The Cascade USB data acquisition program has been written in Labview 2016 to communicate with a Hydrolab Quanta water quality sonde via a Waterlog H-4191 RS-232 to SD-12 interface and through a Measurement Computing USB Data Acquisition Device.

The main program uses a tab format to display multiple controls, indicators and graphs. The following screen shots display the front panel of the program and the tabs in order from left to right. Readings from the sonde and other readings from the pressure and flow sensors are displayed below the tab control in a "cluster indicator." This indicator displays readings of the current head pressure, the current depth, and the cumulative volume, with the following readings from the sonde itself: the specific conductivity reading, the dissolved oxygen reading, the pH reading, the oxidation reduction potential (ORP), the temperature of the water, and the water salinity. Readings from the 3 auxiliary inputs to the USB DAQ are also shown. On the far right hand side, control buttons are shown. Below the control buttons, two indicator lights, one indicating the status of power and communications with the USB DAQ and one indicating the status of power and communications with the sonde are displayed. These buttons and indicators will be discussed further below.

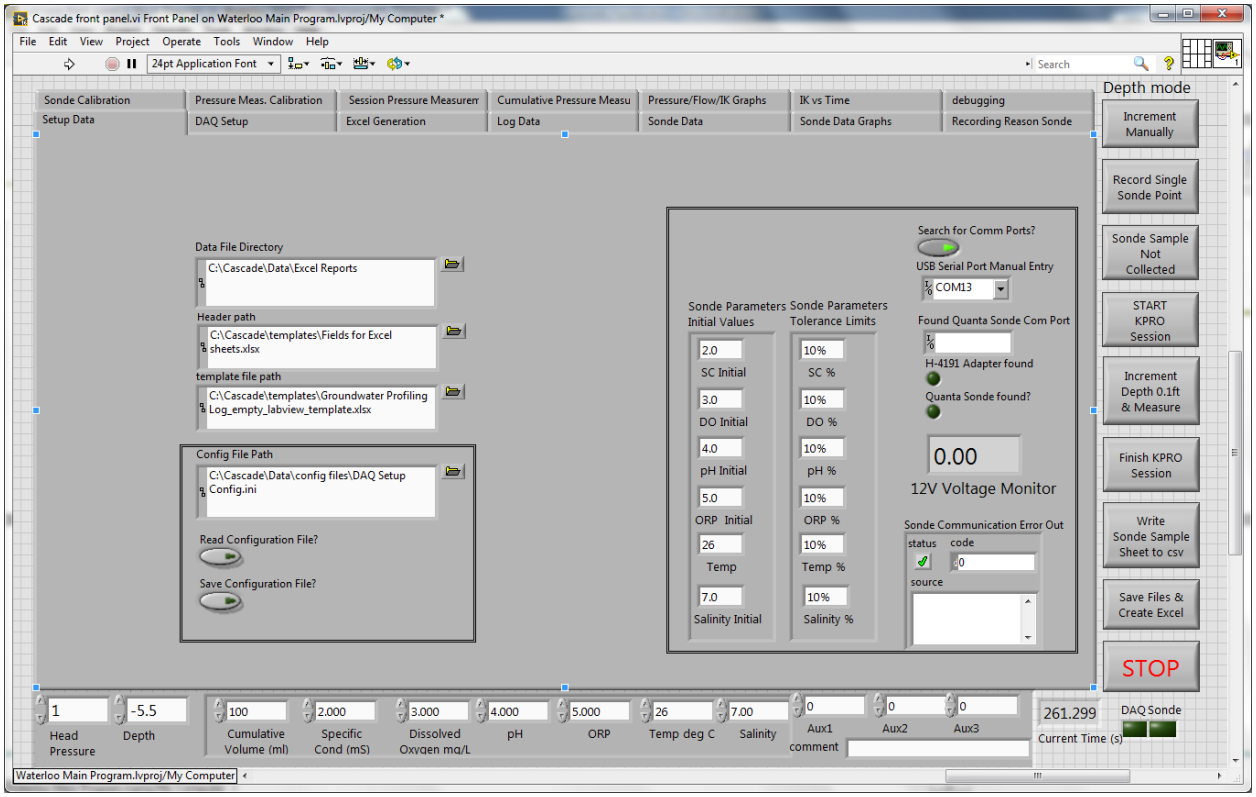

Figure 1: Setup Tab

1. The first tab is the "Setup Data" tab shown below in Figure 1; this tab has the controls for the main data directory for Excel Reports, the control for the Excel templates and the path to the template that is copied to the profile directory and then populated. Below those controls is the controls for the configuration file path and the usage of the configuration files.

a. The configuration file settings will save out ***all*** the control settings and indicator settings in the program (all the tabs) into a configuration file. This occurs if the "Save Configuration File" button is set to on and the file is written during the exit routine when the "STOP" button is pressed.
b. If the "Read Configuration File" button is set to on, then the configuration file location shown in the "Config File Path" is used as the source file to read all the control and indicator settings for the program.
c. On the right hand side of the "Setup Data" tab are the controls and indicators for communicating with the sonde.
    i. The first control is the "Search for Comm Ports" control button. When this button is turned on, the program will automatically read all available serial communication ports on the computer to search for the proper response from the Waterlog H-4191 RS-232 to SD-12 interface. If the proper response is received, then the communication port is saved and displayed in the "Found Quanta Sonde Port" indicator. If the "Search for Comm Ports" button is turned off, then the serial port displayed in the "USB Serial Port Manual Entry" is used to communicate with the sonde.
    ii. If the Waterlog H-4191 RS-232 to SD-12 interface has been properly found and communications have been established, then the "H-4191 Adapter Found" indicator light will be illuminated. (It is not illuminated on the example shown above in Figure 1.) The Waterlog H-4191 interface also reads and reports the 12V power supply input from the external power supply. This reading is shown in the "12V Voltage Monitor" numerical indicator. If this reading is greater than or equal to 11.75V, then the "Sonde" square indicator in the lower right hand corner of Figure 1 will be illuminated.
    iii. If the H-4191 Adapter is found, then the program requests the ID string from the Quanda Sonde, if this is received correctly, then the "Quanta Sonde Found" indicator light will be illuminated.
    iv. The last indicator on the "Setup Data" tab is the error indicator for communications with the H-4191 and the Quanta Sonde. For the case of the screen capture shown in Figure 1, the computer was not connected to the H-4191 adapter or the sonde, so the error message shown indicates that the "Quanta Sonde was not found and no USB serial ports were found," and a red X is displayed in the status indicator. If communications were properly established, then the status indicator would have a green check and the error message would be blank.
    v. The "Sonde Parameters Initial Values" indicator shows the reference values that are used to calculate the percentage changes for each of the logged sonde values. This indicator will update to hold the last logged value, but the values shown here at the start are used to calculate the percentage changes for the first reading.

vi. The “Sonde Parameters Tolerance Limits” control cluster are used to calculate the percentage limits that is used to determine if a logged sonde reading is within tolerance. By default these are set to 10%.

2. The second tab is the “DAQ Setup Tab,” and is displayed in Figure 2. This tab has controls and indicators that deal with the setup and communincations with the Measurement Computing Corporation (MCC) Data Acquisition (DAQ) USB Model USB-2408-2AO, which is a 16 channel (single ended or 8 channel differential) data acquisition module with 2 analog outputs (AO). Setup and control of the MCC DAQ is accomplished through the Instacal program which can be accessed from the start menu and programs tab under “Measurement Computing.” The Instacal program is shown in Figure 3. If the MCC DAQ is found and properly identified, then the “PC Board List” will display the serial number and model number. Since the development computer was not attached to the Waterloo Water Sampling Module, the Instacal program displays the error message shown in the lower window in Figure 3. *The Labview program will not properly communicate the MCC DAQ if the Instacal program does not find the device. When first installing the MCC software and connecting a new MCC DAQ to a computer, the Instacal program will need to be run manually to find and identify the MCC DAQ device and create the CB.CFG file.* The device name of the USB device found in the Instacal CB.CFG file is shown in the “Device Name in Instacal” indicator.

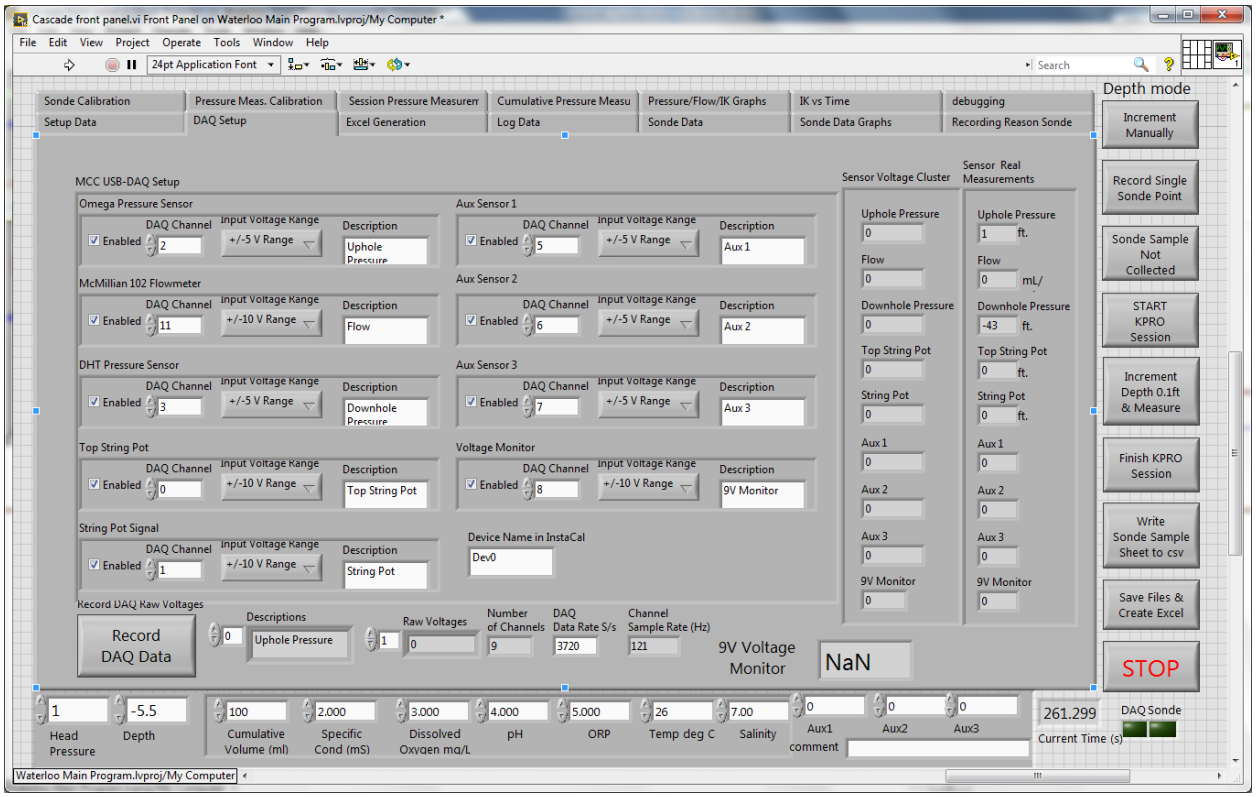

Figure 2: DAQ Setup Tab

The channel setup for the MCC DAQ occurs in the MCC USB-DAQ Setup Control Cluster shown on the left hand side of Figure 2. This control associates the readings from a specific DAQ channel with the physical measurement. It should not be necessary to change these values except to turn off unused sensors, if desired.

