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 N₂ 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 WindowsTM-style menus and buttons:

🞛 BW Controller - Aerobi	c digester + Air O	n-Off control.bcf			
File Tools Help					
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Controllers	Controller Input/Output	ut	Controller Parame	ters	
D0 controller #1	Select Measured	Variable	Set point	2.00	mg/L
	Measured element	Pass #3	Proportional gain	40.00	(m3/hr)/(mg/L)
	Measured variable	Dissolved oxygen	Reset time	10.00	1/min
	Select Manipulater	d Variable	Derivative time	0.00	min
	Manipulated element	Pass #3	Bias	0.00	m3/hr
	Manipulated variable	Air supply rate	Output bounds	0.00	to 2000.00 m3/hr
	Controller Type C On/Off	C P	Reverse cont	roller action	
Add Damas	C High/Low C High/Low/Zero	© PI © PID	Control interval	1.00	minute(s)
Add Remove	C Ratio				

BW Controller interface

The following sections provide a quick outline of each part.

Toolbar

The toolbar shows four buttons.

Main	Description
6	New: Click this button to close the current controller setup and start a new one.
B	Open BW Controller File: Click this button to open a controller file from disk.
₽ <mark>₽</mark>	Save: Click this button to save the current controller setup to disk.
<u> </u>	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.

🔛 BW Controller - Aerobi	c digester + Air On-Off + DO setpoint control.b	cf	
File Tools Help			
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Controllers	Controller Input/Output	Controller Parameters	
 ✓ Air On/Off control ✓ D0 setpoint control 	Select Measured Variable	Set point 2.00	mg/L
	Measured element Aerobic Digester	Proportional gain 200.00	(m3/hr)/(mg/L)
	Measured variable Ussolved oxygen	Reset time 0.01	1/min
	Select Manipulated Variable	Derivative time 0.00	min
	Manipulated element Air On/Off control	Bias 0.00	m3/hr
	Manipulated variable On setting	Output bounds 0.00	to 2000.00 m3/hr
	Controller Type C On/Off C P C Visit a C P	Reverse controller action	
Add Remove	High/Low/Zero C PID	Control interval 1.00	minute(s)
Aug Hemove	C Ratio		

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.

Select Measured Variable	
Select element 3M Lime Aerobic Digester Digested Studge Effluent FST Influent Pass #1 Pass #2 Pass #3 WAS splitter	Variable type: State variables Continned Select variable Select variable Benent specific Mater dennisty Benent specific Materia suppended solids Total suppended solids Particulate COD Filtered COD Soluble PO4-P Total P Filtered COD Filtered TKN Particulate TKN Total Keldahi Nitrogen Filtered Carbonaceous BOD Nitrite + Nitrate Total In Total Inorganic N Alkalinity pH Valatile fatty acids Total inorganic suspended solids Total inorganic suspended solids
	Accept Cancel

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.

Select Manipulated Variable	
Select element 3M Lime Aerobic Digester F5T Influent Pass #1 Pass #2 Pass #3 WAS splitter Air On/Off control	Select variable Air supply rate
	Accept Cancel

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'.

🔛 BW Controller - Aerob	ic digester + Air O	n-Off + DO setpoint cor	ntrol. b	cf			
File Tools Help							
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Controllers	Controller Input/Outp	ut		Controller Parame	eters		
 Air On/Off control D0 setpoint control 	Select Measured	l Variable		Nitrite + Nitrate in	Aerobic Digeste	r	
	Measured element	Aerobic Digester	_	Upper setting	4.00	mgN/L	
	Measured variable	Nitrite + Nitrate		Lower setting	0.50	mgN/L	
	Select Manipulate	d Variable		Air supply rate in a	Aerobic Digester		
	Manipulated element	Aerobic Digester	_	On setting	2000.00	m3/hr	
	Manipulated variable	Air supply rate	-	Off setting	0.00	m3/hr	
	Controller Type	,		Reverse cont	troller action		
	On/Off High/Low	C P C P		Control interval	1.00	minute(s) 💌	
Add Remove	C High/Low/Zero C Ratio	C PID					

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.

