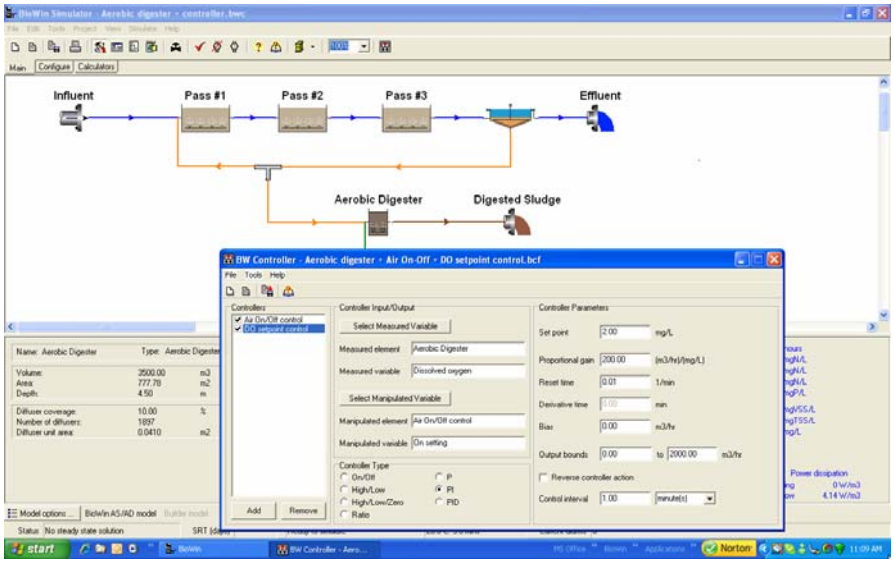
BW Controller Feature Tour

Welcome

Welcome to the BioWin Controller – BW Controller. This is a separate Windows application which links to a BioWin configuration and allows specification of a range of process control features commonly employed in wastewater treatment systems.

EnviroSim has developed the BW Controller to address these process control issues. BW Controller introduces another level of sophistication into your BioWin simulations without increasing the complexity of using BioWin.

Because BW Controller is a separate Windows application, you can choose to add this analysis to any BioWin configuration or continue to use BioWin (with its variety of embedded control features) without being forced to worry about control issues.



The BW Controller with a BioWin treatment process configuration in the background

BW Controller in Brief

Improvements in online measurement technology (increased number of measurable parameters; improved reliability; decreased cost and maintenance requirements) have allowed the development of more complex, innovative, and effective control systems for wastewater treatment. The BW Controller allows you to simulate these more advanced process control strategies; for example:

- Setting dissolved oxygen setpoint levels based on reactor ammonia concentration. The dissolved oxygen concentration itself is then controlled by manipulating the air flow rate.
- Control of mixed liquor recycle stream flow rate based on effluent nitrate concentration.
- Control mixed liquor suspended solids concentrations by adjusting wastage flow rate.
- Using pH measurements to adjust/switch air flow to control sidestream nitrogen removal processes.
- Change chemical dosing rates based on influent and effluent flows or concentrations.
- Adjusting on/off aeration periods to maintain alkalinity/pH levels.

BW Controller is a separate Windows application which links to BioWin via the COM interface in Windows. For ease-of-use, BW Controller is started from within BioWin. If a configuration is open in BioWin, you merely click on a toolbar button to initiate the BW Controller application. This opens the BW Controller interface. At this point BW Controller creates a list of all the elements in the BioWin configuration, and monitors the concentrations of all the state variables, a range of combined variables (e.g. VSS, TSS), as well as a number of calculated variables (e.g. pH, total volatile fatty acids concentration, specific N_2 production rate) in each element.

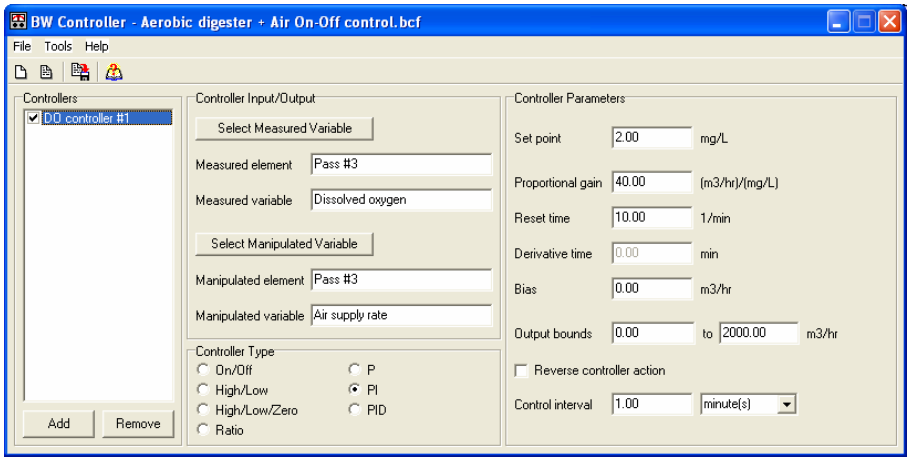
The essence of control involves measuring a variable (i.e. the controller input) and manipulating an 'adjustable' parameter (i.e. the controller output); the value of the manipulated variable is set by the controller. For example, the measured variable could be DO concentration in a bioreactor, with a PID controller adjusting the air flow rate to maintain a DO setpoint.

Setting up controllers in the BW Controller is straightforward; the interface is very intuitive. Each time a new controller is added [each controller must be named] the first step is to select the measured variable (e.g. DO) in a particular element. The variable to be adjusted by the controller is then selected. The third step is to select the type of controller and specify the controller parameters.

Once a controller (or multiple controllers) has been specified, dynamic simulations are initiated from within BioWin in the usual way. You will likely view the response of the controlled process in BioWin Album charts.

