DCVG Training Manual – Gx Version

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MANUAL CONTENTS

Continued Over/

SECTION V: HOW TO PERFORM DCVG SURVEYS

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SECTION I: INTRODUCTION

Unlike Close Interval Potential Surveys (CIPS or CIS), Direct Current Voltage Gradient (DCVG) surveys do not involve an electrical connection to the pipe, other than, temporarily, to determine IR drop values at pipe connection locations (please see Section II for details). Instead, readings on DCVG surveys involve soil-to-soil potential difference measurements, as opposed to pipe-to-soil potential difference measurements.

DCVG surveys are typically performed on well-coated pipelines with a view to determining the location of coating-related anomalies. In addition to locating coating-related anomalies, data collected specifically at anomaly locations (side-drain data) are integrated with the survey data and are used by the software to determine size factors (severity factors) for the anomalies.

Since DCVG surveys are close-interval in nature, i.e. survey data are recorded every 2.5 feet or every 5 feet, for example, they can be considered complementary to close interval potential surveys (CIPS or CIS) and both types of surveys are typically performed on the same pipeline as part of the ECDA (External Corrosion Direct Assessment) protocol regarding “Indirect Inspections”. With regard to the ECDA protocol, at least 2 types of close-interval “Indirect Inspection” surveys are required to be performed on all sections of a buried pipeline and, typically, DCVG and CIS surveys are employed to satisfy this requirement on well-coated pipelines.

The physical principles associated with DCVG surveys are discussed in Section II and the procedures to setup the data-logger for a DCVG survey are detailed in Section III. Sections IV and V outlines the equipment hook-up requirements for DCVG surveys and how to actually conduct a DCVG survey, respectively. Finally, Section VI describes how to copy DCVG survey files to a PC.

SECTION II: PHYSICAL PRINCIPLES

II. 1 Potential (Voltage) Gradients

When a buried pipeline experiences impressed current cathodic protection, the DC rectifier current that flows in the soil to the pipeline causes the pipeline to be polarized with respect to the surrounding soil. As illustrated in Figure 1 below, a potential gradient exists between the pipeline and the surrounding soil in such a case, the potential being largest at the pipe itself (largest negative value) and dropping off rapidly with distance away from the pipe. The potential at "remote earth" is zero and the potential gradient is the potential difference between the pipe potential (negative potential at the pipe) and remote earth.

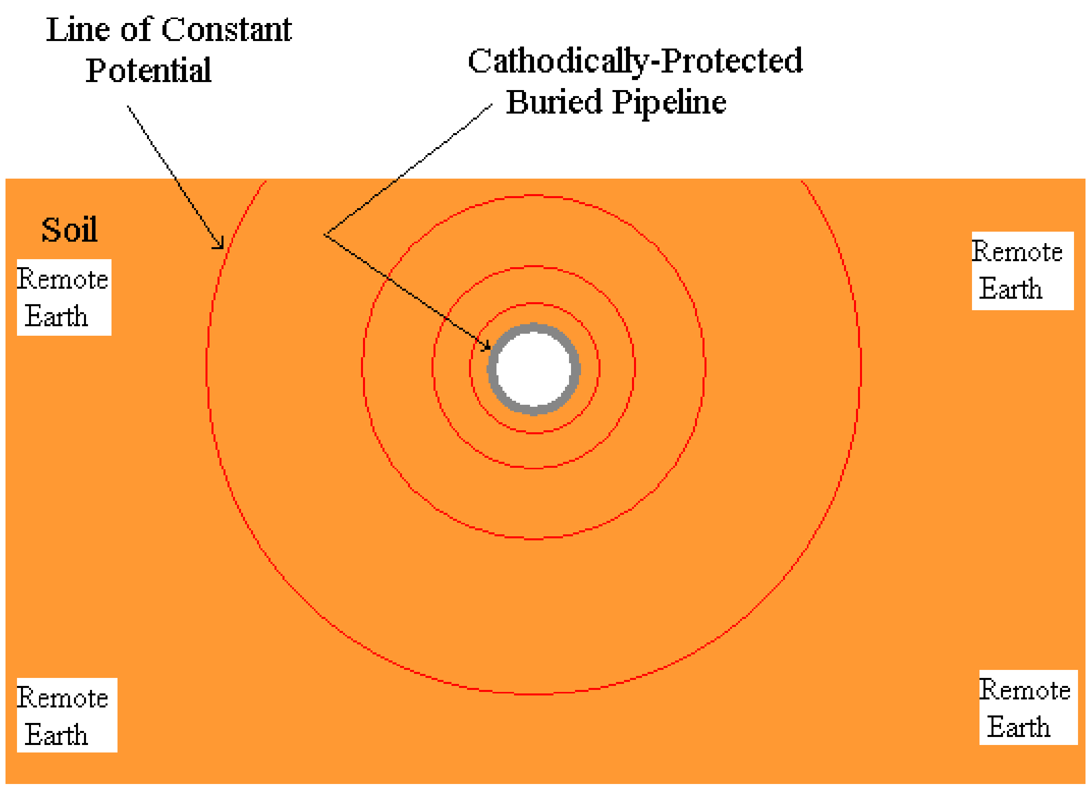


Figure 1: Potential Gradient Associated with a Cathodically-Protected Pipeline (Equipotential Lines are closer together near the pipe, indicating that the potential drops quickly (initially) with distance away from the pipe).

In the case of a well-coated section of pipeline, the potential at ground level in the vicinity of the pipe will be close to zero (close to remote earth potential).

However, when coating defects (holidays) are present, the local potential at the defect locations increases significantly, since the impressed current flows through the soil primarily to the defects. This situation is illustrated schematically in Figure 2 below.

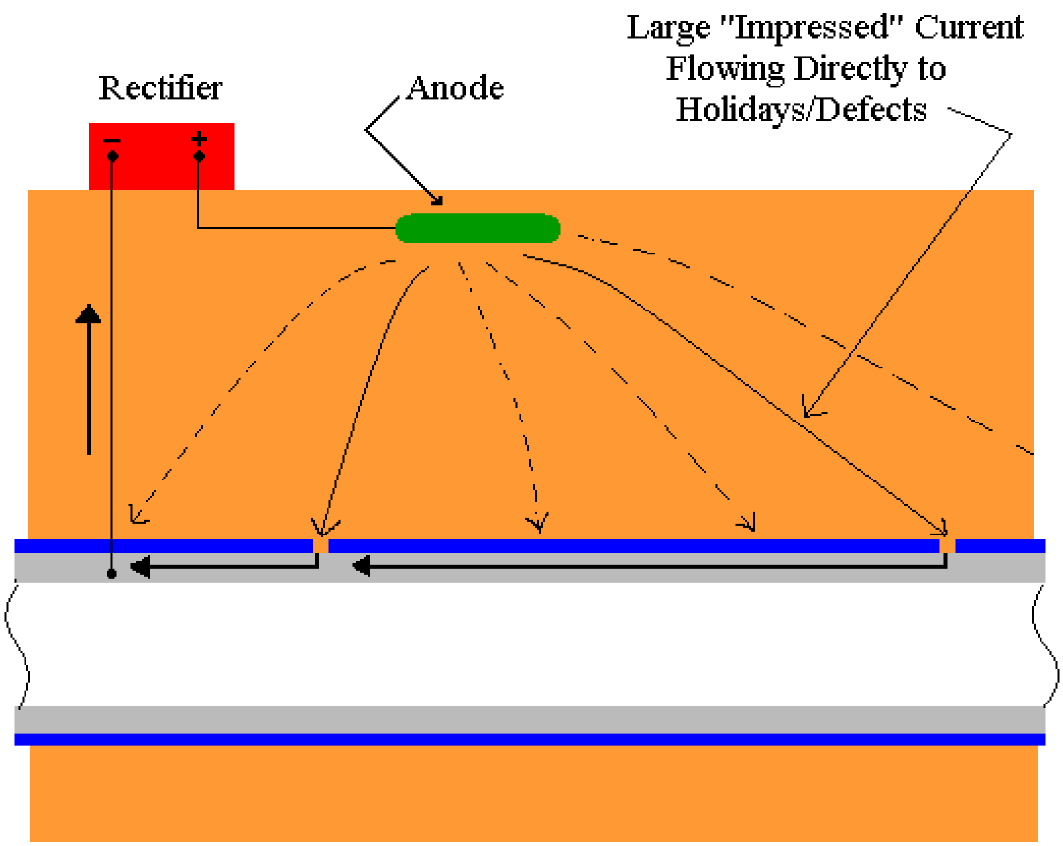


Figure 2: The Influence of Coating Defects on Impressed-Current Flow Distribution along a Pipeline (locally high potentials occur at defect locations due to locally large currents flowing to the defects).

A small amount of current will also flow to the pipeline through the coating (the coating will not be a perfect electrical insulator), however, this current will be negligible compared to that flowing to the coating defect areas.

Since the pipe potential can be high at the site of a defect (due to large impressed-current flow to the defect), the potential at ground level above the pipe (above the defect site) can be significantly higher than zero (the remote earth potential). Consequently, the measurement of a significant "above the defect" soil potential (voltage) with respect to remote earth, is a good indication that a coating-defect has actually been located, especially if the soil potential above the pipe away from the defect location is essentially zero with respect to remote earth.

Since the defect site is surrounded by soil, a voltage gradient will exist between the defect site and the soil. A voltage gradient will actually exist in 3 dimensions. Consider the defect site as being the center of a series of concentric spheres with the surface of each sphere being a surface of constant potential. Near the defect, the concentric spheres will be closely-spaced which means that the potential will drop-off quickly with distance from the epicenter (the defect site). The spheres (constant potential surfaces) will be spaced further and further apart, implying a slower potential drop-off rate, with distance away from the defect site.

If we consider the surface of the ground above the pipeline to be a "plane", the ground will have an "in-plane" potential gradient in the region above the site of the defect. Imagine taking a slice through the ball of concentric spheres (spherical surfaces of constant potential). The slice would represent the surface of the ground, with the distance from the epicenter of the concentric spheres to the slice being the distance from the defect to the ground, ie, the depth of the pipeline.

Figure 3 illustrates the "in-plane" potential gradient (**voltage gradient**) associated with the surface of the ground in the vicinity of a coating defect on a buried pipeline. The defect location is indicated by the X symbol on the buried pipeline and the **voltage gradient on the surface of the ground,** arising as a consequence of the defect, is represented by the concentric circles of constant potential. The separation between constant potential circles is small in the vicinity of the defect, indicating a rapid drop-off in potential near the defect while the separation between constant potential circles increases with distance from the defect, indicating a less rapid drop-off rate with distance as the remote earth potential is approached. In order to illustrate this point, the constant potential circles have been labeled as percentages. It is assumed that the potential on the surface of the ground directly above the defect is 100% of the maximum potential, ie, the largest potential measurable for this defect.

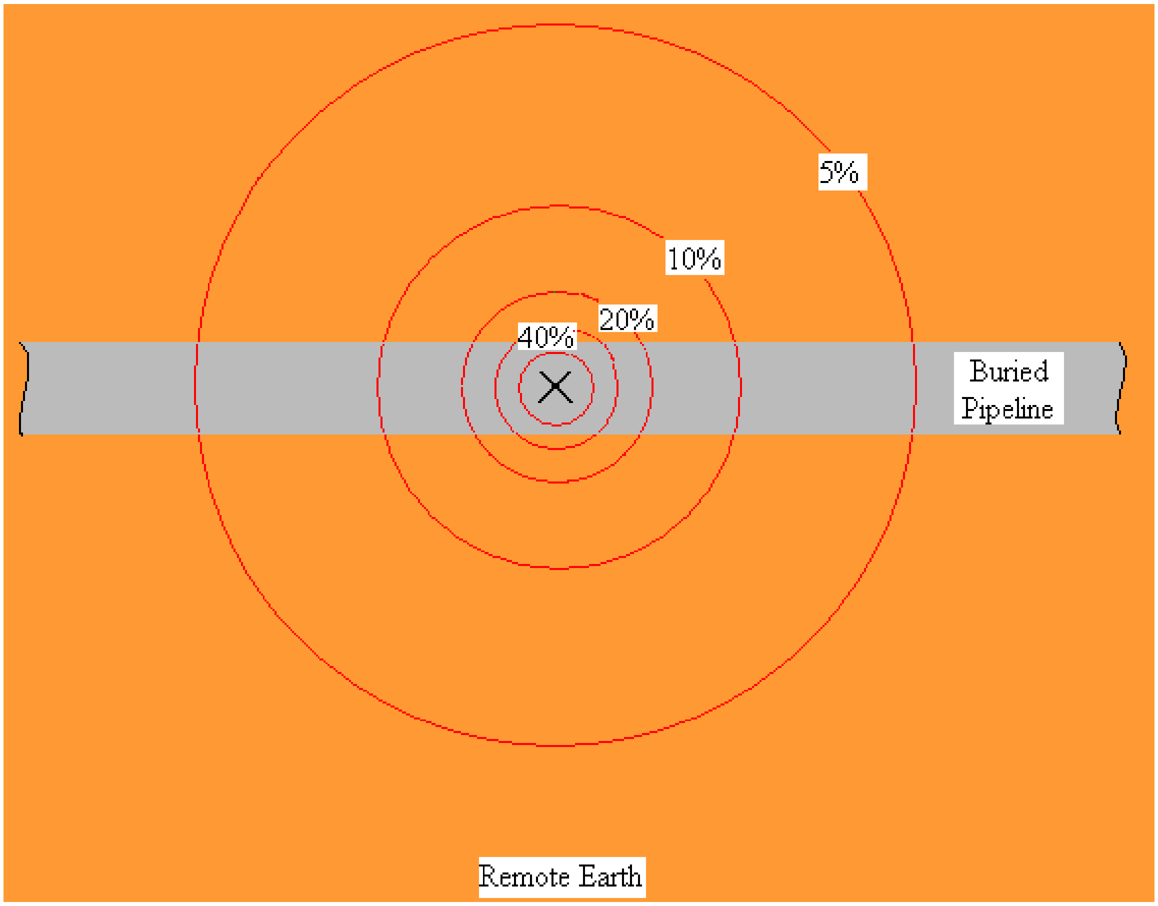


Figure 3: Potential (Voltage) Gradient at the Surface of the Ground associated with a Coating Defect on a Buried Pipeline (concentric circles represent constant potential lines). The "X" symbol represents location of coating defect.

If we imagine pushing a pole vertically from the surface of the ground directly above the defect down to the defect itself, and then walking on the surface of the ground away from the pole, we'll encounter lower potentials (with respect to our maximum potential at the pole) as we move further and further away from the pole. The percentages indicated in Figure 3, would represent percentages of the maximum potential measured at the pole location.

Since such surface potential (voltage) gradients exist above pipeline defects, we can perform soil-to-soil potential difference surveys to detect the defects. Such surveys are know as DCVG surveys (Direct-Current Voltage Gradient surveys).

DCVG surveys can be performed in two different ways: Perpendicular Mode and In-Line (or Parallel) Mode. In the case of Perpendicular DCVG surveys, an imaginary line drawn between the reference electrodes on the surface of the ground would be **perpendicular** to the direction of the pipeline and, in the case of In-Line DCVG surveys, an imaginary line drawn between the reference electrodes on the surface of the ground would (ideally) be **in-line** with the center of the pipeline (directly above the pipeline).

II. 2 Perpendicular DCVG Survey Technique:

As illustrated in Figure 4 below, this technique involves placing a matched-pair of reference electrodes (canes) on the surface of the ground perpendicular to the pipeline direction, with the left-hand cane (red-handled cane) positioned (ideally) over the centerline of the pipe and the right-hand cane (green-handled cane) spaced typically 4 or 5 feet from the left-hand cane. With this cane spacing maintained, the operator walks down the length of the pipeline, triggering readings every 2.5 feet (or some other length interval, typically 5 to 10 feet). Since the left-hand cane connects to the negative side of the voltmeter (data logger’s voltmeter) and the right-hand cane connects to the positive side of the voltmeter, the voltage recorded at each triggering location is the **difference** between the soil potentials at the two reference electrode positions in each case.

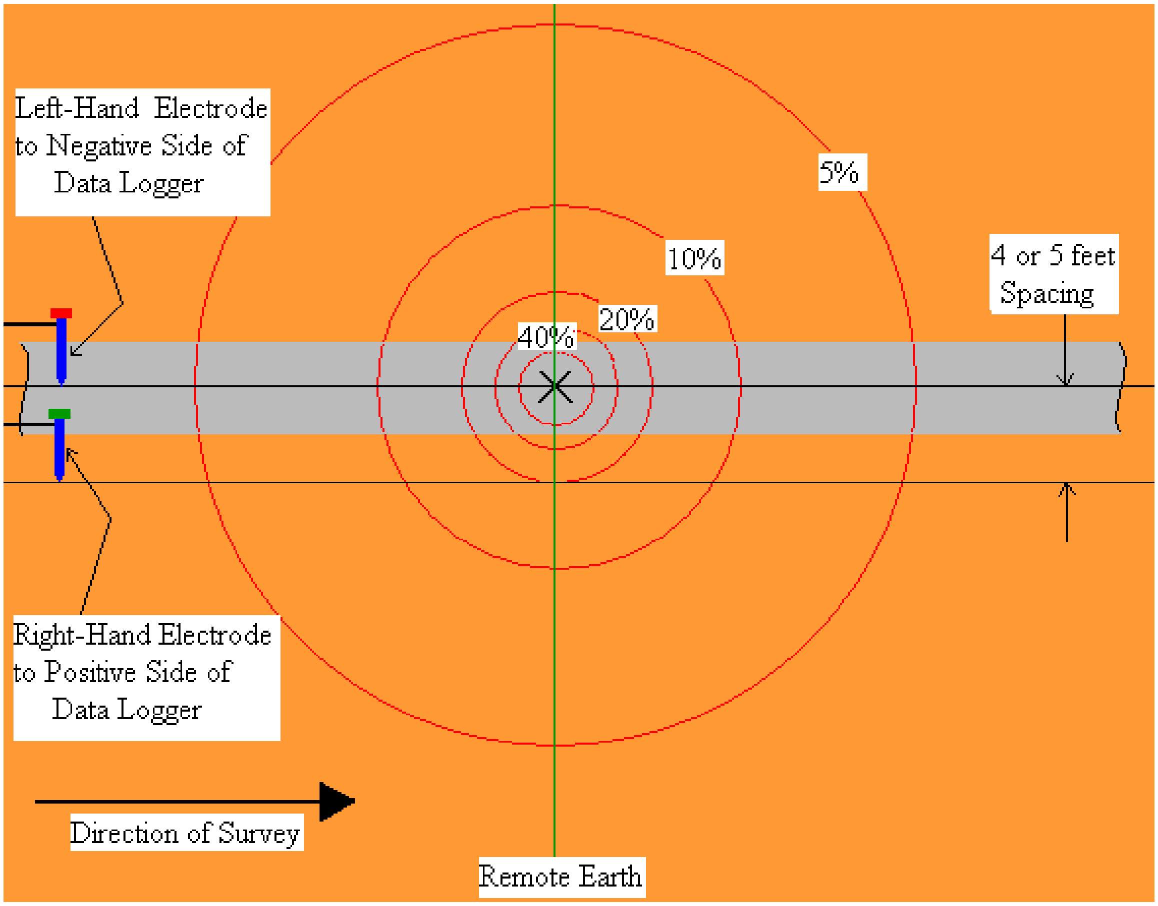


Figure 4: Reference Electrode Positioning for a Perpendicular DCVG Survey. Potential difference measured at the green line will represent the maximum voltage recorded.

As can be seen from Figure 4, prior to encountering the coating defect, the potential difference measured between the reference electrodes will be essentially zero, since we are currently outside the "voltage gradient field". As we enter the "voltage gradient field", walking towards the defect, the difference between the soil potentials at the reference electrode positions will begin to increase in magnitude and reach a maximum value when we are level with the defect (the green line location in Figure 4). As an example, if the maximum potential at the defect is -100mV (with respect to remote earth), the potential difference measured by the data logger's voltmeter at the green line location (defect location) would be +80mV, since the right-hand reference electrode would be positioned on the 20% constant potential line.

The +80mV reading would occur since the voltmeter would subtract -100mV from -20mV to give +80mV [-20mV - (-100mV) = +80mV]. Remember that the right-hand electrode is connected to the positive side of the voltmeter and the left-hand electrode is connected to the negative side of the voltmeter.

If we continue walking past the location of the defect, the difference between the soil potentials at the reference electrode positions will begin to decrease in magnitude and eventually will be zero again as we exit the "voltage gradient field". Consequently, a profile such as that shown below in Figure 5 will be observed in the case of Perpendicular DCVG surveys as a coating defect is encountered.

