Drinking Water Operator Certification Training
Instructor Guide

Module 1:
General Overview

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:

The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
Penn State Harrisburg Environmental Training Center

A Note to the Instructor

Dear Instructor:

The primary purpose of this course, *General Overview,* is to provide a brief outline of the public water system, including the responsibilities of the operator, public water system classifications, federal and state regulations, and water treatment processes. This module has been designed to be completed in 3 hours, but the actual course length will depend upon content and/or the delivery modifications and results of dry runs performed by the DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the DEP course approval process. To help you prepare a personal lesson plan, timeframes have been included in the instructor guide at the Unit level and at the Roman numeral level of the topical outline. You may adjust these timeframes as necessary to match course content and delivery modifications made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by DEP.

Web site URLs and other references are subject to change, and it is the training sponsor's responsibility to keep such references up to date.

Delivery methods to be used for this course include:

- Lecture
- Open Discussion
- Exercises
- Case Study

To present this module, you will need the following materials:

- One workbook per participant
- Extra pencils
- Flip Chart
- Markers
- Laptop (loaded with PowerPoint) and an LCD projector **or** overheads of presentation and an overhead projector
- Screen

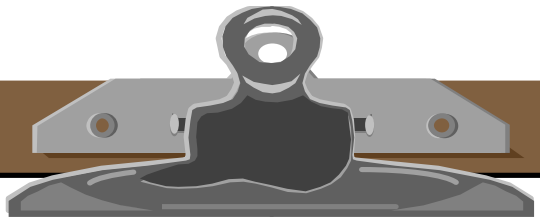
Icons to become familiar with include:

Participant Workbook	Instructor Guide
 Exercise/Activity	Same icons for Participant Workbook apply to the Instructor Guide.
 Case Study	**Ans:** Answer to exercise, case study, discussion, question, etc.
 Discussion Question	 PowerPoint Slide
 Calculation(s)	 Overhead
 Key Definition(s)	 Flip Chart
 Key Point(s)	 Suggested "Script"

Instructor text that is meant to be general instructions for the instructor are designated by being written in italicized font and enclosed in brackets. For example:

[*Ask participants if they have any questions on how to read the table. Answer any questions participants may have about how to read this table.*]

If your module includes the use of a PowerPoint presentation, below are some helpful controls that you may use within the Slide Show.



PowerPoint Slide Show Controls

You can use the following shortcuts while running your slide show in full-screen mode.

To	**Press**
Advance to the next slide	N, ENTER, or the SPACEBAR (or click the mouse)
Return to the previous slide	P or BACKSPACE
Go to slide <number>	<number>+ENTER
Display a black screen, or return to the slide show from a black screen	B
Display a white screen, or return to the slide show from a white screen	W
Stop or restart an automatic slide show	S
End a slide show	ESC
Return to the first slide	Both mouse buttons for 2 seconds
Change the pointer to a pen	CTRL+P
Change the pen to a pointer	CTRL+A
Hide the pointer and button temporarily	CTRL+H
Hide the pointer and button always	CTRL+L
Display the shortcut menu	SHIFT+F10 (or right-click)
Erase on-screen annotations	E
Go to next hidden slide	H
Set new timings while rehearsing	T
Use original timings while rehearsing	O
Use mouse-click to advance while rehearsing	M

INTRODUCTION OF MODULE: 5 minutes

Display Slide 1—Module 1: General Overview

[Welcome participants to "Module 1 – General Overview." Indicate the primary purpose of this course is to provide a brief overview of the public water system, including the responsibilities of the operator, public water supply system classifications, federal and state regulations, and water treatment processes.]

[Introduce yourself.]

[Provide a brief overview of the module:]

This module contains 4 units. On page i, you will see the topical outline for **Unit 1 – Overview** and **Unit 2 – Public Water Supply System Classifications**.

[Briefly review outline.]

If you turn the page, you will see the topical outline for **Unit 3 – Federal and State Regulations** and **Unit 4 Overview of Water Treatment Processes**.

[Continue to briefly review outline.]

UNIT 1: 40 minutes

[Display Slide 2—Unit 1: General Overview.]

At the end of this unit, you should be able to:

- Describe the responsibilities of the water supply facility and the treatment plant operator.
- List the 5 drinking water treatment objectives.
- Describe three important historical achievements in water treatment that link contaminated water to disease.

RESPONSIBILITIES OF WATER SUPPLIER AND TREATMENT PLANT OPERATOR : 10 minutes

Job of Public Water Supplier

We will begin this unit by demonstrating how water is essential to life and how it is necessary to treat water for public consumption since most water sources are contaminated.

[Review paragraph under Job of Public Water Supplier.]

Can you name any examples of contaminants? Which of these classifications (i.e., suspended, chemical, biological, natural, man-made) would they fall under?

Ans:

Contaminant	Type	Natural/Man Made
Iron	Chemical	Natural (usually) Can be man made (industrial or mine discharge)
Cryptosporidium (a spore forming parasite)	Biological	Natural (from animal droppings)
Clay particles	Suspended	Natural
MTBE (a gas additive)	Chemical	Man made
Nitrates	Chemical	Usually man made (from farm manure, chemical fertilizer, or malfunctioning septic systems)
Legionella (a virus)	Biological	Natural
Fluoride	Chemical	Natural (This is a trick question. Many systems add fluoride to promote dental health, but it occurs naturally in some waters in high enough concentrations to be harmful)

These are just a few examples. Has anyone had to deal with any other interesting or unusual contaminants?

[Emphasize the key point.]

Job of Water Treatment Plant Operator

Since uncontaminated natural water sources are rare, raw water sources must be treated to remove harmful contaminants. Various chemical and physical processes that take place inside the water treatment plant accomplish treatment. These processes are covered in more detail later in other modules.

*[Emphasize that the Water Treatment Plant Operator **must** execute his duties diligently. If contamination breaks through the treatment process and reaches a consumer, it's too late. If a piece of equipment or treatment process breaks down, you can't just shut the plant down and wait until it gets fixed -- consumers can't do without water for a week because the plant is down.]*

WATER AND PUBLIC HEALTH : 20 minutes

Water Treatment Objectives

We've just discussed the job of the Water Supplier and Treatment Plant Operator. Now let's discuss the relationship between Drinking Water and Public Health.