Familiar & Intuitive Interface

The BW Controller main window consists of several sections, with the usual Windows™-style menus and buttons:



BW Controller interface

The following sections provide a quick outline of each part.

Toolbar

The toolbar shows four buttons.

Main	Description
	**New:** Click this button to close the current controller setup and start a new one.
	**Open BW Controller File:** Click this button to open a controller file from disk.
	**Save:** Click this button to save the current controller setup to disk.
	**Help Contents & Index:** Click this button to access the help system.

Controller List

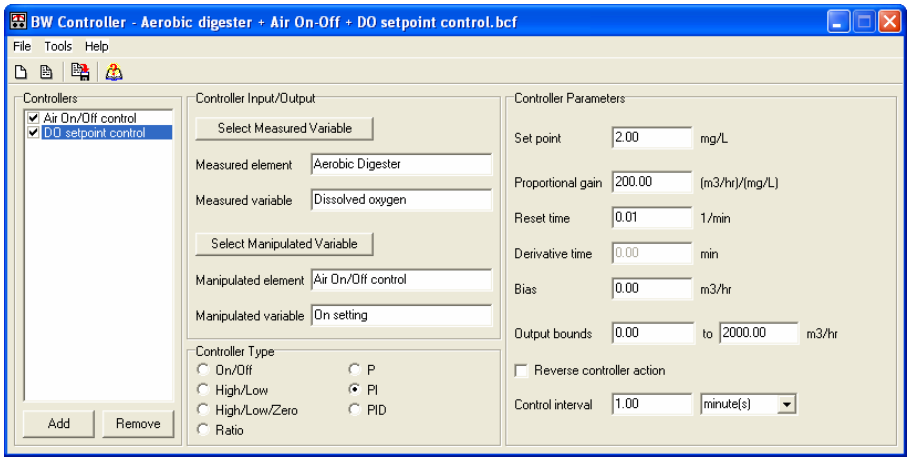
The names of controllers defined in a particular system are listed in this part of the interface.

To add a new controller, click on the **Add** button below the list. You will be prompted to specify a name for the new controller.

To remove (delete) a controller, click on the controller name so that the name is highlighted, and then click on the **Remove** button below the list.

Clicking on an item in the list highlights the controller name. When a controller is selected, information on that controller (i.e. controller input/output, controller type and controller parameters) appears in the interface.

Any controller can be deactivated by removing the check mark in the box to the left of the controller name.



The Controller list showing two named controllers

Controller Input/Output

The basis of control involves measuring a variable (i.e. the controller input) and manipulating an 'adjustable' parameter (i.e. the controller output); the value of the manipulated variable is set by the controller. For example, the measured variable could be DO concentration in a bioreactor, with a PID controller adjusting the air flow rate to maintain a DO setpoint.

To select the measured variable, click on the **Select Measured Variable** button. A dialog box opens, and the variable can be selected.

To select the manipulated variable, click on the **Select Manipulated Variable** button. A dialog box opens, and the variable can be selected.

Controller Type

A range of controller types can be selected:

- **On/Off control** – to maintain a monitored variable between upper and lower setpoints.
- **High/Low control** – similar to On/Off control, but where the 'off' value of the manipulated variable can be set to a value greater than zero.
- **High/Low/Zero control** –High/Low control, but with an additional 'off' setting.
- **Ratio control** – the manipulated variable is adjusted in proportion to the measured variable.
- **Proportional (P) feedback control**.
- **Proportional-Integral (PI) feedback control**.
- **Proportional-Integral-Derivative (PID) feedback control**.

Details on specifying types of controller and the associated controller parameters are provided in the section on **Types of Controller and Controller Parameters**.

Controller Parameters

Controller parameters are specified in this part of the interface.

The appearance depends on the type of controller selected.

Details on specifying types of controller and the associated controller parameters are provided in the section on **Types of Controller and Controller Parameters**.

Setting Up A Controller

The essence of control involves measuring a variable (i.e. the controller input) and manipulating an 'adjustable' parameter (i.e. the controller output); the value of the manipulated variable is set by the controller. For example, the measured variable could be DO concentration in a bioreactor, with a PID controller adjusting the air flow rate to maintain a DO setpoint.

Setting up controllers in the BW Controller is straightforward; the interface is very intuitive. Each time a new controller is added [each controller must be named] the first step is to select the measured variable (e.g. DO) in a particular element of the BioWin configuration. The variable to be adjusted by the controller is then selected.

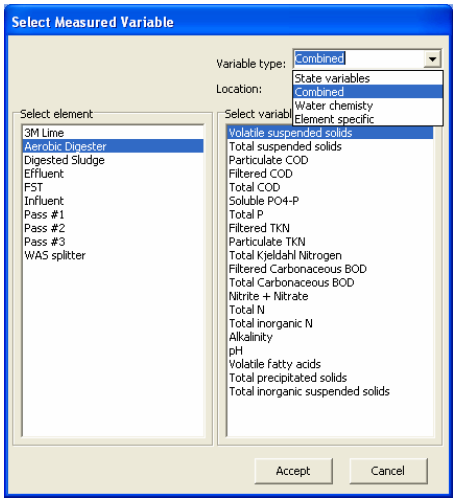
Selecting the Measured Variable

To select the measured variable, click on the **Select Measured Variable** button. A dialog box opens listing all the BioWin elements on the left, and variables that can be measured on the right.

The appearance of the dialog may differ slightly depending on whether this is a new or an existing controller. If it is an existing controller the name of the measured variable and the BioWin element are highlighted.

Selecting the measured variable is very simple:

- Click on the element name in the list on the left.
- Click on the measured variable in the list on the right.
- Click on the **Accept** button.