😨 BW Controller - Aerato	r 1 power high-low-zero control.bcf		
File Tools Help			
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Controllers	Controller Input/Output	Controller Parameters	
Aerator 1 Hi/Lo/Off cont	Select Measured Variable	Dissolved oxygen in Reactor 4	
	Measured element Reactor 4	Upper setting 0.40 mg/L	
	Measured variable Dissolved oxygen	Lower setting 0.30 mg/L	
	Select Manipulated Variable	Total power uptake in Aerator #1	
	Manipulated element Aerator #1	High setting 100.00 kW	
	Manipulated variable Total power uptake	Low setting 50.00 kW	
	Controller Tune	Reverse controller action	
	C On/Off C P	Control interval 2.00 minute(s)	
Add Remove	C High/Low/Zero C PID C Ratio		

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.

🞛 BW Controller - Aerato	r 1 power high-low-zero control.bcf		
File Tools Help			
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Controllers	Controller Input/Output	Controller Parameters	
Aerator 1 Hi/Lo/Off cont	Select Measured Variable	Dissolved oxygen in Reactor 4	
	Measured element Reactor 4	Upper setting 0.40 mg/L	
	Measured variable Dissolved oxygen	Lower setting 0.30 mg/L	
	Select Manipulated Variable	Total power uptake in Aerator #1	
	Manipulated element Aerator #1	High setting 100.00 kW	
	Manipulated variable Total power uptake	Low setting 50.00 kW	
		Reverse controller action	
	Controller Type C On/Off C P C High/Low C PI	Control interval 2.00 minute(s) -	
Add Remove	© High/Low/Zeroj C PID C Ratio		

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.

🞛 BW Controller - Aceta	te PI control for bioP.bcf	
File Tools Help		
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Controllers Ratio controller Add	Controller Input/Output Select Measured Variable Measured variable Soluble P04-P Select Manipulated Variable Manipulated element Manipulated variable Flow Controller Type C Dn/Dff C P High/Low C PI G High/Low/Zero C PID G Ratio	Controller Parameters Note Ratio = Manipulated variable : Measured variable Ratio 0.5 (m3/d)/(mgP/L) Manipulated variable bounds 0.00 to 5.00 mainutes(s)

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.

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File Tools Help			
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Controllers	Controller Input/Output	Controller Parameters	
 Air On/Off control D0 setpoint control 	Select Measured Variable	Set point 2.00	mg/L
	Measured element Aerobic Digester Measured variable Dissolved oxygen	Proportional gain 200.00	(m3/hr)/(mg/L)
		Reset time 0.00	1/min
	Select Manipulated Variable	Derivative time 0.00	min
	Manipulated element Air On/Off control	Bias 0.00	m3/hr
	Manipulated variable On setting	Output bounds 0.00	to 2000.00 m3/hr
	Controller Type	Reverse controller action	
Add Remove	C High/Low C PI C High/Low/Zero C PID C Ratio	Control interval 1.00	minute(s)

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 - Aerobi	: digester + Air On-Off + D	O setpoint control.bo	cf		
File	Tools Help					
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	ontrollers	Controller Input/Output		Controller Paramet	ters	
	 All Un/Ultr control D0 setpoint control 	Select Measured Variable		Set point	2.00	mg/L
		Measured element Aerobic Di	gester	Proportional gain	200.00	(m3/hr)/(mg/L)
		Measured variable Dissolved	oxygen	Reset time	0.01	1/min
		Select Manipulated Variable	1	Derivative time	0.00	min
		Manipulated element Air On/Off	control	Bias	0.00	m3/hr
		Manipulated variable On setting		Output bounds	0.00	to 2000.00 m3/hr
		Controller Type C On/Off C I	P	Reverse contr	oller action	
		C High/Low	PI	Control interval	1.00	minuto(a)
	Add Remove	C High/Low/Zero C I C Ratio	PID	Control Interval	1.00	

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.

🞛 BW Controller - Aerobic digester + Air On-Off + DO setpoint control.bcf						
File Tools Help						
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Controllers Controller Input/Output	Controller Parameters					
Select Measured Variable	Set point 2.00 mg/L					
Measured element Aerobic Digester	Proportional gain 200.00 (m3/hr)/(mg/L)					
Measured variable Dissolved oxygen	Reset time 0.01 1/min					
Select Manipulated Variable	Derivative time 15.00 min					
Manipulated element Air On/Off control	Bias 0.00 m3/hr					
Manipulated variable On setting	Output bounds 0.00 to 2000.00 m	3/hr				
Controller Type C Dn/Dff C P	Reverse controller action					
Add Remove C High/Low/Zero C PID C Ratio	Control interval 1.00 minute(s)					

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.