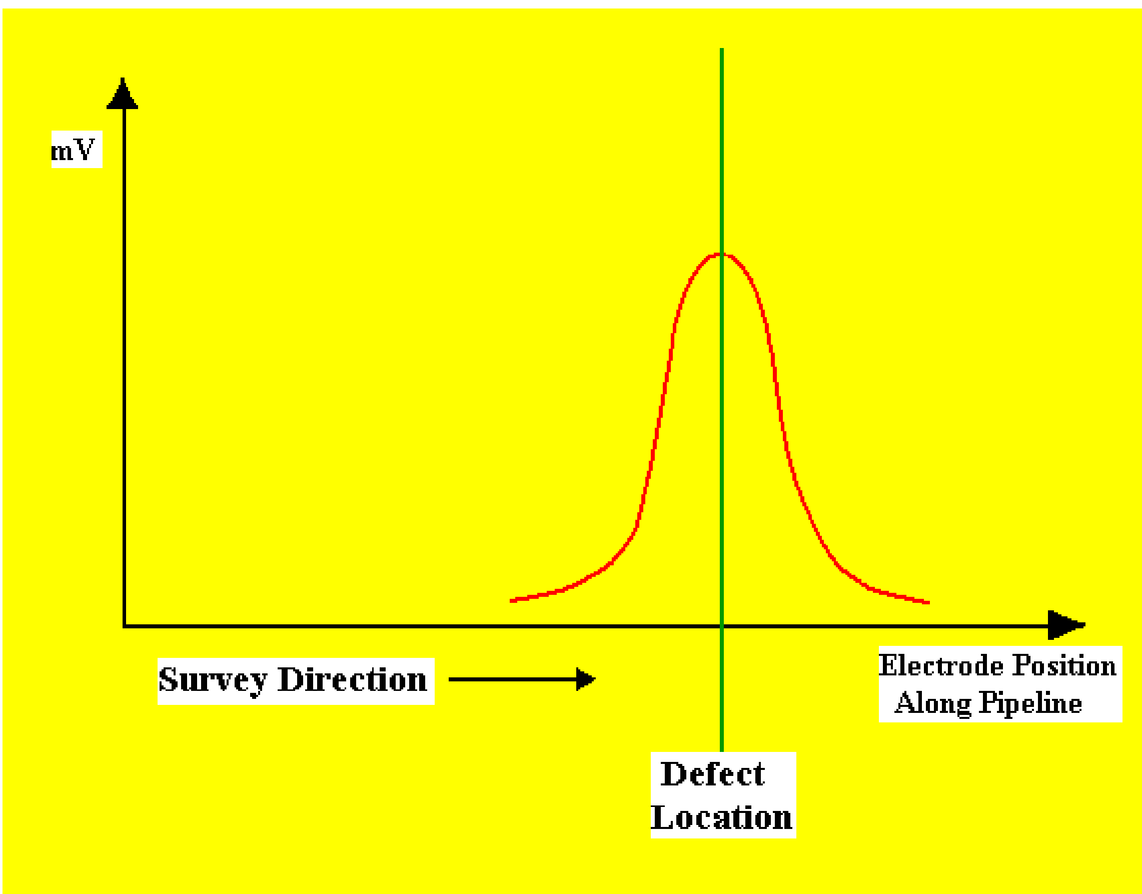


Figure 5: DCVG Voltage as a Function of Electrode Position along Pipeline in the vicinity of a Coating Defect as measured with electrodes in perpendicular configuration (see Figure 4)

II. 3 Definition of DCVG Voltage:

DCVG surveys are performed in the rectifier-current ON/OFF mode, ie, the rectifier current is switched ON and OFF in a cyclic fashion. This allows soil-to-soil potential differences to be recorded during the ON portion of the current cycle and also during the OFF portion of the current cycle.

For DCVG surveys, the MCM data logger's software calculates the difference between the soil-to-soil potential difference recorded during the ON part of the cycle [delta V(ON)] and the soil-to-soil potential difference recorded during the OFF part of the cycle [delta V(OFF)]. The polarities of both delta V(ON) and delta V(OFF) are also recorded at defect sites (more on these polarities later).

Since delta V(ON) represents the soil-to-soil potential difference with current contributions from the pipeline's CP system **as well as** from all other sources (stray interference, foreign pipelines etc.), and, since delta V(OFF) represents the soil-to-soil potential difference with only the "other" current sources contributing, a DCVG reading will represent the soil-to-soil potential difference with **only** the pipeline's CP system contributing to the current flow to the defect.

For the remainder of this manual, the term "**DCVG voltage**" will be taken to mean the difference between the "CP current ON" soil-to-soil voltage reading and the "CP current OFF" soil-to-soil voltage reading.

II. 4 Definition of Total mV:

The, so-called, "Total mV" is the difference between the maximum potential at a defect location and the potential at remote earth, arising due to the CP system's contribution to the current flow to the defect. Since, as shown in Figure 4, a typical electrode spacing is 4 to 5 feet and the "voltage gradient field" associated with a defect typically extends a significant distance beyond the right-hand reference electrode location, several measurements are actually required in order to determine the total voltage gradient (Total mV) associated with a defect.

II. 5 Procedure to determine Total mV:

When the defect location has been identified as described above (ie, the location where a maximum DCVG voltage reading has been observed), a set of DCVG voltage readings is made by moving in a straight line perpendicular to the pipeline direction.

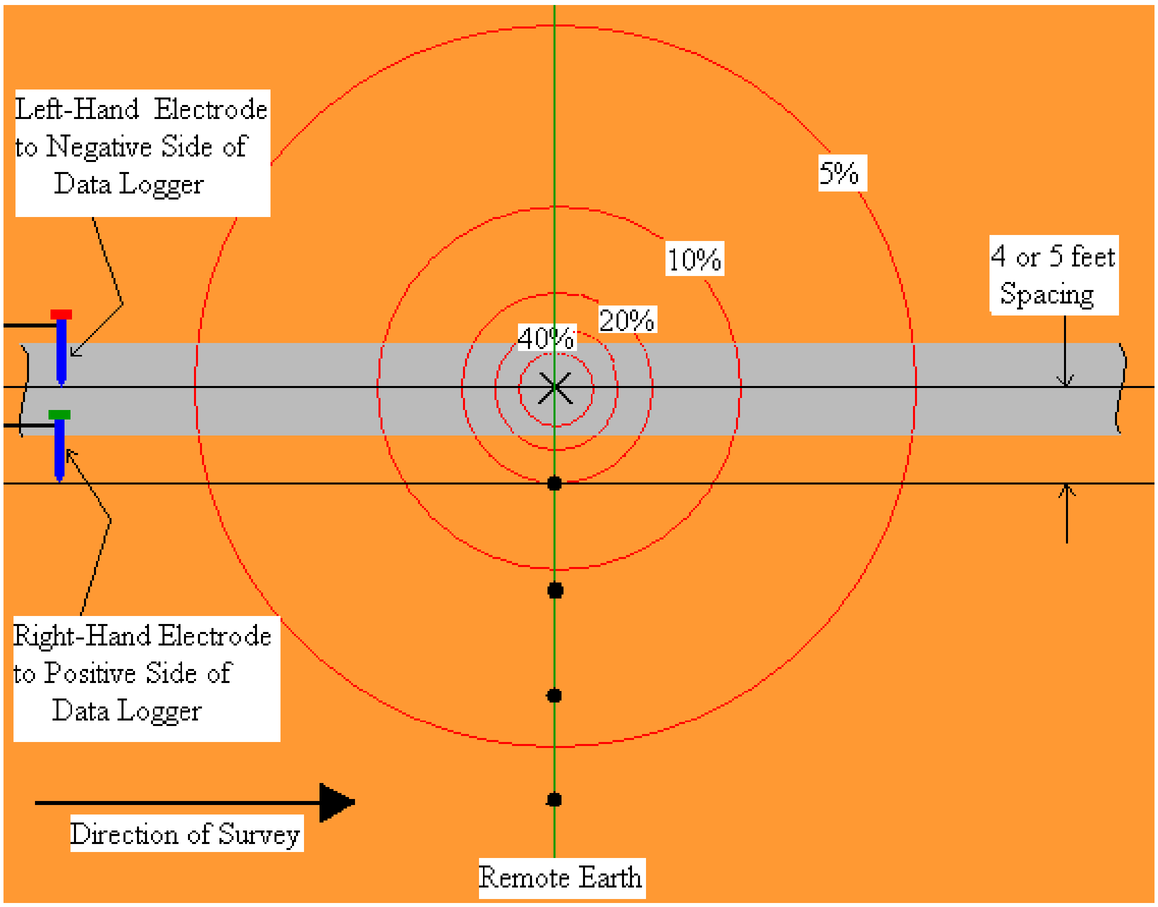


Figure 6: Reference Electrode Positions (black dot locations along green line) for "Total mV" Determination

With reference to Figure 6 above, a recording is first made with the left-hand reference electrode positioned over the defect and the right-hand reference electrode positioned at the first black dot location along the green line. The DCVG voltage recorded here is known as the **Max mV** recording, as this is, typically, the maximum DCVG voltage that will be recorded for this defect.

This Max mV value becomes the first component of the Total mV determination.

Once the Max mV has been recorded, a DCVG voltage recording is made by placing the left-hand reference electrode in the previous position of the right-hand electrode and moving the right-hand electrode to the location of the second black dot along the green line (all black dots shown in Figure 6 are spaced at 4 to 5 feet intervals). Once a DCVG voltage recording has been made with the electrodes in this position, the electrodes are moved in the same fashion to the next measurement positions and a third DCVG voltage recording is made. This process is continued (typically 3 or 4 measurements are required for a significant defect) until the soil-to-soil potential difference is basically zero, ie, you have reached remote earth.

The MCM data logger's software will calculate the sum of these DCVG voltage recordings to generate the "**Total mV**". This will represent the voltage gradient on the surface of the ground associated with this defect.

II. 6 Defect "Size" Considerations:

Since "Total mV" represents the voltage gradient on the surface of the ground associated with CP current flowing to a defect, if we can relate the Total mV to a measure of the magnitude of the CP current, we can obtain a measure of the "size" of the defect.

Since the CP current is being switched ON and OFF, we can measure the IR drop associated with the CP current flowing in the soil (primarily to the defect), which is just the difference in the pipe-to-soil voltage measured during the ON portion of the cycle and the pipe-to-soil voltage measured during the OFF portion of the cycle. Consequently, we can have a measure of the current flowing to the defect (through the IR drop determination), which we can relate to the voltage gradient (Total mV).

II. 7 Definition of % IR:

The magnitude of the voltage gradient on the surface of the ground (Total mV), arising as a consequence of ionic current flowing to the pipe in the vicinity of the defect (CP current magnitude = I), expressed in relationship to the IR voltage drop in the soil (due to the CP current flowing), is a quantity known as the % IR.

% IR = [Total mV/IR drop] x 100

In order to determine the IR drop value to use in the above equation, pipe-to-soil voltages are recorded at the test stations "bracketing" a defect location. The software then calculates the difference between the ON and the OFF pipe-to-soil voltages (IR drop values) at each of the test stations. If the IR values recorded at both test stations are essentially the same, the software uses this IR drop value to calculate the % IR value for the defect using the above equation. If, on the other hand, the IR drop values recorded at the two test stations bracketing the defect are significantly different, the software will generate an average IR drop value to use in the equation, based on the defect's location relative to the locations of the two test stations.

For example, if the two test stations bracketing a defect are 1 mile apart, and the defect is located as shown below, and, if the IR drop values are

```
  <---- 1/3 mile ---------> <---------------  2/3 mile  --------------------- >
 TS1-----------------------X-----------------------------------------------TS2
300mV                 Defect                                              500mV
(IR drop)                                                               (IR drop)
```

recorded as shown at the two test stations (300mV and 500mV), the software will determine the IR drop value for the % IR calculation to be:

300mV + [1/3 x (500mV – 300mV)] = 366.67mV

Consequently, if the Total mV has been determined and the IR drop has been determined, a value for the "size" of the defect, ie, the % IR, can be calculated by the software.

For example, if the Total mV for the above defect was determined to be 100 mV, the % IR for the defect would be calculated by the software as follows:

% IR = (100mV/366.67mV) x 100 = 27.27%

II. 8 Summary of DCVG Parameters at Defect Locations

Assuming that IR drop recordings were properly made at “bracketing” test stations and that the appropriate DCVG voltages were recorded at each anomaly location (with reference to Figure 6 above), the software determines the following important parameters for each “marked” anomaly:

> Maximum delta V(ON) or Max mV(ON): Magnitude and Polarity
> Maximum delta V(OFF) or Max mV(OFF): Magnitude and Polarity
> Max mV (Max mV(ON) – Max mV(OFF)): Magnitude (always positive)
> Total mV: Magnitude
> % IR: Magnitude

II. 9 Polarity Considerations

By noting the polarities of the maximum soil-to-soil potential difference recorded with rectifier-current ON and rectifier-current OFF at a defect site, we can determine the corrosion condition of the defect with the CP system current flowing (ON state) and without the CP system’s impressed current flowing (OFF state).

A **positive** value for delta V, given the polarities of the data-probes and their positioning relative to the pipe, indicates that net current is flowing **to** the pipe, which is a **cathodic** condition. Whereas, a **negative** value for delta V, indicates that net current is flowing **away** the pipe, which is an **anodic** condition.

Since we are able to record the polarity of Max mV(ON) and Max mV(OFF), we can determine the corrosion condition of the defect, both when the CP current is impressed and when the CP current is not flowing to the defect.

The best case scenario is cathodic/cathodic, however, cathodic/anodic is also acceptable, since, in this case, the CP system’s impressed current is doing its job, ie, it is preventing corrosion taking place at the defect site. The worst case scenario would be anodic/anodic, since in this case the defect is not protected even with CP current flowing.

II. 10 In-Line (Parallel) DCVG Survey Technique:

There is a second method of performing DCVG surveys, known as In-Line (or Parallel) Mode

In this case, DCVG voltages are recorded in a close interval fashion by placing the reference electrodes in-line with the pipeline (directly over the pipeline), as opposed to placing the reference electrodes perpendicular to the pipeline direction.

This technique is illustrated in Figure 7 below.

As can be seen from Figure 7, as the operator enters the “voltage gradient field” associated with the defect and places the reference electrodes as indicated with the right-hand electrode connected to the positive side of the data logger’s voltmeter and the left-hand electrode connected to the negative side of the voltmeter, the DCVG voltage measured will begin to increase and have a positive polarity.

As the defect location is approached, the DCVG voltage will increase more sharply, since the circles of constant potential are spaced closer together. A maximum DCVG voltage will be measured when the left-hand reference electrode is directly over the defect.

As indicated in Figure 7, however, the DCVG voltage will drop to zero when the operator is straddling the defect, since in this position, the reference electrodes will be measuring the same potential and, hence, the potential difference between them will be zero.

Continuing down the line, with the right-hand electrode directly over the defect, the DCVG voltage will again have a maximum value, however, this time the polarity will be negative.

Finally, as the operator continues down the line, the magnitude of the DCVG voltage measured will decrease quickly near the defect and then decrease more gradually moving further away from the defect.

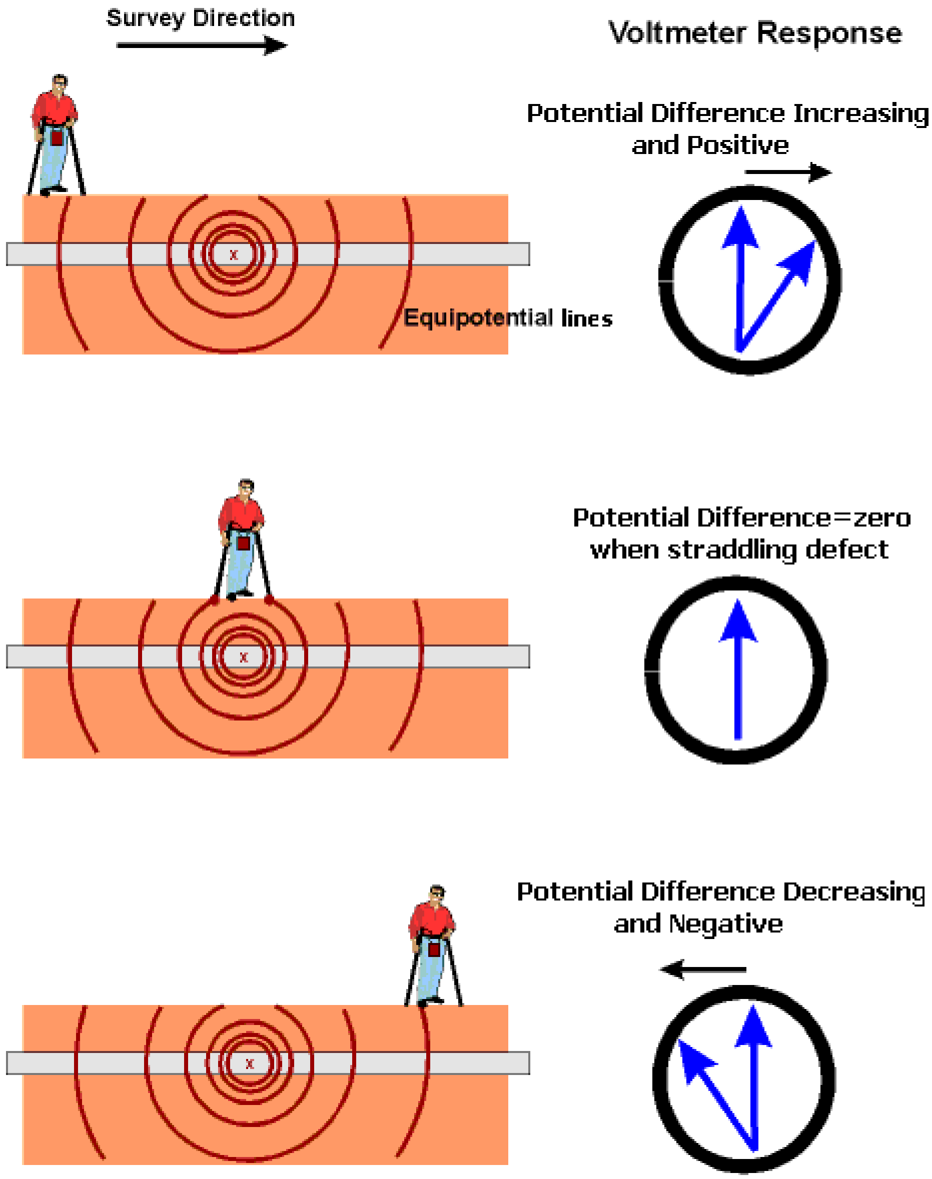


Figure 7: In-Line DCVG Survey Technique

Consequently, the DCVG voltage profile recorded in the vicinity of a defect will be considerable different in appearance from that observed in the case of a Perpendicular DCVG survey (see Figure 5).

Figure 8 represents an illustration of the type of DCVG voltage profile that is recorded during an In-Line DCVG survey when a defect is encountered.