Dialog for selecting the measured variable

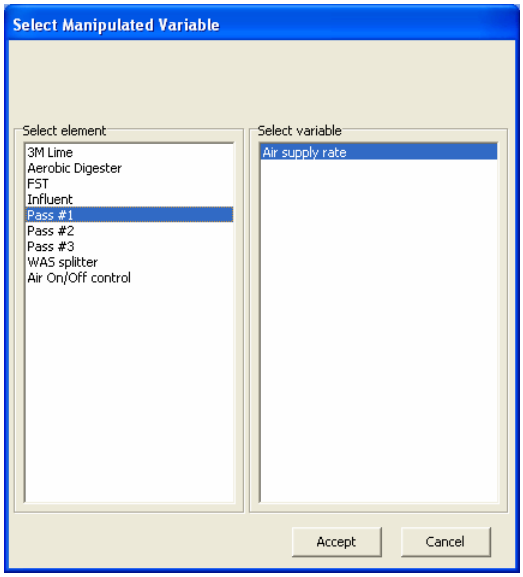
Selecting the Manipulated Variable

To select the variable to be adjusted by the controller, click on the **Select Manipulated Variable** button. A dialog box opens listing all the BioWin elements (and other controllers already defined) on the left, and variables that can be manipulated on the right.

The appearance of the dialog may differ slightly depending on whether this is a new or an existing controller. If it is an existing controller the name of the manipulated variable and the BioWin element are highlighted.

Selecting the manipulated variable is very simple:

- Click on the element name in the list on the left.
- Click on the manipulated variable in the list on the right.
- Click on the **Accept** button.



Dialog for selecting the manipulated variable in a bioreactor

Types of Controller

A range of controller types can be selected in the **Controller Type** radio button group:

- **On/Off control**
- **High/Low control**
- **High/Low/Zero control**
- **Ratio control**
- **Proportional (P)**
- **Proportional-Integral (PI)**
- **Proportional-Integral-Derivative (PID)**

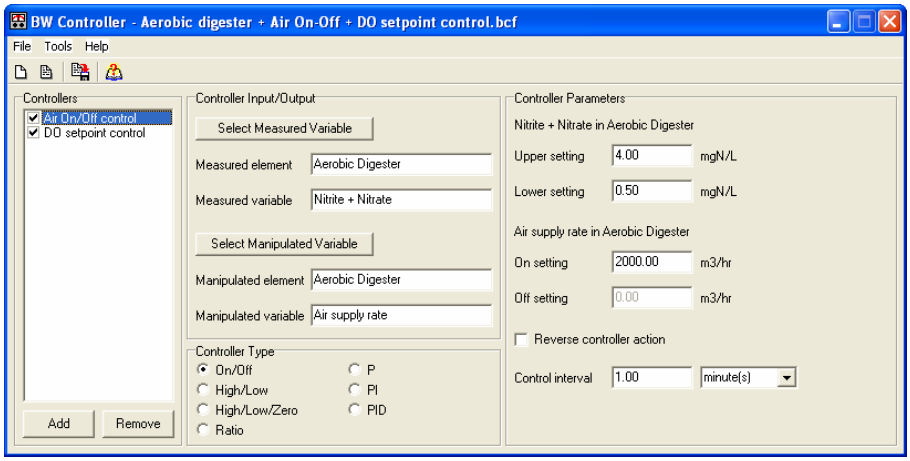
Information displayed in the Controller Parameters section of the interface changes, depending on the type of controller selected.

Information required for the different controller types is specified below.

On/Off Control

The On/Off controller is used to maintain a monitored variable between upper and lower setpoints. Controller action switches the manipulated variable to a specified value when 'on', and to zero when 'off'.

Interface appearance – On/Off control



BW Controller interface when an On/Off controller is selected

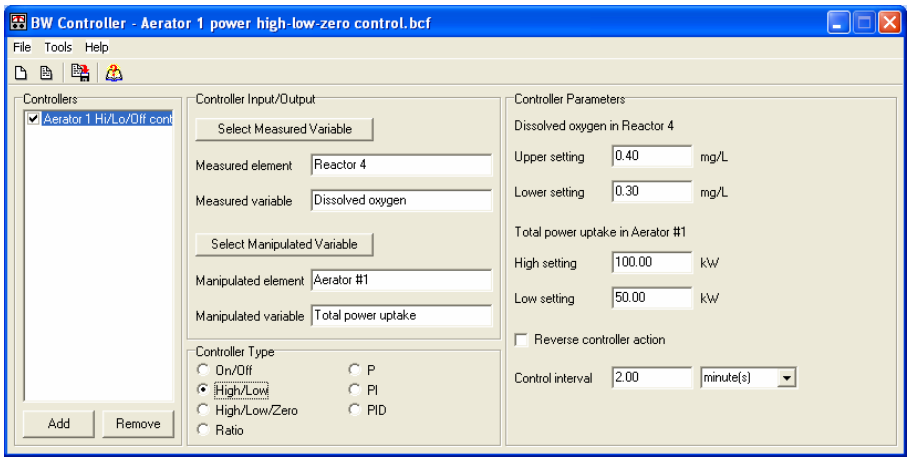
On/Off control parameters

- **Upper setting:** Upper setpoint for the measured variable.
- **Lower setting:** Lower setpoint for the measured variable.
- **On setting:** The value of the manipulated variable when the controller switches the manipulated variable on.

High/Low Control

The High/Low controller is similar to the On/Off controller, and is used to maintain a monitored variable between upper and lower setpoints. However, controller action switches the manipulated variable between a high value and a low value; that is, the 'off' value of the manipulated variable can be set to a value greater than zero.

