



## **CANARY Quick Start Guide**

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## **Disclaimer**

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# 1. Introduction

This document presents a step-by-step guide to downloading, installing, and running CANARY on a PC with a Microsoft® Windows™ operating system. The steps described in this document are the prerequisites for deploying CANARY as a water quality event detection tool.

Detailed information on CANARY can be found in the CANARY User's Manual (Hart and McKenna 2011). Additional background on the motivation and theory behind CANARY can be found in the EPA report, Water Quality Event Detection Systems for Drinking Water Contamination Warning Systems: Development, Testing, and Application of CANARY (Murray et al. 2010).

## 1.1 Purpose

This document provides step-by-step instructions on where to download the CANARY software, how to install CANARY on a computer, how to obtain and install the latest update to the software, how to run the software, and how to analyze output files. This document also describes the folders and files that are installed on a PC when CANARY is installed.

More detailed information on CANARY, such as algorithm definitions and configuration file format, can be found in the CANARY User's Manual (Hart and McKenna 2011).

Please note that the screen shots contained in this Quick Start Guide may appear slightly different depending on the operating system of the computer on which CANARY is installed.

## 2. CANARY Installation

An automated CANARY installer is available that contains a set of executable files. Email Terra Haxton at [Haxton.Terra@epa.gov](mailto:Haxton.Terra@epa.gov) to receive a link and a password to an FTP site containing the files. From this FTP site, download and save the files “setup.exe” and “update.exe” on the computer that will be running CANARY.

When installing CANARY for the first time, both files are executed as described in Section 2.1.

If an older version of CANARY is already installed on the computer, only the “update.exe” file needs to be executed to update the software to the latest available version. Updates are available on the website: <http://software.sandia.gov/trac/canary>. In this case, skip ahead to Section 2.2.

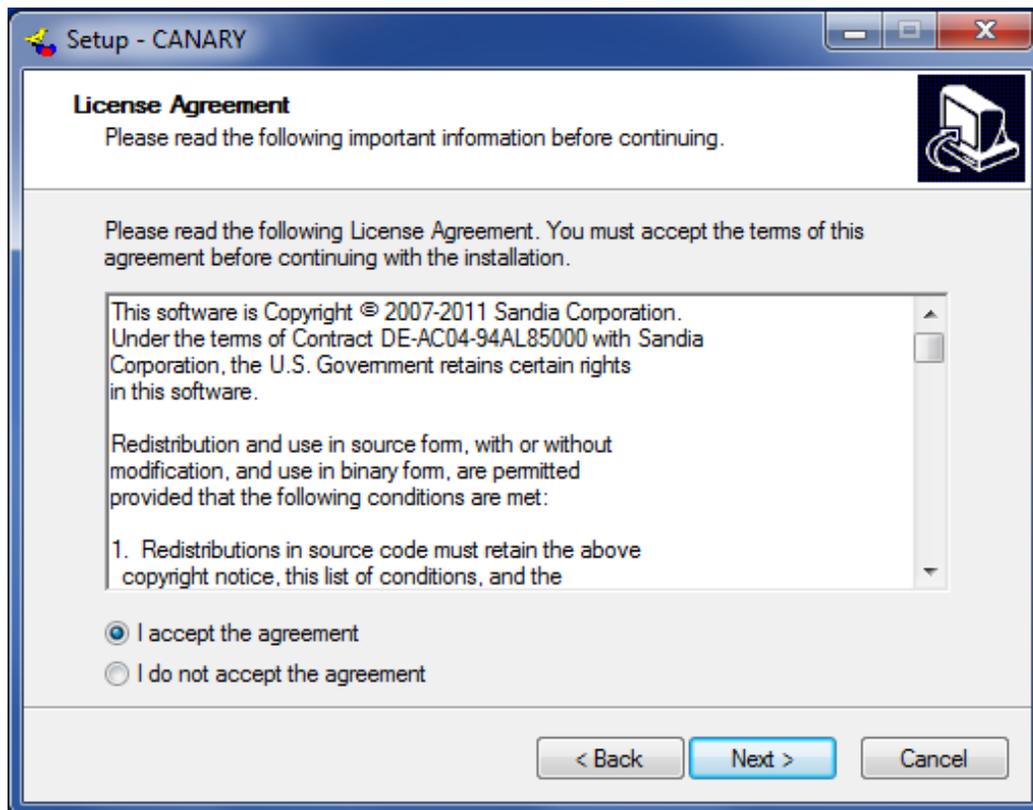
### 2.1 Installing the CANARY Software

1. Double-click the "setup.exe" file to start the installation. Click "Next" on the CANARY Setup Wizard dialog box (Figure 1).



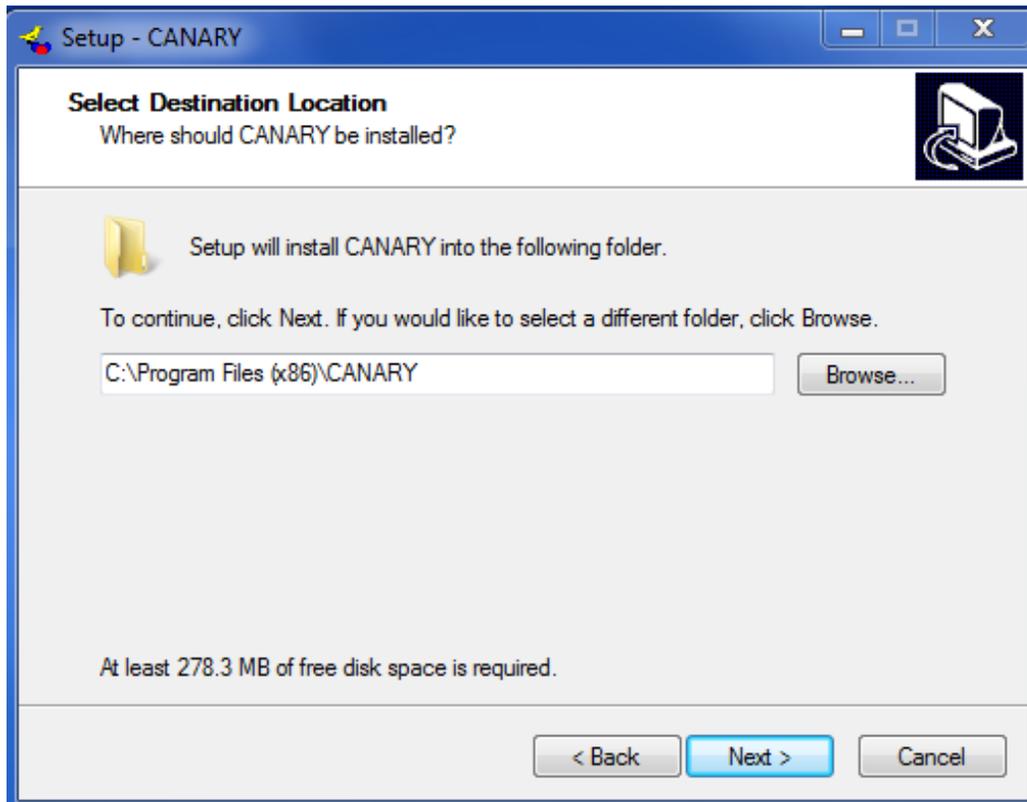
**Figure 1: Installation Startup Dialog Box**

2. After reading the license agreement, select “I accept the agreement” and click “Next” to continue the installation (Figure 2). The license agreement must be accepted in order to install and run CANARY. The full license agreement is included in Section 3.1 of this document.



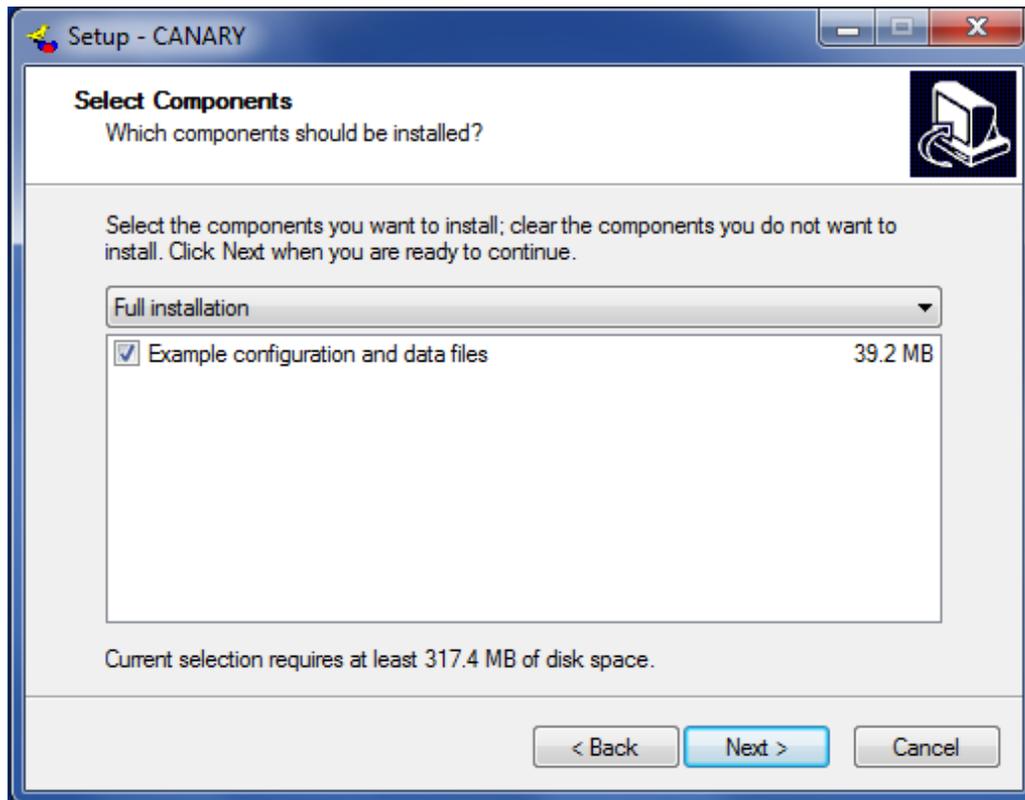
**Figure 2: License Agreement Dialog Box**

3. Click “Browse” to choose the folder location where CANARY should be installed (Figure 3) or use the default location and click “Next.” Typically, software is installed in a new folder under the Program Files folder. This new folder, in this case called CANARY, will be created during the installation process.



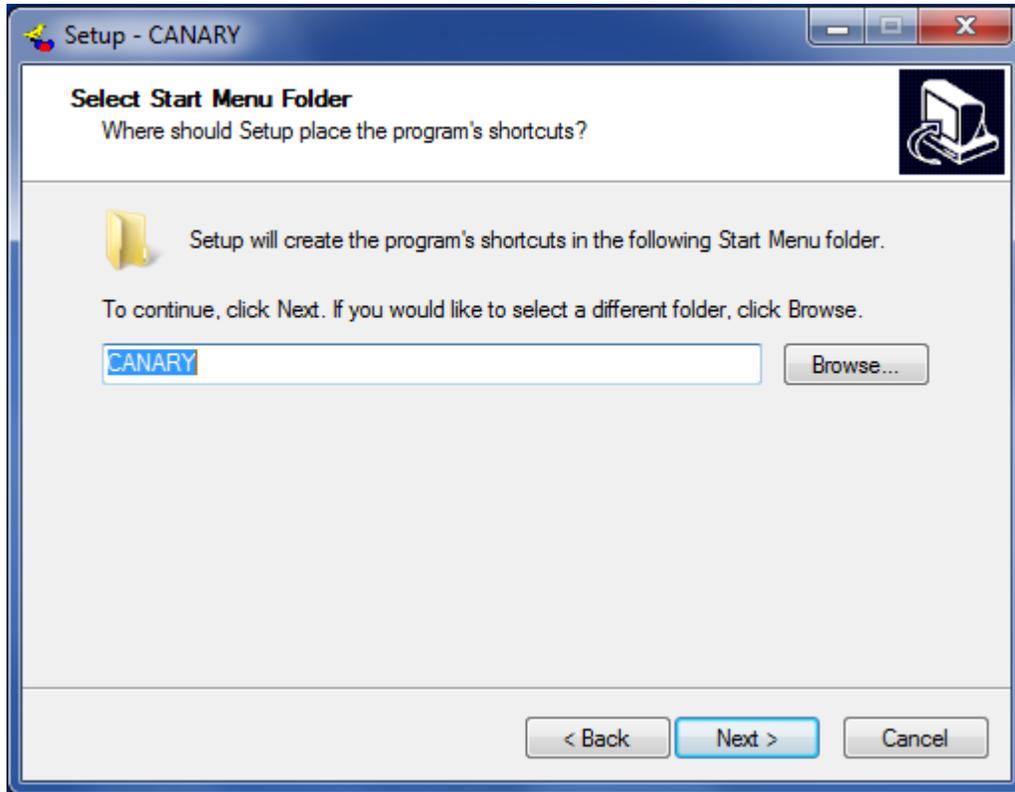
**Figure 3: File Location Dialog Box**

4. Select “Example configuration and data files” (Figure 4), and click “Next.” These files contain example input data and CANARY configuration files which will be installed in a folder called “My CANARY.” With these files, users can practice running CANARY and modifying configuration files.



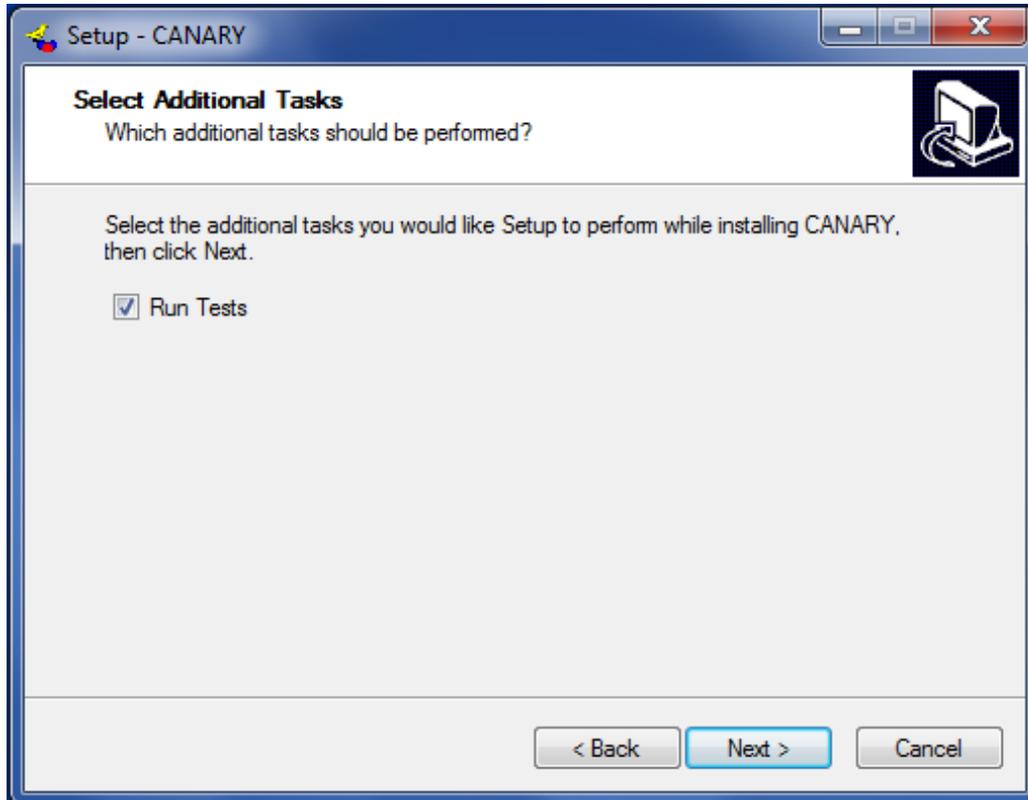
**Figure 4: Select Components Dialog Box**

5. Click “Browse” to choose the location in the Start Menu for a shortcut to CANARY (Figure 5) or use the default location and click “Next.” This shortcut allows the user to access CANARY from All Programs under the Start Menu.



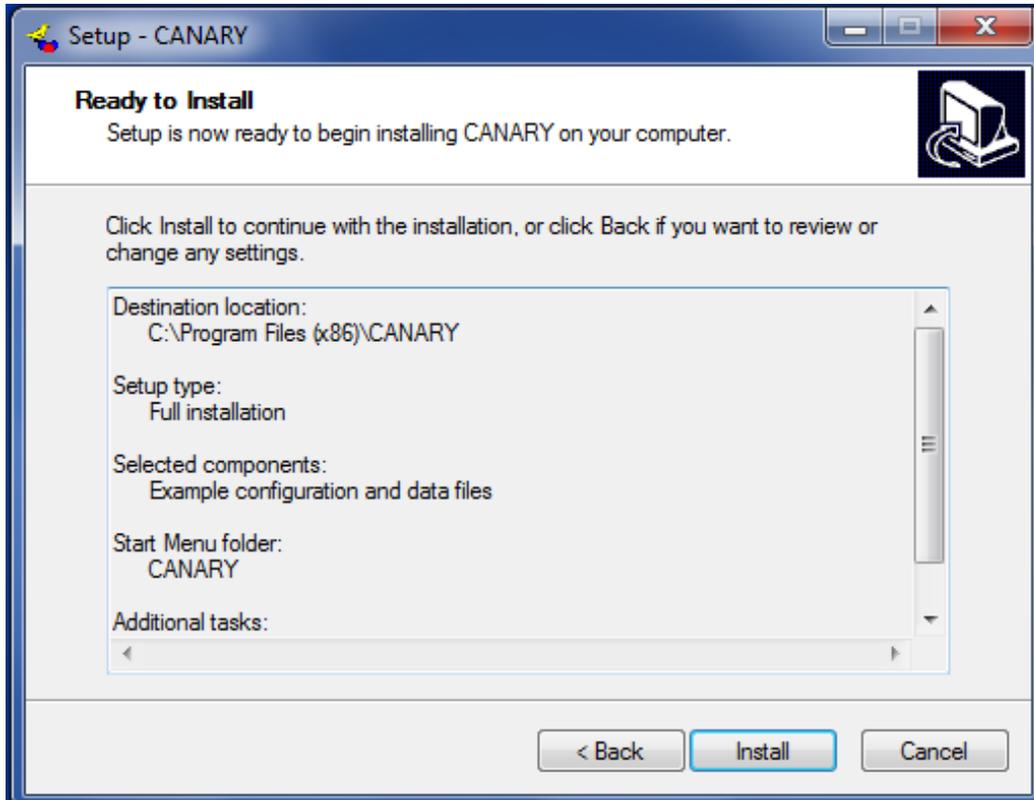
**Figure 5: Select Start Menu Folder Dialog Box**

6. Select “Run Tests” to have CANARY run a short example calculation as part of the installation process (Figure 6) and click “Next.” This will ensure CANARY has been installed correctly.