[Review water treatment objectives.]

[Note that the actual treatment processes used to meet these objectives are covered individually in later modules.]

History of Water Treatment

There is a history of water treatment going all the way back to 4000 B.C. Let's look at some key historical developments.

[Review paragraph under History of Water Treatment.]

[Display Slide 3 – Timeline of Significant Developments in Water Treatment

Indicate that this is a graphic representation of significant developments in water treatment.]

*[Review **Timeline of Early Water Treatment Advances**]*.

 In your opinion, what are the three key historical achievements in water treatment and why?

Ans: The key historical achievements are those that link water quality to human health.

400 B.C. – Hippocrates made a connection between water and health. He recommended boiling and filtering rainwater through a cloth bag. This is the first time that someone realized that there was more to water quality than clarity and taste, and that water quality had a direct effect on human health.

1854 – Dr. John Snow linked contaminated water supplies with disease in 1854 cholera outbreak in London. This discovery conclusively proved that many diseases are carried by contaminated water. If you can deal with the contamination in the water, you can curb the spread of disease.

1906 – Ozone used for disinfection in France and 1908 – Chlorination used for disinfection in U.S. Widespread disinfection of public water supplies finally brought many diseases under control.

Timeline of Water Quality Regulations

Once the connection between water quality and health was firmly established in the late 1800's and early 1900's, legislation regulating water quality soon followed. A timeline of key regulations is given on page 1-5.

[Review Timeline of Water Quality Regulations. Point out that the particulars of the Safe Drinking Water Act will be discussed in Unit 2.]

[Display Slide 4 – Unit 1 Key Points

[Review the Key Points to summarize the unit.]

This concludes Unit 1. Does anyone have any questions?

[Move on to Unit 2.]

UNIT 2: 25 minutes

[Display Slide 5—Unit 2: Public Water Supply System Classifications.]

At the end of this unit, you should be able to:

- Describe the different classifications of water systems and an example of each.

PURPOSE AND DEFINITION: 2 minutes

Now let's discuss the various ways to classify water systems. First, let's review the purpose of classification.

Purpose of Classification

[Review paragraph.]

You will see some specific examples in the next unit, which goes into the regulations in more detail.

Definition of Public Water Supply System

- *[Review definition of public water supply system.]*

Water systems are classified as either "community" or "non-community" water systems. Community systems are then classified as either "small" or "large" based on the number of people they supply. And non-community systems are divided into "transient" and "non-transient" based on the number of people they serve continuously. Let's discuss each of these in a little more detail.

[Go on to page 2-3]

BASIS USED FOR CLASSIFICATION: 20 minutes

Non-Community or Community

[Review definition of Community Water System and examples.]

[Review definition of Non-Community Water System.]

Non-Transient or Transient

Non-community water systems are further broken down into Transient and Non-Transient systems.

[Review definition of Non-Transient Water System and example.]

Can you think of an example of a Non-Transient Water System?

Ans: A school or college with its own water supply

[Review definition of Transient Water System and examples.]

What would be some examples of a Transient Water Systems?

Ans: A vacation resort or campground with it's own water supply

A restaurant with a private well

Size Classifications of Community Water Systems

[Review definition of Small Water Systems. Mention that some of these differences are noted in the discussions in Unit 3, which covers specific regulations.]

[Review definition of Large Water Systems.]

- Some specific regulations use other size classifications to define compliance requirements. An example is the total coliform rule, which is discussed in more detail in Unit 3 of this module.

Exercise

Look at the descriptions of water systems on page 2-4 in your workbook. Identify them as Community or Non-Community. If Non-Community, further identify them as Transient or Non-Transient. We'll go over your answers together as a group.

1. A hospital has its own private well and water treatment system.

ANS: A hospital would serve more than 25 persons, but not the same people continuously year-round. Therefore, it is a non-community system. It would likely be a transient system, as people would be there (hopefully) for less than six months.

2. A farmer has a good spring on his property and provides drinking water to 16 of his neighbors, free of charge.

ANS: This is a community system because it has more than 15 service connections and serves them year-round. The fact that the farmer does it free of charge is irrelevant.

3. A real estate developer buys bulk water from United Philadelphia American Water Company through a single metered connection and resells the water to the 17 homes in his development.

ANS: Even though the developer does not treat the water, since he has control over the final service connections he is considered the "supplier". Since there are more than 15 service connections served year-round, this is a community system.

4. The same developer gets rid of the metered connection and lets UPAW Co. bill the 17 homes directly.

ANS: This is still a community system, as it doesn't matter who has the service connections, only how many and whether they are served year-round.

5. A restaurant with its own well supply has an apartment above that's connected to the restaurant's plumbing system.

ANS: This is a non-community system as it doesn't serve 25 of the same people or 15 service connections year-round. It is also a transient system, in spite of the fact there is a permanent resident (or residents) above because it serves less than 25 of the same people for more than six months.

6. A campground has sites with camper trailers set up permanently.

ANS: This is a little bit of a trick question. It is most likely a non-community system, as most people do not live in their campers year round. Whether it is transient or non-transient depends on whether 25 or more people do live in their campers for more than 6-months out of the year.

It is absolutely essential that operator become familiar with water system classifications. Many water treatment requirements that operators must meet are based on the classification of the water system.

[Display Slide 6– Unit 2 Key Points]

[Review the Key Points in the workbook to summarize the unit.]

This concludes Unit 2. Does anyone have any questions?

[Move on to Unit 3.]

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UNIT 3: 80 minutes

[Display Slide 7—Unit 3: Federal and State Regulations.]

At the end of this unit, you should be able to:

- State the roles of federal, state, and other government agencies regarding drinking water
- Explain the requirements to becoming and maintaining operator certification
- Identify key regulations that directly affect the water treatment plant operator
- Identify the maximum contaminant levels, and monitoring and reporting requirements for regulated contaminants

ROLES OF VARIOUS GOVERNMENT AGENCIES: 5 minutes

The discussion in this workbook is only intended to be an overview. It is not a comprehensive compilation of all that a water system operator needs to know related to state and federal regulations. Additional information is available from several sources. Some of these sources are discussed later in this workbook under "Regulatory Guidance – State and Federal". It is absolutely necessary for a water treatment plant operator to use these sources and become familiar with all regulations that may impact his duties.