Interface appearance – High/Low control



BW Controller interface when a High/Low controller is selected

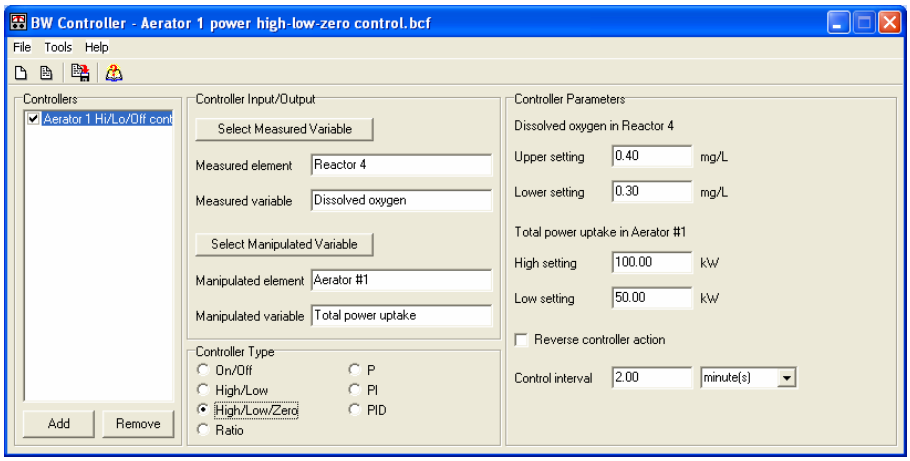
High/Low control parameters

- **Upper setting:** Upper setpoint for the measured variable.
- **Lower setting:** Lower setpoint for the measured variable.
- **High setting:** The value of the manipulated variable when the controller switches the manipulated variable to the High setting.
- **Low setting:** The value of the manipulated variable when the controller switches the manipulated variable to the Low setting.

High/Low/Zero Control

The High/Low/Zero controller is similar to the High/Low controller, and is used to maintain a monitored variable between upper and lower setpoints. However, controller action switches the manipulated variable between three settings: a high value, a low value, and zero.

Interface appearance – High/Low/Zero control



BW Controller interface when a High/Low/Zero controller is selected

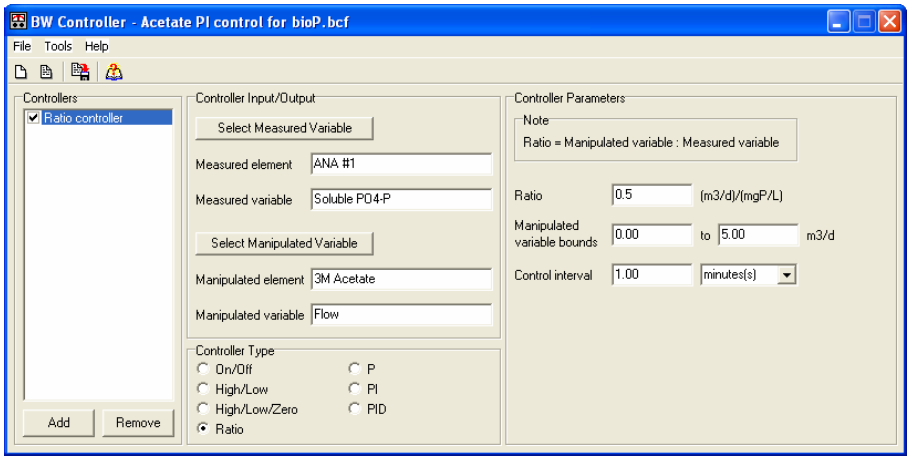
High/Low/Zero control parameters :

- **Upper setting:** Upper setpoint for the measured variable.
- **Lower setting:** Lower setpoint for the measured variable.
- **High setting:** The value of the manipulated variable when the controller switches the manipulated variable to the High setting.
- **Low setting:** The value of the manipulated variable when the controller switches the manipulated variable to the Low setting.

Ratio Control

The Ratio controller adjusts the manipulated variable in a fixed proportion to the measured variable.

Interface appearance – Ratio control



BW Controller interface when a Ratio controller is selected

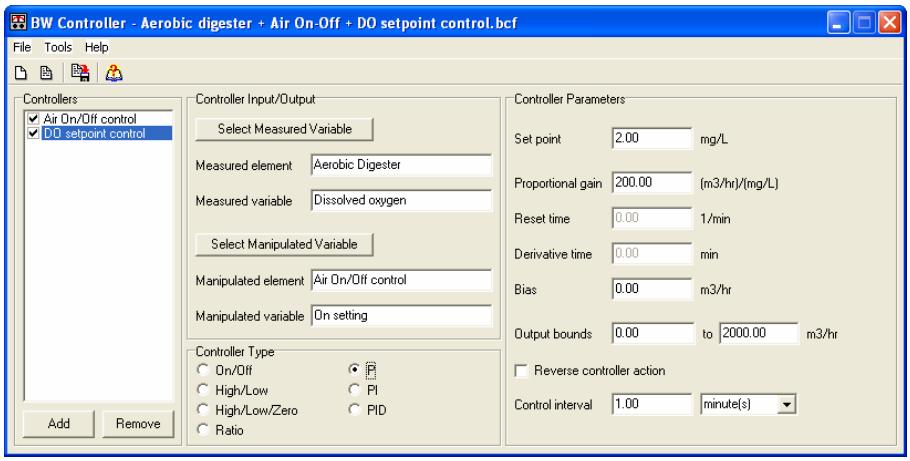
Ratio control parameters

- **Ratio:** Setpoint for the ratio of the manipulated variable to the measured variable.
- **Manipulated variable bounds:** The minimum and maximum possible values for the manipulated variable.

Proportional (P) Control

The Proportional (P) controller is a standard feedback controller, adjusting the manipulated variable with the objective of maintaining the measured variable at a setpoint.

