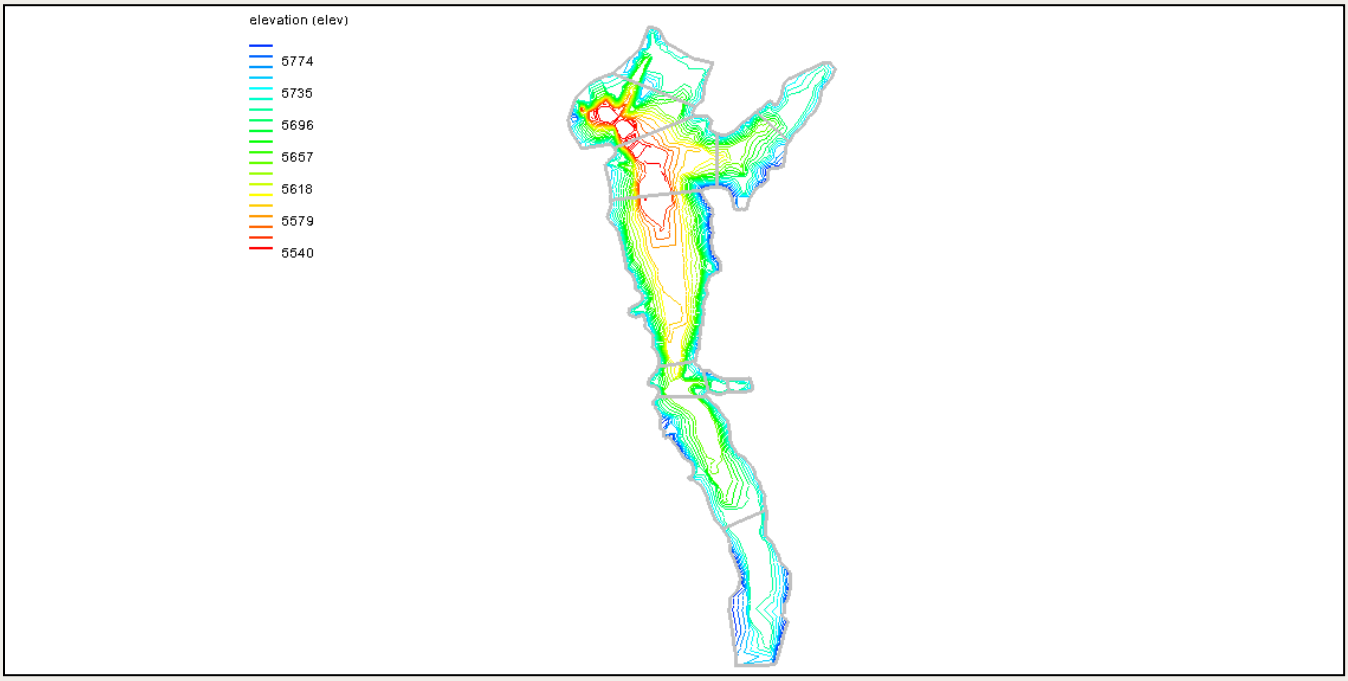
WMS 11.4 Tutorial

CE-QUAL-W2 Interface

Learn how to set up a CE-QUAL-W2 model using the WMS interface



Objectives

In this tutorial, a CE-QUAL-W2 model is set up with its bathymetry data for a reservoir. Water quality data will also be set up, and the files necessary to run CE-QUAL-W2 will be exported.

Prerequisite Tutorials

- Basic Feature Objects
- Using TINs

Required Components

- WMS Core
- CE-QUAL-W2 Model

Time

- 20–40 minutes

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1 Introduction

CE-QUAL-W2 is a 2D laterally averaged hydrodynamic and water quality model. It can model vertical variance, eutrophication, seasonal turnover, algal blooms, etc. if incoming pollutants are known.

Setting up a CE-QUAL-W2 simulation involves dividing the reservoir into segments, branches, and layers and determining the geometric properties of each segment, branch, and layer.

This exercise will walk through the CE-QUAL-W2 WMS interface. It uses a previously generated TIN and creates CE-QUAL-W2 input files.

