widen or tighten the shape. Once the shape is matched (Figure 8-13 and right hand image of Figure 8-14), you now have the correct Soil Cal and the measured depths will be most accurate. Press **Apply** to use this value.

If you get a Soil Cal near 300, this could be an Air Wave (Section 7.5), and you should calibrate to a different hyperbolic response.

Interp

Short for "field interpretation", Interps are used to mark subsurface features. Seven colours are available, allowing you to designate different colors to different types of subsurface objects.

During collection, back-up or review, you can simply touch anywhere on the screen to add an Interpretation (Figure 8-15). This appears as a dot of whatever colour is selected. To change the color, press the **Interp** button to see a selection of colors and to select a new one (Figure 8-16).

To remove an Interp, ensure the same color is currently active, then simply touch the Interp to make it disappear.

These field interpretations get exported with the data as a .CSV file, which show the positional information of all interps. They can be used to check if a feature is linear (in Map View or in Google Earth™), but only if the more accurate external GPS is used.
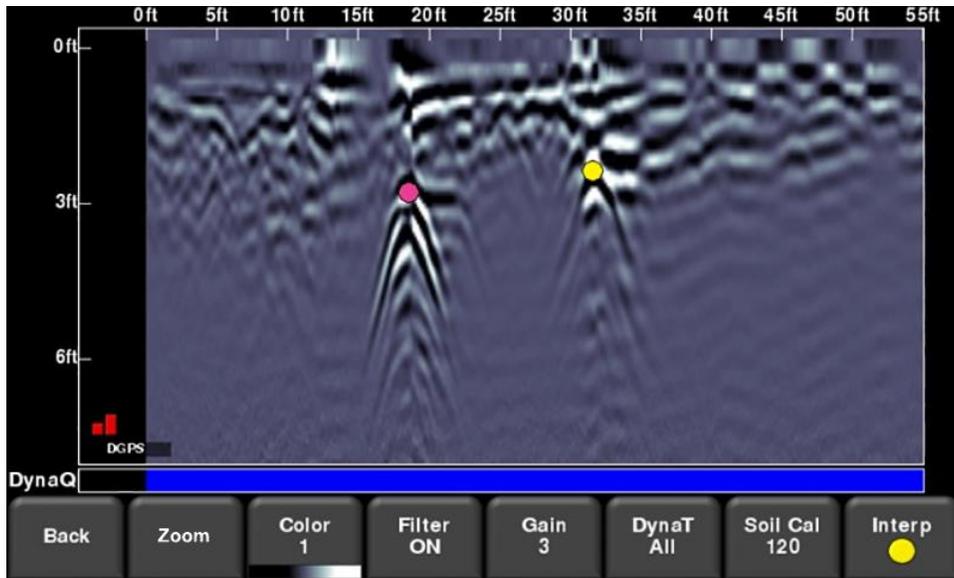
Figure 8-15: Touching the screen to add Interps
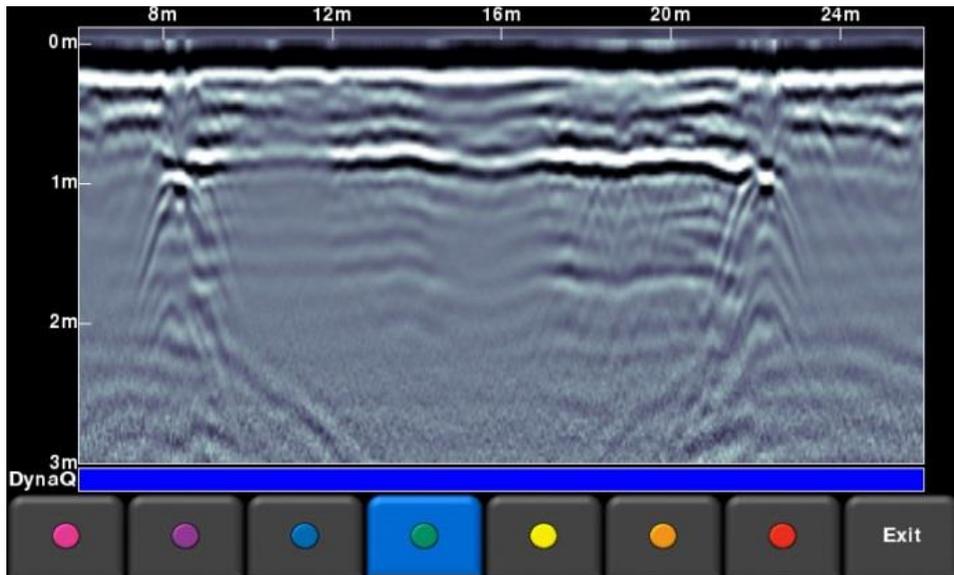
Figure 8-16: Available colors for Interps

Pause button (only available in No Save Mode)

The Pause button allows you to stop data collection temporarily, and then resume again, without clearing the data from the screen. This might be useful if you want to collect a series of parallel lines over a target and show all the passes on the screen for comparison.

Once you collect some data, press **Pause.** You can now move the RD1500 without data scrolling on the screen. When you are ready to resume collecting data, press **Start**. You will see a thick, red vertical line, corresponding to when you hit the Pause button and then restarted (Figure 8-17).
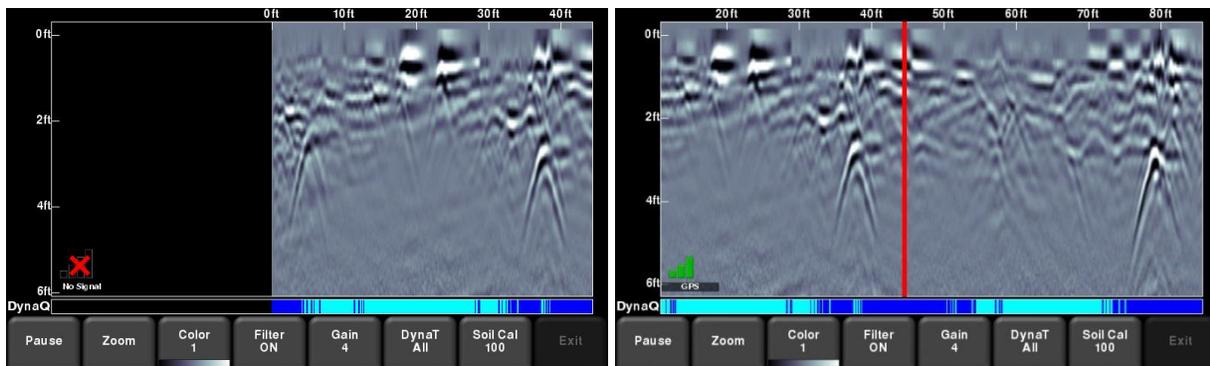
Figure 8-17: Pressing Pause and resuming data collection.

Drawing arrows (only available in No Save Mode)

There is no option for Interps in this mode, as the data is not being saved. However, you do have the ability to draw arrows on the screen (Figure 8-18).
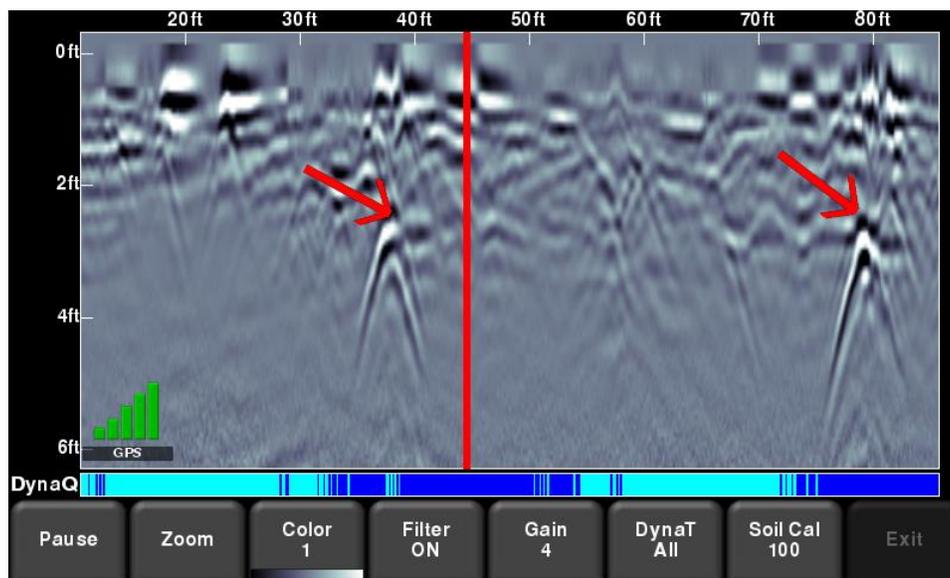
Figure 8-18: Drawing arrows on the screen to highlight targets and features

Touch the screen where you want the head of the arrow to appear, and then swipe away in the direction of the shaft. In the example in Figure 8-18, the user touched near the hyperbola, then swept their finger towards the top left to create the arrows. Just like Interps, any number of arrows can be drawn on this screen. Touch any arrow to remove it.

Remember that pressing the **Camera** button will take a screenshot and save it in the currently selected project.

Section 9 - Grid Scan

Grid scans are conducted to generate depth slices over a given area. This is useful for locating all known and unknown objects, as well as their orientation, in a graphical manner that is easy to interpret.

From the main menu (see Figure 5.2 or 5.3), press the **Grid Scan** button to enter the Grid setup menu.

9.1 Grid Parameters

The screen will change to look like Figure 9-1, which will allow you to set the parameters of the grid, before data acquisition begins.
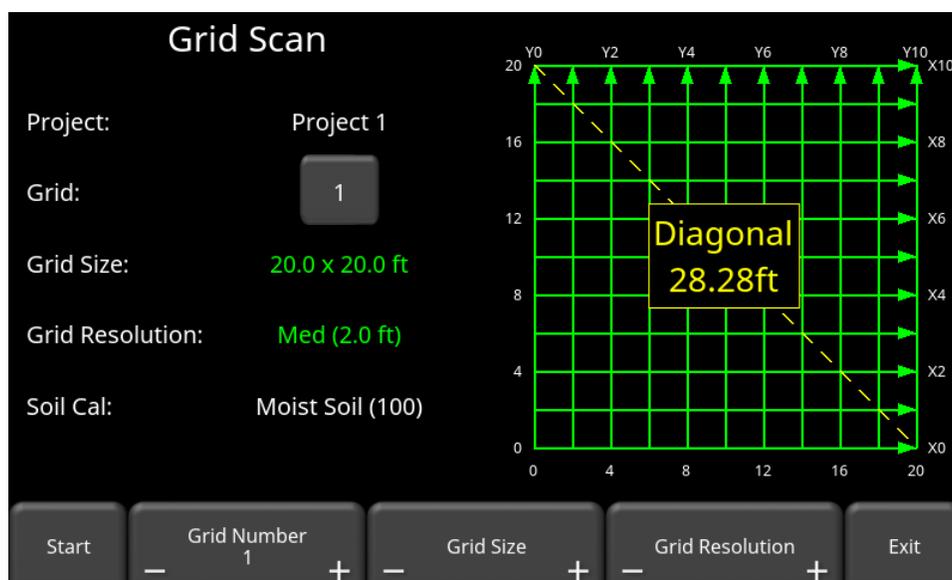
Figure 9-1: Grid Scan setup, from the Enhanced system. On the standard RD1500, it will be the same, except there will not be a project number