Customize 🛛 🔀		
State variable naming Full names		
C Abbreviated		
Flow units		
⊛ m3/d		
⊂ L/d		
⊂ ML/d		
C mgd		
Number formatting		
Decimals places: 2		
Accept Cancel		

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 (**m³/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.

🞛 Start BW Controller

2. Click the **Start BW Controller** button on the toolbar in BioWin. This opens the BW Controller with a blank interface.

BW Controller Manual

BW Controller		
File Tools Help		
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Controllers	Controller Input/Output	Controller Parameters
	Select Measured Variable	
	Measured element	Upper setting
	Measured variable	Lower setting
	Select Manipulated Variable	On setting
	Manipulated element	
	Manipulated variable	Off setting
	Controller Type	Reverse controller action
	C On/Off C P C High/Low C PI C High/Low/Zero C PID	Control interval
Add Remove	C Ratio	

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.

😨 BW Controller - Aerobi	c digester + Air On-Off + DO setpoint control.b	ocf	
File Tools Help			
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Controllers	Controller Input/Output Controller Parameters		
✓ Air On/Off control ✓ D0 setpoint control	Select Measured Variable	Set point 2.00	mg/L
	Measured element Aerobic Digester	Proportional gain 200.00	(m3/hr)/(mg/L)
	Measured variable Dissolved oxygen	Reset time 0.01	1/min
	Select Manipulated Variable	Derivative time 0.00	min
	Manipulated element Air On/Off control	Bias 0.00	m3/hr
	Manipulated variable On setting	Output bounds 0.00	to 2000.00 m3/hr
	Controller Type C On/Off C P	Reverse controller action	
Add Remove	C High/Low C PI C High/Low/Zero C PID C Ratio	Control interval 1.00	minute(s)

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		
ile Tools Help		
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Controllers	Controller Input/Output	Controller Parameters
Air On/Off control	Select Measured Variable	Nitrite + Nitrate in Aerobic Digester
	Measured element Aerobic Digester	Upper setting 0.00 mgN/L
Mei	Measured variable Nitrite + Nitrate	Lower setting 0.00 mgN/L
	Select Manipulated Variable	Air supply rate in Aerobic Digester
	Manipulated element Aerobic Digester	On setting 0.00 m3/hr
Manipulated variable Air supply	Manipulated variable Air supply rate	Off setting 0.00 m3/hr
	Controller Tupe	Reverse controller action
	© On/Off C P	Control interval 1.00 minute(s)
Add Remove	C High/Low/Zero C PID	

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 - Aerato	r 1 power PI control.bcf		
File Tools Help			
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Controllers	Controller Input/Output	Controller Parameters	
Aerator 1 Power PI contr	Select Measured Variable	Set point 0.35	mg/L
	Measured element Reactor 4	Proportional gain 100.00	kW/(mg/L)
	Measured variable Dissolved oxygen	Reset time 0.20	1/min
	Select Manipulated Variable	Derivative time 0.00	min
	Manipulated element Aerator #1	Bias 0.00	kW
	Manipulated variable Total power uptake	Output bounds 0.00	to 100.00 kW
	Controller Type	Reverse controller action	
Add Remove	C High/Low Pl High/Low/Zero PlD	Control interval 2.00	minute(s)
Aug Hemove	C Ratio		





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 $10,000 \text{ m}^3/\text{day BNR}$ 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 - Acetat	e PI control for bioP.bcf		
File Tools Help			
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Controllers	Controller Input/Output	Controller Parameters	
Acetate to Anaerobic co	Select Measured Variable	Set point 6.00	mgP/L
	Measured element ANA #1	Proportional gain 0.02	(m3/d)/(mgP/L)
	Measured variable Soluble PO4-P	Reset time 40.00	1/min
	Select Manipulated Variable	Derivative time 0.00	min
	Manipulated element 3M Acetate	Bias 0.00	m3/d
	Manipulated variable Flow	Output bounds 0.00	to 2.00 m3/d
	Controller Type	Reverse controller action	
Add Remove	C High/Low C Pl C High/Low/Zero C PlD	Control interval 1.00	minute(s)
	10 Hatto		

BW Controller interface showing the completed PI controller set up



Acetate addition and effluent PO4 response