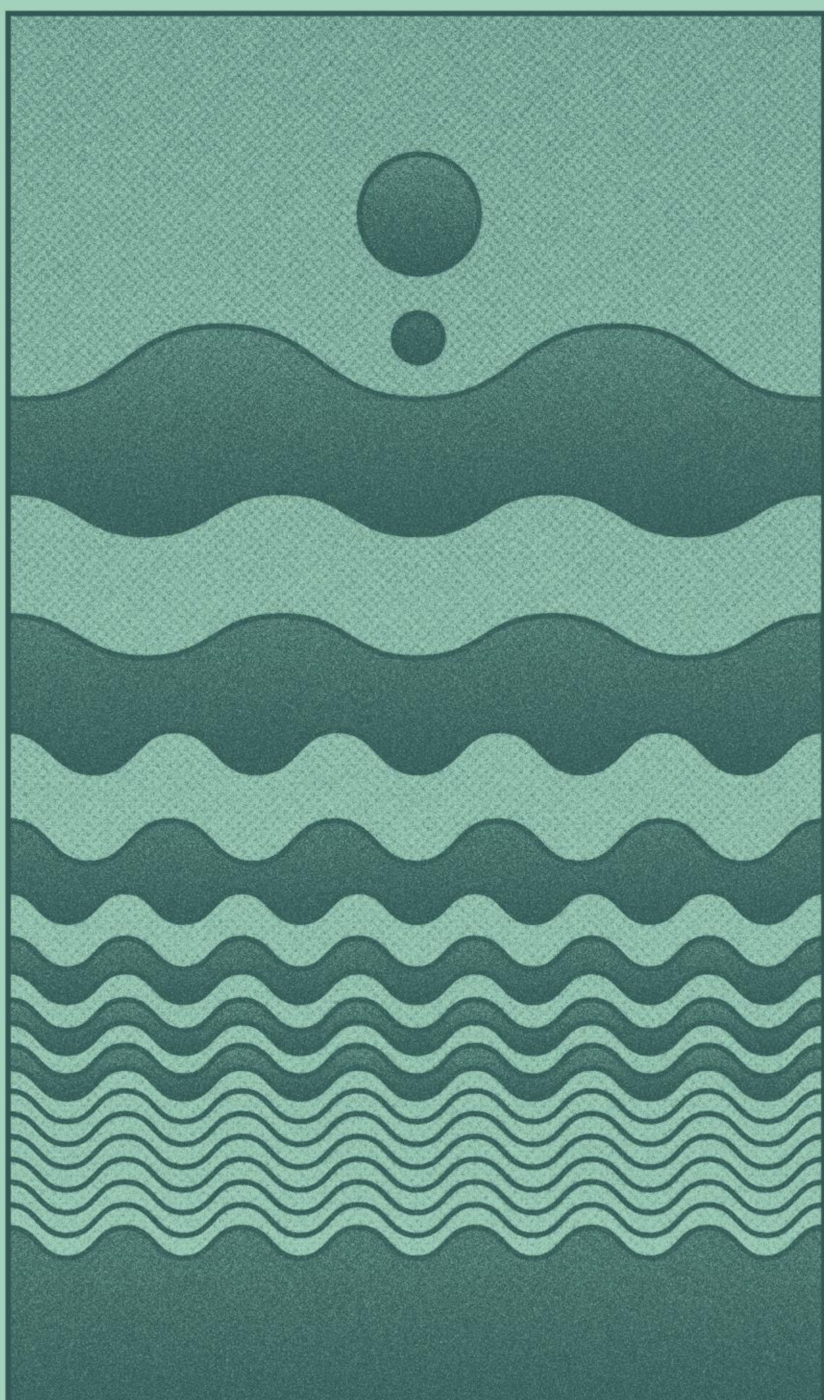
INTRODUCTION TO WATER SYSTEMS TECHNOLOGY



COLLEGE OF THE CANYONS

INTRODUCTION TO WATER SYSTEMS TECHNOLOGY

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CHAPTER 1: INTRODUCTION TO WATER SYSTEMS TECHNOLOGY

Water Systems Technology is a program designed to provide the student with enough information to build a successful and lasting career in the water and wastewater industries. It is a program that has been developed by professionals within the industry and within academia. Upon successful completion of the program and after completing any required general education course work, the student can earn an Associate of Science degree in Water Systems Technology. In addition, each course provides supplemental course work hours required for renewal of existing certifications in the water and wastewater industries and many provide specialized training coursework to qualify students to take state certification exams. The program has several general topic course options, includes coursework related to waterworks mathematics, and has specialized courses covering water distribution, water treatment, and wastewater.

Introduction to Water Systems Technology (Water 120) is a general overview course of the entire Water Systems Technology program. Topics covered include the requirements to obtain a career in the water and wastewater industries, and an overview of specific disciplines covered throughout the program. The various courses will provide the student a broad understanding of both the drinking water and wastewater industries, as well as specific technical background. This course and the accompanying text will provide the student with enough information to determine if “water” is the type of career for them.

Water is a vital resource to sustain both animal and plant life. It is a resource that many take for granted. As long water flows out of the faucets within a home, many people don’t think much more about it. However, if the flow of water stops, people take notice. Think for a moment about all the things we use water for: washing, bathing, drinking, cooking, cleaning, restrooms, brushing teeth, the list goes on and on. And this is only some of the indoor water usage. Most of the water used by residential consumers is outdoors. Whether it is landscaping, swimming pools, washing cars, or growing crops, outdoor water use can account for up to 70% of a customer’s water usage. In addition, commercial and industrial businesses use water for a variety of different processes. Some industries might use millions of gallons of water a year while others might only use a few thousand gallons. Take for example an insurance office with 10 employees. More than likely the office will have a restroom and perhaps a small kitchen area. The water use at this type of business would probably be rather low. Maybe a couple hundred gallons of water flushed down the toilet and a couple pots of coffee a day might be all. Now, take the example of chemical manufacturing plant with 100 employees. In addition to restrooms and possibly a kitchen, this type of business might have boilers, water treatment and conditioner systems, and may also use a lot of water in the production of chemicals. You can see how water use can vary from business to business. Lastly, and the biggest user of water, is the agricultural industry. In California, growing crops throughout the state can account for up to 80% of the total water use. Water is not only a health and safety need of millions of people, it is a vital resource for keeping the economic system flourishing. Some of these topics and a discussion of the various uses of water will be covered throughout this course.

First, we will take a look at the classes offered in the Water Systems Technology program. There are 11 different classes, including Water 120. Each class focuses on different topics in order for the student to gain unique perspectives on the water industry as a whole and to gain an understanding on specific areas to help the student become a certified operator within specific fields. The courses are broken into several broad categories:

General Topics
- **Water 120 – Introduction to Water Systems Technology**
- **Water 132 – Water Supply**
- **Water 135 – Water Quality**

Mathematics
- **Water 130 – Waterworks Mathematics**
- **Water 131 – Advanced Waterworks Mathematics**

Drinking Water Distribution
- **Water 140 – Water Distribution Operator I**
- **Water 141 – Water Distribution Operator II**

Drinking Water Treatment
- **Water 150 – Water Treatment Plant Operation Processes I**
- **Water 151 – Water Treatment Operation Processes II**

Wastewater Treatment
- **Water 160 – Wastewater Treatment and Disposal I**
- **Water 161 – Wastewater Treatment and Disposal II**

The following are general descriptions of each course within the program. Water 120 aims to introduce you to the program as a whole and provide a high-level overview of the various topics covered throughout the program.

