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EPA WATER TREATMENT PLANT MODEL FOR MS WINDOWS 3.1

VERSION 1.51

Water Treatment Plant Model
for MS Windows 3.1
Version 1.51

The Water Treatment Plant Model (WTP) was originally developed in support of the Disinfectant/Disinfection Byproducts Rule. It was prepared with the understanding that the predictions should reflect the central tendency for treatment. It is not to be construed that the results from the model will necessarily be applicable to individual raw water quality and treatment effects at unique municipalities. This model does not replace sound engineering judgement based on site-specific treatability data to evaluate the best manner in which to address the requirements of the SWTR or potential D/DBP Rule.

It is understood that one limitation of the model is the extent of the data base available to verify model predictions. In a desire to systematically improve the overall predictive capability, the intent of this release is to solicit public comment on the usefulness and relative accuracy of the predictions on a case-by-case basis. To this end, WTP model includes a method to enter laboratory analysis so that a comparison can be made to the model predictions.

The USEPA encourages constructive comments on methods to improve the model, results from verification efforts, and utility data that can be used to enhance the overall applicability of the model. Please forward comments to:

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Updates to the model can be obtained by calling the Safe Drinking Water Act Hot Line 1-800-426-4791.

The guidance provided herein may be of educational value to a wide variety of individuals in the water treatment industry, but each individual must adapt the results to fit their own practice. The USEPA shall not be liable for any direct, indirect, consequential, or incidental damages resulting from the use of the WTP model.

The user manual for version 1.5 is in preparation and is expected to be available January 1994 by calling the Safe Drinking Water Act Hot Line. The following contains information on installing WTP and using the model.

Hardware requirements:

WTP will run on any system equipped with MS-Windows 3.1 or later however due to the intensity of the calculations a numerical coprocessor is recommended.

Hard Disk Installation:

The distribution disk contains a simple 'Install' program which will create a directory named C:\WTPWIN and copy the distribution files into the directory.

1) Insert the distribution disk into drive A or B and, from the C prompt, type in the following.

```
C:\> A:Install A
       or
C:\> B:Install B
```

2) If you have been using a previous DOS version of WTP and have process train data files that you wish to use with the windows version of WTP then copy the process train data files to the WTPWIN directory as follows.

```
C:\>copy C:\WTPDOS\*.WTP  C:\WTPWIN
```

where C:\WTPDOS is the name of the directory containing your dos version of WTP.

3) The following procedure is preformed in MS-Windows and will create a group icon for WTP and create an item icon for WTP.EXE model. Start MS-Windows as follows.

```
C:\> win
```

You should now be in windows 'Program Manager'

First Time Windows Users:

MS-Windows has an on-line tutorial which covers the basics of using windows. The tutorial is accessed from the 'Program Manager' by clicking (left mouse button) on the menu selection 'Help' and then clicking on 'Windows Tutorial'. If you feel uncomfortable using the following procedure then use the tutorial to get an overview of using windows.

a) Using the mouse, click (left button) on the Program Manager menu selection 'File' located at the top left of the screen. A drop down menu will appear.

b) Using the mouse, click on the drop down menu selection 'New'. A 'New Program Object' requester will appear.

c) Select 'Program Group' by clicking on it. The black dot should be located to the left of 'Program Group'.

d) Click 'OK' in the 'New Program Object' requester. A 'Program Group Properties' requester will appear.

e) In the Description box type in WTP. This is the title that will appear below the group icon. Note: the title no relation to the name of the WTPWIN directory.

f) Click on 'OK' in the 'Program Group Properties'. The requesters will disappear and a program group window titled WTP will appear.

g) Using the mouse, click on the Program Manager menu selection 'File' and 'New' as done in step a) and b).

The 'New Program Object' requester will reappear.

h) This time select 'Program Item' by clicking on it. The black dot should now be located to the left of 'Program Item'.

i) Click on 'OK' in the 'New Program Object' requester. A 'Program Item Properties' requester will appear.

j) In the 'Description' box type in WTP.

k) Move the cursor to the next box by using the mouse to click on the 'Command Line' box. The cursor should now be in the 'Command Line' box.

l) In the 'Command Line' box type in the following:
C:\WTPWIN\WTP.EXE

m) Click on 'OK' in the Program Item Properties. The requester will disappear and the WTP item icon will appear in the WTP group window.

n) Re-size the WTP group window to a reasonable small size.

o) Close the WTP group window by double clicking the system close button located in the upper left of the WTP group window. The window will close and the WTP group icon will appear at the bottom of the screen.