Grid Number

To select a grid number, press the **+** and **-** buttons under **Grid Number** at the bottom of the screen. Alternatively, pressing the grid number button itself will show the screen in Figure 9-. From here, you can go directly to any grid. Grids that contain no data will have the text shown in green.
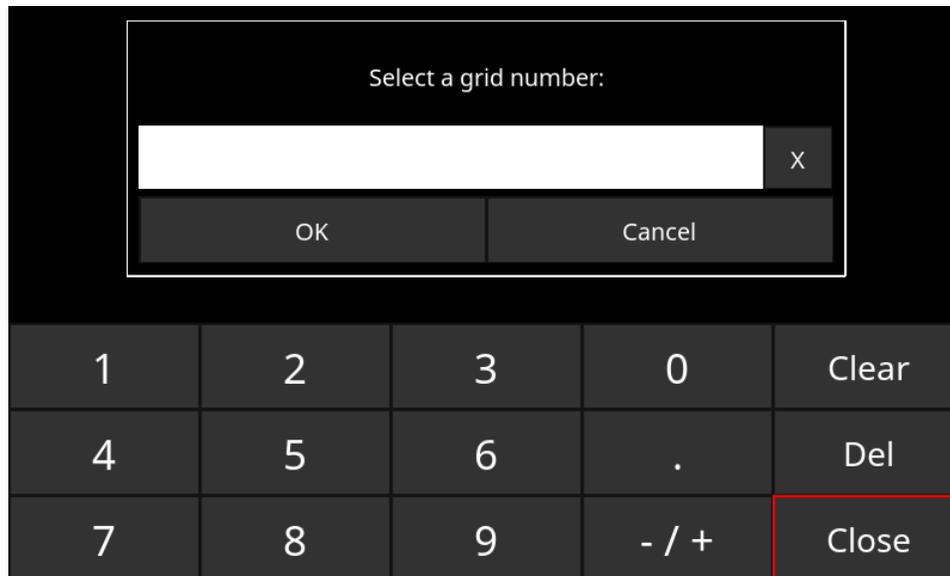
Figure 9-2: When the button showing the grid number is pressed, this screen allows the user to directly input the grid they wish to go to

If a grid already contains some data, it will be shown in red and you will not be able to change the size or resolution. You will just have the option to select:

- **Slice View** – view the depth slices

- **Delete Grid** – delete all the data in this grid

- **MapView** – display MapView. ** only the RD1500 will have the MapView option on this screen, not the RD1500 Enhanced

You can press **Start** to enter a previously collected grid, either to view data or recollect a line.

Grid Size

Press the **+** and **-** buttons under **Grid Size** at the bottom of the screen to change the dimensions of the grid. Alternatively, you can press the **+** and **-** buttons on the screen beside **Grid Size** on the upper part of the screen.

In metric units, the available grid sizes are 5m x 5m, 10m x 10m and 15m x 15m.

In US standard units, the available grid sizes are 10ft x 10ft, 20ft x 20ft and 50ft x 50ft

Grid Resolution

Grid resolution determines the spacing between grid lines. This can be varied by pressing the **+** and **-** buttons under **Grid Resolution** at the bottom of the screen. Alternatively, you can press the **+** and **-** buttons on the screen beside **Grid Resolution** on the upper part of the screen.

Available options are 0.25m, 0.5m and 1.0m in metric units and 1, 2 and 5 ft in US standard units. The best images will result when the smallest resolution value is used.

Calculating Resolution

The size of target will determine line spacing. The RD1500 must pass over a target to detect it, so line spacing needs to be of the order of the size of the target or smaller when practical. This can be adjusted to a larger spacing for larger targets or targets that are linear. Tighter line spacing does take longer to collect and the highest resolution may not be economically feasible in all circumstances.

NOTE: The system will not allow you to select a 10ft x10ft grid with a low resolution of 5ft, as this resulting image will be very poor due to inadequate data collected.

Starting data collection

Press **Start** when all the parameters are set up and data collection is ready to begin.

9.2 Laying out the grid

Positional accuracy of each line is vital to locating targets of interest once data has been processed.

For linear targets such as pipes and utilities, the best GPR responses occur when the GPR survey line crosses the target at right angles. Keep this in mind when laying out the grid and the orientation

An example grid layout is shown in Figure 9-3.

Figure 9-3: Example of a grid survey. The red lines are superimposed just to illustrate the concept.

Physical Data collection

It is critical that the starting position is consistent on every line. Position the middle of the unit with the starting line, and then push the system straight towards the end of the line. It is often helpful to have a marker at the end so you have something to aim for.

Not all lines have to be finished. If there is an obstruction preventing you from finishing the line, you can simply press Stop and end the line early. Do not try to steer the system around the obstruction, as this will throw off the positioning of the data.

In addition, not all lines have to be collected. If your area of interest is only 4m x 3m, set the Grid Size to 5m x 5m, but do not collect the outer lines.

Data collection on the Display Unit

The data collection screen is shown in Figure 9-4. The right half of the screen is a graphic representation of the grid, illustrating the size of the grid and the lines that need to be collected.

The left half of the screen will display the last grid line collected.
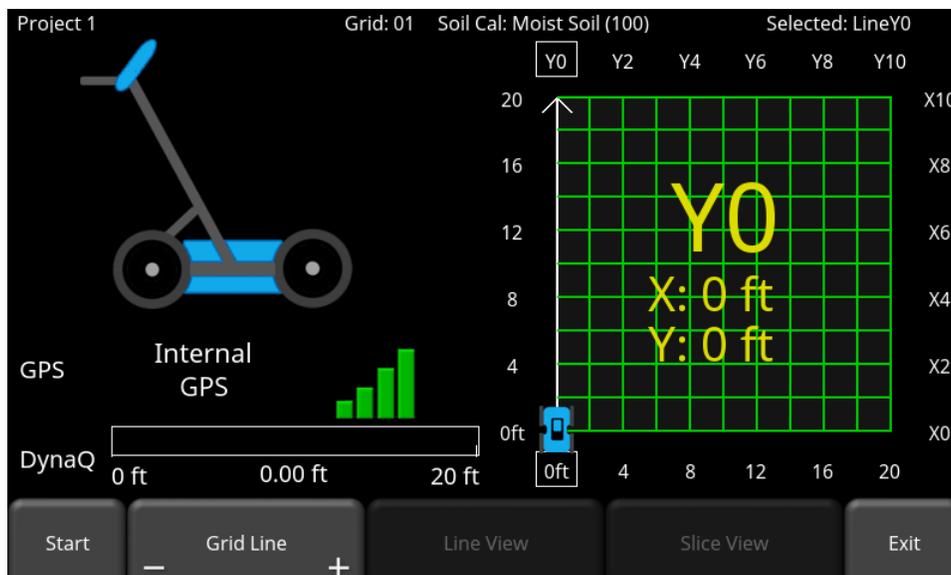
Figure 9-4: Grid data collection screen

Press **Start** when you are positioned at the start of the line. Push the RD1500 in a straight line towards the end of the line. The system knows the length of each line, and will automatically stop acquisition once that distance has been covered. If the data acquisition ends prior to reaching the end of the line, or continues noticeably past it, you are recommended to do an Odometer Calibration (see **Odometer Calibration** in **Section 6.4** for details).

Once data is collected, the Grid Line will turn red. The current line will now advance to the next one and is shown in white. The remaining lines to be collected remain shown in green.

Move back to the start of the next line, adjacent to the start of the previous line, and repeat the process. Once all the lines are done in one direction, it will automatically prompt you to collect lines in the other direction.

LineView

To display the currently selected grid line on the full screen, press the **Line View** button. You also have the option of modifying the image by changing the Zoom, Color, Filter, Gain and Soil Cal values.

It is also possible to display other collected grid lines using the keypad arrow buttons.

To exit from the Line View screen and return to Grid View, press the **Back** button. The Grid View screen respects any display settings changed while in Line View. If the Soil Cal is changed, the depth slices will be reprocessed.

Recollecting and skipping lines

You may want to recollect a line if you make a mistake. You can move to a different line by doing one of the following:

- Press the **+** and **-** buttons under **Grid Line**, or
- Touch any **line** on the grid image on the right, or
- Use the **4-way directional keypad**

Then simply hit **Start**. You will be prompted with a message asking if you want to overwrite that line (Figure 9-5). Press **Yes** to proceed.
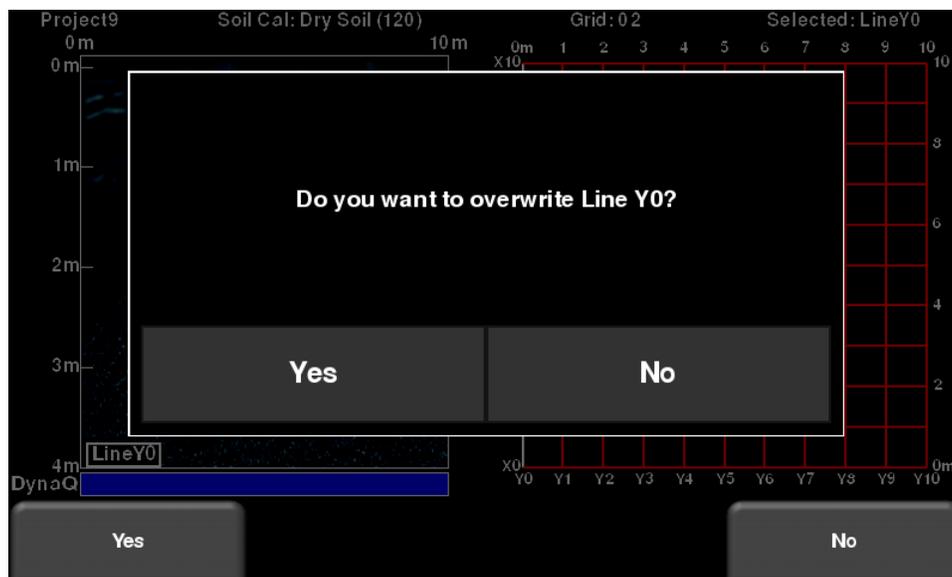
Figure 9-5: Overwriting a line

Processing data

Once you have finished collecting all the data, press **Slice View** at the bottom of the screen. Before the data is processed and depth slices created, you must ensure the Soil Cal is accurate; this will results in the most accurate and sharpest images.

A message will display advising the Soil Cal that will be used. If you have adjusted this already for the ground you are on, you can press **OK** to proceed and create the depth slices.

If not, then it is recommended to press **Cancel** and adjust the Soil Cal by using a good hyperbola on one of the collected lines. Then return and press **SliceView** and press **OK** to proceed and create the depth slices.