WATER 120 – INTRODUCTION TO WATER SYSTEMS TECHNOLOGY

This course explores the technologies, potential career opportunities, and the State of California certification requirements in the water industry. Introduction to Water Systems Technology is an introductory course that introduces the student to the various career opportunities within the industry. The course also provides a brief description and overview of each course within the program. Although Water 120 is a required course to earn an A.S. degree in Water System Technology, it is designed for students that are not currently in the industry and provides a high-level overview for those seeking a new career path.

Water 120 begins with a general description of the entire Water Systems Technology program, with a brief introduction to each of the courses offered in the program. The course reviews the requirements of Operator Certification regulations that were part of the 1996 Safe Drinking Water Act Amendments. It examines dozens of career opportunities and assists the student with preparing an effective cover letter, résumé, and application for entry-level positions within the industry. Other topics of discussion include drinking water and wastewater quality, treatment, distribution, supply, use, conservation, and recycling.

WATER 130 – WATERWORKS MATHEMATICS

Water 130 is an introduction to waterworks mathematics. Math plays an important role in water systems technology and this course prepares the student for basic level water-related math problems. The course begins with a review in basic mathematical principles such as fractions, decimals, percentages, and equations. Memorization is discouraged in this course, which is why the first few weeks are designed to reintroduce basic math topics to build a foundation for water-related concepts. There is plenty of information to memorize within this program, so understanding how to “solve” math problems is a more efficient approach than memorizing. The course focuses on UNITS as an underlying theme. Numbers without units are meaningless and in the word of water units such as gallons, cubic feet, miles, inches, minutes, liters, acre-feet, and million gallons are used routinely. Understanding how to use these types of units and the concepts introduced in this course will give the student enough background to pass the math portion of lower level certification exams and a foundation to tackle more complex and advanced water-related math topics.

Entry-level topics include the calculation of areas, volumes, and circumferences, chemical dosage, pressure, flow rate, and beginning treatment process mathematics. There are no prerequisites for this course, but being able to solve elementary math level questions is desired. However, even if the student has taken a math class in years, the first few weeks of this course will bring back memories of teachers of the past!

WATER 131 – ADVANCED WATERWORKS MATHEMATICS

Water 131 builds on the topics learned in Water 130. Water 130 is a prerequisite for taking Water 131. However, if a student has previously taken a college level math course or has strong math skills they can petition to “test out” of the Water 130 prerequisite. If approved, a Water 130 test will be administered. If the student passes the exam they are allowed to attend Water 131 without completing Water 130.

Water 131 moves at a rapid pace and spends only a small amount of time reviewing information learned in Water 130. The course covers math concepts and ideas that prepare the student for advanced certification exams. Discussions of advanced water distribution and treatment processes and concepts are also incorporated into each lesson in order to present practical applications of the math topics.

The course provides advanced instruction on topics covered in Water 130, such as chemical dosage, treatment processes, flow rates, pressure, and volume calculations. In addition, the course introduces new concepts in the areas of horsepower, pump efficiency, blending, and budget calculations.

WATER 132 – WATER SUPPLY

Water 132 takes an overall look of water supplies. This course explores the sources of drinking water supplies with a special emphasis of water in California. The course looks at the various uses of water from residential, commercial, and industrial, to irrigation landscaping water demands. Discussions will include the differences between surface and groundwater supplies, and emergency water sources. Water quality and source water protection are other topics covered in this broad overview course of water supply principles. Water 132 begins with a general overview of the hydrologic water cycle, which illustrates the point of water’s endless cycle through various phases (gas, liquid, and solid.) The course wraps up with a discussion of water conservation and alternative sources of supply such as recycled water.

WATER 135 – WATER QUALITY

Water quality is one of the most important aspects of drinking water. There are numerous state and federal regulations that water utilities must adhere to. It is the number one issue customers are most concerned about. Water 135 examines the chemical and microbiological principles of water and applies them to drinking water quality. The course also focuses on major water quality regulations and how and why they are set at their respective values.

The remaining courses offered in Water Systems Technology are grouped by category within the water industry. These three (3) main disciplines within the industry are Water Distribution, Drinking Water Treatment, and Wastewater. Whether the student wants to work in distribution, treatment, or wastewater, all three of these require state certification. Each of these courses prepares the student for their respective certification exams as well as valuable information within each discipline to help the student succeed as a water professional.

WATER 140 – WATER DISTRIBUTION OPERATOR I

Water 140 introduces basic concepts and processes of drinking water distribution systems. It provides a wide range of knowledge including a general background of drinking water sources, regulations, water system design, and various distribution system components and appurtenances. Water distribution is followed from the source to the tap in this introductory level course.

Water 140 also assists the student in the preparation of Division of Drinking Water Distribution Operator Certification Exams for Grades D1 and D2. These certification exams require a broad range of entry-level knowledge of water distribution systems. Water 140 is designed to provide the knowledge and understanding needed to pass these exams and to provide the student with a general understanding of how distribution systems operate.

WATER 141 – WATER DISTRIBUTION OPERATOR II

Water 141 builds on the knowledge gained in Water 140 and presents the student with an intermediate to advanced level understanding of water distribution systems. Topics covered in Water 140 will be expanded in Water 141 creating a deeper understanding of how the various systems are interrelated.

Water 141 will assist the student in their preparation for Division of Drinking Water Certification Exams for Grades D3 and D4. These intermediate and advanced certification exams take the practices and principles of the Grade D1 and D2 exams and investigates a more in depth understanding of those topics. Although Water 140 is not a prerequisite for taking Water 141, it is recommended.

WATER 150 – WATER TREATMENT PLANT OPERATION PROCESSES I

Similar to Water 140, Water 150 introduces basic concepts and processes to drinking water treatment. Basic operating principles and techniques of direct filtration and conventional surface water treatment plant processes of coagulation, flocculation, sedimentation, and filtration. In addition, an overview and basic discussion of various disinfection processes are covered.

Water 150 will assist the student in their preparation for Division of Drinking Water Certification Exams for Grades T1 and T2. These certification exams require a broad range of entry-level knowledge of drinking water treatment systems. Water 150 is designed to provide the knowledge and understanding needed to pass these exams and to provide the student with the understanding of how drinking water treatment plants operate.

WATER 152 – WATER TREATMENT PLANT OPERATION PROCESSES II

Similar to Water 141, Water 152 builds on the knowledge gained in Water 150. Water 150 topics are discussed at the intermediate and advanced levels of understanding. Additional water treatment principles are introduced and a complete understanding of drinking water treatment processes is expected.

Water 152 will assist the student in their preparation for Division of Drinking Water Certification Exams for Grades T3 and T4. These intermediate and advanced certification exams take the practices and principles of the Grade T1 and T2 exams and looks into a more in-depth understanding of those topics. Although Water 150 is not a prerequisite for taking Water 152, it is recommended.

WATER 160 – WASTEWATER TREATMENT AND DISPOSAL I

Water 160 continues the pattern of the distribution and drinking water treatment course. Water 160 is an introduction to wastewater treatment plant operations. After water is used by the consumer, it typically flows through an underground sewer piping system to a Water Reclamation Plant (WRP) or Wastewater Treatment Plant (WTP) for treatment before it is discharged back into the environment. This course takes an introductory look at the basic treatment processes wastewater goes through.

Similar to drinking water certification exams, there are a series of certification exams for wastewater treatment plant operators. These exams are administered by the State Water Resources Control Board. This course is designed to assist the student in preparation for the introductory exams.

WATER 161 – WASTEWATER TREATMENT AND DISPOSAL II

In Water 161 the treatment processes discussed in Water 160 will be expanded upon to provide the student with intermediate and advanced level knowledge of wastewater treatment principles and practices.

