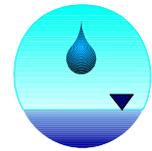


The CEDRA Corporation's COMMAND OF THE MONTH

A monthly information bulletin

March 2006

FEATURED COMMAND
Importing an
EPANET Model



Application Description

The United States Environmental Protection Agency (U.S.E.P.A.) offers a software package called EPANET which performs extended period simulations and water quality modeling within pressurized pipe networks. This software is widely used by the civil engineering community due to its functionality and robustness as well as the fact that it is free.

Presently, there are two versions of the EPANET software with the latest version called EPANET 2. EPANET 2 is a stand-alone software package that employs its own user interface for developing and modeling pipe networks, such as a water distribution system.

From a GIS point of view, particularly an ArcView/ArcMap point of view, it would be very useful to be able to run the EPANET 2 modeler using data stored in the GIS.

The CEDRA Solution

The CEDRA-AVwater software incorporates an interface for both versions of the EPANET software (EPANET and EPANET 2) thereby enabling the user to perform an analysis from within the ArcView® GIS or ArcGIS® environment.

In addition to being able to execute the EPANET software from within ArcView/ArcMap, CEDRA-AVwater provides functionality for importing an existing EPANET model. This ability eliminates the need for the user to redefine the model.

Required Files

To build a CEDRA-AVwater model from an existing EPANET model, the user must have: (a) an EPANET map file (.map) and (b) the corresponding EPANET input file (.inp). The map file contains a list of the nodes and their coordinates, as shown in Figure 1, while the input file contains the data associated with the model, see Figure 2. CEDRA-AVwater will process both of these files and build an equivalent CEDRA-AVwater model. Note that both of these files must share the exact same root name. For example, if the EPANET map file is called A.MAP, the EPANET input file must be called A.INP in order for the importing to properly work.

Command Of The Month bulletin

This month's issue discusses the process of importing an existing EPANET water model from within the CEDRA-AVwater software.

EPANET users can create the map file (.map) from within EPANET using the {File} [Export] [Map...] command. Likewise, the input file (.inp) can be created from within EPANET using the {File} [Export] [Network...] command. By executing these commands from within EPANET, the user can create the required files.

Once these two files have been established, the user should create a separate folder or directory on the hard disk and

copy these files into this folder. It is a good idea to create a separate folder for each model that is to be created. The {Import} [Points] command, within CEDRA-AVwater, will be used to import the EPANET model. Depending upon the environment, this command can be displayed by performing the following:

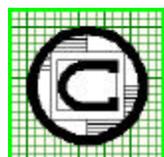
- (a) ArcGIS® users should:
 - Activate the Editor, CEDRA-AVcad-Menus and CEDRA-AVwater-Menus toolbars.
- (b) ArcView® GIS users should:
 - Activate the CEDRA-AVwater, CEDRA-AVwater-EPANET-Import and the CEDRA-ImportPoints extensions.

A sample EPANET 2 map file (.map) is shown below. Data lines with the semi-colon (;) character are comment lines.

```
[COORDINATES]
;Network Nodal coordinates
 2 50 90
 9 10 70
10 20 70
11 30 70
12 50 70
13 70 70
21 30 40
22 50 40
23 70 40
31 30 10
32 50 10

[LABELS]
0 70 "Source" 9
12 68 "Pump" 9
55 90 "Tank" 2
```

Figure 1
Sample EPANET 2 Map File



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A sample EPANET 2 input file (.inp) is shown below.

```
[TITLE]
EPANET Sample Network

[JUNCTIONS]
;-----
;      Elev      Demand
; ID      ft      gpm
;-----
10      710      0
11      710      150
12      700      150
13      695      100
21      700      150
22      695      200
23      690      150
31      700      100
32      710      100

[TANKS]
;-----
;      Elev      Init      Min      Max      Diam.
; ID      ft      Level      Level      Level      ft
;-----
2      850      120      100      150      50.5
9      800

[QUALITY]
;-----
;      Initial
;Nodes      Concen. mg/L
;-----
2      32      0.5
9      1.0
2      1.0

[PIPES]
;-----
;      Start      End      Length      Diam      Rough.
; ID      Node      Node      ft      in      Coeff.
;-----
10      10      11      10530      18      100
11      11      12      5280      14      100
12      12      13      5280      10      100
21      21      22      5280      10      100
22      22      23      5280      12      100
31      31      32      5280      6      100
110     2      12      200      18      100
111     11     21      5280      10      100
112     12     22      5280      12      100
113     13     23      5280      8      100
121     21     31      5280      8      100
122     22     32      5280      6      100

[PUMPS]
;-----
;      Start      End      Design H-Q
; ID      Node      Node      ft      gpm
;-----
9      9      10      250      1500
```