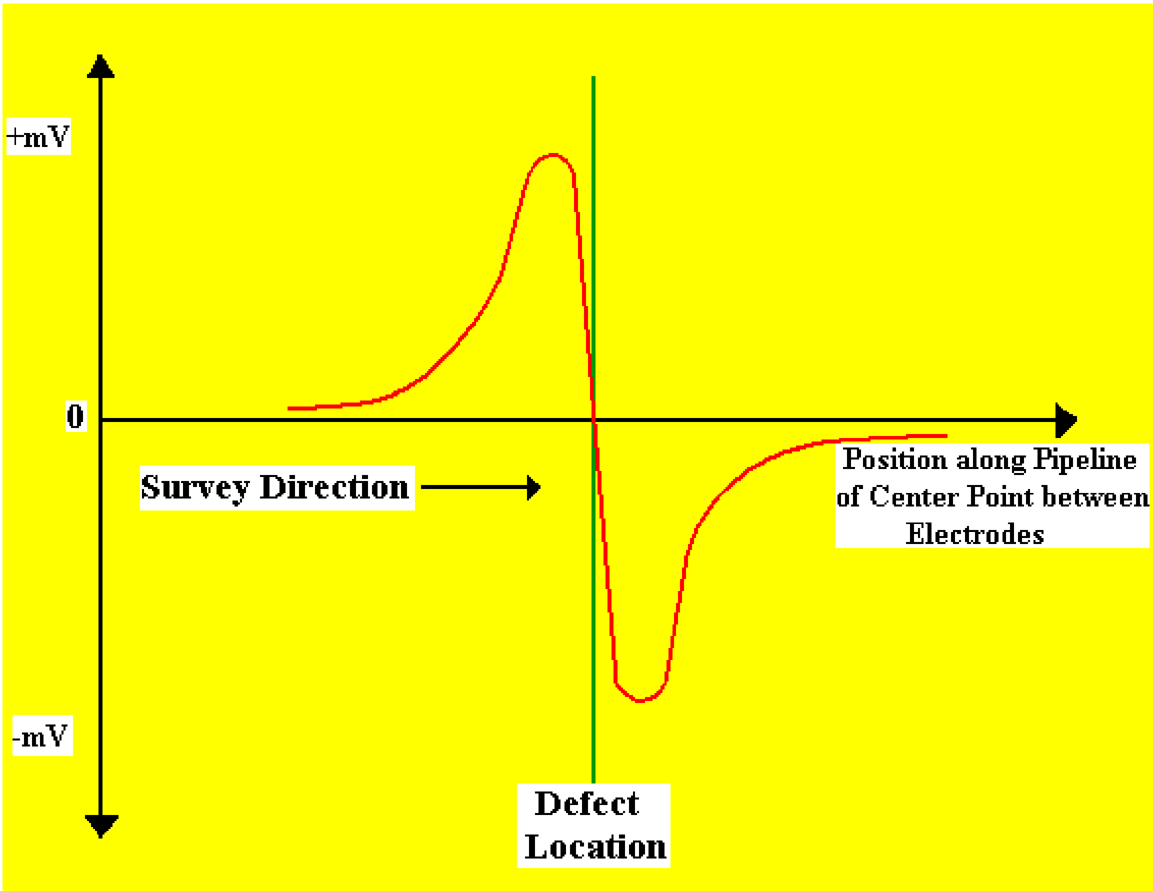


Figure 8: DCVG voltage in the vicinity of a coating defect as a function of the position along the pipeline of the center point between the electrodes with the electrodes configured as shown in Figure 7 (In-Line or Parallel)

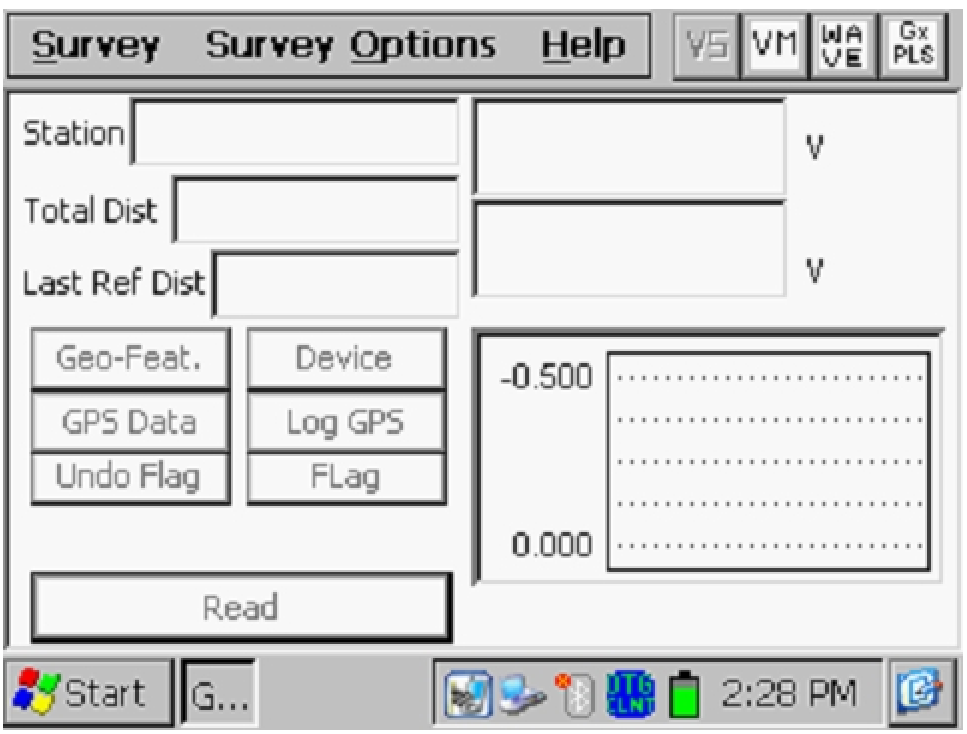
It should be noted that once a defect has been located during an In-Line DCVG survey, the critical parameters noted above in Section II. 8 for defect-size determination, need to be determined using the Perpendicular DCVG technique illustrated in Figure 6.

SECTION III: HOW TO SETUP THE Gx DATA-LOGGER FOR DCVG SURVEYS

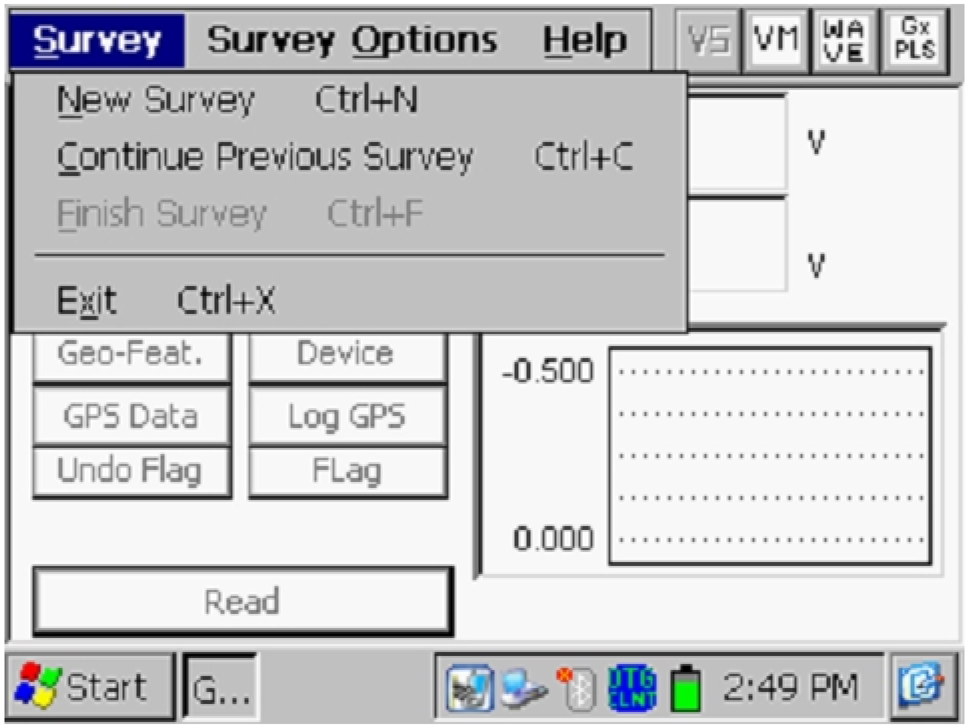
Your Gx data-logger will arrive from MCM with the Windows operating system and our pipeline survey application program (Gx_PLS) pre-installed. The survey application will remain installed unless the batteries are allowed to fully-discharge. Application re-installation is an automatic process, however, during a Cold Boot process (please see the Gx Pipeline Survey Data-Logger User's Manual for details). However, your pipeline survey data will always be safe, regardless of battery status, as these data are stored in a non-volatile Flash memory on the Gx.

III. 1 Gx Data-logger Setup for DCVG Surveys

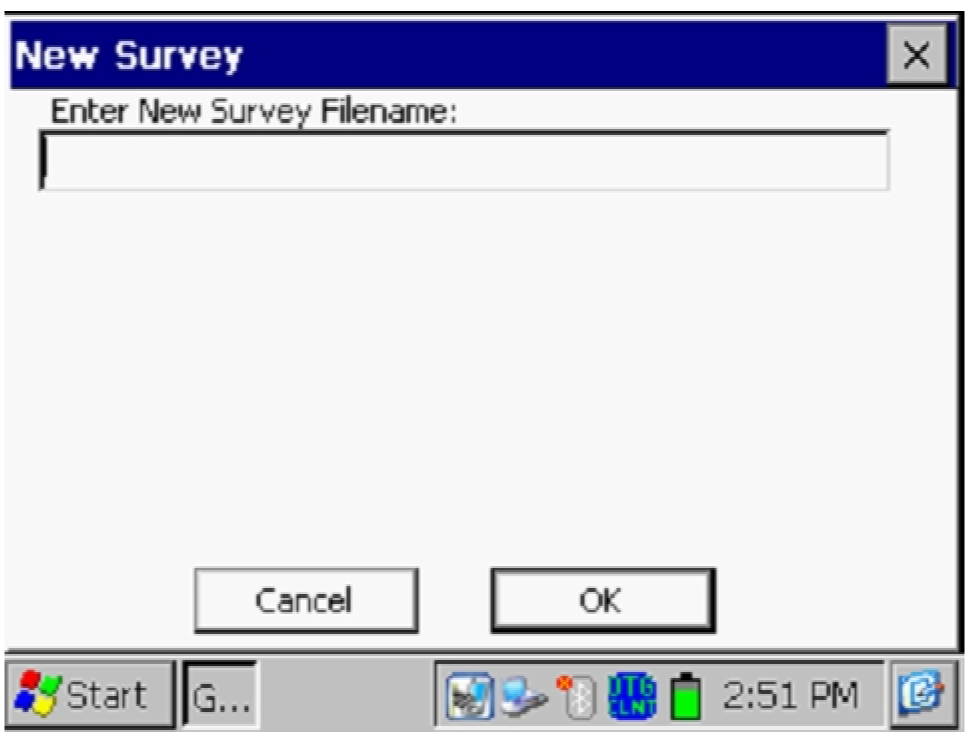
Step 1: Double-tap on the Gx_PLS icon on the Gx desktop. The screen shown below will be displayed.



Step 2: Tap on the "Survey" button located on the menu bar. The screen shown below will be displayed.



Under "Survey" there are several options. If this is a new survey (not a continuation of a previous survey) tap on "New Survey". The screen shown below will be displayed.

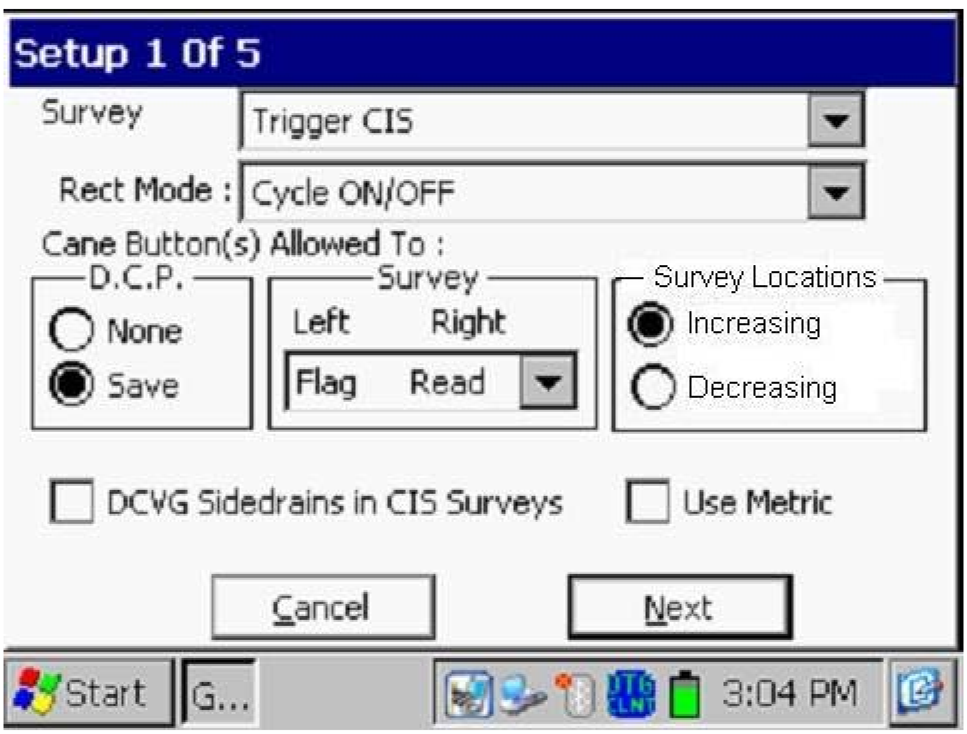


Step 3: Enter a "filename" for the Survey.

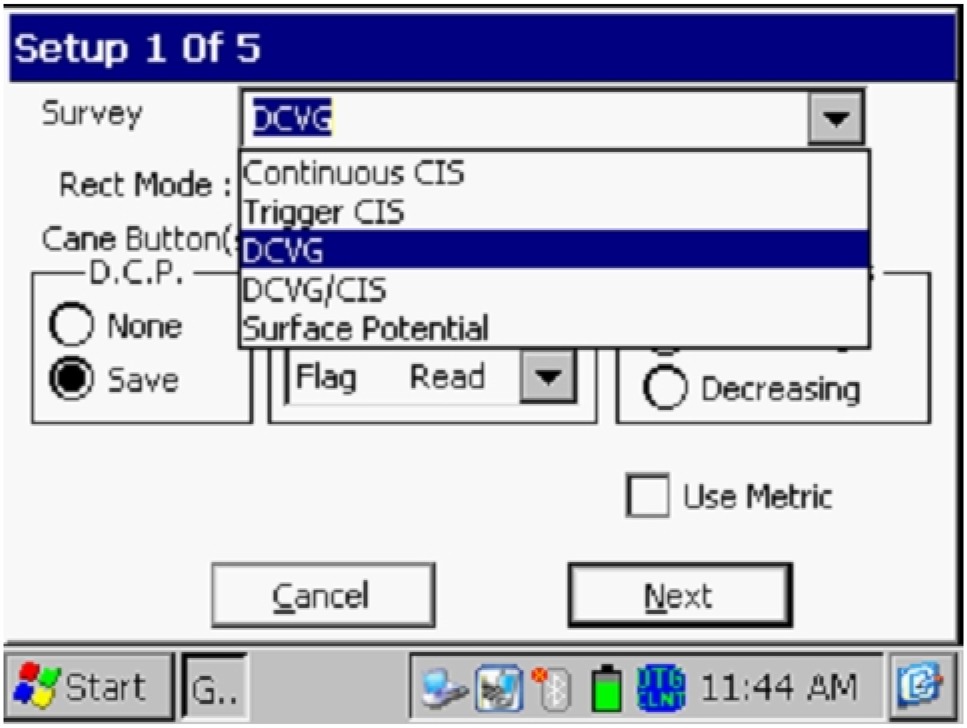
This should be a descriptive name that will help you identify the survey at a later stage. Perhaps the name of the section of pipe you are surveying could be part of the filename. "DCVG" and the survey date do not have to be part of the filename as these tags are incorporated with the survey on the ProActive side (assuming that you will be downloading the survey data to the ProActive application).

Note: You will not be permitted to use invalid characters, such as slashes(/ or \ ), as part of a filename. You will be alerted if you try to use any invalid characters.

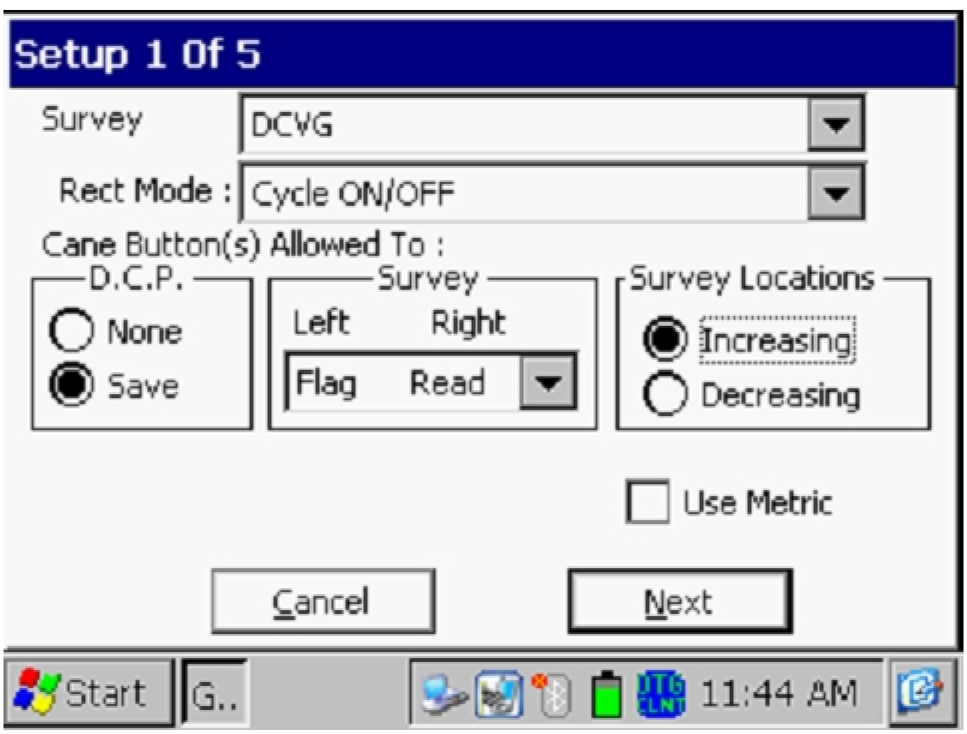
Step 4: Once you have entered a filename, tap the OK button on the above screen. The screen shown below will be displayed. The specific selections indicated on the screen will reflect the selections made for the previous survey.



Step 5: Select the survey type by tapping on the menu button in the "**Survey Type**" field and highlighting the survey type of your choice.



By tapping on the “DCVG” option, the screen shown below will be displayed, depending on the previous survey selections



Survey
The functionality of the data-probe push-button switches during a survey is selected by tapping on the menu button in the “Survey” field.

“R**ead Read”** means that both switches can be used to trigger readings

“Flag Read” means that the left hand switch will designate the location of a survey flag and the right hand switch will be used to trigger readings

“Read Flag” means that the left hand switch will be used to trigger readings and the right hand switch will designate the location of a survey flag

“Flag Flag” means that both switches can be used to designate survey flags (and neither switch can be used to trigger readings).

D.C.P.
D.C.P. stands for Data Collection Point and on a DCVG survey usually would represent a test station where the IR drop is determined by connecting the voltmeter temporarily for pipe-to-soil readings.

The data probe switches can have no functionality at these “devices” (the “**none**” selection) or they can be used to save the D.C.P. readings, such as Pipe-to-Soil (On/Off) readings at a test station (the “**Save**” selection).

*Note***:** When “Marking” DCVG anomalies (see Section V), the data-probe switch functionality becomes “accept”, regardless of whether “save” or “none” is selected here.

Step 7: Make “**Survey Locations**” selection

Once a value has been entered for the “Distance between Readings” (see the Setup 3 of 5 screen), that distance, for example 5.0 feet, can be added to each successive station number each time a reading is triggered, or, it can be subtracted from each successive station number each time a reading is triggered.

Your selection of “Increasing” or “Decreasing” will depend on your walking direction over the pipe with respect to the pipe’s stationing.

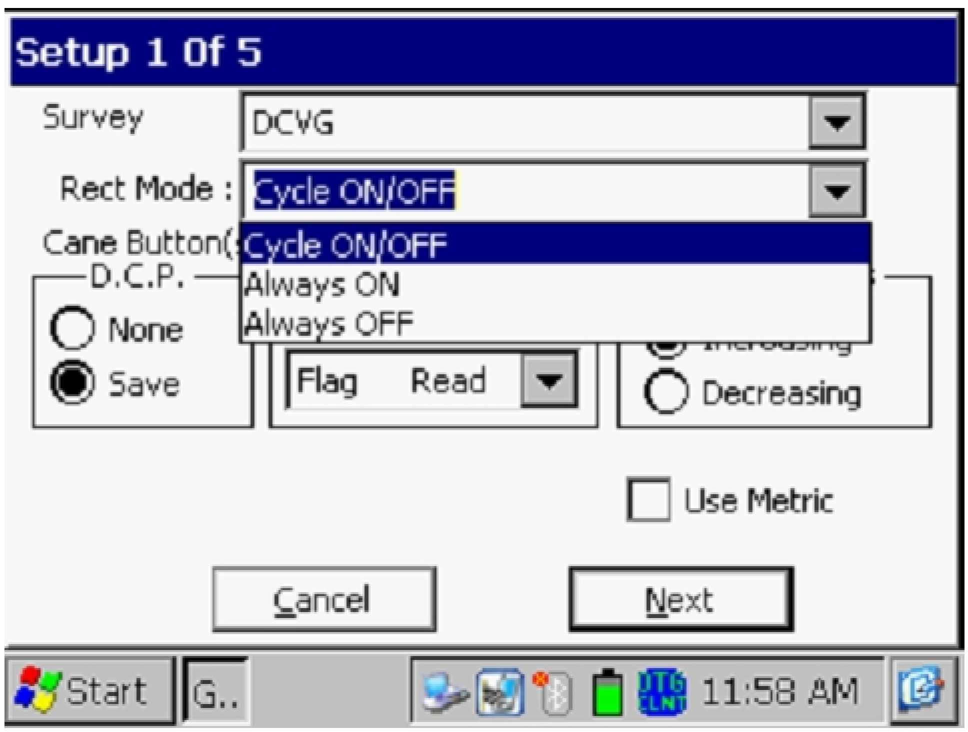
You would select “**Increasing**” if the station number will be increasing as you perform the survey and you would select “**Decreasing**” if the station number will be decreasing as you perform the survey.

Step 8: Make selection of “Metric” units, if required.

By checking off the box labeled “**Metric**”, the reading interval (distance between triggered readings) and the flag internal (survey flag spacing) will be displayed on the Setup 3 of 5 screen in meters, as opposed to feet.