Water 161 is designed to assist the student in preparation for the intermediate and advanced certification exams. Although Water 160 is not a prerequisite for taking Water 161, it is recommended.

WATER SYSTEMS TECHNOLOGY PROGRAM

The program has an overarching goal referred to as Student Learning Outcome (SLO) that states, “Students will be able to demonstrate proficiency in the core skills and knowledge required for employment in the water industry.” In order to earn a Certificate of Achievement in Water Systems Technology, a total of 21 units are required. A student must take fifteen (15) “core” units, plus six (6) additional elective units. In addition to the program certificate, a student can earn an Associate in Science Degree in Water Systems Technology after completing the 21 program units plus the general educational requirements.

The program requires the following fifteen (15) units;

- **Water 120 – Introduction to Water Systems Technology**
- **Water 130 – Waterworks Mathematics**
- **Water 131 – Advanced Waterworks Mathematics**
- **Water 132 – Water Supply**
- **Water 135 – Water Quality**

The remaining six (6) units are made up of two of the following;

- **Water 140 – Water Distribution Operator I**
- **Water 141 – Water Distribution Operator II**
  OR
- **Water 150 – Water Treatment Plant Operation Processes I**
- **Water 152 – Water Treatment Plant Operation Processes II**
  OR
- **Water 160 – Wastewater Treatment and Disposal I**
- **Water 161 – Wastewater Treatment and Disposal II**

As with all "classroom" learning, it is only part of what is required to be a successful water worker. Education is a valuable resource and can provide general knowledge and information about process and theories, but nothing can compare to actual on the job training and experience. In any industry or any field, job experience is something most employers would like to see in an applicant. However, in order to gain on the job experience, you must be employed. Sometimes in order to get employed, you need experience. You can see the apparent problems with this conundrum and you may experience it when you start searching for work.

When applying for a job, there are a couple of things that can be done to help combat this challenge. First, you may have to start at the "bottom." The bottom can be an entry level position or it might be a position where you have some experience but the job might not necessarily be the one you are seeking. Never lose sight of your ultimate goal but sometimes you will need to take several steps before you get there. For example, ABC Water Agency might be hiring for a Customer Service Representative and you might be looking for a Water Utility Operator position. The problem is that you do not have any experience as a utility operator. However, you might have some experience in customer service. Why not apply for the Customer Service Representative position? Sometimes, just getting your "foot in the door" is enough to help gain the experience needed. Once you start working for a water utility, you will begin to hear the terminology used, learn how the business operates, and gain a general understanding of operations. Many times, it is easier to transfer from one department to another than it is getting hired from the outside. Sometimes agencies open up positions to existing employees before they start looking on the outside. Getting a job within the industry you want to work in can be the first step to getting your career started and landing the position you are seeking. Second, you can try to tailor your experience to fit with some of the required experience for a specific job. For example, you may have worked in some type of construction related business in the past. You can use this as experience for field positions. Maybe the experience is not directly related, but you can try and word the experience on a resume to fit the job or at least demonstrated some of the same qualities that a similar position might require. Preparing cover letters, resumes, and applications will be discussed later in this text.

Chapter 3 of this text takes an in depth look at the various career opportunities in the industry. There are always general types of jobs in most industries such as customer service, accounting, human resources, etc. Remember, that these types of jobs might just lead into the career you are seeking. However, you might also find a very rewarding career in one of these disciplines too. Working in water and wastewater provides dozens of opportunities in a variety of different areas. Find what works for you and you'll have a successful and productive career.

CHAPTER 2: OPERATOR CERTIFICATION AND REGULATIONS

There are numerous regulations that pertain to the water industry as a whole. In addition to general business and accounting regulatory requirements, health and safety requirements, environmental requirements, labor requirements, etc., there is a set of regulations that specifically govern water utilities. These regulations are referred to as the Safe Drinking Water Act. The Environmental Protection Agency promulgated these regulations in the early 1970s and required states to adopt them or create similar regulations that meet the minimum requirements. The practical application of the California Safe Drinking Water Act (SDWA) encompasses the federal act and in some instances has added additional requirements that have made some of the water quality regulatory standards more stringent. California's SDWA can be found in California Code of Regulations Title 22, Division 4 Environmental Health. Much of the SDWA deals with water quality regulations, which will be discussed in a later chapter. However, there are other operational requirements that are specified as well. In 1996, the SDWA was amended for the second time. Some of the changes included provisions for "Operator Certification" requirements. Treatment Operator certification requirements were part of the original SDWA regulations establishing the level at which water treatment facilities should be manned, the minimum qualifications for testing at five (5) different grade levels, and criteria for the renewal and revocation of certificates. The recent amendments now include the certification and recertification requirements for distribution operators at five (5) different grade levels.

Operator Certification refers to requirements for both treatment and distribution operators in order for them to perform certain work. Both treatment and distribution operators are classified by five (5) different certification grade levels. Treatment Operators are listed as T1, T2, T3, T4, and T5 and Distribution Operators as D1, D2, D3, D4, and D5. T1 and D1 are the lowest certification levels and T5 and D5 are the highest. Generally, entry level positions require lower level certifications such as D1, D2, T1, or T2. These positions are primarily labor-related jobs and require little contact and or control of the water supply. Supervisors and managers sometimes require higher certification levels depending on their job descriptions. However, there are specific regulations that spell out minimum certification requirements for certain job-related tasks.

The Operator Certification regulations provide very specific requirements for becoming certified and who actually needs to be certified. In addition, there are a number of definitions.

Among them are definitions for what is referred to in the regulations as “Shift” and “Chief” Operators.

- **Shift Operator** - “Shift Operator” means a person in direct charge of the operation of a water treatment or distribution system for a specified period of the day.
- **Chief Operator** - “Chief Operator” means the person who has overall responsibility for the day-to-day, hands-on, operation of a water treatment facility or the person who has the responsibility for the day-to-day, hands-on, operation of a distribution system.

Although these definitions may seem specific, they do have some ambiguity. What if you have a distribution operator who is in charge of a certain operation for the day, but he has been told to call a supervisor before making any decisions or changes in the system. Is this person a “shift operator” per the definition above? Can a manager that is responsible for a treatment facility, but doesn’t actually work on the treatment facility be a “chief operator”? As you can see, there needs to be some clarification to these and other definitions in the regulations.

The regulations do offer some clarification. For example, they specify that water systems shall utilize only certified operators to make decisions addressing the following operational activities:

1. Install, tap, re-line, disinfect, test and connect water mains and appurtenances
2. Shutdown, repair, disinfect and test broken water mains
3. Oversee the flushing, cleaning, and digging of existing water mains
4. Pull, reset, rehabilitate, disinfect and test domestic water wells
5. Stand-by emergency response duties for afterhours distribution system operational emergencies
6. Drain, clean, disinfect, and maintain distribution reservoirs (tanks)
7. Operate pumps and related flow and pressure control and storage facilities manually or by using a system control and data acquisition (SCADA) system
8. Maintain and/or adjust

What determines the level of certification needed? Each treatment facility and distribution system are classified at a certain level. Meaning a treatment facility and distribution system are either classified as a T1 - T5 facility or D1 - D5 system respectively. The facility and system classification are based on a number of different parameters and in California is specified by the Division of Drinking Water (DDW), a branch within the State Water Resources Control Board of California (SWRCB.) In general, classifications are based on a point system. Treatment Facility Classification is primarily based on the type and quality of water being treated and the treatment/disinfection processes used. Distribution System Classification is based on population served. If the population served is five (5) million or less than a point system is used based on number of pressure zones, disinfectants used, size of pumping equipment, and number of storage tanks. If the point-based system total exceeds 20 points then the classification is upgraded by one (1) level. Once the facility and system have been classified, the regulations then stipulate the minimum certification requirements needed by the staff. The following table specifies the minimum certification requirements for each treatment facility and distribution system classification.