See the next section on using Slice View.
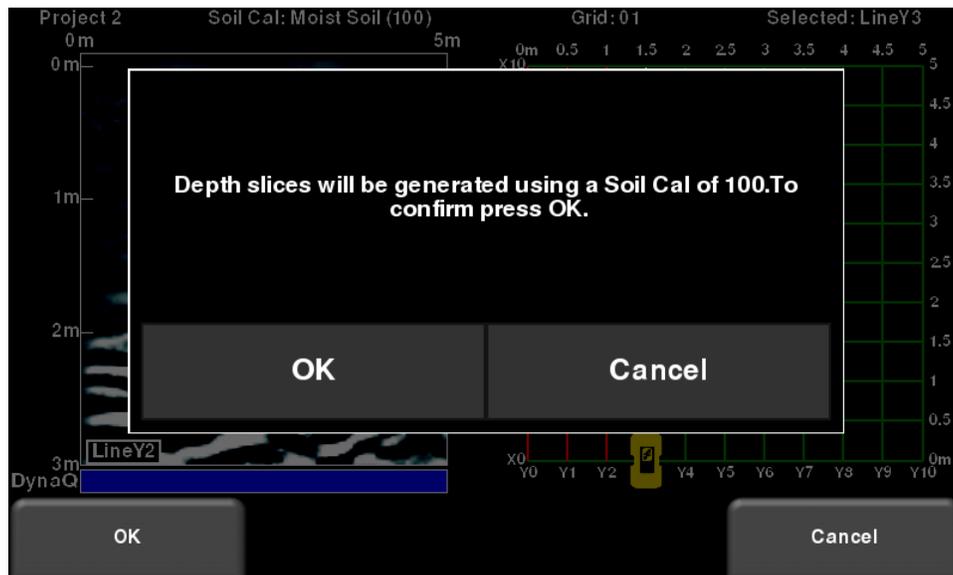
Section 10 - Slice View

Slice View displays data collected in a grid as a series of depth slices moving deeper into the subsurface. Objects and features appear in plan view, which can be an easier way of visualizing the data. In addition, data in this view can be exported into other software, such as Google Earth™.

When you enter **Slice View**, you will see the screen displayed in Figure 10-1.
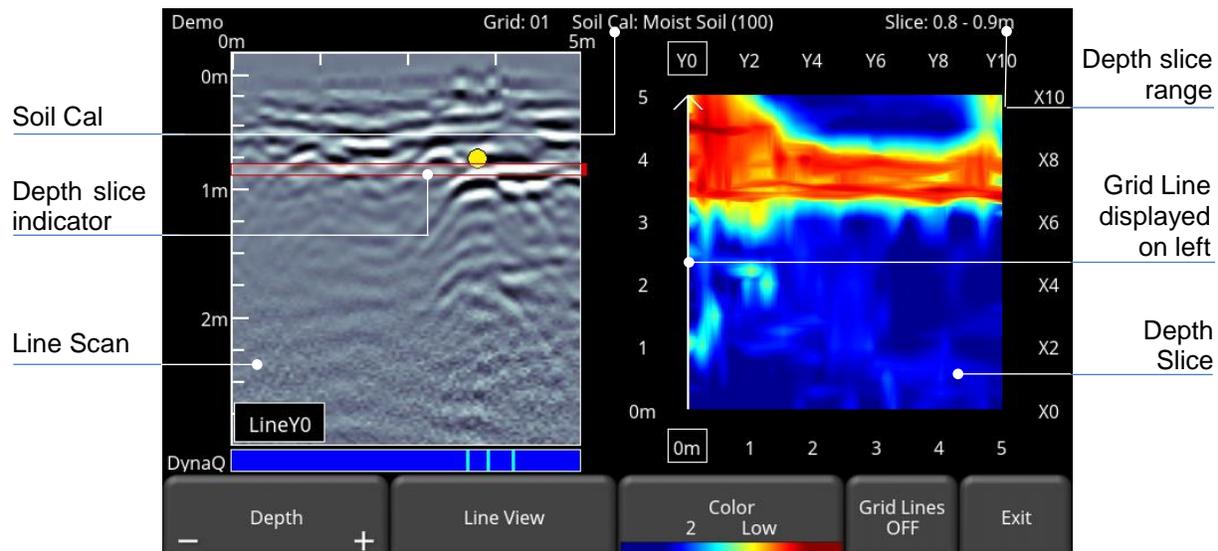
Figure 10-1: Slice View screen

The right half of the screen shows one of the depth slices. These slices are 10cm or 4" thick. The top and right sides of this image show the dimensions of the grid while the left and bottom sides show the line numbers.

The left half of the screen displays one of the grid lines, and any flags or interpretations that were made. The shaded area in between the horizontal red lines corresponds to the depth slice shown on the right. To move to another grid line, use the 4-way directional keypad on the Display Unit.

At the top of the screen, the grid number is listed, along with the slice thickness range. The Soil Cal number was automatically determined when the grid data was processed and is also indicated here.

The button functionality is explained below:

10.1 Depth

Pressing the **+** and **-** buttons on the **Depth** button will increase or decrease the depth of the depth slice currently displayed. You can also drag the depth slice indicator on the line scan image. This allows the user to "slice through" the ground, and locate features that appear at different depths.

10.2 Color

This heading has two button functions beneath it:

a) **Color Palette** - the number corresponds to the color palette used for the depth slice image. Pressing this button cycles between the 9 available color palettes available on the system.

b) **Color Sensitivity** - cycles between **LOW**, **MEDIUM** and **HIGH**. A setting of HIGH is useful for revealing weaker targets which can sometimes be difficult to see. Setting to LOW will help "clean up" the data and only show the stronger targets, but will hide some of the weak signals so be CAREFUL when setting to LOW. Figure 10-2 shows the variations in color sensitivity
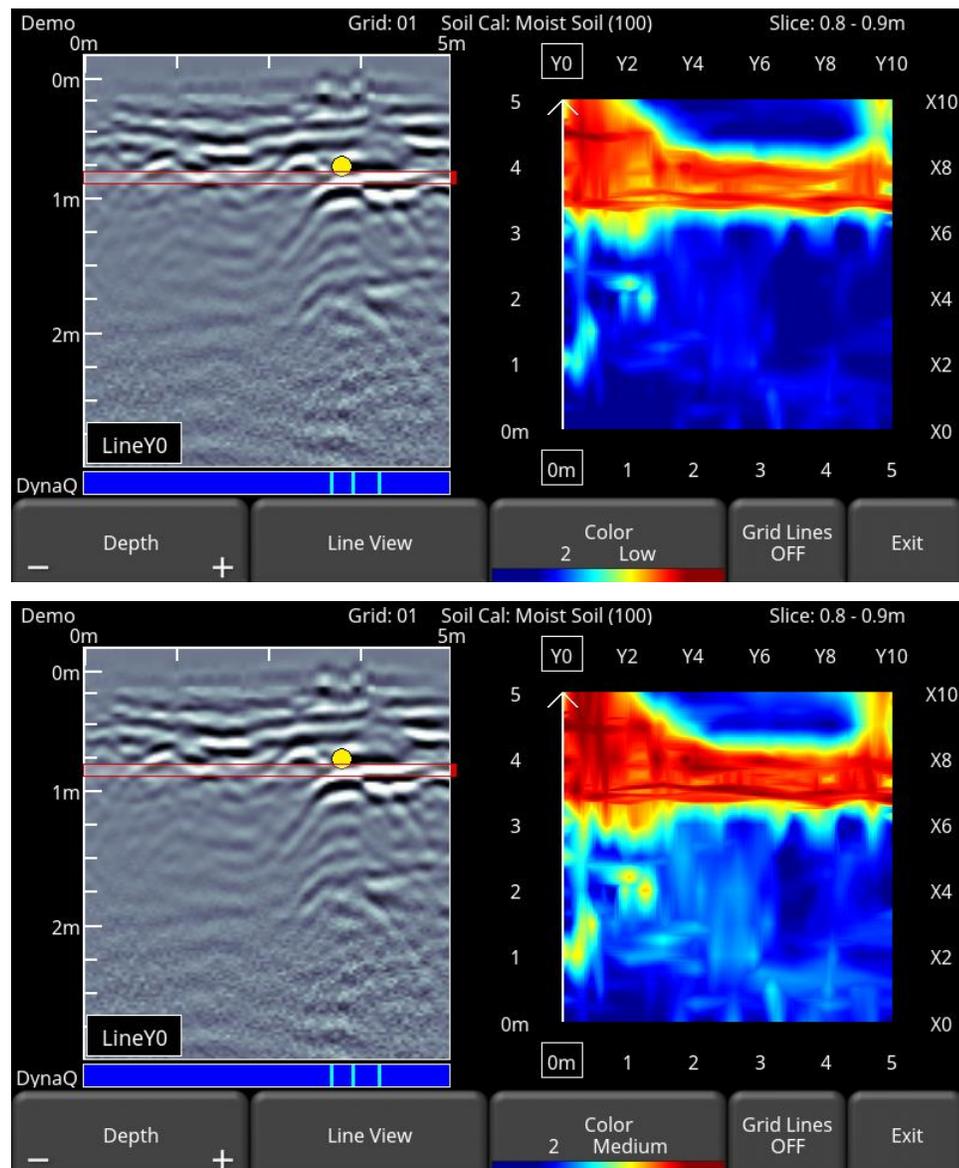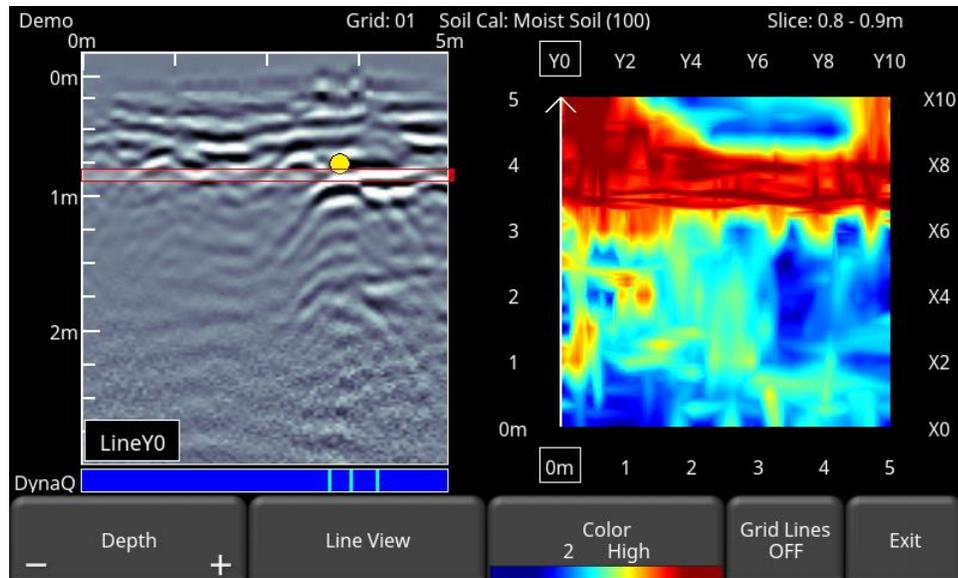
Figure 10-2: Varying the sensitivity, from top to bottom: Low, Medium and High settings. High shows more subtle targets but may sometimes appear cluttered while the Low setting only displays the strongest targets so be cautious when using it.

10.3 Grid Lines

Press this button to overlay the grid lines on the depth slice image. It is useful to see grid lines so you know the position of the GPR Line in the grid (displayed in white). Press this button to cycle between **ON**, **PARTIAL** and **OFF**. When set to **ON**, all the collected lines are displayed. When set to **PARTIAL**, only some of the grid lines are displayed. This can help identify targets in some larger grids, for example, when having all the grid lines **ON** may obscure the image beneath (Figure 10-3).