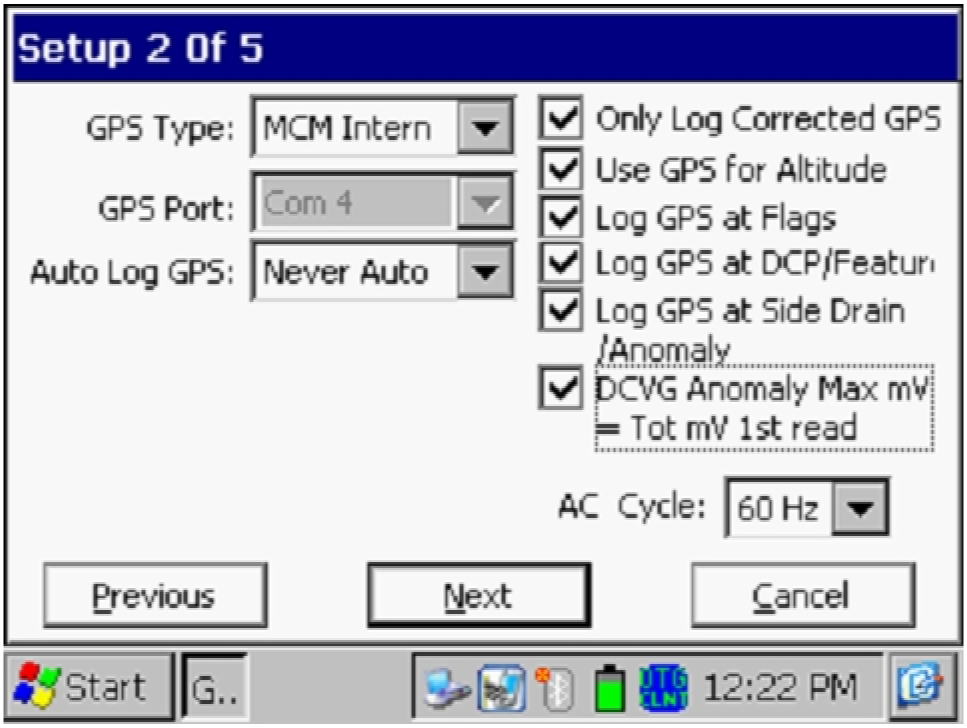
Step 9: Make “**Rectifier Mode**” selection.

By tapping on the menu button in the “Rectifier Mode” field on the above screen, the screen shown below will be displayed.



As can be seen from the above screen, there are 3 choices for “Rectifier Mode”. However, only the “Cycle On/Off” option should be selected for DCVG surveys, as rectifier current interruption is a requirement for this survey type.

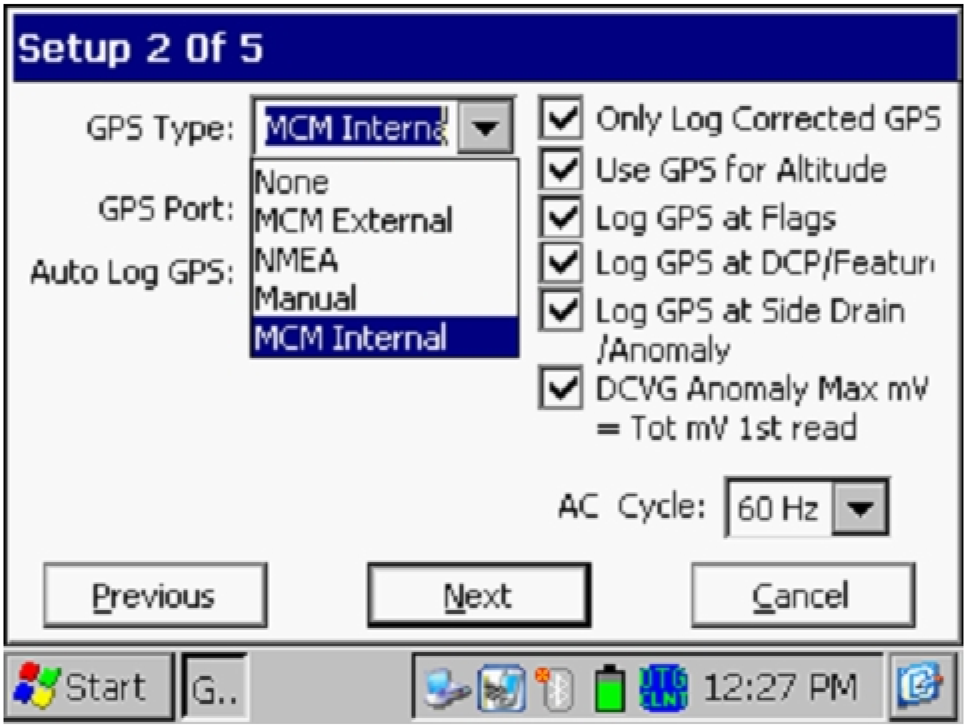
Step 10: Tap on the "Next" button on the above screen. The screen shown below will be displayed, depending on the selections made for the previous survey.



Step 11: Select Local Electricity AC Frequency
By tapping on the menu button in the "**AC Cycle**" field on the screen shown above, you will have the choice of 60Hz or 50Hz AC. Select 60Hz for all U.S. applications. This is an important select with regard to the AC filtering system that's applied to all of the DC voltage channels.

Step 12: Select the Type of GPS Receiver Being Used (If Any).

By tapping on the menu button in the "**GPS Type**" field on the above screen, the screen shown below will be displayed.



As can be seen from the above screen, there are 5 choices for "GPS Type":

None:	This means that a GPS receiver is not being used
MCM External:	This means that an external MCM GPS Accessory is being used (currently not available)
NMEA:	This means that an external NMEA-compatible GPS receiver is being used (such as a Trimble unit)
Manual:	This means that location data will be entered manually when the GPS button is tapped on the survey screen during a CIS
MCM Internal:	This means that the Gx's internal GPS unit will be used (a u-blox NEO, WAAS-enabled, receiver)

Select the appropriate choice by tapping on your selection.

<u>Com Ports</u>
When using an external GPS unit (NMEA option) connected via a serial cable, select the COM 1 option, which represents the built-in serial port located under the flap on the bottom left-hand side of the Gx data-logger. The COM 4 option will be automatically selected when the MCM Internal GPS receiver option is selected.

Step 13: Select GPS Data Logging Options.

Only Log Corrected GPS
This box should be checked if you only want differentially-corrected GPS data to be logged by the Gx data-logger on the survey. Leaving this box un-checked will result in standard GPS data being logged in cases where differentially-corrected data are not available.
Note: If this boxed is checked and the unit is not receiving a differential correction message, no GPS data will be logged.

Use GPS Altitude
If this box is checked, altitude data will be logged, in addition to the Lat/Long data whenever GPS data are logged. (Note: Altitude data on some GPS units are not particularly accurate).

Log GPS at Flags
If this box is checked, GPS data will be logged automatically at survey flags when either the flag button is tapped (directly on the Survey screen) or when the push-button switch on the designated “flag cane” is pressed.

Log GPS at DCP/Features
If this box is checked, GPS data will be logged automatically at “Devices” or “Geo-Features” when either the “Device” button is tapped on the Survey screen and a “Device” reading is logged or when the “Geo-Feat.” button is tapped on the Survey screen and a geo-feature is registered.

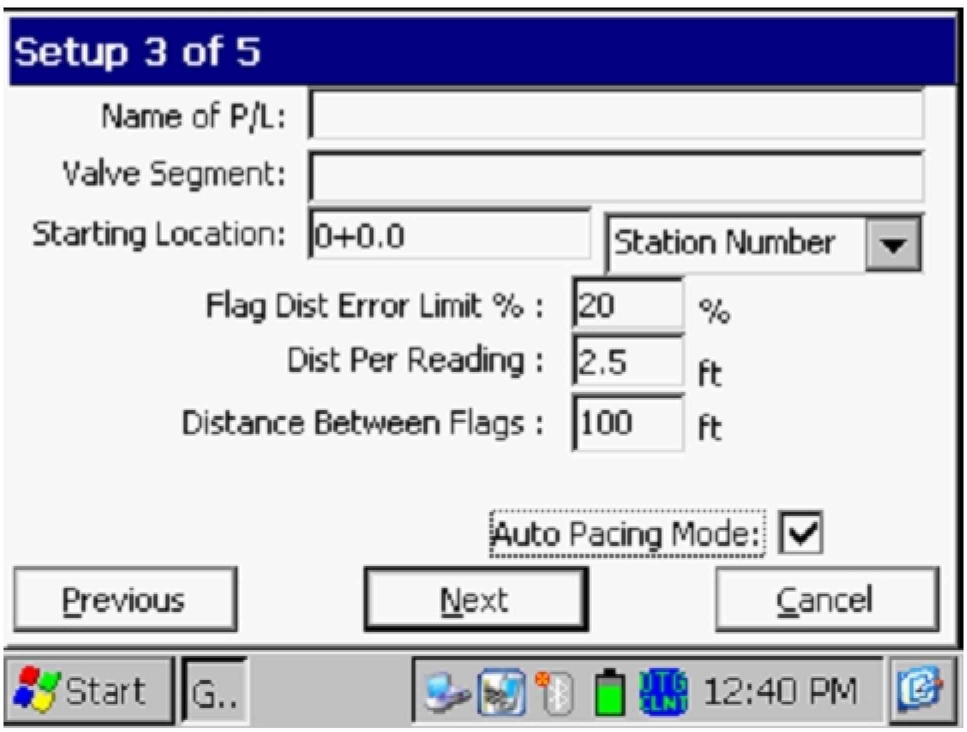
Log GPS at Sidedrain/Anomaly
If this box is checked, GPS data will be logged automatically when DCVG anomalies are “marked”, as described in our DCVG Training Manual – Gx Version.

Auto Log GPS
By tapping on the menu button in the “Auto Log GPS” field, the selections available will be displayed.

By selecting one of these options, you can elect to have GPS data logged automatically at every DCVG reading, at every second DCVG reading, at every fifth DCVG reading, at every tenth DCVG reading, or not at all (never) at DCVG readings.

DCVG Anomaly Max mV = Total mV 1st Reading
The last check box on the above screen is actually not related to GPS Options.
If this box is checked, the Max mV voltage recorded at an anomaly location will automatically become the first voltage value used by the data-logger's software to calculate the Total mV (total voltage gradient). Otherwise, if this box is un-checked, you will have to repeat the Max mV recording a second time as part of the Total mV determination process. (See our DCVG Training Manual – Gx Version).

Step 14: Tap on the "Next" button on the above screen. The screen shown below will be displayed, depending on the selections made on the previous survey.



Dist Per Reading
By tapping in the field on the above screen labeled, "Dist Per Reading" you can type in the interval distance, in feet (or meters for the metric case), expected between reading. Typically, in DCVG work this expected interval distance is 5.0 feet (or 2 meter in the metric case).

Distance Between Flags
By tapping in the field labeled, "Distance Between Flags", you can type in the survey flag interval (distance between survey flags) for the section of pipeline being measured, assuming that survey flags have been laid out. Typically, survey flags are located at 100 feet intervals. In such a case, you would have a new reference (a stationing correction) every 100 feet.

Note: If survey flags are not in use, enter zero in this field. In this case, tapping accidentally on the Flag button will not adversely impact your stationing.

Flag Dist Error Limit %
Select the maximum permissible error between the **actual** number of readings logged between 2 survey flags and the **expected** number of readings.

By tapping in the field labeled, "Flag Dist Error Limit %" you can type in the maximum permissible error. For example, the maximum permissible error is indicated as 20% on the above screen. If the reading interval is expected to be 2.5 feet and the survey flag separation is 100 feet, this means that 40 readings are **expected**. If, however, only 30 readings are **actually** logged between survey flags, an error window will appear on the screen, since there is a 25% difference between the expected and actual number of reading in this example. No error window will appear if the difference is less than 20%. For this example, you could have a minimum of 32 readings and a maximum of 48 readings between survey flags to stay within the 20% (max.) error allowance.

Auto Pacing Mode (optional):
Select whether or not you would like the readings to be uniformly spaced between any two survey flags, regardless of the actual locations of the readings between the two flags.

By checking the box labeled, "Auto Pacing Mode", you will enable the data-logger to automatically adjust the reading locations in order to evenly-space the readings between two survey flags.

Name of P/L (optional)
By tapping in the field labeled, "Name of P/L", you can enter the pipeline name.

Note: This is **not** necessarily the same name as the filename for the DCVG survey that you used to setup the survey file.

Valve Segment (optional)
By tapping in the field labeled, “Valve Segment”, you can enter the name or number of the valve segment to be surveyed, if known.

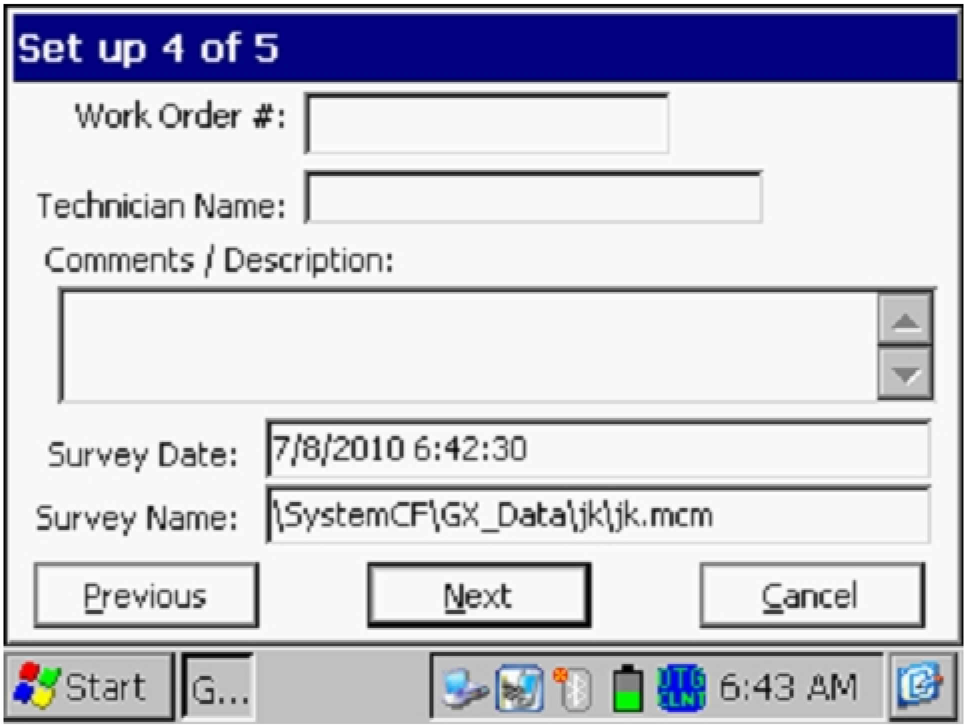
Starting Location (very important)
Provide the Starting Location for the survey by tapping in the field labeled, “Starting Location” and entering the location.

You can select to have location information displayed on the survey screen as station number, feet or milepost (station number, meters or kilometer post for the metric case).

Whichever selection you make here will determine how you enter your starting location information.

For example, if your pipeline locations are represented by station numbers, you would select “Station Number” from the menu list and you would enter a starting location for the survey in the form of a station number. [If you do not know the station number associated with the beginning your survey, enter 0+0.0].

Step 15: Tap on the **Next** button on the above screen. A version of the screen shown below will be displayed, depending on the current Date & Time and also the filename entered for your survey.



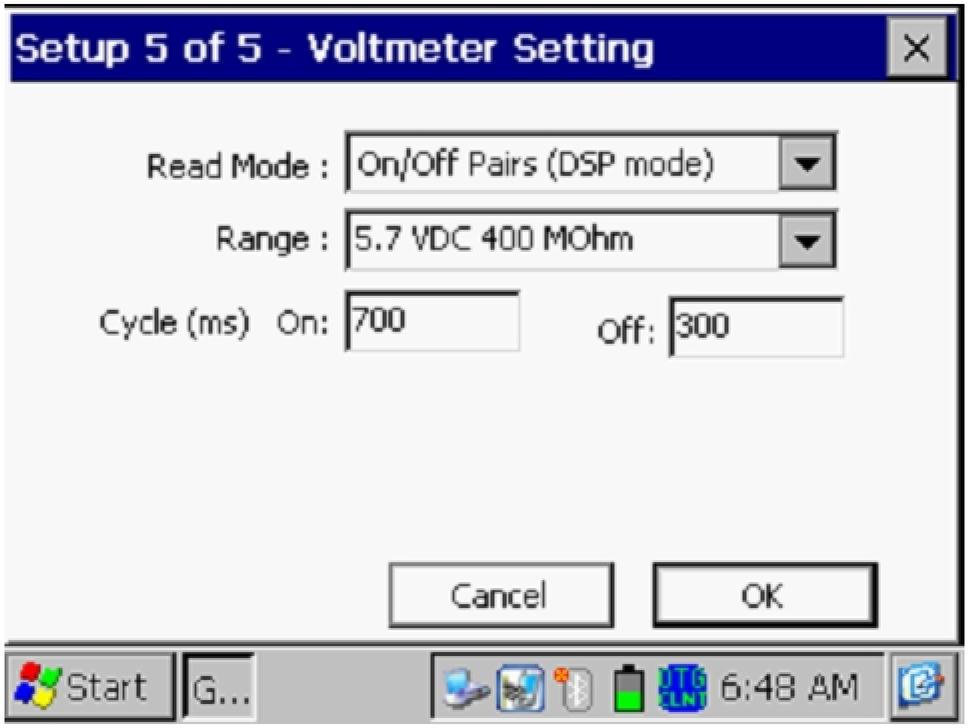
Work Order # (optional)
By tapping in the field labeled, "Work Order #", you can enter the work order number associated with the survey, if known.

Technician Name (optional)
By tapping in the field labeled, "Technician Name", you can enter the name of the surveyor.

Comments/Descriptions
By tapping in the field labeled, "Comments/Descriptions", you can enter any general comments you might have regarding the survey (perhaps weather conditions, soil conditions etc.).

Also shown on the above screen are the survey filename ("Survey Name" field) and the Start Date and Start Time for the survey ("Survey Date" field). *Note:* The survey files are stored in the Gx_Data folder on the Gx data-logger's CompactFlash memory (SystemCF) – a non-volatile memory. *Note:* These data cannot be changed manually.

Step 16: Tap on the "Next" button on the above screen. A version of the screen shown below will be displayed, depending on the settings selected for the previous survey.



<u>Read Mode</u>
DCVG surveys are performed with the rectifier-current switched ON and OFF in a cyclic fashion and, as can be seen by tapping on the menu button in the field labeled, "Read Mode", there are only two choices available for the reading mode of the voltmeter. The choices are "On/Off Pairs (DSP mode)" and "On/Off Pairs (GPS Sync)".

Note: On/Off Pairs (Min/Max) is not a option here since DCVG surveys require a measurable difference between On and Off voltages, i.e., they require a significant IR drop.

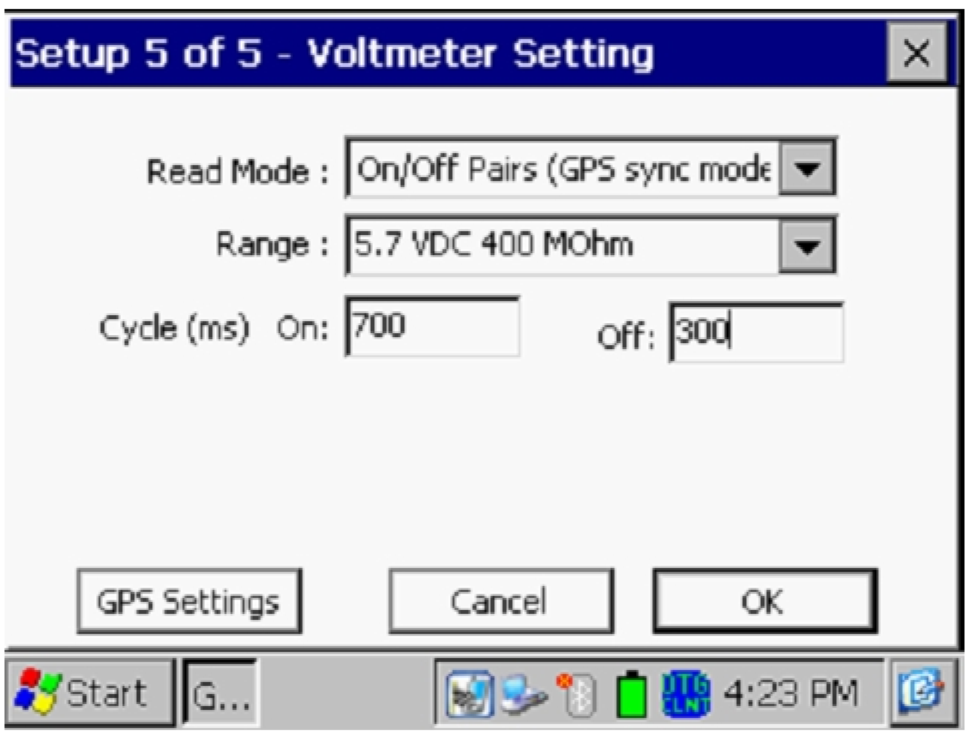
On/Off Pairs (DSP mode):
In this mode, the voltmeter uses digital signal processing techniques to determine the "flat" portions of the waveform for both the On and Off parts of the cycle. ΔV values (please see the DCVG Training Manual – Gx Version) are then determined for the On and the Off portions of the cycle from which the DCVG voltage is calculated [ΔV(On) minus ΔV(Off)].

For these measurements to be successful, the data probes must remain in good electrical contact with the soil for at least one full waveform period following the initial contact of the probes with the soil, for a stable DCVG voltage value to be displayed.