Treatment Facility and Distribution System Classification	Minimum Certification of Chief Operator	Minimum Certification of Shift Operator
T1 / D1	T1 / D1	T1 / D1
T2 / D2	T2 / D2	T1 / D1
T3 / D3	T3 / D3	T2 / D2
T4 / T4	T4 / D4	T3 / D3
T5 / D5	T5 / D5	T3 / D3

How does someone become certified? There are certain requirements and prerequisites to becoming a certified operator. As previously mentioned, the first certification level (T1, D1) is the lowest level and has the least amount of requirements to become certified. Similarly, T5 and D5 are the highest certification levels and have the most requirements to reach these levels. There are two requirements for each level, one for being able to take the certification exam and the other to receive the actual certification. Let's take a look at the requirements for each certification level. Since the requirements are similar for both treatment and distribution, they will be referred to as 1 - 5 in this discussion.

Level 1 - The only requirement to take a level 1 exam is a high school diploma or equivalent. A General Education Diploma (GED) is an example of something that is equivalent to a high school diploma. Even though there is no water-related requirement to take a level 1 exam, most people would have difficulty passing the exam without having any experience or knowledge of water systems. For example, do you know the difference between a butterfly valve and a gate valve? Or, the difference between flocculation and coagulation?

In order to receive the level 1 certification, the only requirement is the passing of the exam with a score of seventy percent (70%) or better.

Level 2 - Level 1 is the only certification level that can be skipped. If you meet the minimum requirements of a Level 2 exam, you can skip Level 1. In order to take a Level 2 certification exam, you must also have a high school diploma or equivalent. In addition, you must complete thirty-six (36) hours of instruction in a water-related field. A three (3) unit course meets the thirty-six (36) hour requirement. The course must meet certain minimum specifications in either water supply, distribution, treatment, or similar topics. Any of these classes would provide you with the information needed to pass both a Level 1 and Level 2 exam. Therefore, it is very common for people to skip Level 1, take the required course work and then take Level 2. However, some people are curious as to the format and type of questions that are asked on these exams and take a Level 1 exam while they are also completing courses in a water-related field.

The requirements for receiving a level 2 certification are the same as level 1, you must pass the level 2 exam with a score of seventy percent (70%) or better.

Level 3 - The requirements for taking exams and becoming certified for Level 3 and higher are a little more restrictive. In order to be able to take a Level 3 exam, you must complete two (2) thirty-six (36) hour courses. One course must meet the same requirements as described for a Level 2 and the other can be a supplemental water-related course. A supplemental course can be a less specific water-related course such as waterworks mathematics, water quality, or some other course that don't specifically focus on distribution or treatment. Once you successfully complete and pass the required coursework, you can take a Level 3 exam.

Once you have successfully passed a Level 3 exam with a score of seventy percent (70%) or better you are not automatically eligible for a Level 3 certification. In addition to completing and passing the required two (2) courses, you must also be a certified Level 2 Operator for at least one (1) year. Therefore, you cannot skip Level 2 and become a Level 3.

Level 4 - The requirements for Level 4 certifications are similar to Level 3. In addition to the two (2) classes required as Level 3, an additional supplemental course is required. Therefore, a total of three (3) thirty-six (36) hour (or 3 unit) courses are required to be able to take a Level 4 exam.

After successfully passing a Level 4 exam with a score of seventy percent (70%) or better and you have been a Level 3 certified operator for one (1) or more years you can obtain a Level 4 certificate.

Level 5 - Four (4) thirty-six (36) hour (3 unit) courses are required to qualify for taking a Level 5 exam. One (1) class must be specialized training and the other three (3) can be a supplemental course.

After passing a Level 5 exam and meeting a minimum of one (1) year experience as a certified Level 4 operator a Level 5 certificate can be obtained.

DIVISION OF DRINKING WATER CERTIFICATION EXAMS

The DDW website provides recommended reading material and an expected range of knowledge section to help prepare for the exams:
http://www.waterboards.ca.gov/drinking_water/certlic/occupations/DWopcert.shtml

In addition, this website provides all the required material to apply and prepare you to become a Certified Operator. Exams for Treatment and Distribution are each offered two times a year approximately six (6) months apart. The Treatment Exams are offered in May and November of each year with their respective filing dates March 1st and September 1st of each year. The Distribution Exams are offered in March and September of each year with their respective filing dates January 2nd and July 1st of each year. Although these are the exam schedules at the time this text was being written, the DDW website should always be visited for any updates.

TREATMENT EXAMS

The Treatment exams consist of multiple-choice questions covering topics of Source Water, Water Treatment Processes, Operation and Maintenance of Treatment Facilities, Laboratory Procedures, Safety, Regulations, and Administrative Duties. Below is a summary breakdown of each category:

Source Water

- Wells and Groundwater
- Surface Water and Reservoirs
- Raw Water Storage
- Clear Well Storage

Water Treatment Processes

- Coagulation
- Flocculation
- Sedimentation
- Filtration
- Disinfection
- Demineralization
- Corrosion Control
- Iron and Manganese
- Fluoridation
- Water Softening
- Best Available Technology

Operation and Maintenance

- Chemical Feeders
- Pumps and Motors
- Blowers and Compressors
- Water Meters
- Pressure Gauges
- Electrical Generators

Laboratory Procedures

- Sampling
- General Laboratory Practices
- Disinfectant Analysis
- Alkalinity Analysis
- pH
- Specific Conductance
- Hardness
- Fluoride
- Color Analysis
- Taste and Odor
- Dissolved Oxygen
- Algae Count
- Bacteriological Analysis
- Safety
- Administrative Duties
- Regulations

In addition to all the above knowledge you must have, there are always a series of math-related questions on each exam. There are typically fifteen math-related questions and are usually worth two (2) points each compared to one (1) point for the general knowledge questions. The math questions range from a variety of topics and include some simple addition type computations on the lower grade exams to complex algebraic and geometric computations. Below is a brief outline of what one can expect on the exam.

Math-Related Computations

- Areas
- Volumes
- Pressure
- Flow
- Chemical Dosage
- Filtration
- Horsepower
- Milliamps

This list is not complete and there are various topics within each of the above but it does provide you an insight into some areas of waterworks mathematics.