The first section covers who makes the regulations and who enforces them.

United States Environmental Protection Agency

[Review role of the EPA. State that most regulations start at the federal level.]

State of Pennsylvania Department of Environmental Protection

[Review role of the Pa. DEP. State that individual states may enact regulations that are more strict than EPA regulations, but under the primacy arrangement, all of a state's regulations must be at least as strict as EPA's.]

Other Agencies

As water treatment plant operators, you will likely have regular interaction with Pa. DEP. Another agency you may have to interact with is a River Basin Commission.

List the two Pennsylvania River Basin Commissions and the issues they deal with.

SPECIFIC REGULATIONS: 30 minutes

Now that we've covered who makes the regulations and who enforces them, we will discuss the specific provisions of some of the key regulations that directly affect the water treatment plant operator.

Operator Certification Act

The purpose of the operator certification (ACT 11) is to protect public health, safety and the environment. The act ensures that certified operators have appropriate skills, knowledge and abilities to make appropriate process control decisions during the operation of water systems and water distribution systems. To achieve this, the State Board of Certification of Water and Wastewater Systems Operators and the Pa. DEP sets the training, experience and examination standards for operator certification. This was done in ACT 11.

ACT 11

Every water system regulated under ACT 11 must have an appropriately certified operator and an appropriately certified operator must make all process control decisions of system operation.

What is an appropriately certified operator?
What is a process control decision?

An **appropriately certified operator** is defined as having a certificate containing the class and subclass(es) matching the class and subclass(es) of the system that they operate.

A **process control decision** is a decision, which maintains or changes the quality or quantity of water or wastewater in a water system that may affect the public health or environment.

Act 11 does not require all operators that work at a water system to be certified; however only appropriately certified operators can make process control decisions. Uncertified and not appropriately certified operators can only make process control decisions when:

- Under the direction of an appropriately certified operator or,
- Using Standard Operating Procedures (SOP) that were developed by an appropriately certified operator.

Additionally, an appropriately certified operator must be available at all times during system operations.


Available means that an appropriately certified operator is on-site or able to be contacted in a timely manner to make process control decisions to protect the environment and the public health.

The requirements to becoming an appropriately certified operator include:

- **Education Requirement**
  - The applicant must be at least a high school graduate, possess a GED or have been an operator before February 21, 2002.
- **Examination** We'll take more of a look at an examination section later.
- **Criminal History Check**
  - Completed not more than 90 days before the date the operator signs the application
- **Experience Requirement** We'll expand on the experience requirements later.
- Final **official approval by the Board** and awarded a certificate of a class and subclass(es) commensurate with you experience. Final approval will be granted after a thorough review of the applicant's information.

Certification Requirements

The table below shows the varying experience requirements depending on the classification of the certification.

[Display Slide 8 – Table 3.1 Experience Requirements for Certified Operators. Be sure to point out that there is a key in the workbook for the letter designations of the various educational achievements in the table.]

Experience Requirements

Classification	High School Diploma	AS	CP	ASP	BS/BA
A	4 years	3 years	2 years	1 year	2 years
B	3 years	2 years	2 year	6 months	1 year
C	2 years	1 year	6 Months	6 Months	6 Months
D	1 year	1 year	6 Months	6 Months	6 Months
Dn	1 year	1 year	6 Months	6 Months	6 Months
Dc	6 Months	1 year	0	0	0
E	6 Months	1 year	0	0	0

Education/Experience Substitution (for High School Diploma ONLY)

Education/Experience	Total Experience Allowed
Successful completion of every 10 hours of post high school or post GED water or wastewater related training (as applicable) approved by DEP and determined by the State Board for Certification of Water and Wastewater Systems Operators (Board) to be applicable to the certification sought.	1 month experience per 10 hours of training.
Successful completion of a college course approved by DEP as being specifically applicable to the water or wastewater disciplines (Each semester college credit is equivalent to 15 hours.)	1.5 months experience for each semester college credit.

Experience can be demonstrated by participating in any of the following activities under the supervision of a certified operator or a certified operator of a higher classification than requested:

(1) Operation of mechanical equipment,

(2) Maintenance of mechanical equipment,

(3) Collection of samples,

(4) Analysis of chemical and biological samples,

(5) Performing calculations related to process control,

(6) Preparing or standardizing chemical and biological solutions,

(7) Compiling and completing monitoring data, determining appropriate process control measures

An applicant for operator certification may also receive credit toward the total experience requirement by substituting education for experience.

Examination Requirements

Types of Exams

Certification examinations measure the knowledge, skills and abilities necessary to successfully operate specific system sizes and technologies associated with the classification and subclassification of the water or wastewater system.

Examination for certification consists of a two (2)-part examination.

(i) Part I of the examination measures the applicant's general knowledge, skills and abilities common to all water or wastewater systems regardless of size.

(ii) Part II of the examination measures the applicant's specific knowledge, skills and abilities necessary to operate treatment technologies or system components and will parallel the water and wastewater sub-classifications.

The master examination for water systems measures the applicant's general knowledge, skills and abilities and their competency to operate all available treatment technologies and system components.

Separate and single water system examinations are prepared for both Class Dc and Class Dn water treatment plants. Also a separate and single examination for Class E water distribution systems and consecutive systems without treatment will be prepared for operator certification as well as a separate and single examination for wastewater collection systems.

Examination and experience requirements must be met before the Board can issue a certificate. On the next page are three tables that illustrate the Water system classes, subclasses and requirements for the Dc and Dn certificates.

[Instructor: Review the figures below highlighting the following information]

The boxes on page 3-7 of your workbook identify the different water treatment plant classifications. You should also be aware of the following information:

- If you have *any* treatment you cannot be classified as an E or Dn.
- If you have treatment other than disinfection you cannot be classified as a Dc.
- In order to have an appropriate license an operator must certified in both the class and sub-classes of the treatment plant they are operating.
- The advantage of being classified as either Dn or Dc is that the testing process is simplified. Both the Dn and Dc classes have stand-alone tests, and no sub-classification tests are required.

These three illustrations below identify the Water system classes and subclasses.