---
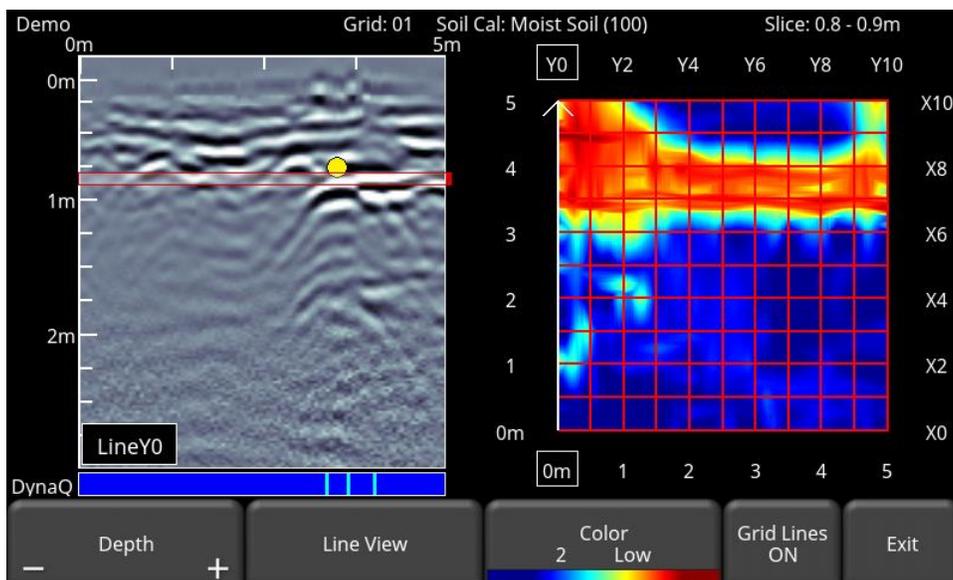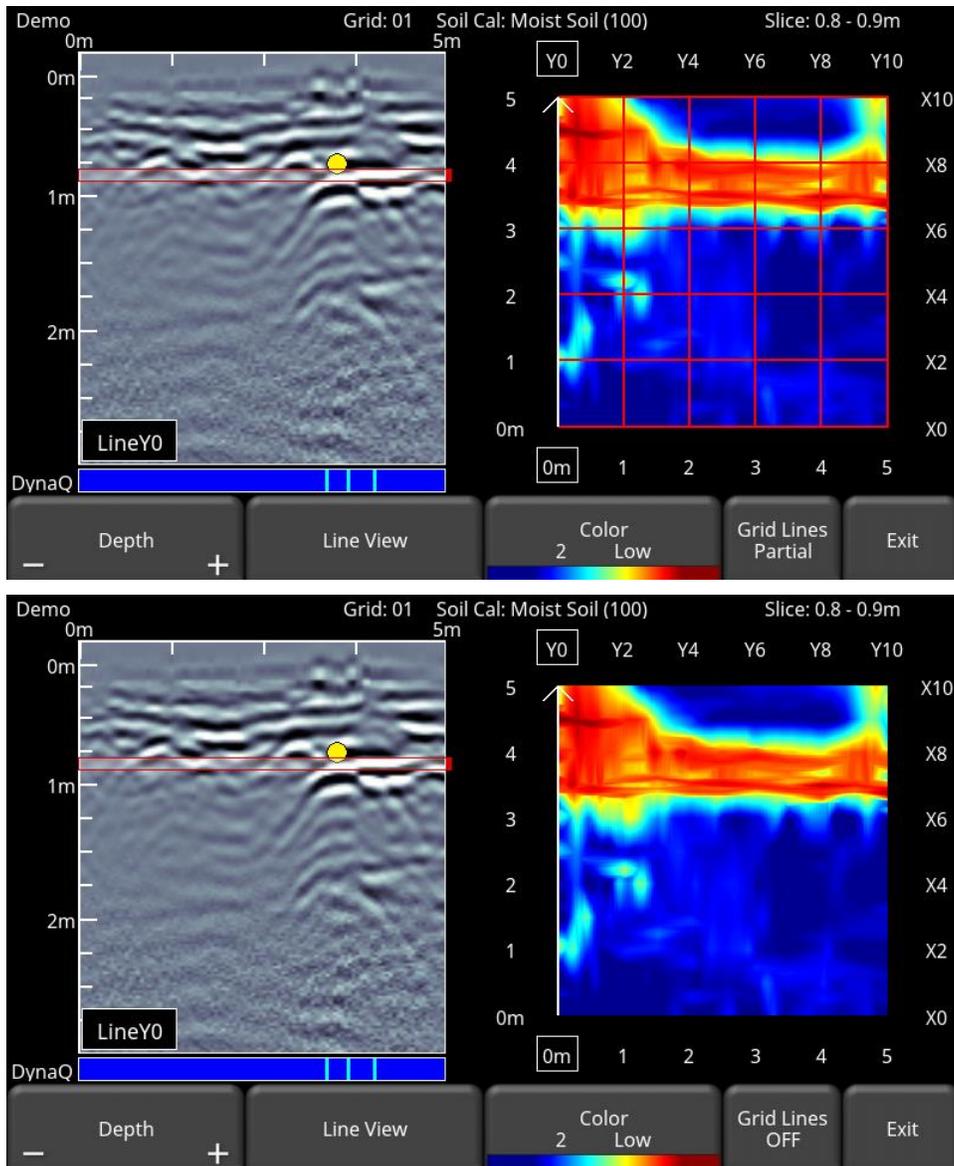
*Figure 10-3: Varying the Grid Lines, from top to bottom: **ON, PARTIAL** and **OFF** settings.*

10.4 Line View

Pressing this button displays the currently selected GPR line as a full screen image. All the functionality of Line Scan (such as depth, color, filter, gain, Frequen*See*, Soil Cal, interps) are available here. Use the **4-way directional keypad** to change to a different line.
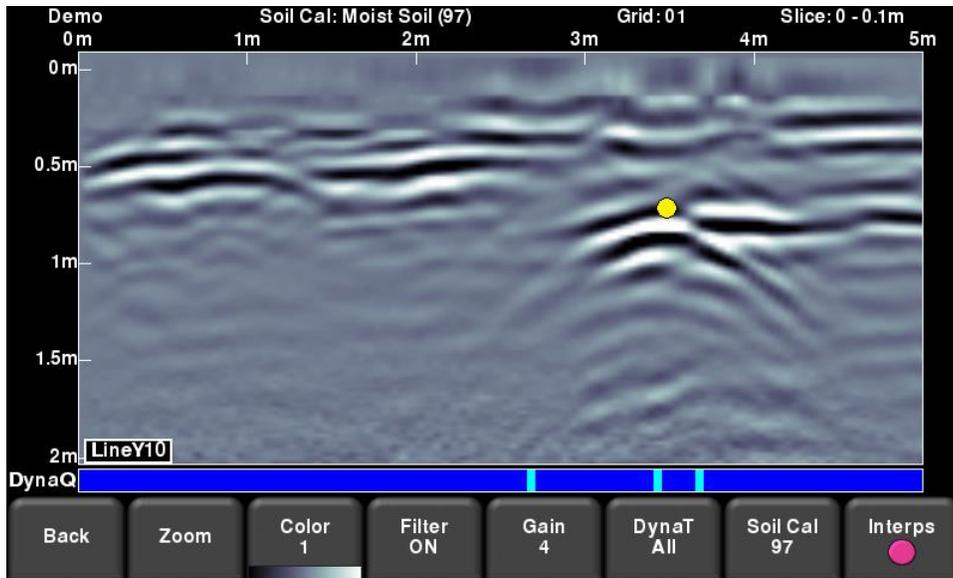
Figure 10-4: Changing Line View settings from within Slice View.

Press **Back** to return to Slice View. Any changes made will be reflected on the GPR line in Slice View mode. If you change the Soil Cal or Zoom (depth), this will cause the depth slices to be re-processed.

Users may want to change these display settings to make it easier to correlate line scan data with depth slices.

10.5 Recollecting lines

After looking at the grid data in Slice View you may discover that one or more grid lines need to be recollected (for example, maybe the starting position was offset). If so, you will need to enter the Grid Scan menu again and select the appropriate grid number and press Start (the grid number will be in red, since data exists).

Select the grid line that needs to be recollected. When you press **Start**, it will display a prompt confirming if you want to overwrite the line. After recollecting the grid line(s), press the **Slice View** button to re-process the grid data.

Section 11 - Map View

Map View is a unique feature that allows the user to graphically view the path travelled by the system, and any flags or interpretations made. This is helpful in determining the linearity and consistency of buried objects. It will also display a view showing the lines collected as part of a grid.

A common use of this feature is to snake back and forth over a given area. Each time you cross a target producing a hyperbola, back up to the top of the hyperbola and add an interpretation. If the object is a linear feature, all the interpretations will line up when viewed in Map View.

Map View only works if GPS data is collected with the GPR data. This is what allows the lines and/or grids to be positioned correctly (with the right orientation).

If you use the internal GPS, only grid data will be shown in Map View. If an external GPS is connected, both line and grid data will be shown.

11.1 Accessing Map View (RD1500)

You will only see Map View when you enter either a line or grid
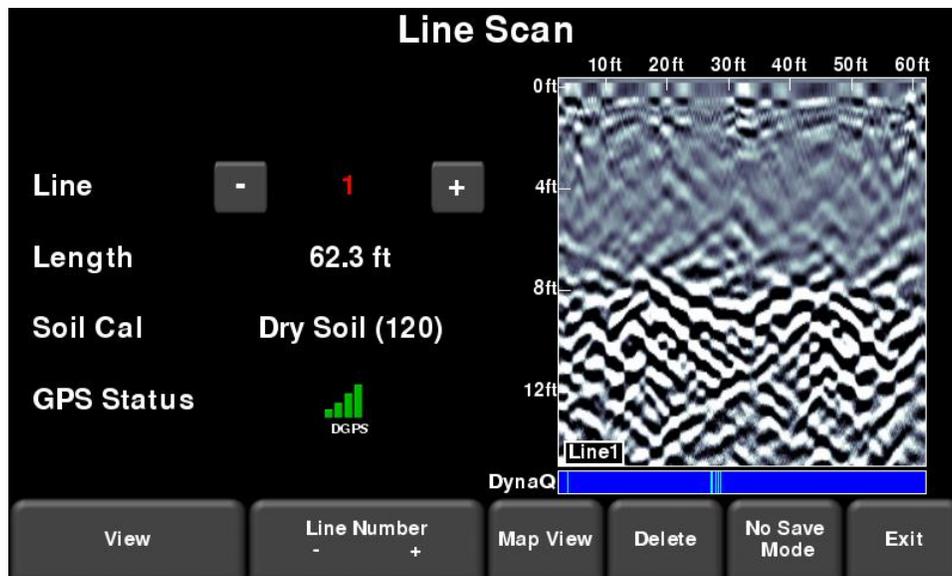
Figure 11-1: Accessing Map View from RD1500

11.2 Accessing Map View (RD1500 Enhanced)

Map View can be accessed from the File Management menu or from the main screen. Remember that in the Enhanced configuration, Map View is *project* based, meaning it will display all lines and grids that are present in a given project.
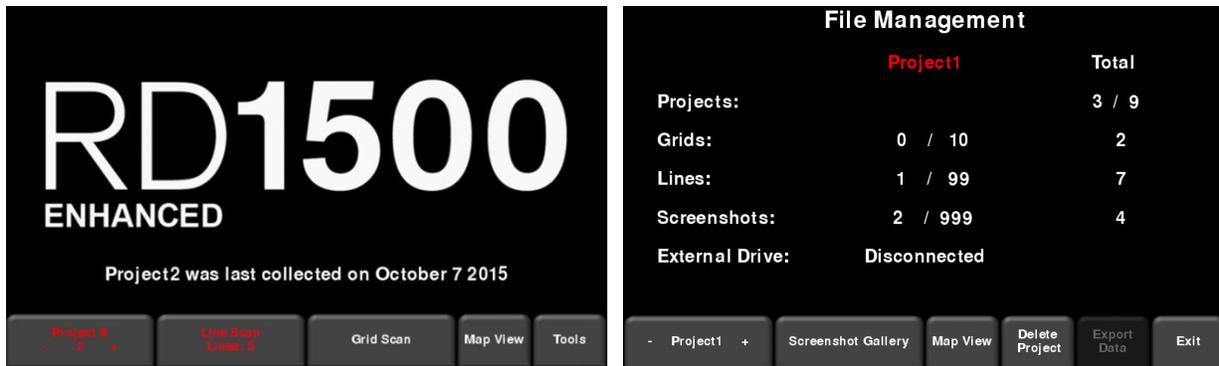
Figure 11-2: Accessing Map View from RD1500 Enhanced, either from the a) Main screen or b) File Management menu