2 Getting Started

1. Select *File* | **Open** to access the *Open* dialog.
2. Locate the “cequal” folder.
3. Select “EastCanyon.wms” and click **Open** to open the project and exit the *Open* dialog.

3 Determining Reservoir Extent

Now that the TIN has been imported, the boundary of the reservoir must be defined.

There are two ways to generate the boundary of a reservoir. If the TIN has been refined such that the boundary of the TIN is the same general shape as the reservoir (see *Using TINs* tutorial), then let WMS automatically generate the bounding polygon. If not, manually create the bounding reservoir polygon.

1. Right-click on "new" under "Terrain Data" in the Project Explorer and select *Convert* | **TIN Boundary** → **Feature**.
2. Switch to the **Map Module**.
3. Select *Feature Objects* | **Build Polygon**.
4. Click **OK** at the prompt to use all arcs.

4 Create Branch Coverage and Branches

For WMS to process the data correctly, certain types of data must be grouped together as a coverage. In CE-QUAL-W2 modeling, two types of coverages must be created: branch and segment. This tutorial will begin by creating the branch coverage.

4.1 Create Branch Coverage

1. In the Project Explorer, right-click the coverage labeled "Drainage" and select **Properties** to open the *Properties* dialog.
2. Change the *Coverage type* to "CE-QUAL-W2 Branch".
3. Set the *Elevation* as "6000.0" ft, or any elevation above the maximum elevation of the TIN.
4. For the *Coverage name*, enter "Branch".
5. Select **OK** to exit the *Properties* dialog.

4.2 Create Branches

Now that the branch coverage has been created, the next step is to define the branches.

1. Select the **Create Feature Arc** tool.
2. Use Figure 1 as a guide to create two feature arcs (branches) where indicated, by clicking on one bank to begin the arc and then clicking on the other edge of the bank to complete the arc.

It is possible to create a curved boundary. Although this is not common practice, it can be done by simply creating more points along the arc. These steps can be followed to define as many branches as desired, but the two shown in Figure 1 are sufficient for this tutorial.

Figure 1 Branch segments as indicated by arrows.

3. Right-click on the "Branch" coverage and select **Build Polygon**.
4. Select **OK** at the prompt to use all arcs.
5. Choose the **Select Feature Polygon** tool.
6. Click within each of the sections to make sure that polygons are correctly defining the branches. If they are, then the branch should become highlighted.

If the branches are not correctly identified when selected, then most likely the arcs created to define them did not snap to the boundary polygon or polygons have not been built. Using the zoom tool can help identify these problems. The polygons can also be rebuilt after making sure all arcs are correctly snapped. If problem persists, delete the created arcs, recreate the arcs, and rebuild polygons.

5 Create Segment Coverage and Segments

Now everything is ready to start creating segments. It is best to start by creating a segment coverage. Because the branches have already been defined, it is possible to use the branch boundaries to help define the segments.

5.1 Create Segment Coverage

1. In the Project Explorer, right-click the "Branch" coverage and select the **Duplicate** option.
2. Right-click the duplicated coverage, "Copy of Branch", and select the **Properties** option to open the *Properties* dialog.
3. Change the *Coverage type* to "CE-QUAL-W2 Segment".
4. Make sure that the *Elevation* is set to "6000.0", or any elevation above the high point of the TIN.
5. Change the *Coverage name* to "Segment".
6. Select **OK** to exit the *Properties* dialog.

5.2 Create Segments

Now it is possible to create multiple subdivisions (segments) within the reservoir. While doing so, it is unnecessary to create segments where branches were defined previously.

1. Select the **Create Feature Arc** tool.
2. Use Figure 2 as a guide to create feature arcs (segments) where indicated by clicking on the edge of one bank to begin the arc, and then clicking on the other side of the bank to complete the arc. Remember that it is unnecessary to create segments where branches were defined previously.