Interface appearance – P control



BW Controller interface when a Proportional (P) controller is selected

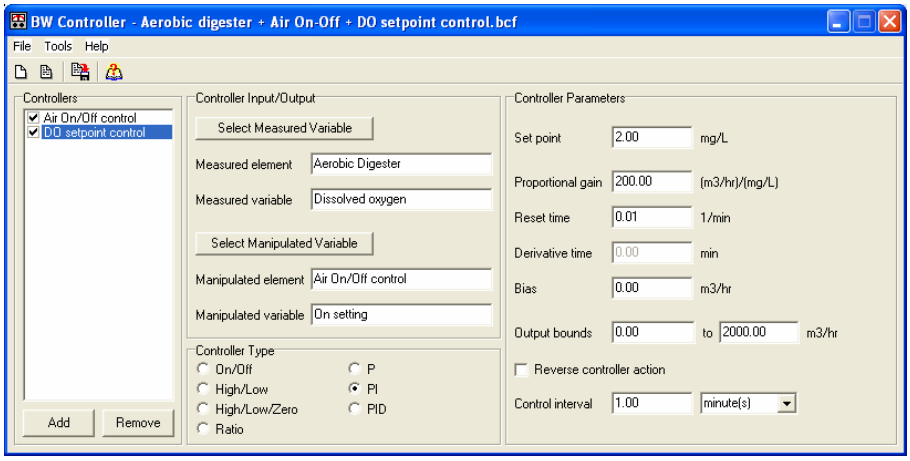
Proportional (P) control parameters

- **Setpoint:** Setpoint for the measured variable.
- **Proportional gain:** Controller gain constant.
- **Bias:** Value of the manipulated variable when control if first initiated.
- **Output bounds:** The minimum and maximum possible values for the manipulated variable.

Proportional-Integral (PI) Control

The Proportional-Integral (PI) controller is a standard feedback controller, adjusting the manipulated variable with the objective of maintaining the measured variable at a setpoint.

Interface appearance – PI control



BW Controller interface when a Proportional-Integral (PI) controller is selected

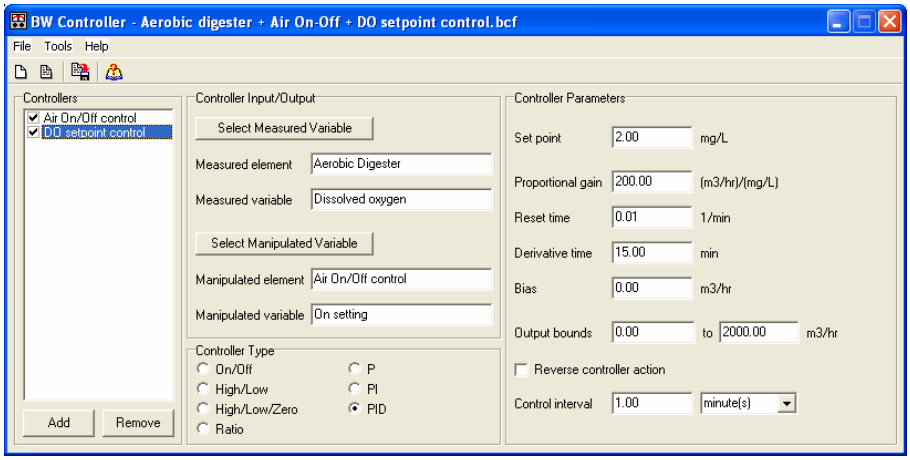
Proportional-Integral (PI) control parameters

- **Setpoint:** Setpoint for the measured variable.
- **Proportional gain:** Controller gain constant.
- **Reset time:** Controller reset time [reciprocal of integral time].
- **Bias:** Value of the manipulated variable when control if first initiated.
- **Output bounds:** The minimum and maximum possible values for the manipulated variable.

Proportional-Integral-Derivative (PID) Control

The Proportional-Integral-Derivative (PID) controller is a standard feedback controller, adjusting the manipulated variable with the objective of maintaining the measured variable at a setpoint.

Interface appearance – PID control



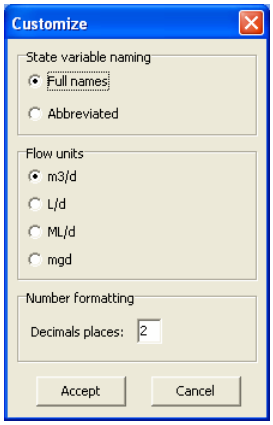
BW Controller interface when a Proportional-Integral-Derivative (PID) controller is selected

Proportional-Integral-Derivative (PID) control parameters

- **Setpoint:** Setpoint for the measured variable.
- **Proportional gain:** Controller gain constant.
- **Reset time:** Controller reset time [reciprocal of integral time].
- **Derivative time:** Controller derivative time.
- **Bias:** Value of the manipulated variable when control if first initiated.
- **Output bounds:** The minimum and maximum possible values for the manipulated variable.

Customizing BW Controller

Some features can be customized in the BW Controller. Selecting the menu command **Tools|Customize…** opens the dialog shown below.



Dialog for customizing BW Controller

Variable Naming

To control the display of variable naming, use the radio buttons in the **Variable naming** section to choose between **Full names** and **Abbreviated**. For example, the full name for AOBs is 'ammonia oxidizing biomass', and the abbreviated name is Z_{AOB}.

The selection in BW Controller does not change the selection in BioWin.