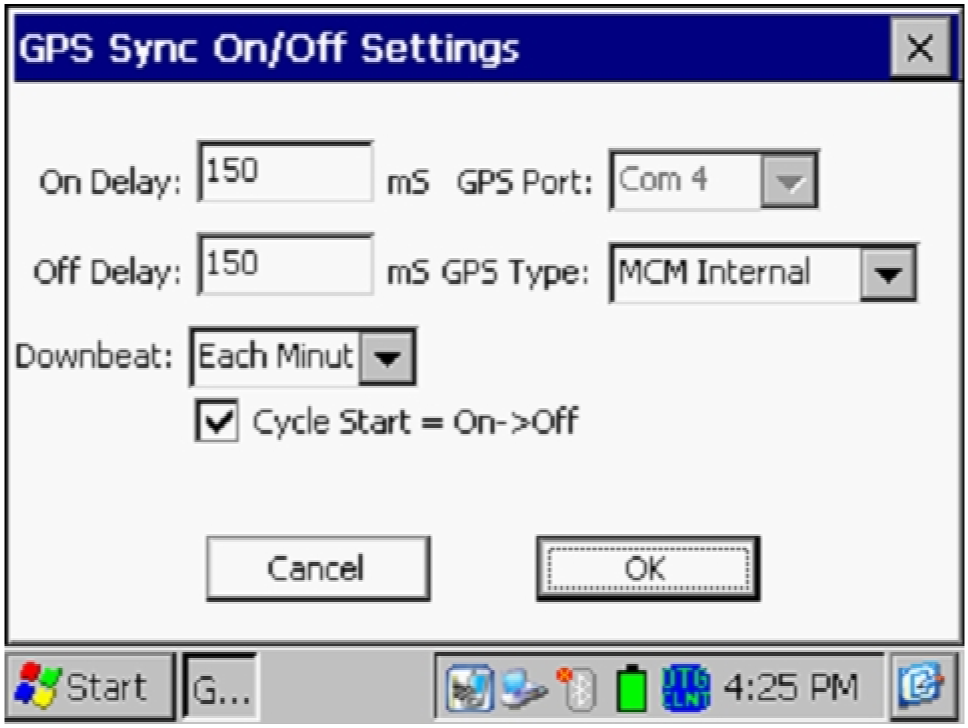
On/Off Pairs (GPS Sync)
This voltmeter reading mode can only be selected if you are using the built-in "MCM Internal" GPS receiver **AND** GPS current-interrupters.

With this reading mode elected, you can select the recording times on the waveform for both the On and Off readings, with respect to the On-to-Off transitions and the Off-to-On transitions of the waveform, as opposed to the software determining appropriate locations on the waveform for you (as in the case of the On/Off Pairs D.S.P. reading mode – see above).

With this voltmeter reading mode selected, the screen shown below will be displayed revealing an additional button ("GPS Settings")



<u>*GPS Settings*</u>
By tapping on the "GPS Settings" button, the screen shown below will be displayed, depending on the previous settings.



GPS Type
Select the type of GPS receiver being used. Currently, only the MCM Internal GPS Receiver can be used with the GPS Sync reading mode.

On Delay & Off Delay
By tapping in the fields labeled, "On Delay" and "Off Delay", you can enter specific times (in milli-seconds) for these parameters.

For example, if 150 ms was selected for the "Off Delay", the data-logger would record the voltage value sampled 150 ms after the rectifier-current was switched from the ON to the OFF state. Also, if 150 ms was selected for the "On Delay" the data-logger would record the voltage value sampled 150 ms after the rectifier-current was switched from the OFF to the ON state.

The delay times selected should be based on knowledge of the waveform, particularly in terms of any transition spiking. The idea is to select sampling times that will avoid any spiking.

Downbeat

By tapping on the menu button in the "Downbeat" field, you can select the downbeat schedule associated with the particular current interrupters you are using for the survey. The three options are: Each Minute, Each Hour and Midnight.

For example, if "Each Minute" is applicable to your interrupters, and you select this option for the Downbeat schedule, you are indicating to the data-logger software that at the top of each minute, there will be an On to Off transition (the rectifier current will switch from On to Off at the top of each minute). This would mean, in this example, that the software would only have to count back to the top of the last (previous) minute to have a timing reference.

Cycle Start

Finally, if your interruption cycle starts with the current in the ON state (the first transition is from ON to OFF), check off the box labeled, "Start Cycle" (un-check this box if the opposite is true).

Click on the "OK" button on the "GPS Settings" screen in order to return to the Voltmeter Settings screen (Screen 5 of 5).

Cycle On & Off (Times)

The specific On and Off times setup on the current interrupters should be entered in the "On" and "Off" fields, respectively, on the Setup 5 of 5 Screen.

Note: The On and the Off times should be entered in milli-seconds.

Note: Consequently, the rate at which DCVG voltages can be captured and saved depends critically on the interruption waveform period. This is a particularly important issue in the case of larger waveform periods. For example, if a 10 second On/2 second Off waveform is employed (12 second waveform period), stabilization times between 12 and 24 seconds could be possible (at each measurement location) before each DCVG voltage reading can be made. In contrast, the stabilization period would be only on the order of 1 to 2 seconds for a 700ms On, 300ms Off interruption cycle.

Range:

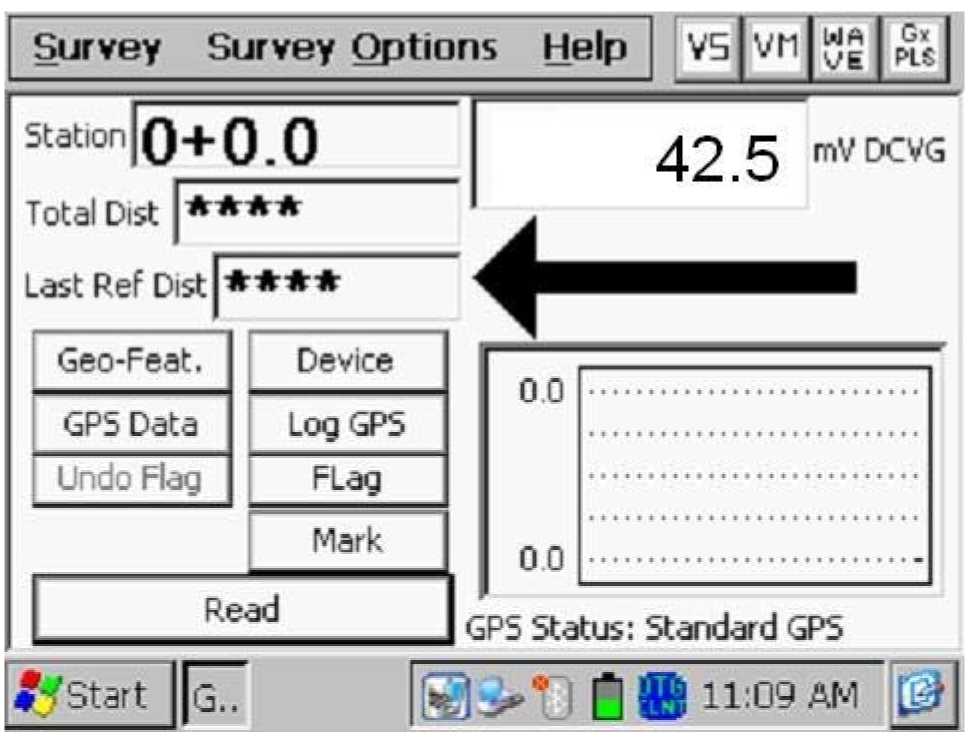
By tapping on the menu button in the "Range" field, you can select the voltmeter range and associated input impedance setting for your application from the full list of available options.

Note: Use the scroll bar to view all options.

Note: Since all of the voltmeter DC ranges (DC channels) on the Gx data-logger are "fast response" channels, each DC range is an option for DCVG surveys. However, since DCVG survey readings are typically small (either tens of mV or hundreds of mV only), with respect to sensitivity, the most appropriate DC ranges are the 5.7V, 400mV and 40mV ranges, depending on the size of the gradient fields that you encounter. Another issue is the signal-to-noise ratio with respect to being able to "find" and "mark" anomalies. For small signals (small gradient fields), the voltmeter's noise level is the limiting factor. The noise levels associated with the 5.7V, the 400mV and the 40mV ranges are approximately as follows: ±5mV, ±1mV and ±0.5mV, respectively.

Step 17: Tap on the "OK" button on the "Setup 5 of 5" screen.

A version of the screen shown below will be displayed, depending on the start location entered previously and the location type entered previously (station number, feet or milepost (or station number, meters or kilometer post, for the metric option)).



In the above "active" DCVG survey screen, the direction of the arrow (pointing to the left or pointing to the right) depends on the polarity of the DCVG voltage being measured. In the above case, the voltage being measured was positive which produced an arrow pointing to the left. The opposite would be true if the DCVG voltage reading had been negative (i.e., the arrow would point to the right).

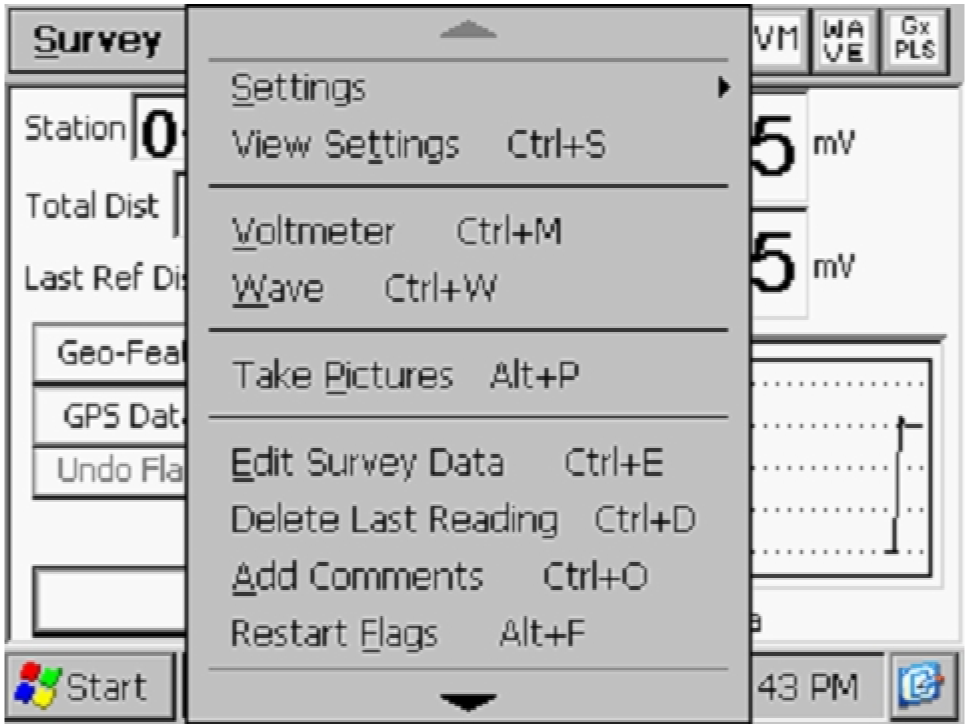
Note: With the reference electrodes (data-probes) properly positioned, the polarity of the DCVG voltage will always be positive (above the noise level) in the case of perpendicular DCVG surveys. In this case, the arrow on the survey screen will always point to the pipe.

However, a change in arrow direction will be evident when performing parallel, or in-line, measurements in the vicinity of a DCVG anomaly (coating defect). In this case, the arrow will always point in the direction of the defect location on the pipe with respect to where you are currently standing. As you approach the defect, the arrow will point towards the upcoming defect location and when you are past the defect, the arrow will point back to the defect location. Consequently, performing in-line measurements in the vicinity of a defect can be a good way to pin-point its precise location, by monitoring the arrow's polarity switches. When you are actually straddling a defect location (with the reference electrodes in-line with the pipe), the DCVG voltage will be zero (although, a true zero is not possible with a digital voltmeter).

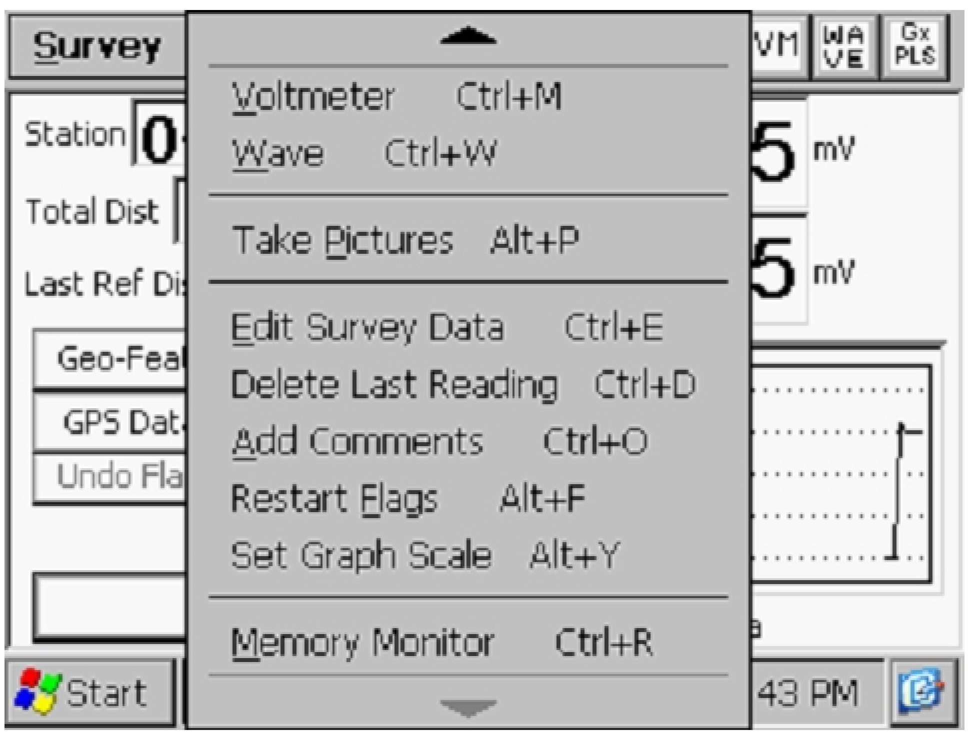
You are now ready to perform a DCVG Survey.

III. 2 "Survey Options" Menu including Picture Taking Options and Editing Options

By tapping on the "Survey Options" button on the Survey screen, the Survey Options menu will be displayed as indicated below.



Tapping on the down arrow on the above menu will reveal additional options, as illustrated in the screen shown below.



Settings

Once you've setup the Gx data-logger for a particular pipeline survey, you can make changes to your setup selections with the exception of your "Survey Type" selection and the currently indicated "Station". If you have selected a DCVG survey type, for example, you cannot change to a Surface Potential type, without setting up a new survey.

You can, however, make other selection changes mid stream. For example, you might decide to switch to a more sensitive voltmeter channel (Range), say 5.7V to 400mV. Or, in another case, you might decide to change the "Distance Per Readings" interval from 2.5 feet to 5.0 feet, for example.

To change survey settings, tap on "Settings" and tap on "Change Global Settings".

View Settings

To simply view your setup selections, you can tap on "View Settings" on the above menu. Alternatively, you can use the Ctrl and S keys.

Voltmeter

To run the stand-alone voltmeter, either tap on the "Voltmeter" option on the menu or use the Ctrl and M keys.

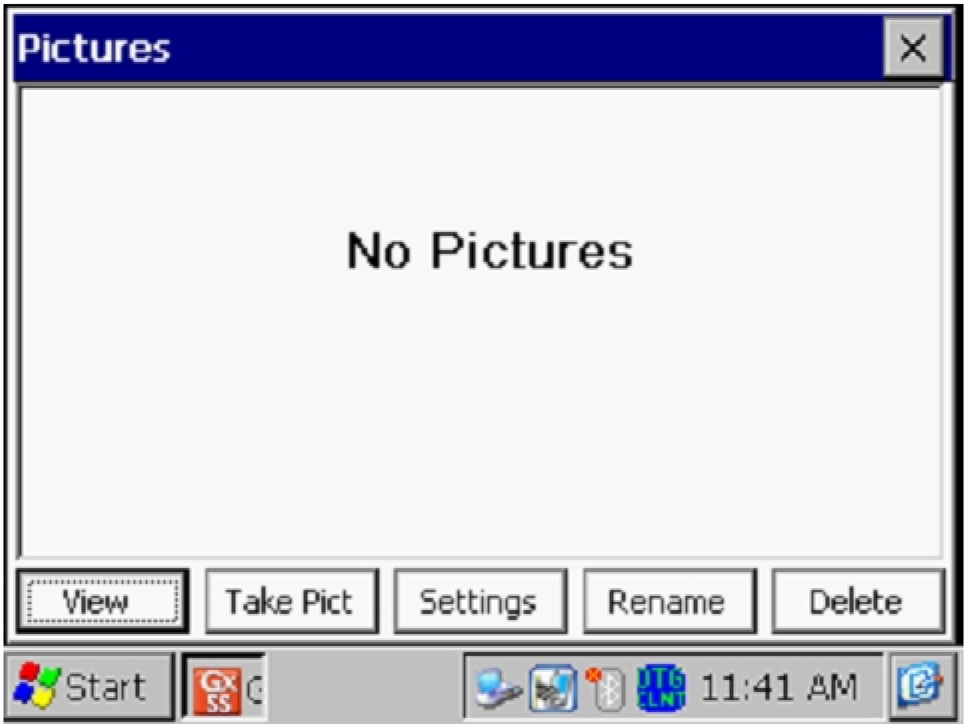
Wave

To run the stand-alone waveprint generator, either tap on the "Wave" option on the menu or use the Ctrl and W keys. Please see section IV.6 below for more information on running the stand-alone voltmeter.

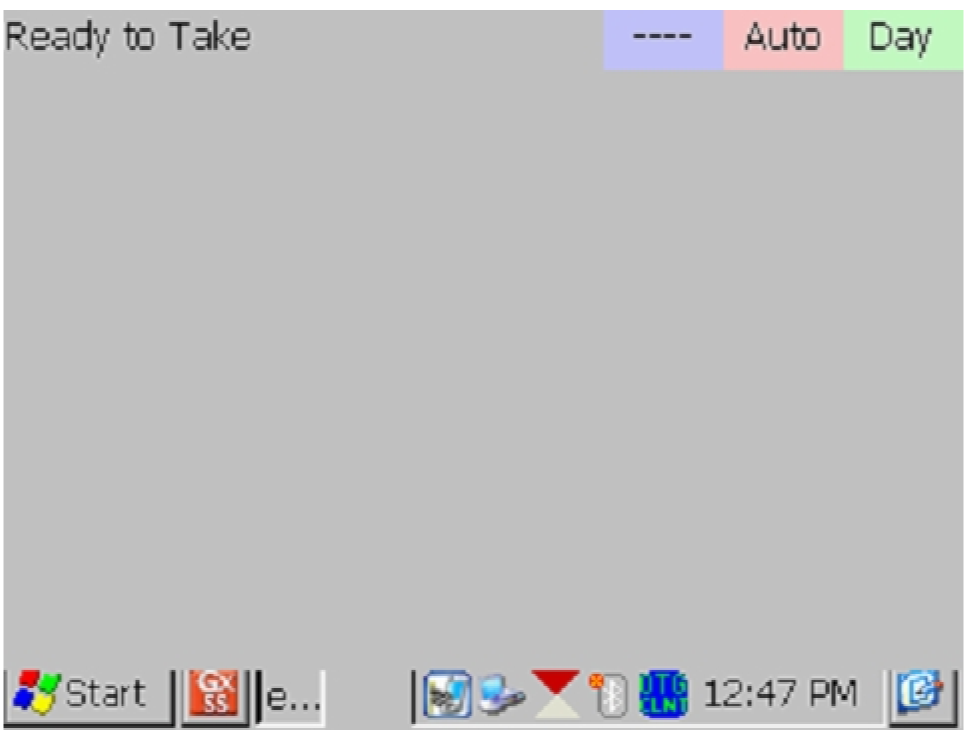
Take Pictures

You can run the integrated camera program by either tapping on the "Take Pictures" option on the menu or by using the Ctrl and A keys.
Note: Several seconds are required to open and close the camera program.

The "Pictures" screen shown below will be displayed.