Figure 2(a)
Sample EPANET 2 Input File

```
[CONTROLS]
;-----
; Pump 9 is on when Tank 2 level < 110 ft
; Pump 9 is off when Tank 2 level > 140 ft
;-----
LINK 9 OPEN IF NODE 2 BELOW 110
LINK 9 CLOSED IF NODE 2 ABOVE 140

[PATTERNS]
;-----
; ID      Multipliers.....
;-----
1      1.0  1.2  1.4  1.6  1.4  1.2
1      1.0  0.8  0.6  0.4  0.6  0.8

[REACTIONS]
;-----
GLOBAL BULK      -.5      ; Bulk decay coeff.
GLOBAL WALL     -1       ; Wall decay coeff.

[TIMES]
;-----
DURATION 24      ; 24 hour simulation
PATTERN TIMESTEP 2 ; 2 hour pattern time

[OPTIONS]
;-----
QUALITY Chlorine ; Chlorine analysis
MAP      Net1.map ; Coordinate file
[END]
```

Figure 2(b)
Sample EPANET 2 Input File

Importing the EPANET Model

Once the required EPANET files have been established and the appropriate menus displayed, the user is able to import the existing EPANET model. To do so, perform the following:

1. Define the Map Units

The first step in importing an existing EPANET model is to create a new data frame (view) and define the map units for the new data frame (view). It is recommended that a new data frame (view) be created specifically for the model to be imported. Any additional background information (layers/themes) can then be added to the new data frame (view). As such, the user should use native ArcMap/ArcView functionality to:

- Create a new data frame (view) that will contain the imported EPANET model,

- Set the Map and Distance units of this new data frame to be feet (meters) or any other appropriate unit,
- Set the name of the new data frame (view) and finally
- Save the document file (project file) using the {File} [Save As...] command, ArcGIS users, or the {File} [Save Project As...] command, ArcView GIS users.

2. Set the Current Working Directory

When importing a model, the CEDRA-AVwater software will create model files in the current working directory. As such, it is important to verify that the current working directory is as desired.

ArcGIS Users

Use the [Set Working Directory] command within the {CEDRA Commands} combo-box (see Figure 3) to verify that the current working directory is set appropriately.

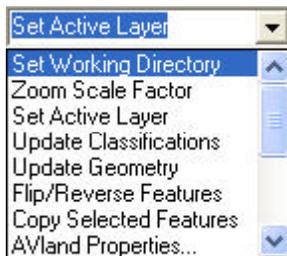


Figure 3
CEDRA Commands Combo-Box

Upon selection of the [Set Working Directory] command, a file navigation dialog box similar to that shown in Figure 4 will be displayed. The user can double-click at the appropriate directory to display it in the topmost data field (the one to the left of the OK button), and then click the OK button to confirm the setting of the current working directory. After the OK button is selected, the pathname for the current working directory will be displayed in the status bar area.

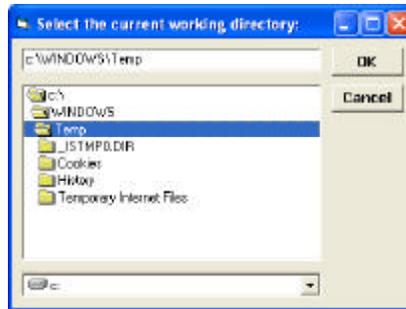


Figure 4
Set Working Directory Dialog Box

ArcView GIS Users

Use the {File} [Set Working Directory] command to verify that the current working directory is set appropriately. Upon activation of the command an input message box will appear, see Figure 5, identifying the current working directory.