In the display shown above, Channel 2 is enabled (indicated by the check in the the Enabled check box) and is associated with the Uphole Pressure sensor, through the "Description" control. The voltage range for the input is the +/- 5V range. Similarly, Channel 11 is enabled and associated with the McMIllian Flow meter; as the maximum voltage output from the flow meter is 6V, the range for Channel 11 has been set to +/- 10V. Similarly, the controls for the rest of the channels and the association with physical parameters are shown for the rest of the control cluster. By default the range of the auxiliary channels is set to +/- 5V; this can be adjusted depending on the range of the sensor attached to the input. The Labview program reads the control to determine the number of enabled channels and displays the result in the "Number of Channels" indicator; in the above display it is 9, the number of enabled channels in the MCC USB-DAQ Setup Control Cluster. The "Descriptions" array also is filled with the descriptions of the enabled channels at the same time. The data acquisition rate each individual channel is determined by two parameters, the number of enabled channels and the board data acquisition rate, which is shown in the DAQ Data Rate s/S" as 3720 samples/second. (s/S). For each individual channel, the sample rate is shown in the "Channel Sample Rate Hz" indicator as 121 Hz, which is equal to $(\text{int}(((\text{DAQ Data Rate})^{-1}+0.00064)*9)-1)^{-1}$.

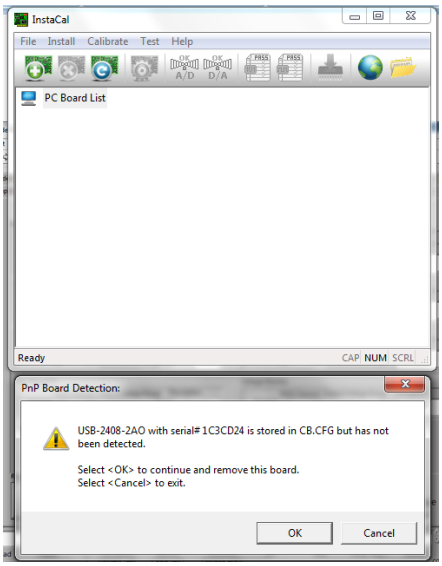

Figure 3: Instacal Program Window (top) and Error Warning (bottom)

As the maximum voltage range for the MCC DAQ is +/-10V, a small 9V DC/DC converter is used to generate 9V from the input 12V to supply voltage and current to the string pot. The 9V output is fed to channel 8 as the voltage monitor. The reading from this channel is displayed in the "9V Voltage Monitor Display" on this tab. A reading of 8.75V or greater on this monitor will also illuminate the DAQ LED indicator on the lower right hand side of the screen.

Pressing the “Record DAQ Data” button will result in an immediate reading of the inputs of the MCC DAQ which is displayed in the “Sensor Voltages Cluster” on the right hand side as ***raw voltages***. This set of indicators is also updated approximately every 100 ms. The readings displayed in the “Sensor Voltages Cluster” are converted to readings of physical parameters (by applying the slope and offset calibration values in the slopes csv file and the “Input Variables and Slopes” indicator from the Log Data tab (Figure 5 below)) and displayed in the “Sensor Real Measurements” cluster.

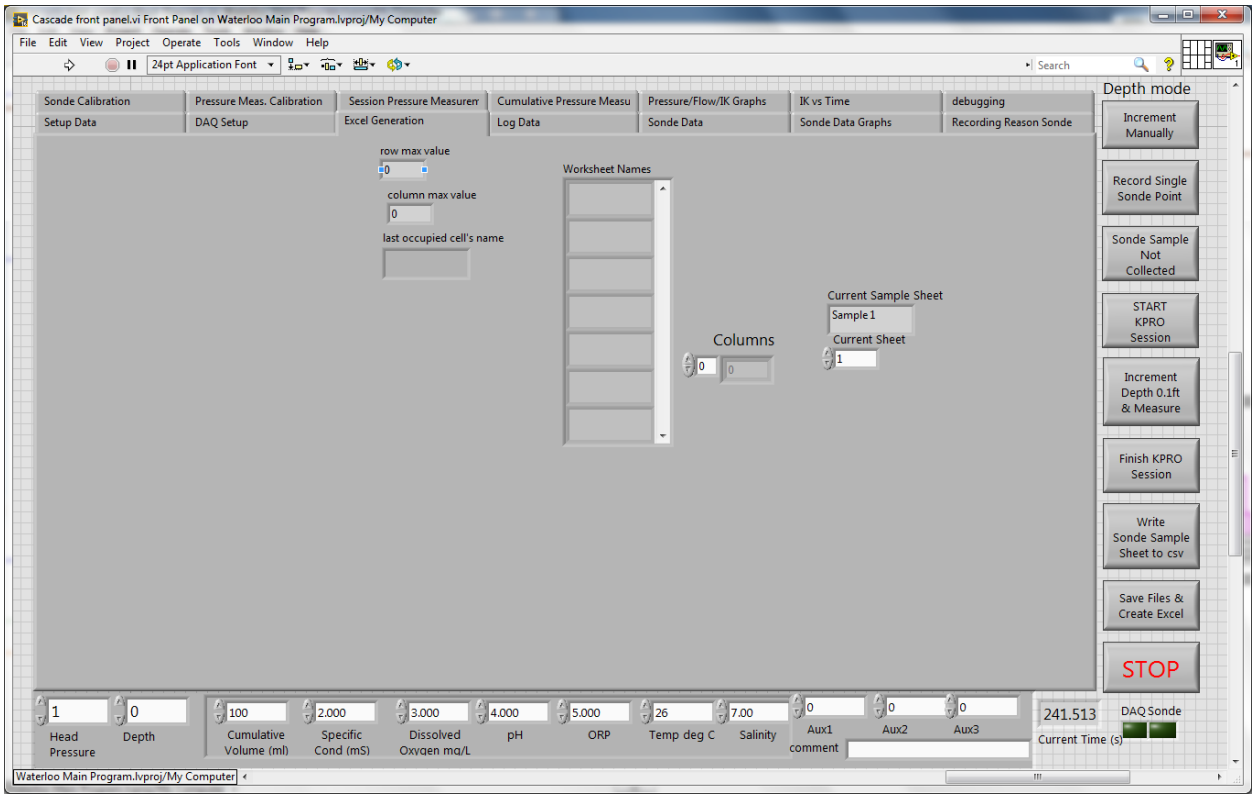

Figure 4: Excel Generation Tab

The next tab is the “Excel Generation” tab which displays the appropriate parameters from the Excel template file as to the number of worksheets, the names of the worksheets, the current active worksheet. This is displayed in Figure 4.

The excel worksheet header is shown on the “Log Data” tab which is shown on the left hand side of Figure 5. Some of these fields can be populated by the subsequent pop-up windows for Profile ID, KPRO Box serial number, and resevoir pressure. The rest can be entered here. The header values can be cleared by pressing the “Clear Groundwater Header Values” clear button, which is enabled when the program first runs. The sonde serial number will be populated automatically by interrogating the attached sonde for it’s serial number.

The Temporary Data Files Directory path control should be set to the default “C:\Cascade\Data\Output Files.” This setting is used to determine where the two sensor slopes files are located. The locations of these two files will be displayed on the right hand side of the tab in the “Slopes File Path” and ” Slopes

History File Path" indicators. (The slopes csv file will also be copied to the directory created by the Profile ID entry, as discussed below.)

The profile ID setting in the worksheet header is read in from a pop-up window as shown in Figure 6. This entry should not contain any special characters such as tabs or carriage return/line feeds or new lines. The profile ID is also used to create a directory in the folder indicated in the Temporary Data Files Directory Path indicator if one does not exist. The profile ID is also used as a prefix on all the csv files and the excel file. In the example shown in Figure 5, the profile ID is "ara-5" and the created directory is shown in the "Output File Path" indicator. The appended path indicator shows the Output File Path with the profile-ID as the prefix. The remaining path indicators are built from the "appended path" indicator to generate the appropriate csv files and the xlsx excel file.

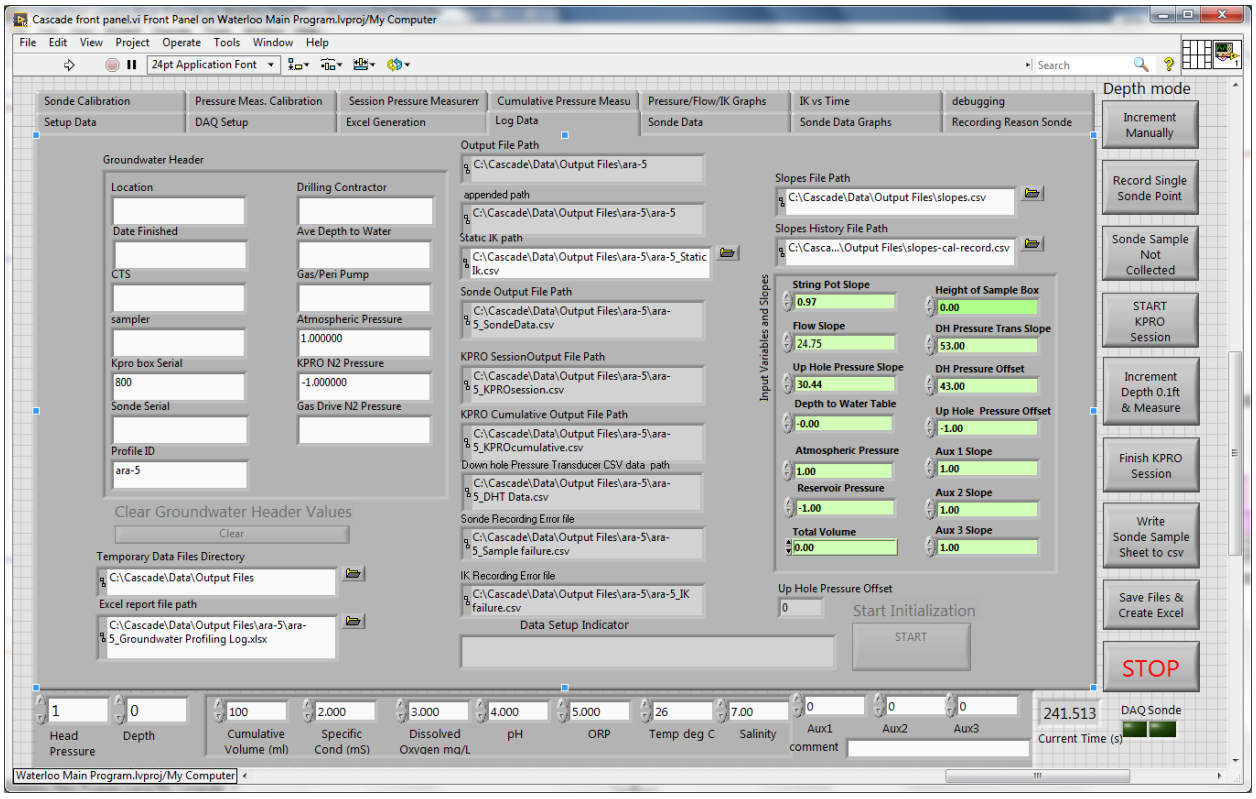

Figure 5: Log Data Tab

The "Data Setup Indicator" indicator and the Start Initialization Button will be discussed later, when discussing running the program.