DISTRIBUTION EXAMS

The Distribution exams consist of multiple-choice questions covering topics of Disinfection, Distribution System Design, Hydraulics, Equipment Operation, Maintenance, Inspections, Drinking Water Regulations, Management, Safety, Water Mains, Piping, Water Quality, and Sources of Supply. Similar to the Treatment Exams, there are a series of math-related questions as well. In addition, there is some overlap between the information on both the Treatment and Distribution exams. Below is a summary breakdown of each category covered on the Distribution exams:

Disinfection

- Water Main, Well, Storage Reservoir Disinfection
- Disinfection By-Products
- Chloramination and Various Types of Disinfectants
- Chlorine Curve Chemistry

Distribution System Design and Hydraulics

- System Layout
- Storage Facilities
- Cross Connection Control and Backflow Devices
- Service Connections
- System Maps
- Flow Rates and Velocity
- Pressure and Head Loss
- Water Hammer

Drinking Water Regulations

- Disinfection By-Products (DBP) and Lead and Copper Rules
- Maximum Contaminant Level (MCL)
- Monitoring and Sampling
- Total Coliform Rule (TCR)
- Safe Drinking Water Act (SDWA)
- Compliance
- Budgets
- Emergency Response
- Conservation Planning
- Water Rates

Equipment Operation, Maintenance, and Inspections

- Valves
- Meters
- Hydrants
- Chemical Feed
- Corrosion
- Sensors
- SCADA
- Pumps
- Horsepower
- Water Mains
- Repair and Installation
- Wells

Water Mains and Piping

- Excavation
- Installation
- Joints and Fittings
- Leak Detection
- Repair
- Material Selection

Water Quality and Sources of Supply

- Coliform Group
- Heterotrophic Bacteria
- Organic and Inorganic Compounds
- pH
- Hardness
- Turbidity
- Flushing
- Disease
- Groundwater
- Surface Water
- Sanitary Surveys

This is not a complete list of all the topics covered on the Distribution Certification Exams but it is a good overview of the topics and areas that are covered. In addition, the mathematical computations you are expected to know are similar to the math questions found on the Treatment exams.

Drinking Water Distribution and Treatment were both governed by the California Department of Public Health (CDPH). However, in 2014 the Division of Drinking Water Programs within CDPH was moved under the State Water Resources Control Board (SWRCB) and is now referred to as Division of Drinking Water (DDW.) SWRCB also governs wastewater and the certification program for wastewater operators. In addition, the California Water Environment Association has a wastewater certification program that SWRCB recognizes. Certified Wastewater Operators can apply for an examination waiver with SWRCB if they meet certain requirements.

WASTEWATER EXAMS

The following information is a review of the areas of expertise and topics covered on Wastewater Certification exams:

- **Collection System Maintenance** – This vocation deals with sewer maintenance and repair. The collection system is the from the customer's property to the treatment plant.
- **Laboratory Analyst** – Wastewater needs to be analyzed in a laboratory. The Laboratory Analyst has the responsibility of testing the water in the laboratory.
- **Environmental Compliance Inspector** – Wastewater treatment facilities have a number of regulations that they must follow. The Environmental Compliance Inspector is in charge of inspecting and monitoring the wastewater that empties into the sewer system. This is also known as "Source Control," "Industrial Pretreatment Inspection," "IPP," and "Industrial Waste Inspection."
- **Plant Maintenance** – This work deals with the maintenance and repair of wastewater treatment plants. Electrical/Instrumentation (EIT) and Mechanical Technology (MT) are the two specialties within this career. The EIT deals with the maintenance and repair of wastewater treatment plant electrical and instrumentation systems while the MT focuses on mechanical systems such as pumps and motors.
- **Industrial Waste Treatment Plant Operator** – This type of operator works at wastewater treatment plants in private industrial facilities.
- **Biosolids Land Application Management** – Biosolids are the inert biological materials (sludge) resulting from the wastewater treatment process. This work focuses on the management of these wastes.

Most of the careers within the water and wastewater industries will require some type of certification. However, there are other specialty areas such as engineering and accounting that may require a specific degree. Throughout this course and program, you will be exposed to a variety of career choices. Find the one(s) that you are interested in and pursue that discipline.

CHAPTER 3: CAREER OPPORTUNITIES IN THE WATER INDUSTRY

Finding a job is dependent on a number of factors. Timing, current economic conditions, work skills, and more all play a part in trying to land a job. However, with a little bit of discipline and effort, finding a job is not too difficult. Although finding a “job” might not be too difficult, finding a career can be. What is the difference between a “job” and a “career”? A “job” for discussion purposes in this chapter is a place of employment that may or may not be full-time and will probably not lead to multiple years of employment in the same industry. That is not to say that someone cannot turn a “job” into a successful long-lasting place of employment. It is just to distinguish between some place to work and a career in a specific industry. In this chapter, a career refers to a place of employment in a similar industry for many years—a career in the “water” industry.

There are some industries that will flourish at times and then feel the downward effects of a slowing economy. For example, a career in the aerospace industry usually reaps the benefits from defense contracts but can also see a significant hit when the government decides to implement cuts in the defense budget. Although the “Tech” industry saw tremendous financial gains during the “dot com” boom of the late 1990s, there was a hit to that industry after the turn of the century. In addition, when the housing market crashed in 2008, many home builders and the construction industry saw profits plummet along with high levels of unemployment. All of these examples can be profitable and long-lasting careers but they are also susceptible to economic uncertainty.

Water and wastewater industries are a little different. This is not to say there are never layoffs or periods of economic challenges in these industries. However, people will always need a safe and reliable supply of drinking water and people will always create wastewater. Therefore, water utilities in general are very sustainable and recession proof industries. The water and wastewater industries will be referred to collectively as “water industry” throughout the text. Within each industry, there are multiple layers of careers from office functions to field construction workers. Some of these positions require specific job training and expertise while others might only require a high school diploma. The careers discussed in this text will fall under water distribution, water treatment, and wastewater treatment. Within each of these industries, distribution and treatment operators will be the main focus.

A general understanding of distribution and treatment should be explained first. Water that is delivered to millions of people throughout the United States is transported through an array of aqueducts, storage reservoirs, large and small diameter pipes, treatment plants, pumps, valves, meters, and various appurtenances before it arrives at the customer's faucet. In California, most of the water treated for domestic use moves through the State Water Project, Los Angeles Aqueduct, or the Colorado River Aqueduct. These large water conveyance systems are owned and operated by a variety of state and local agencies. For example, the State Water Project (SWP) is managed by the California Department of Water Resources (DWR). DWR manages the movement of water from an area just north of Sacramento down into Southern California. They employ hundreds of people who have the responsibility of delivering water to SWP contractors. There are twenty-seven member agencies including the local Santa Clarita Valley Water Agency and Metropolitan Water District. Much of the water we use for domestic purposes requires some type of treatment. There are dozens of treatment plants throughout the state and thousands throughout the country. These treatment plants rely on a network of sophisticated treatment process to provide safe and reliable drinking water to millions of people. Operating these treatment plants require highly trained and certified treatment operators, engineers, maintenance workers, managers, and office staff to keep the treatment process running effectively and efficiently. Once treated water leaves a treatment plant, it must move through a network of pipes, pumps, storage structures, and appurtenances before it reaches each customer. This is where water distribution systems step in. Water distributors are typically referred to as water purveyors or water retailers. A water purveyor might have as few as a couple employees or as many as hundreds to thousands. Field distribution operators are trained professionals and are required to be certified. Once the water has been used by customers, it ends up in either a storm drain, which predominantly is left untreated as it makes its way to the ocean, or it ends up in a sanitary sewer system and is treated through a Water Reclamation Plant (WRP), Publicly Owned Treatment Works (POTW), or a Wastewater Treatment Plant (WTP). WTP will be used in this text to collectively refer to all wastewater (sewer) treatment facilities. For all practical purposes, these are all similar facilities where wastewater (sewer water) is treated before being discharged. In addition, WTPs will have a network of piping leaving home and businesses to the WTP.

WATER INDUSTRY CAREERS

Water industry employees are responsible to provide customers with safe and reliable drinking water and to safely treat wastewater to further protect human life and the environment. Safe water means it must comply with both state and federal drinking water regulations (discussed later in this text). Reliable water means that when a customer turns on their faucet water flows out. People tend to take things like electricity and water for granted. We flip a switch and the light goes on. We turn a faucet and water comes out. It is not until these resources are interrupted people get concerned and sometimes upset.