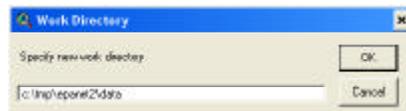


Figure 5
Set Working Directory Dialog Box

If the path that is displayed is not the desired location, the user will need to explicitly type the desired path, followed by clicking the OK button.

3. Set the Active Layer

In importing an existing EPANET model, the user has the option of storing the points which appear in the map file in either an existing layer, or in a new layer. To set the appropriate layer, or the current active layer as it is referred to, the user can:

ArcGIS Users

Activate the [Set Active Layer] command within the {CEDRA Commands} combo-box (see Figure 3).

Upon selection of the [Set Active Layer] command, a dialog box similar to that shown in Figure 6 is displayed.

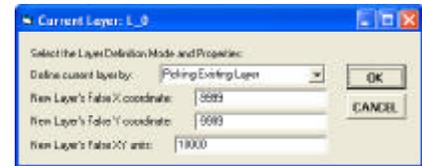


Figure 6
Set Active Layer Dialog Box

If an *existing layer* is to be selected, the user should:

- Accept the default Picking Existing Layer option;
- Click at the OK button to display a list of all of the visible feature layers;
- Click at the appropriate layer in said list, and then
- Click at the OK button.

If a *new layer* is to be established, the user should:

- Scroll down in the top data field of Figure 6 and select the Entering New Layer Name option (see Figure 7).

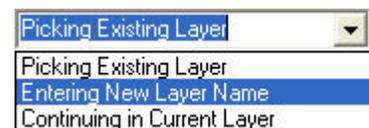


Figure 7
Layer Definition Choice List

- If the layer to be created is to be:
 - (a) a geodatabase, the user will need to enter the appropriate False X, False Y and False XY Units values in the appropriate three data fields of Figure 6.
 - (b) A shapefile, the user should accept the defaults in the above said three data fields.
- Click at the OK button to display the input dialog box of Figure 8.
- Enter the name of the new layer to be created (for example: ModelA), and then



Figure 8
Entering New Layer Name Input Box

- Click the OK button.

Note, if the EPANET map file contains the [LABELS] command, the user should store the data that is processed in a geodatabase and not a shapefile. In processing the [LABELS] command, text or annotation features will be created by the program. By storing the data in a geodatabase, the user will be able to store both, the points and annotation features in a single file, rather than, having the points stored in a shapefile and the annotation features in a geodatabase.

The reader is referred to the May 2005 issue of Command of the Month for detail information describing the False X, False Y and False XY Units parameters. However, summarizing, the False X and False Y values pertain to the coordinates of the low left corner of a rectangle which encloses the points being imported. These values should be such that no data will fall below or to the left of this point.

The False XY units value controls the number of digits to the right of the decimal point that are stored in the PGD for coordinate values. An adequate value for the False XY units parameter would be 10000, which indicates 4 digits to the right of the decimal point will be stored, while a value of 1000 indicates 3 digits. This parameter also controls the upper right corner coordinates of the PGD's extent. A value of 10000 for the False XY units parameter denotes that the upper right corner coordinates of the PGD's extent can be computed by adding 214,748.3647 to each of the False X and Y coordinate values (for a 32 bit computer).

ArcView GIS Users

Use the [Layers] button  in the CEDRA-AVwater button bar, see Figure 9, to set the current active layer.



Figure 9
Entering New Layer Name Input Box

Upon selection of the command, the choice list message box shown in Figure 10 will appear.



Figure 10
Set Active Layer Choice List

The user can then: (a) pick an existing theme or (b) specify the name of the new theme to be created by selecting the appropriate item in the choice list and clicking the OK button.

If the Pick Existing Layer option is selected, the user will pick the current active layer from a list that will be displayed.

If the Enter New Layer Name option is selected, the user will be prompted to enter the name of the new layer to be created. In this case, an input message similar to that shown in Figure 8 will be displayed.

4. Import the Map File

Once the current working directory and active layer have been defined, the user can select the {Import} {Points} command to process the EPANET map and input files. To import the existing EPANET model, the user should now:

ArcGIS Users

- Scroll down in the {CEDRA Commands} combo-box (see Figure 3) and select the [Import Points] command. Upon activation of the command the Browse button will appear as shown below in Figure 11. The user should select this button.