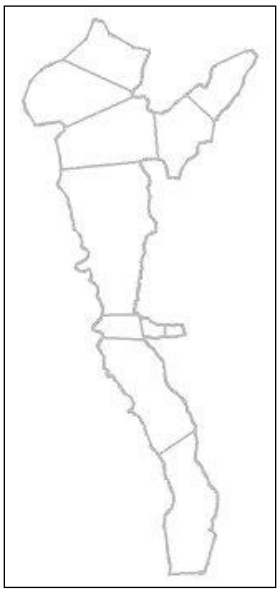

Figure 2 Segment locations

A few notes about segment creation:

- The arcs used to divide the segments should be roughly perpendicular to the general flow direction.
- Only one segment can be present in the area where a branch intersects the main body (branches can only open into one segment).

3. Right-click on the "Segment" coverage and select **Build Polygon**.
4. Select **OK** at the prompt to use all arcs.
5. Choose the **Select Feature Polygon** tool and click within each of the segments to make sure that polygons are correctly defining the segments.
6. Select *File* | **Save As** to bring up the *Save As* dialog.
7. Enter "EastCanyon2.wms" as the *File name*.
8. Click **Save** to save the project and exit the *Save As* dialog.

6 System Modeling

After the segments and the branches have been created, it is a good idea to create a conceptual model of the system. Figure 3 shows a subdivided reservoir, and its accompanying model.

Important parts of the system model include the segments in each branch, the segment that a branch enters into, and the numbering. The general trend in the numbering is that the most upstream segment in each branch has the lowest value (beginning with the segments in the main branch). All segments in a branch should be numbered sequentially. In addition, the first segment in the model should be numbered 2. This is to allow for a dummy segment required by CE-QUAL-W2 to be created as segment 1. Dummy segments are also required at the end of each branch.

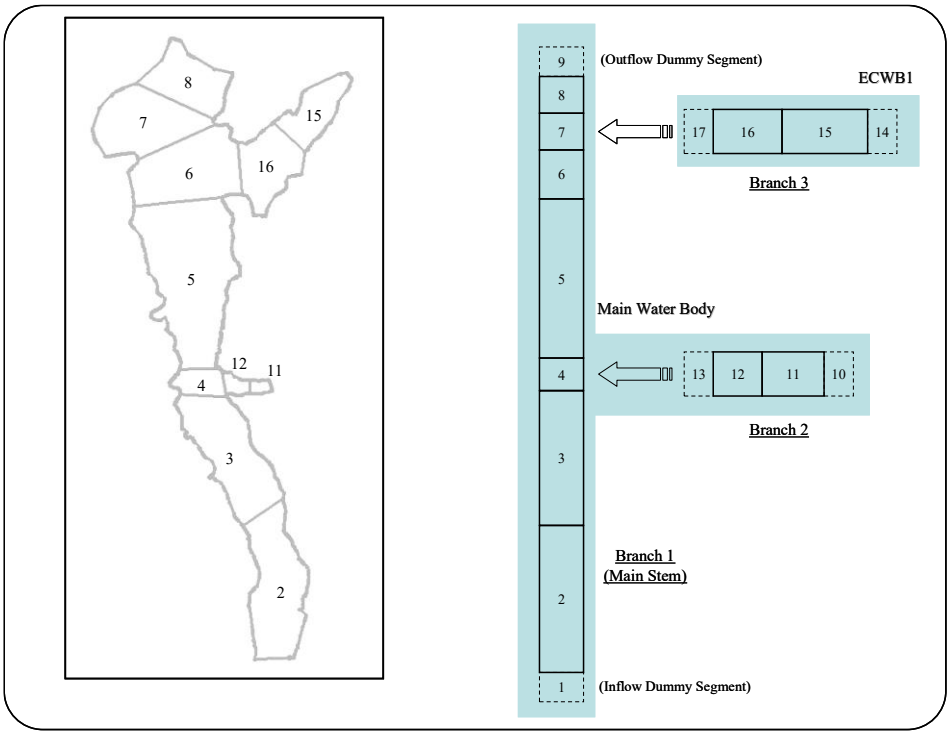

Figure 3 System model

6.1 Initializing CE-QUAL-W2 Simulation

For WMS to generate input files required for CE-QUAL-W2, the interface must be initialized.

1. Select *CE-QUAL-W2* **| New Simulation** in the drop-down menu.

The CE-QUAL-W2 interface is now initialized.