Water System Classes

A **>5 MGD**
B **>1 MGD but ≤ 5 MGD**
C **>0.1 MGD but ≤ 1 MGD**
D **≤ 0.1 MGD**
E **Distribution systems and consecutive water systems without treatment**

Small Water Systems

Dc systems

1. **system serves less than 500 individuals or has no more than 150 connections, whichever is less;**
2. **the source of water for the system is exclusively groundwater,**
3. **requires only disinfection, and**
4. **meets other applicable requirements provided by the Act and is not in violation of the Act or other PADEP rules and regulations.**

Dn system

Same criteria as Dc system except for condition #3. A Dn system is one where the water requires no treatment.

Water System Subclasses

1. **Conventional filtration**
2. **Direct filtration**
3. **Diatomaceous earth filtration**
4. **Slow sand filtration**
5. **Cartridge or bag filtration**
6. **Membrane filtration**
7. **Corrosion control and sequestering**
8. **Chemical addition**
9. **Inorganic removal**
10. **Organic removal**
11. **Gaseous chlorine disinfection**
12. **Non-gaseous chemical disinfection**
13. **Ultraviolet disinfection**
14. **Ozone disinfection**

Let's see if you have a feel for it.

Answer the next three questions.

1. What certificates would be needed to run a 1 MGD conventional filtration water system that requires treatment for copper (due to low pH), manganese and uses gaseous chlorination as a disinfectant? *Class B, Subclasses 1, 7, 11,*

How much experience would be needed for a person with only a high school diploma before the board would grant a certificate to make process control decisions at this plant? *3 years*

2. What certificates would be needed to run a 10 MGD water system that uses conventional filtration and sodium hypochlorite disinfection? *Class A, Subclasses 1 and 12*

How much experience would be needed for a person with an associates degree in environmental science before the board would grant a certificate to make process control decisions at this plant? *3 years*

3. What certificates would be needed to run a groundwater system with 100 connections and 450 customers and treats with non-gaseous disinfection? *Class Dc*

A Dc class infers that the system disinfects, so the Dc operator does not need a disinfection subclass.

How much experience would be needed for a person with only a high school diploma before the board would grant a certificate to make process control decisions at this plant? *6 months*

Continuing Education Requirement

Certified operators are required to obtain continuing education depending on the operator class. The continuing education requirements are different for each operator class. Continuing education must be earned in their 3-year renewal cycle and the education must be approved by DEP.

[Display Slide 9 –Figure 3.2: Continuing Education Requirements]

Figure 3.2: Continuing Education Requirements

Operator Class	Contact Hours First 3-Yr Cycle	Contact Hours Subsequent 3-Yr Cycles
A	15	30
B	15	30
C	15	30
D	8	15
E (Distribution)	8	15
Dc	4	9
Dn	3	6
Grandparented	8	15

Certified Operator and Owner Responsibility

Certificate holders are required to make sound judgment and must consider the health and welfare of their customers, community and the environment. If it is found that an operator has been negligent, committed fraud, falsified an application, falsified operating records, or failed to use reasonable care or judgment in performance of duties the board may revoke suspend or modify a certificate.

Another important part of this responsibility is liability, with the new certification requirements liability of owners and operators comes to the forefront. Always use your best judgment or your system might find itself hit with a lawsuit.

Certified Operators must

- Meet all the requirements for recertification.
- Report to the system owner any know violation or system condition that may be or are causing violations of any department regulation or permit condition
- Report to the system owner any action to permit or eliminate a violation of applicable water system laws.
- Providing for the suitable O&M of a water system utilizing available resources to comply with all laws.
- Making or implementing process control decisions, or directing actions related to process control decisions for specific water systems.

Owners must:

- Employ, identify and report to the department the names of available operators required by DEP
- Require, supervise and direct certified operators to take such action so that the water system is in compliance with all laws.
- Providing a copy of permit conditions to the certified operator in responsible charge.

Owners, Operators, non-certified operators and maintenance staff can be prosecuted for failing to comply with the **Drinking Water and Wastewater Systems Operators Certification Act.**

Exercise II

Complete the following sentences by filling in the blanks.

1. Every water system regulated under ACT 11 must have *an appropriately certified operator.*

2. Class B operators must obtain ____ hours of continuing education during their first renewal cycle and _____ hours during all subsequent renewal cycles.

3. Owners, *operators*, non-certified operators and maintenance staff can be prosecuted for failing to comply with the **Drinking Water and Wastewater Systems Operators Certification Act.**

4. A *process control decision* is a decision, which maintains or changes the quality or quantity of water or wastewater in a water system that may affect the public health or environment.

5. An *appropriately certified operator* is defined as an operator having a certificate containing the class and subclass(es) matching the class and subclass(es) of the system that they operate.

Safe Drinking Water Act

 *[Review definitions for Safe Drinking Water Act and Primary and Secondary Standards.]*

[Note that "MCL" is an abbreviation that Operators need to know, as it shows up in almost every regulation.]

[Refer participants to tables of MCL's for primary and secondary contaminants (Table 3.1 and 3.2) at the end of the unit.]

Other Relevant Federal Regulations

[Review introduction to Other Relevant Federal Regulations, on page 3-4. Remind participants that this section is only intended to be an overview of regulations.]

*[Note that while the Safe Drinking Water Act only established MCL's, many of the other regulations that built upon the Safe Drinking Water Act also affect **how** a treatment plant is operated.]*

Surface Water Treatment Rule.

This rule was enacted in June 1989. Pa. DEP has primacy for enforcement. National Interim Primary Drinking Water Regulations (NIPDWR) were implemented in 1976. These regulations focused on turbidity limits. It soon became obvious, based on disease outbreaks in both filtered and unfiltered supplies, that these regulations alone were not enough to protect public health. The major components of the Surface Water Treatment Rule were implemented to overcome the shortfalls of the NIPDWR.

[Review major components of Surface Water Treatment Rule.]

[When mentioning "3-log removal" in bullet 2, say:]

"Log removal" is covered in detail in Module 5 – Disinfection

[*When mentioning "Establishes CT as the basis for disinfection", say:]*

The concept of CT, baffling factors, and the effects of temperature and pH on required contact time are covered in Module 5 – Disinfection.

[Review remaining bullets on Surface Water Treatment Rule.]