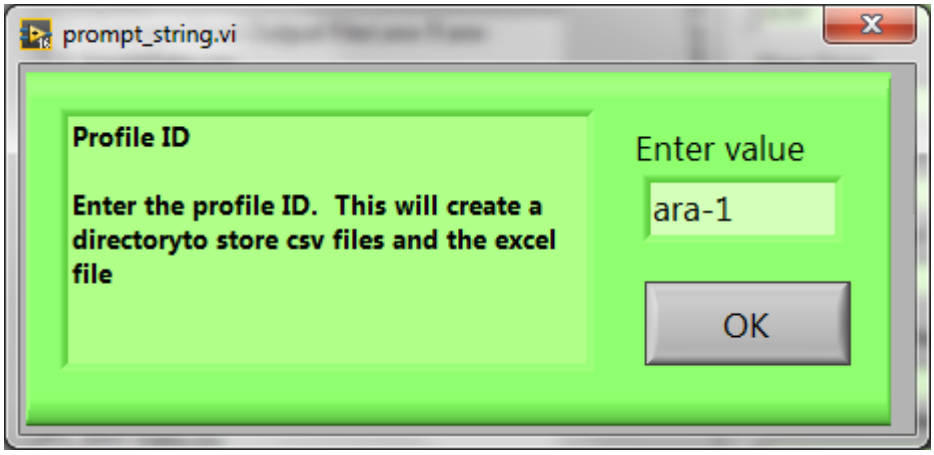

Figure 6: Profile ID Popup

The" Input Variables and Slopes" cluster of input variables shows the result of reading the slopes calibration file. The slopes variables and offsets are populated as part of the initialization process immediately following the File Dialog popup. The "Depth to Water Table," "Atmospheric Pressure," " Reservoir Pressure," and "Height of Sample Box" indicators will be populated by the appropriate pop-ups, discussed in the program operation section later. The default settings for the auxiliary inputs are 1.00 but can be changed in either this cluster or in the calibration popup if required.

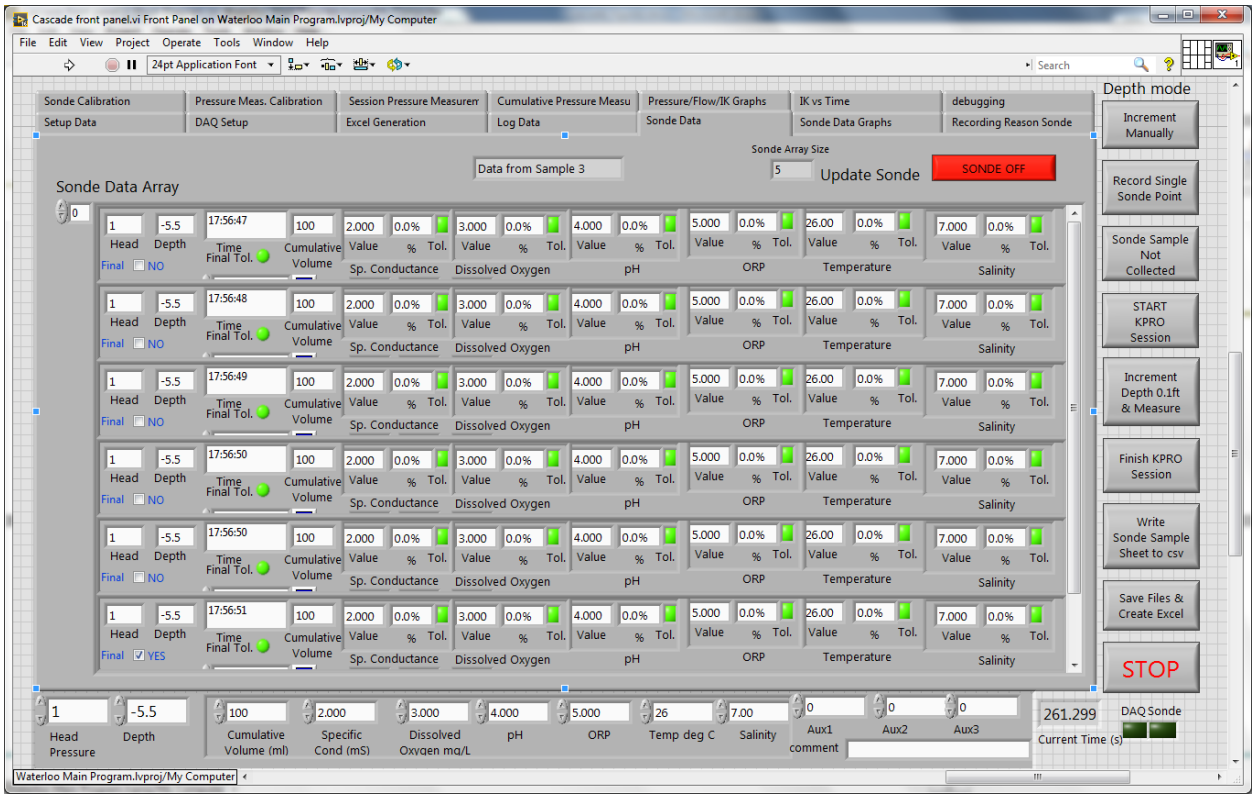

Figure 7: Sonde Data Tab

The next tab is the “Sonde Data” tab. The main indicator on this page displays the logged measurements from the sonde, as well as the head pressure, the depth, the time, the cumulative volume and the readings from the auxiliary sensors. Also shown for each sonde parameter is the percentage change from the stored initial sonde parameter value from the reference values as indicated on the Setup Data tab (Figure 1). The default parameters are used for the first percentage calculations; following that, the reference values are updated to store the previous logged sonde measurement. If the percentage change from one reading to another for an individual sonde parameter measurement is below the limits shown in the “Sonde Parameters Tolerance Limits” control on the Setup Data tab (Figure 1), (default 10%) then the tolerance (“Tol.”) indicator will illuminate. If all the tolerance indicators are illuminated, then the “final tolerance” indicator will also illuminate. The text indicator on the top center indicates to which sample set the parameter readings belong; in the case shown in Figure 7 it is for sample set 3.

