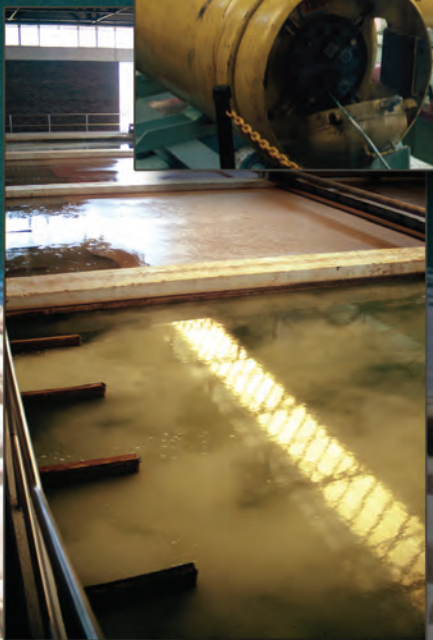
WATREX

Expert System for Water Treatment Plant Design

User Manual - Release 5.0

FR Sutherland



TT 206/03

Water Research Commission

WATREX EXPERT SYSTEM

for

Water Treatment Plant Design

User Manual

Release 5.0

Report to the Water Research Commission

By

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SUMMARY - WATREX EXPERT SYSTEM

This is a Windows-based software package that applies expert system technologies to water treatment plant design. The software allows data acquisition, unit process design and modelling, process selection, and dynamically responding plant design, modelling and sensitivity analyses.

An expert system shell and populated knowledge base concept is used, with modular data storage for knowledge acquisition frames. Data for a selected number of water treatment unit operations and processes has already been researched and entered into the knowledge base. The knowledge base acts as a repository for expert knowledge about unit processes and is also called upon by the expert system during plant design and process selection. It can be extended and edited by the user.

The unit processes are text-book designs that can perform: sizing of the tanks, complex estimation of performance and effects on water, relative applicability to various situations and warnings on limits and design criteria. The level of detail depends only on the complexity of relationships entered for the unit process design (behaves much like a conventional spreadsheet). The existing data was collated from public sources of information and interviews with Southern African experts in the field. The user has full access to the knowledge base, and thereby control over the unit process' content, design and performance (e.g. calibration).

Raw water definitions are easily entered and processes (and plants) respond dynamically to changes. Desired final water qualities are set at default values but others are quickly selected from a pre-defined set of categories (in this software configuration). The magnitudes of all values can be quickly edited by the user. For this configuration a default list of 19 key water parameters (including plant flowrate and water temperature) are used. These 19 were considered as a reasonable balance between sufficient detail to describe a water and yet not too much data to be estimated or collected. The water parameters allow description of the water by pathogenic, aesthetic and problematic indicators. Values for every water parameter are not essential, and additional parameters can be added.

The 'Worktop' component provides a tool for design, modelling, comparison and demonstration of water treatment plant streams. An interactive semi-automatic process selection phase allows the user to design streams to different raw water qualities and to both technical and non-technical requirements. The user is always required to make the final key selection decisions. This schematic-based user-friendly plant presentation component allows the user complete freedom to edit an existing water treatment plant stream, or design one from scratch using the exert system or by picking out desired items from the knowledge base directly (for the experts). Each consultation exercise results in portable data files that store the complete contents and settings of the water treatment plant stream.

A conventional rule-base is used to enhance the process selection component of the expert system, adding sophisticated decision-making power to the largely technically based unit process 'text-book' design and calculation engine components. Knowledge about what unit processes already exist in the plant design, their relative positions, upstream water qualities, and suitable candidates for a position in the plant can be used as information by the rule-base. The rule-base also forms part of the knowledge base and can be easily edited by the user to influence the decision logic.

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1. Minimum System Requirements for Watrex

- Windows 2000
- 233 MHz Pentium or higher microprocessor (or equivalent). Windows 2000 Professional supports up to two processors on a single computer.
- 128 megabytes (MB) of RAM recommended.
- A 2 GB hard disk with 60 MB of free space.
- SVGA or higher resolution monitor. (800x600 Minimum)
- Keyboard.
- Microsoft Mouse or compatible pointing device.

For CD-ROM installation:

- A CD-ROM or DVD drive.

2. Software Installation

1) Insert CD into Drive

2) If install does not automatically start, open the CD with Explorer and double click setup.exe

3) Update The customer info if necessary

4) Proceed with the prompts (If an error box appears informing of a locked control – simply press ignore)

5) Reboot

The installed software will be found at

Start\Programs\watrex

It is installed in

C:\program files\expsys

3. Introduction: Watrex Expert System Concept

This is a PC-based expert system shell and populated knowledge base to aid in potable water treatment works design. The emphasis of the expert system component is on the exercise of process selection. In addition to plant design however, the system can equally be used for sensitivity analyses (eg. in raw water quality), options testing (e.g. modifying unit processes or adding new processes), and works modelling (e.g. modelling an existing treatment works). Process sizing, water quality effects and 'broad-brush' costing information can be quickly generated.

Two modules make up the Watrex expert system: a knowledge base editing tool, referred to as the **Editor**, and the main expert system inference engine and modelling platform, referred to as the **Worktop**. The editor can be accessed through a button icon on the Worktop.

The Editor maintains the information contained in the knowledge base, allowing data entry, editing and extraction. The knowledge base is open-ended and can be added to by the user. This feature is a key indicator of an expert system, and forms one of their main strengths - allowing the information contained within it to develop with time and remain current. The knowledge base forms the 'container' of all the expert information contained by the Watrex system.

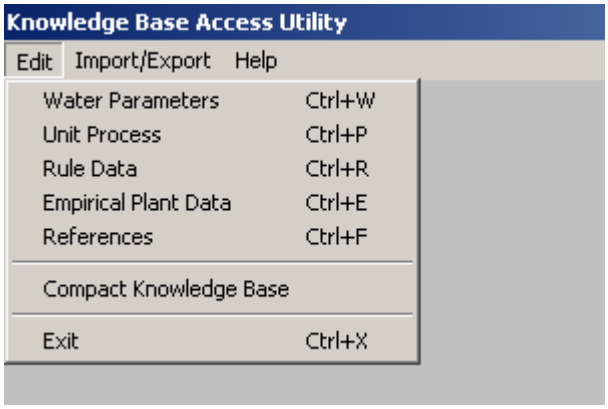
The Worktop is responsible for applying the information contained in the knowledge base, undergoing a process (and creating a file) called a **Consultation**. This process is not totally automatic as it requires user-input at critical decision-making junctures. The user is prompted however, with detailed information enabling them to make a rational and reasoned choice. The system makes extensive use of fuzzy logic for decision making.

They both have their own detailed on-line help system. The components and features of the Watrex system are however discussed below in brief.

4. Knowledge Base Editor

As mentioned above, the knowledge base is the container of all the expert information in the Watrex system. It has been organised into sections so that it can be applied by the Worktop at the appropriate juncture, and also to provide a framework for gathering, or acquiring, expert information.

The five main sections in the knowledge base are: system water parameters and related information, unit process 'text-book' designs, a process selection rule-base, an empirical plant and typical water database, and a reference section for the rule-base.



Three of these sections (water parameters, process designs and rule-base) are contained in a single main knowledge base file. The other two sections have their own ASCII files. The rule-base also has a binary file component created by the system for speed optimisation.

The knowledge base Editor gives the user the tool to edit these sections - for knowledge acquisition and correction. The Editor also provides a means of exporting the main knowledge base to a proprietary ASCII format, or importing from the same format. Printing facilities are also available.