There are hundreds of drinking water treatment plants throughout the U.S. These treatment plants have the responsibility to treat surface water to certain standards making it safe for human consumption. There are a variety of highly skilled positions within a treatment plant and staff responsibilities can range from operator to laboratory technician, from administrative assistant to water resource engineer.

The distribution of water is an unseen necessity by millions of people throughout the world. There are over 18 billion miles of distribution piping throughout the U.S and over 50,000 community water systems. All of these drinking water systems require people to operate and run them. There are thousands of employment opportunities available throughout the U.S. However, operating a distribution system is a complex operation requiring trained personnel in a variety of job functions. Water purveyors can have different sources of supply including surface water, purchased water, groundwater, and recycled water. They can have few customers or thousands, a handful of employees or hundreds, but all of them will have similar functions.

Making sure wastewater is properly treated is important for human and animal safety as well as for protecting the environment. WTP operators are responsible for making sure sewer flows coming into the plant are adequate for treatment purposes and must respond to any and all releases should they occur. Solids that are removed during the wastewater treatment process must also be properly handled and disposed.

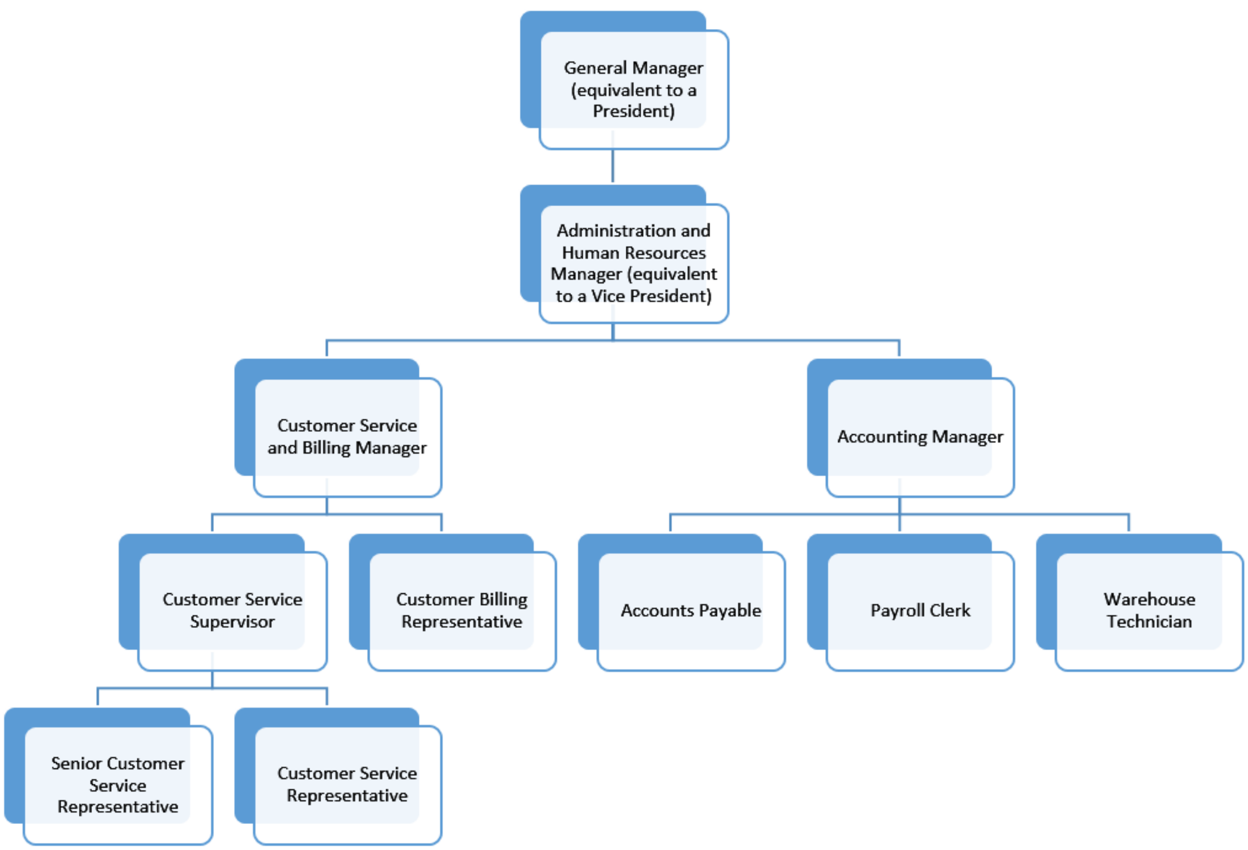
Although there are many unique and specialized job functions within a utility that require certification, there are also a number of “common” job opportunities as well. Most utilities will have staff positions that are similar to many other industries such as customer service, office management, accounting, etc. While some of the terminology might be different, many of these jobs will not require specific water-related training.

The previous paragraphs briefly introduced the areas of drinking water distribution and treatment and wastewater treatment. The remaining pages of this chapter will look at specific career opportunities in the water industry and how someone should go about applying for these jobs.

The Office Staff

Most offices are staffed with accounting, financial, human resource, billing, and customer service departments. Depending on the size of the organization these departments can be interrelated while other times there can be a number of employees staffing each department.

Los Angeles Department of Water and Power (LADWP) for example has over 8,500 employees serving a total population of greater than one million. Approximately half of this staff is responsible for the water side while the other half is responsible for the electric side of the utility. Although there might be some overlap between the human resource and administration functions, there will still be staff that provide office and field-related services to their respective areas. Typically, in larger organizations there will be multiple employees in each department providing specific support needs and functions. While in smaller organizations, certain functions might be covered by the same staff person. For example, sometimes billing and customer service functions might fall under a Customer Service Department and financial, accounting, and human resources might be under an umbrella such as an Administration Department. Regardless of department titles, all utilities must provide similar services, such as creating and mailing water bills, collecting money from customers, answering phone calls, responding to customer questions and complaints, ordering supplies, paying bills, providing salaries and services to employees as well as other vital job tasks. Although some operational staff spend much of their time in the office, we will consider them “operational” employees and list them under “Field Staff.” For the purpose of this text let’s look at a smaller sized utility as an example. Below is an organizational chart for the office staff of fictitious XYZ Water Department:



The above chart represents a medium sized water utility with eleven (11) office employees. Remember, this is just an example and may not reflect what an agency looks like exactly. Some utilities are very large and have hundreds of employees and are usually separated into multiple departments, while other utilities can be quite small and one employee might perform multiple jobs/tasks. Let's analyze the above example and discuss what some of the general functions might look like for each position and department. The next several paragraphs are some typical examples of what each job might entail. Remember, these are just examples to get you familiar with the industry as a whole and may not represent a specific job that you can apply for in the future.

- **General Manager** – The General Manager (GM) is typically the position at the top of a water utility organization. However, in a privately (investor) owned utility, the title of the person at the top of the organizational chart would be referred to as the President. Regardless of the exact title, a President and General Manager have similar job functions. The GM oversees the daily operations of the entire organization. This oversight is not usually direct, which means that the GM does not typically discuss day-to-day operations with the staff on a daily basis. They might get updates through meetings or from managers. Although they may not be involved in the day-to-day operations, they are ultimately **responsible** for all aspects of the utility. In public agencies, they usually report to a board of directors, city council, water commission or some other entity that is either elected or appointed. In private (investor owned) water utilities, they would report to shareholders, which would be equivalent to a board of directors. The primary responsibility of a General Manager is to manage upper level staff, sources of water supply, budgeting, provide support to staff, and create meaningful and efficient policies for the governing body to review and adopt. General Managers are usually contracted employees and are hired by the governing boards whereas Presidents are typically hired employees and do not have any guaranteed contract. Education and background for people seeking a GM type of position would be in the areas of engineering, science, and public administration. Sometimes a General Manager will also serve as the "Chief Engineer" of an agency. They may also have an advanced degree in a science-related field. Regardless of their background and education, this position would have similar responsibilities in all three (3) types of water-related industries.