11.3 Map View screen

Irrespective of the system configuration, entering **Map View** will show an image similar to the one in Figure 11-3. You will always have the same options in Map View which are described below:
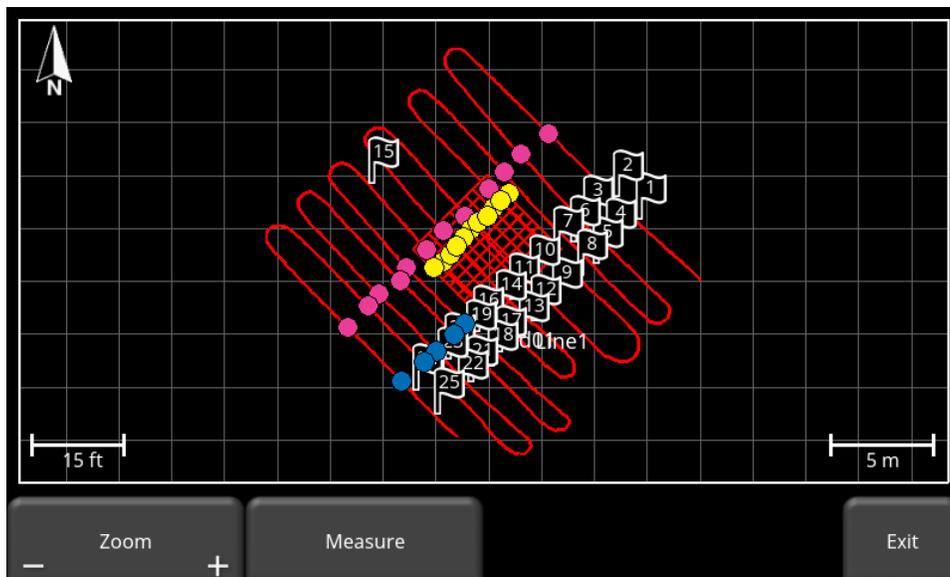
Figure 11-3: Map View showing the position of two grids and one line

- Pressing **Zoom +/-** will zoom accordingly. To reposition the image in the middle of the screen, simply swipe the screen until the image is positioned properly.

- When the **Measure** button is pressed, it is highlighted in blue. During this time, you can touch the screen and drag your finger a certain distance to get a measurement value for that distance. The distance value is displayed in the top right corner (Figure 11-4). Pressing the Measure button again exits from Measure mode and removes the yellow measured line and the measured value.
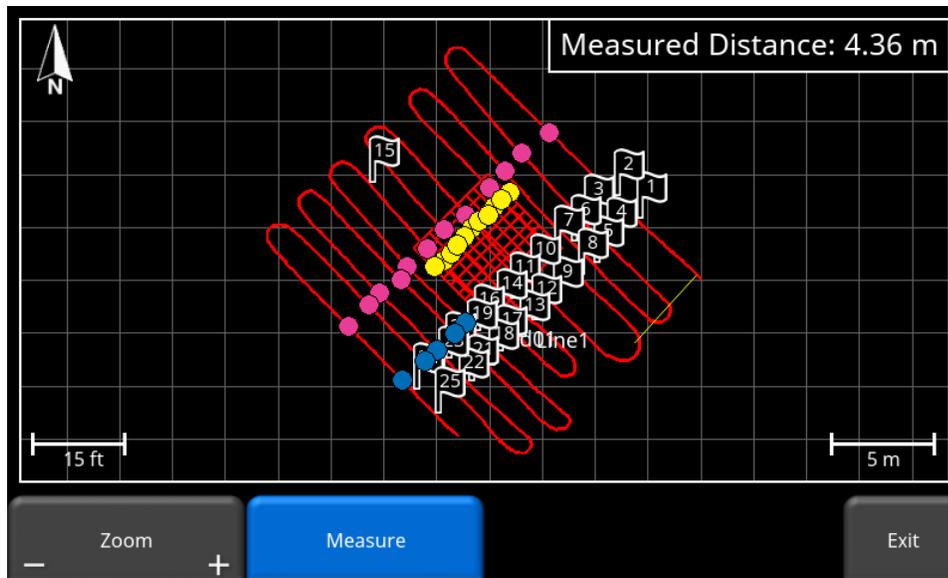
Figure 11-4: Using the Measure tool to draw a line on the screen

Section 12 - Capturing Screens and Emailing mini-reports

12.1 Capturing Screens

If you would like to save an image of the current screen in Line Scan, Grid Scan, Slice View or Map View, press the **Camera** button on the Display Unit. This saves the screen as a Screenshot image (.JPG), which you can view in your preferred viewing software. If any GPS is enabled, the screenshot image (only for Line Scan and Slice View screens) will also contain a geo-tagged reference.

If you are not connected to a WiFi network, a message appears confirming the filename of the saved image (Figure 12-1).
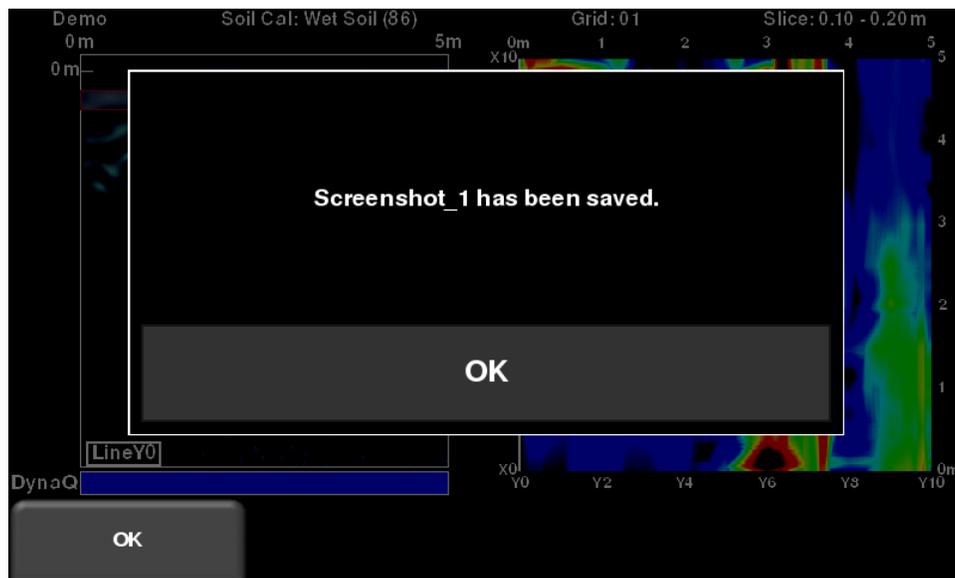
Figure 12-1: Message displayed after pressing the camera button on the Display Unit to capture the screen (no WiFi present).

If you are connected to a wireless network and have a sending email address configured, you will see the message in Figure 12-2, asking if you would like to email the screenshot and prompt you to enter the email address. Tapping on the address box brings up an on-screen keyboard and allows you to enter a new email address. The email address defaults to the last one entered. Pressing the "**…**" button to the left of the email address displays the last 5 email addresses used, allowing you easily to select a recent email, rather than having to re-enter it.

Screenshots can always be emailed at a later time from the Screenshot Gallery (see **Screenshot Gallery** in **Section 6.3** for details).

Figure 12-2: Message displayed after pressing the Camera button on the Display Unit to capture the screen with WiFi enabled and a connection to a wireless network. The user can enter an email address to send the mini-report to.

12.2 Mini-Reports

When a screenshot is emailed, it is sent as part of a mini-report. This mini-report also contains a table with information about the collected data including the settings used, date and time (Figure 12-3).

RD1500 Mini Report

Project	Demo
Screen Capture Number	6
Date Collected	March 30 2016 2:29 PM
Mode	Slice View
Grid	Grid01
Grid Size	5 x 5 m
Grid Resolution	Medium (0.5 m)
Soil Cal	Moist Soil (97)
Slice Depth	0.8-0.9 m
Slice Color Palette (Contrast)	2 (Medium)
Grid Line Visibility	OFF
Selected Line	LineY0
Depth	1.0 m
Line Color Palette	1
Filter	ON
Gain Level	4
DynaT	All

RADIODETECTION
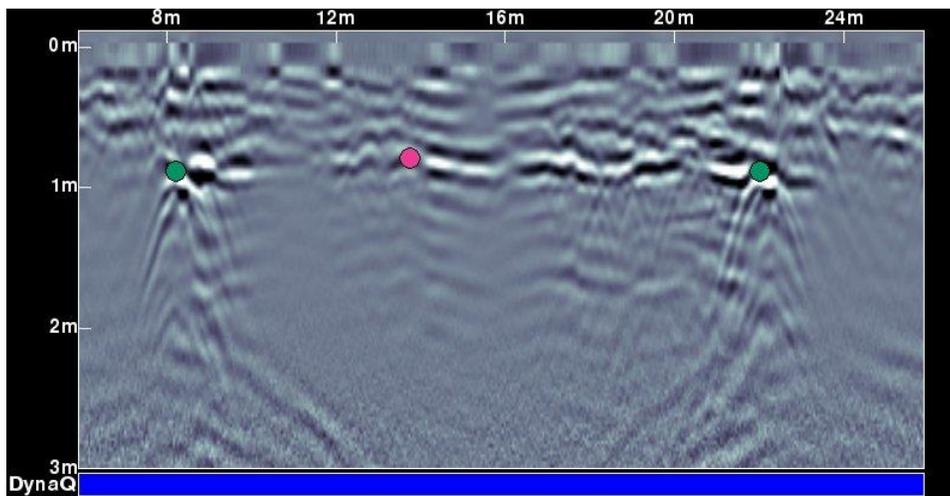
Figure 12-3: Example of a Mini-Report

Section 13 - Transferring Data to a PC

Screenshot images (and data, if you have the Enhanced system) can be exported to a PC via a USB memory stick.

USB-memory stick

Figure 13-1: Insert a USB memory stick into the USB port on the Display Unit to export data.