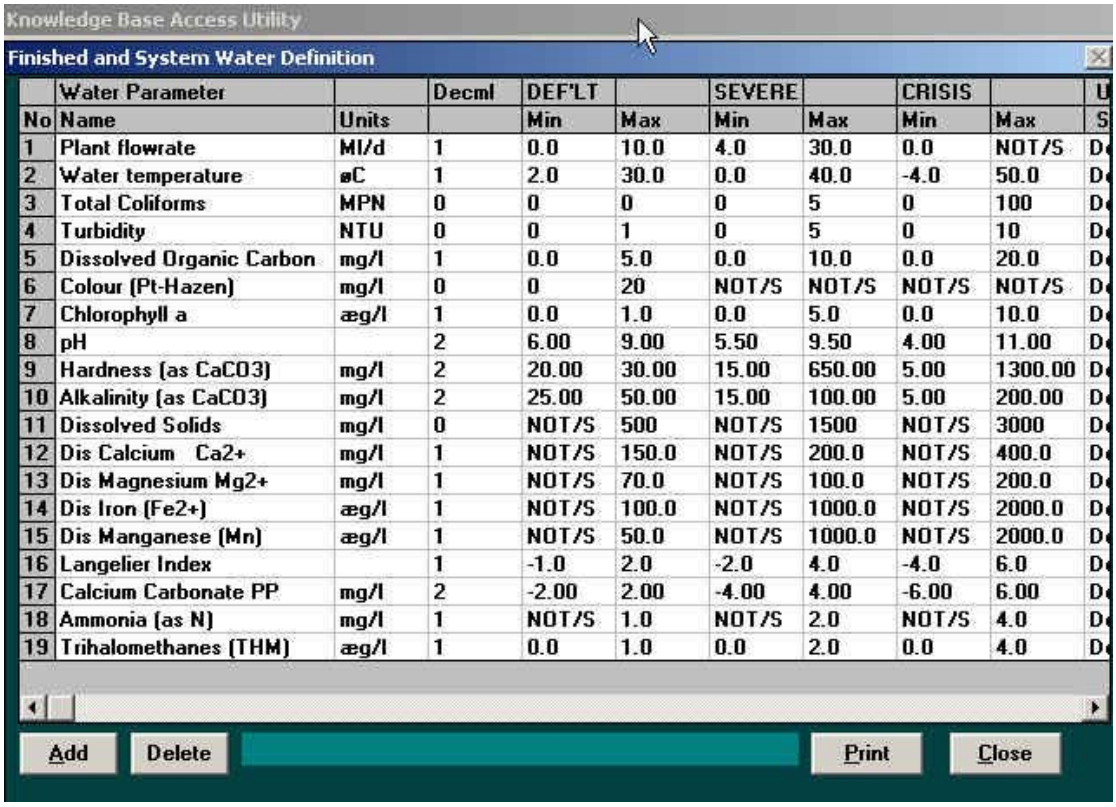
To run the Editor, the user must double-click on an Icon called Dbedit in the Watrex Group, and enter the password.

4.1 Editing data in the Knowledge Base

The five main knowledge base sections each have an entry under the **Edit** options of the menu bar. Selecting any of these will open the appropriate editing window. The menu options are discussed below.

4.1.1 Water Parameters

The number and name of water parameters used by the system are listed and defined here. There is a system minimum of 19 parameters, although these can be added to by the user. Be aware that there is not much point in adding a water parameter to this list if there is no information relating to how it is modified by unit processes contained in the knowledge base.



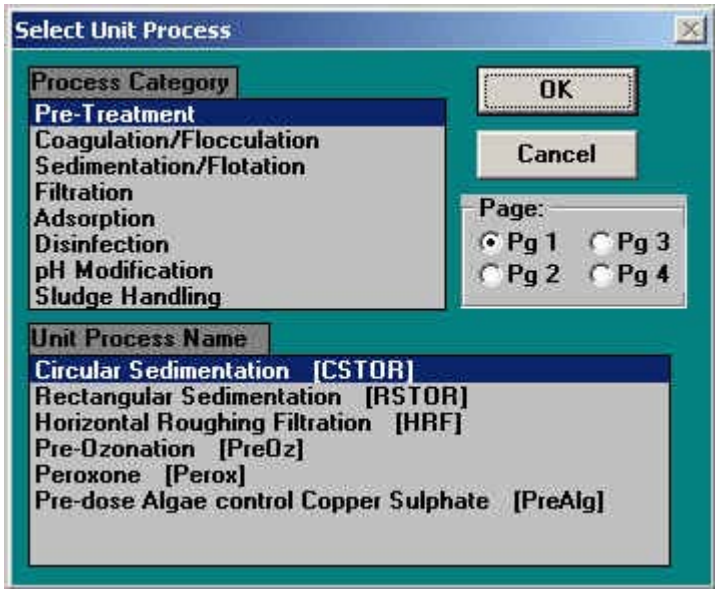
	Water Parameter		Decml	DEF'LT		SEVERE		CRISIS		U
No	Name	Units		Min	Max	Min	Max	Min	Max	S
1	Plant flowrate	Ml/d	1	0.0	10.0	4.0	30.0	0.0	NOT/S	D
2	Water temperature	øC	1	2.0	30.0	0.0	40.0	-4.0	50.0	D
3	Total Coliforms	MPN	0	0	0	0	5	0	100	D
4	Turbidity	NTU	0	0	1	0	5	0	10	D
5	Dissolved Organic Carbon	mg/l	1	0.0	5.0	0.0	10.0	0.0	20.0	D
6	Colour (Pt-Hazen)	mg/l	0	0	20	NOT/S	NOT/S	NOT/S	NOT/S	D
7	Chlorophyll a	æg/l	1	0.0	1.0	0.0	5.0	0.0	10.0	D
8	pH		2	6.00	9.00	5.50	9.50	4.00	11.00	D
9	Hardness (as CaCO3)	mg/l	2	20.00	30.00	15.00	650.00	5.00	1300.00	D
10	Alkalinity (as CaCO3)	mg/l	2	25.00	50.00	15.00	100.00	5.00	200.00	D
11	Dissolved Solids	mg/l	0	NOT/S	500	NOT/S	1500	NOT/S	3000	D
12	Dis Calcium Ca2+	mg/l	1	NOT/S	150.0	NOT/S	200.0	NOT/S	400.0	D
13	Dis Magnesium Mg2+	mg/l	1	NOT/S	70.0	NOT/S	100.0	NOT/S	200.0	D
14	Dis Iron (Fe2+)	æg/l	1	NOT/S	100.0	NOT/S	1000.0	NOT/S	2000.0	D
15	Dis Manganese (Mn)	æg/l	1	NOT/S	50.0	NOT/S	1000.0	NOT/S	2000.0	D
16	Langelier Index		1	-1.0	2.0	-2.0	4.0	-4.0	6.0	D
17	Calcium Carbonate PP	mg/l	2	-2.00	2.00	-4.00	4.00	-6.00	6.00	D
18	Ammonia (as N)	mg/l	1	NOT/S	1.0	NOT/S	2.0	NOT/S	4.0	D
19	Trihalomethanes (THM)	æg/l	1	0.0	1.0	0.0	2.0	0.0	4.0	D

The number of significant decimal points, a three-tiered desired product water definition (for comparing with the final output from a plant) and default setting, fuzzy logic extreme value settings and default trial water parameter values (used by the unit processes in the Editor) are defined in this window.

All values (except the names and units of the first 19 water parameters) can be edited using this window.

4.1.2 Unit Processes

A significant component of the knowledge base is the 'library' of unit process designs. Unit process is used as a generic term to include physical and chemical processes in this system. Each unit process is a complete design in its own right, of a particular example of a process (e.g. mechanical flocculation, rapid sand filtration etc.).



Information associated with a unit process is organised into 4 pages, each of which can be viewed using the unit process editor. Note that this editor is also used for editing unit processes contained in a plant design, or consultation file (accessed using the Worktop).

The four pages are:

Page 1: Feed water quality limits and non-technical criteria ranking. Define what the feed water restrictions are for the unit process, and set values on 5 non-technical criteria for assistance in unit process evaluation in the Worktop.