Before beginning branch identification the coordinates will need to be converted from U.S. survey feet to meters. This cannot be performed after obtaining the lengths of the branches since the measured lengths will not be converted along with the contours and polygons.

2. Select *Edit* **| Reproject…** to open the *Reproject Current* dialog.
3. In the *New projection* section, change the *Units* in both the *Horizontal* and *Vertical* sections to “Meters” (make sure *No projection* is selected in the *Horizontal* section).
4. Select **OK** to exit the *Reproject Current* dialog.

6.2 Branch Identification

Each branch must be given its corresponding identification as created in the system modeling step.

1. Select *CE-QUAL-W2* | **Map Segments** ↔ **Branches**.
2. Select the **Select Feature Polygon** tool.
3. Make "Branch" the active coverage by selecting it in the Project Explorer.
4. Double-click on the main branch to bring up the *Polygon Branch Attributes* dialog.
5. Select the **Initialize branch properties** button if it is not dimmed (If this button is dimmed, this means that this particular branch's properties are already initialized).
6. Check the box for *Main stem*.
7. Select the **Get lengths and orientation of branch segments** tool.
8. Select **OK** to exit the dialog that pops up explaining how to use the tool.
9. Click just outside of the most upstream part of the branch (located at the southern end of the reservoir).

NOTE: The upstream segments of the different branches are labeled 2, 11, and 15 in Figure 3.

The length of the branch should generally be equal to the average length of flow that will occur in a branch. To account for a curved flowpath, add as many points along the line as desired.

While tracing the line through the branch, it is best to click at or in each segment to provide a better representation of the orientation of the branch and its segments. Avoid using one line to span multiple segments.

10. Click within each segment of the branch, and then end the line by double-clicking just outside of the most downstream part of the branch. This will open the *Polygon Branch Attributes* dialog.

NOTE: The downstream segments of the different branches are labeled 8, 12, and 16 in Figure 3.

11. Select **OK** to exit the *Polygon Branch Attributes* dialog.

This will give lengths and orientation to each segment in the branch and it also maps the segments to the respective branches.

12. Repeat steps 2–5 and 7–11, for each of the remaining two branches.

6.3 Segment Numbering

Before continuing it is helpful to find the most upstream segment of each branch.

1. Select the **Select Feature Polygon** tool.
2. Double-click on the main branch to open the *Polygon Branch Attributes* dialog.
3. Select the *Segments* tab and highlight the most upstream segment ID.

NOTE: To determine the most upstream segment, exit out of this dialog, highlight the segment coverage, and double-click on the most upstream segment in the desired branch. The segment number will be visible in the *Polygon Segment Attributes* dialog.

4. Select the **Make upstream segment** button.
5. Repeat steps 2-4 for the other branches, by selecting the branch from the list on the left of the dialog.
6. Select **OK** to exit the *Polygon Branch Attributes* dialog.
7. Select *CE-QUAL-W2* **| Segment Numbering**.
8. Select **Yes** in the dialog that appears asking to continue.

This numbers the segments starting with the upstream segment as segment 2 (segment 1 is a dummy segment that is inactive). This also designates the upstream and downstream segments of each branch.

6.4 Editing Segment Properties

Within each segment, many individual properties must be defined. These include the segment length, the layer properties, and the width computations. Figure 4 shows the different parameters required for the segment.