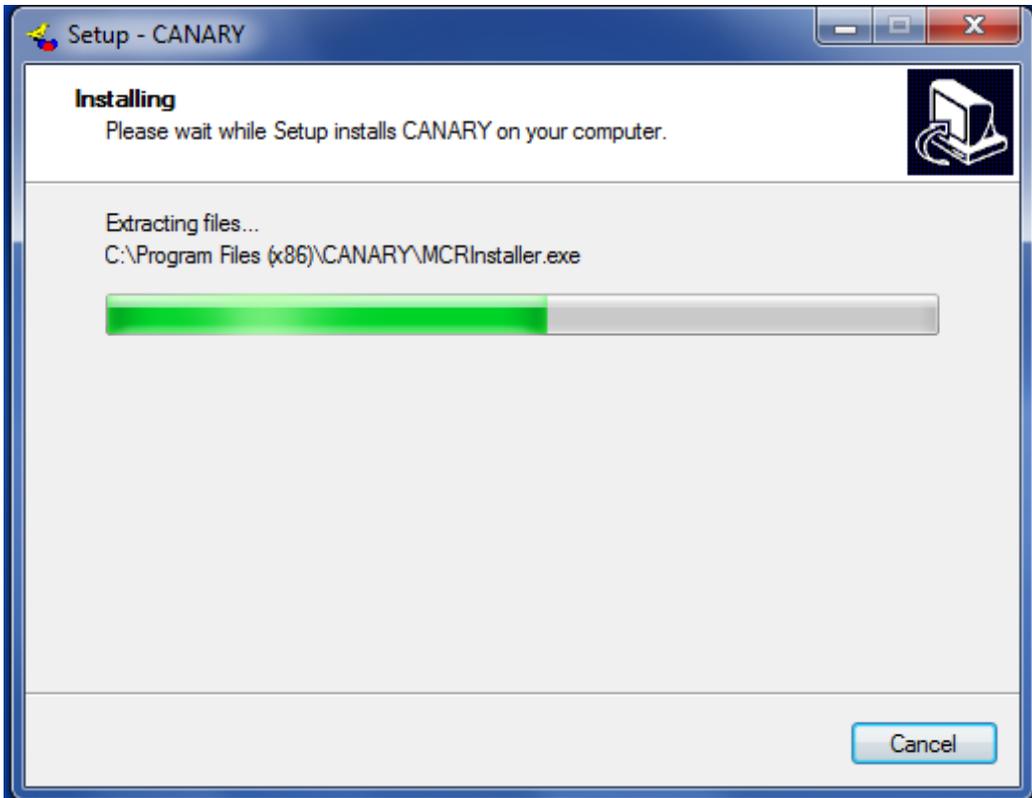


**Figure 6: Select Additional Tasks Dialog Box**

7. Click “Install” if the information listed on the “Ready To Install” dialog box is accurate (Figure 7). If this is the first time CANARY has been installed on the computer, the progress bar will be shown (Figure 8).



**Figure 7: Installation Verification Dialog Box**



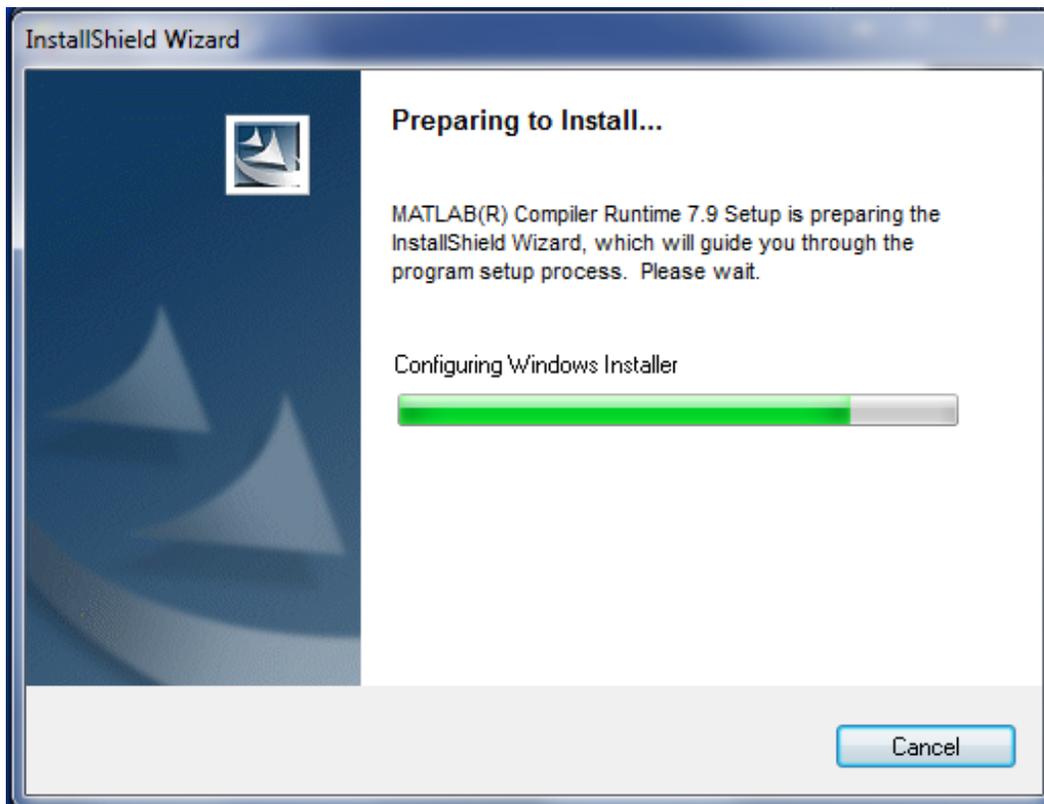
**Figure 8: Installation Progress Dialog Box**

The setup application will automatically begin installing the MATLAB Compiler Runtime. This library contains a number of functions that CANARY accesses when running.

8. Choose setup language or use the default option and click “OK” (Figure 9). Next, a progress bar will be shown (Figure 10).

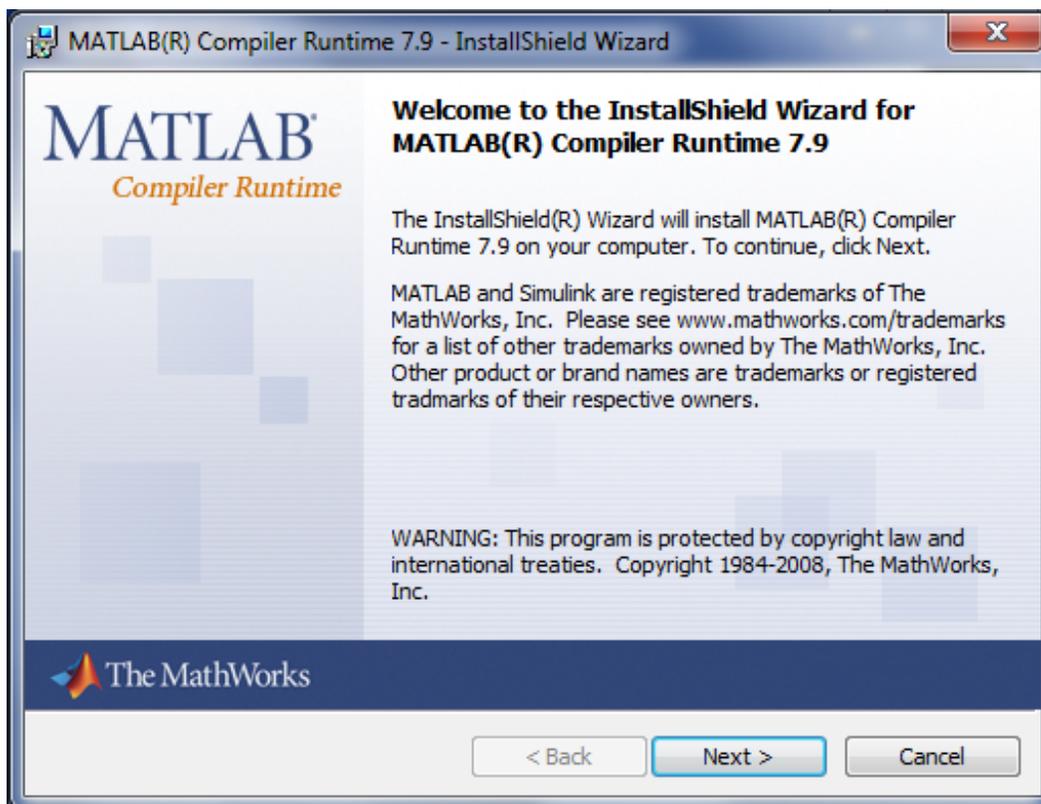


**Figure 9: MATLAB Language Selection Screen**



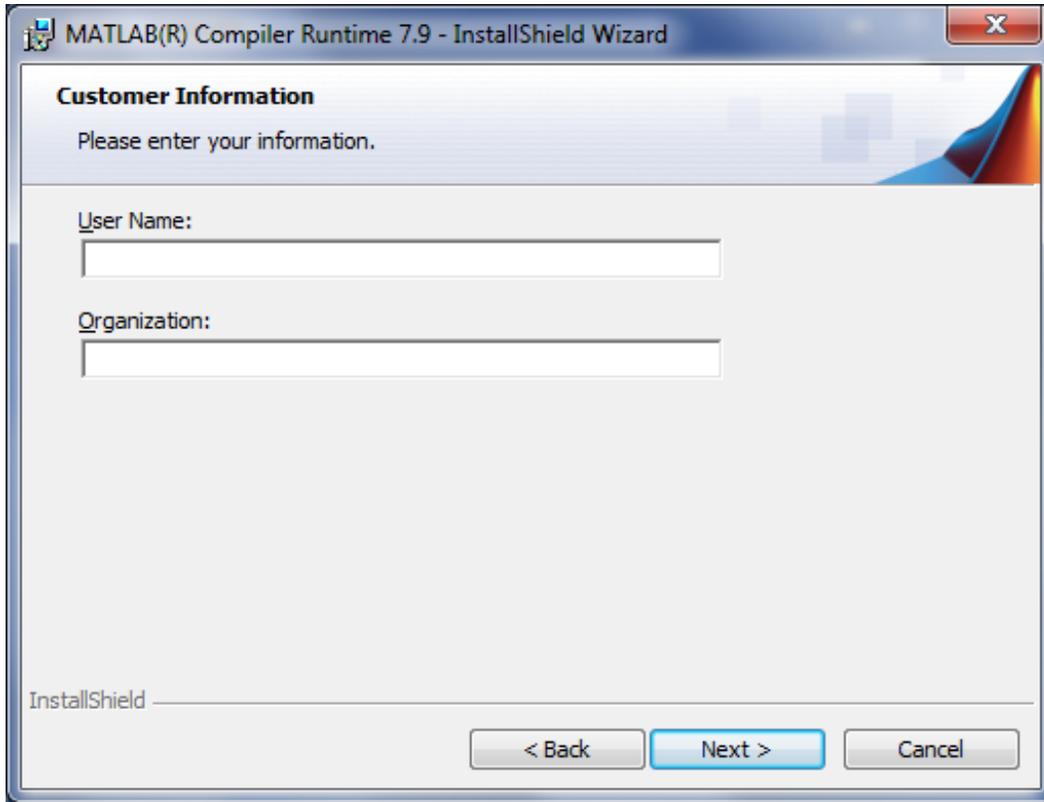
**Figure 10: MATLAB Install Screen**

9. Click “Next” (Figure 11) to begin installing the MATLAB Compiler Runtime.



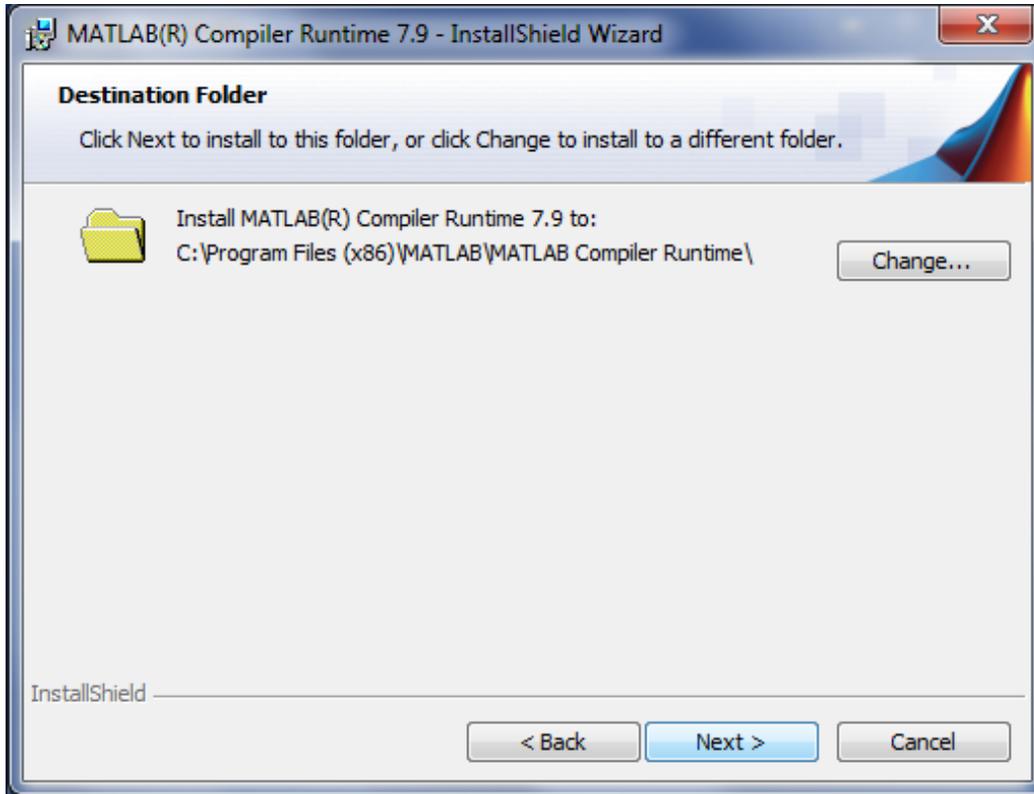
**Figure 11: MATLAB Compiler Runtime InstallShield Wizard**

10. Type in the user's information (Figure 12) or use the default name and organization and click "Next." This window is part of the MATLAB installer.



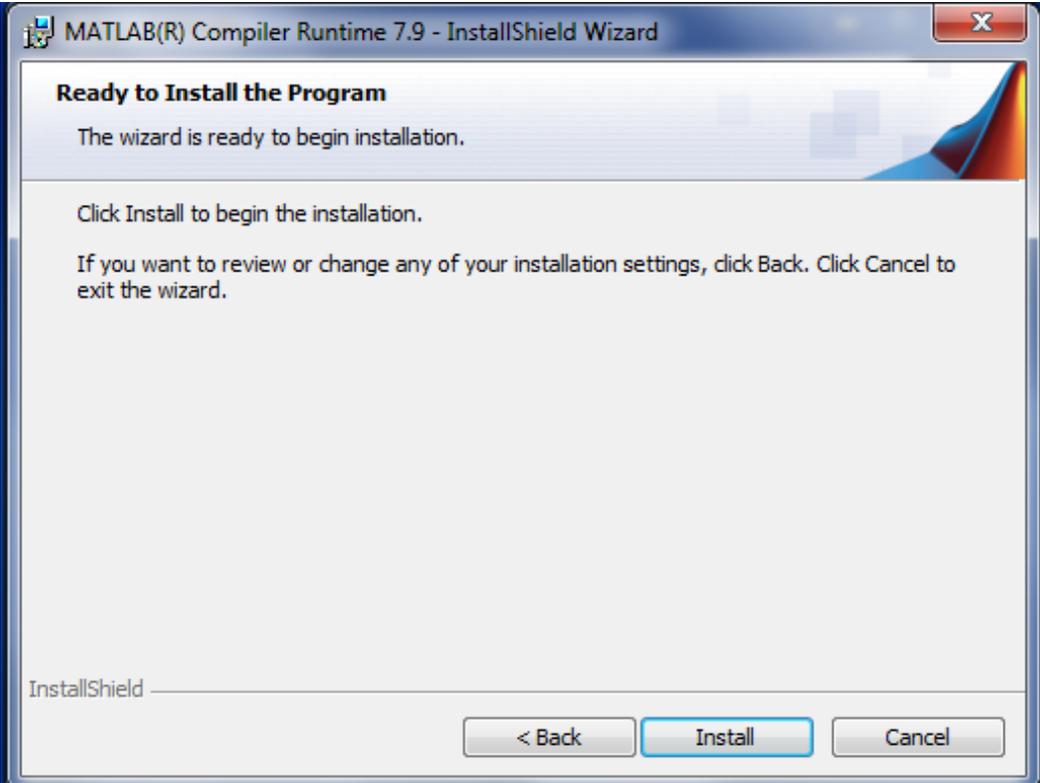
**Figure 12: Customer Information Window**

11. Click “Change” to select another location other than the default to install the MATLAB Compiler Runtime (Figure 13) and click “Next.” Typically, the default location is selected.