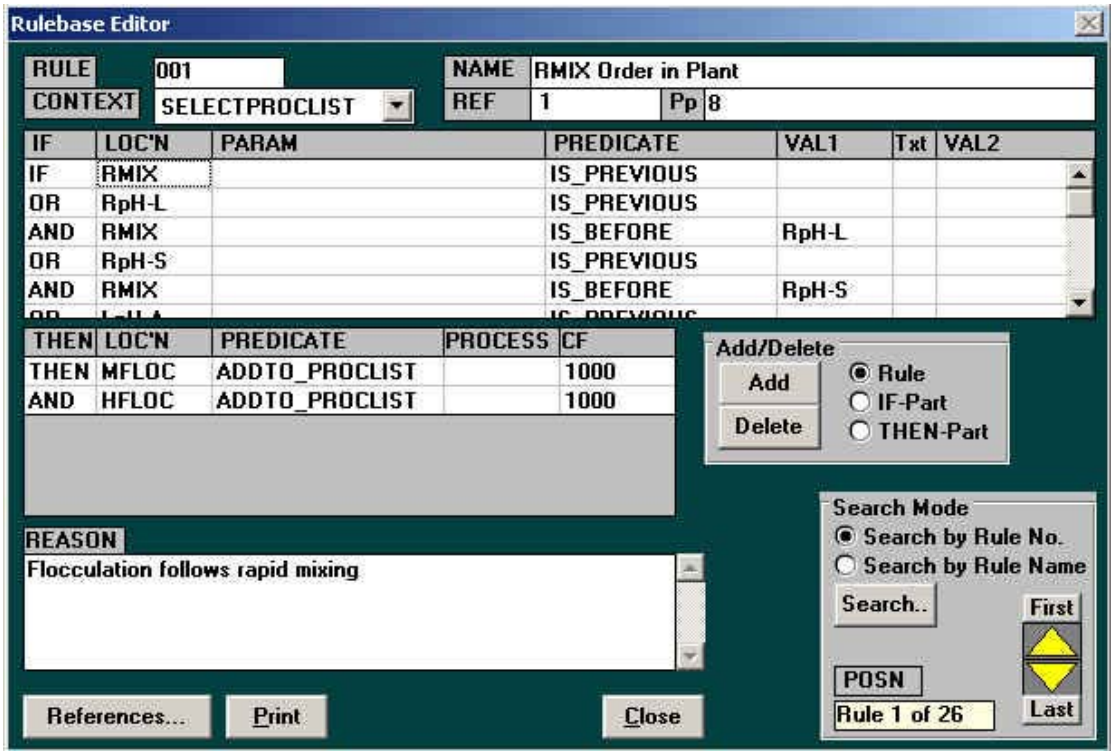
Page 2: Process design and costing calculations. Define the inputs and design formulae associated with this particular unit process, and how it affects the water quality. Also define broad Capital costing relationships. These calculations will respond dynamically to incoming water quality.

Page 3: Displays a picture of the process, and provides an area for defining key summary information and a sludge handling parameter.

Page 4: A free-format textual window for additional notes related to the unit process.

4.1.3 Rule Data

A conventional rule-base is provided to assist the Worktop during the process selection phase of plant design. The rules are in a traditional If-Then format, with three system-defined contexts defining when the associated rules are applied.



The rules are only used to refine the choice of unit processes presented to the user as viable alternatives for a position in a plant during a Consultation (and later ordering processes in the plant). They are not applied to any operational aspects of the unit processes or the plant.

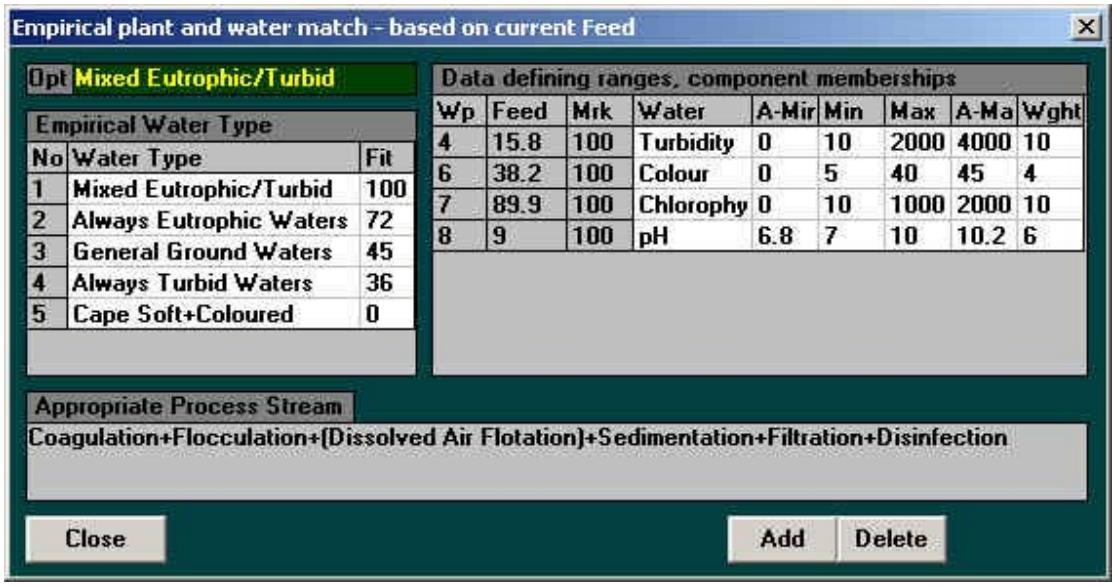
One rule is viewed and edited at a time. Various features are provided for rule editing (searches, context sensitive data entry).

Rules are compiled into a series of binary index files, which the system used for better performance.

4.1.4 Empirical Plant Data

A database of empirical plant data is contained in an ASCII file. It lists typical water types (defined by water quality ranges for appropriate water parameters), and the appropriate plant process stream to treat this water type.

The process stream and typical water parameter name do not have any relationship to the contents of the knowledge base. The water parameters defining the typical water parameter on the other hand, are defined using the system water parameters.



The empirical plant data feature tests the current feed water (where the cursor is in the Worktop, or the current position during a Consultation, or the default trial water values in the Editor) and matches this against the water quality ranges defined for each typical water type. It ranks the water types by fuzzy logic and presents the most appropriate Plant process stream.

This window allows editing of all the parameters defining the empirical plant data. A similar window is displayed during a Consultation (on request) for additional decision-making information.

4.1.5 References

The rule-base may contain information distilled from a complex argument in a journal or text-book. A provision for linking a rule to a reference is provided in the rule-base editor. The maintenance of references in carried out with the reference editor. References are stored as an ASCII file.

4.2 Importing and Exporting data

Three components of the main knowledge base can be imported from ASCII files, and also exported to ASCII files. This provides a second copy of the data, and also allows access to the data by other software.

The three components are the System Database (including system water parameters and a list of operations that the rule-base can use), the Process Database (the unit processes) and the Rule Database (the contents of the rule-base).

In some cases the ASCII file is easier to edit, and then can be recompiled back into the knowledge base. Note that the system water parameters are imported from more than one ASCII file.

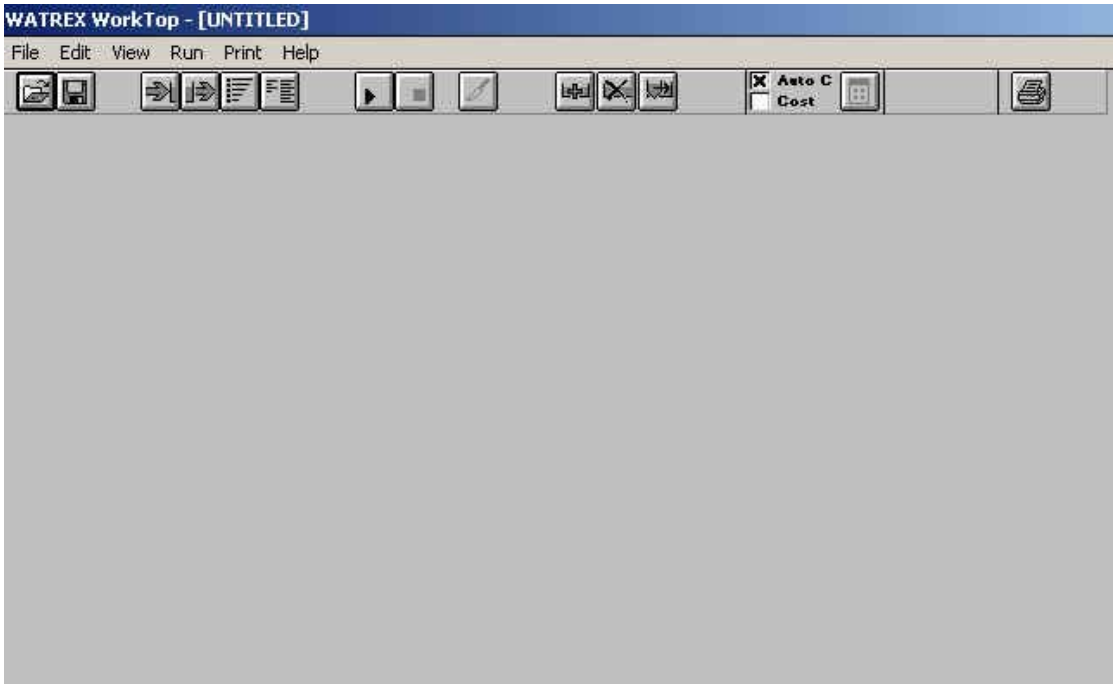
Single unit processes can be imported and exported to ASCII files (provided the process already exists in the knowledge base) as well as the complete contents of the unit process database.