Flow Units

In the **Flow units** radio button group, you may choose from the following:

- Cubic meters per day (**m^3/d**)
- Liters per day (**L/d**)
- Megaliters per day (**ML/d**)
- US million gallons per day (**mgd**)

Number Formatting

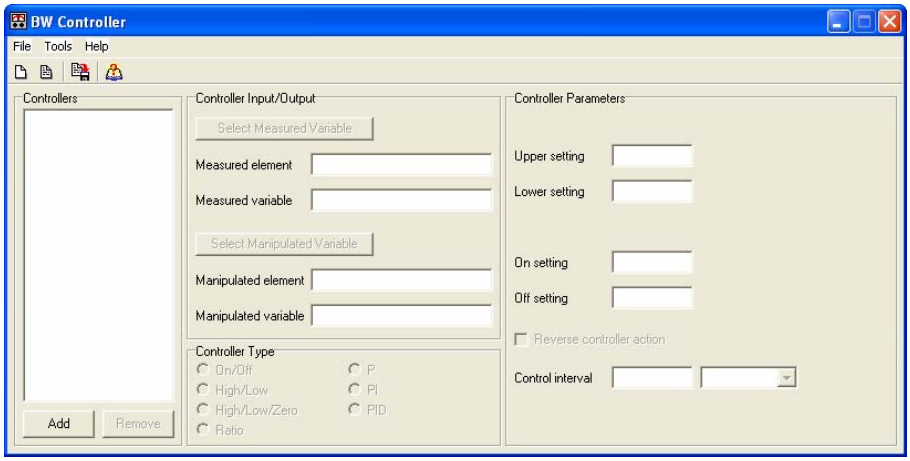
In the **Number formatting** section you may specify the number of decimal points for values displayed in the BW Controller interface.

Running Simulations

The typical sequence of running the BW Controller linked to BioWin is as follows:

1. Start BioWin, and open a BioWin configuration file.
2. Click the **Start BW Controller** button on the toolbar in BioWin. This opens the BW Controller with a blank interface.

Start BW Controller

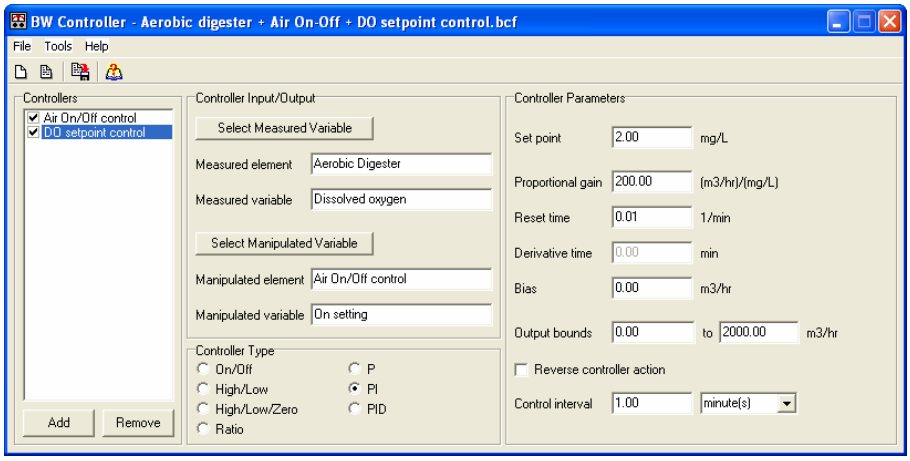


Blank BW Controller interface

3. Either open an existing BW Controller file or add a controller(s) by clicking on the **Add** button at the lower left. Adding a new controller involves:

   - Specifying the controller name;
   - Selecting the **Measured** and **Manipulated Variables**;
   - Selecting the **Controller Type**;
   - Specifying **Controller Parameters**.

An example of how the interface may appear after specifying the required information is shown below.



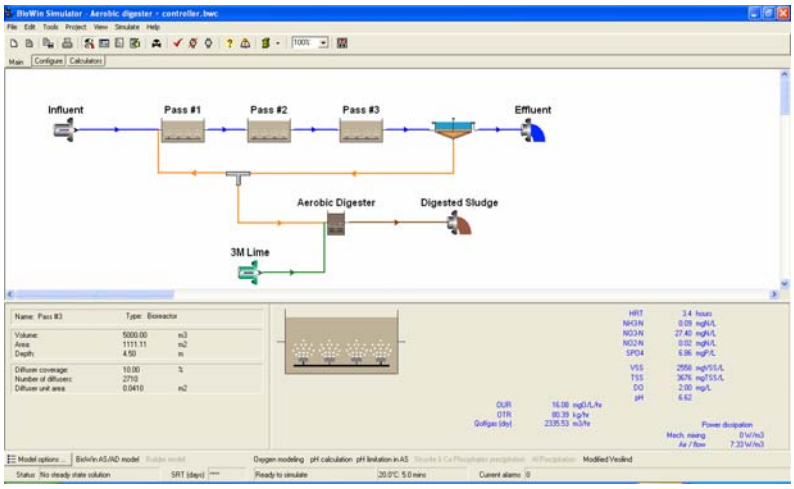
Example of BW Controller interface after setting up two controllers

4. Return to BioWin, and run dynamic simulations in the usual manner.
5. View response of the controlled process in BioWin Album charts.

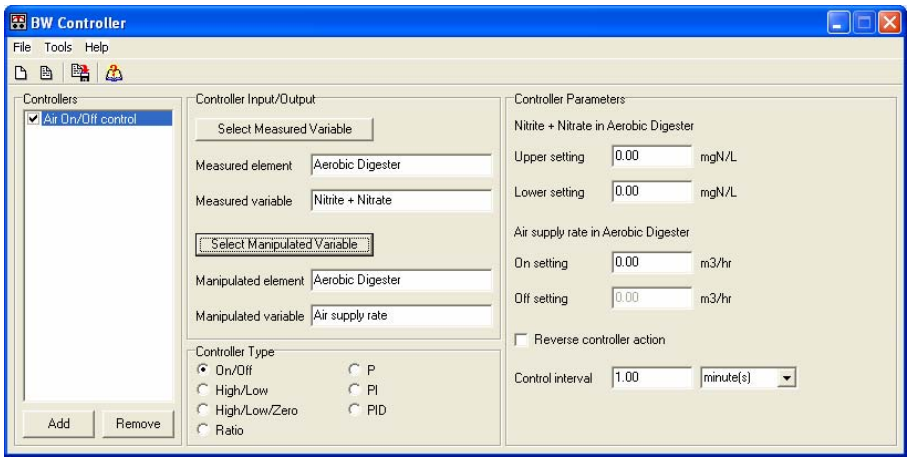
Example – Aerobic Digester Air Control

In aerobic digestion of waste activated sludge there is an issue with pH control because nitrification of lyzed organic nitrogen removes alkalinity. Rather than adding alkalinity, one solution is to operate with alternating aerated/unaerated cycles.