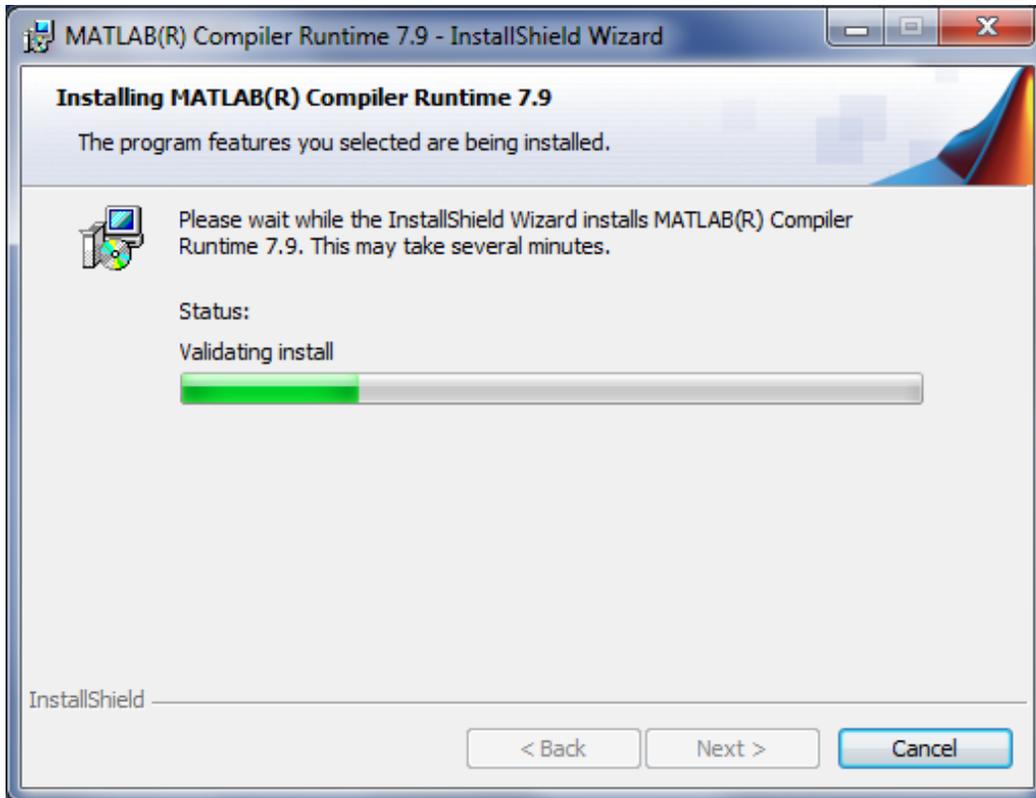


**Figure 13: MATLAB Compiler Runtime Destination Folder Window**

12. Click “Install” (Figure 14) to begin installation of the MATLAB Compiler Runtime. As the installation progresses, the status will be shown (Figure 15).

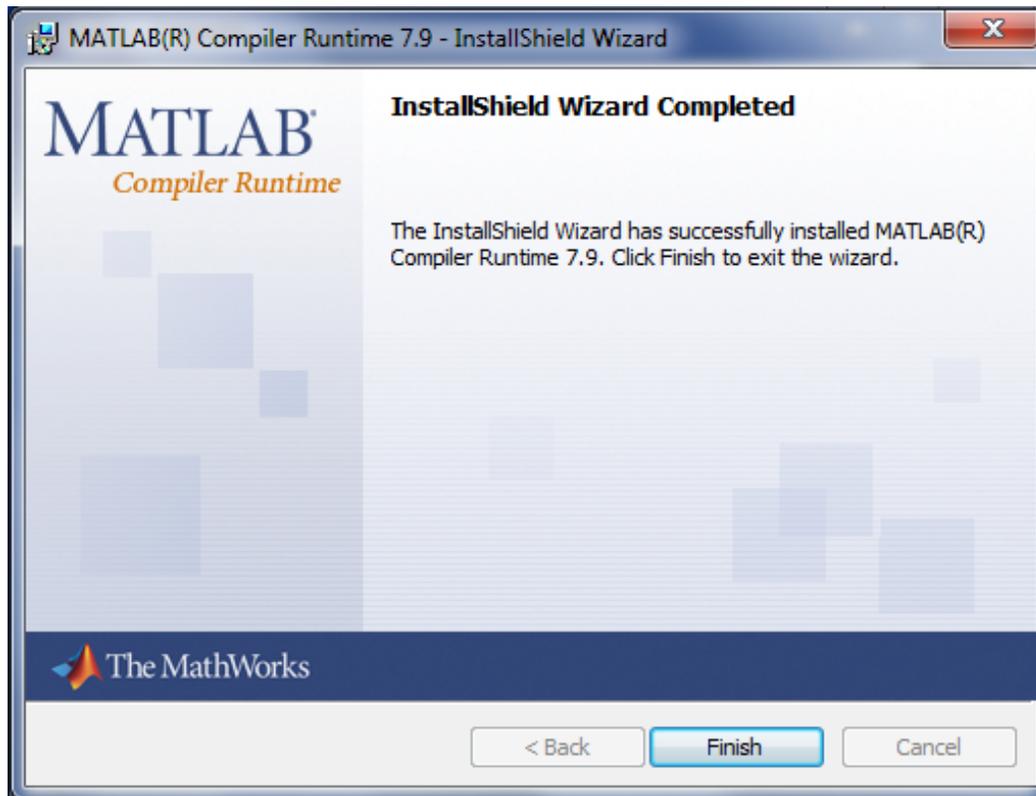


**Figure 14: Begin Installation Window**



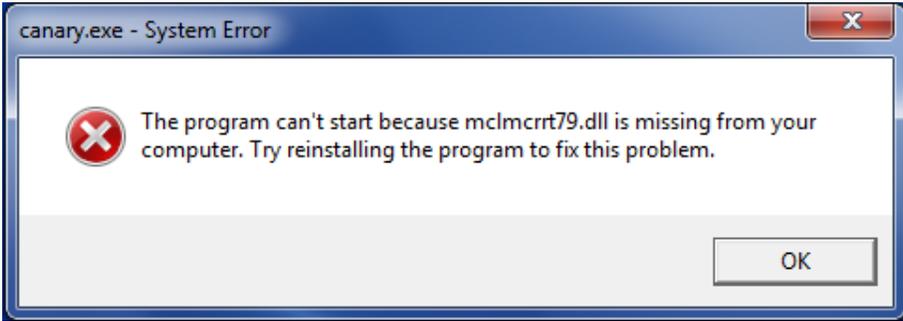
**Figure 15: MATLAB Installation Status Window**

13. Click “Finish” (Figure 16) and the MATLAB Compiler Runtime is now installed.

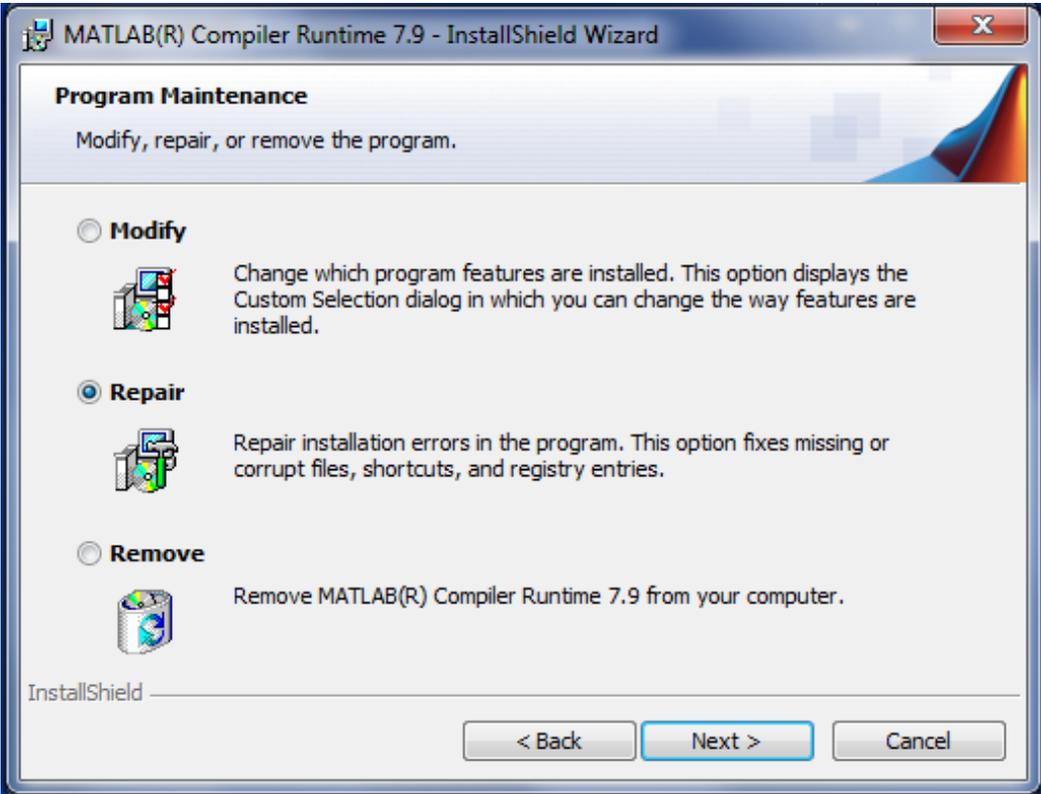


**Figure 16: MATLAB InstallShield Wizard Complete**

14. If an error message appears (Figure 17), click “OK” and then click “Finish.” To fix this problem, the installation needs to be repeated starting with step 1. During the process, another error might occur stating that the UM is read only – click “Ignore.” A dialog box will show with the options to modify, repair, or remove the MATLAB Compiler Runtime (Figure 18), choose “Repair” and click “Next.”

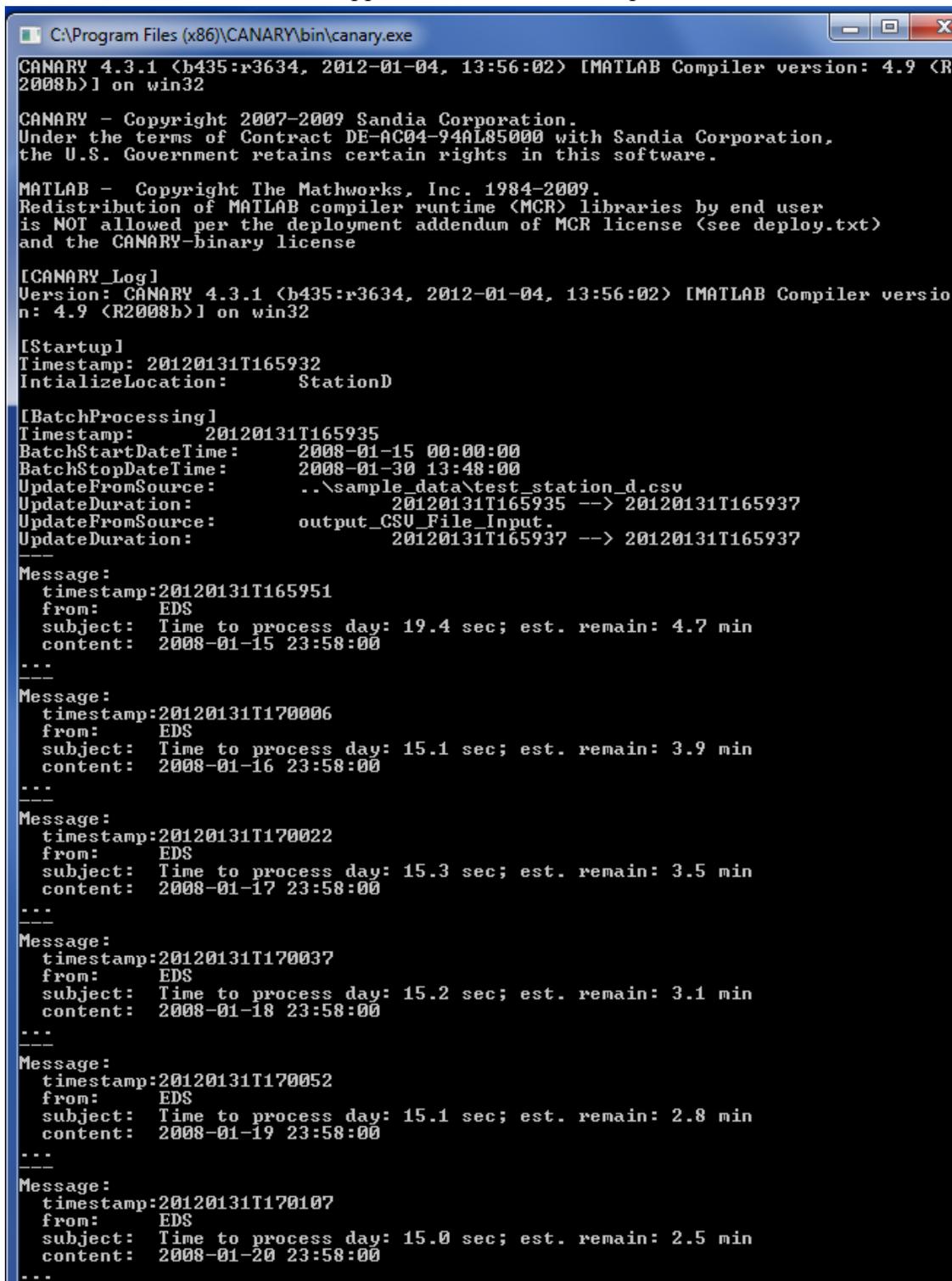


**Figure 17: CANARY.exe System Error**



**Figure 18: MATLAB Compiler Modify, Repair, and Remove**

15. If there were no errors, and if the “Run Tests” option was selected, a DOS window will show and a test will be completed for a simple example (Figure 19). If the installation was successful, this window will disappear once the run is complete.



```
C:\Program Files (x86)\CANARY\bin\canary.exe
CANARY 4.3.1 (b435:r3634, 2012-01-04, 13:56:02) [MATLAB Compiler version: 4.9 (R2008b)] on win32

CANARY - Copyright 2007-2009 Sandia Corporation.
Under the terms of Contract DE-AC04-94AL85000 with Sandia Corporation,
the U.S. Government retains certain rights in this software.

MATLAB - Copyright The Mathworks, Inc. 1984-2009.
Redistribution of MATLAB compiler runtime (MCR) libraries by end user
is NOT allowed per the deployment addendum of MCR license (see deploy.txt)
and the CANARY-binary license

[CANARY_Log]
Version: CANARY 4.3.1 (b435:r3634, 2012-01-04, 13:56:02) [MATLAB Compiler version: 4.9 (R2008b)] on win32

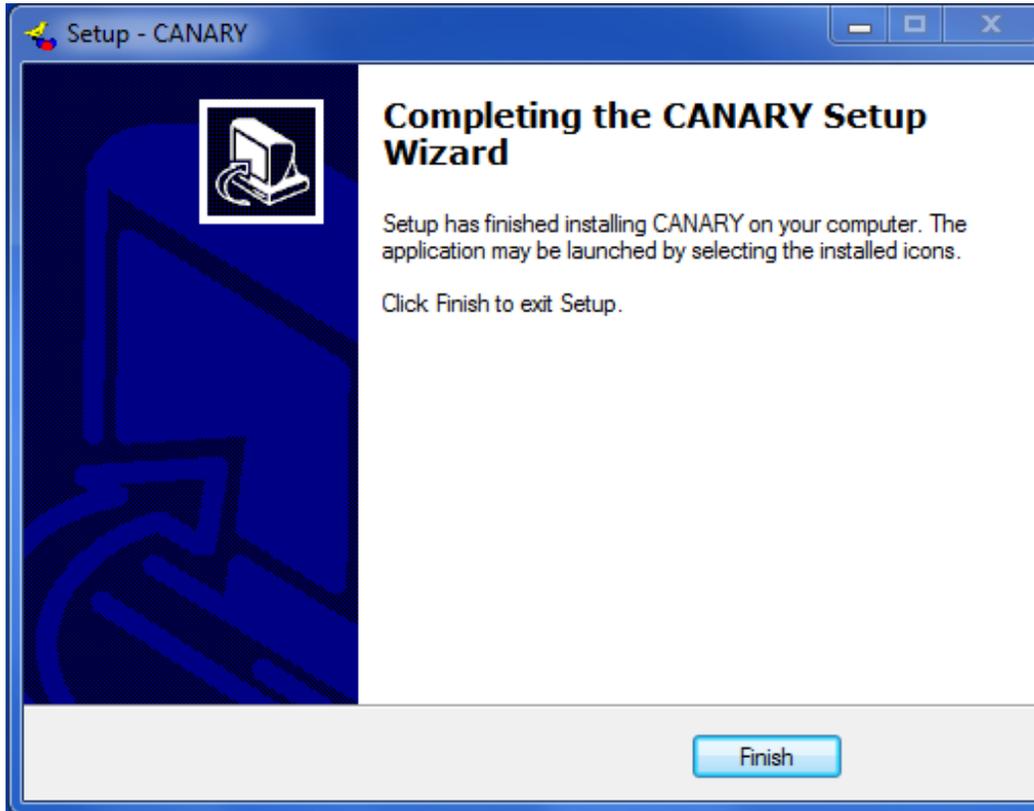
[Startup]
Timestamp: 20120131T165932
InitializeLocation: StationD

[BatchProcessing]
Timestamp: 20120131T165935
BatchStartDateTime: 2008-01-15 00:00:00
BatchStopDateime: 2008-01-30 13:48:00
UpdateFromSource: ..\sample_data\test_station_d.csv
UpdateDuration: 20120131T165935 --> 20120131T165937
UpdateFromSource: output_CSU_File_Input.
UpdateDuration: 20120131T165937 --> 20120131T165937

---
Message:
timestamp:20120131T165951
from: EDS
subject: Time to process day: 19.4 sec; est. remain: 4.7 min
content: 2008-01-15 23:58:00
...
---
Message:
timestamp:20120131T170006
from: EDS
subject: Time to process day: 15.1 sec; est. remain: 3.9 min
content: 2008-01-16 23:58:00
...
---
Message:
timestamp:20120131T170022
from: EDS
subject: Time to process day: 15.3 sec; est. remain: 3.5 min
content: 2008-01-17 23:58:00
...
---
Message:
timestamp:20120131T170037
from: EDS
subject: Time to process day: 15.2 sec; est. remain: 3.1 min
content: 2008-01-18 23:58:00
...
---
Message:
timestamp:20120131T170052
from: EDS
subject: Time to process day: 15.1 sec; est. remain: 2.8 min
content: 2008-01-19 23:58:00
...
---
Message:
timestamp:20120131T170107
from: EDS
subject: Time to process day: 15.0 sec; est. remain: 2.5 min
content: 2008-01-20 23:58:00
...
---
```

Figure 19: CANARY Run Test DOS Window

16. Click “Finish” (Figure 20). The installation is complete!



**Figure 20: CANARY Setup Complete**

## **2.2 Updating the CANARY Software**

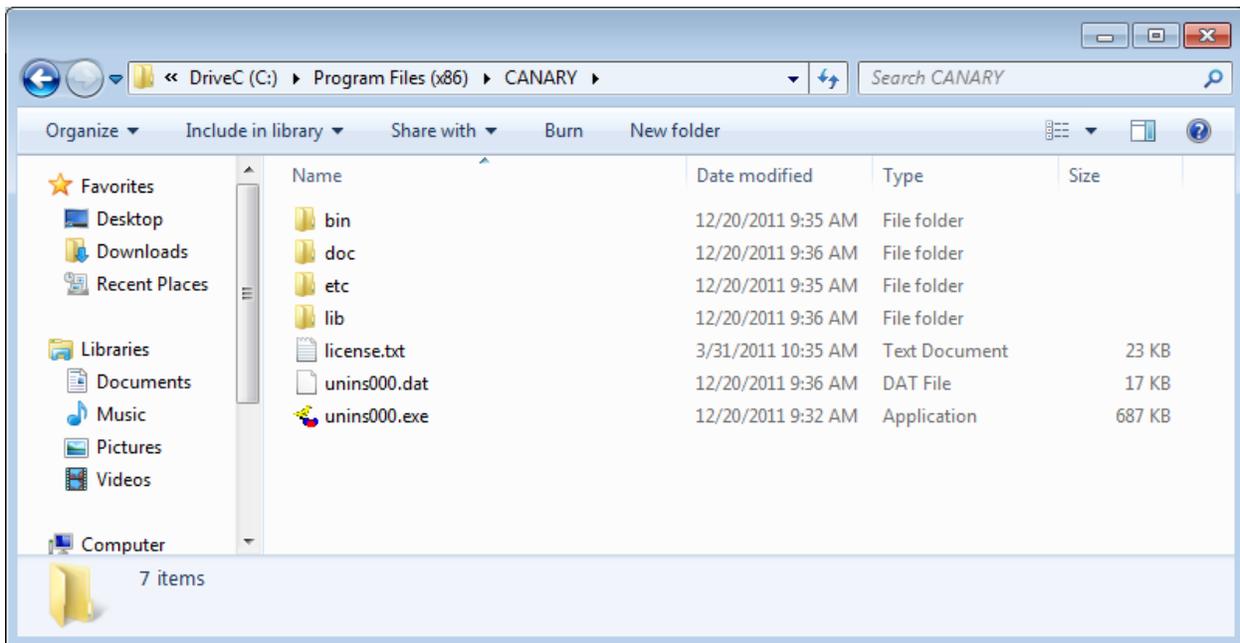
Double-click the "update.exe" file to start the installation. Follow steps 1-7 above. During the process, an error might occur that says the UM is read only – click “Ignore.” Then follow steps 15-16 above. The update is complete!