4.3 Printing Data

Each editing window has its own print option, and the contents of the window or database are sent to the printer.

5. Expert System Worktop

As mentioned in chapter 3, the expert system Worktop applies the information contained in the knowledge base. In expert system terminology, it therefore contains the inference engine (a framework defining when and how expert information is applied to a problem). The expert system component is applied if the Worktop is used to design a treatment plant (discussed under chapters 5.1 and 5.2 below).



The process of using the expert system to design a treatment works is termed a Consultation. At each stage of the Consultation, a unit process will be added to the process stream until a desired product water quality is produced. The end result is a datafile containing chiefly a raw water definition, collection of unit processes, a trace of water quality through the unit processes and a desired product water quality. This file is also called a Consultation file.

In addition to the expert system component, the Worktop can also be used as a water treatment works modelling platform. Unit processes can be added, deleted and replaced, directly from the knowledge base. Existing unit processes can be modified to represent known conditions (they can in fact be completely re-designed using the unit process editor). A known treatment works can thus be built up and saved as a self-contained Plant model.

The Plant model is exactly the same as the Consultation file, except that it was produced by a different means. The terms are often used interchangeably in the software. A trace of how these files are produced is stored as an ASCII file called a Logic Trace. It contains detailed information about decisions made during the ‘building’ of the model.

Raw water qualities can be varied to perform sensitivity analysis on models. The effect of replacing existing process units with other units from the knowledge base can also be studied. Whenever a change is made to the plant (raw water quality or unit process information), the plant is automatically updated (if the auto-calculate flag is set) and the plant will respond dynamically to the new status.

Note that the unit processes added to a Consultation file are initially copies of the knowledge base information, but once added to the Consultation file are completely independent. Changes made to

Consultation file unit processes are only made to the copy in the Consultation file. No changes are made to the knowledge base.

A large rectangular cursor (grey) is used to indicate the currently selected unit process in the Worktop.

To run the Worktop, the user must double-click on an Icon called Expmain in the Watrex Group.

Some of the main features associated with the Worktop are discussed below.

5.1 Creating a New Consultation

5.1.1 Initial Consultation Configuration'

The way that the rule-base is applied to the Consultation can be altered: the rule-base can be turned off (default is on), rule-base confidence values can be applied to rule-added processes (default is on/apply), and unit processes can be edited once added to the Consultation file (default is not to edit). These settings are valid until changed or Watrex is restarted.

5.1.2 File Creation

Four stages are required to create a new Consultation file. These stages are provided as a series of iconised buttons on the toolbar (the third to sixth) in the order that they should be carried out. It takes only a few minutes to create a new Consultation file. An example is given in chapter 7 below.

Stage 1: Define the raw water. Three values for each water parameter are possible, representing a min, mean and max value. Quick scenario modelling can be carried out once a plant is completed using these values. Relative weights of importance of water parameters can be defined for the process selection exercise. An option of excluding a water parameter from decision making (e.g. deselecting during a consultation because it is no longer important) is also included. Note that this does not affect unit processes operating on the water parameter.

Stage 2: Define the desired product water quality. The raw water and desired product water together define the problem that the expert system will attempt to 'solve'. One of the ranges from the three-tiered water quality system must be selected. Note that the numerical value of these ranges cannot be changed from the Worktop.

Stage 3: Define Consultation resources. The resources provide a constraint, against which each Unit Processes' consumption can be evaluated and compared, relative to other Unit Processes. This provides a non-technical decision making tool for the system. Combinations of ranking can be investigated during the process selection phase.

Stage 4: Define the unit process sub-set. It is anticipated that some unit processes will sometimes be known to be inappropriate or undesirable. A selection of possible unit processes can be defined, which will form a sub-set within the unit processes contained in the knowledge base. The sub-set is unique to each consultation.

Once these stages have been completed, the expert system can be initiated. This is discussed below in more detail.

5.2 Initiating and Actions of the System

The expert system is initiated by pressing the 'GO' (or 'Play') button on the toolbar, or by selecting the **Run** and **GO** menu items. Note that a datafile has to be loaded (or a new one created as described in chapter 5.1 above) before the expert system can be initiated.

The process selection exercise is a controlled means of adding unit processes from the knowledge base to the Consultation file. The logical starting point is always the raw water definition. Note that any processes present in the plant are deleted at the start of a new process selection exercise.

The current feed water (initially the raw water, later the most recently calculated water quality) is used to determine a short-list of appropriate processes based on the feed water limits defined for the processes. This short list is then modified by the rule-base, based on the content of the short-list and processes already in the plant.

The processes in the short-list are then 'designed' by the system, and product water qualities for each processes in the short-list estimated. This short list is then modified again by the rule-base, based on the content of the short-list, product water quality, and processes already in the plant.

Various ranking weights for the processes in the short-list are calculated, and the user is then faced with the short-list and other decision-making information. The user has to choose a process for the system to continue. This is the focal point of the expert system, as it represents the combining of all the information components.

Once a process has been selected, it is copied from the knowledge base to the Consultation file. The water quality leaving this new process is now treated as the new feed water quality for the next phase of the plant design. The plant is then modified by the rule-base for a third time, based on the processes already in the plant, and their order.

A test is performed before the next short-list is generated to determine if the current water quality meets the desired product water quality. If it does, the process selection exercise will stop. Otherwise the system will continue finding processes to add to the plant, or until the user clicks on the Abort button on the Select Unit Process window.

5.3 Adding, Deleting and Replacing Unit Processes

Note that in principle any unit process contained in the knowledge base can be added to a plant datafile. Similarly, any unit process contained in a plant can be replaced with a unit process from the knowledge base. Any unit process in a plant can be deleted.

Three buttons on the toolbar allow the user to Add, Delete and Replace unit processes. The same functions can be carried out by selecting the menu bar **Edit** option, and the appropriate sub-menu option.

Note that the sludge handling unit process can only be Edited and Deleted via the menu bar headings. It is not shown as a regular unit process on the Worktop, and consequently cannot have the cursor placed over it.

6. Other Features

- Unit processes can be edited by double-clicking on the unit process schematic. This will load the same process editor mentioned above, and the comments made in discussing the knowledge base unit process editor apply to the Worktop too.

- Magnitudes of sludge output from unit processes contained in the plant are collected by the system and provided to a sludge handling unit process, if it is present in the plant. This is discussed in more detail in the Worktop on-line help.

- Various initial run settings and levels of warning and error reporting detail can be set. These will change the way the system will behave as an expert system, and the level of detail generated when warnings and errors occur during a Consultation.

- A Logic Trace, which is a detailed record of initial water quality and decisions made is created during a Consultation. It is recreated for each Consultation. The information can be viewed by the user and printed as a record of why the plant was designed in the way that is was.

- Selected data from unit processes, and water trace information can be printed from a Plant Printing window (printer icon on the toolbar) as well as from the unit process editor.

7. Worked Example Consultation

This is a practical example of the topics discussed in chapters 5.1 and 5.2 above. Note that the software also has an extensive on-line help system.