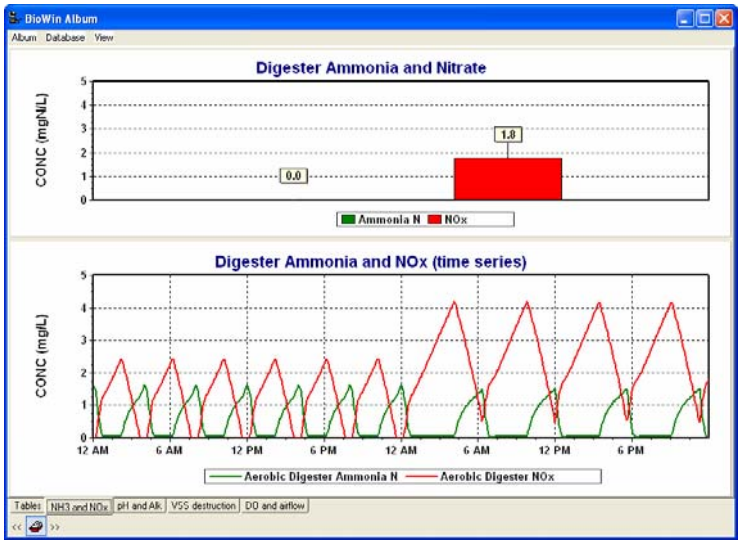
During the aerated phase nitrate increases and during the unaerated phase denitrification of the nitrate produced recovers alkalinity; if all the nitrate is denitrified there is a net-zero alkalinity change and pH is held constant.



An aerobic digester configuration



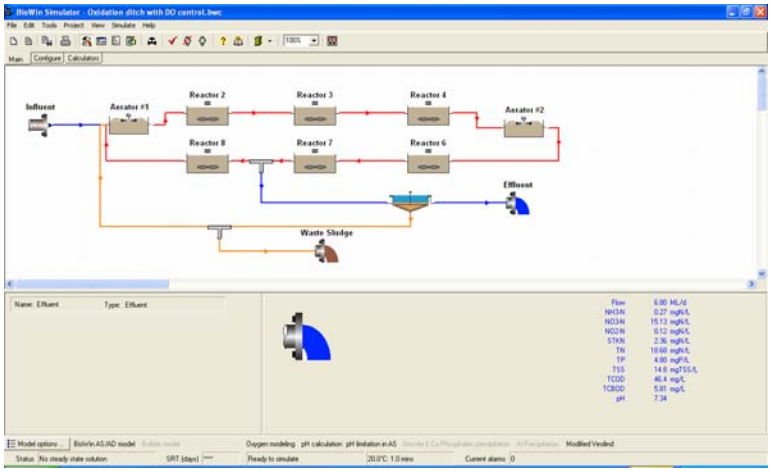
BW Controller interface showing the measured and manipulated variables



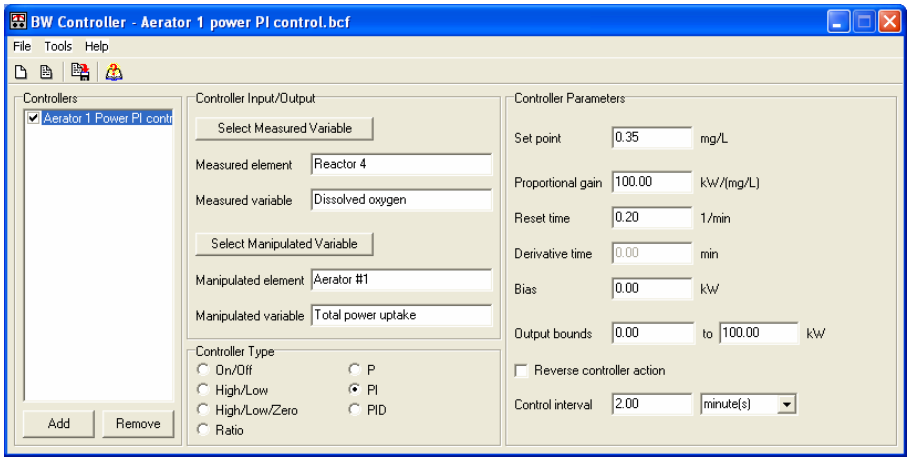
NOX and ammonia response in the aerobic digester with On/Off control