## 2.3 Files and Associations

A list of the main directories and files associated with the CANARY installation are described below. The options under the CANARY shortcut are also described.

The “CANARY” folder under “Program Files” has four subfolders and three files (Figure 21). The folders are listed below and should not be modified. Typically, a user might never access these subfolders directly. Screen shots of each folder’s contents are provided in Section 3.2.

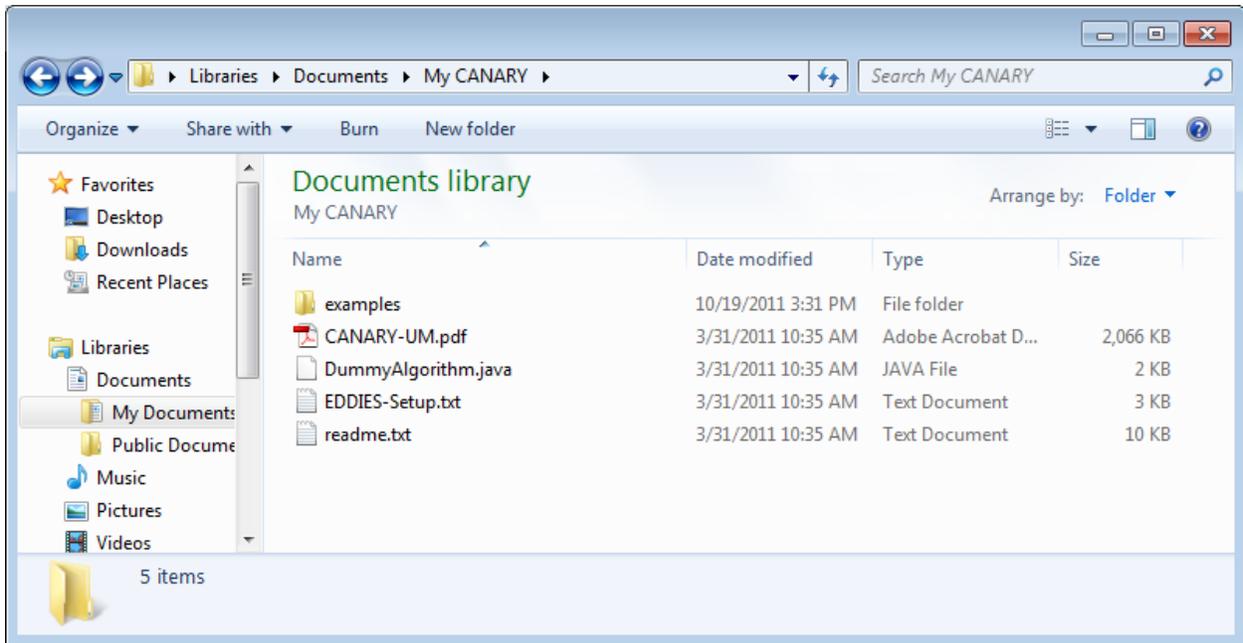
- bin – contains the executables for running CANARY
- doc – contains documentation, including the CANARY User’s Manual
- etc – contains icons and configuration files associated with databases
- lib – contains information the code needs to run



**Figure 21: CANARY Directory**

A “MY CANARY” folder is installed under “My Documents,” which contains one subfolder and four files (Figure 22). The four files are:

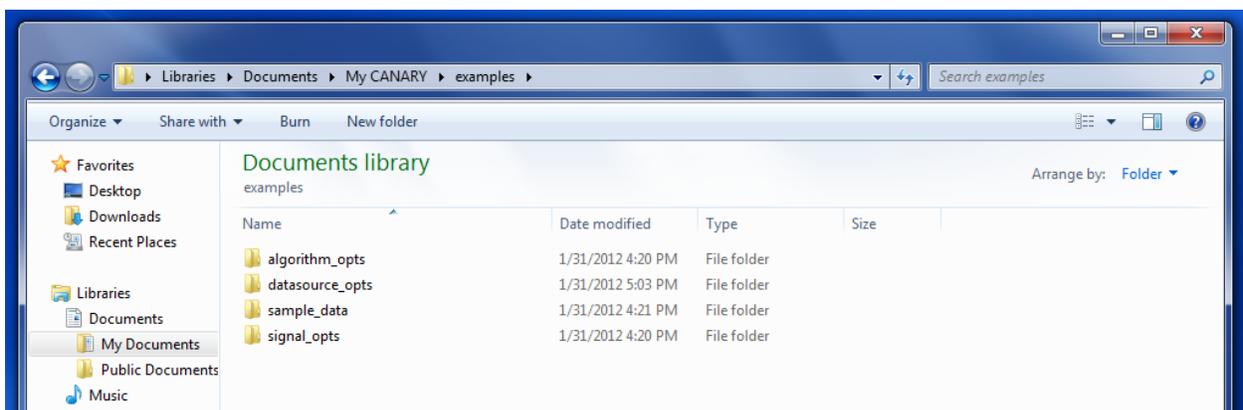
- CANARY-UM.pdf – the CANARY User’s Manual
- DummyAlgorithm.java – an example custom algorithm written in java
- EDDIES-Setup.txt – a help file for using the EDDIES SCADA interface
- readme.txt – a help file for the MATLAB Runtime Compiler



**Figure 22: My CANARY Directory**

If the example configuration and data files option was selected during installation, then a subfolder called “examples” is located within the MY CANARY folder. The examples folder contains four additional folders, in which two of the folders (algorithm\_opts and signal\_opts) are place holders for future CANARY releases (Figure 23). Screen shots of the contents for the two folders listed below are provided in Section 3.3.

- datasource\_opts – contains example configuration files
- sample\_data – contains example monitoring station data files



**Figure 23: My CANARY/examples Directory**

Under the Start Menu, click on “All Programs” and then “CANARY.” Several options are available:

- CANARY – option to run CANARY
- Uninstall CANARY – option to uninstall CANARY
- Cluster Pattern Editor – option to edit cluster patterns
- Graph Data Files – option to graph CANARY output

Four file types are associated with CANARY after running the software and are stored in the MY CANARY folder. These files have the following endings:

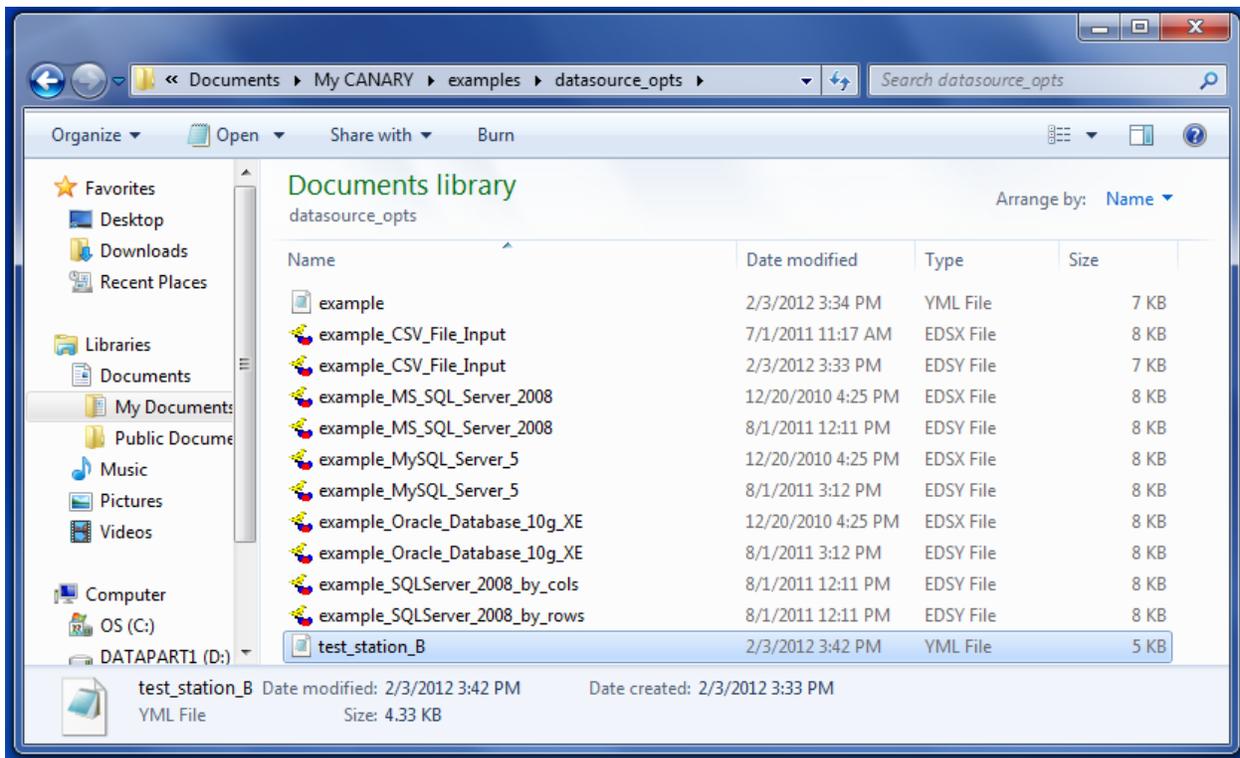
- .EDSY – This is a CANARY configuration and settings file in the YML format. Double click this type of file to run CANARY, or right-click and choose "Edit" to open the configuration editor in a text editor (see Configuration Details section in the CANARY User’s Manual). Older configuration files were written in XML format and ended in EDSX. These older files can still be read by CANARY.
- .EDSD – This is a CANARY output data file, which is graphed when double-clicked.
- .EDSC – This is a CANARY clustering-pattern library file.
- .log – This is a CANARY log file. It will open in a text editor if double-clicked.

## 2.4 Running CANARY

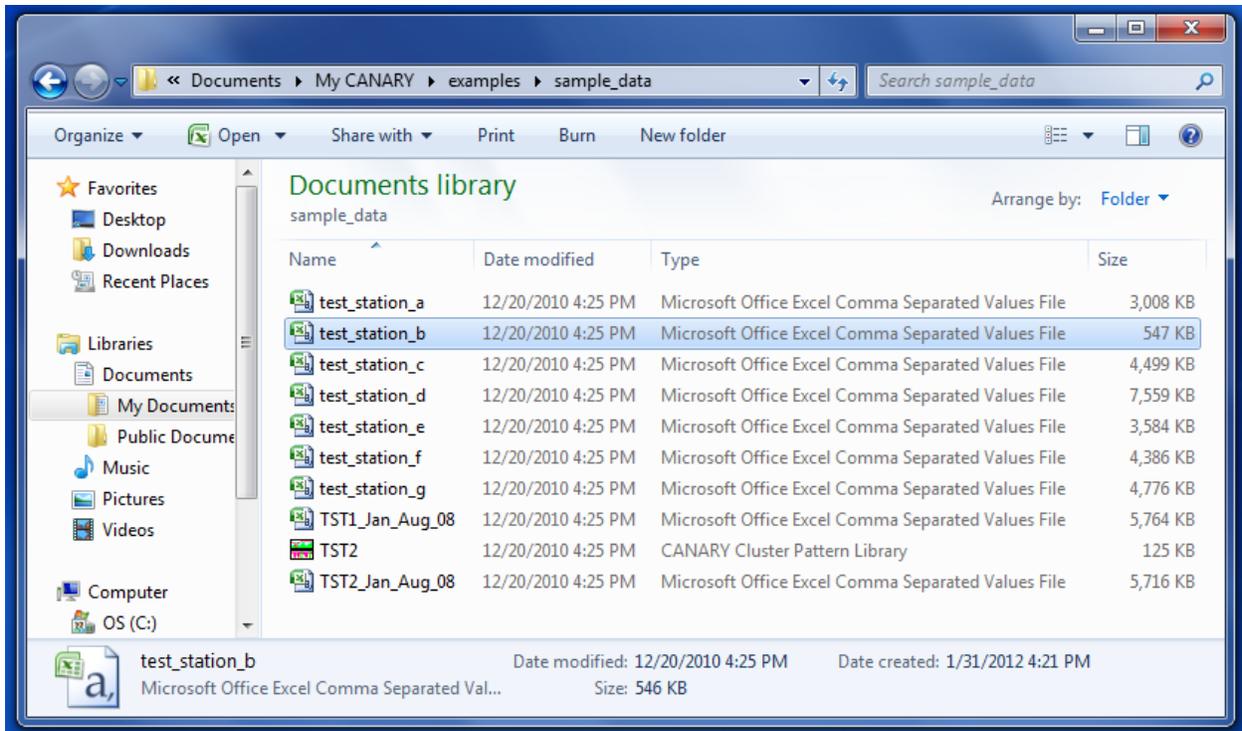
The process of running CANARY is demonstrated through an example. Readers can follow along using their own installation of CANARY.

In order to run CANARY, a data source is needed (a data file or database) as well as a configuration file. Typically, the data source is made up of data from water quality sensors collected over a period of time. Configuration files contain information about how to run CANARY on a specific data set. These files typically end in \*.yaml or \*.edsy; see the Configuration Details section in the CANARY User’s Manual for more details.

In Figure 24, “test\_station\_B.yaml,” located in the datasource\_opts folder, is the configuration file that is used in this example. The data file used in this example, “test\_station\_b.csv,” is located in the sample\_data folder and shown in Figure 25.