7.1 Start the Expert System software

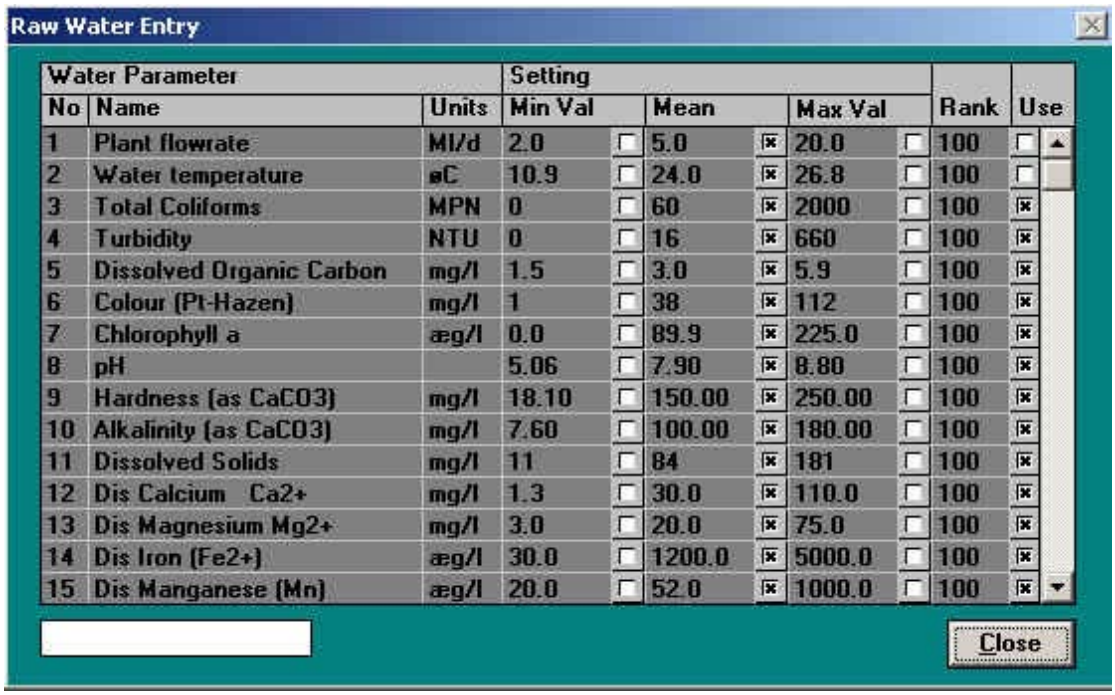
1. Start the **Worktop** (file called Expmain). The software will start with a blank grey worktop with menus and buttons across the top.

7.2 Initial Consultation Configuration

Select which options are required for the consultation. The default options are recommended for most purposes. These settings remain until changed or the Worktop is restarted.

7.3 Consultation File Creation

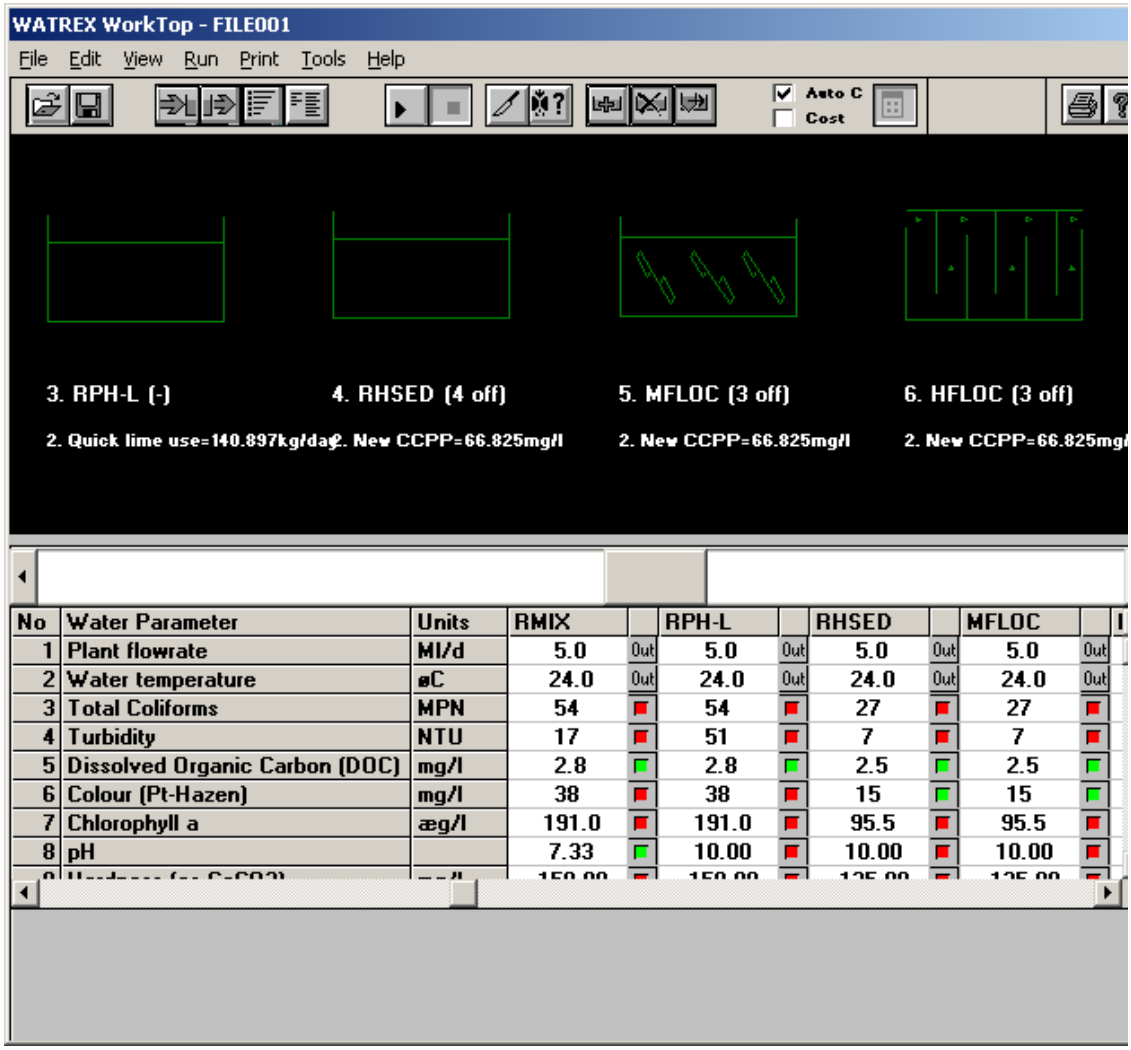
1.  Click on the Define raw water button on the toolbar to load the Raw water data entry form. Default values are supplied for all three columns for each water parameter. Use these values, or type in other data. A checked box to the right of a value means that the value in that column will be used by Watrex during the consultation.



1. The values in the Rank column allow definition of relative importance of water parameters (percent). A checked box in the Use column means that the water parameter will be used for decision making by the Expert System component.

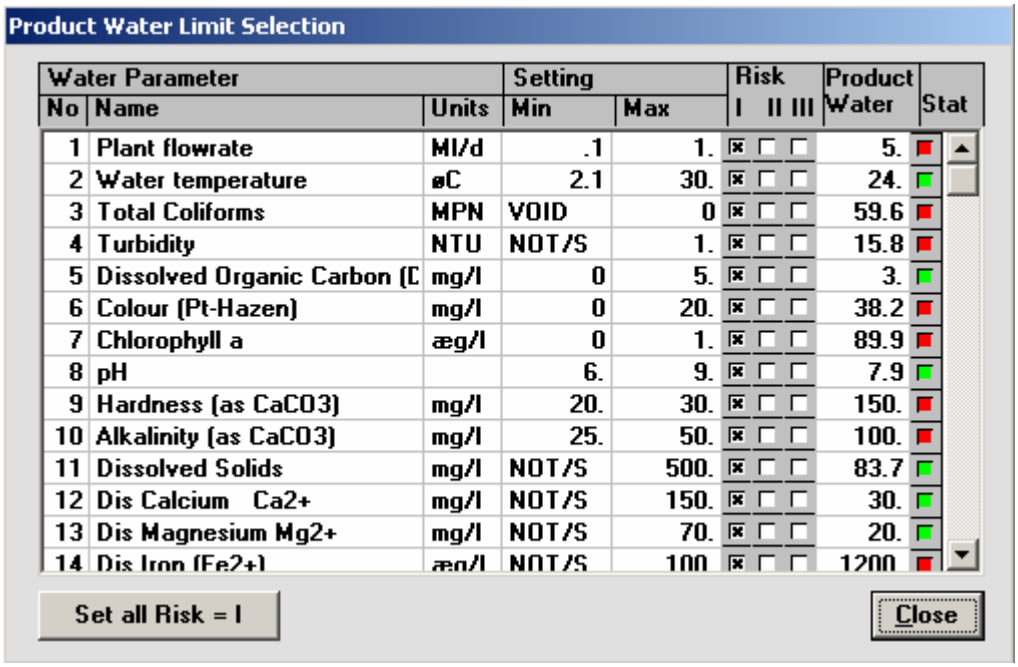
2. Click Close to accept the values, and save the Consultation file as TEST.CON (for example).