Water treatment plant model is now installed.

Starting WTP Model:

1) Double click on the WTP group icon.

2) Double click on the WTP item icon.

3) First time use of WTP Model:
At this point the main screen of WTP will fill the monitor. Across the bottom of the window is a series of buttons that can be clicked using the mouse. The user interface is designed such that the buttons across the bottom control most of the action. A menu is at the top which contains additional selections for 'File', 'Display', and 'Edit'.

4) In the following guided tour a conventional water treatment plant is made up which is out of compliance with the THM MCL. The plant is brought into compliance by improving coagulation, adjusting pH, and changing the point of chlorination.

Using the mouse, click (left button) on the 'Edit' button. The 'Edit Process Train' screen will appear. On the left half of the screen is the process train -- at the moment there is only an 'Influent'. At the bottom of the left half of the screen are four buttons to manipulate the process train. The four buttons are labeled 'Move', 'Edit', 'Delete' and 'Clear'. Use of these buttons are described later in this guided tour.

On the right half of the screen are three lists of "Available Selections" that can be added to the process train. The three lists are 'Unit Processes', 'Chemical Feeds' and 'Sample Points'.

Now generate a conventional treatment process train by clicking on the following selections in the "Available Selections" section of the screen.

Alum
Rapid Mix
Flocculation
Settling Basin
Filtration
Contact Tank

Clearwell
WTP Effluent
End of System

The left half of the screen should now show 'Influent' followed by above unit processes, chemical additions, and sample points.

5) Chlorine was purposely not included in the above so that moving the point of chlorination could be demonstrated. On the right side of the screen, click on 'Chlorine' in the Chemical Feeds list. Chlorine will appear at the end of the process train list on the left side of the screen. To move the point of chlorination to follow the Influent is a three step process. First click on 'Chlorine' in the process train. A highlight will appear on Chlorine. Second, click on the 'Move' button. A small check mark will appear next to the 'Move' button to indicate that the process train editor is in the move mode. The move mode can be canceled by clicking the 'Move' button a second time. Try it, when finished set the check mark to move mode. Third, with "Chlorine" highlighted and the check mark next to the 'Move' button, click on "Influent". The point of chlorine addition will move to follow Influent.

The 'Move' button is designed to be intuitive and will respond to other combinations of mouse clicks. The fundamental logic is that the highlighted unit process will be moved to FOLLOW the next click. The highlight can be placed on anything in the process train and any unit process can be moved to any point in the process train except before the Influent. Influent will always be first. Experiment with the "Move" button until you feel comfortable with its operation.

6) Now challenge this plant with a poor water quality. Click on the 'Edit' button at the bottom left of the 'Process Train' screen. The "Influent Parameters" screen will appear. The default values shown in the "Influent Parameters" screen (and all other parameter screens) are generally believed to be national averages. Index through the parameters using the tab key on the keyboard to go forward, shift tab to go backward, or using the mouse to click (left button) directly on any parameter. The 'Enter' key does nothing.

Challenge this plant by changing the following:

TOC	12.0
UV	1.0
Turbidity	50.0

This plant now has a challenge!

In the lower right of the screen are buttons labeled 'Next' and 'Prev'. These buttons accept any changes made and index to the next or previous unit process in the process train. Click on the 'Next' button at the lower right of the Influent Parameters screen and the parameters for the next unit process will appear. It should be "Chlorine Parameters". Experiment with 'Next' and 'Prev' until you feel comfortable. If you happen to drop back to the "Edit Process Train" screen, click "Edit" to return to the Influent Parameters screen.

Bring up the Chlorine Parameters screen and change the chlorine dose to 10 mg/L.

Many of the screens have buttons labeled 'OK' and 'Cancel'. The 'OK' button will accept any changes made and return to the parent screen. The 'Cancel' button will cancel any changes made and return to the

parent screen. Each screen also has a system close button located at the top left of the screen which functions identically to the 'Cancel' button.

After changing the chlorine dose to 10 mg/L on the Chlorine Parameters screen click the 'OK' button and return to the "Edit Process Train" screen.