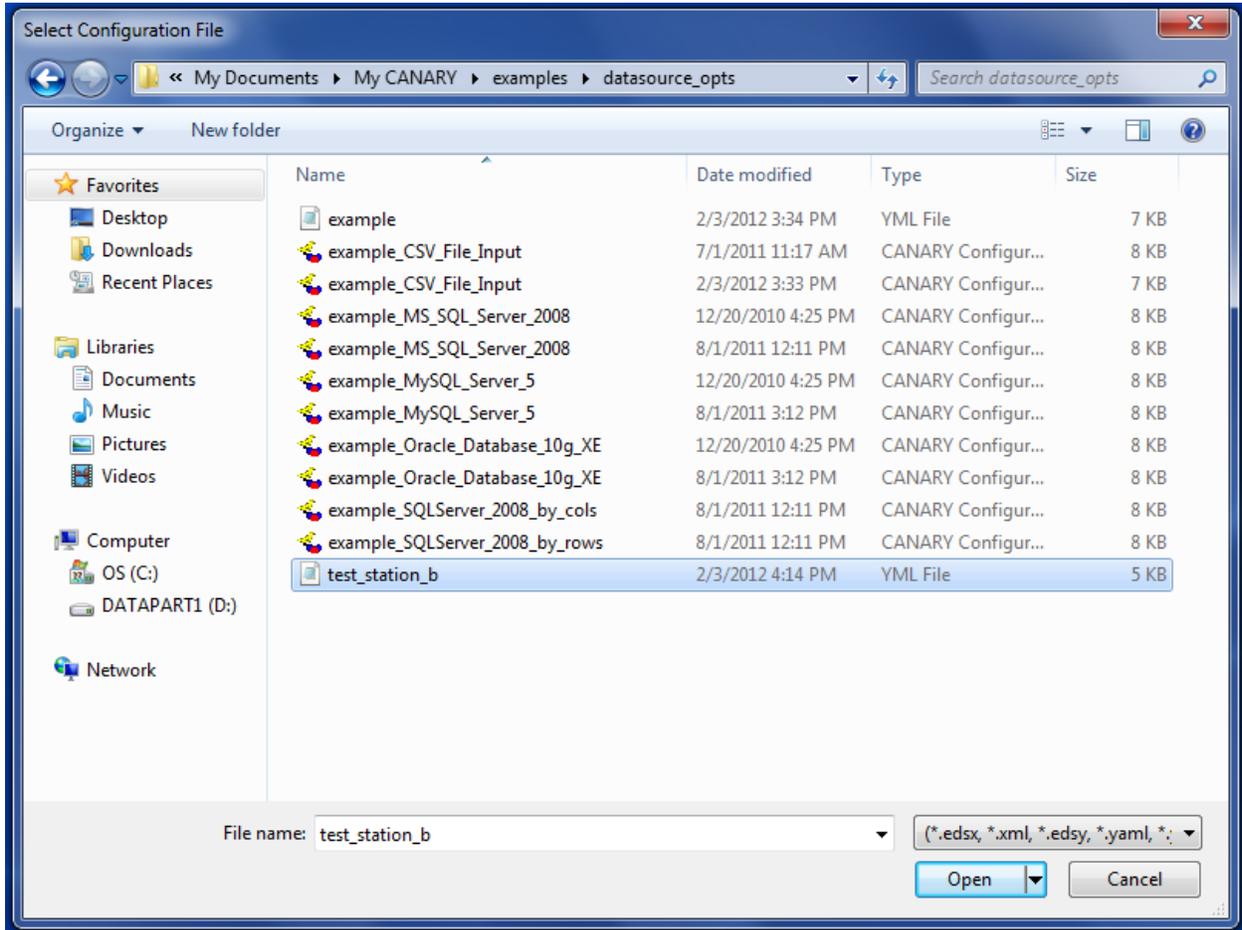


**Figure 24: Location of YML Configuration File**



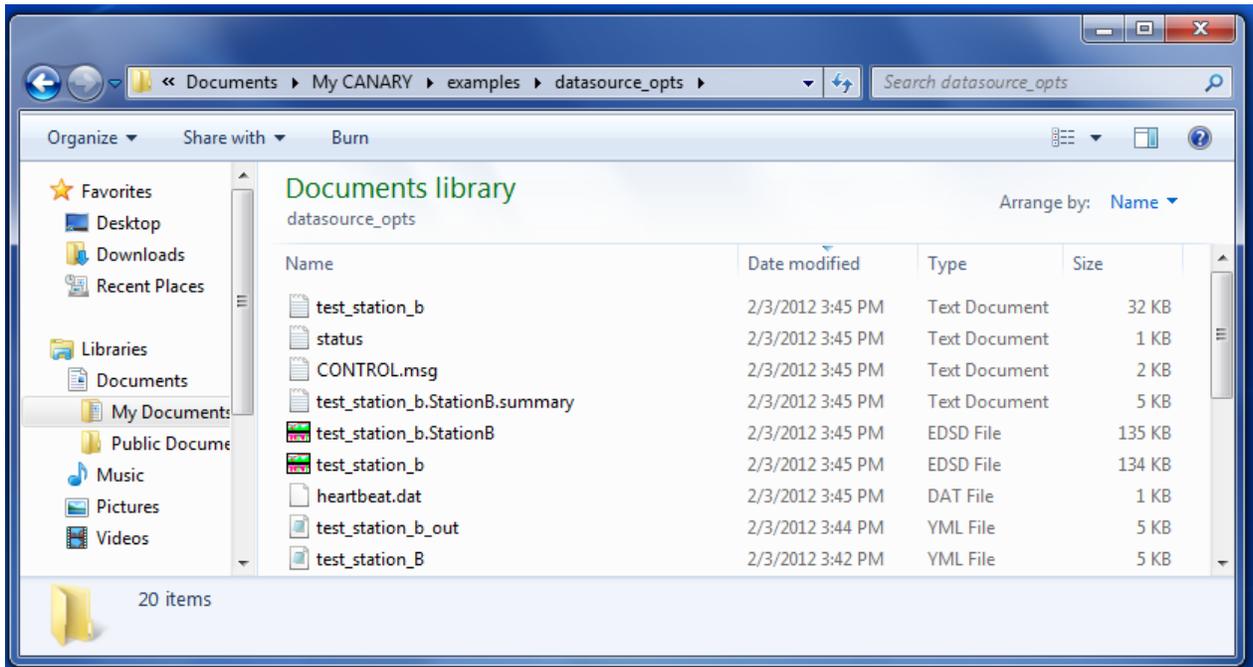
**Figure 25: Location of CSV Data Source File**

If the default installation Start Menu shortcut was selected, CANARY can be accessed by going to “All Programs,” “CANARY,” “CANARY.” This will bring up a browser window in which a CANARY configuration file should be selected (Figure 26). The user should browse to the directory in which the correct YML file is located and select it. In this example, browse to the directory shown in Figure 24 and select the “test\_station\_B.yml” configuration file.



**Figure 26: Selection of Configuration File**

After the execution of the “test\_station\_B.yml” configuration file, the following files (Figure 27) are created:



**Figure 27: Initial CANARY Run File Creation**

- test\_station\_B.log – Log file for every day that CANARY runs. This log is generated from the information that prints out onto the DOS window.
- status.log – Status log that tracks when CANARY is running.
- CONTROL.msg – File which contains the messages passed between CANARY and Control.
- test\_station\_B.StationB.summary.text – Summary of the current CANARY run, which explains the inputs and outputs of the YML (or EDSY) file and provides log information of every event detected.
- test\_station\_b.edsd – Comprehensive output file.
- test\_station\_b.StationB.edsd – Output file just for the Station B sensor station. Note this file will be created for every individual sensor station included in the configuration file.
- heartbeat.dat – File which states the specific date and time CANARY was run.
- test\_station\_b\_out.yml – A copy of the YML file which was run.

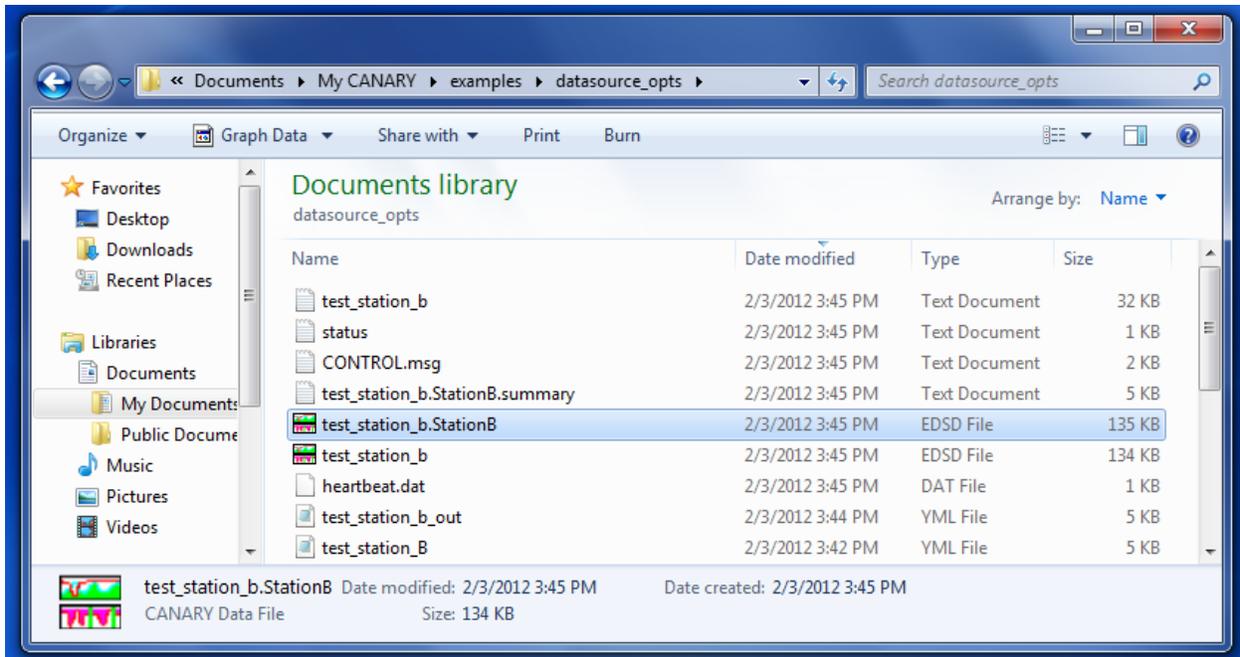
## 2.5 Analysis of CANARY Output

To visualize and utilize the output data contained in the EDSY files, four different automated methods are available. The different methods are Graph Data, Convert to CSV, Create Cluster Library, and Combine EDSY Files. All of these methods can be accessed by right-clicking on the EDSY file. The following sections provide examples of each method.

## 2.5.1 Graph Data

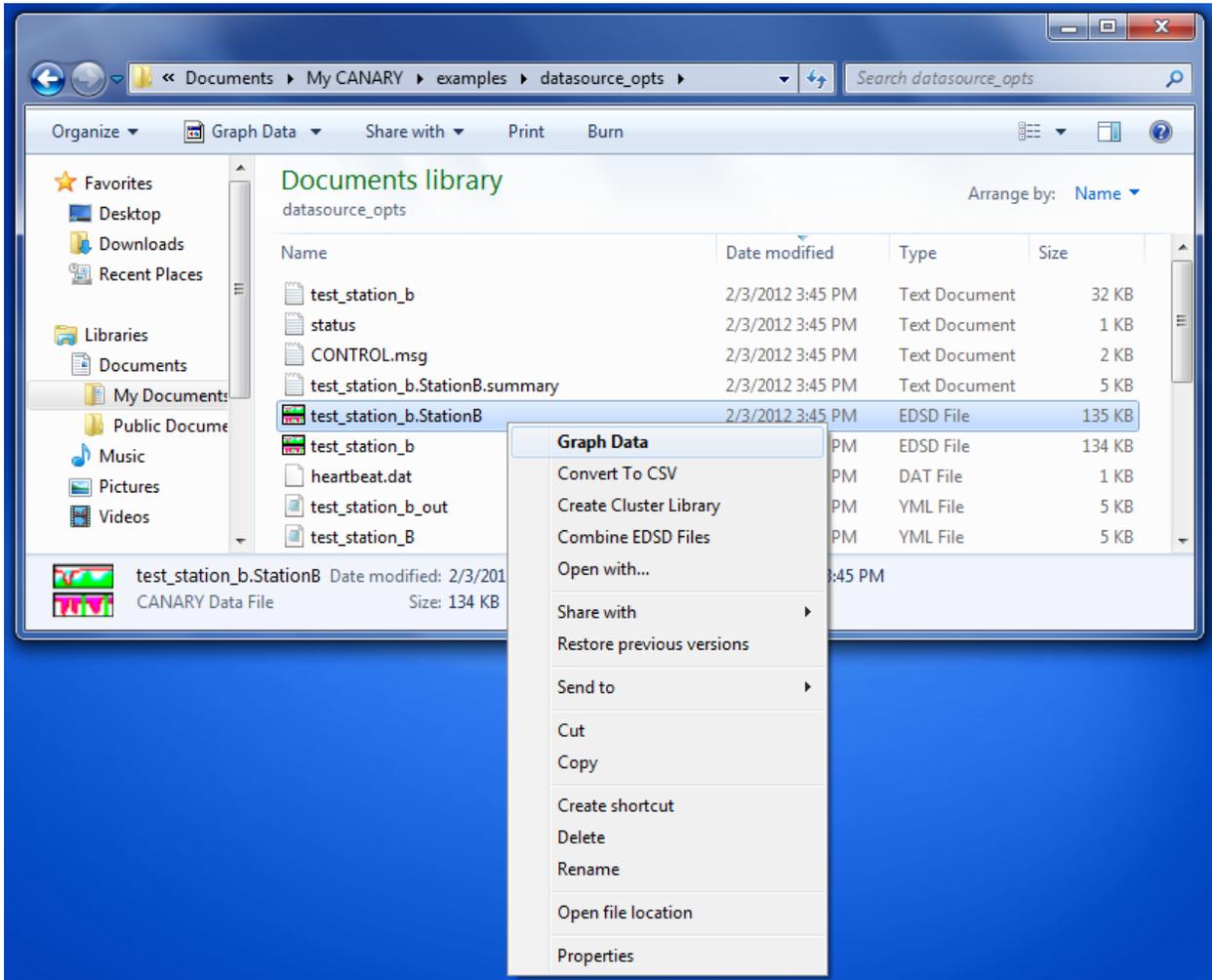
To visualize the results of the CANARY analysis, the Graph Data option can be utilized. The process is demonstrated using the test\_station\_B example files.

1. Open the datasource\_opts folder under the My CANARY examples folder to locate the test\_station\_b EDSB files (Figure 28).



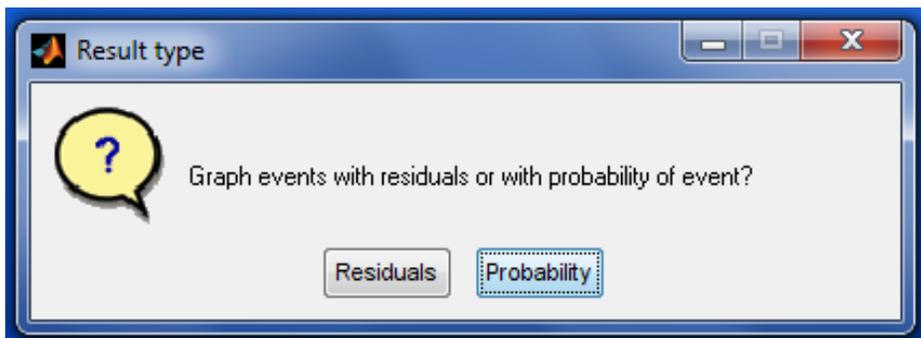
**Figure 28: Directory Window Where EDSB File is Located**

2. Right click on “test\_station\_b.StationB.edsd” and select “Graph Data” (Figure 29).



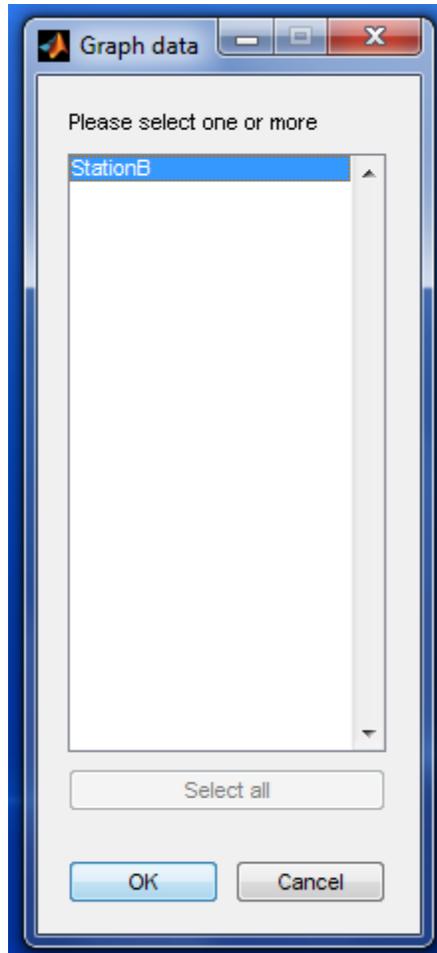
**Figure 29: Selecting the Graph Data Option**

3. Select “Probability” (Figure 30) to graph the probability of an event.



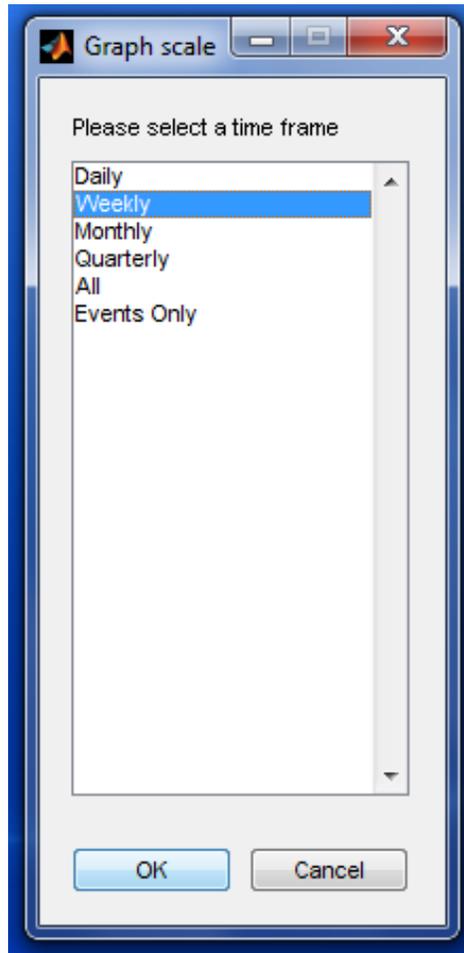
**Figure 30: Graph Result Type Window**

4. Select “StationB” (Figure 31) and Click “OK.” Note that an ESDS file can contain results from more than one sensor station.