3. The **Worktop** should now have a black background with a greyed box in the top left of the screen, with the text RAW underneath it, and the water quality information bar across the bottom of the screen.



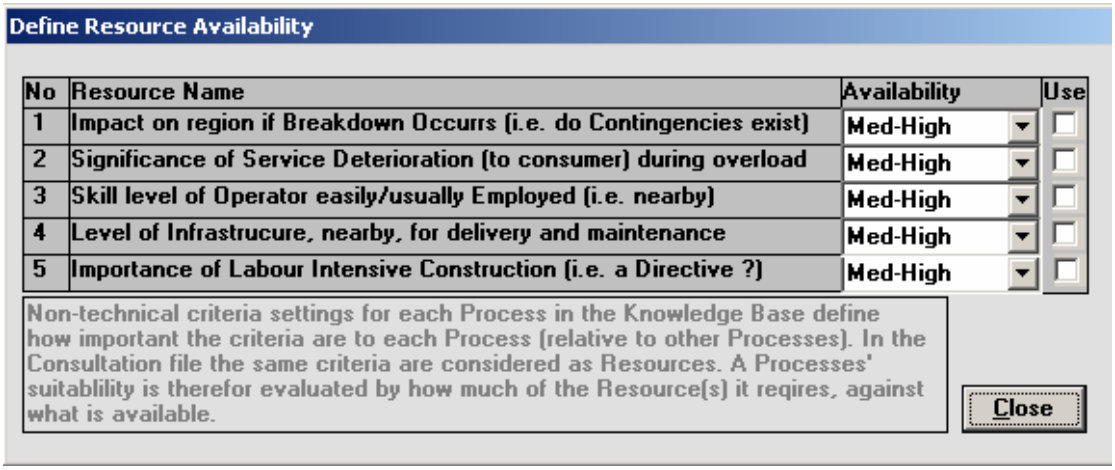
No	Water Parameter	Units	RMIX		RPH-L		RHSED		MFLOC	
1	Plant flowrate	Ml/d	5.0	Out	5.0	Out	5.0	Out	5.0	Out
2	Water temperature	øC	24.0	Out	24.0	Out	24.0	Out	24.0	Out
3	Total Coliforms	MPN	54		54		27		27	
4	Turbidity	NTU	17		51		7		7	
5	Dissolved Organic Carbon (DOC)	mg/l	2.8		2.8		2.5		2.5	
6	Colour (Pt-Hazen)	mg/l	38		38		15		15	
7	Chlorophyll a	æg/l	191.0		191.0		95.5		95.5	
8	pH		7.33		10.00		10.00		10.00	

1.  Click on the Define product water button on the toolbar to load the Product water definition form. Default settings are supplied for each water parameter, from the pre-defined Risk Level I, II or III (default, sever and crisis ranges defined using the **Editor**). The current product water quality is also given.



1. Click Close to accept the values and (automatically) save them to the Consultation.

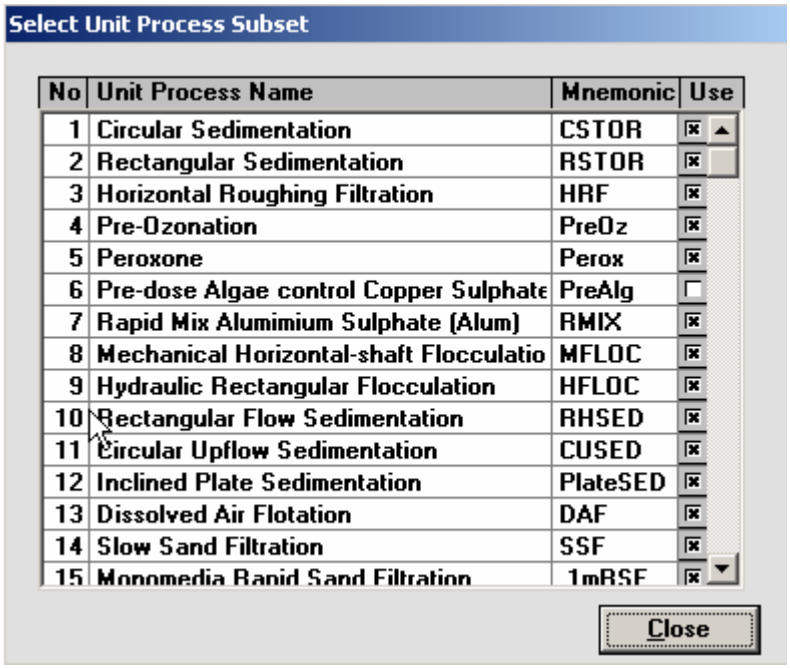
2.  Click on the Define resource availability button to load this form. This allows the Consultation resource limitations to be set (five non-technical criteria are system-defined to assist in process selection on criteria other than technical performance), and the selection or de-selection of each of the criteria from the process selection phase.



1. Click Close to accept the values and (automatically) save them to the Consultation.

2.  Click on the Unit Process subset button to load the Consultation subset pool definition. This allows the user to specifically exclude Unit Processes contained in the Knowledge Base

from the Expert System process selection phase. Those with a checked box are included. Note that PreAlg and CGST are excluded, and must remain so.



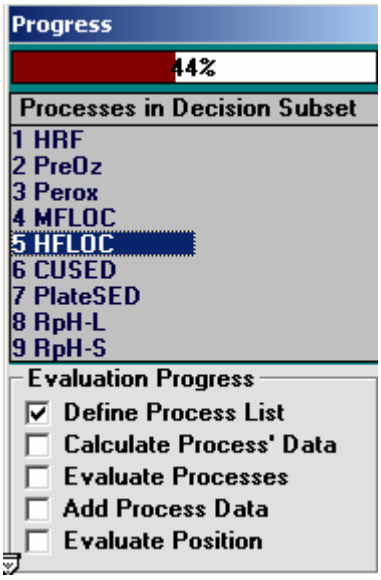
1. Click Close to accept the values and (automatically) save them to the Consultation.

The Consultation file is now set up. This sets up the starting point for a Consultation, and is equivalent to loading an existing file. This can be demonstrated by clicking on the File load button  and selecting TEST.

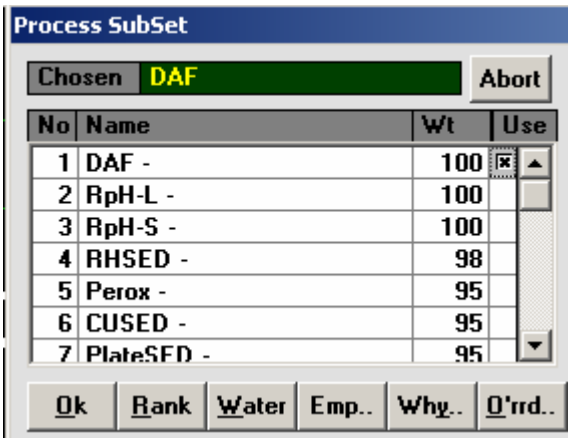
7.4 Performing a Consultation

Follow the steps described in chapter 7.2 and 7.3 above, or load an existing Consultation. Follow the steps below to use the semi-automatic process selection phase, which is the application of the expert system technology incorporated in the Watrex system.