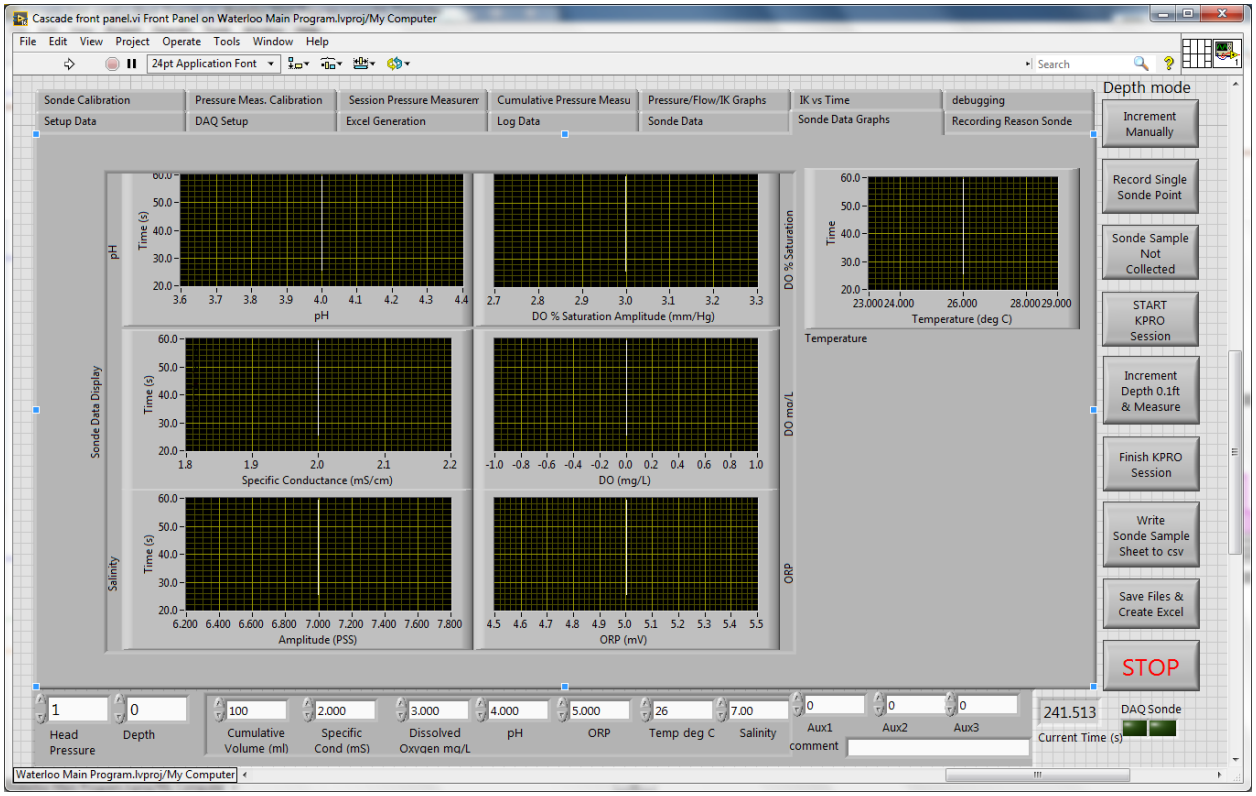

Figure 8: Sonde Data Graphs Tab

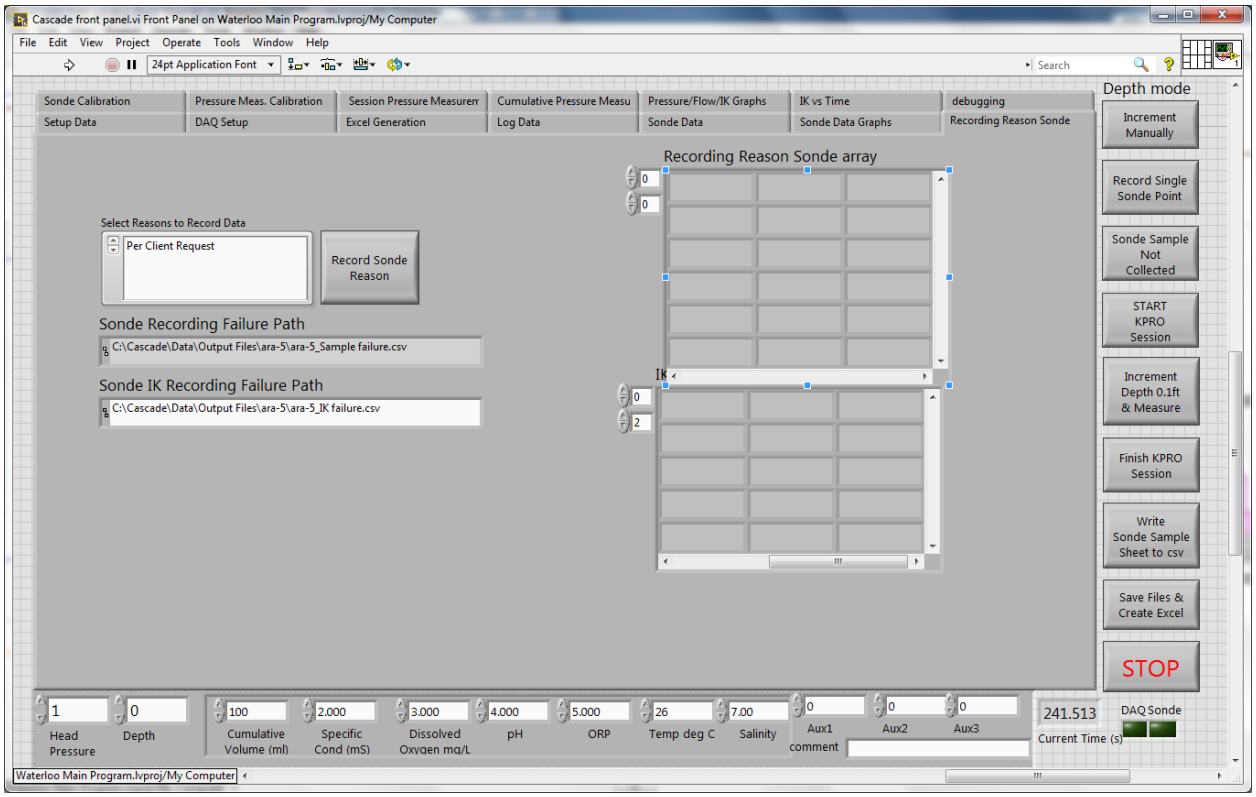

Figure 9: Recording Reason Sonde Tab

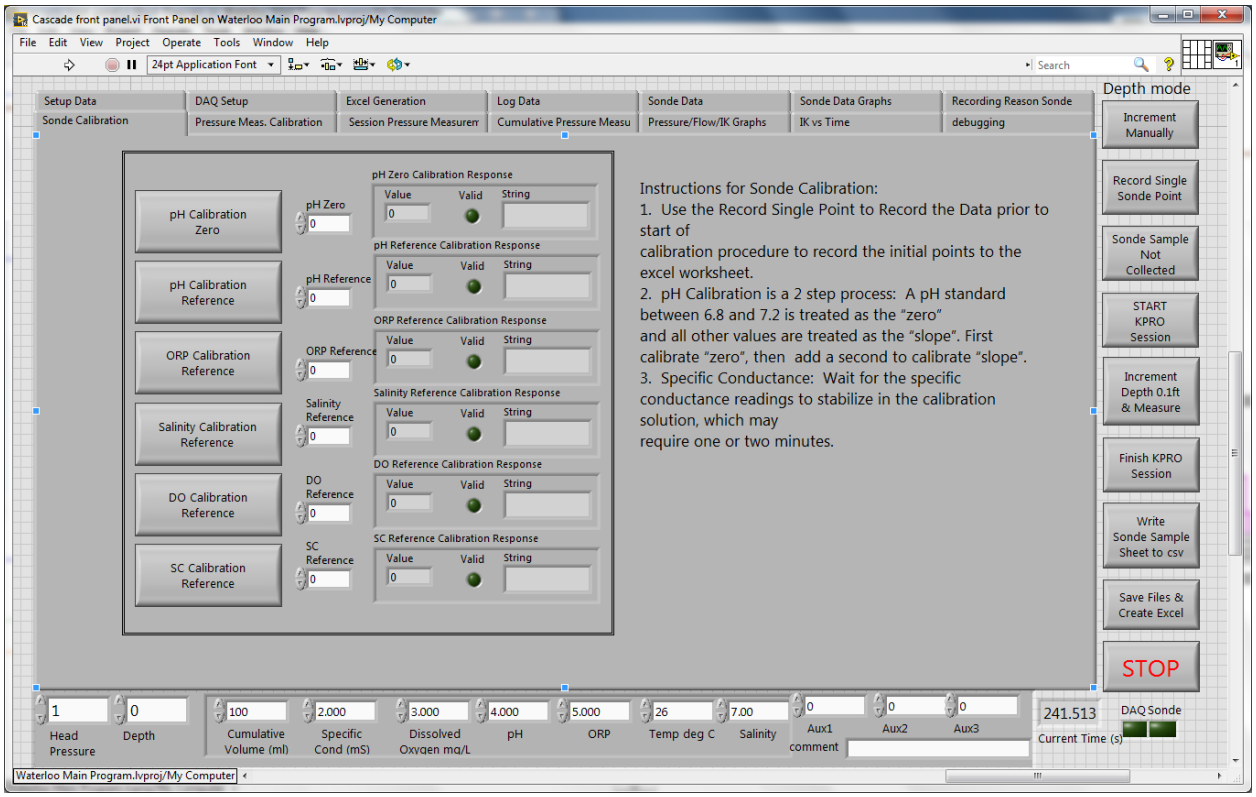

Figure 10: Sonde Calibration Tab

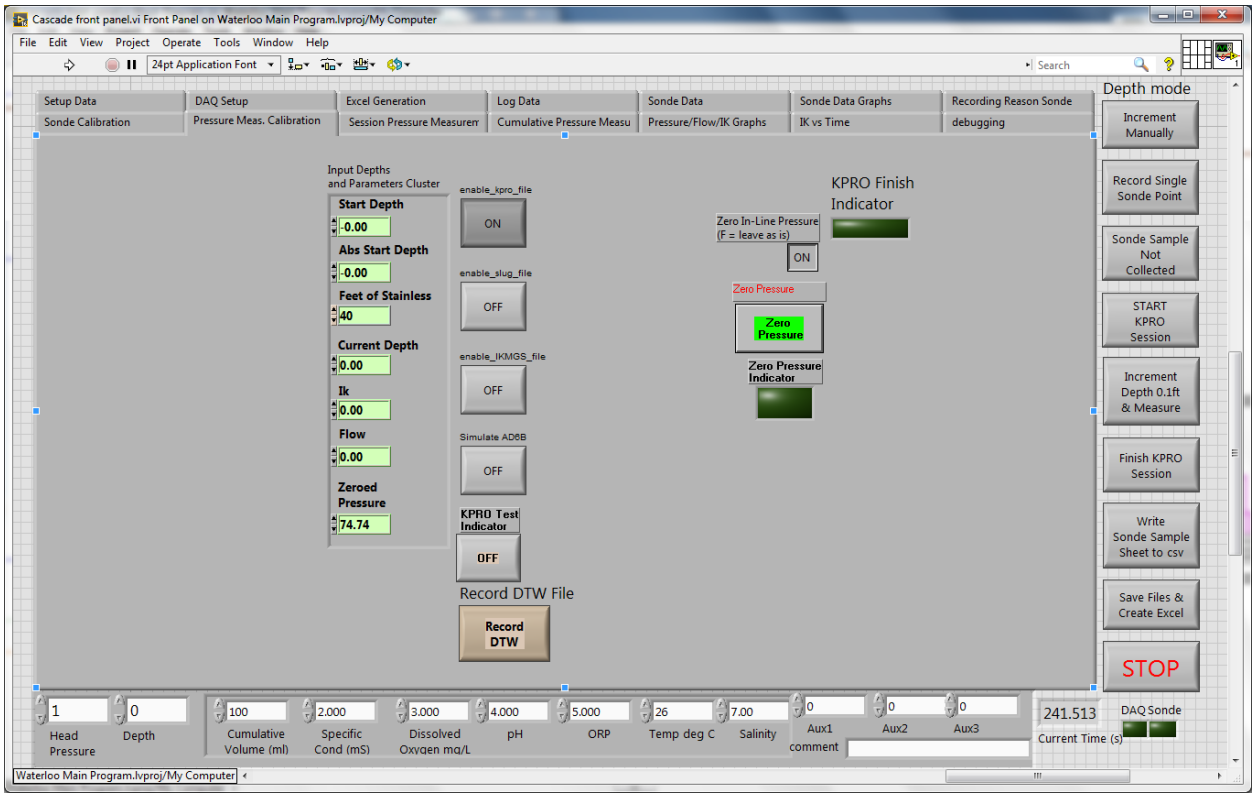

Figure 11: Pressure Measurement Tab

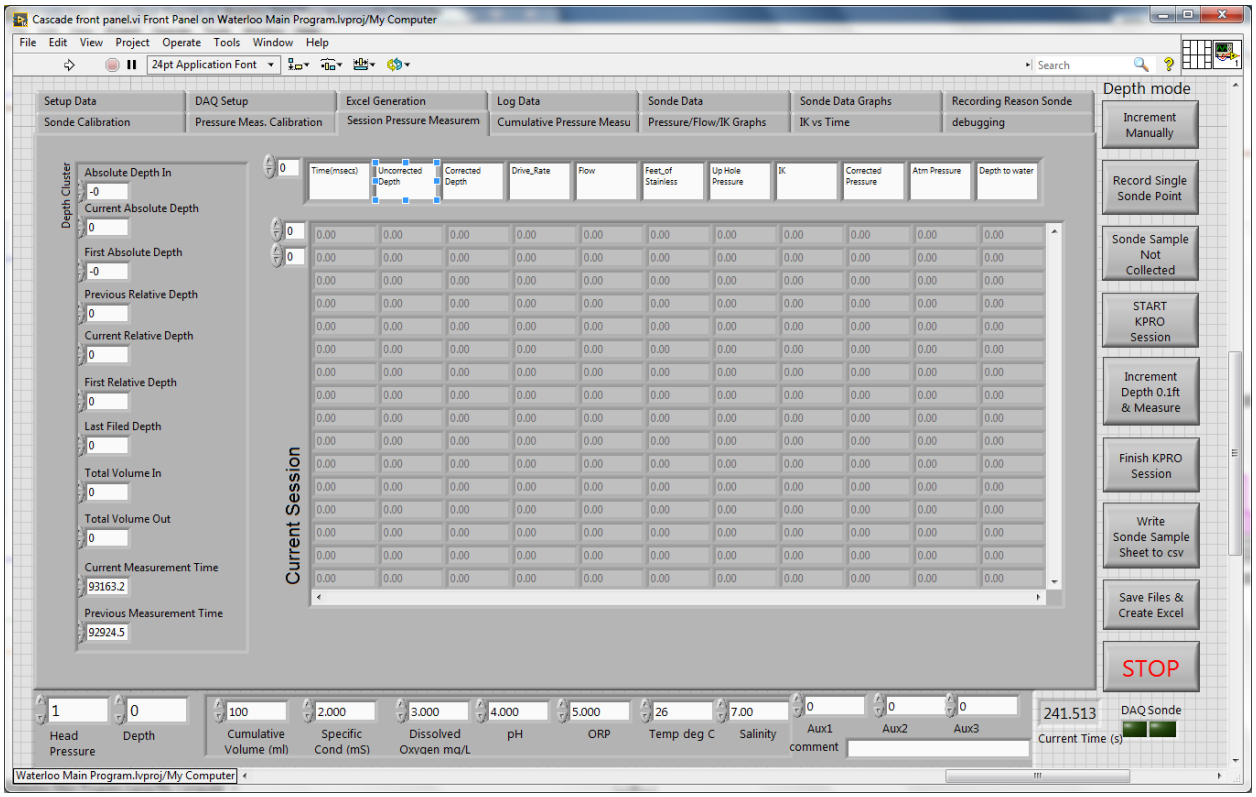