Groundwater Rule:

This rule was proposed in May of 2000. Generally groundwater is thought to be free of microbial contamination; however, this is not always the case. As of now, only surface water sources (and groundwater under direct influence of surface water) must provide disinfection meeting the CT requirements outlined in the Surface Water Treatment Rule. Groundwater sources only need to provide 20 minutes of disinfectant contact time. This rule provides guidelines for identifying groundwater sources at risk for contamination and taking corrective action.

[Review provisions of the Groundwater Rule.]

[Continue to review Groundwater Rule.]

Interim Enhanced Surface Water Treatment Rule:

This rule became effective February 16, 1999. This rule builds upon the Surface Water Treatment Rule to improve control of microbial pathogens and address risk trade-offs with disinfection byproducts. This rule generally only affects systems that serve 10,000 people or more.

[Review provisions of the Interim Enhanced Surface Water Treatment Rule.]

[After reviewing the Interim Enhanced Surface Water Treatment Rule, say:]

The second and third provisions most directly impact the water treatment plant operator. The operator is responsible for monitoring filter effluent turbidity and must make the necessary adjustments in treatment if a filter or filters are not performing properly. The operator is also responsible for monitoring disinfectant residual, water temperature, pH, and detention time to insure the minimum required level of disinfection is always achieved.

Long Term 1 Enhanced Surface Water Treatment Rule:

This rule became effective February 13, 2002. In Pennsylvania, the final version of the rule was published in the PA Bulletin on June 19, 2004 and water systems must begin compliance starting in January 2005. Just like the Interim Enhanced Surface Water Treatment Rule, this rule was put in place to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium,* and to address risk trade-offs with disinfection by-products. However, this rule applies to public water systems that serve fewer than 10,000 people. The Interim Enhanced Surface Water Treatment Rule applied to larger systems.

[Review the major provisions of the Long Term 1 Enhanced Surface Water Treatment Rule.]

[After reviewing the Long Term 1 Enhanced Surface Water Treatment Rule, say:]

The impacts on the operator are basically the same as the impacts of the Enhanced Surface Water Treatment Rule, except that they now also apply to operators of smaller systems.

Filter Backwash Recycling Rule:

This rule became effective August 7, 2001. Many water treatment plants recycle backwash water and water from sludge dewatering processes back through the treatment plant. This can be done to conserve water. Many times it is also done because the water system operator is unable to obtain a permit to discharge the backwash water to a river or stream. Recycling filter backwash or water from sludge dewatering processes may compromise the water treatment process by reintroducing some of the microbes that were removed by the filters in the first place and/or upsetting chemical coagulation, if not properly controlled. This rule was passed to regulate recycling methods and prohibit practices that may compromise treatment.

See Unit 4 of this module and Module 14 for additional information on coagulation.

[At the end of the section, say:]

- The operator is responsible for monitoring recycle flows. The operator must understand the impacts that recycle flow may have on the water treatment process.

Stage 1 Disinfectants and Disinfection Byproduct Rule:

This rule became effective February 16, 1999. Chemicals used for disinfection can react with organic chemicals in the water being treated. These reactions may produce chemical by-products that are hazardous to human health. Two classes of by-products that are of particular concern are trihalomethanes and haloacetic acids. This rule sets maximum contaminant levels (MCL's) for total trihalomethanes (TTHM's) and the total of five haloacetic acids (HAA5). It also sets maximum disinfectant residual concentrations for chlorine, chloramines, and chlorine dioxide.

[Review Stage 1 Disinfectant/Disinfection Byproduct Rule.]

[Display Slide 10 – Table 3.3: Required Removal of Total Organic Carbon (Percent) by Enhanced Coagulation.]

[Go over removal requirements in Table 3.3. Note that required percent removal varies with both initial TOC concentration and with source water alkalinity.]

[At the end of the section, say:]

Operators must be aware of the organics present in their raw water source and how they impact formation of disinfection byproducts. Operators must also understand the principles of enhanced coagulation to meet the TOC removal requirements.

Total Coliform Rule:

This rule became effective December 31, 1990. Pa. DEP has primacy for enforcement. This rule sets the monitoring and compliance requirements for coliform bacteria.

[Review Total Coliform Rule.]

[Go over sampling requirements in Table 3.4. Note that number of samples required based on population served.]

[Continue to review Total Coliform Rule.]

Arsenic Rule: This rule became effective March 23, 2001. Inorganic arsenic can occur naturally in raw water sources. Long term exposure to arsenic can cause a variety of adverse health affects, including skin lesions, liver damage, hardening of the arteries, high blood pressure, and cancer of the skin, liver, kidney, lungs, and colon. This rule reduces the MCL for arsenic in drinking water from its previous concentration of 0.05 mg/L (50 ppb) to 0.01 mg/L (10 ppb). This rule also examines the "best available technologies" (BAT's) for arsenic removal.

[Display Slide 11 – Table 3.5: Best Available Technologies For Arsenic Removal.]

[Review Table 3.5.]

The rule also discusses BAT's for small systems and point of use treatment.

Lead and Copper Rule: This rule was originally enacted in 1991. Minor revisions have been made to the rule since its original enactment. These revisions became effective April 11, 2000. This rule deals mainly with lead and copper levels in water at the customers' tap. High levels of lead and copper may originate in the raw water supply, but more often they are caused by corrosion of lead service lines and copper plumbing in the customers' own facilities.

[Review Lead and Copper Rule.]

[Continue to review Lead and Copper Rule.]

[At the end of the section, say]

Most of the systems affected by this rule have completed their lead and copper surveys and have instituted corrosion control practices, if required. The water system operator is responsible for maintaining the corrosion control treatment practices.

In your experience, which of these specific regulations are most relevant to you and your plant? [*Open-ended question for participants to discuss personal experiences*.]

Pennsylvania Water Supply Regulations

As was noted at the beginning of this unit that Pa. DEP is responsible for enforcing all the federal regulations we just covered. Pa. DEP also has its own regulations, in addition to the federal regulations.

[Review the Pennsylvania Water Supply Regulations.]

MONITORING AND REPORTING: 10 minutes

Key Monitoring and Reporting Requirements

We've now covered what's in many of the key regulations. That still leaves the question of how they are enforced. Pa. DEP has developed monitoring and reporting requirements to use as an enforcement tool.