Figure 11
File Browsing Button

After the Browse button has been selected, the command will display a File Selection dialog box, see Figure 12.

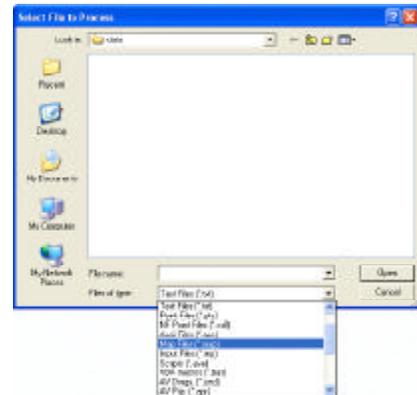


Figure 12
File Selection Dialog Box

- From the Files of Type pull-down list, the user should select the Map Files (*.map) option. Once done, the command will display all of the .map files in the current directory. The user should select the appropriate EPANET map file followed by selecting the Open button.

After the Open button has been selected, the command will display the File Type choice list as shown in Figure 13.

- The user should select the EPANET Map File option and click the OK

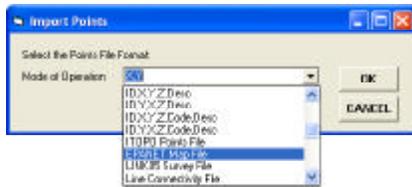


Figure 13
File Type Choice List

button. Selecting this option signifies that the specified file, which was previously selected, is an EPANET map file and that once the map file has been processed the command is to process the associated EPANET input file. If the corresponding EPANET input file does not exist, only the point features in the .map file will be created. No model information is established.

In processing the .map file, the command will store the point features which are created in either an existing layer or a new one, depending upon the name of the current active layer.

If a point layer whose name matches that of the current active layer can be found, the point features will be stored in that particular layer.

If a point layer can not be found, the command will display a dialog box similar to the one shown in Figure 14. Using this dialog box, the user is able to specify the location and name of the new point layer to be created.

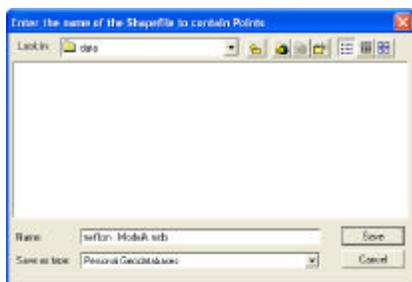


Figure 14
New Point Layer Dialog Box

- Enter the name of the shapefile or the name of the FeatureClass and personal geodatabase to be created and click the Save button.

In Figure 14 it can be seen that the text net1pn ModelA.mdb has been entered in the data field to the right of the Name: label and that to the right of the Save as type: label the option Personal Geodatabases has been selected. This information denotes that the program is to store the point features in a FeatureClass called net1pn within a personal geodatabase called ModelA.mdb.

The FeatureClass name, net1pn, is derived from the name of the EPANET map file (in this case net1.map) and the extension, pn, denoting a point FeatureClass. The name of the personal geodatabase represents the name of the model being imported which in this case is ModelA.

In creating a new layer, the user has the option of storing the point features which are created in either a shapefile or a personal geodatabase. In this example we have specified a personal geodatabase because we know that the EPANET map file contains the [LABELS] command which will result in the creation of annotation features. As stated earlier, when annotation features are to be created, it is recommended that both the point and annotation features be stored in the same personal geodatabase.

Once the Save button has been selected, the program will create and store the point features it comes across in the .map file. If the .map file contains the [LABELS] command, the program will create annotation features. If a layer does not exist whose name matches the name of the current active layer, the user will be asked to specify the name of the layer to be created, see Figure 15.



Figure 15
New Annotation Layer Dialog Box

- Enter the name of the shapefile or the name of the FeatureClass and personal geodatabase to be created and click the Save button.

To store the annotation features in the same personal geodatabase as the point features, the user can enter a text string such as net1tx ModelA.mdb in the data field to the right of the Name: label. Note that we have followed the same convention in establishing the name of the FeatureClass with the exception we have used the extension, tx, to denote a text or annotation FeatureClass rather than the extension, pn, which was used to denote a point FeatureClass.