Figure 12: Session Pressure Measurement Tab

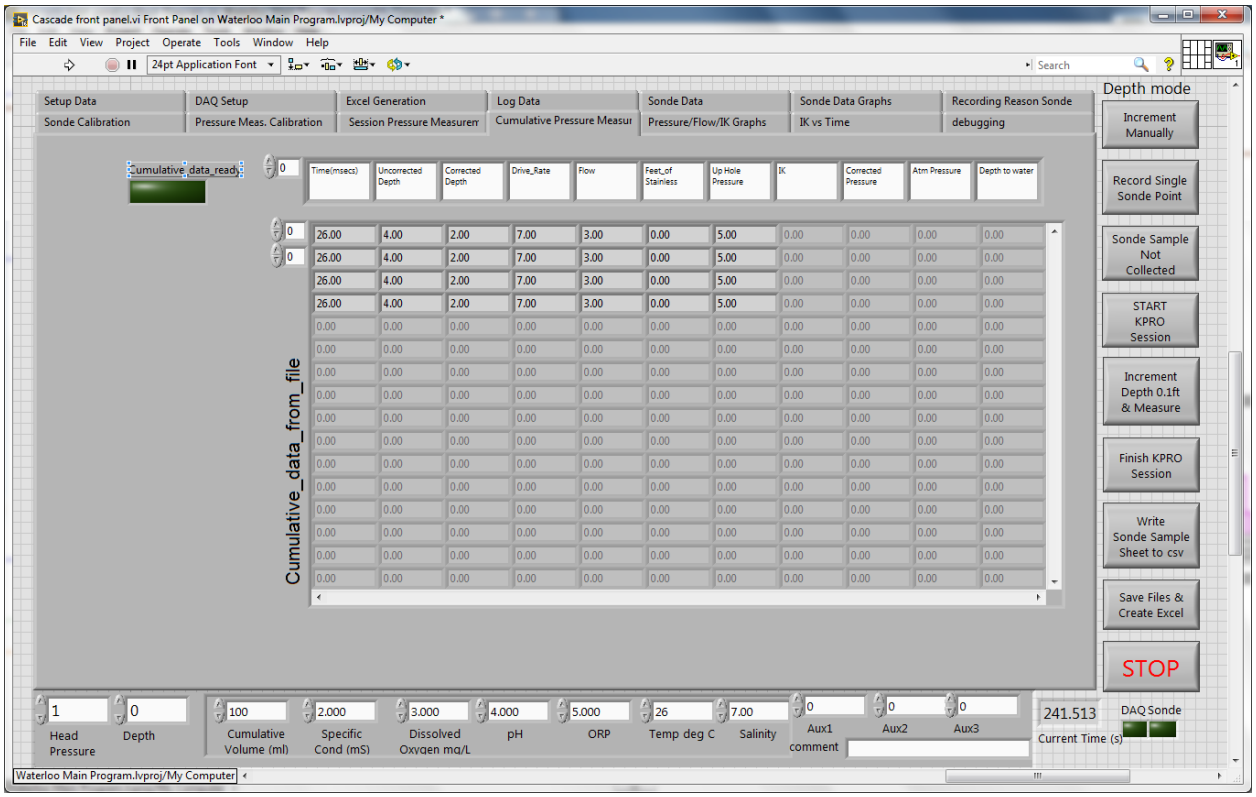

Figure 13: Cumulative Pressure Measurement Tab

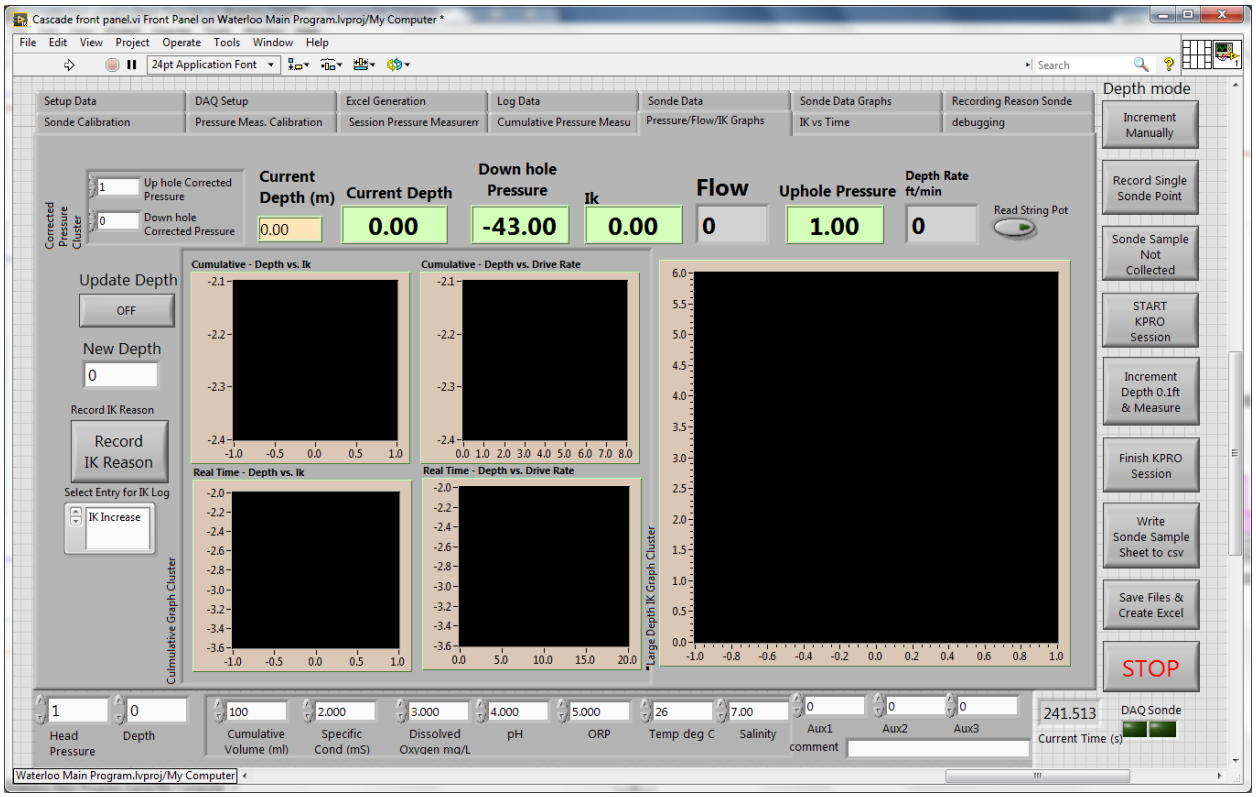

Figure 14: Pressure/Flow/IK Graphs Tab

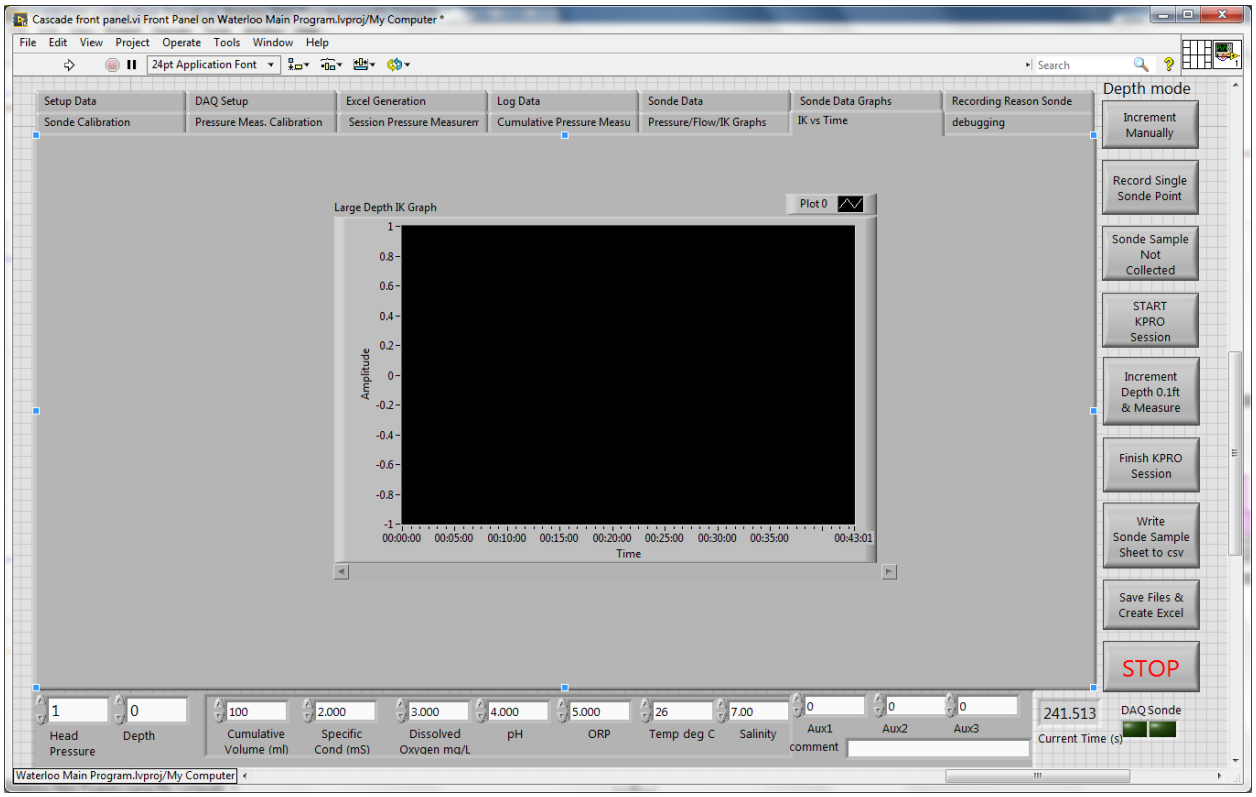

Figure 15: IK versus Time Graph Tab

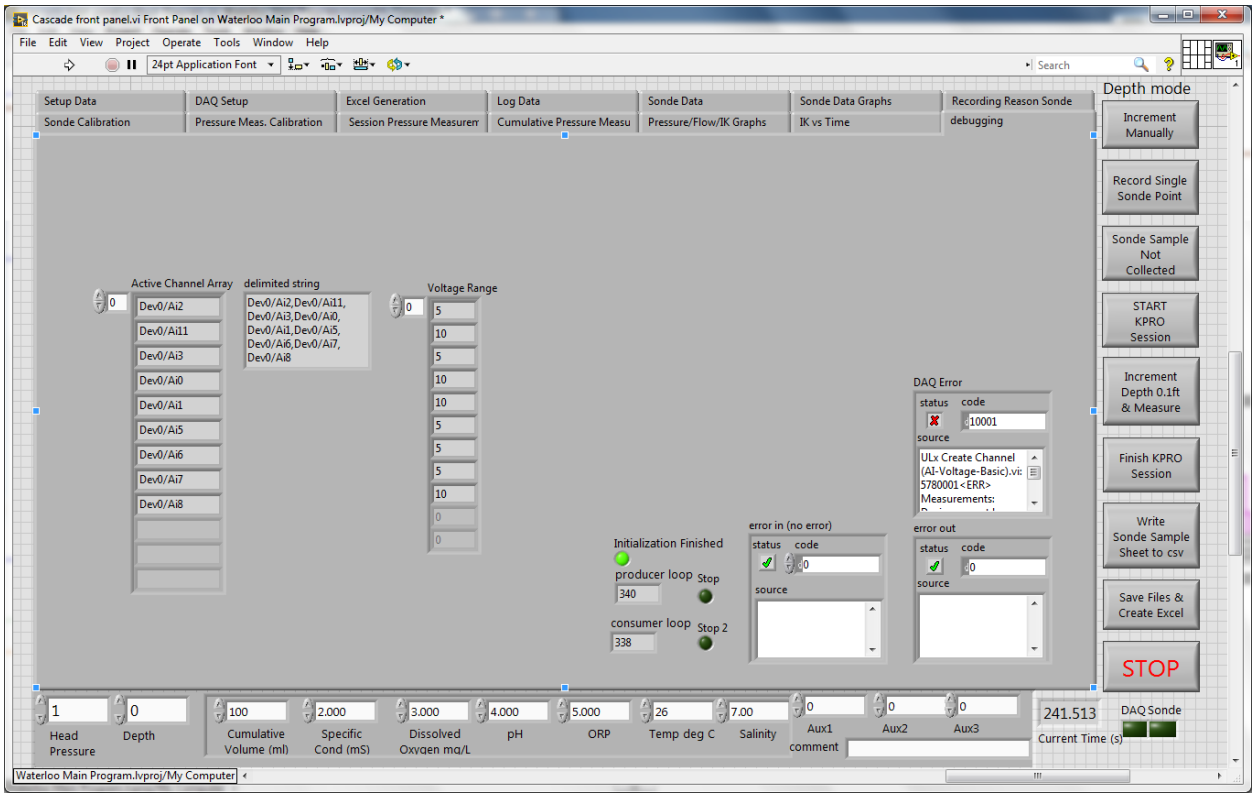

Figure 16: debugging Tab

Program Operation:

When the Cascade.exe executable program first starts, the Log Data tab will be displayed with the following message in the “Data Setup Indicator”

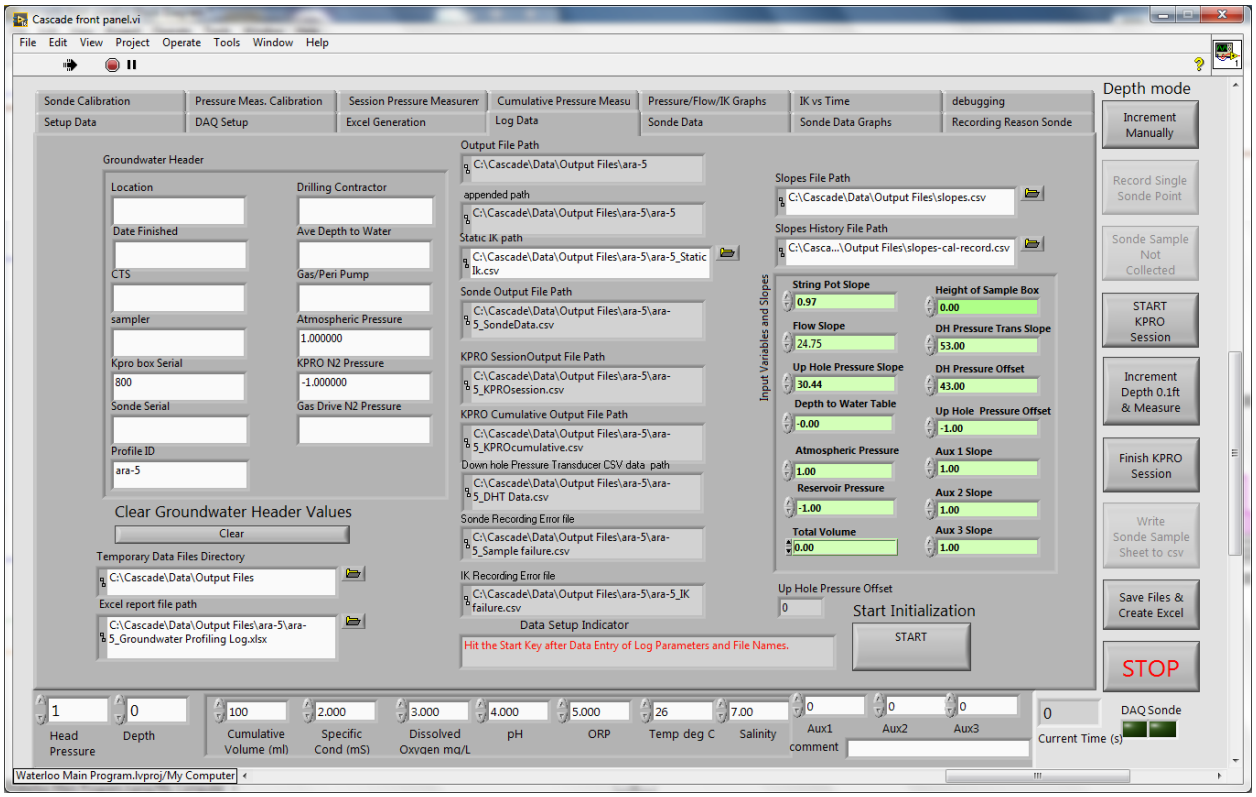

Figure 17: DAQ Setup Tab at Program Start

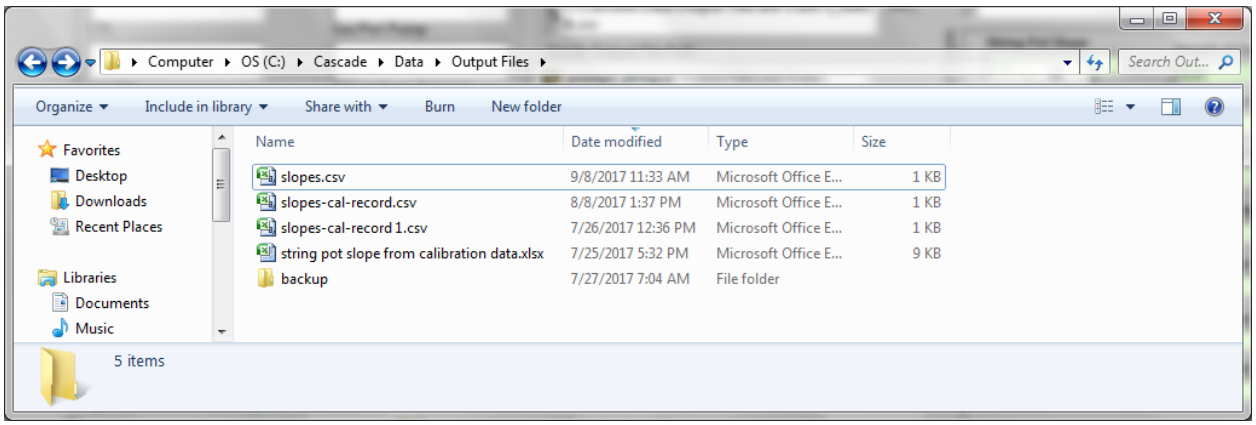

Figure 18: Output Files Directory prior to Profile ID popup

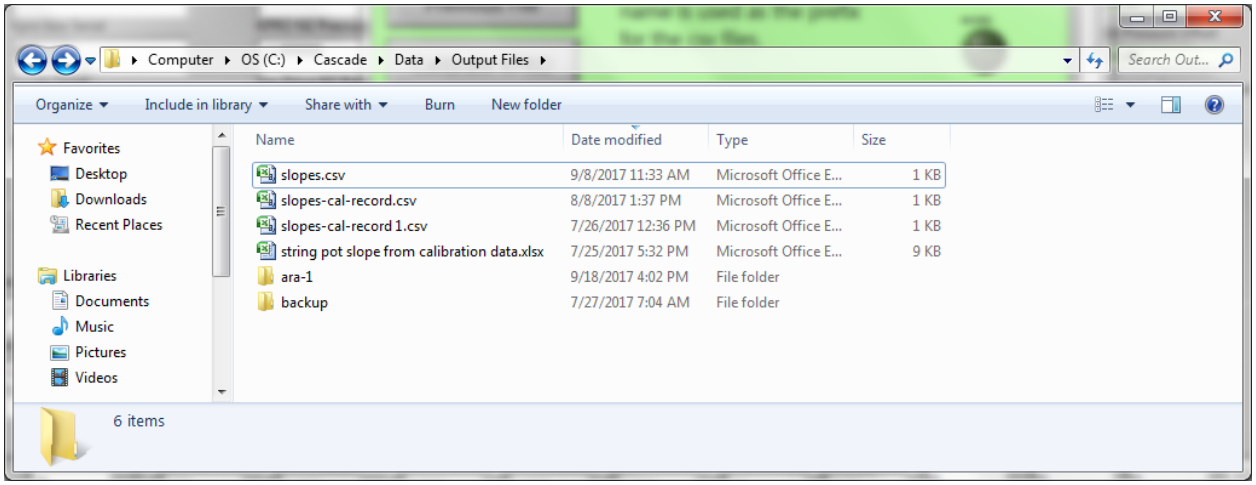

Figure 19: Output Files Directory after Profile ID popup showing the directory with the profile id