Water treatment plant operators are responsible for monitoring many water quality parameters on a regular basis as part of their normal duties. Some of the key monitoring and reporting requirements are outlined on pages 3-19 to 3-22 of your workbooks. Pennsylvania monitoring and reporting requirements are also covered in Part I of the Pennsylvania Water Supply Manual, as mentioned in the last section.

[Review monitoring and reporting requirements for Microbiological, Inorganic Chemicals, Volatile Organic Chemicals and Synthetic Organic Chemicals, Nitrate/Nitrite.]

[Continue to review monitoring and reporting requirements for Disinfection Byproducts, Radionuclides, and Turbidity.]

[Continue to review monitoring and reporting requirements for Disinfectant Residual, Lead and Copper and Secondary Contaminants.]

The water treatment plant operator is generally responsible for collecting samples within the treatment plant and at the point where water enters the distribution system. In small systems, the operator may also be responsible for collecting distribution samples. Measurement of disinfectant residual, turbidity, and secondary contaminants are usually performed by the water treatment plant operator at the water treatment plant. Samples for the other contaminants may be sent to an outside laboratory for analysis. Some larger water treatment plants have in-house fully equipped certified analytical laboratories that can perform these tests on the premises.

[Review first paragraph on page 3-22 of the workbook.]

[Review key Pa. DEP notification requirements.]

- Have any of you ever experienced a situation requiring public notification?

[*Open-ended question designed to elicit participants personal experiences*.]

RISK ASSESSMENT AND REGULATIONS: 5 minutes

Impacts on Future Rulemaking and Regulations

Regulations related to water quality and water treatment are constantly changing. The EPA is starting to take a new approach toward regulations that includes "Risk Assessment".

[Review risk assessment and regulations.]

This process of "Risk Assessment" will impact new regulations that you, as an Operator, will have to deal with, and may also impact many existing regulations.

Can you see how this could potentially impact your job as operators?

Ans It could add new contaminants to the list of those you need to monitor and treat, if treatment is cost-effective. It could also ease limits on some contaminants that are very difficult and expensive to treat and pose relatively low health risks.

Any questions?

REGULATORY GUIDANCE: 1 minute

Regulatory Guidance - State and Federal

[Point participants to the sources of additional information on state and federal regulations.]

[Remind participants that this was just an overview of all that you need to know regarding regulatory guidance. It is by no means a comprehensive listing. For additional information, they can refer to the sources of information mentioned under "Regulatory Guidance".]

[Display Slide 12 – Unit 3 Key Points]

Key Points

- The United States Environmental Protection Agency (EPA) studies health issues related to water quality and develops regulations, standards, and guidance documents related to drinking water.
- The Pennsylvania Department of Environmental Protection (Pa. DEP) has **primacy**, i.e. responsibility for enforcement of EPA drinking water regulations.
- The Operator Certification Act ensures that certified operators have appropriate skills, knowledge and abilities to make appropriate process control decisions during the operation of water systems and water distribution systems.
- There are many regulations that dictate the various duties of a water treatment operator. It is the operator's responsibility to maintain full knowledge of not only existing water treatment requirements, but also new requirements as they are developed.

Exercise (30 minutes)

Let's try an exercise to practice what you have learned before we move on to Unit 4.

[Split the participants into groups of 3 or 4. Have them spend 15 minutes on the exercise as a team, then hold a group discussion at the end.]

1. The manganese level in your treated water is 0.18 mg/l. What steps do you need to take under current regulations?

1. The first step is to determine if you're over the MCL. Looking at Tables 3.1 and 3.2, you will find manganese in Table 3.2, as it is a secondary contaminant. The MCL is 0.05 mg/l. You're over the MCL.
2. The second step is to determine if you need to notify Pa. DEP within one hour. Manganese is a **secondary** MCL. It is not an MCL violation that needs to be immediately reported to Pa. DEP. (It will be reported along with normal required monthly water quality reports.)
3. The third step is to determine if additional public notification is required. Again, since this is not a primary MCL, no additional public notification is required.

2. Your water system fluoridates the water. The fluoride feed system malfunctions and fluoride residual goes from 1.0 mg/l to 5.0 mg/l. What steps do you need to take?

1. The first step, of course is to shut down the fluoride feed system until the problem can be located and repaired. (Fluoride is not essential to the treatment process.)
2. Then follow the same basic steps as in the first question. Fluoride is in Table 3.1, as it is a **primary** contaminant (listed under Inorganic Chemicals). The MCL is 4.0 mg/l. You're over the MCL.
3. Fluoride is a primary MCL. Any single sample for a primary inorganic chemical over the MCL must be reported to Pa. DEP within one hour.
4. As the system is not in compliance with a primary MCL, the public must also be notified.

3. Look at the turbidity data in the table below. Is this system in violation of the MCL for turbidity? If so, identify which measurements constitute a violation and identify the type of each violation.

Clear Water Conventional Treatment Plant Turbidity Data			
Time	Filter 1	Filter 2	Combined Filter Effluent
0800	0.23	0.19	0.20
0815	0.25	0.19	0.22
0830	0.25	0.20	0.22
0845	0.24	0.19	0.21
0900	0.25	0.19	0.22
0915	0.26	0.18	0.23
0930	0.25	0.19	0.23
0945	0.25	0.29	0.27
1000	0.26	0.74	0.52
1015	0.25	0.76	0.53
1030	0.25	0.78	0.54
1045	0.23	0.80	0.54
1100	0.24	0.89	0.63
1115	0.23	0.97	0.72
1130	0.24	1.21	0.89
1145	0.24	2.81	1.89
1200	0.24	-Taken offline-	0.24
1215	0.23		0.23
1230	0.24		0.24
1245	0.24		0.24

Ans: This system is guilty of two separate violations. 1) They have exceeded the maximum allowable turbidity level for a single measurement of combined filter effluent. The MCL is 1 NTU and the measurement taken at 1:45 was 1.89 NTU. 2) They have exceeded the MCL for 2 consecutive individual filter effluent turbidity measurements taken 15 minutes apart. The MCL states that 2 consecutive measurements exceeding 1.0 NTU is a violation. The measurements taken at 11:30 and 11:45 were 1.21 NTU and 2.81 NTU, repectively.

4. Your system is required to take 20 samples for lead and copper. The results of those 20 samples are given in the table below. Are you in compliance?