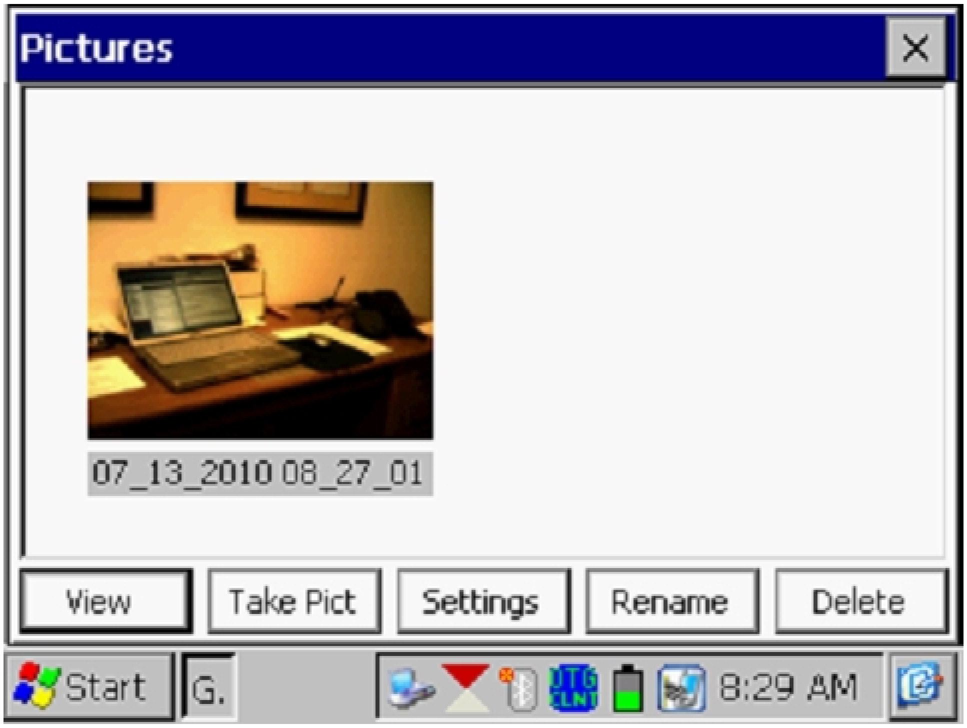


To take a photograph, tap on the "Take Pict" button. The camera will go through a focusing process and you will see a "Ready to Take" indication at the top of the screen when you can take a picture, as indicated below.



At this point, press (and release) the camera button located at the top right hand corner of the keypad. You will have the choice of saving the picture or deleting it, as indicated by the “4 to Save/1 to Delete” indication on the screen below. To save the picture, press (and release) the #4 key.

An example of a saved image is shown below on the Picture screen.



As indicated in the above screen, the image is given a filename, by default, which represents the date/time stamp for the image. The above image, for example, was recorded on July 13, 2010 at 8:27am.

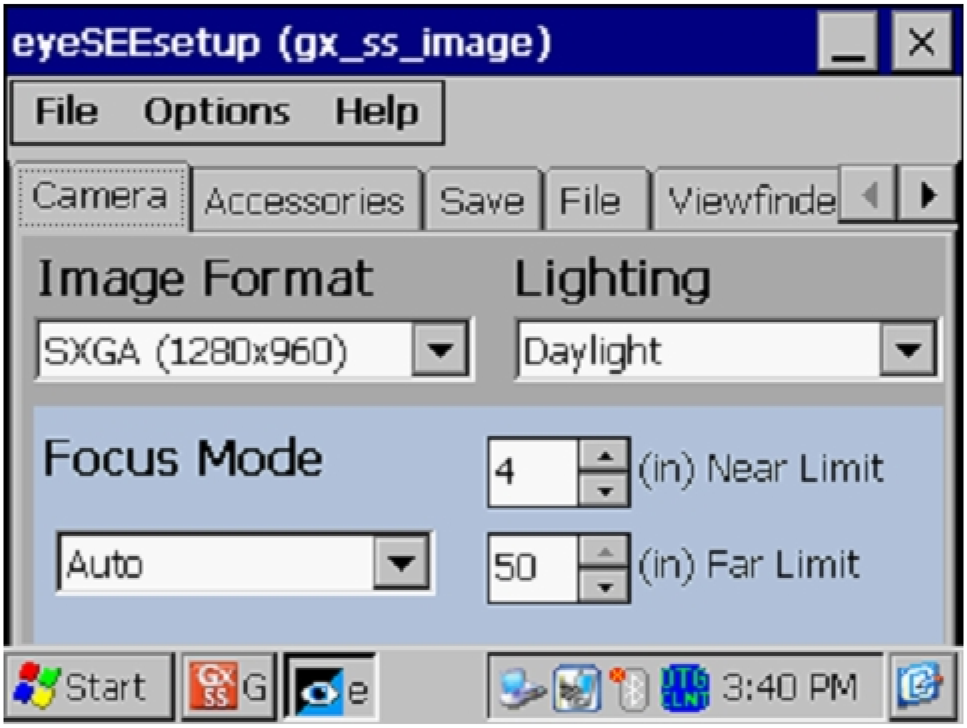
You can rename the image, if you prefer, by highlighting the image (tapping on the image) and tapping on the “**Rename**” button. You can then enter a new name for the image. For example, the image above has been renamed, “Office Desk” on the screen shown below.

You can view a larger version of the image by highlighting the image (tapping on the image) and tapping on the "**View**" button.

You can take multiple photographs at a test site by repeating the process outlined above. For example, the Picture screen shown below shows two (renamed) images.

If you would like to adjust the camera settings from their default settings you can do so via the “**Settings**” button on the Pictures screen. For example, you can change the size and resolution of the image to be captured, the lighting conditions under which the image will be captured and the focusing method to be used, for example.

By tapping on the settings button, the screen shown below will be displayed.



As indicated on the above screen, there are a number of page tabs labeled, "Camera", "Accessories", "Save" etc. For information on the selections available via the various tabs, please see Appendix 3 (Camera Settings) of the Gx Pipeline Survey Data-logger User's Manual.

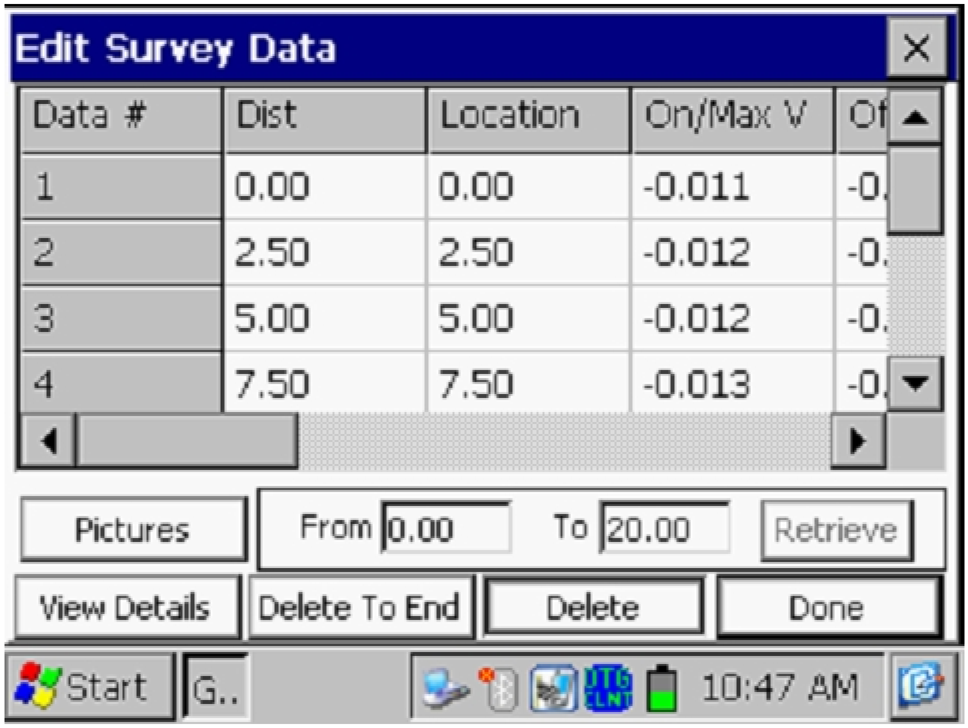
Note: For the default picture size (SXGA (1280x960)), the Flash light is not available. However, you can turn on the LED Lamp (which is turned OFF by default), if direct light is required. You can do so via the "Accessories" tab on the above screen. Also, please note that the Flash light is available for the largest picture size (highest resolution) setting (QSXGA 2048x1944).

You can return to the "Survey" screen (after the picture taking process) by tapping on the "X" button on the Picture screen.

Edit Survey Data

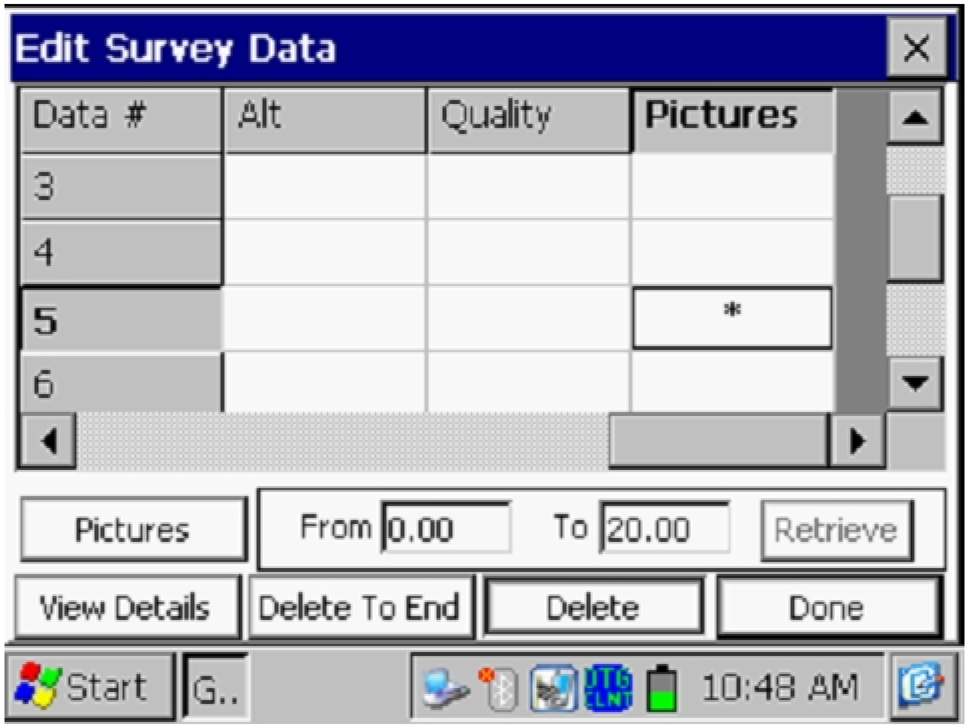
Collected survey data can be edited by tapping on the "Edit Survey Data" button or by using the Ctrl and E keys.

The screen shown below will be displayed, depending on the readings values and reading interval etc.



The data to be viewed can be selected by entering values in the "From" and "To" fields and tapping on the "**Retrieve**" button. Using the horizontal and vertical scroll bars, you can scroll through the collected data. A row of data can be deleted by highlighting the row and tapping on the "**Delete**" button. Multiple rows can also be deleted at the same time.

Pictures can be viewed and/or deleted by first highlighting the location (see screen below) and tapping on the "Pictures" button.



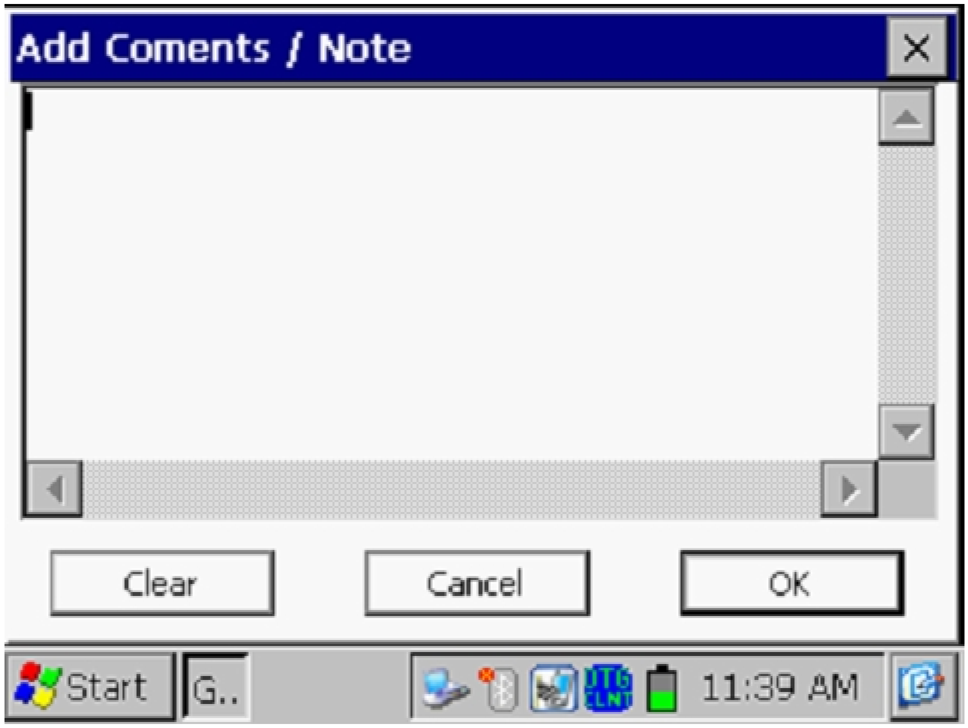
Once highlighted, the picture can be deleted by tapping on the "Delete" button, or viewed by tapping on the "Pictures" button.

Delete Last Reading

By selecting the "**Delete Last Reading**" option from the menu, you can have your last reading deleted, without having to go through the "Edit Survey Data" option. Alternatively, you can use the Ctrl and D keys to access the function.

Add Comments

You can add remarks (comments) at anytime on your survey by selecting the "Add Comments" option and manually entering data on the screen shown below.



Alternatively, you can use the Ctrl and O keys to access the function.

Tap on the "OK button on the above screen to return to the Survey screen after entering your comments.

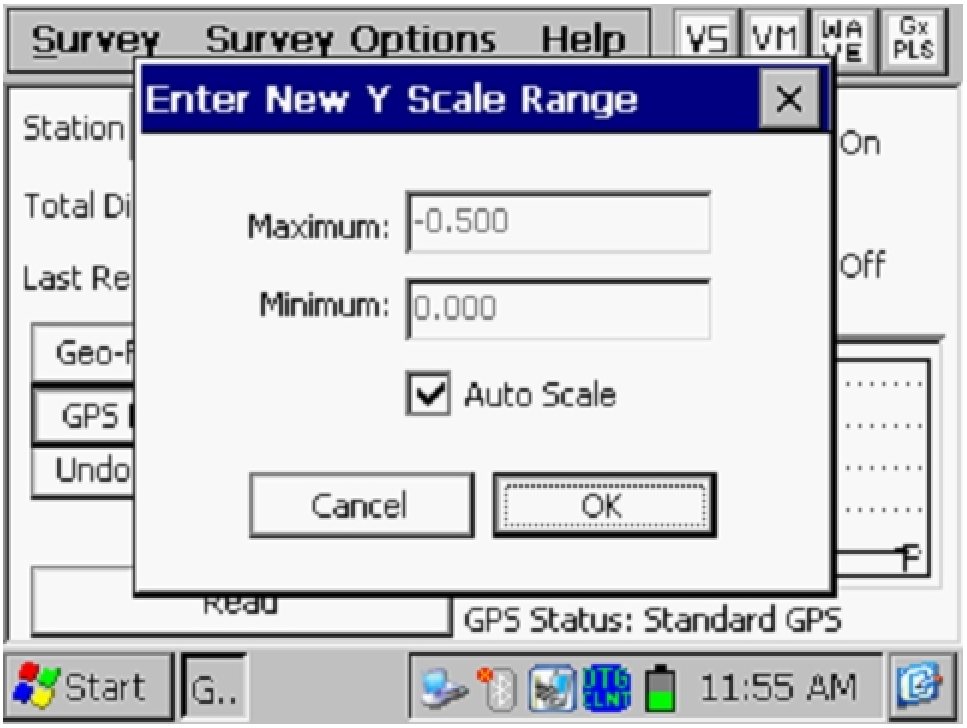
Restart Flags

You can reset survey flags by selecting the "Restart Flags" option from the menu. This action will establish your current location as the new zero reference, as far as flagging is concerned, and "zero" should be entered automatically in the "Last Reference Distance" field on the Survey screen.

Set Graph Scale

Rather than having the software auto scale the graph on the Survey screen to accommodate the actual data values logged, you can establish the maximum and minimum values for the graph scale in order to restrict the data values to be displayed on the graph.

To do so, you would un-check the box labeled, "Auto Scale" on the window shown below and enter specific values for "maximum" and "minimum".

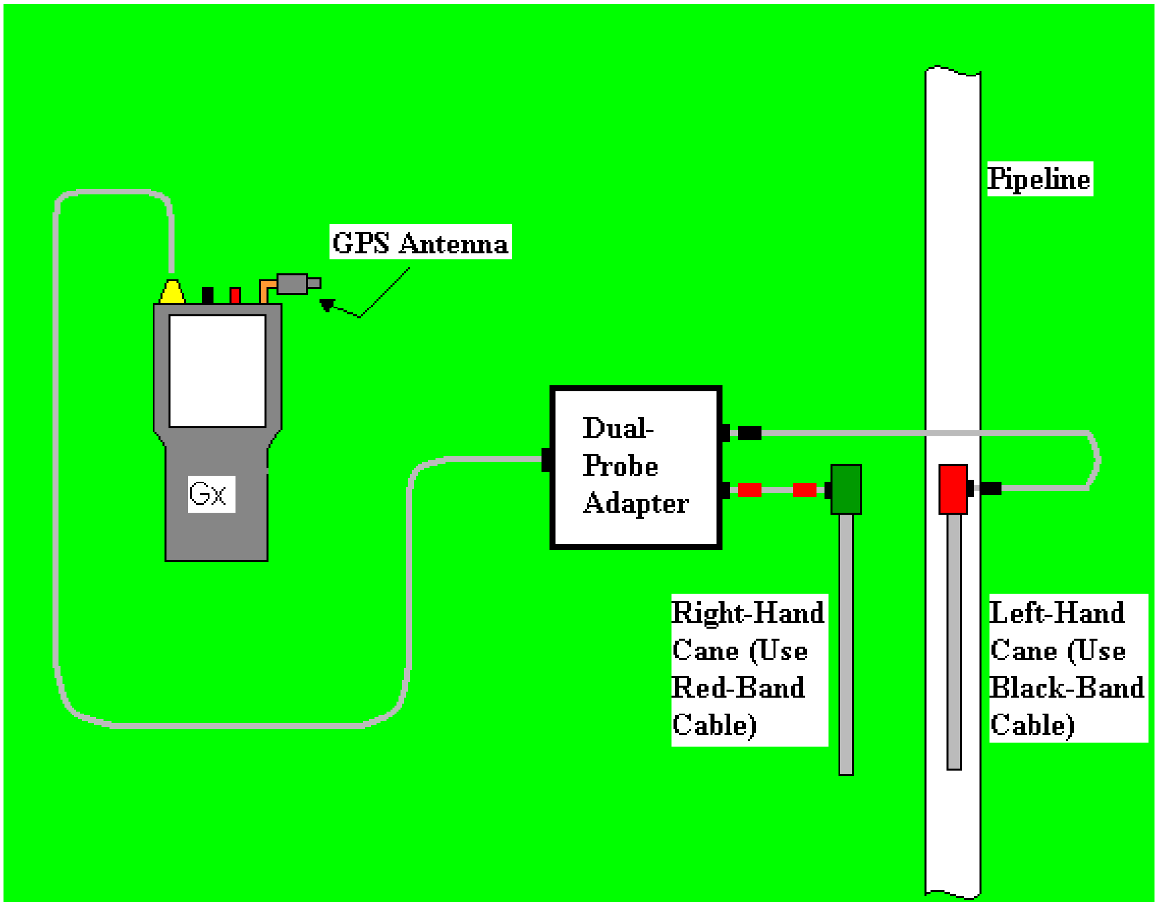


Tapping on the "OK" button will return you to the Survey screen.

SECTION IV: TEST EQUIPMENT HOOK-UPS FOR DCVG SURVEYS

IV. 1 How to make Cable Hook-Ups for DCVG Surveys

The cable connections for DCVG surveys employing MCM test equipment are illustrated in the figure below.