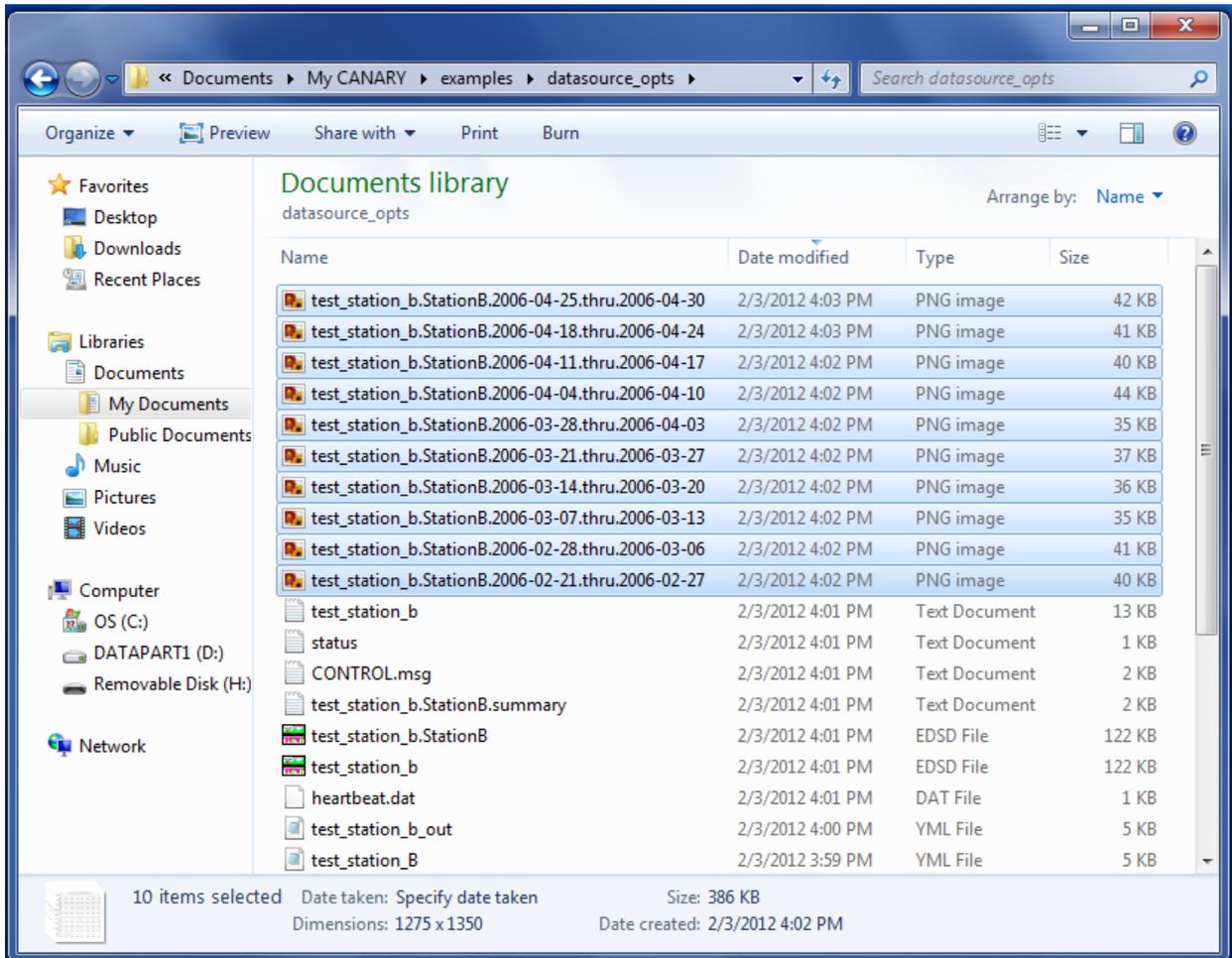
**Figure 31: Station Selection Window**

5. Select “Weekly” to graph the data on a weekly basis (Figure 32) and click “OK.”



**Figure 32: Graph Scale Window**

Once this process is completed, the graphs are created and added to the folder in which the EDSO was located (Figure 33).



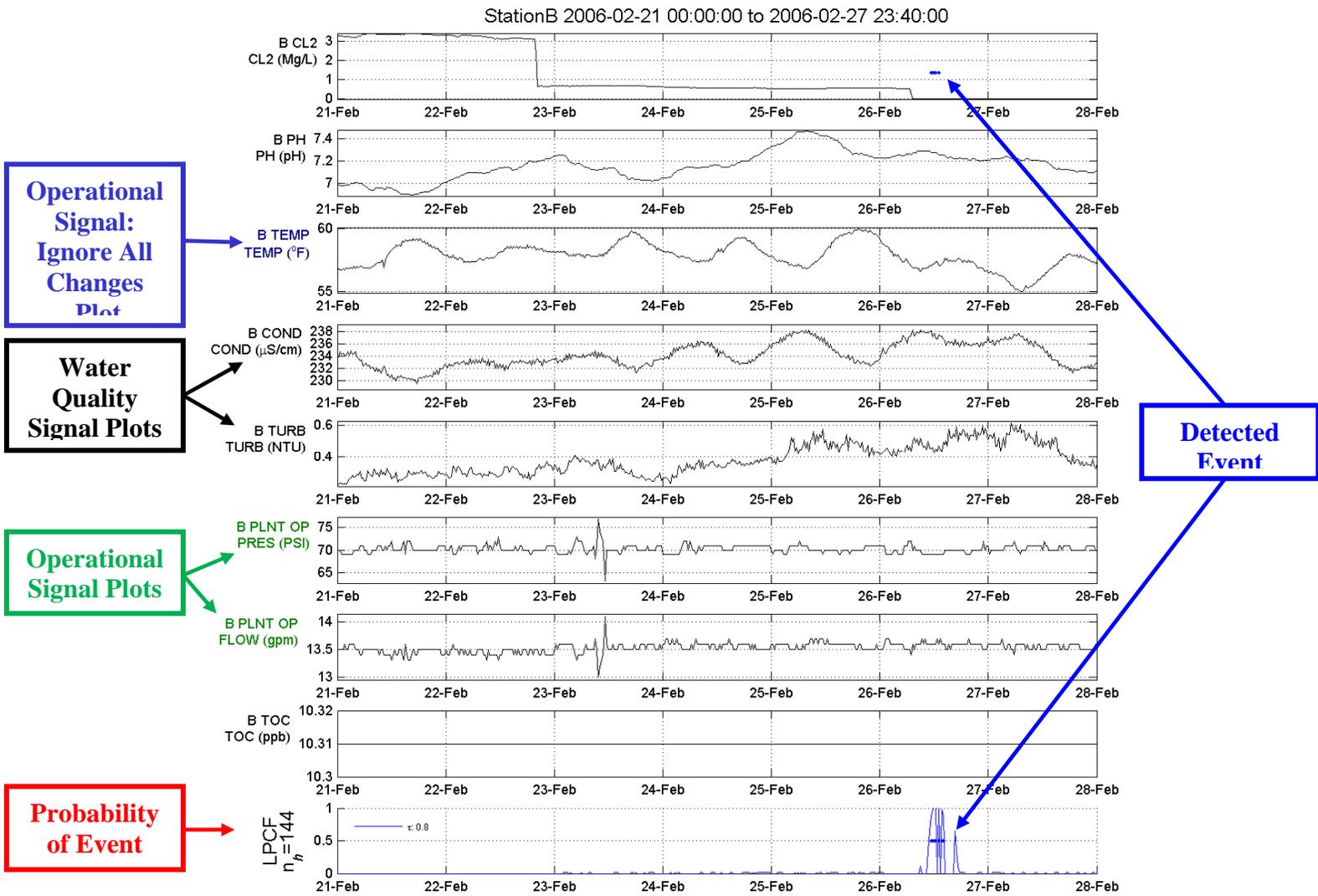
**Figure 33: Output files from Graph Data**

After the graphs are created, they can be opened and viewed. Each graph contains the water quality signals analyzed, any operational signals, and a probability of event plot for each algorithm utilized. Water quality signal labels are in black, operational signal labels are green, and operational signals that are ignored are labeled in purple. The probability of event plots are at the bottom of the graph. A blue dot on the probability of event plot indicates an event. In addition, a dot will be located on each water quality signal that contributed to the detection of the event.

- Double-click the “test\_station\_b.StationB.2006-02-21.thru.2006-02-27.png” file to examine the results.

Figure 34 shows the content of this file: the water quality signals are chlorine (CL2), pH (PH), conductivity (COND), turbidity (TURB), and total organic carbon (TOC). The operational signals in this example are the temperature (TEMP), plant pressure (PLNT OP PRES), and flow

(PLNT OP FLOW). The probability of an event plot shows the probability that an event is occurring at each time step as computed by CANARY using the LPCF algorithm. The first event detected was caused by an unexpected change in the chlorine signal (CL2).



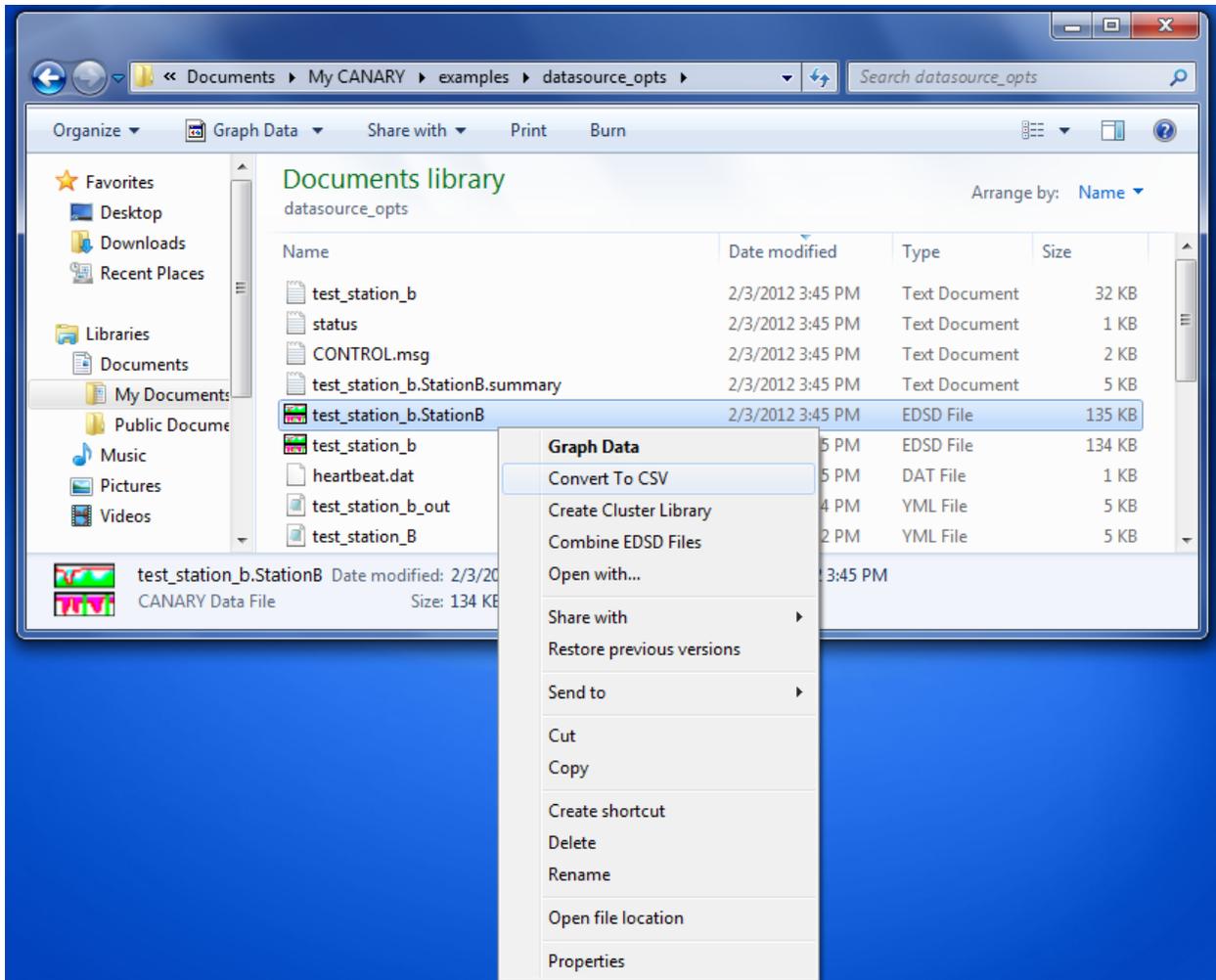
**Figure 34: CANARY Output Graph**

### 2.5.2 Converting to CSV Files

To view the contents of the EDSD file, it is recommended that the “Convert to CSV” option be utilized. This converts the contents of the file to a comma separated values (CSV) file that can be opened in Microsoft Excel. Two types of CSV are created, a summary file and a details file. The summary file provides the probability of an event and the CANARY status at every time step. The details file provides extensive details on CANARY results for every time step, including the CANARY status, the probability of an event, and the residuals for each active

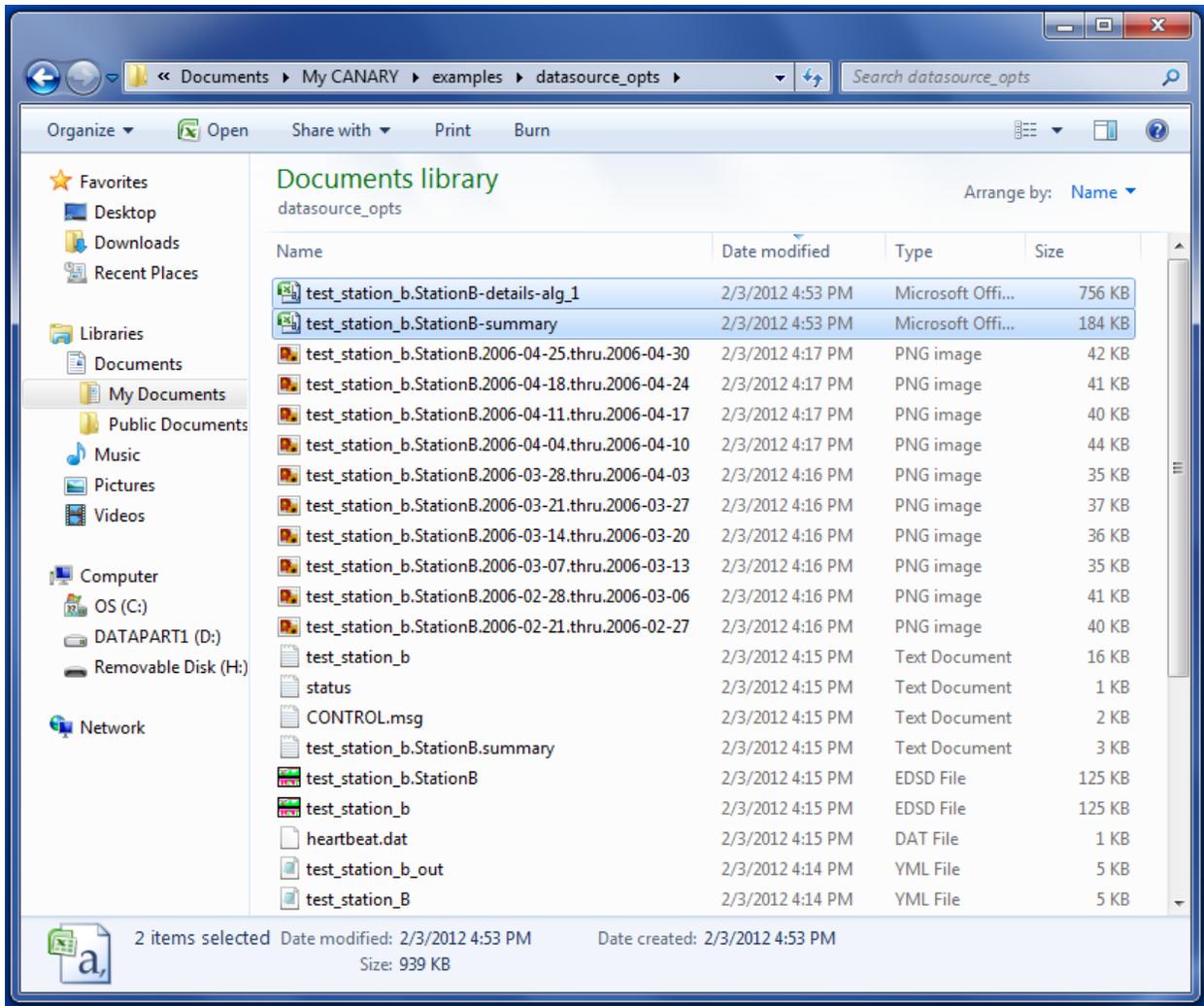
water quality signal. A details CSV file is written for each active algorithm in the configuration file. The process is demonstrated below using the previous example files.

1. Open the `datasource_opts` folder under the My CANARY examples folder to locate the “`test_station_b.StationB.edsd`” (Figure 28).
2. Right click on “`test_station_b.StationB.edsd`” file and select “Convert to CSV” to convert the format of the results data (Figure 35).



**Figure 35: Selecting the Convert to CSV Option**

The converted CSV files are added to the folder (Figure 36). The new files are “`test_station_b.StationB-summary.csv`” and “`test_station_b.StationB-details-alg_1.csv`.”



**Figure 36: Converting to CSV File Output**

### 2.5.3 Create Cluster Library

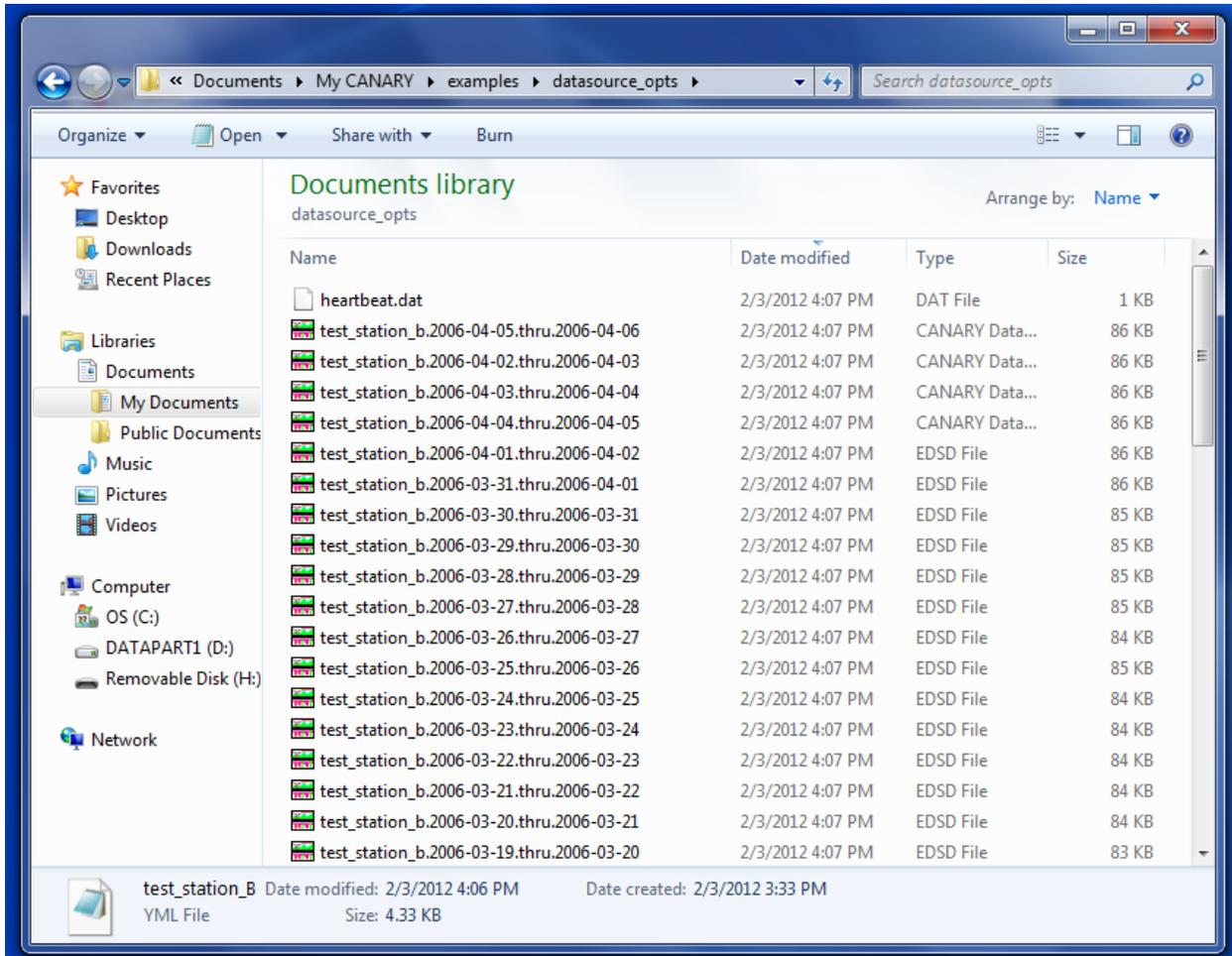
Another option available by right-clicking on the EDSD file is “Create Cluster Library.” This is an advanced option for CANARY users; for details, please refer to the CANARY User’s Manual section on Water Quality Pattern Matching (Hart and McKenna 2011).