[Display Slide 13– Answers to Exercise Question #4

1. First arrange the samples in order from lowest concentration to highest concentration.

Sample No.	Lead Concentration (mg/L)	Sample No.	Copper Concentration (mg/L)
4	0.002	13	0.3
18	0.003	12	0.5
8	0.004	19	0.5
12	0.005	4	0.6
19	0.006	18	0.6
3	0.007	2	0.7
15	0.008	5	0.7
2	0.009	10	0.7
10	0.009	11	0.7
11	0.009	20	0.8
9	0.011	3	0.9
20	0.011	14	0.9
16	0.012	9	1.0
17	0.012	15	1.0
1	0.013	1	1.1
14	0.013	17	1.1
13	0.014	6	1.2
6	0.016	8	1.2
5	0.017	16	1.2
7	0.020	7	1.4

2. Next determine 90th percentile. This is the value where 90% of the samples values are lower and 10% of the sample values are higher. Since we have 20 samples, and 90% of 20 is 18, the 90th percentile value is between the 18th and 19th samples when arranged in order from smallest to largest. The 90th percentile value for lead is between 0.016 and 0.017 mg/L. The 90th percentile value for copper is 1.2 mg/L.

3. Compare 90th percentile values to action levels. For lead, the action level is 0.015 mg/L. The 90th percentile is 0.016 mg/L. Therefore, this system has exceeded the action level for lead. The action level for copper is 1.3 mg/L. The 90th percentile is 1.2 mg/L. Therefore, this system is in compliance for copper.

UNIT 4: 65 minutes

[Display Slide 14—Unit 4: Overview of Water Treatment Processes.]

At the end of this unit, you should be able to:

- Name and describe different water treatments and specify in what order they are used.

WATER TREATMENT PROCESS: 5 minutes

- This unit presents a brief general look at the basic water treatment processes, how they work, and what they're used for. Each process will be covered in more detail in later modules.

[Go over the treatment processes and their purpose]

[Display Slide 15—Figure 4.1: Water Treatment Process.]

[Review schematic of typical unit processes section.]

A schematic of typical unit processes and the order in which they are used on an overall treatment system is shown in Figure 4.1. The individual unit processes are discussed in the remainder of this unit, and in more detail in later modules.

[Briefly discuss processes used for surface water vs. processes used for groundwater.]

1. PRE-TREATMENT PROCESSES: 15 minutes

Pretreatment is used to remove large debris in the water by physical removal (bar screens, racks, etc.) and by using chemical processes, to help control taste and odor causing substances. Many substances are dissolved in the raw water. Substances in solution cannot be easily removed by conventional physical treatment processes. Dissolved substances can be removed by adsorption or chemical oxidation.

Adsorption

[Review adsorption process, and substances typically removed by adsorption.]

Chemical Oxidation

[Review chemical oxidation process, typical oxidizing chemicals, and substances typically removed by chemical oxidation.]

[Display Slide 16—Figure 4.2: An Oxidation Reduction Reaction]

Figure 4.2 shows an oxidation reduction reaction.

2. Coagulation

Some contaminants in water are in the form of very small suspended particles. These particles often carry like electrical charges. Since like charges repel, these particles resist each other and stay uniformly distributed throughout the water.

[Review coagulation process and chemicals typically used.]

[Display Slide 17: Figure 4.3: Rapid Mixer]

Figure 4.3 shows a rapid mixer. The impeller on the mixer spins at a relatively high speed in a relatively small chamber to provide intense mixing.

3. Flocculation

[Display Slide 18: Figure 4.4: Horizontal Reel Flocculator]

- Figure 4.4, on the other hand, shows a flocculator. The paddles rotate slowly to provide gentle mixing.

4. Sedimentation/Settling

[Review the settling process.]

[Display Slide 19: Figure 4.5: Conventional Settling Basin]

Figure 4.5 shows an example of a conventional settling basin.

[Review Lamella settling.]

[Display Slide 20: Figure 4.6: High Rate Tube Settlers]

In Figure 4.6, you can see the tops of the tubes installed in a sedimentation basin.

[Continue to review the sedimentation processes.]

4. Filtration: 20 minutes

[Review filtration process, when and how it would be used, and typical materials used.]

[Display Slide 21: Figure 4.7: Cross Section of Dual Media Filter]

Membrane Filtration

[Review membrane processes and when and how it would be used.]

Membranes are classified by the size of the pores and the size of the particle (or even molecule) that they will remove.

[Review pore sizes.]

[Display Slide 22: Figure 4.8: Reverse Osmosis Membrane Filter]

Figure 4.8 shows an example of a reverse osmosis membrane filter.

- *[Before we talk about the last primary Water Treatment Process, Disinfection, let's discuss a few other additional treatment processes. Depending on the quality of the raw water, these processes may be needed after filtration to ensure a high-quality finished water.]*

Additional Water Specific Treatment Processes

Adsorption/Ion Exchange

[Review when you would typically use adsorption/ion exchange. State materials typically used for adsorption, how they are applied, and how adsorption is typically used to remove organic compounds.]

[Review ion exchange, including when and how it is applied.]

Corrosion Control

[Review corrosion control, when and how it is applied, and chemicals typically used. Note differences between sequestering and stabilization.]

6. Disinfection

[Review the disinfection process, chemicals used, and when and how it is applied.]

[When discussing Ultraviolet light,]

[Display Slide 23: Figure 4.9: UV Disinfection Units]

Figure 4.9 shows a cutaway view of a typical UV disinfection unit.

Case Study: 25 minutes

[Work through case study (on pages 4-14 and 4-15 of the workbook) as a class discussion. Slide 24 displays the answers as you discuss them one at a time.]

[Point out the space for notes under each Raw Water Quality Parameter. Point out the Water Treatment Process Schematic on page 4-16 of the participant workbook]
[Note that the right hand column in the raw water quality table has "Maximum Contaminant Level Goals"]

It is always a good practice to set goals for your treatment process that are more stringent than the levels set by regulation. You should always strive to obtain the maximum reduction of contaminants that your process can possibly provide. This will insure the consumer receives the best quality product possible. Also, if you can consistently operate at levels below the levels set by regulation, you will have time to adjust to changes in raw water quality or deal with treatment upsets before contaminant levels in your treated water actually exceed the MCL's established by regulation.