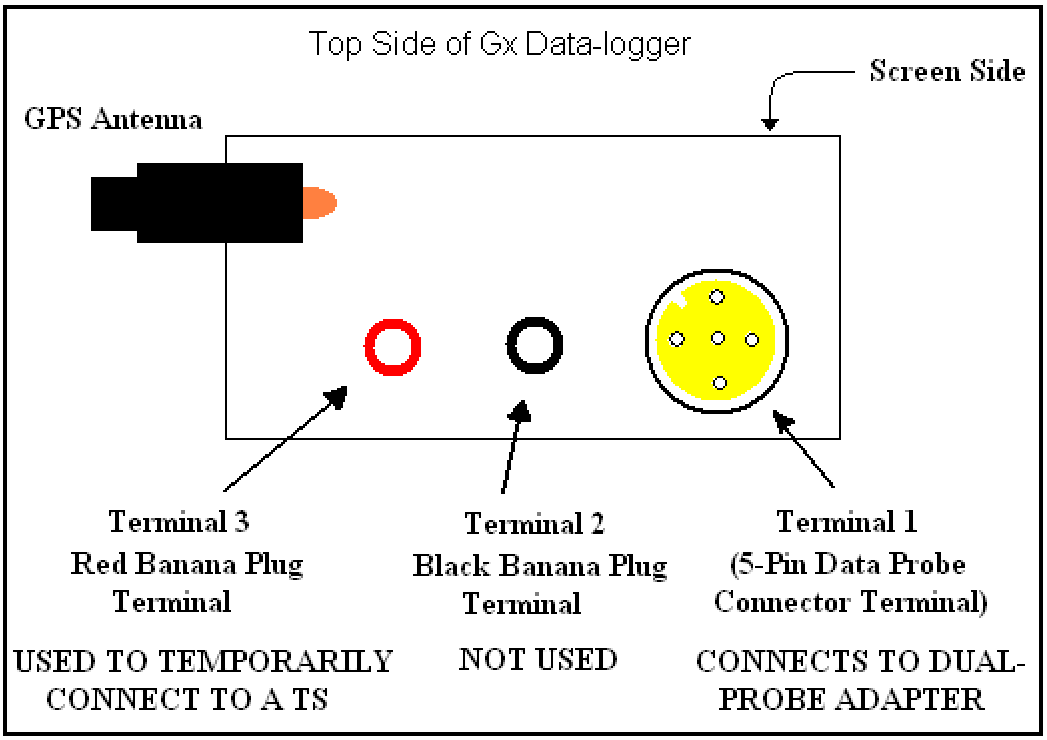
Cable Connections for Hook-Up of MCM's DCVG Survey Test Equipment

As can be seen from the above figure, a pair of canes (reference electrode data-probes) is illustrated, the left-hand cane (RED-handled cane) and the right-hand cane (GREEN-handled cane). These canes, which will be placed on the soil above the pipeline in either the "Perpendicular" or the "In-Line" configuration (see Section II), have push button switches on top of the handles so that the operator can "trigger" voltage recordings on his command at each of the pipeline survey measurement locations as well as at "Devices" and "Geo-Features", depending on the selections made for cane button functionality during the survey setup process (see Section III.1).

The canes (data-probes) are connected as shown to the "input" terminals of the dual-probe adapter and the "output" terminal of the adapter is connected to a 5-pin Data Probe connector on the top side of the Gx.

Note: The left-hand reference electrode (red-handled cane) is connected to the dual probe adapter via a "black-band" cable while the right-hand reference electrode (green-handled cane) is connected to the dual-probe adapter via a "red-band" cable. This is important since the **right-hand reference electrode** connects to the **positive** side of the data logger's voltmeter, while the **left-hand reference electrode** connects to the **negative** side of the voltmeter.

The terminals on the Gx data-logger are illustrated in the figure below.



The red banana plug jack on the Gx is used to temporarily connect a test lead from the Gx to a pipe connection in order to record pipe-to-soil potentials for IR drop determination by the software (see Section II).

The GPS Antenna illustrated on the top side of the Gx represents the antenna employed by the data-logger's internal GPS receiver. An extension antenna is recommended for pipeline survey work.

External GPS receiver units, if employed, would be connected to the data-logger via its built-in serial port (Com 1 Port), assuming that connection is made via a serial cable to the Gx.

With either the internal GPS receiver or an external GPS receiver being used, the location of items such as flags, devices, geo-features and anomalies can be recorded during the performance of a DCVG survey, either manually by tapping on the “Log GPS” button on the survey screen at each critical location or automatically by pre-programming the data-logger as described above in Section III.1

SECTION V: HOW TO PERFORM DCVG SURVEYS

V. 1 How to Carry the Test Equipment During a DCVG Survey

With the MCM test equipment connected as shown in Section IV.1, and the Gx data-logger setup as described in Section III.1, you are ready to perform a DCVG survey.

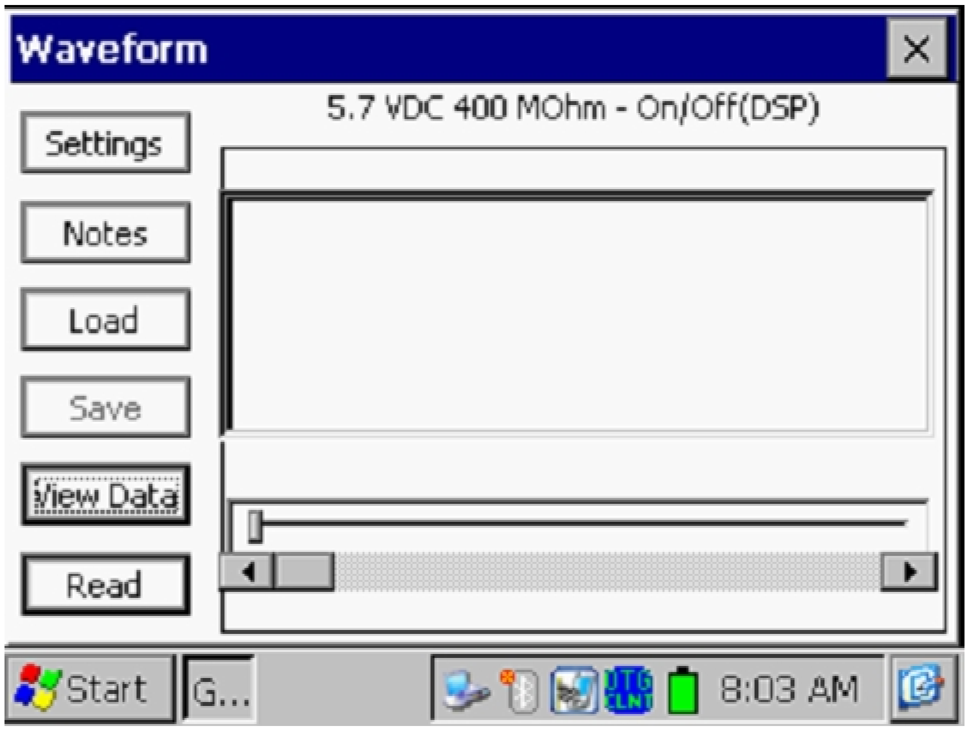
The Gx Belt Pack allows the Gx data-logger to be carried around the waist area in a “hands-free” fashion, allowing the surveyor to be able to position the reference electrode data-probes (canes) on the ground (every 5.0 feet, or so, down the length of the pipeline) and to be able to “trigger” the push button switches when appropriate to do so.

With the Belt Pack option, the Gx data-logger mounts onto a platform at waist level allowing the operator to view the screen at all times and to make any selections required by tapping on the screen. Also, the dual-probe adapter shown in Section IV, is mounted on the underside of the platform, allowing convenient (5 pin cable) connection of the adapter’s “output” to the data-logger.

V. 2 How to View and Save a Pipe-to-Soil On/Off Waveform

When you are performing a DCVG survey, it is recommended that you examine the pipe-to-soil voltage waveform at your starting location (starting test station) and it is suggested that you make a recording of the waveform using your Gx data-logger.

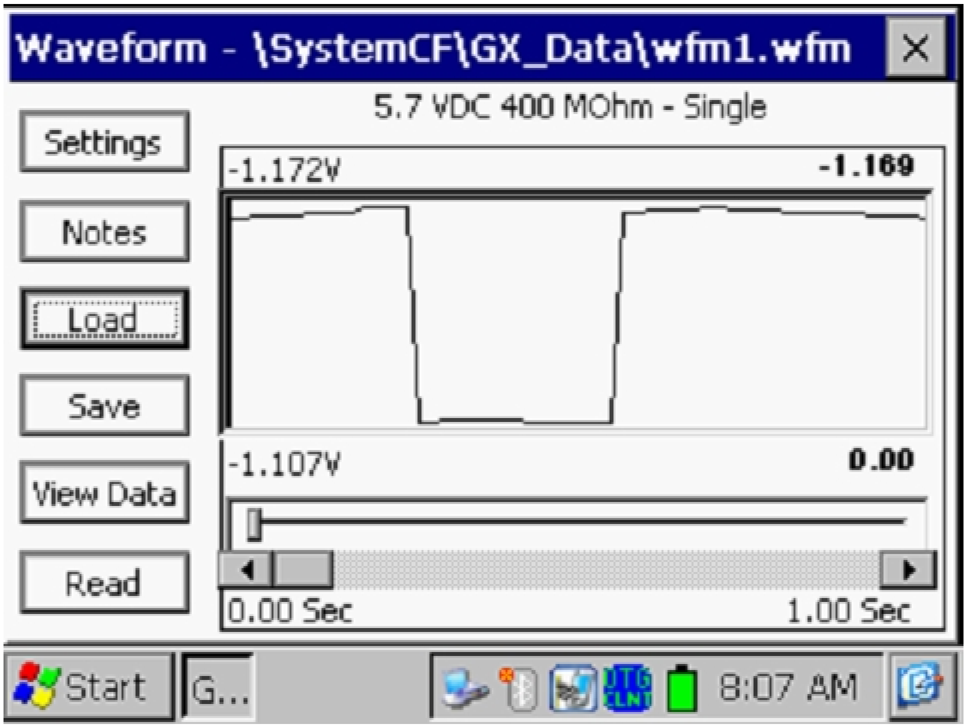
With the red-handled data-probe making good electrical contact with the soil above the pipe at the starting test station and a test cable temporarily connected from the pipe connection to the red banana plug terminal on the Gx, either tap on the “WAVE” button located at the top of the Survey screen or, tap on “Survey Options” and then tap on “Wave”. The screen shown below will be displayed, depending on the previous settings.



Read:
By tapping on the “**Read**” button on the above Waveform screen, you can view the pipe-to-soil voltage waveform at the test site.

A typical waveform would be as shown in the screen below.

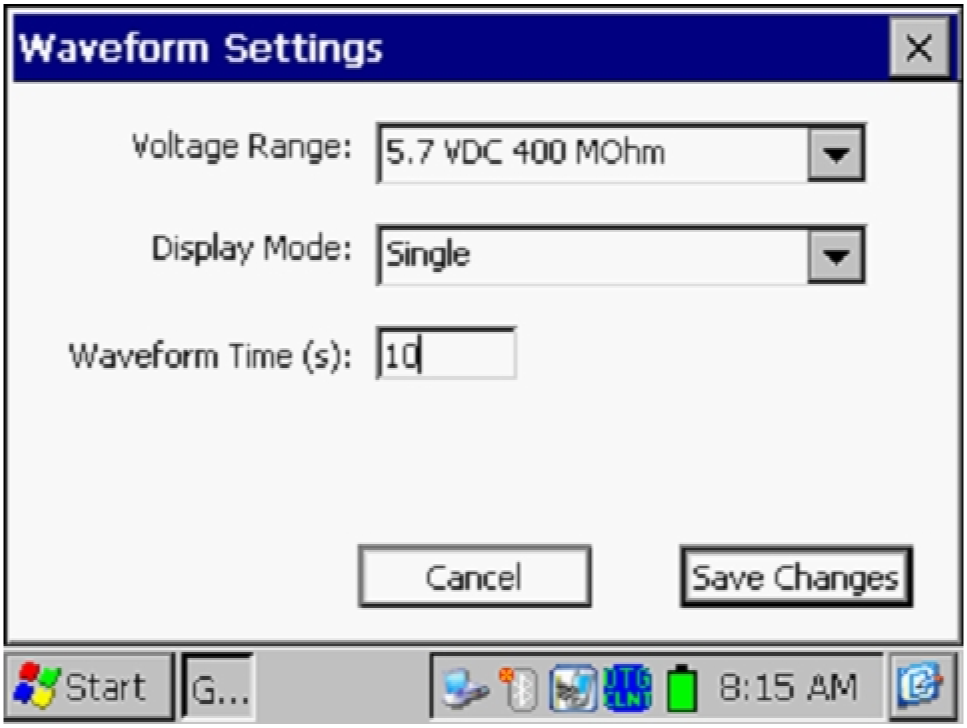
Note: The example waveprint shown is not a “real” waveprint .. it is only presented for illustrative puposes.



Waveprints are very useful with regard to confirming switching synchronization of current interrupters, for example, and with regard to checking for On-to-Off and Off-to-On transition spikes.

Settings

By tapping on the "Settings" button on the Waveform screen, the screen shown below will be displayed, depending on the previous settings.

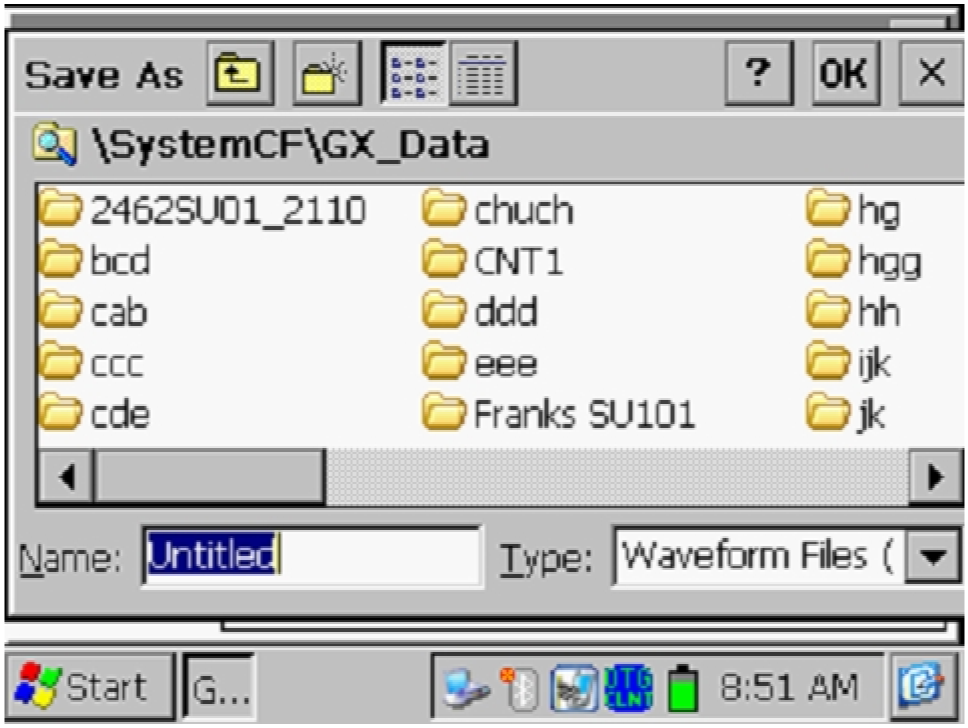


Since all of the DC channels on the Gx data-logger are fast response channels, you can select any "Voltage Range" setting amongst the DC options, regardless of the interruption cycle rate. The main issue with regard to optimum Range selection is sensitivity, in terms of the magnitude of the voltages being measured.

You can also change the "Display Mode" selection, by tapping on the menu button in the "Display Mode" field. In the case of the "Single" reading mode option, you can select the number of waveform periods to be displayed (viewable via the horizontal scroll bar), by tapping inside the "Waveform Time" box and entering a value manually for number of seconds. For example, if the interruption cycle period is 5 seconds (4 seconds On/1 second Off) and you entered 10 (seconds), you would have 2 waveform cycles displayed.

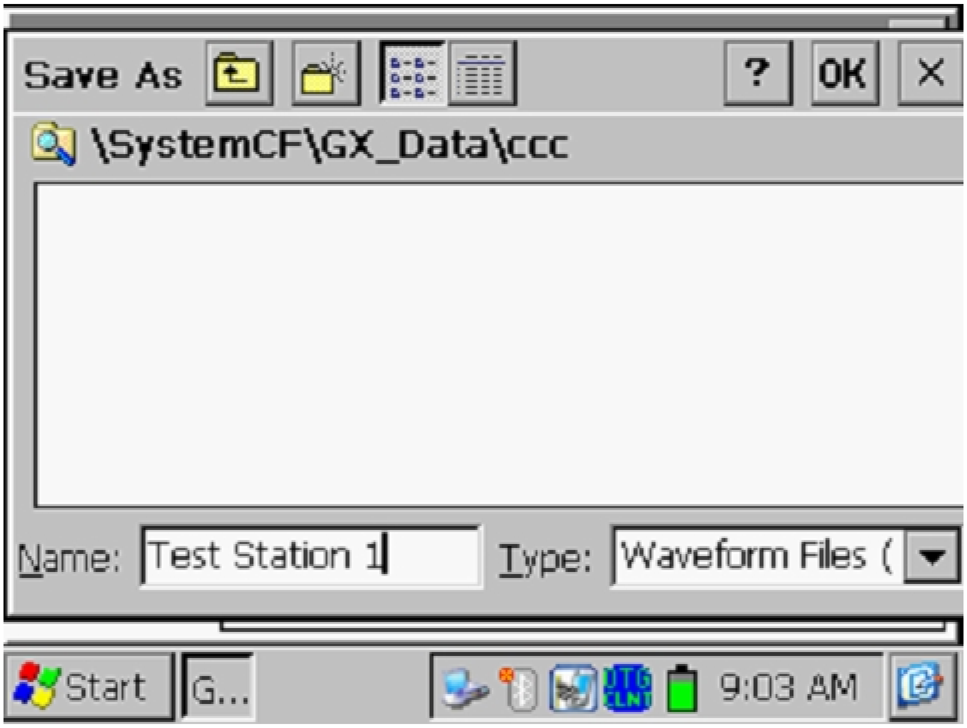
<u>*Save*</u>

To record a waveprint, tap on the "**Save**" button on the Waveform screen. The screen shown below will be displayed. *Note:* The specific folders presented on the screen will reflect the contents of the Gx_Data folder on your Flash memory card (SystemCF). The Gx_Data folder is used to store all of your survey files.



You have a number of options regarding saving the waveform data.

The recommended option, if you are recording waveform data in the context of a pipeline survey, is to save the waveform data file inside the actual pipeline survey file. To do so, you would double-tap on the survey file (folder) and enter a descriptive name for the waveform data file in the "Name" field. For example, the screen shown below would be displayed for the case of selecting the "ccc" survey file for storage of the waveform data file named, "Test Station 1".



Alternatively, you could just enter a name of the waveform data file in the "Name" field and tap on the "OK" button. In this case, the waveform data file will be saved directly to the Gx_Data folder.

Regardless of your target folder, you should tap on the "OK" button to save the waveform data file.

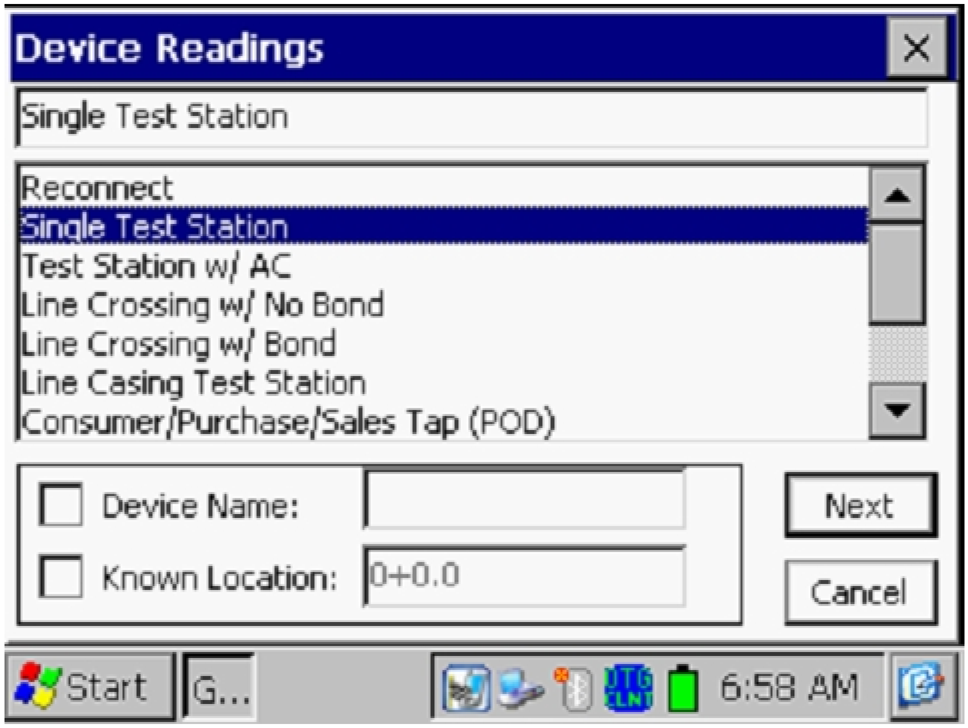
Load:

By tapping on the "**Load**" button on the Waveform screen, and highlighting a particular waveform data file displayed, you can have the previously-saved waveprint displayed by tapping on the "OK" button on the screen

V. 3 How to Record the Pipe-to-Soil Potential(s) at a Starting Test Station

It is required that you record the pipe-to-soil potential(s) at the starting test station. This will represent the first "**Device**" (Data-Collection Point) associated with the survey.