Insert a USB drive into the USB port (Figure 13-1). Once the USB drive is recognized, a message will appear telling you that a drive has been inserted and ask you if you wish to export your data to it (Figure 13-2). Click **Yes** to begin the transfer
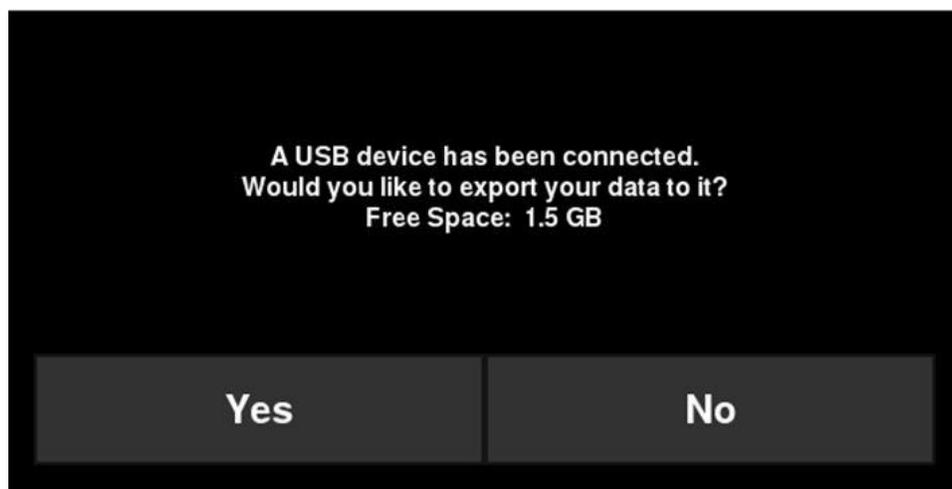
*Figure 13-2: When a USB drive is connected to the Display Unit, a message opens asking if you would like to export all your data to it. Select **Yes** to transfer immediately. If you select **No**, you can export the data later by going to the **Setup > File Management** menu option.*

If there are grids that were collected, but not processed, it will alert you after you select **Yes** to exporting the data. This is important, as unprocessed grids will not automatically show up in EKKO_Project as depth slices.

Alternatively, if you want to export the data later, you can select **No**. Later, when you are ready to export your data, select **Setup > File Management** from the main menu and press **Export Data** (Section 13).

The directory structure on the USB drive can be viewed on your PC, and will look as follows:

- GPR Data
  - RD1500
    - Export01
      - Project1
        - Screen Shots
          - All Screenshots as .JPG files
        - Project1.GPZ file
        - Project1.KMZ file
        - Field Interp Report.CSV
      - Project2
        - Screen Shots
          - All Screenshots as .JPG files
        - Project2.GPZ file
        - Project2.KMZ file
        - Field Interp Report.CSV
      - System Info
    - Exportxx
      - Projectx
        - Screen Shots
          - All Screenshots as .JPG files
        - .GPZ file
        - .KMZ file
        - Field Interp Report.CSV
      - System Info

All screenshot files are saved as .JPG files.

The actual GPR data files are all contained in a .GPZ file. This can be opened by the EKKO_Project software.

If data was collected with GPS (internal or external), a .KMZ file is also generated. This contains positional information and can easily be opened in Google Earth™.

If any Interpretations were made, these are saved in a .CSV file. This is a spreadsheet file, which shows the positional information of any interps made.

The System Info folder contains log files and a system summary diagnostic report.

Each successive export of data will create a new directory called ExportXX, where XX is incremented by 1 from the previous directory.

Section 14 - Troubleshooting

The RD1500 system is designed to minimize user problems; however, all electronic devices are subject to possible failure. The following are troubleshooting hints which can be referred to if your system fails to operate.

14.1 Power Supply

The most common problem that can occur while trying to run the system is insufficient power. The battery may be dead, have a low voltage or the fuse may be blown.

Once boot up is complete, the color of the LED (see Figure 5-1) indicates the amount of battery power remaining:

- Green   =   20% to 100%
- Orange   =   10% to 20%
- Red   =   0% to 10%

You can check the battery voltage with a voltmeter. Try to do this while the system is still attached to the Cart to get a true measure of the voltage while under load (it will be necessary to open the battery case and connect the voltmeter to the positive and negative battery terminals). A fully charged battery will show a voltage of 13.8V, whereas a voltage of 10.8V or lower will not power the system. If the battery has a low voltage or seems dead, try using another battery (if available), or give the battery a good 12-14 hour charge and try running the system again.

If the battery does not charge up to 12 Volts or more, it should be replaced.

Batteries are fused to protect the system. Open the battery case and check that the 10 Amp fuse is OK. If necessary, replace it with one of the spare fuses available inside the battery case.

If the battery seems OK but the system still does not power up, check the battery cable connections and inspect the battery cable for damage.

14.2 System Communications

- If the battery is OK and the Display Unit turns on but the GPR sensor does not scan, there may be a communication failure between the Display Unit and the GPR sensor. If an error occurs, an error message will appear. Power Off the system and disconnect the battery.
- Make sure the display cable is not damaged, all pins are straight, and there is no dirt or debris in the connector. Ensure that the cable connections are tightly secured. Vibrations can sometimes cause the cable connections to loosen slightly and break contact, leading to errors. Disconnecting the cable and reconnecting it may provide a better contact and solve the problem. Plug in the battery, turn on the system and try scanning again.
- If the Battery, Battery Cable and Display Cable are OK, the problem is either a failure of the Display Unit or the GPR sensor. These units have no user-serviceable parts so they will have to be returned to the vendor for inspection and repair.

14.3 System Overheating

The RD1500 GPR system is designed to operate to a maximum *internal* temperature of 70ºC or 158ºF. In situations of high ambient temperatures or long exposure to direct sun, this maximum internal temperature may be exceeded and cause the system to fail.

If you suspect that the GPR sensor is overheating, shut it off and give it a chance to cool down in a shady location before trying to run it again.

If the situation is such that the high temperatures or direct sun cannot be avoided, putting some sort of shade over the GPR sensor may help to reduce the internal temperature.

14.4 Display Unit Problem

The Display Unit, which is weatherproof and rugged, should be handled in much the same way as a notebook computer is. If the Display Unit does not power up, check the battery power and all cable connections. If that doesn't work, contact the vendor.

14.5 Wobbly Wheels

Over time, a wheel may become wobbly, in which case you will need to tighten it manually.

For the rear right wheel only (which is connected to the direct drive odometer), insert a large slotted screwdriver into the end of the axle (there's already a slot there for it) and use a large wrench to slightly tighten the wheel nut. The nut only has to be turned slightly, 1/8th -1/16th of a turn is usually enough. Spin the wheel to make sure it is still free and not too tight.

14.6 Creating a Test Line for Data Quality

After receiving the system and getting comfortable with its operation, one of the best ways of detecting any problems is to collect a line of data at a convenient, easily accessible location. The line does not have to be too long but long enough to fill one screen is a good guide. This data line should be saved electronically and perhaps plotted out on paper and dated. If there is a suspected problem with the system later, this test line could be re-scanned and compared with the earlier results.

NOTE: When comparing data, take weather and environmental conditions into account, as changes could skew the comparisons slightly.

14.7 Contacting the Vendor for Service

When returning the system to the Vendor, have the following information available:

1) GPR sensor serial number displayed at the top of the **System Settings Screen (**see **Section 6.2)**.

2) Display Unit (DVL) serial number, which can also be found in the **System Settings Screen**.

3) A brief description of when the error is happening and the operating conditions (temperature, humidity, sunshine, system settings, etc.).

4) System log files downloaded to your computer

14.8 Using the Hotspot on your Smartphone

If a WiFi signal in unavailable, you may be able to use your Smartphone as a WiFi access point, by creating a Personal Hotspot. If you are experiencing difficulty connecting to a cell phone Personal Hotspot, ensure that the phone is in discovery mode while connecting. On iPhone (iOS 10.3.3), for example, this involves going to **Settings - Personal Hotspot**. Ensure that the Personal Hotspot setting is turned on, and wait on this screen until the RD1500 connection has been established. Once you have received confirmation on the Display Unit, the cell phone can resume normal use.
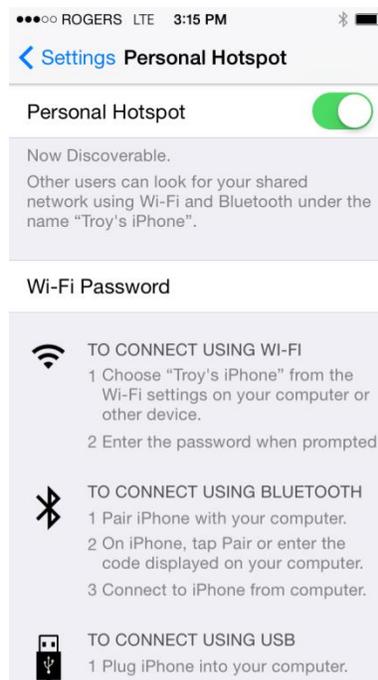
NOTE: When setting up a Personal Hotspot, you may be disconnected from any WiFi networks. Vice versa, if you have a Personal Hotspot setup, attempting to connect to a WiFi network may disconnect your Personal Hotspot.

Section 15 - Care and Maintenance

15.1 Battery Care

The RD1500 uses a 9-Amp-hour, 12-Volt sealed lead acid battery. It is fused with a 10 Amp fuse to protect it from short circuit damage.

The battery unit should run the RD1500 continuously for 6 hours before recharging is necessary. If long days of data surveying are typical, a second battery may be useful.

The battery is strapped onto the cart base and is normally recharged without removing it from the cart. However, the battery can be easily removed for maintenance or for recharging, if required.

If batteries are maintained in a charged condition they will give long life and reliable service. Improper use and lack of maintenance will greatly reduce their life.

Sealed lead acid batteries should **NEVER** be left in a discharged condition for any period of time. Charge the batteries as soon as possible after use.

Charge the battery at room temperature whenever possible.

The RD1500 has a voltage monitoring circuit that will turn off the unit when the input voltage drops below 10.8 volts.

If a battery has been deeply discharged or left in a discharged condition for some period of time it may not accept charge immediately when it is connected to the charger (the fast charge light will not illuminate). If the fast charge light does not come on within 6 hours the battery should be considered damaged and should be discarded.

Do not assume that a battery that is still charging after 8 hours is nearing the end of its charge cycle. Typical charging time for an empty battery is 12-14 hours from the start of fast charge.

Ensure that the batteries are fully charged before storing. If practical, store the batteries in a cool place. 10°C (a refrigerator is ideal), but make sure the temperature is not likely to drop below -30°C or the electrolyte may freeze and possibly split the case.

15.2 Cable Care

1) The cable connectors as well as the connectors on the GPR Sensor and Display Unit need to kept clean and free of dust and moisture. Use a brush or air spray to clean dust, lint and other foreign particles from these connectors.

2) When the system is not being used, make sure the connections are protected to prevent dust and moisture from collecting inside. If the connectors are exposed, cover them with some sort of dust cap.

3) Cables are designed to be as tough as practical.

4) Careless and/or improper use of cables, such as making them carry loads that they are not designed for, can cause internal damage.

5) Connectors are weak points in any system. With the use of this product in rough, dusty and outdoor environments, users can minimize potential downtime if they care for cables and treat connectors with respect.

6) Cables and connectors are not designed to suspend or tow or otherwise carry the weight of systems. They are part of the electronic circuit and should be treated accordingly. When not in use they should be placed in their storage box.

15.3 Skid Pads

The bottom of the GPR Sensor is covered with one large wear-resistant skid pad. The skid pad is designed to take the majority of the abrasive wear. If the pad wears down enough, the less-resistant plastic housing may start to wear. If this occurs, it is best to replace the skid pad. It is easily removed with a screwdriver and a new one can be purchased from the vendor.

15.4 Odometer

The odometer should be periodically calibrated (refer to Section 6.4) to ensure accuracy.

15.5 Storage Cases

Equipment that is transported and stored loosely is more susceptible to damage. All equipment should be stored in its shipping case or a storage box. Radiodetection has optional shipping cases available for all RD1500 systems.

15.6 Upgrading Embedded Software on Display Unit

From time to time, Radiodetection may release new software for the Display Unit. The instructions below describe how to update this software. Please note that this procedure will erase all GPR data from the system, so export any valuable data before continuing.