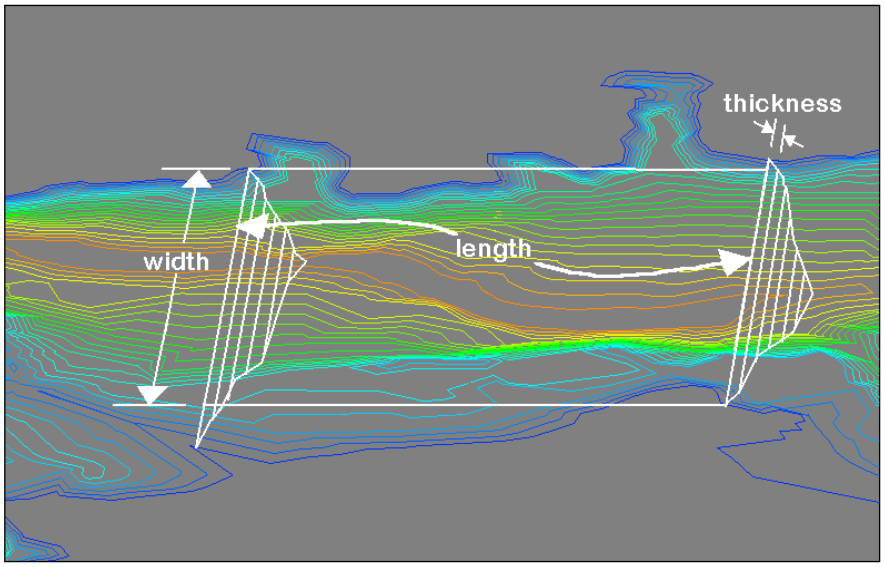

Figure 4 Segment bathymetry

1. Switch to the "Segment" coverage by selecting it in the Project Explorer.
2. Highlight the entire reservoir by selecting *Edit* **| Select All**.
3. Select *CE-QUAL-W2* **| Layers** to open the *CE-QUAL-W2 Layer Editor* dialog.
4. Enter "1768" (meters) in the field labeled *Top Elevation*.

The **Compute Top Elevation** button can also be clicked to automatically compute the overall top elevation for the model.

5. Select the **Compute Rating Curve** button. This will bring up the *CE-QUAL-W2 Layer Editor* dialog.

The computation of the storage capacity curve may take some time. A visual display is generated showing the locations and elevations that are being modeled. Figure 5 shows the CE-QUAL-W2 layer editor where the storage capacity curve is shown.

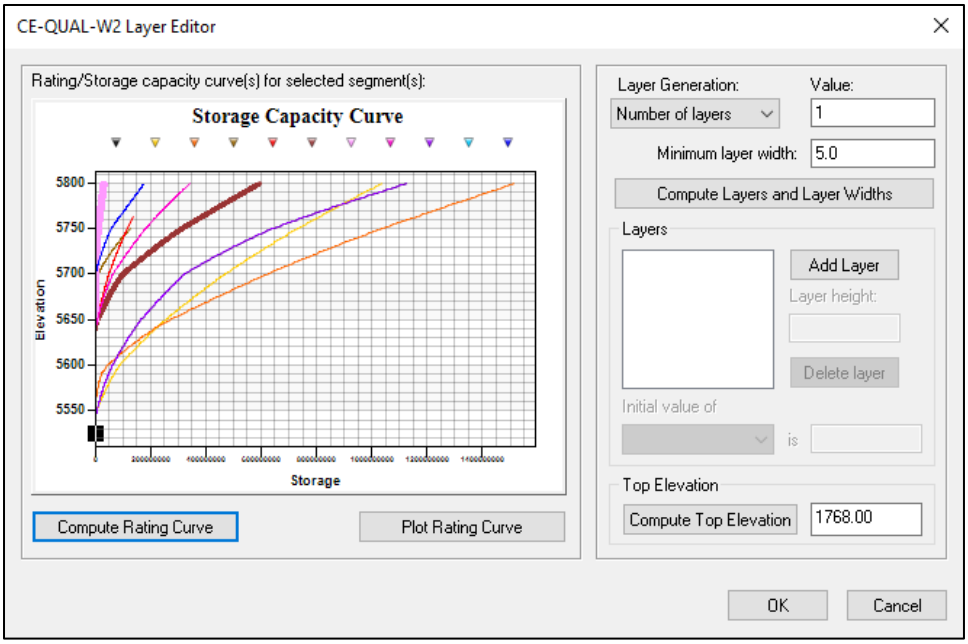

Figure 5 CE-QUAL-W2 Layer Editor

6. Using the *Layer Generation* drop-down menu, select “Layer heights”.
7. Enter “10.0” in the *Value* field.

Notice that the number of layers can be entered instead of a layer height. If the number of layers option is chosen, then the layer height will be calculated using the following equation:

H = (Max elevation on TIN – Min elevation on TIN) / Number of layers

If the layer height option is used, then all of the layers will be that specified thickness, except for the top layer, which will be a remainder of what is left.