Once the Save button has been selected, the user will be asked to confirm if the personal geodatabase is to be appended, see Figure 16.

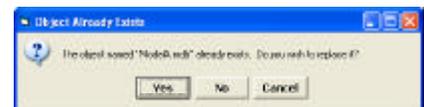


Figure 16
Overwrite / Append PGD Query

- Select the No button to signify that the net1tx FeatureClass is to be added to the ModelA.mdb personal geodatabase.

After the No button has been selected, the program will generate annotation features for each one of the items that appear under the [LABELS] command within the EPANET map file.

Once the EPANET map file has been processed, the command will change the view to display all of the point and any annotation features which were created.

The command then searches for the corresponding EPANET input file. If one can not be found, the command will terminate.

If the corresponding EPANET input file exists, the command will scan the points that have been imported and determine the lowest and highest node numbers

that have been assigned. If the lowest node number is greater than or equal to 1000 the message shown in Figure 17 will be displayed.

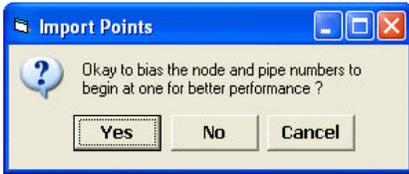


Figure 17
Bias Node / Pipe Numbers Query

At the same time a message similar to the one shown in Figure 18 will appear in the status bar area.

- Select the Yes, No or Cancel button in response to biasing the node and pipe numbers query.

In performing an analysis, the best performance in terms of speed is achieved when a sequential node numbering scheme, beginning at one, is used. To assist the user in obtaining this, the program queries the user if a new node numbering scheme is to be developed. The original node numbers are preserved under the NODENO_OLD field and the new node numbers, beginning at one, are stored under the NODENO field. In computing the new node numbers the program subtracts from the original node numbers, one less than the lowest node number assigned. For example, if the lowest node number is 1001, the program will subtract 1000 from each node number. In so doing the new node numbering scheme begins at one.

If the node numbers are biased, the same process will be applied to the pipe numbers. The original pipe numbers are stored under the PIPNUM_OLD field.

At this point of the model establishment, the user is asked to specify the name of the service area, node and pipe layers

that are to be created. A multi-input dialog box, as shown in Figure 19, will be displayed.

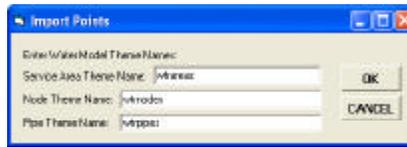


Figure 19
CEDRA-AVwater Model Layer Names

In addition, in the status bar, the program will display the name of the file that was processed and the number of points that were created.

- Enter the name of the CEDRA-AVwater model layers and click the OK or Cancel button.

If the user selects the Cancel button, the command will abort with only the point features in the .map file being created. No model information will be established. If the user enters a theme name that exists, the program will query the user as to if the existing theme is to be overwritten.

A response of Yes will overwrite the existing theme while a response of No will abort the command with only the point features in the .map file being created. No model information will be established.

Once the theme names have been established, the command will process the EPANET input file (.inp) and create the service area, node and pipe themes, as well as, all of the pertinent speciality node tables. As the model is being created, the status bar will be updated reflecting the progress.

Upon successful completion of importing the EPANET model, an information message box similar to that shown in Figure 20 will be displayed.



Figure 20
Importing Results Information Box

- Click the OK button.
- Click the Editor button, on the Editor toolbar, and then select the Stop Editing menu option to commit the edits to disk.

Note that this command generate a complete CEDRA-AVwater model and will replace the model in the current active view if one exists.

Should the EPANET input file reflect a water quality analysis, the user will need to modify the Control Data manually to reflect this. The {Modify} [Control Data] command can be used to accomplish this. The Water Quality option within this command should be selected. The user can then indicate the type of water quality analysis to be performed.

Shown in Figure 21 is a view of the model that is created using the sample .map and .inp files which appeared at the beginning of this bulletin.