1. **Download** the zip file provided by Radiodetection
2. **Insert** a clean USB stick into your PC
3. **Unzip** the file by double clocking the file in Windows Explorer
4. **Copy** the unzipped folder to the root of the USB key. The resulting folder structure on the USB key should be:

dvl apps

> app1

> > PACKAGE_NAME.en

> > PACKAGE_NAME.pkg

Where PACKAGE_NAME is the name of the item to be installed.

---

5. **Turn off** the Display Unit. Remove the USB stick from your PC and insert it into the USB port on the side of the Display Unit

6. **Turn on** the Display Unit. You will see a list on the screen showing all software installations. The USB key may hold one or more packages which are displayed as numbered items:

Select app to run:

      1. PACKAGE_NAME

7. **Select** the package to run by pressing the associated numbered key on the Display Unit. The selected software will now be installed. The process may require multiple reboot cycles initiated by the system. When complete, the system will shut down and the red light on the front of the Display Unit will turn off.

8. **Remove** the USB stick from the Display Unit

9. **Turn on** the Display Unit and access the System Info screen (see Section 6) to verify the newly installed version number.

Section 16 - Technical Specifications

Specifications	Values
GPR Sensor size	630 x 410 x 230mm (25 x 16 x 9in)
GPR Sensor weight	5kg (11lbs)
Display Unit weight	2.83kg (6.24lbs)
Display Unit screen	8.0" diagonal, high-visibility, sunlight-readable LCD display with touch screen Adjustable backlighting 1500 NIT and 800:1 contrast ratio
Wireless	Integrated modules: WiFi (IEEE 802.11 b,g,n) GPS/GLONASS
Audio	Built-in speaker - 85dBA speaker with volume control
Battery	Lead acid gel cell Battery Life: 4-6 hours Battery Capacity: 9.0 Ah
Battery weight	3.6kg (7.9lbs)
Battery charger	Built-in charger with status indicator Universal AC mains charger input: 100-240V ∿, 1.5A, 50/60Hz Output: 12 Volts @ 3 Amps
DVL-500N Display Unit Input	11-18V ⎓, 4A maximum
Temperature & Environmental ⚠	Ruggedized, environmentally sealed unit and connections. Ingress protection (IP) rating: DVL-500N Display Unit is rated to IP65 under IEC 60529 Relative Humidity operation (non-condensing): 10 – 90% GPR Sensor and DVL-500N operating temperature range: -40 to 50°C (-40 to 122°F) Do not use touch screen below -20°C (-4°F) Use battery charger between 0 and 30°C (32° to 85°F).
Regulatory Specifications	EMC-FCC, CE, IC, ACA, RSM Safety-TUV, CE

Section 17 - Warranty

Subject to the conditions set out herein, Radiodetection Limited expressly and exclusively provides the following warranty to original end user buyers of Radiodetection products.

Radiodetection hereby warrants that its products shall be free from defects in material and workmanship for one year starting from point of sale to end customer. Extensions of this warranty period may be available where the same terms and conditions apply.

17.1 Statement of warranty conditions

The sole and exclusive warranty for any Radiodetection product found to be defective is repair or replacement of the defective product at Radiodetection's sole discretion. Repaired parts or replacement products will be provided by Radiodetection on an exchange basis and will be either new or refurbished to be functionally equivalent to new.

In the event this exclusive remedy is deemed to have failed of its essential purpose, Radiodetection's liability shall not exceed the purchase price of the Radiodetection product. In no event will Radiodetection be liable for any direct, indirect, special, incidental, consequential or punitive damages (including lost profit) whether based on warranty, contract, tort or any other legal theory.

Warranty services will be provided only with the original invoice or sales receipt (indicating the date of purchase, model name and dealer's name) within the warranty period. This warranty covers only the hardware components of the Radiodetection product.

Before a unit is submitted for service or repair, under the terms of this warranty or otherwise, any data stored on the unit should be backed-up to avoid any risk of data loss. Radiodetection will not be responsible for loss or erasure of data storage media or accessories.

Radiodetection is not responsible for transportation costs and risks associated with transportation of the product. The existence of a defect shall be determined by Radiodetection in accordance with procedures established by Radiodetection.

This warranty is in lieu of any other warranty, express or implied, including any implied warranty of merchantability or fitness for a particular purpose.

This warranty does not cover:

a. Periodic maintenance and repair or parts replacement due to wear and tear.

b. Consumables (components that are expected to require periodic replacement during the lifetime of a product such as non-rechargeable batteries, bulbs, etc.).

c. Damage or defects caused by use, operation or treatment of the product inconsistent with its intended use.

d. Damage or changes to the product as a result of:

    i. Misuse, including: - treatment resulting in physical, cosmetic or surface damage or changes to the product or damage to liquid crystal displays.

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ii. Failure to install or use the product for its normal purpose or in accordance with Radiodetection instructions on installation or use.

iii. Failure to maintain the product in accordance with Radiodetection instructions on proper maintenance.

iv. Installation or use of the product in a manner inconsistent with the technical or safety laws or standards in the country where it is installed or used.

v. Virus infections or use of the product with software not provided with the product or incorrectly installed software.

vi. The condition of or defects in systems with which the product is used or incorporated except other 'Radiodetection products' designed to be used with the product.

vii. Use of the product with accessories, peripheral equipment and other products of a type, condition and standard other than prescribed by Radiodetection.

viii. Repair or attempted repair by persons who are not Radiodetection warranted and certified repair houses.

ix. Adjustments or adaptations without Radiodetection's prior written consent, including:

    a. upgrading the product beyond specifications or features described in the instruction manual, or modifications to the product to conform it to national or local technical or safety standards in countries other than those for which the product was specifically designed and manufactured.

x. Neglect e.g. opening of cases where there are no user-replaceable parts.

xi. Accidents, fire, liquids, chemicals, other substances, flooding, vibrations, excessive heat, improper ventilation, power surges, excess or incorrect supply or input voltage, radiation, electrostatic discharges including lightning, other external forces and impacts.

Section 18 - Appendix A: Health & Safety Certification

Radio frequency electromagnetic fields may pose a health hazard when the fields are intense. Normal fields have been studied extensively over the past 30 years with no conclusive epidemiology relating electromagnetic fields to health problems. Detailed discussions on the subject are contained in the references and the web sites listed below.

The USA Federal Communication Commission (FCC) and Occupational Safety and Health Administration (OSHA) both specify acceptable levels for electromagnetic fields. Similar power levels are mandated by corresponding agencies in other countries. Maximum permissible exposures and time duration specified by the FCC and OSHA vary with excitation frequency. The lowest threshold plane wave equivalent power cited is 0.2mW/cm^2 for the general population over the 30 to 300MHz frequency band. All other applications and frequencies have higher tolerances as shown graphically in Figure A-1.
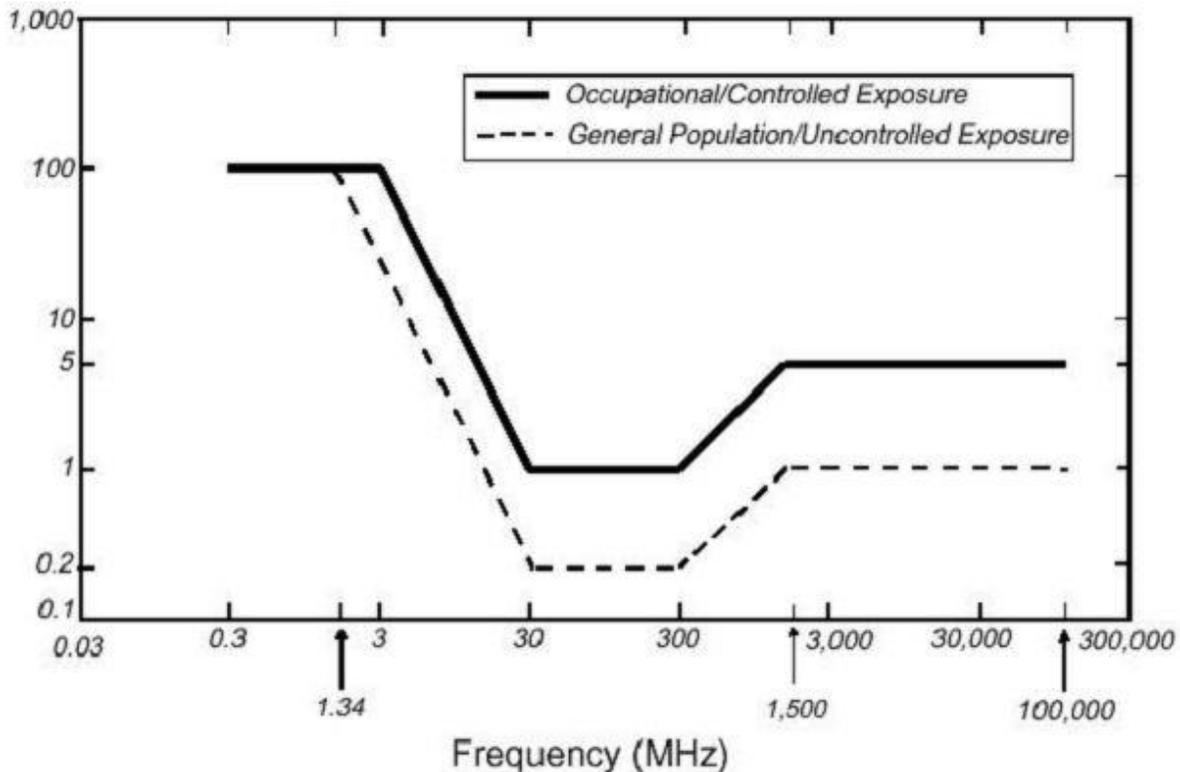
Figure A-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density mW/cm^2.

All Radiodetection Ltd GPR products are normally operated at least 1m (3') from the user and as such are classified as "mobile" devices according to the FCC. Typical power density levels at a distance of 1m or greater from any Radiodetection products are less than 10^{-3}mW/cm^2 which is 200 to 10,000 times lower than mandated limits. As such, Radiodetection products pose no health and safety risk when operated in the normal manner of intended use.

Section 19 - Appendix B: GPR Emissions, Interference and Regulations

Most governments have regulations on the level of electromagnetic emissions that an electronic apparatus can emit. The objective is to ensure that one apparatus or device does not interfere with any other apparatus or device in such a way as to make the other apparatus non-functional.

The manufacturer tests their GPR products using professional, independent testing houses and complies with the regulations of the USA, Canada, European Community and other major jurisdictions on the matter of emissions.

Electronic devices have not always been designed for proper immunity. If a GPR instrument is placed in close proximity to an electronic device, interference may occur. While there have been no substantiated reports of interference to date, if any unusual behavior is observed on nearby devices, test if the disturbance starts and stops when the GPR instrument is turned on and off. If interference is confirmed, stop using the GPR.

Where specific jurisdictions have specific GPR guidelines, you must comply with them. Some of these are described below.

B-1 FCC Regulations

This device complies with Part 15 of the USA Federal Communications Commission (FCC) Rules. Operation in the USA is subject to the following two conditions:

- this device may not cause harmful interference and

- this device must accept any interference received, including interference that may cause undesired operation.

Part 15 – User Information

This equipment has been tested and found to comply with the limits for a Class A digital device, where applicable, and for an ultra-wide bandwidth (UWB) device where applicable, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his/her own expense.