### 2.5.4 Combine EDSD Files

This option is most often needed for long-term CANARY runs in online mode (i.e., connected to a database) when a separate EDSD file is created every day. This option allows multiple EDSD files to be combined into a single EDSD file. Note that CANARY expects the EDSD file names being joined to have a particular naming convention, see Figure 37. This is the same naming convention used for the daily EDSD files created during an online run. This convention is also followed for intermediate files created in offline mode (i.e., running from a CSV file). At the

end of an offline run, CANARY automatically deletes the intermediate files and combines them into the final ESDS file. The process is demonstrated below through an example.

1. Open the folder where the ESDS files are located (Figure 37).



**Figure 37: Example ESDS Naming Convention**

2. Right click on any of these intermediate EDSD files and select “Combine EDSD Files” (Figure 38)

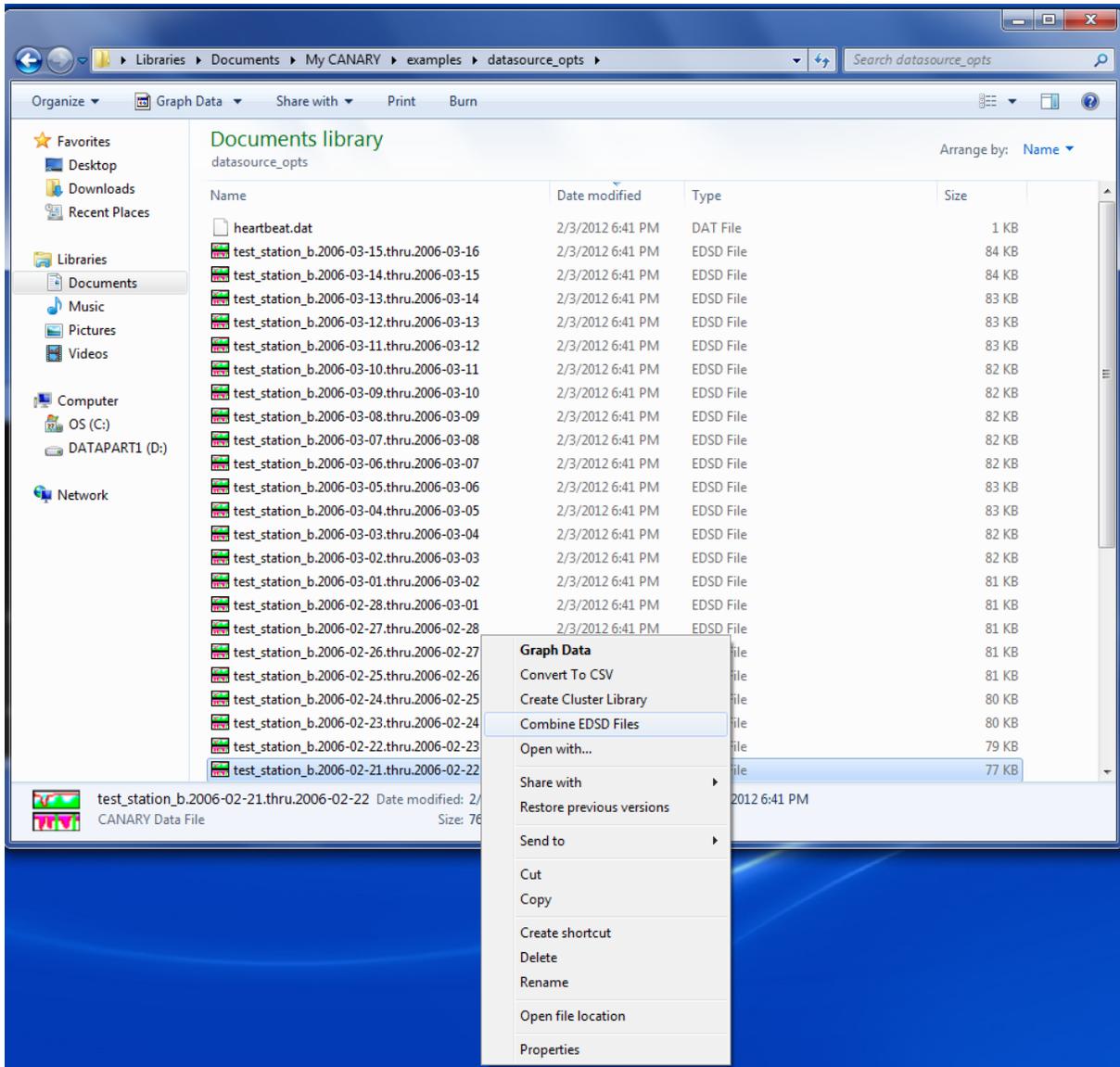
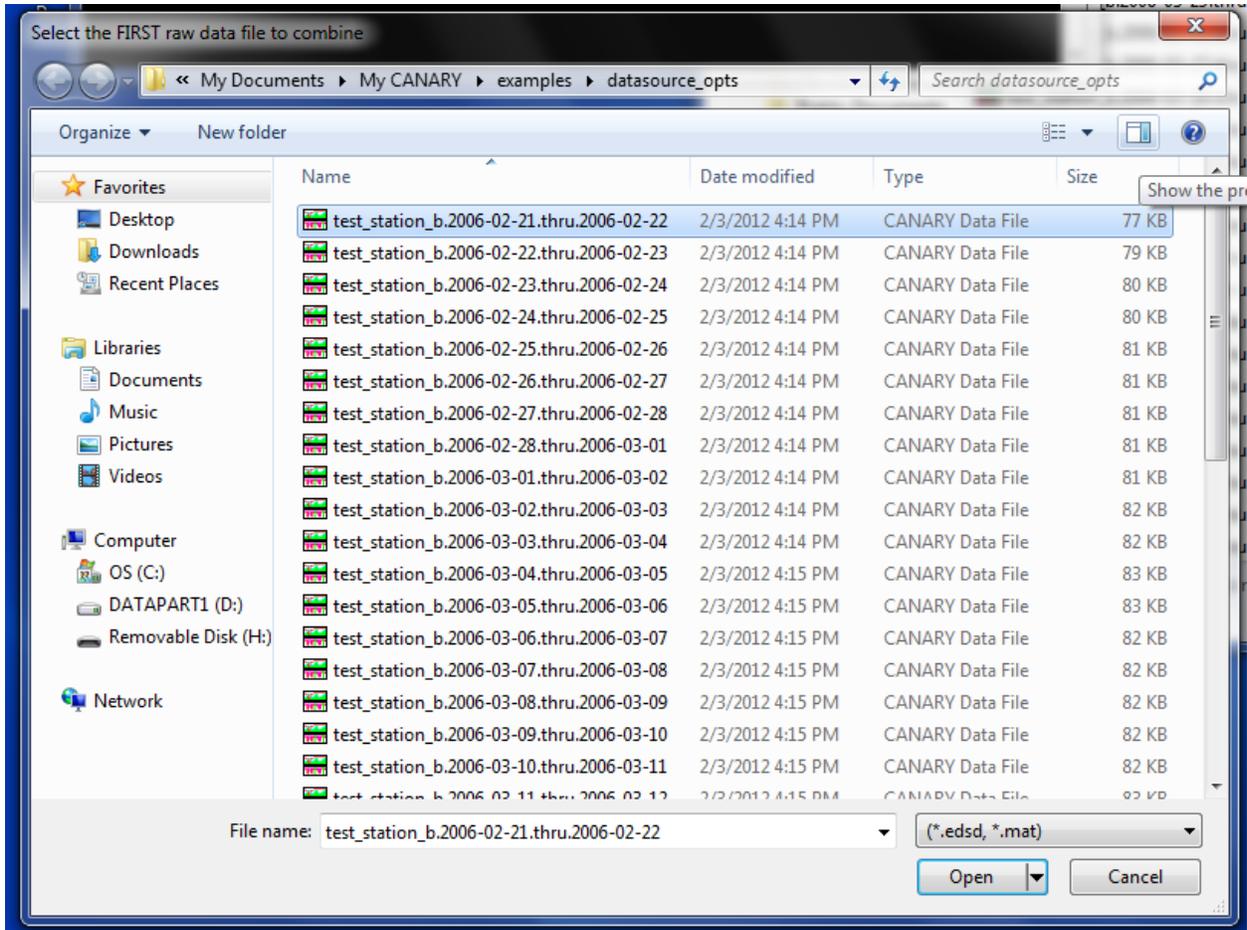


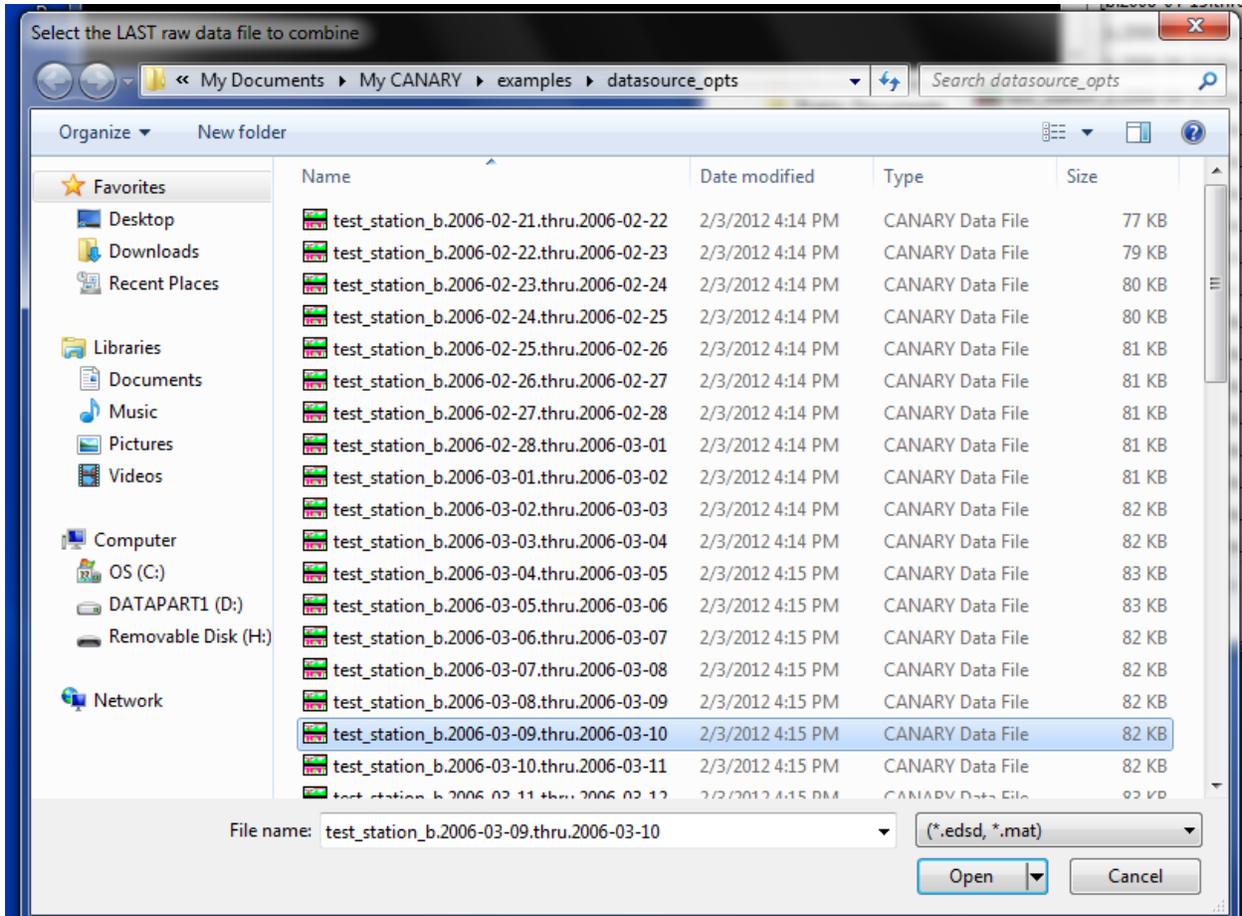
Figure 38: Selecting Combine EDSD Files Option

3. Select the “test\_station\_b.2006-02-21.thru.2006-02-22.edsd” file as the first EDSD file to be included in the combined file (Figure 39).



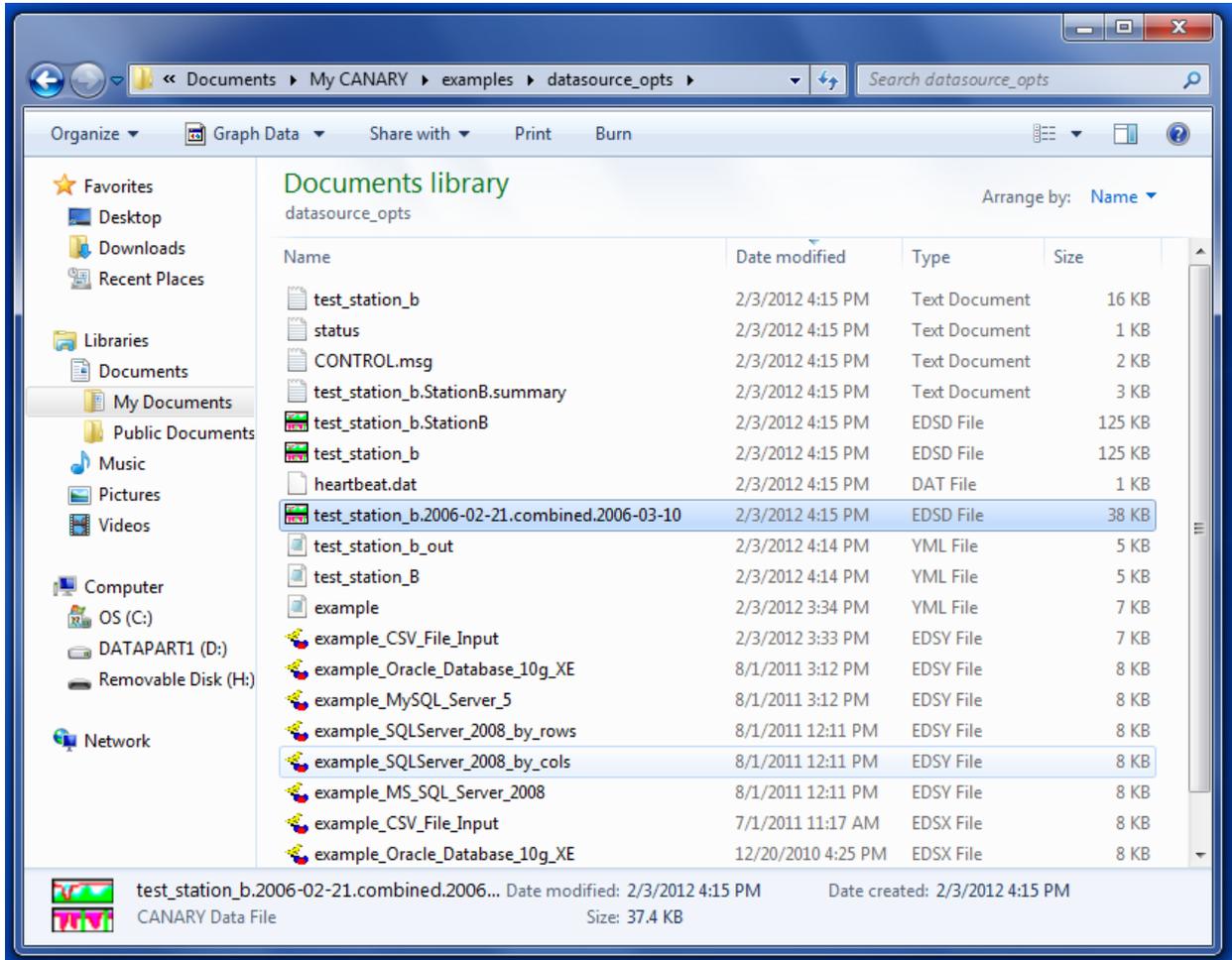
**Figure 39: First EDSD File to Combine**

4. Select the “test\_station\_b.2006-03-09.thru.2006-03-10.edsd” file as the last EDSD file to be included in the combined file (Figure 40).



**Figure 40: Last EDSD File to Combine**

Once the last ESDS file is selected, CANARY creates a combined ESDS file, “test\_station\_b.2006-02-21.combined.2006-03-10.edsd,” containing the first, the last, and all the intermediate files (Figure 41).



**Figure 41: Combined ESDS File Created**

### 3. Additional Resources

In this section, the CANARY license text, an example YAML configuration file, and screen captures of CANARY related directories are provided.