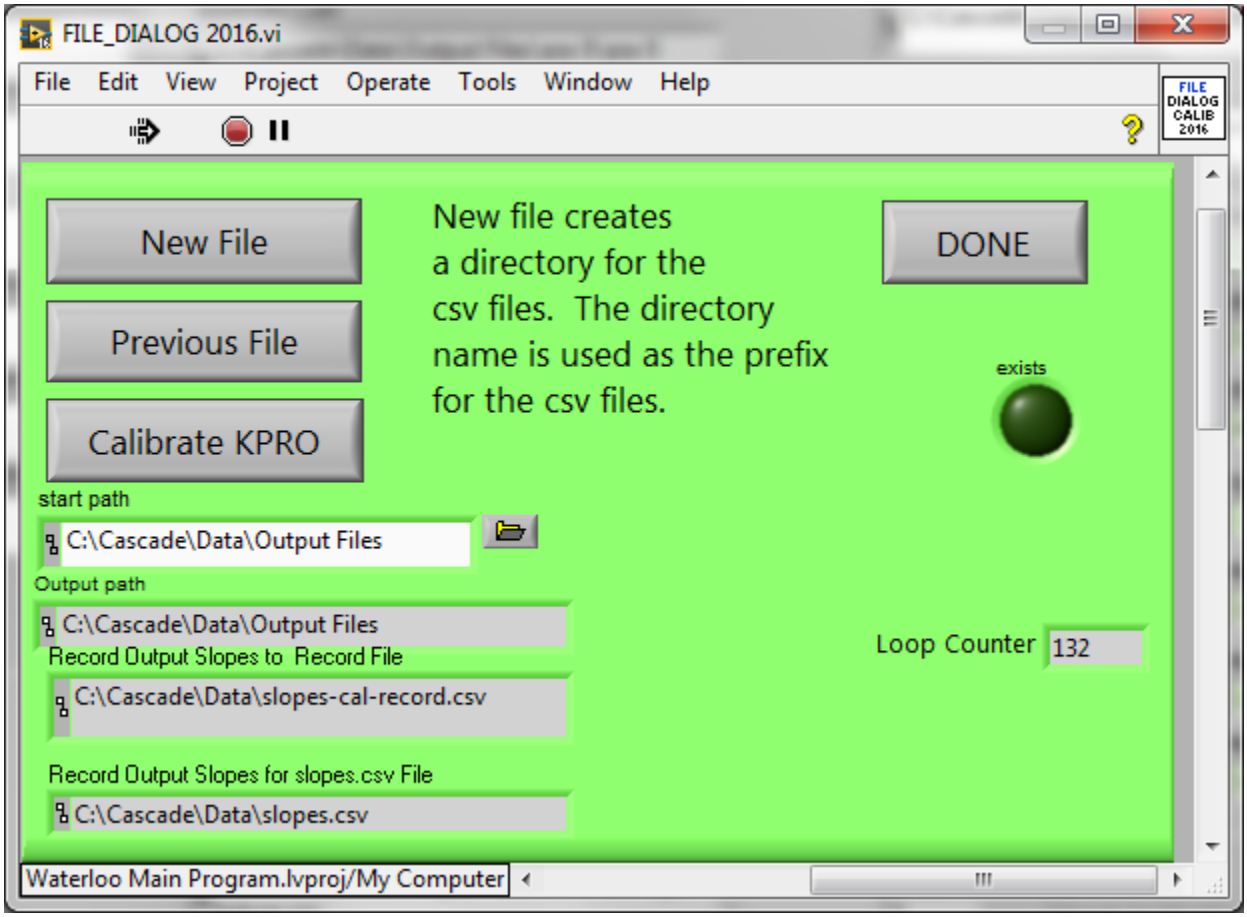

Figure 20: File Dialog Pop-up

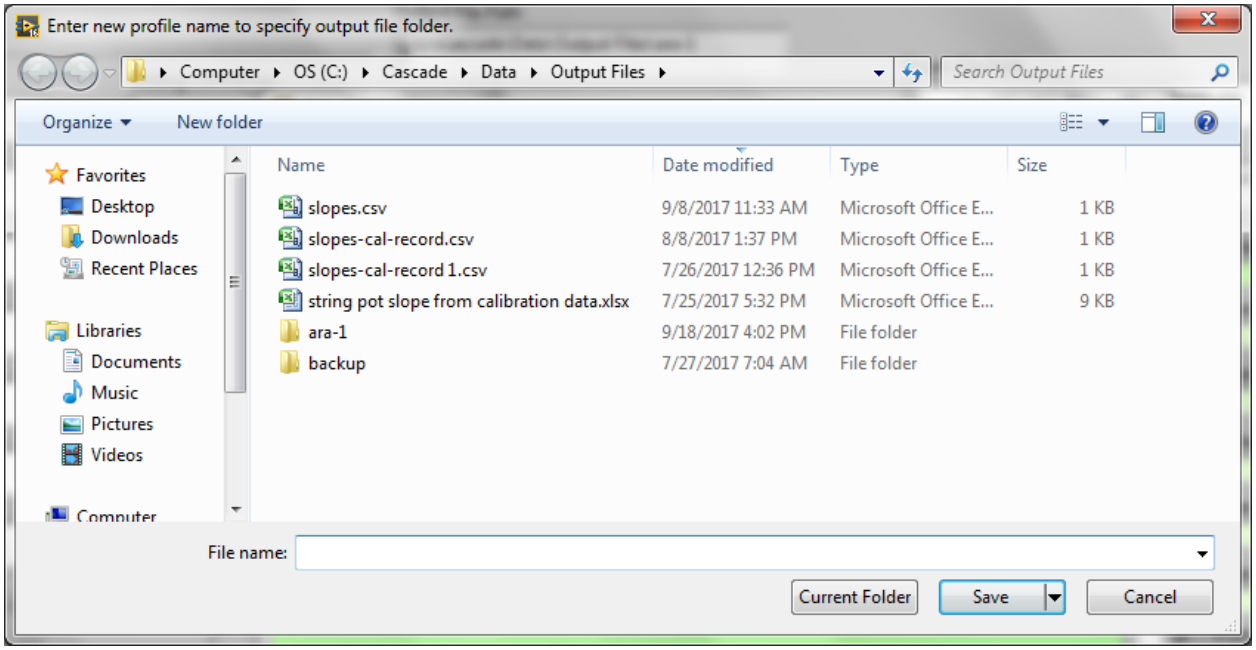

Figure 21: Output Files Directory after pressing the 'New' button on the Profile ID popup

Click on the newly created folder (profile ID). In this example, it is the ara-1 folder.

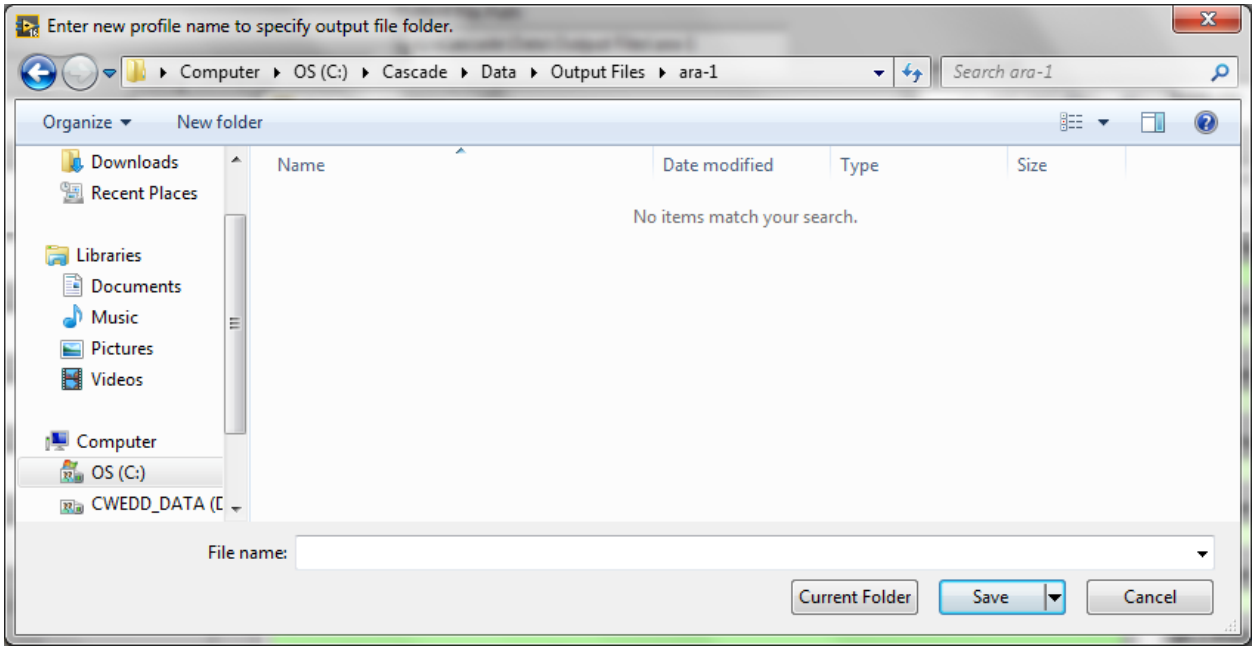

Figure 22: Output Files Directory after clicking on the Profile ID directory.

Click the Current Folder button so that the Output File Directory Path will be set to "C:\Cascade\Data\Output Files\ara-1".