Example – Oxidation Ditch Aeration Control

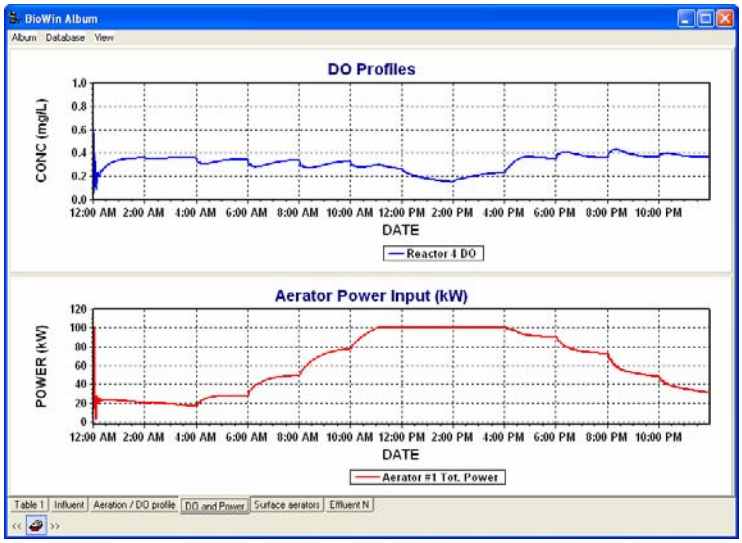
A simple oxidation ditch has two 100 kW surface aerators, one at each end of the ditch. Each aerator can operate at high speed (100 kW) or low speed (50 kW), and obviously can be switched off. Operations staff at the plant find that if both aerators operate continuously at high speed, then the mixed liquor is over-aerated for a significant period each day. By trial the operators find that if one aerator operates at high speed continuously but the other aerator is switched between high/low speed settings (or switched off at times), then it is possible to maintain a reasonably low DO at the downstream ends of each side in the ditch. This improves nitrogen removal performance through SND. The staff now wishes to automate this switching process through online control.



The oxidation ditch configuration



BW Controller interface showing the completed PI controller set up

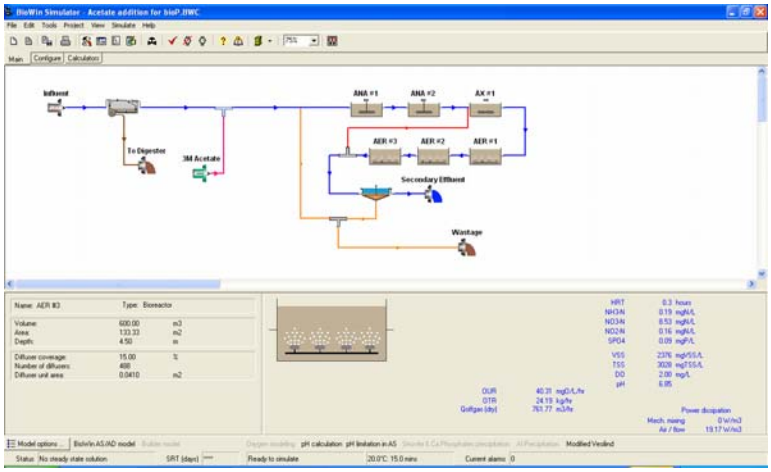


DO response and required power input with PI control

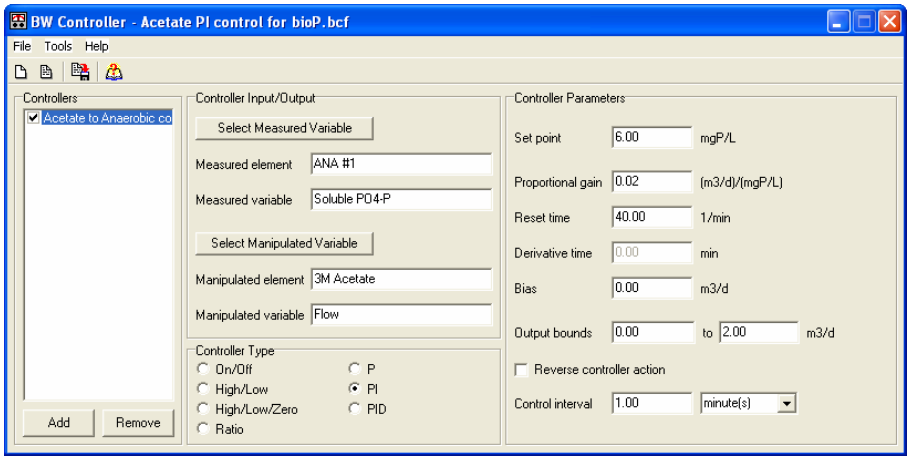
Example – Biological P Removal System

A problem may occur in biological phosphorus removal (BPR) systems if the influent COD concentration decreases; for example, during rain events. In this situation internal storage products may become depleted.

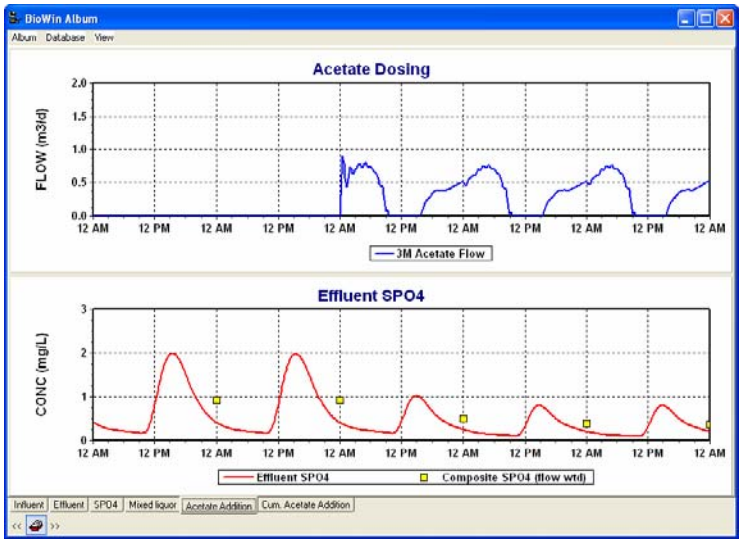
This case study looks at this situation for a continuous flow 10,000 m^3/day BNR system where the plant is experiencing difficulties meeting an effluent P limit of 1 mg/L. As a short-term measure, various strategies for adding sodium acetate to the anaerobic zone of the system were considered, using different control approaches.



The BNR configuration



BW Controller interface showing the completed PI controller set up



Acetate addition and effluent PO4 response