- **Administration, Finance, and Human Resource Manager** - This position can have various titles, but the function is to manage and oversee the day-to-day operations within the office. In a private utility, this position is typically referred to as a Vice President. They usually have multiple direct reports and in smaller utilities it might be one (1) person handling all human resource-related tasks as well as administration and financial-related responsibilities. Typical functions include preparing documents such as policy, safety, emergency response, and employee manuals. These types of managers keep the office organized and running efficiently. In larger organizations there may be separate positions for Administration, Finance, and Human Resource responsibilities with a staff reporting to each manager. These types of positions typically require a degree in business and or public administration.

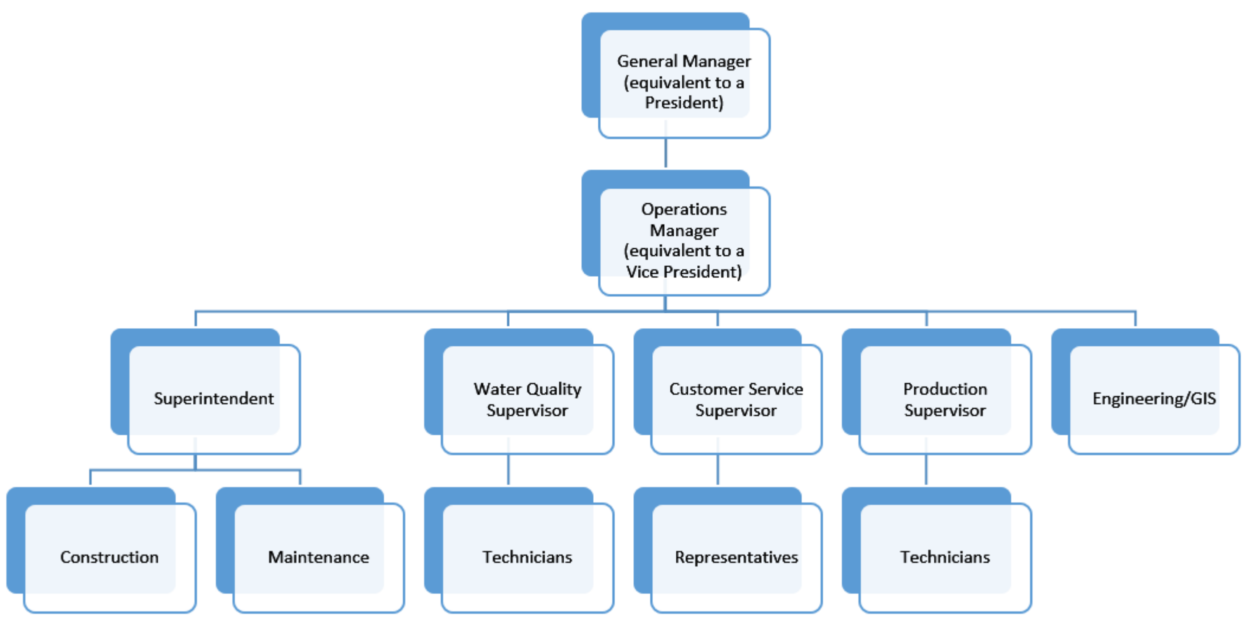
- **Customer Service Managers and Departments** - Customer Service staffs are the “face” of the organization. They deal directly with the public on a daily basis. They make sure that water meter reads are accurate and input correctly into the billing system. They issue water bills, accept payments, send reminders to late paying customers, and handle any issue a customer has when they call or come into the office. Many interactions with customers are related to complaints of incorrect billings, high usage, and other customer account-related inquiries. However, other times customers will call to complain about operational problems such as leaks, low pressure, no water, poor quality, etc. Sometimes, customer service staff can resolve these types of complaints by asking a few questions and responding the customer’s concern. Other times, work orders are generated and forwarded on to the appropriate operations department. As with most managerial positions, a degree is usually required. However, sometimes organizations will promote long time employees that have shown a dedication to the agency and a willingness and ability to learn on the job.

- **Accounting Managers and Departments** - The flow of money moves through accounting departments. The primary revenue source for most water utilities is through water usage payments. However, some utilities collect taxes, rents, and various other sources of revenue. Just as money comes into a utility it goes out as well. Salaries, benefits, and insurance are some of the more costly expenses that utilities must balance. In addition, office supplies are purchased and an inventory of parts and materials are maintained so operational staff can make repairs and replacements as they present themselves. Consulting is also a large part of a utilities expense. Engineering consultants, attorneys, and specialized contractors are all a part of a utilities operation. Every utility has a **warehouse** to store and maintain a variety of inventory items. Although operational staff are using the material in inventory, it is the responsibility of the accounting department to reconcile the “ins and outs” of each item and the associated costs. Typically accounting managers will be Certified Public Accounts (CPA) and have a business-related degree.

Typically, all of the above-mentioned managers and departments will have support staff. The support staff will process paperwork, deal directly with customers, and provide a variety of support related responsibilities. These employees will need to be proficient with computers and be able to write memos, input data into spreadsheets, and use specialized software to handle billing, inventory, purchasing orders, and other various tasks. Many of these positions are entry level and will not require a degree.

The Field Staff

Every utility has a staff that predominantly works in the office and a staff that occupies most of their time outside (or in the "field"). As explained earlier in this text some of the operational managers and supervisors spend most of their time in the office, but will be discussed as "field staff" in this text. Field staff and operational duties range from reading meters, fixing leaks, collecting water samples, installing services and pipelines to responding to complaints, maintaining facilities and appurtenances. Many utilities are separated into several departments such as Maintenance, Construction, Water Quality, and Customer Service while others might divide departments even further. For instance, there might be a department for valve operators, leak repairs, electricians, etc. Regardless of the structure of a utilities operation, they all have the same basic functions of getting water from the source to the customer in a reliable and safe manner. Below is a generic organizational chart for a medium sized utility:



In this example, there would be crews under each Supervisor/Superintendent. Sometimes the Superintendent is a step up and oversees the various departments. Crews can be large or small. For instance, construction and maintenance crews tend to be larger than water quality technicians, primarily because there are more construction and maintenance related activities compared to collecting water quality samples. Let's take a look at common tasks and responsibilities of the various operation positions.

- **General Manager** - As previously mentioned, the GM (and President) is responsible for the entire organization. In addition to the various administrative and personnel related functions, a GM quite often gets involved in planning and design of the vast array of different facilities. Many times, a GM will have an engineering degree, water quality experience, or some science and business-related background.

- **Operations Manager** - This position is responsible for the overall day-to-day operations of a utility. Although Operations Managers spend most of their time in an office, they meet regularly with the various operations supervisor getting updated and briefed on daily activities. An operation manager will typically be responsible for the operations budget and tracks expenses incurred for various construction and maintenance related projects. Many times, an operations manager and GM work closely together to strategically plan system improvement projects and future development. This type of position is typically equivalent to the Vice President position of a private utility. Most Operations Managers will have some type of four (4) year degree in engineering, science, or sometimes business.