On the Edit Process Train screen, click "OK" to return to the main screen.

7) Predicting water quality:
One of the objectives of WTP is to predict water quality through the treatment process train and distribution system using water chemistry and correlation equations. The calculations are performed by clicking on the 'Run' button (Run for the lack of a better name) on the main window.

Now click on the 'Run' button and the display is filled with the predicted water quality. Note: on a 386-SX this takes about 5 seconds.

There are a total of 5 tables of which Table 1 is now fully visible. The scroll bar at the right will scroll the display through the other tables. Try scrolling the display now by using the mouse left button to press and hold the small down arrow at the bottom right of the screen. The screen scrolls down until the button is released. Now try the up arrow at the top of the scroll bar. The scroll bar also has a knob between the two arrows which can be "dragged" using the mouse. Drag the knob now using the mouse left button to hold down the knob and move the mouse down the screen. The screen scrolls as the knob is moved. The screen can also be scrolled by clicking inside the scroll bar between the arrow and knob. The screen will scroll by about 8 lines each time the scroll bar is clicked. (The smoothness of the scrolling is dependent on the processor and video board).

Table 1 includes pH, TOC, UV, Bromide, Temperature, free chlorine residual (Cl2), monochloramine (NH2Cl) and ammonia (NH3-N). These parameters are the major inputs to disinfection byproduct formation.

Now scroll to Table 2. Table 2 includes pH, Alk, Ca and Mg hardness, and sludge production. This table would illustrate softening if it occurred.

Table 3 and 4 contain the predicted trihalomethane (THM) and predicted haloacetic acid (HAA) formation. This plant has problems with both the THM and HAA.

The predictions in Tables 1 through 4 are at the average operating conditions. Specifically, the average temperature and average flow. Table 5, however, is disinfection/inactivation and is at the minimum temperature and maximum flow which is the worst case condition for disinfection. Of interest is the column labeled "Inactivation Ratio". The Inactivation Ratio is the disinfection/inactivation achieved divided by the inactivation goal. For surface water plants the inactivation goal is based on the influent Giardia cysts concentration as described in the SWTR guidance manual. For groundwater plants the inactivation is based on 4 log (99.99%) inactivation of virus. The inactivation ratio is estimated through the treatment plant up to the first customer. Inactivation Ratios

greater than 1.0 have sufficient disinfection and values less than 1.0 do not have sufficient disinfection.

This plant is meeting the inactivation goal, but not meeting the current TTHM MCL (Table 3). The plant will also probably be out of compliance with any potential HAA MCL (Table 4).

8) Enhance Coagulation:
Now increase the alum doses to 50 mg/L and add sulfuric acid after alum addition to lower the pH to achieve better removal in the coagulation/settling unit processes and better inactivation with free chlorine. Also move the point of chlorination to after the settling basin to cut down on byproduct formation. A general guide is to add sufficient sulfuric acid to lower the pH to about 6. The amount of sulfuric acid to add is a trial and error procedure. Try it on your own before reading the following detailed directions.

a) From the main window, click on the 'Edit' button and the Edit Process Train screen will appear.
b) Move the point of chlorination to after the settling tank by clicking on Chlorine in the process train list, clicking on move, and clicking on Settling Basin in the process train list.
c) Here is a new trick. Insert Sulfuric Acid after Alum in the process train by first clicking on Alum. The highlight is now on Alum. New additions to the process train are inserted after whatever is highlighted. Now click on Sulfuric Acid in the Chemical Feed list. Sulfuric acid is inserted into the process train following Alum. There are many ways to accomplish the above objective.
d) Here is another new trick. Change the Alum dose by double clicking (left mouse button twice, quickly) on Alum in the *Process Train* screen. *The Alum Parameters screen will appear.* Double clicking on any unit process in the process train will activate its parameter screen. Change the alum dose to 50 mg/L.
e) In the Alum Parameters screen, click on the 'Next' button to look at the sulfuric acid dose. How much sulfuric acid is needed to achieve a pH of 6.0? It's try and error, don't worry about it now. Leave the sulfuric acid dose at 1.0 mg/L for now. (Note: if the influent pH was accidentally changed, the original value was pH 7.7).
f) Click 'OK' on the sulfuric acid screen and the Edit Process Train screen will appear. The process train should be as follows:
    Influent
    Alum
    Sulfuric Acid
    Rapid Mix
    Flocculation
    Settling Basin
    Chlorine
    Filtration
    Contact Tank
    Clearwell
    WTP Effluent
    End of System
g) Click 'OK' on the Edit Process Train screen and the main window will appear with Table 1 updated to reflect the changes. On a 386-SX this will take about 5 seconds.
h) In Table 1, note the pH at the point of sulfuric acid addition. We want a pH of about 6.0 at this point thus, more sulfuric acid is needed to lower the pH. On the main window click