[Display Slide 24: Water Treatment Process Schematic]

*[Have the participants look at raw water source and quality, and work through treatment processes step by step. As you discuss each **bolded** point below, hit enter on the PowerPoint slide to allow for the point to show up on the schematic.]*

- Turbidity:
  - Turbidity is well above the MCL of 0.3 NTU
  - Turbidity is generally removed by coagulation, flocculation, sedimentation and filtration.
  - Going back to the flow chart in Figure 4.1, **coagulation** is accomplished by adding one of several chemicals (in our example, we've added **aluminum sulfate**), followed by a period of intense (rapid) mixing and then gentle mixing (**flocculation**).
  - Of the **sedimentation** processes available, **lamella**, conventional or sludge blanket would work well. For this example we've selected lamella settling. Ballasted flocculation may be a good application, as it works well on high turbidity water. Contact clarification would not be a good choice for this water, as it only works well for raw water turbidities up to 15 or 20 NTU.
  - Since this is a surface source, we must also provide **filtration** according to the Surface Water Treatment Rule discussed in Unit 3. **Gravity filters** are generally used in large plants, and were chosen for this example. Pressure filters are usually more practical for small plants. In looking at the flow chart in Figure 4.1, filtration would follow clarification.
  - Because of the high turbidities and levels of other contaminants, **membrane filtration** may not be practical (labeled "**Not Used**" in the slide).
- Iron and Manganese:
  - Iron is only occasionally above the MCL, and is a secondary contaminant. Treatment specifically for iron would not necessarily be required.

- Manganese levels are consistently above the MCL, and although it's a secondary contaminant, treatment should be provided.
- Manganese is usually treated by **oxidation** with **potassium permanganate**. (This treatment will also remove the iron.)

- Nitrates:
  - Nitrates are consistently above the MCL and are a primary contaminant. Treatment must be provided.
  - Nitrates are often removed by ion-exchange (labeled as "**Provided**" under **ion exchange**).

- Alkalinity:
  - Alkalinity is a measure of carbonate in the water. Carbonate is not a regulated contaminant.
  - Alkalinity levels in this water would be considered "moderate", therefore are not labeled on the schematic.
  - If alkalinity levels were very low, it can hinder coagulation. In that case, you would add lime (calcium carbonate) to increase alkalinity and aid in coagulation.

- Hardness:
  - These levels of hardness would also be "moderate" and would not require treatment", therefore are not labeled on the schematic.
  - You should consider treatment for hardness levels consistently over 150 to 200 mg/l.
  - If treatment for hardness was required, it could be provided by ion exchange.

- Color and Odor:
  - Levels of color and odor are sometimes over the MCL. Treatment should be provided.
  - Since this is a surface reservoir, color and odor are probably from organics in the water (algae, dead leaves, etc.)
  - Color and odor can often be removed by **chemical oxidation**. However, these organics are often precursors to disinfection byproducts. Therefore, they should not be oxidized with chlorine. Chlorine dioxide or **ozone** would be better choices. We selected ozone for this example.
  - Color and odor can also be removed by **adsorption** with granular activated carbon (**GAC**) or powdered activated carbon (PAC). We selected GAC for this example.

- pH:
  - Raw water pH is within acceptable limits.
  - However, the chemicals used for coagulation and chemical oxidation can lower pH.
  - If pH gets too low, it can be increased by feeding sodium hydroxide (**caustic soda**) or lime. This is considered a **corrosion control** treatment.
  - If the pH is within an acceptable range but the water is still corrosive, the corrosivity can by reduced by feeding a **phosphate** compound.
  - In looking at the flowchart in Figure 4.1, corrosion control treatment is usually done near the end of the overall treatment process.

- Total Organic Carbon:
  - Total organic carbon (TOC) removal by enhanced **coagulation** will be required under the Stage 1 Disinfectant Byproduct Rule discussed in Unit 3.
  - Removal requirements are outlined in Table 3.3 in Unit 3.
  - We already have coagulation for turbidity removal. The coagulation process may need to be modified (by changing coagulant chemical, dosage, or pH during coagulation) to meet the enhanced coagulation requirements.
  - Chemical oxidation with chlorine dioxide or ozone for color and taste removal may also help reduce TOC.

- Total Dissolved Solids:
  - This is a secondary contaminant, and is below the MCL. No treatment is required.

- Pathogens:
  - Fecal Coliform, the indicator organism for pathogenic bacteria, is present. **Disinfection** will be required.
  - Disinfection requirements are outlined in the Surface Water Treatment Rule, Interim Enhanced Surface Water Treatment Rule, and Long Term 1 Enhanced Surface Water Treatment Rule discussed in Unit 3
  - Disinfection with chlorine can be effective against coliforms and Giardia. Giardia inactivation with chlorine usually takes fairly long contact times.
  - Since this water is high in organics, byproducts may be a concern if chlorine is used. Disinfection with ozone may be a better choice.
  - Inactivation of Cryptosporidium with chlorine or ozone requires very high doses and very long contact times. Chemical activation of cryptosporidium may not be practical. **UV disinfection** may be more practical, and was selected for this example.
  - In looking at the flow chart in Figure 4.1, disinfection is usually at the end of the overall treatment process.

- Other Considerations:
  - Since an interstate highway crosses the headwaters of the reservoir, there is the risk of a fuel spill in the reservoir.
  - Since the watershed is an agricultural area, there is the risk of contamination by pesticides or herbicides.
  - **Adsorption** should be provided to remove these contaminants.

Summary: A treatment plant using this hypothetical reservoir as a source may include the following processes:

- Chemical oxidation with potassium permanganate and ozone for removal of iron, manganese, taste, and color, and reduction of TOC and disinfection byproducts.
- Coagulation/Flocculation (most often using aluminum sulfate).
- Sedimentation using lamella settling for turbidity removal.
- Gravity filters with a layer of GAC filter media for turbidity removal and adsorption of color, taste, fuel, and or pesticides.
- Ion exchange for nitrate removal.
- Caustic soda for pH adjustment and phosphate for corrosion control
- Final disinfection with UV, followed by enough chlorine to maintain a residual in the distribution system.

[Display Slide 25 and 26 – Unit 4 Key Points]

[Review the Key Points to summarize the unit.]

This concludes Unit 4 and the course. Does anyone have any questions?

[Thank the participants.]