WARNING

Changes or Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

Certification of this equipment has been carried out using approved cables and peripheral devices. The use of non-approved or modified cables and peripheral devices constitutes a Change or Modification outlined in the warning above.

Operating Restrictions

Operation of this device is limited to purposes associated with law enforcement, firefighting, emergency rescue, scientific research, commercial mining, or construction. Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of this chapter.

FCC Interpretation of Operation Restrictions issued July 12, 2002

(FCC Order DA02-1658, paragraph 9)

The regulations contain restrictions on the parties that are eligible to operate imaging systems (See 47 C.F.R. 5.509(b), 15.511(b), and 15.513(b)). Under the new regulations, GPRs and wall imaging systems may be used only by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies, and by construction companies. Since the adoption of the *Order*, we have received several inquiries from the operators of GPRs and wall imaging systems noting that these devices often are not operated by the users listed in the regulations but are operated under contract by personnel specifically trained in the operation of these devices. We do not believe that the recent adoption of the UWB rules should disrupt the critical safety services that can be performed effectively only through the use of GPRs and wall imaging systems. We viewed these operating restrictions in the broadest of terms. For example, we believe that the limitation on the use of GPRs and wall imaging systems by construction companies encompasses the inspection of buildings, roadways, bridges and runways even if the inspection finds no damage to the structure and construction does not actually result from the inspection; the intended purpose of the operation of the UWB device is to determine if construction is required. We also believe that the GPRs and wall imaging systems may be operated for one of the purposes described in the regulations but need not be operated directly by one of the described parties. For example, a GPR may be operated by a private company investigating forensic evidence for a local police department.

FCC Permitted Mode of Usage

The GPR antenna must be kept on the surface to be in compliance with FCC regulations. Use of the antenna is not permitted if it is lifted off the surface. Use as a through-the-wall imaging device is prohibited.

GPR Use Coordination

FCC regulation 15.525(c) (updated in February 2007) requires users of GPR equipment to coordinate the use of their GPR equipment as described below:

TITLE 47--TELECOMMUNICATION

CHAPTER I--FEDERAL COMMUNICATIONS COMMISSION

PART 15_RADIO FREQUENCY DEVICES

Subpart F_Ultra-Wideband Operation Sec.

15.525 Coordination requirements.

    (a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address and other pertinent contact information of the user, the desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to:

Frequency Coordination Branch, OET

Federal Communications Commission

445 12th Street, SW, Washington, D.C.

20554

Attn: UWB Coordination

(**Manufacturer's note**: The form given on the following page is a suggested format for performing the coordination.)

(c) The manufacturers, or their authorized sales agents, must inform purchasers and users of their systems of the requirement to undertake detailed coordination of operational areas with the FCC prior to the equipment being operated.

(d) Users of authorized, coordinated UWB systems may transfer them to other qualified users and to different locations upon coordination of change of ownership or location to the FCC and coordination with existing authorized operations.

(e) The FCC/NTIA coordination report shall identify those geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging system is prohibited. If additional coordination is required for operation within specific geographical areas, a local coordination contact will be provided. Except for operation within these designated areas, once the information requested on the UWB imaging system is submitted to the FCC no additional coordination with the FCC is required provided the reported areas of operation do not change. If the area of operation changes, updated information shall be submitted to the FCC following the procedure in paragraph (b) of this section.

(f) The coordination of routine UWB operations shall not take longer than 15 business days from the receipt of the coordination request by NTIA. Special temporary operations may be handled with an expedited turn-around time when circumstances warrant. The operation of UWB systems in emergency situations involving the safety of life or property may occur without coordination provided a notification procedure, similar to that contained in Sec. 2.405(a) through (e) of this chapter, is followed by the UWB equipment user.[67 FR 34856, May 16, 2002, as amended at 68 FR 19751, Apr. 22, 2003]

Effective Date Note: At 68 FR 19751, Apr. 22, 2003, Sec. 15.525 was amended by revising [[Page 925]] paragraphs (b) and (e). This amendment contains information collection and recordkeeping requirements and will not become effective until approval has been given by the Office of Management and Budget.

FCC GROUND PENETRATING RADAR COORDINATION NOTICE

NAME:

ADDRESS:

CONTACT INFORMATION [CONTACT NAME AND PHONE NUMBER]:

AREA OF OPERATION [COUNTIES, STATES OR LARGER AREAS]:

FCC ID: QJQ-NG250

EQUIPMENT NOMENCLATURE: NG250

Send the information to:

Frequency Coordination Branch, OET

Federal Communications Commission

445 12th Street, SW

Washington, D.C. 20554

ATTN: UWB Coordination

Fax: 202-418-1944

INFORMATION PROVIDED IS DEEMED CONFIDENTIAL

B-2 ETSI Regulations for the EC (European Community)

In the European Community (EC), GPR instruments must conform to ETSI (European Technical Standards Institute) standard EN 302 066-1 v1.2.1. Details on individual country requirements for licensing are coordinated with this standard. For more information, contact Radiodetection's technical support staff.

All Radiodetection ground penetrating radar (GPR) products offered for sale in European Community countries, or countries adhering to ETSI standards, are tested to comply with EN 302 066 v1.2.1.

It is the user's responsibility to check and ensure that they satisfy individual country licensing requirements.

The UK for example, does currently require a licence to operate Ground Penetrating Radar, details are available from OFCOM. (https://licensing.ofcom.org.uk).

We recommend that users check with the Radio and Telecoms Licensing authority in the country of use. Radiodetection sales and support staff can help with contact details and information.

For those who wish to get more detailed information, they should acquire copies of the following documents available from ETSI.

ETSI EN 302 066-1 V1.2.1 (February 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 1: Technical characteristics and test methods

ETSI EN 302 066-2 V1.2.1 (February 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive

ETSI TR 101 994-2 V1.1.2 (March 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band technology (UWB); Part 2: Ground- and Wall- Probing Radar applications; System Reference Document

B-3a Industry Canada Regulations - English

Industry Canada published its regulations for ground penetrating radar (GPR) on Mar 29 2009 as part of the RSS-220 titled 'Devices Using Ultra-Wideband (UWB) Technology'.

Industry Canada has made a unique exception for GPR by not requiring user licensing. The user does have to comply with the following directives:

This Ground Penetrating Radar Device shall be operated only when in contact with or within 1m of the ground.

This Ground Penetrating Radar Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

Should the ground penetrating radar be used in a wall-penetrating mode then the following restriction should be noted by the user:

This In-wall Radar Imaging Device shall be operated where the device is directed at the wall and in contact with or within 20 cm of the wall surface.

This In-wall Radar Imaging Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

Since operation of GPR is on a license-exempt basis, the user must accept the following:

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

B-3b Règlement d'Industrie Canada - Français

Industrie Canada a publié des règlements pour les appareils géoradar (GPR) le 29 mars 2009, dans le cadre du RSS-220 intitulé "Dispositifs utilisant la bande ultra-large (UWB)".

Industrie Canada a faite une exception unique pour GPR en n'exigeant pas de licence par utilisateur. L'utilisateur doit se conformer aux directives suivantes:

Ce géoradar périphérique doit être utilisé que lorsqu'il est en contact avec ou moins de 1 m du sol.

Ce géoradar périphérique doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.

Si le géoradar est utilisé dans un mode de pénétration au mur, la restriction suivante est à noter par l'utilisateur:

Ce dispositif d'imagerie radar doit être utilisé lorsque l'appareil est orienté vers le mur et en contact avec ou dans les 20 cm de la surface du mur.

Ce dispositif d'imagerie radar doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.

Parce que l'exploitation de GPR est sur une base exempte de licence, l'utilisateur doit accepter le texte suivant:

La fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositive

Section 20 - Appendix C: Instrument Interference

Immunity regulations place the onus on instrument/apparatus/device manufacturers to ensure that extraneous interference will not unduly cause an instrument/apparatus/device to stop functioning or to function in a faulty manner.

Based on independent testing house measurements, Radiodetection systems comply with such regulations in Canada, USA, European Community and most other jurisdictions. GPR devices can sense electromagnetic fields. External sources of electromagnetic fields such as TV stations, radio stations and cell phones, can cause signals detectable by a GPR which may degrade the quality of the data that a GPR device records and displays.

Such interference is unavoidable but sensible survey practice and operation by an experienced GPR practitioner can minimize such problems. In some geographic areas emissions from external sources may be so large as to preclude useful measurements. Such conditions are readily recognized and accepted by the professional geophysical community as a fundamental limitation of geophysical survey practice. Such interference being present in the GPR recordings is not considered as an equipment fault or as a failure to comply with immunity regulations.

Section 21 - Appendix D: Safety around Explosive Devices

Concerns are expressed from time to time on the hazard of GPR products being used near blasting caps and unexploded ordnance (UXO). Experience with blasting caps indicates that the power of Radiodetection's GPR products is not sufficient to trigger blasting caps. Based on a conservative independent testing house analysis, we recommend keeping the GPR transmitters at least 6 feet (2m) from blasting cap leads as a precaution. Some customers do experimental trials with their particular blasting devices to confirm safety.

We strongly recommend that GPR users routinely working with explosive devices develop a systematic safety methodology in their work areas.

The UXO issue is more complex and standards on fuses do not exist for obvious reasons. To date, no problems have been reported with any geophysical instrument used for UXO. Since proximity and vibration are also critical for UXO, the best advice is to be cautious and understand the risks.

Section 22 - Appendix E: WiFi Module

FCC Notice:

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his/her own expense.

Industry Canada Notice:

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:

(1) This device may not cause interference; and

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Section 23 - Appendix F – Import/Export

Dual Use

The definition of 'dual use items' is given as:

'Dual-use items' shall mean items, including software and technology, which can be used for both civil and military purposes, and shall include all goods which can be used for both non-explosive uses and assisting in any way in the manufacture of nuclear weapons or other nuclear explosive devices.

The manufacturer warrants that the RD1500 is not dual-use.

RADIODETECTION®

SPX

Visit **www.radiodetection.com**

Global locations

Radiodetection (USA)

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Toll Free: +1 (877) 247 3797 Tel: +1 (207) 655 8525 rd.sales.us@spx.com

Pearpoint (USA)

39-740 Garand Lane, Unit B, Palm Desert, CA 92211, USA

Toll Free: +1 800 688 8094 Tel: +1 760 343 7350 pearpoint.sales.us@spx.com **www.pearpoint.com**

Radiodetection (Canada)

344 Edgeley Boulevard, Unit 34, Concord, Ontario L4K 4B7, Canada

Toll Free: +1 (800) 665 7953 Tel: +1 (905) 660 9995 rd.sales.ca@spx.com

Radiodetection Ltd. (UK)

Western Drive, Bristol, BS14 0AF, UK

Tel: +44 (0) 117 976 7776 rd.sales.uk@spx.com

Radiodetection (France)

13 Grande Rue, 76220, Neuf Marché, France

Tel: +33 (0) 2 32 89 93 60 rd.sales.fr@spx.com

Radiodetection (Benelux)

Industriestraat 11, 7041 GD 's-Heerenberg, Netherlands

Tel: +31 (0) 314 66 47 00 rd.sales.nl@spx.com

Radiodetection (Germany)

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Tel: +49 (0) 28 51 92 37 20 rd.sales.de@spx.com

Radiodetection (Asia-Pacific)

Room 708, CC Wu Building, 302-308 Hennessy Road, Wan Chai, Hong Kong SAR, China

Tel: +852 2110 8160 rd.sales.asiapacific@spx.com

Radiodetection (China)

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