1.  Click on the Begin or 'GO' button to start the Expert System process selection phase. Appropriate unit Processes will be continually selected by Watrex until either the most recent water quality matches the desired product water quality, or the user aborts this process. The user must always choose a Unit Process from a list created by Watrex, and ranked according to the various Consultation settings, the water quality, and the individual Unit Processes.



2. The user must choose a Unit Process when presented with the Process short-list form. This is the fulcrum of the Expert System, and presents a significant amount and detail of information. The user is expected to choose the most appropriate Unit Process from a short-list that the Expert System has generated. Use the on-line help to examine the meaning of the information presented on this form. It is strongly suggested that ALL the information associated with this screen be reviewed.

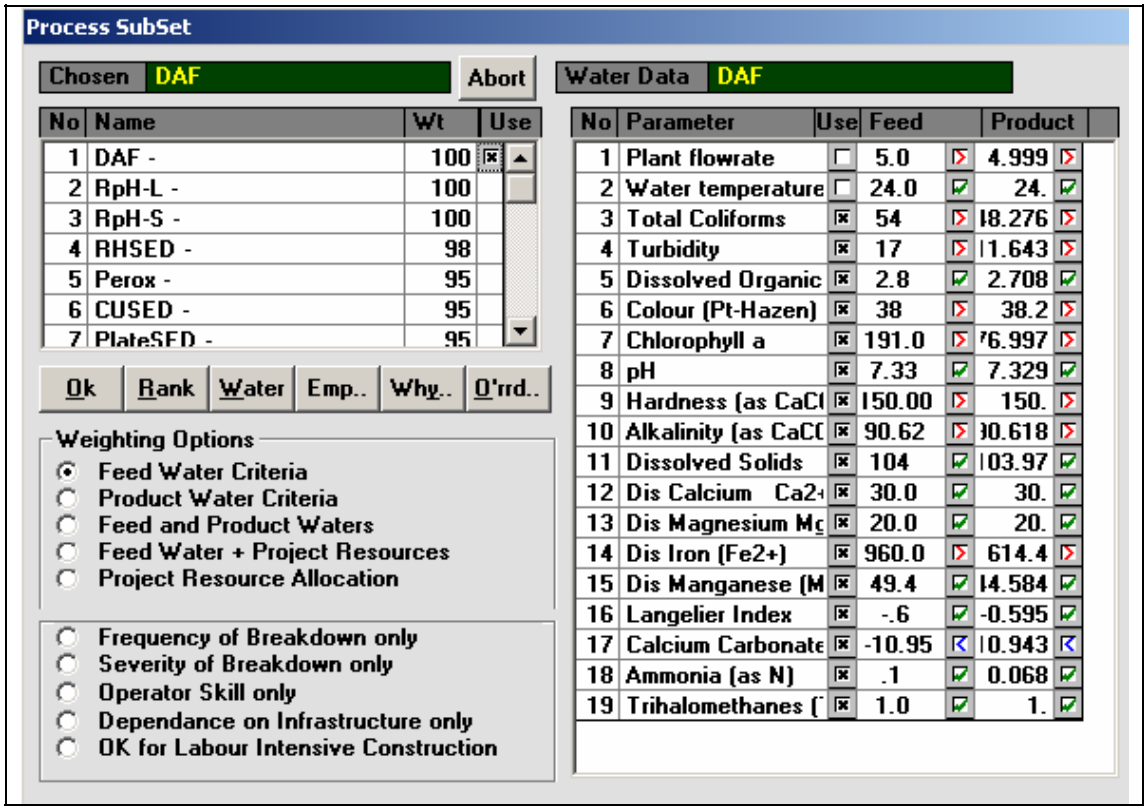


3. The Process Subset selection form can be expanded to show additional and important information. Pressing the Rank, Water or Emp… (for empirical data) buttons show the appropriate information. This information is initially confusing, and may not be necessary to experienced users. Examples of the additional information are shown in the two snapshots below.

4. The means of ranking alternatives can be changed in the Process Subset form by clicking on the Rank button and selecting a new Weighting Option from those provided (see snapshot below). Those below the separator line are the individual non-technical resources. Those above the separator line indicate useful methods or combinations of methods. The second snapshot shows the Water button information expansion: how the water quality will change when passing through the Unit Process. Examine the effect of different processes by clicking on processes in the subset list.

5. Select an appropriate Unit Process by clicking the Use Check Box, and clicking on OK. The selected Process will be added to the end of the process train schematic displayed on the

Worktop, it's data will be copied from the Knowledge Base to the Consultation file (and hereafter become independent of the Knowledge Base) and the current water quality will be revised.



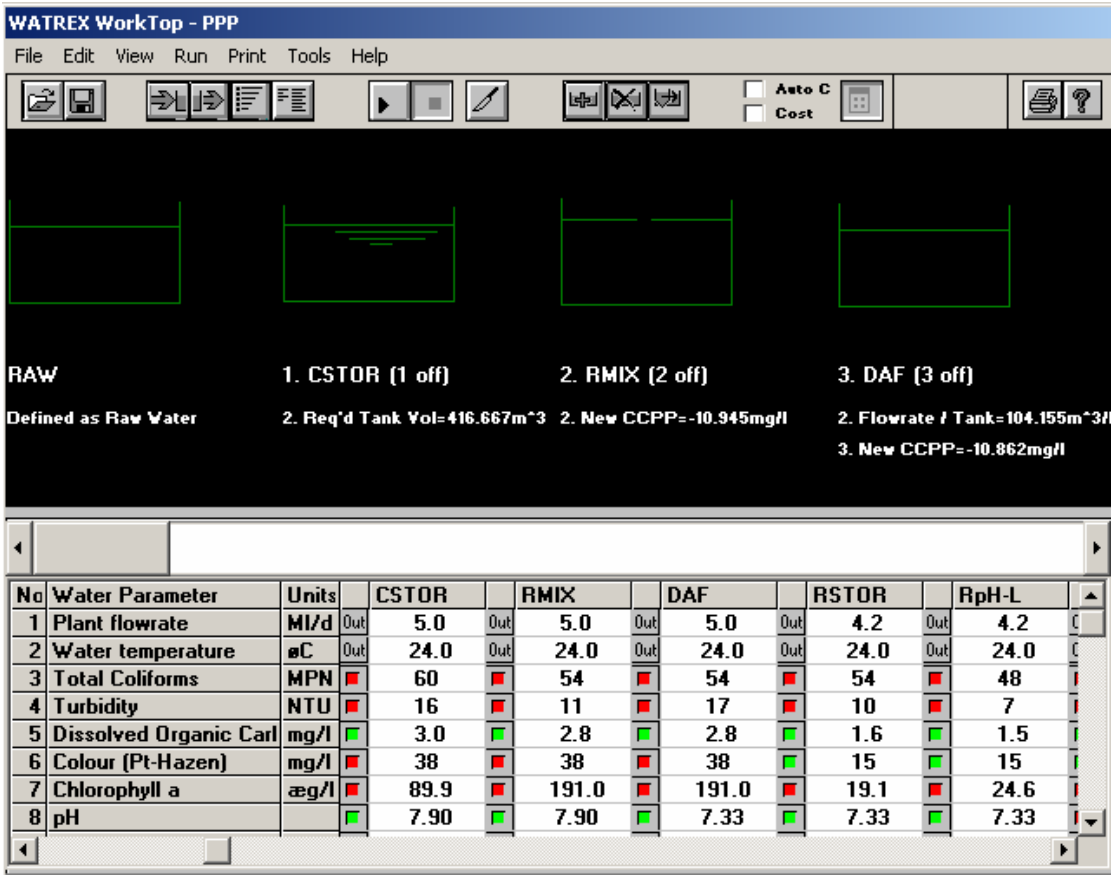
6. Continue the process selecting Unit Processes. Use the Override button to include a flocculation option (e.g. HFLOC) after RMIX. Continue selecting Unit Processes, and use the Override to add a filtration option (e.g. 1mRSF) after a pH-raising process has been added. The process selection phase should end with a message to the effect that the water quality is not within the specified limits but no more suitable processes can be found.