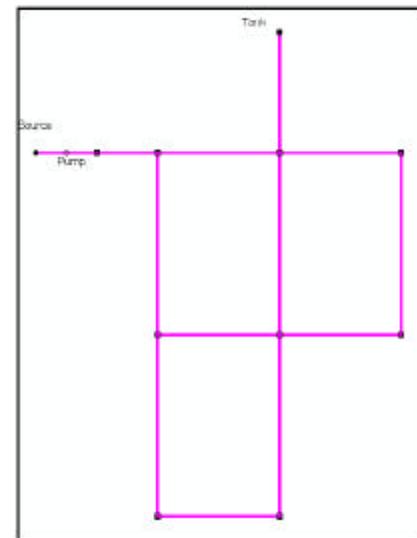


Figure 21
Importing EPANET Model Results

11 Points created. Large node numbers encountered, the lowest node number used is: 2002 and the highest is: 2032

Figure 18 - Information regarding the EPANET Map File Importing

Shown in Figure 22 is the Table of Contents and its contents upon completion of importing the sample .map and .inp files. As can be seen, the net1tx and net1pn layers contain the data in the EPANET map file. The wtrnodes, wtrpipes and wtrareas layers represent the CEDRA-AVwater model layers that were created as a result of the information contained in the EPANET input file.

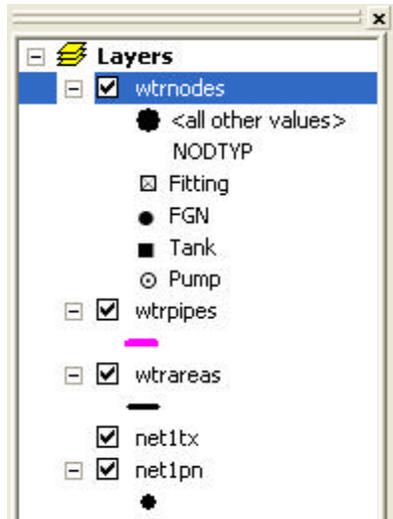


Figure 22
Table of Contents Display

The user can now use any of the available CEDRA-AVwater commands to manipulate the model as desired.

ArcView GIS Users

The importing process is very similar to that described above for ArcGIS users with the exceptions of:

- the location of the {Import} [Points] command,
- there is no ability to create a personal geodatabase, and
- graphic text elements are created rather than annotation features.

Aside from these differences the process of importing the EPANET map file is the same. As a matter of fact, many of the dialog boxes which are displayed look very much the same as those which appear in the ArcGIS version.

As such, ArcView GIS users should perform the following:

- Select the {Import} [Points] command as shown in Figure 23. Upon activation of the command the file selection dialog box of Figure 24 will appear.

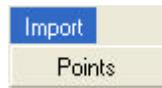


Figure 23
Import Points Command

- Navigate to the folder containing the EPANET map file and select the appropriate file. Once the file has been identified, select the OK button.

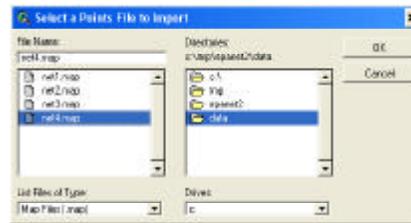


Figure 24
File Selection Dialog Box

- From the file type choice list shown in Figure 25, select the EPANET Map File option and click the OK button.

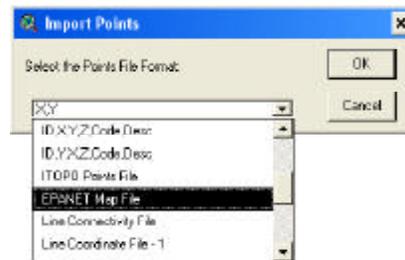


Figure 25
File Type Choice List

Once the EPANET map file has been processed, the command will change the view to display all of the point and any annotation features which were created.

The command then searches for the corresponding EPANET input file. If

one can not be found, the command will terminate.

If the corresponding EPANET input file exists, the command will scan the points that have been imported and determine the lowest and highest node numbers that have been assigned. If the lowest node number is greater than or equal to 1000 the message shown in Figure 26 will be displayed.

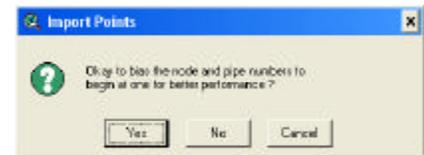


Figure 26
Bias Node / Pipe Numbers Query

- Select the Yes, No or Cancel button in response to biasing the node and pipe numbers query.