8. Click on the **Compute Layers and Layer Widths** button.
9. Exit out of the *CE-QUAL-W2 Layer Editor* dialog by selecting **OK**.

WMS computes the widths of the segments using the layer height, length, and the volume computed from the storage capacity curve. In order for a layer to have a zero width, then its volume must be zero, meaning that the minimum elevation of the segment lies above the maximum elevation of the layer.

7 Editing an Existing CE-QUAL-W2 Model (Control File)

There are two main input files required by CE-QUAL-W2: bathymetry and control files. This section demonstrates how to generate/modify control file parameters.

7.1 Time Step Job Control

1. Select *CE-QUAL-W2* **| Time Step Job Control** to open the *Time Step* dialog.
2. Enter “CE-QUAL-W2 exercise model” in the first line of the *Title* field.
3. Enter “East Canyon” in the second line of the *Title* field.

4. Under the *Start Date/Time* section, select **Modify…** to activate the *Reference Time* dialog.
5. Enter “1998” for the *Year*, “2” for the *Month* and “1” for the *Day*.
6. Select **OK** to exit the *Reference Time* dialog.
7. Under the *End Date/Time* section, select **Modify…** to activate the *Reference Time* dialog.
8. Enter “1999” for the *Year*, “11” for the *Month* and “30” for the *Day*.
9. Click **OK** to exit the *Reference Time* dialog.
10. In the *Time Step Intervals* section, click on **Add Interval**.
11. In the *Time Step Intervals* list box, click on the generated interval.
12. Select **Modify** in the *Selected Interval Parameters* section to bring up the *Reference Time* dialog.
13. Change the *Day* to “9”.
14. Select **OK** to exit the *Reference Time* dialog.
15. Modify the *Maximum Timestep [DLTMAX]* to be “100.0”.
16. Change the *Fraction of Timestep [DLTF]* to be “0.9”.
17. In the *General Timestep Parameters* section, modify the *Maximum Output Dates [NDAY]* to “100”.
18. Click **OK** to close the *Time Step* dialog.

Now that the time step parameters have been set up along with some other general model parameters, more model-specific parameters can be discussed.

7.2 Water Body Job Control

The new version of CE-QUAL-W2 uses the concept of water bodies. A water body can contain one or more branches. Any CE-QUAL-W2 model must have at least one water body. At the start of building a model, WMS will create one water body, main water body, which has all branches assigned to it by default. Nevertheless, water bodies can be created, named as desired, and branches can be switched back and forth between water bodies.

WMS recognizes which segments lay within which branches. This helps WMS when assigning branches to the main water body and automatically detects the location of each water body.

1. Select *CE-QUAL-W2* **| Water Body Job Control** to open the *Water Body Job Control* dialog.
2. Select *Main water body* from the *Current Water Bodies* list box on the left (by doing this, all tabs in the dialog will be undimmed accordingly).
3. Choose the *General* tab.

NOTE: The values shown for X and Y coordinates are the automatically detected locations of the first segment that lies in the main water body. These values can be manually edited to write geographic coordinates (required by CE-QUAL-W2), or use the Convert to Lat/Lon button.

4. Enter “41.5” for the *Latitude* and “-118.0” for the *Longitude.*
5. Click the *Output* tab.

6. Turn on *Screen Output*, *Profile Plot Output*, and *Snap Shot Output*.
7. Click on the **Dates** button to the right of *Screen Output* to open the *Dates – Screen Print* dialog.
8. Click **Add Date**.
9. Select the added date and click **Edit** to open the *Reference Time* dialog.
10. Change the *Year* to “1998”, the *Month* to “5”, and the *Day* to “1”.
11. Click **OK** to exit the *Reference Time* dialog.
12. Change *Frequency* to “10”.
13. Click **OK** to exit the *Dates – Screen Print* dialog.
14. Repeat steps 7-13 for *Profile Plot Output* and *Snap Shot Output*.
15. Click **OK** to close the *Water Body Job Control* dialog.

The initial input parameters for CE-QUAL-W2 can now be used. The *Water Body Job Control* dialog will be used later to enter constituent details and kinetic coefficients.