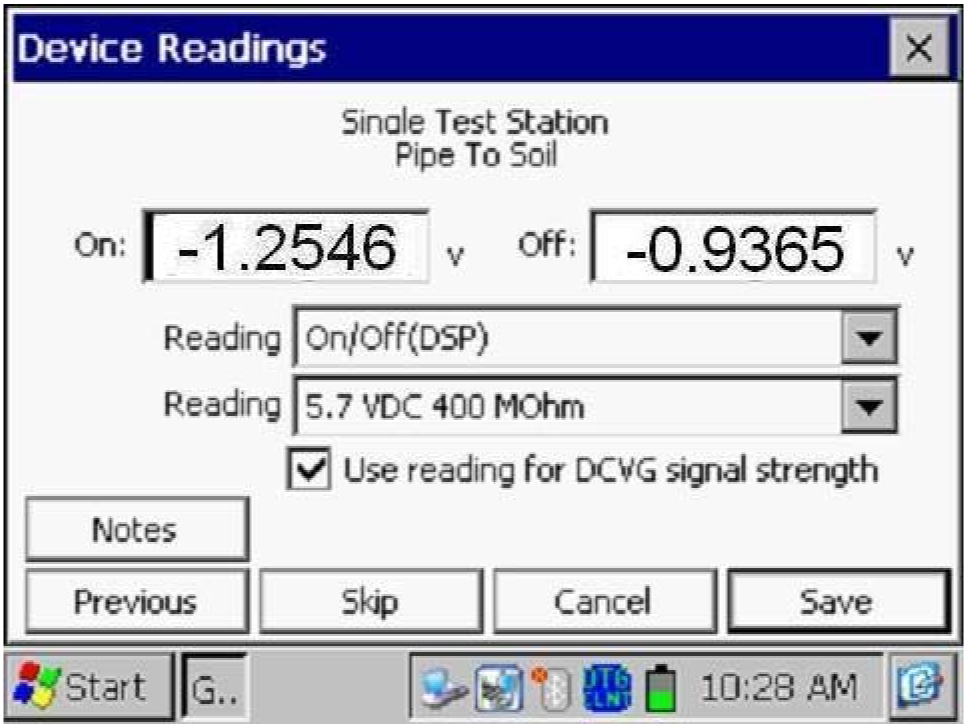
To do so, tap on the "Device" button on the survey screen. The screen shown below will appear.



As can be seen from the above screen, you can choose from a number of "Devices". In this case, you would tap on "**Single Test Station**" to highlight this selection.

Optional:
By checking off the box labeled, "Device Name", you can manually enter a descriptive name for the test station. The name you enter here will be associated with this device, as opposed to a default name. Also, by checking off the box labeled, "Known Location", you have the opportunity to manually enter the actual stationing for the test station, if known (if it is different from the location entered during survey setup for the Start Location).

You should then tap on the "**Next**" button. The screen shown below will be displayed, depending on the previous settings.



The On and Off pipe-to-soil potentials measured (per cycle) at the starting test station will be displayed on the above screen, assuming that one of the On/Off pairs voltmeter reading modes has been selected (see the "Reading" field on the screen).

Make sure that the box labeled, "Use reading for DCVG signal strength" is checked. This will mean that the software will have its first value for IR drop to use in its %IR calculations (see Section II).

The above procedure should be performed at each pipe connection opportunity so that the software will be able to apply appropriate IR drop values for each "marked" anomaly.

Note: A significant IR drop value is necessary in order to be able to detect DCVG anomalies, as the IR drop value represents the signal strength for the process.

For example, for the 5.7V, 400MΩ voltmeter setting, a minimum IR drop value of ~200mV is suggested for the following reason:

If it is assumed that you would like to "mark" defects having, as a minimum, a 10% IR "size", the minimum Total mV value, in the example case of a 200mV IR drop, would be 20mV. This means, in turn, that the minimum "Max mV" value that you'd be measuring would only be ~10mV or so, since, typically, about 50% of the total voltage gradient is accounted for in the first side drain reading (the Max mV reading). Since the noise level associated with the 5.7V, 400MΩ voltmeter setting is around ±5mV, you can see why ~200mV would be a suggested minimum IR drop value. An IR drop value around 500mV would make small size anomaly detection significantly easier.

Alternatively, a lower noise level voltmeter setting could be used. For example, the 400mV, 10MΩ setting has a noise level around ±1mV and the 40mV, 10MΩ setting has a noise level around ±0.5mV.

For the 400mV Range, for instance, the minimum IR drop value required to reasonably detect a 10% anomaly would be around 40mV, by the above reasoning (as compared to 200mV for the 5.7V range).

The 400mV and the 40mV Ranges would also provide a higher level of sensitivity, compared to the 5.7V Range, since DCVG voltages tend to be only in the tens of milli-volts range.

You would then tap on the "**Save**" button to record the data at the first test station. As an alternative, you could press the push button switch on either one of your data-probes (canes) to record the data, assuming that you selected the "save" option for the canes at D.C.P.s during the survey setup process.

When the data are saved, you will be given the opportunity to take a photograph at the "Device" location, as indicated by the question displayed on the screen shown below.

Answering “Yes” on the above screen will take you to the “Pictures” screen, as described in Appendix 3 of the Gx Data-logger Pipeline Survey User’s Manual.
Note: Several seconds are required to open the picture program.

<u>How to Position the Camera for a Picture:</u>
Since the camera on the Gx is located on the underside of the handheld unit, it is necessary to remove the unit from its mounting platform by grasping the unit around its mid section and pulling in an upward motion. The unit should snap out of its retaining brackets. You can now position the camera to take your photograph, since the coiled cable connecting the Gx to the dual-probe adapter provides a considerable degree of flexibility. The unit can then be snapped back into position on the platform, after picture taking, by lining up the groove on the bottom orange bumper with the registration post on the platform and pressing in a downward motion.

Note: By tapping on the “X” button on the “Pictures” screen (top right hand corner), after taking a photograph, you will be returned to the Survey screen.

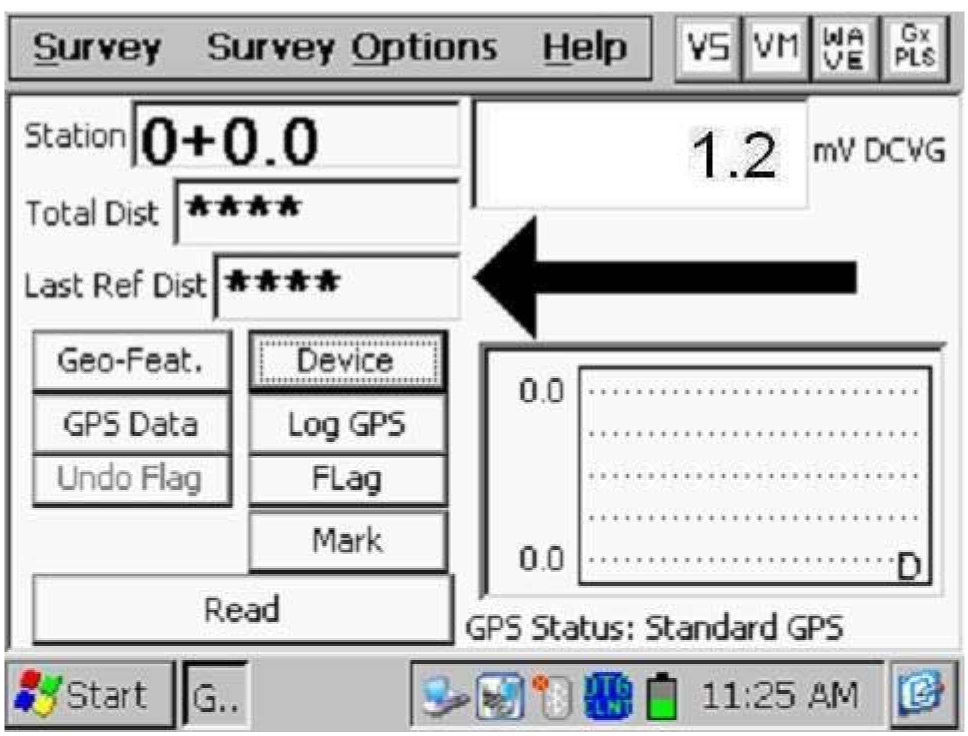
Answering “No” on the above screen will return you directly to the Survey screen.

You are now ready to proceed with the "walking" portion of the DCVG survey.

V. 4 How to Locate and "Mark" Defects

Once you have recorded the pipe-to-soil voltages and observed the magnitude of the signal strength (IR drop), you should disconnect the test cable from the red banana plug jack on the Gx and re-introduce the positive (green-handled) cane. You are now ready to record DCVG voltages down the length of the pipeline.

For Perpendicular DCVG surveys, you would place the canes (data-probes) about 4 to 5 feet apart, as indicated in Section II, with the left-hand cane (negative cane) directly over the pipe and the right-hand cane (positive cane) off to the right-hand side. The survey screen will be displayed as indicated below and the DCVG mV reading value displayed (in the field labeled "mV DCVG") will depend on whether or not you are inside of a voltage gradient field. If not, the DCVG reading should be around zero. *Note:* Since the Gx's voltmeter is digital, a true zero is never displayed and the reading will be somewhere in the ± noise level associated with the particular voltmeter Range selected.

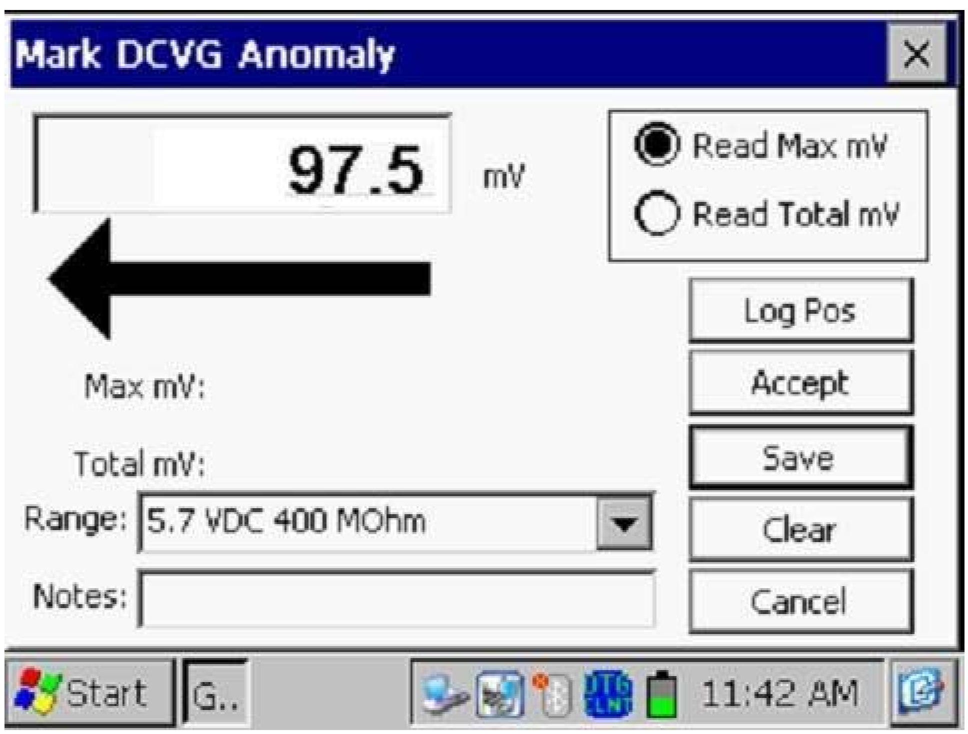


Note: The arrow on the Survey screen indicates the polarity of the DCVG voltage reading. For positive values, the arrow points to the left and for negative values, the arrow points to the right. This behavior is utilized to locate anomalies using the in-line approach (see Figure 7 in Section II.10).

If you set up the cane push-button functionality as indicated in Section III.1, ie, with the right-hand cane set to trigger voltage recordings and the left-hand cane set to designate the location of survey flags, you would trigger the right-hand cane every 5 feet or whatever recording interval you selected during the set-up process (see Section III.1).

As discussed in Section II. 2, if you are outside of the "voltage gradient field" of a coating defect, the DCVG voltages will essentially be zero. However, as you enter a defect's voltage gradient field, you will observe an increase in the DCVG voltage values displayed on the Survey screen (see Figure 5 in Section II. 2). When you observe a peak (maximum value) in the DCVG voltage readings, you would interrupt the triggering to perform the "Mark" process.

To do so, you would tap on the "**Mark**" button on the Survey screen. The screen shown below will be displayed depending on previous settings.



If you selected automatic logging of GPS position data at Sidedrains/Anomalies during the survey setup process (see Section III), the Gx data-logger will log the GPS data for the DCVG anomaly site when you "accept" the first side drain reading (see below). If you did not select this option during survey setup, you should tap on the "Log Pos" button if you would like to have GPS data logged for the anomaly location.

You would record the **Max mV** reading (first side drain reading) by tapping on the radio button labeled "Read Max mV" and tapping on the "Accept" button (do **not** tap on the "Save" button at this time). Alternatively, you could use either push-button switch to "accept" the reading, which is actually more convenient.

You will notice that the software automatically applies the "Max mV" value as the first value in the "Total mV" determination, for the case where this option was selected during the survey setup process (see Section III.1). If this were not the case for your survey setup, you would "Accept" the Max mV reading a second time and this would become the first voltage used in the Total mV determination.

You should then proceed to move the electrodes to their second positions (see Section II. 5) and you should "Accept" the second reading. You should proceed in this fashion until you are outside of the defect's voltage gradient field, ie, the DCVG voltage reading is essentially zero (typically DCVG voltages less than about ±5mV would be considered essentially zero, on the 5.7V, 400MΩ voltmeter setting).

At this point, you should tap on the "**Save**" button which will save all of the data associated with this defect.

When the data are saved, you will be given the opportunity to take a photograph at the "Anomaly" location, as indicated by the question displayed on the screen shown below.

Answering "Yes" on the above screen will take you to the "Pictures" screen, as described in Appendix 3 of the Gx Data-logger Pipeline Survey User's Manual.
Note: Several seconds are required to open the picture program.

How to Position the Camera for a Picture:
Since the camera on the Gx is located on the underside of the handheld unit, it is necessary to remove the unit from its mounting platform by grasping the unit around its mid section and pulling in an upward motion. The unit should snap out of its retaining brackets. You can now position the camera to take your photograph, since the coiled cable connecting the Gx to the dual-probe adapter provides a considerable degree of flexibility. The unit can then be snapped back into position on the platform, after picture taking, by lining up the groove on the bottom orange bumper with the registration post on the platform and pressing in a downward motion.

Note: By tapping on the "X" button on the "Pictures" screen (top right hand corner), after taking a photograph, you will be returned to the Survey screen.

Answering "No" on the above screen will return you directly to the Survey screen.

You would then pick up the survey where you left off and continue triggering DCVG voltage readings until you encounter the voltage gradient field associated with another anomaly.

SECTION VI: HOW TO COPY SURVEY FILES FROM THE Gx DATA-LOGGER TO YOUR PC

VI. 1 Introduction

Survey data are stored in independent files (one file for each survey) on the Flash memory card on the Gx data-logger and you can copy survey files to your PC using one of two approaches; manually or via the driver in the ProActive software program.

The ProActive software program represents MCM's CP data management system and this program allows integration of pipeline survey data in a database system and offers extensive reporting (both textual and graphical) capabilities on the survey data.

If you have the ProActive software program installed on your PC, or you can bring your Gx to a PC that has ProActive installed on it, you can use the ProActive program to automatically access survey files on the Gx. If either of these situations applies, you would proceed to Section VI. 3.

Note: The ProActive program is required to actually view the survey data.

If you do not have ProActive installed on your PC and you cannot bring your Gx to a PC that has ProActive installed on it, you can copy survey files manually from your Gx to your PC and you can subsequently send the copied files to a recipient who is a ProActive user. If this situation applies, you would proceed to Section VI. 2.

VI. 2 The Manual Approach

Step 1: Establish a connection between the Gx and your PC.

Gx Data-loggers can be connected to a PC using the USB cable supplied with the unit.

Connection via the USB Cable:
The requirements and procedures with regard to Gx Data-logger/PC connectivity depend on the operating system of the PC.

<u>Case 1: Windows XP (or earlier) PC Operating System</u>
The Microsoft "ActiveSync" communication program is required on the PC. If not currently installed, the application can be installed from the CD provided with the Gx Data-logger. Once installed, make sure that the "Allow USB Connections" option is selected in the "Connection Settings" window of the ActiveSync application.

Next, connect the USB cable from the Gx Data-logger to the PC and switch ON the Gx (via the RED power button). The connection should be automatic and you will be asked if you'd like to set up a partnership or not between the Gx and the PC. Answer NO to this question, as the ability to transfer file data is all that is required, as opposed to a synchronized partnership. You can then exit the Activesync application.

If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

<u>Case 2: Windows Vista or Newer (such as Windows 7) PC Operating System</u>
The Gx Data-logger connects to these systems via the "Mobile Device Center" which replaces the Activesync program on the PC side.

Make sure that the USB connection option is set up via the Mobile Device Center. Connect the USB cable between the Gx Data-logger and the PC and switch ON the Gx. The connection should be established automatically.
If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

Step 2:
Follow the procedures detailed below:

* Double-click on "My Computer" on your PC
- Double-click on "Mobile Device"
- Double-click on "SystemCF"
- Double-click on "Gx_Data"
- Right-click on the survey file you wish to copy & select "Copy"
- "Paste" the file into a local folder on your hard-drive
- Create a compressed (zipped) version of the file

You would now be in a position to send the compressed file via email, for example, to a recipient who has access to the ProActive software program.

Note: Do not rename the survey file prior to sending the file to the recipient, as the survey file must have the same name as the survey itself.

VI. 3 Using the Driver in the ProActive Software Program

Step 1:
Create a folder on your PC's hard-drive (perhaps in your "My Documents" folder) that will be used to "permanently" save files copied from your data-logger. You might choose to name this folder something like, "Surveys".

Step 2: Establish a connection between the Gx and your PC.

Gx Data-loggers can be connected to a PC using the USB cable supplied with the unit.

Connection via the USB Cable:
The requirements and procedures with regard to Gx Data-logger/PC connectivity depend on the operating system of the PC.

Case 1: Windows XP (or earlier) PC Operating System
The Microsoft "ActiveSync" communication program is required on the PC. If not currently installed, the application can be installed from the CD provided with the Gx Data-logger. Once installed, make sure that the "Allow USB Connections" option is selected in the "Connection Settings" window of the ActiveSync application.

Next, connect the USB cable from the Gx Data-logger to the PC and switch ON the Gx (via the RED power button). The connection should be automatic and you will be asked if you'd like to set up a partnership or not between the Gx and the PC. Answer NO to this question, as the ability to transfer file data is all that is required, as opposed to a synchronized partnership. You can then exit the Activesync application.

If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

<u>Case 2: Windows Vista or Newer (such as Windows 7) PC Operating System</u>

The Gx Data-logger connects to these systems via the "Mobile Device Center" which replaces the Activesync program on the PC side.

Make sure that the USB connection option is set up via the Mobile Device Center. Connect the USB cable between the Gx Data-logger and the PC and switch ON the Gx. The connection should be established automatically.
If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

<u>Step 3:</u>

Double-click on the "ProActive" icon on your PC's desktop screen.

This will open up ProActive's main menu window. A window labeled "Entire Database" will also be seen here. The suggested organization of your database is discussed in the **ProActive Training Manual**.

<u>Step 4:</u>

Click on the "Surveys" speed button on the main menu bar.

This will open a window labeled "Data Logger: Get Pipeline Survey".

By clicking on the menu button in the “Data Logger” field, you can select the data-logger from which you are copying the survey file. The various data-loggers currently supported by ProActive are offered as choices in the menu list.

Step 5:
Select the Gx Data-logger Option.

Highlight “GX” in the menu list and make the appropriate “Survey Type” selection (CIS in this case). Next, click on the “Go” button. This will open up a window labeled, “Gx Driver (Pipeline Survey)”.

Note: It may take a few seconds for the “Driver” Window to appear.

Step 6:
Identify the Survey File to be Copied.

The “Get Pipeline Survey from Gx” field on the “Gx Driver” window will list all of the survey files currently stored on your Gx’s Flash memory card.

Highlight the survey file that you would like to be copied to your PC. Also, check-off the box labeled “Copy to Local Folder” and identify the target folder’s location on your hard-drive in the field underneath using the “browse” button.

This is the folder that you set up previously (Step 1 above) in which to save all of your survey files copied from your Gx.

Also, if you used the metric system on the data-logger, check off the box labeled, “Use Metric”.

Finally, click on the “Go” button on the Gx Driver window.

Step 7:
Examine the Survey Data Prior to Posting the Data to the ProActive Database.

You will have actually completed the process of copying a survey file to a local folder on your PC by this point, using the Driver in ProActive.

However, before exiting the Driver, it is recommended that you examine your survey data prior to posting the data to the ProActive database. The process of posting the pipeline survey data to the ProActive database is detailed in the **ProActive Training Manual** and is beyond the scope of this manual.

To examine the survey data in the Gx Driver, you can click on the various page tabs now appearing on the Gx Driver (Pipeline Survey) window:

Survey Settings
Readings
Device Readings
Graph

By clicking on these page tabs, you can view information on the Survey settings or you can view the actual survey (and “device”) data - please see the ProActive Training Manual for details.

APPENDIX 1: How to Delete Survey Files from the Gx

Once you have copied your survey files to your PC (see Section VI), you can (if you wish) delete the files from your Gx's Flash memory card.

Since your survey files are stored on the Flash card, you will have to access this memory (SystemCF) in order to delete selected survey files. The procedure would be as follows:

- Tap on the "Start" button on the Gx
- Tap on "Programs"
- Tap on "Windows Explorer"
- Double-tap on "SystemCF"
- Double-tap on "Gx_Data"
- Tap and hold on the Survey File you wish to delete until a menu pops up
- Tap on the "Delete" option. This will delete the highlighted survey file