'Edit', on the Edit Process Train screen double click Sulfuric Acid and on the Sulfuric Acid Parameters screen make a new guess for the proper sulfuric acid dose. Click 'OK' on the Sulfuric Acid Parameters screen and 'OK' on the Edit Process Train screen and note the pH at the point of sulfuric acid addition on Table 1. Repeat this step until pH 6.0 is obtained at the point of sulfuric acid addition. (The sulfuric dose should be about 10 mg/L).

Coagulation has now been enhanced. Examine the 5 tables and observe the effect on the various parameters.

9) DBP and Disinfection display.

On the main window click on the 'DBPs' button and Table 6 will be displayed. Table 6 is a summary table which contains the pH, free chlorine residual, monochloramine, Inactivation Ratio, TTHM and THAA. The Inactivation Ratio is at the minimum temperature and maximum flow while the other parameters are at average conditions.

Now lower the chlorine dose such that 2.0 mg/L or less is at the WTP Effluent and the Inactivation Ratio is 1.0 or greater. This is a trial and error procedure similar to the sulfuric acid dose. The chlorine dose should be about 3.0 mg/L.

On the main window examine the Inactivation Ratio, TTHM and THAA at the WTP Effluent. The plant is now in compliance with the disinfection requirements of the SWTR and in compliance with the current TTHM MCL. But there is more to be done, the pH in the distribution system is too low and there is no chlorine residual at the "End of System".

10) Add Ammonia after the clearwell to convert the free chlorine to monochloramine and maintain a residual in the distribution system. The proper amount of ammonia is about 0.4 mg/L. Observe Table 1, at the point of ammonia addition the free chlorine (Cl2) has been converted to monochloramine (NH2Cl) and there is a small ammonia residual.

11) Add sodium hydroxide after ammonia to adjust the pH to about 8. The proper amount is a trial and error procedure and should be about 30 mg/L. Again observe Table 1 to see the effect. Note: Soda Ash could be used in place of sodium hydroxide.

This completes the guided tour of using WTP. The following describes the menu functions, control buttons and other features of WTP.

Main Window:

Main Title and Working File Name

The title at the top of the main window is generally:
"U.S. Environmental Protection Agency - Water Treatment Plant Model"

The title at the top of the main window is replaced with the working file name when WTP model is working with process train data that is stored on disk. As an example save the guided tour process train (or any process train) as follows.

From the main window menu select 'File ¦ SaveAs'. A "Save Process Train & Unit Process Data" file requester will appear. In the "Filename" box type in test.wtp and click 'OK'. The process train data are saved to the disk and the title at the top of the window will change to reflect the working file name.

Menu

File

New

This selection will prepare WTP model to start a new process train. Any existing process train data are cleared from WTP along with the name of the working file. Data stored in a disk file are not cleared.

Open

This selection will read process train data from a disk file and track the working file name. Internally the Open function preforms a 'New' operation before reading in data.

Save

This selection will write process train data to the working file without prompting the user. If a working file name does not exist then a SaveAs selection is automatically preformed.

SaveAs

This selection will prompt the user for a working file name then save the process train data to the data file. This selection provides an opportunity to change the working file name.

Print

This selection will print the main window display on the system printer.

Print To File

This selection will save the main window display to a disk file in ASCII format. Any previous contents of the disk file are LOST. The user is prompted to supply a file name with a .lst extension. The disk file can then be loaded into word processor for further use.

Append To File

This selection will append the main window display to the end of a disk file thus not loosing the previous contents of the disk file. The user is prompted to supply a file name with a .lst extension. The disk file can then be loaded into a word processor for further use.

Exit

Quit WTP and return to MS-Windows.

Display

Process Train

This selection will display the names of the unit processes, chemical feeds, and samples points in the process train. The display is in the main window display area.

Unit Process Data

This selection is similar to "Display ¦ Process Train" but includes the unit process data.