7.3 Editing Segments

This section demonstrates how to edit segment parameters, define length, and set orientation and friction parameters.

1. Select *CE-QUAL-W2* **| Segments** to open the *Polygon Segment Attributes* dialog.
2. Click on the first segment on the list (“Segment 2” from the *Segments* list box).

Notice that this segment has a length and orientation already defined in the *Length of segment* and *Segment orientation* fields respectively. These values were defined when the measure tool was used to measure the branches in the previous section. If segment length and orientation are not already defined, these values can be defined using the measure tool in the segments dialog.

3. Enter “0.04” for the value of *Bottom Friction*.
4. Enter “0.04” for *Bottom Friction* for all the segments in the model.
5. Click **OK** to exit the *Polygon Segment Attributes* dialog.

7.4 Structures

The next step is to add structures to the model or modify existing structures. WMS allows one structure for each node in the branch coverage. If there are multiple structures in the same place, as many nodes as needed can be added close to that location and a structure for every node can be assigned.

1. Click on the “ Branch” coverage in the Project Explorer to make it the active coverage.
2. Create a new node as shown in Figure 6 using the **Create Feature Point** tool.

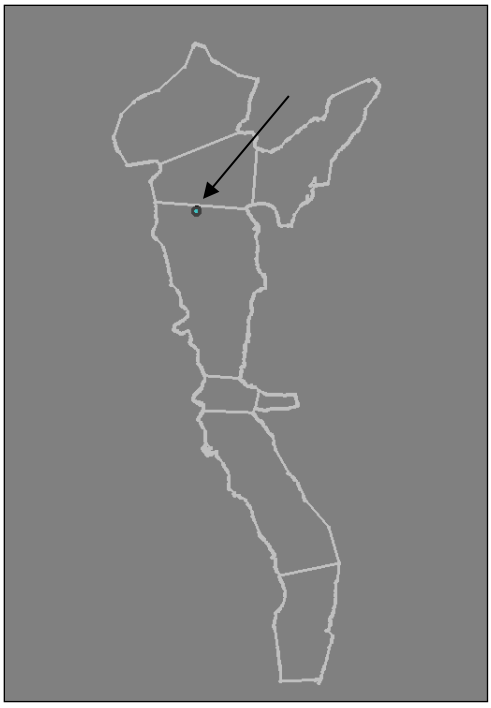

Figure 6 Insert node

3. Click on the **Select Feature Point/Node** tool.
4. Double-click on the new node to open the *Node Attributes* dialog.
5. Select *Spillway* and then **Atts….** to open the *Define Spillways* dialog.
6. Enter “2” for the *Spillway Outflow Segment (IDSP)*, and “1676.4” for the *Spillway Elevation (EGT)*.
7. Enter the following values in the *Spillway Coefficients* section:
    a. *a1(A1SP):* “44”
    b. *b1 (B1SP):* “1.5”
    c. *a2 (A2SP):* “34”
    d. *b2 (B2SP):* “1”
8. Turn on the *Compute Dissolved Gas (GASSPC)* check box.
9. Choose *Spillway Equation (EQSP)* number “2” from the drop-down list.
10. Enter the following values in the *Coefficients* section:
    a. *A (ASP):* “10”
    b. *B (BSP):* “110”
    c. *C (CSP):* “10”
11. In the *Upstream Spillway* section, for *Spillway Flow Type (PUSPC)*, choose “DISTR” from the drop-down menu.
12. Enter the following values in the *Upstream Spillway* section:
    a. *Spillway Top Elevation (ETUSP):* “1697.7”
    b. *Spillway Bottom Elevation (EBUSP)*: “1691.6”

c. *Top Withdrawal Layer (KTUSP)*: “3”

d. *Bottom Withdrawal Layer (KBUSP)*: “4”

13. Click **OK** to close the *Define Spillways* dialog.
14. Click **OK** to close the *Node Attributes* dialog.

The spillway has now been defined at the specified location. Other structures can be defined as needed.