At this point of the model establishment, the user is asked to specify the name of the service area, node and pipe layers that are to be created. A multi-input dialog box, as shown in Figure 27, will be displayed.



Figure 27
CEDRA-AVwater Model Layer Names

- Enter the name of the CEDRA-AVwater model layers and click the OK or Cancel button.

The command will now begin to process the EPANET input file and build a CEDRA-AVwater model.

Shown in Figure 28 is a view of the model that is created using the sample .map and .inp files which appeared at the beginning of this bulletin, while Figure 29 shows the contents of the Table of Contents.

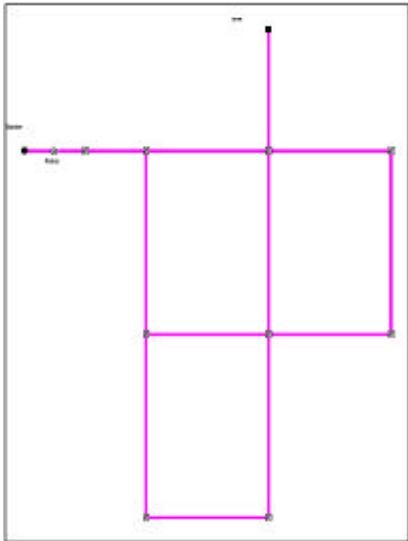


Figure 28
Importing EPANET Model Results

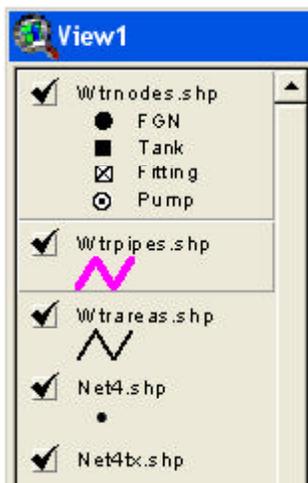


Figure 29
Table of Contents Display

Special Notes

1. When the model is established the pipe features that are created will be two-point lines. Should the pipe features, in actuality, contain intermediate points it is possible to transfer these intermediate points by using the **CEDRA-ChangeFeatures** extension. To do so, a theme containing the true shapes of the pipes should be loaded into the View with the pipes that were created by this command.

The Change Selected Features button, , can then be used with the PIPNUM_OLD field acting as the common field to change in mass the shapes of the water pipes.

If individual pipes are to be processed, the Change Feature's Shape tool, , could be used.

The Change Selected Features button tries to match features in one theme with those in another using a common attribute. In this case the original pipe number acts the common attribute. The user therefore has the option of either creating an alias in the water pipes theme or one in the theme containing the true pipe shapes so that the same field name appears in both themes.

In changing the shapes of features, the Change Selected Features button processes only the selected features. If no features have been selected, an appropriate error message is displayed.

The Change Feature's Shape tool, on the other hand, initially prompts the user to select the feature to be changed followed by picking the feature that represents the new shape. With this tool there does not have to be a common attribute (field).

The reader is referred to the March 2005 issue of Command of the Month for more information describing these two commands.

2. When the user performs an analysis using one of the EPANET interfaces from within CEDRA-AVwater, the program creates the EPANET map (.map) and input (.inp) files during the analysis. As such, the user is able to import these files back into EPANET for additional analysis if desired. Thus, the user is able to import and export EPANET model files using CEDRA-AVwater.

To import a CEDRA-AVwater model into EPANET, the user should select the {File} [Import] [Network...] command and select the appropriate EPANET input file (.inp). All of the model information which appeared in CEDRA-AVwater should now be available within EPANET.

Summary

As stated previously, once the CEDRA-AVwater model has been built, the user can execute the EPANET or EPANET 2 modeler on the imported model. In addition, the results of the analysis are stored as attributes within the CEDRA-AVwater model. As such, the user is able to display, query and graph results of an analysis using the various CEDRA-AVwater commands. This ability further bridges engineering and GIS applications.

If you have a request for Command Of The Month, feel free to phone, fax or e-mail your request to The CEDRA Corporation.