7. The software should add the Cl2 process, and there should be about 7 processes in the schematic train.

8. If the software continues to add Unit Processes (after more than 9 or so), select the Abort button to stop the process selection phase.

9. Various warning messages about feed water quality limits may have been appearing during this operation - this normal and indicates the software is performing it's duties properly.

The Consultation file is now completed. This is equivalent to loading an existing Consultation file. This can be demonstrated by clicking on the File load button  and selecting FILE001 (TEST was used I the example above). This phase of Watrex is complex, and results are dependant on Raw water definition, Product water definition, Resource settings, Unit Process subset definition, Knowledge Base content and Rule Base content.



No	Water Parameter	Units		CSTOR		RMIX		DAF		RSTOR		RpH-L
1	Plant flowrate	Ml/d	Out	5.0	Out	5.0	Out	5.0	Out	4.2	Out	4.2
2	Water temperature	øC	Out	24.0	Out	24.0	Out	24.0	Out	24.0	Out	24.0
3	Total Coliforms	MPN		60		54		54		54		48
4	Turbidity	NTU		16		11		17		10		7
5	Dissolved Organic Carl	mg/l		3.0		2.8		2.8		1.6		1.5
6	Colour (Pt-Hazen)	mg/l		38		38		38		15		15
7	Chlorophyll a	æg/l		89.9		191.0		191.0		19.1		24.6
8	pH			7.90		7.90		7.33		7.33		7.33

7.5 Notes on Performing or Loading a Consultation file

7.5.1 Files and related matters

1. Changes made to a Consultation file are saved automatically (unless the user is presented with a Save Changes dialogue box). A Consultation file can be saved to a new file name using the save  button.

2. Each Consultation file is a self-contained unit, and can be copied to other disks. They are located in the CONSULT subdirectory.

3. Note however that the Logic Trace file should also be copied (same filename, but with a LOG extension). This is an ASCII file and is a record of Consultation settings and the process selection exercise.

4. Also note that the water parameters used (the number, name and units) in a Consultation must match those in the host software on that machine - this is only an issue if Consultation files are copied between machines where users have added different water parameters to Watrex.

7.5.2 Warning messages

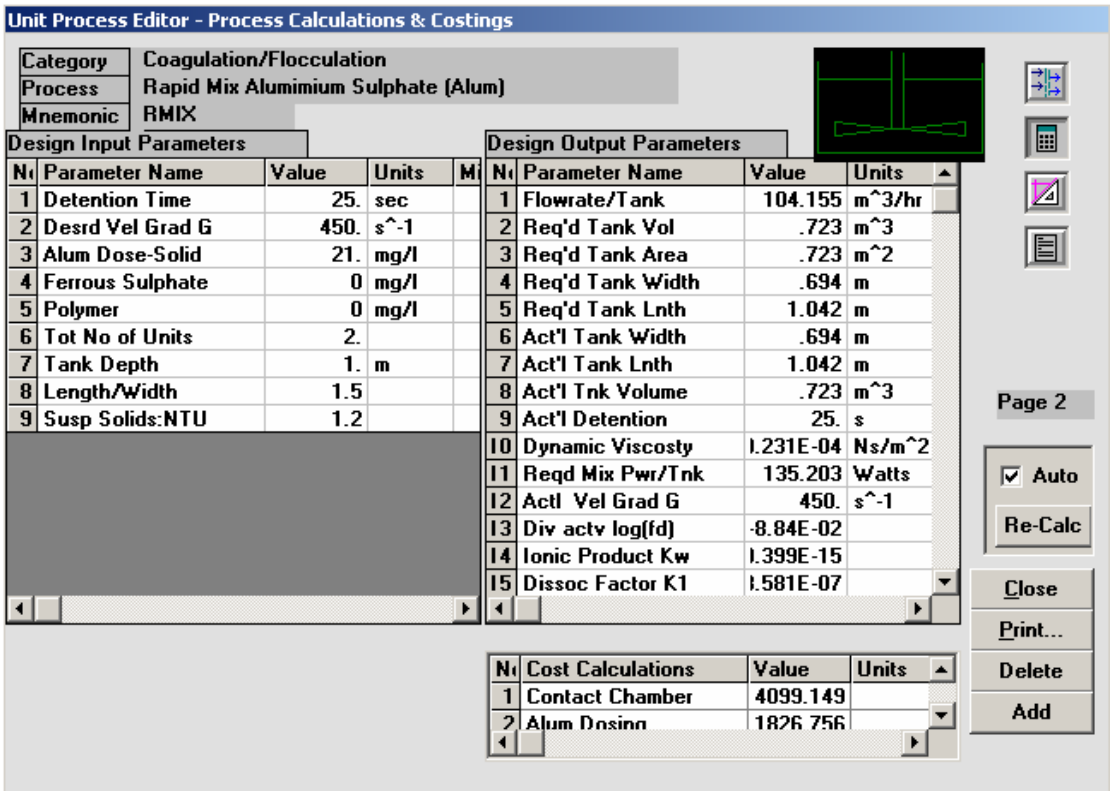
1. The most common warning message displayed indicates that Feed Water Limits to some Unit Process have been exceeded. Each Unit Process has feed water quality limits defined for it. It is possible that water quality through a stream may exceed the limits of processes in the stream. Depending on the magnitude by which the water quality exceeds the Unit Process limits, this is either just a warning or a serious problem. Because the user has the ability to edit Unit

Processes in the Consultation, and that the user may be investigating various water quality variation scenarios, Watrex only indicates that limits have been exceeded. The user has to determine if this is significant. The most rigorous method is to compare the actual Feed Water quality limits for a Unit Process against the feed (upstream) water quality.

7.5.3 Moving around the Worktop and Editing Unit Processes

1. A greyed box over a Unit Process schematic indicates the current cursor position. Clicking on any Unit Process will move the cursor to the new Unit Process.

2. Double-clicking on a Unit Process will launch the **Editor** form, enabling the user to view and edit data (also works for Raw and Product water quality).



1. The current view on the process train can be manipulated by moving the slide located under the water quality display at the bottom of the screen.

2. 

Cost information can be turned on or off by clicking the Cost check box.

3. 

Default settings mean that the whole plant is recalculated after any changes (either to a Unit Process or water quality data). The Automatic recalculation can be turned on or

off by clicking on the Auto C check box. If auto-calc is off, a calculation is forced by clicking on the calculator button alongside.

4.  Adds a Unit Process to the train, directly after the cursor.

5.  Deletes the current Unit Process.

6.  Replaces the current Unit Process.

7.5.4 The Logic Trace

1. An ASCII file, called the Logic Trace, is created during each Consultation. It is located in the CONSULT subdirectory, has the same name as the Consultation file but has a LOG extension.

2.  Opens the Logic Trace. It is greyed out if there is no file, is in black if there is file.

3. The Logic Trace contains a list of the Consultation settings and all the actions performed during a Consultation - both by the user Watrex.

8. Limitations

The system has limitations. The main constraint on the validity of the solutions generated using the system are: the number of unit processes contained in the knowledge base, their accuracy in modelling the changes in water quality passing through them, the rules contained in the rule-base, and the consequences of the assumptions necessarily made while producing a software package to represent the thought processes of a human expert.

While the system is intended to be applicable to the majority of waters found, but is in no way thought of as being all-encompassing. This is more a function of the number and type of unit processes contained in the knowledge base than a true limitation of the software.

The system will not model split flows or recycling. However, it was considered that real treatment works could be broken down into sections for modelling, or processes could be grouped together.

The user must also bear in mind that the Watrex system is aimed at quick and consistent general design - getting key concepts correct, not detailed design.

Although Watrex can incorporate additional water parameters, the user should be aware of the consequences of adding parameters. As each consultation file is a separate unit, adding a new Water parameter to the Knowledge Base will not add it to existing consultation files. Also, there is no benefit to adding a Water Parameter unless known relationships exist for modelling this parameter as it passes through a Process.

9. Software Information and Support

Contact details for software support and information can be obtained from the About submenu off the Help menu on either the **Editor** or **Worktop**. These details are repeated below:

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Telefax (44) 01189-477609"
NeilPatrick@CompuServe.com