7.5 Constituent Control

The constituents and kinetic coefficients will need to be modified by doing the following:

1. Select *CE-QUAL-W2* **|Water Body Job Control** to open the *Water Body Job Control* dialog.
2. Select *Main water body* from the *Current Water Bodies* list box on the left.
3. Click on the *Calculations* tab.
4. In the *Constituent Computations* section, turn on *Compute*.
5. Click the **Constituent Control** button to bring up the *Constituent Control* dialog.
6. In the *Additional Constituents* section, select “Algal Group” from the *Constituent Type* combo box, and leave “Algae 1” as the *Constituent Name*.
7. Click the **Add Constituent** button.
8. Similarly, add another “Algal group” (*Constituent Name*: “Algae 2,”) and two “Epiphyte groups” (*Constituent Names*: Epiphyte 1 and 2) by repeating steps 6-7.
9. Using the *Ctrl* key, multi-select “Algae”, “Algae 1”, “Algae 2”, “CBOD”, “Epiphyte 1” and “Epiphyte 2” in the *Current Constituents* section.
10. Turn on *Active* in the *Current Constituents* section.
11. Click **OK** to exit the *Constituent Control* dialog.

CE-QUAL-W2 enables modelers to create personalized versions of five pre-specified constituent groups: algae, epiphyte, CBOD, generic, and inorganic suspended solids. This section described how to add these. The next section discusses how to modify the constituent-specific kinetic coefficients.

7.6 Kinetic Coefficients

This section demonstrates how to edit algal and epiphyte group parameters.

1. Make sure the *Calculations* tab in the *Water Body Job Control* dialog is open.
2. Click on the **Kinetic Coefficients** button to open the *Kinetic Coefficient* dialog.
3. Make sure that the *Algae* tab is selected.
4. Select “Select All Algal Groups” from the *Algal Group* drop-down menu.
5. Change *AT2* to “32.5”.
6. Select “Algae 2” from the *Algal Group* menu, and change *AT2* to “37.5”.
7. Select “Algae 1” from the *Algal Group* menu, and change *AT2* to “22.5”.

Now assume that all algal groups share the same coefficients except AT2, which is different for Algae 1 and 2 as specified above.

8. Select the *Epiphyte* tab and choose “Select All Epiphyte” from the *Epiphyte Group* drop-down menu.
9. Change *ESAT* to be “55”.
10. Select “Epiphyte 1” from the *Epiphyte Group* menu.
11. Change the following values as listed below:
    a. *ET1:* “10”
    b. *ET2:* “32”
    c. *EK3:* “0.75’
    d. *EK4:* “0.5”
    e. *EG:* “7”
    f. *ER:* “0.1”

Similar to the algal groups, assume that all epiphyte groups share the same coefficients except ET1, ET2, EK3, EK4, EG, and ER, which are different for Epiphyte 1, as specified above.

12. Select **OK** to exit the *Kinetic Coefficient* dialog.
13. Select **OK** to exit the *Water Body Job Control* dialog.

8 Saving CE-QUAL-W2 Input Files

This section discusses the CE-QUAL-W2 input files that will be created. WMS generates one control file for the model, as well as one bathymetry file for each body of water in the model.

1. Select *CE-QUAL-W2* **| Save Simulation** to open the *Save CE-QUAL-W2 Simulation* dialog.
2. Click **Save** to accept the default filenames and exit the *Save CE-QUAL-W2 Simulation* dialog.

For the *Control filename*, make sure that the prefix is no longer than 8 characters long.

Note that only the first four characters of the prefix of the bathymetry filename can be edited. WMS automatically adds four additional characters to that prefix. These are _wb1, _wb2 and so on for as many water bodies as might exist in the model.

In saving the simulation, two main files are created: the control file and the bathymetry file. One control file is generated for the whole model, however, there are multiple bathymetry files generated for each water body in the model.

9 Conclusion

This exercise demonstrated the CE-QUAL-W2 interface in WMS, including the following topics:

1. Creating branches
2. Creating segments
3. System modeling
4. Initializing CE-QUAL-W2 simulation
5. Identifying branches
6. Mapping segments to branches
7. Editing branch/segment properties
8. Saving CE-QUAL-W2 control input file
9. Saving bathymetry as CE-QUAL-W2 input file