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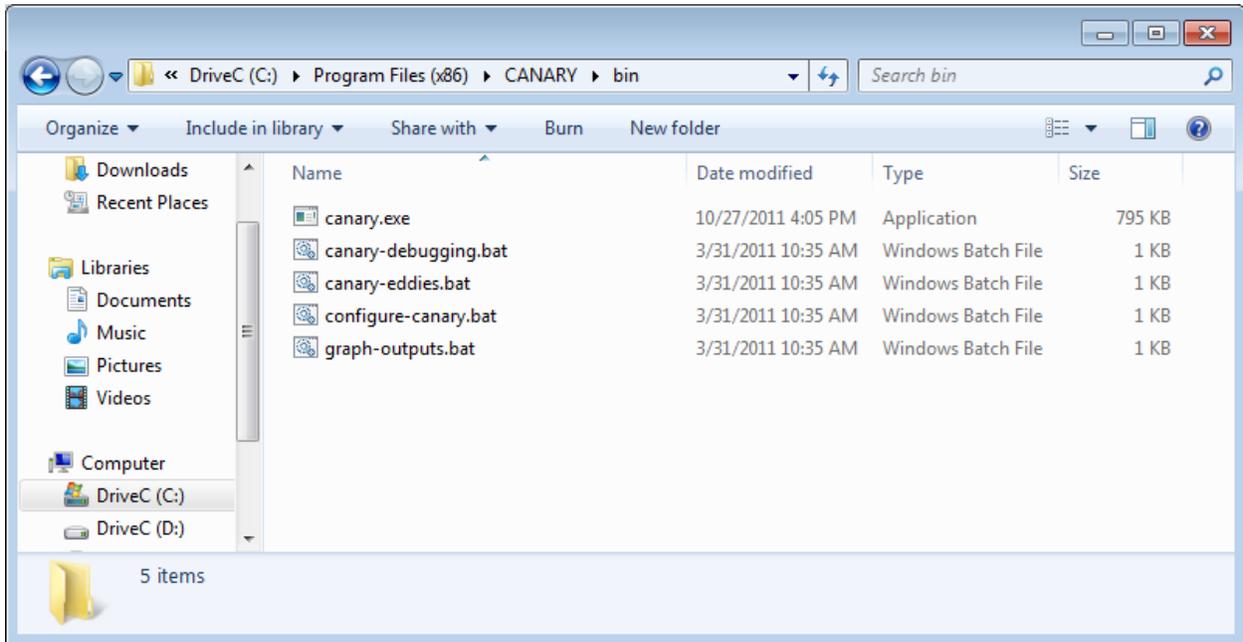
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### 3.2 CANARY Directory Structure

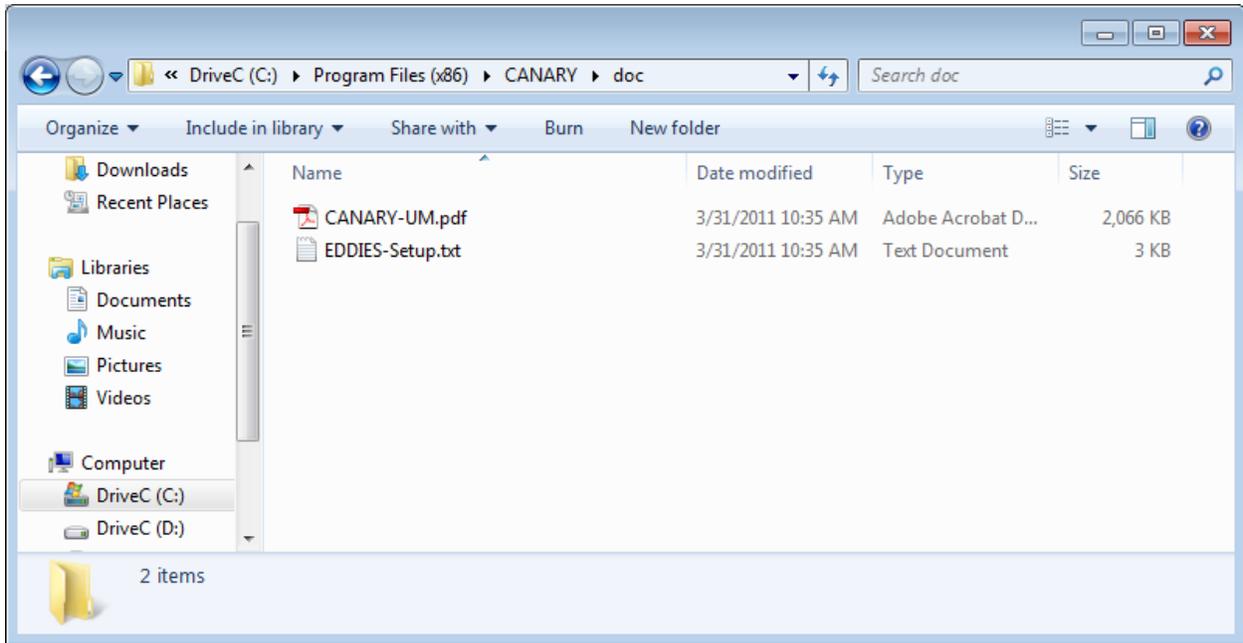
This section provides screen captures of the subfolders and files contained in the CANARY directory under Program Files once the software is installed on a computer.

Figure 42 shows the files contained within the “bin” folder of the “CANARY” directory found under Program Files.



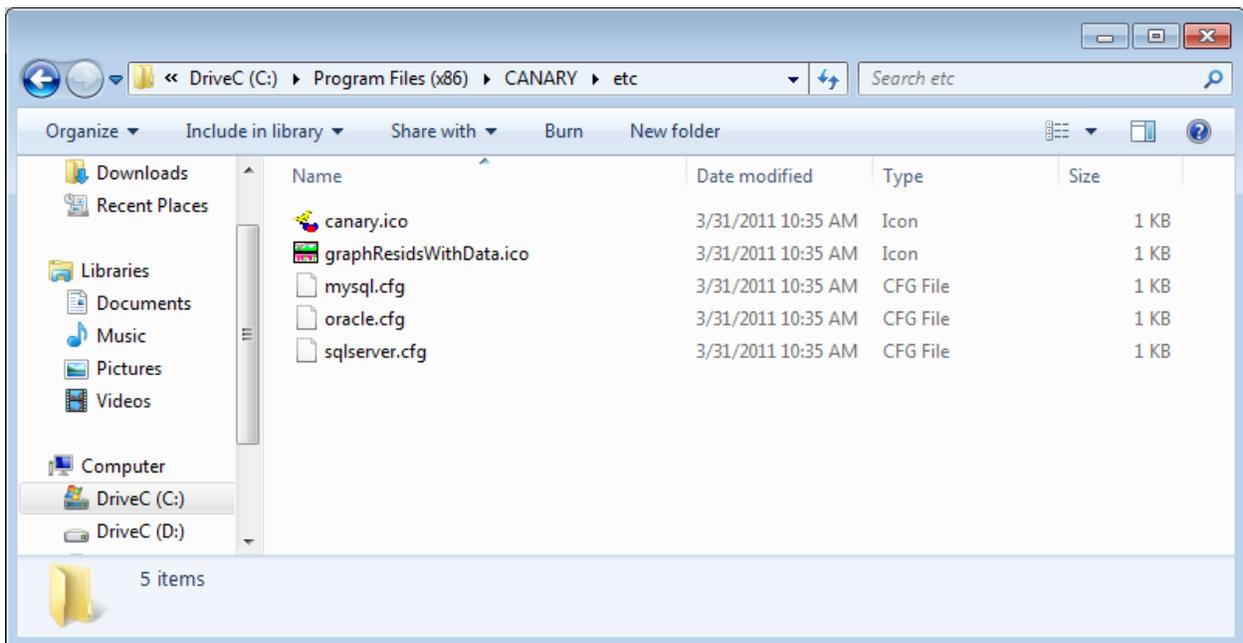
**Figure 42: CANARY\bin Folder**

Figure 43 shows the files contained within the “doc” folder of the “CANARY” directory found under Program Files.



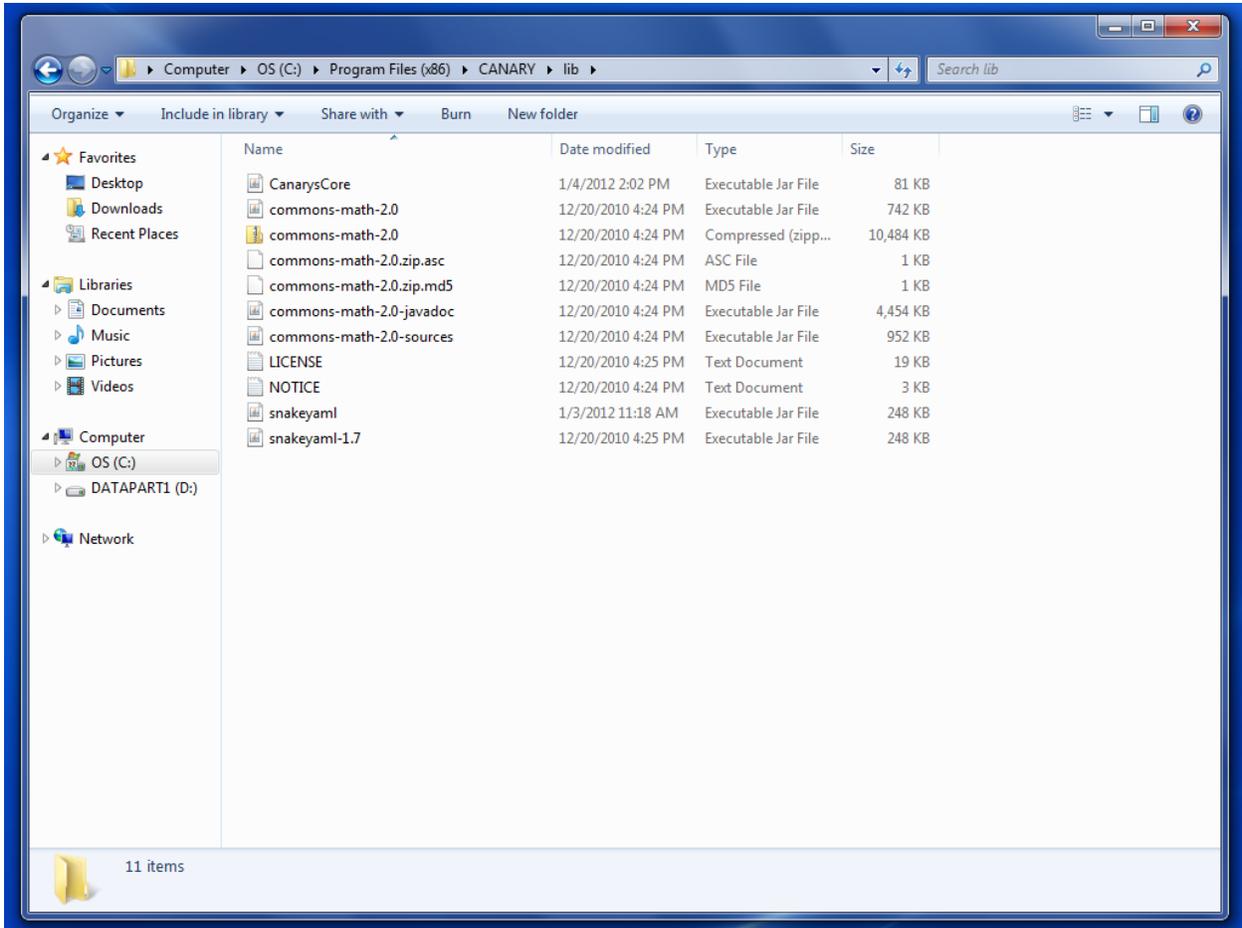
**Figure 43: CANARY\doc Folder**

Figure 44 shows the files contained within the “etc” folder of the “CANARY” directory found under Program Files.



**Figure 44: CANARY\etc Folder**

Figure 45 shows the files contained within the “lib” folder of the “CANARY” directory found under Program Files.

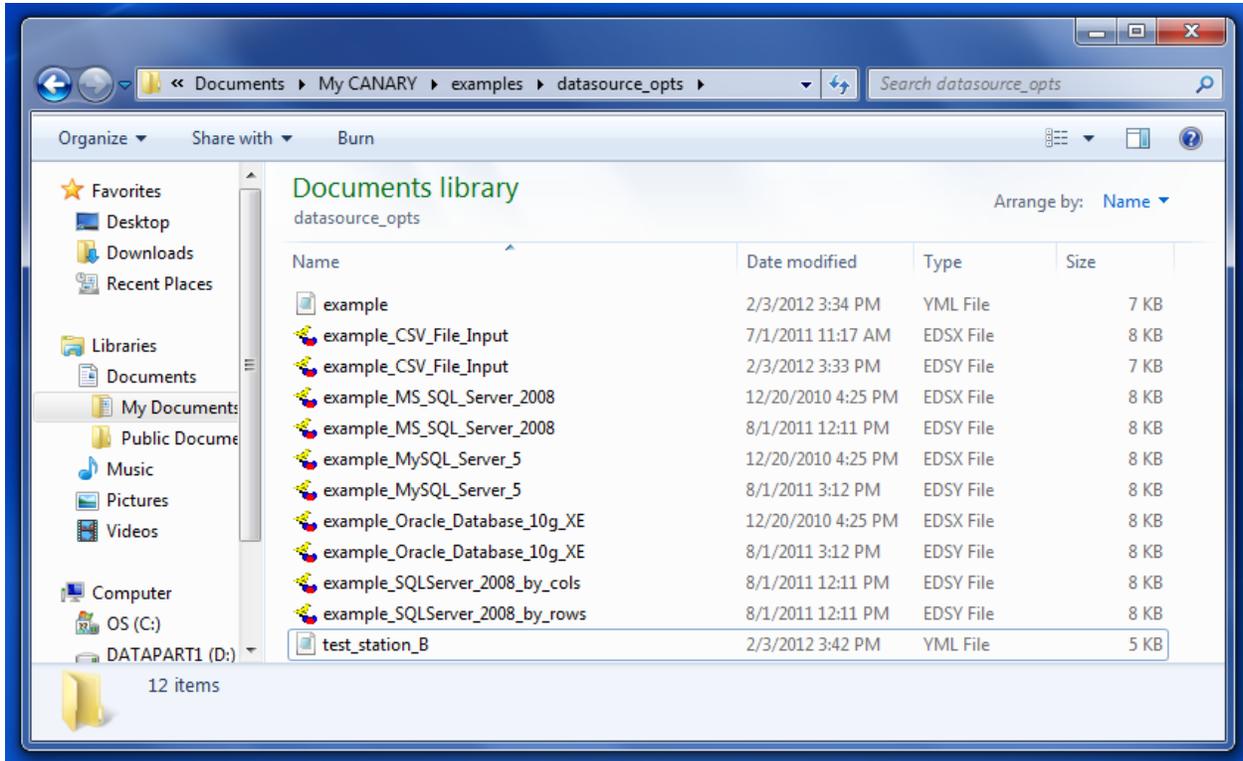


**Figure 45: CANARY\lib Folder**

### 3.3 MY CANARY Directory Structure

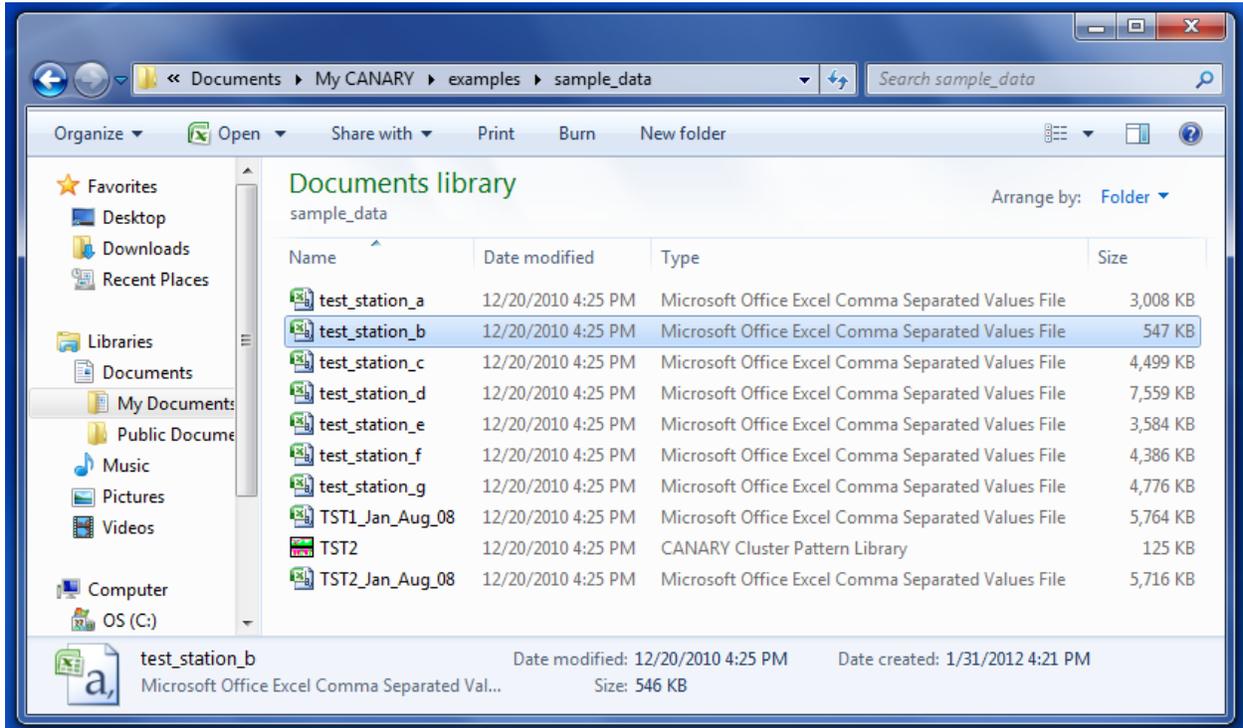
This section provides screen captures of the subfolders and files contained in the examples folder under the My CANARY directory after the software is installed on a computer.

Figure 46 shows the files contained within the “datasource\_opt” folder of the “examples” directory.



**Figure 46: My CANARY\examples\datasource\_opts Folder**

Figure 47 shows the files contained within the “sample\_data” folder of the “examples” directory.



**Figure 47: My CANARY\examples\sample\_data Folder**

## 4. References

Hart, D. B. and McKenna, S. A. (2011). *CANARY user's manual, version 4.3.1*, U.S. Environmental Protection Agency, Office of Research and Development, National Homeland Security Research Center, Cincinnati, OH.

Murray, R., Haxton, T., McKenna, S. A., Hart, D. B., Klise, K. A., Koch, M. W., Vugrin, E., Martin, S., Wilson, M., Cruz, V., and Cutler, L. (2010). *Water quality event detection systems for drinking water contamination warning systems: Development, testing, and application of CANARY*, U.S. Environmental Protection Agency, Office of Research and Development, National Homeland Security Research Center, Cincinnati, OH.