Water Quality

This selection will run the model and display 5 tables of water quality parameters.

Disinfection & DBPs

This selection will run the model and display one summary table containing worst case disinfection and average byproduct formation.

Edit

Process Train

This selection will open the 'Edit Process Train' screen. See 'Edit Process Train' for details.

Control Buttons

Open: Same as menu selection File ¦ Open

Edit: " " " " Edit ¦ Process Train

Run :	"	"	"	Disp	Water Quality
DBPs:	"	"	"	Disp	Disinfection & DBPs
Save:	"	"	"	File	Save
Exit:	"	"	"	File	Exit

Edit Process Train

The "Edit Process Train" screen is used to configure the process train. Unit processes, chemical feeds and sample points can be inserted, repositioned or deleted in this screen.

Process Train

The left half of the screen is the process train and control buttons.

List Box

This section of the Process Train display illustrates the current process train which can consist of any number of unit processes, chemical feeds and sample points (collectively referred to as items). Any of the items in the process train can be highlighted by clicking with the mouse. The highlighted item is the point where new items are inserted into the process train. The highlighted item is also used with the 'Move' button. Double clicking an item will open the parameter data entry screen starting with the selected item. A scroll bar is on the right side of the list box and will become active if the process train contains more items than will fit in the display.

Move button

This selection will reposition an item in the process train. The procedure is to first highlight an item, click the move button, and click on the point in the process train where the highlighted item should be repositioned. The 'Move' operation will reposition the highlighted item such that the highlighted item will follow the clicked item in the process train.

Edit button

This selection will open the Parameter data entry screen starting with the Influent. Note: double clicking any item in the process train list box will open the parameter data entry starting at the selected item.

Delete button

This selection will delete the highlighted item from the process train. Any data associated with the item are lost.

Clear button

This selection will delete all items from the process train. Be careful, 'Clear' may appear to be similar to the main window 'File ¦ New' selection but there are differences. The difference is that the 'Clear' button will retain the working file name while the main window menu 'File ¦ New' selection will also clear the working file name. With 'Clear', WTP considers the now empty process train to be associated with the working file name. Clicking the 'Save' button on the main window will overwrite the working file without a second warning. Please use 'File ¦ New' if a new disk data file is desired.

Available Selections

Unit Processes

Chemical Feeds

Sample Points

These three list boxes contain selections that can be added to the process train. Clicking on any selection will insert the selection into the process train following the highlighted item in the process train or, if no highlight, append the selection to the end of the process train.

Cancel button

This button will cancel all changes made to the process train and also cancel all changes made in the parameters data entry screens. Control is returned to the main window.

OK button

This is the normal method of return to the main window. All changes are passed back to the main window and the display area of the main window is updated.

Data Entry Screen

There are many data entry screens for unit process data, chemical feed doses, location of sample points, and laboratory analysis collectively referred to as data entry screens. All the data entry screens have the following features and control button.

Screen Title

The title at the top of the data entry screen indicates the name of the unit process, chemical feed, sample point, or laboratory analysis that the data entry screen is associated with.

Next button
Prev button
OK button

The 'Next' and 'Prev' buttons will index through the data entry screens associated with the process train. 'Next' indexes to the next data entry screen while 'Prev' indexes to the previous data entry screen. The 'OK' button will return to the Edit Process Train screen. When clicked, 'Next', 'Prev' and 'OK' check for valid data in each data element, pass new data back to Edit Process Train, and then index to the next data entry screen. Both 'Next' and 'Prev' will return to the Edit Process Train screen if the data entry screen is the first or last data entry screen in the process train.

Cancel button

The 'Cancel' button will cancel changes made in the current data entry screen and return to the Edit Process Train screen. Note: changes made on other data entry screens are passed back to Edit Process Train when 'Next' and/or 'Prev' is pressed. If changes are made on other data entry screens and the current data entry screen is arrived at via 'Next' and/or 'Prev' then pressing 'Cancel' will cancel only the current data, not changes made to the other data entry screens.

As stated at the beginning of this document, it is desired to systematically improve the user interface and predictive capability of WTP. The intent of this release is to solicit comment on the usefulness and relative accuracy of the prediction. Please forward constructive comments, results from verification efforts, and utility data to the name and address shown at the beginning of this document. Thank you.