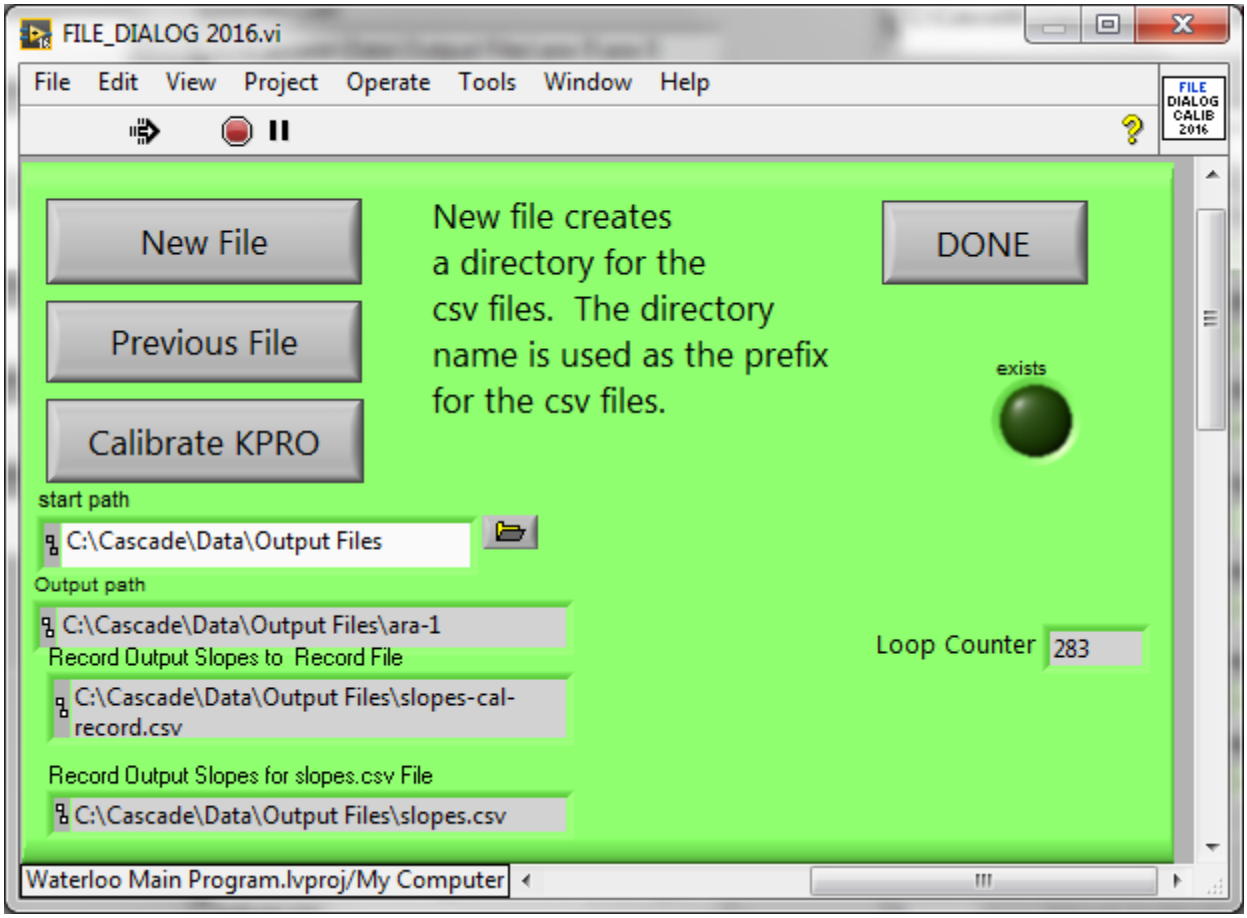

Figure 23: File Dialog Pop-up with updated Output Path Indicator

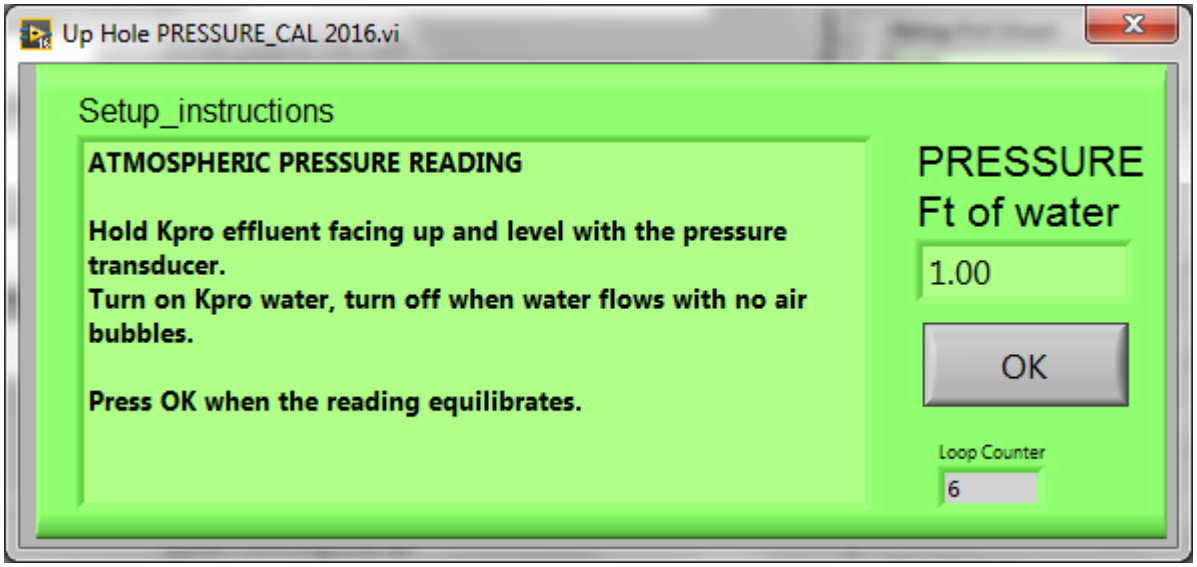

Figure 24: Atmospheric Pressure Pop-up

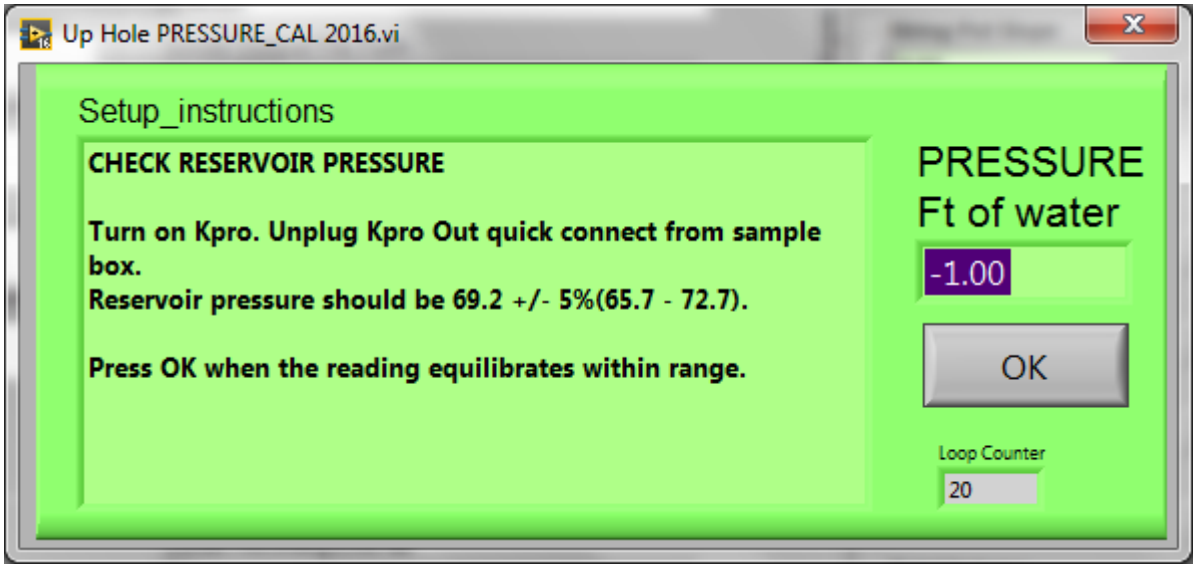

Figure 25: Resevoir Pressure Popup

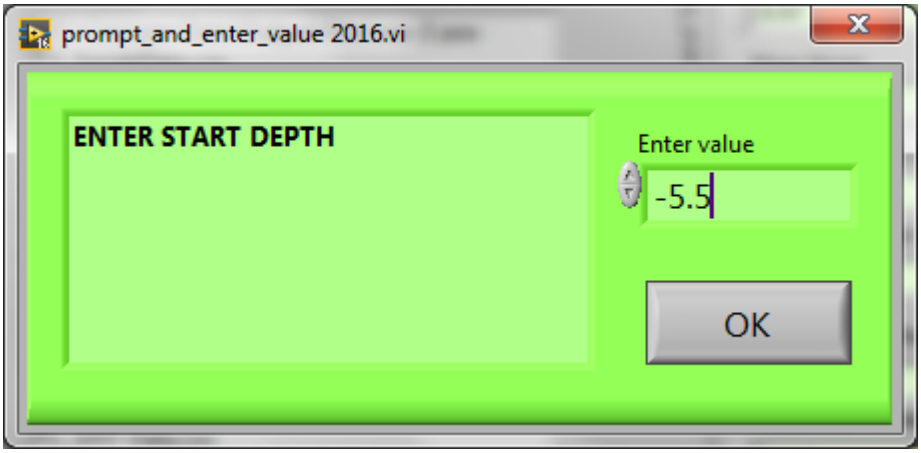

Figure 26: Start Depth Pop-up

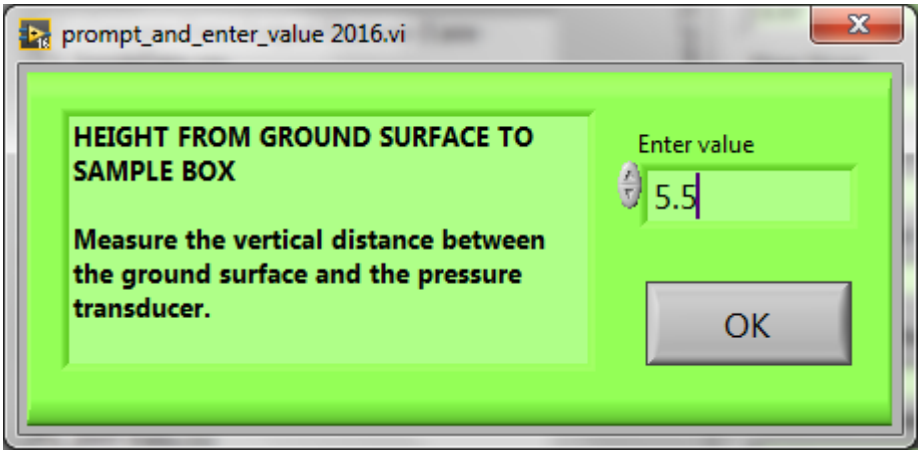

Figure 27: Sample Box Height Pop-up

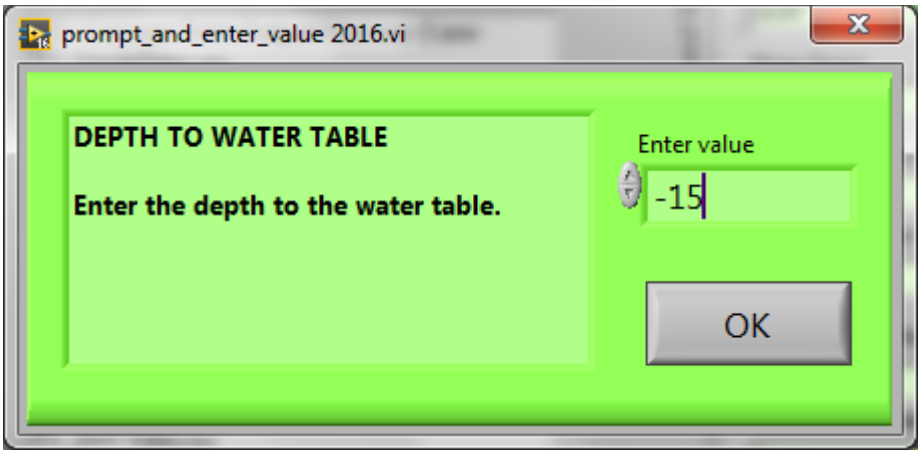

Figure 28: Depth to Water pop-up

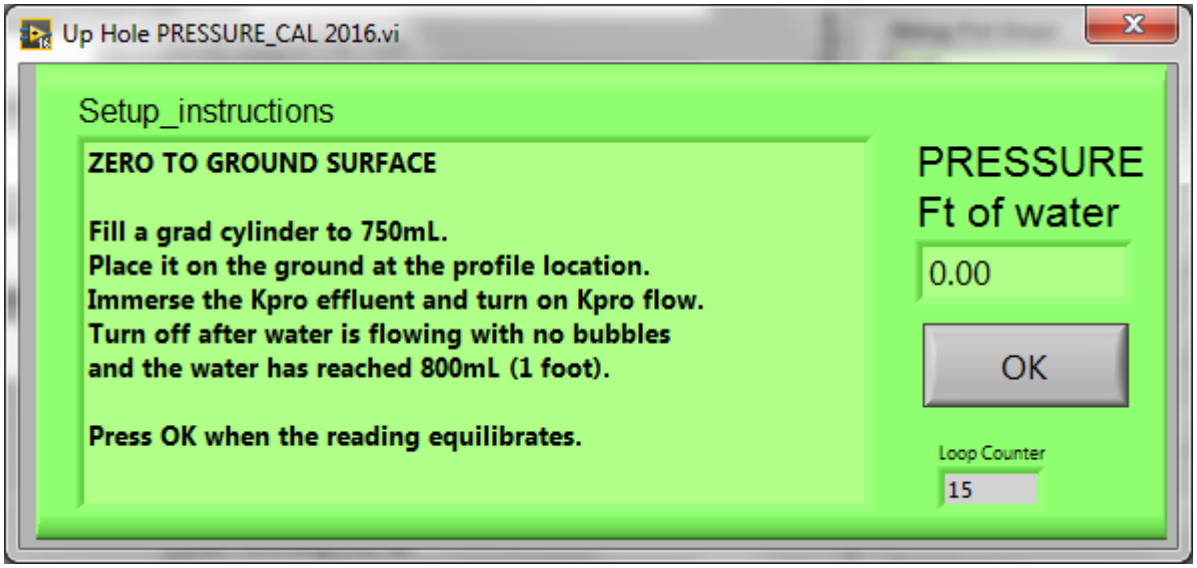

Figure 29: Zero to Ground Surface pop-up

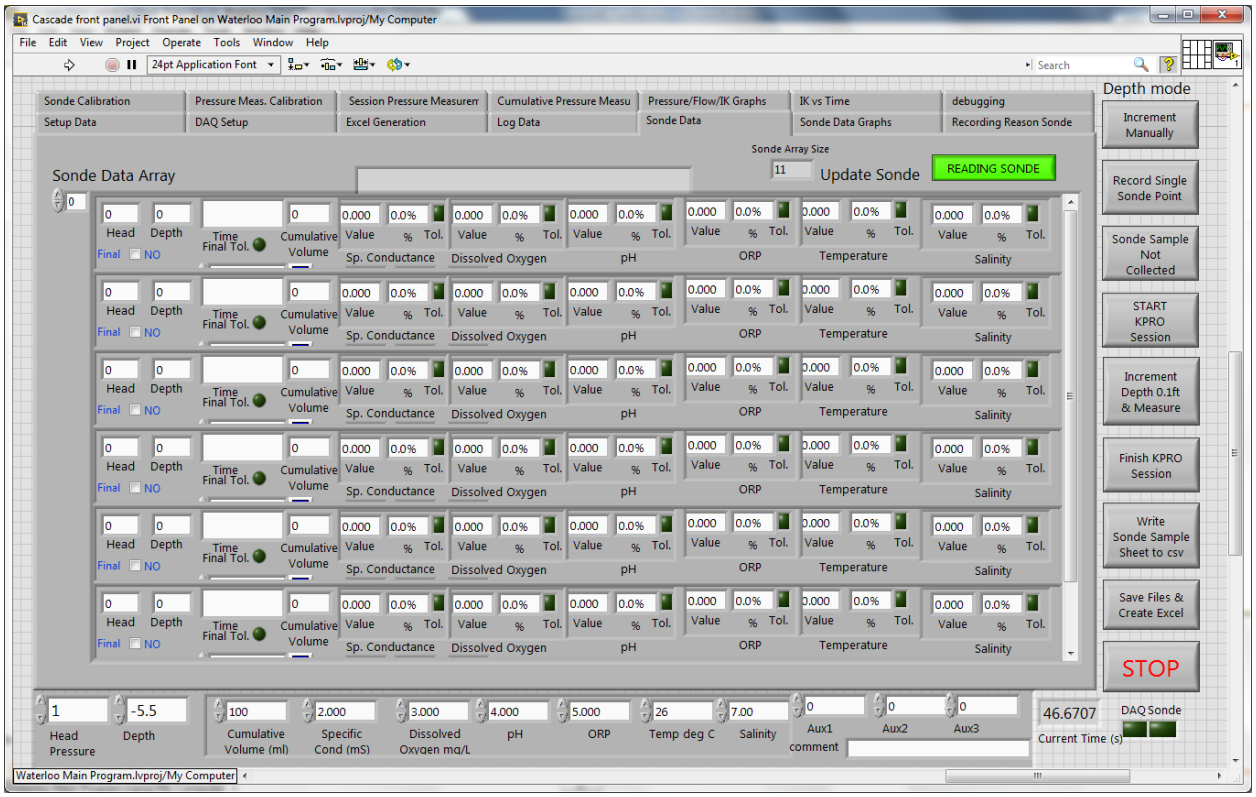

Figure 30: Sonde Data Tab updating the sonde data