- **Superintendent** - Superintendents are usually the eyes and ears of all field activities. They are typically field-based employees that spend some of their time in an office behind a desk. They coordinate and communicate most of the day-to-day activities and assist the various departments including, but not limited to construction, maintenance, water quality, and field customer service. Typically, the Superintendent has many years of experience in the field as an operator or some other field position and works their way up to this position. Usually this position would not require a four (4) year college degree. However, there would be certification requirements and more than likely a D5 certification would be required.

- **Construction** – Not every utility will have a construction crew(s). Sometimes this type of work is contracted out to independent private construction companies. Small and medium-sized water agencies typically hire a construction firm as a contractor rather than have in-house construction services. Either way, construction can be a large part of the responsibilities for water utilities. Construction activities range from the installation of water mains and services to the repair of leaks. Crews may build facilities such as pump stations and they may provide services for new infrastructure installation and capital improvement replacements. A supervisor or foreman typically leads this group and there is usually at least one heavy equipment operator. There are also certification requirements for positions within construction departments, including the required Division of Drinking Water (DDW) certifications and Class A licenses for heavy equipment operators. Typically, very little experience is required for entry level construction jobs. However, positions within construction departments can be the most demanding physically and can often require employees to work nights and weekends.

- **Maintenance** – In addition to the installation and repair of facilities and appurtenances, maintenance of the systems is an important part of every utility. Pumps and motors need routine inspection and adjustments. Valves need to be routinely operated. Fire hydrants need to be flushed and painted periodically. There are also many different types of routine maintenance of buildings and the property facilities are built on. Just as you might maintain a car or a home, water facilities and structures need to be maintained. Typically, there is a supervisor for maintenance crews. The supervisor would be the person in charge of scheduling and assigning the maintenance work. There might be various types of schedules with varying frequency. For example, valves might be on an annual schedule and motors and pumps might be on a semi-annual schedule. Regardless of the schedule, all maintenance activities should be well documented and tracked.

- **Water Quality** – All water utilities will have some type of water quality department. In small organizations it might be one person who handles these responsibilities. In larger utilities, there might be a department with multiple crews. There are minimum sampling, monitoring, and reporting requirements all utilities must abide by. A water quality specialist or technician is usually responsible for these duties. Sometimes agencies will have field technicians and an office water quality position. While other times field and office duties will be the responsibility of the same person or group of people. For example, a technician might be the person collecting the samples and a specialist might be the person preparing the sample bottles, interpreting the results, and preparing the reports. Regardless of who is responsible for what task, a water quality professional will need to be a certified operator and sometimes will need a science-related degree.

- **Engineering and Geographic Information Systems (GIS)** - There are many engineers in the water industry. Treatment plants, pumping facilities, storage tanks, and many other types of facilities need to be designed and constructed. On-staff engineers or hired engineering consultants are the ones responsible for designing and mapping the systems. After a facility, piping infrastructure, or some part of a system is designed and constructed there are “mark-up” plans that come back to the engineering departments. These plans are called “as-built” drawings. They are drawings “as they were built”. Sometimes the construction crew will make field modifications for various reasons. They will then create as-built drawings so the engineers can update their plans and provide the staff will accurate complete drawings. Many utilities employ GIS personnel. GIS is another mapping function and includes facility data and information in a geographic database. For example, pipelines have information associated with them such as, diameter, length, material, installation date, etc. This data can be geographically coded with the pipe and retrieved at the click of a button. Often times field operators will have “paper” maps with minimal information written on them. Sometimes they will need to return to the office or contact someone to retrieve detailed information. Technology is now allowing field crews to carry tablets or laptops in the field enabling them to access GIS data immediately. Engineering and GIS employees will almost always require a four (4) year degree and quite often advanced degrees and special licenses and certifications.

These examples are by no means an exhaustive list of career paths and job opportunities in the water industry. Utilities are unique in size and in their hiring processes. As mentioned above, each department can have few or many employees. For example, there might be a Water Quality Manager with three (3) Water Quality Supervisors each having several Water Quality Technicians reporting to them. In very small utilities one person might make up the entire department. The size of the utility will have an effect on the hiring process and the employment opportunity potential. Large public utilities can have hundreds of people applying for one position and typically have a test that all applicants must complete. This “test” is used to screen out individuals and quite often only the top few scores are called back for an interview. Sometimes you will be interviewing in front of a panel of people, while in small private agencies it might be a one-on-one interview. Regardless of the process a worthy applicant needs to be well prepared. Taking water related coursework, becoming certified operators, and gaining experience will all help to increase the opportunity for gaining employment. Stay focused, work hard, and don’t become discouraged. Landing a job that turns into a career in the water industry is a real possibility and very rewarding.

CHAPTER 4: COVER LETTERS, RESUMES AND INTERVIEWING

Looking for a job can be a very stressful task. No one likes rejection and many times rejection is part of the job-seeking process. The best time to look for a job is when you are currently employed. This way a rejection letter from a prospective employer may not “sting” as much since you are currently working. However, most of us are not that fortunate to be able to search for a new job while we are currently employed. Many times, we are forced into a situation where we are looking for work because we have been laid-off, or the business has closed, or perhaps we are looking for a career change. No matter what the reasons are requiring us to search for new employment, a cover letter, resume, and interview will play an important role in helping us land that ideal job. Taking time to prepare a thoughtful cover letter and a complete resume are extremely valuable tools in presenting your skills and experience to employers.

COVER LETTER

What is a Cover Letter and why is it so important? Is a cover letter needed when submitting a resume and applying for a job? What constitutes a good cover letter? Is there a difference between a “good” cover letter and a “great” cover letter?

Many times, people overlook the importance of a cover letter. Much time is spent on crafting and developing a complete resume; oftentimes, the cover letter is an afterthought. According to www.careerbuilder.com, neglecting a cover letter is a “big mistake.” A cover letter is your first shot at introducing yourself to a prospective employer and making a good or even great first impression can be the difference between landing an interview and receiving the dreaded, “thank you for your interest, but we have selected another candidate.” Cover letters provide you the opportunity to cover everything that cannot be expressed in a resume and begin the “selling” process of your abilities. They also provide the opportunity to address a specific person within an organization making your application for a job more personable. It is advised to find the name of the person you are sending your cover letter and resume to and address it to them specifically. Doing a little research in the organization you are applying with can go a long way. To the person reviewing and filtering applicants it looks better to see their name on the cover letter as opposed to “To whom it may concern.” What makes a cover letter? In general, cover letter should be well written, concise, to the point, and specific to the job you are seeking.

- **Well written** – No one likes to read a cover letter filled with spelling and grammar mistakes. Sometimes simple words like "form" and "from" can be accidentally used because they are both spelled correctly and are just out of context. Long run-on sentences, too many paragraphs, and improperly used punctuation can make a cover letter a struggle to read and can be the difference between landing an interview or having your resume passed over. Make sure you proofread it multiple times. Sometimes reading out loud can help identify mistakes. It also doesn't hurt to have a friend, co-worker, or family member review it for you. Sometimes a second or third set of eyes can pick up things that you might miss.

- **Concise** – Being concise means writing clearly and efficiently. Do not add a bunch of words just to fill space. Identify what you want to say and draft an outline of the key points. Many times, you will be applying for a job with dozens of other candidates and the person receiving and reading cover letters may not have the time to read through paragraphs of writing. Typically, a well-written cover letter should contain:
    - An introduction of who you are and why you are writing the company. A few sentences identifying yourself and why you are applying for this specific job. Include the name of the position you are applying for.
    - A paragraph summarizing your qualifications and experience, without rewriting your resume in the cover letter. You need to make a strong connection between your experience and skills and the position you are applying for. Sometimes a few bullet points listing your strong points works or a short paragraph of your highest-level abilities and experiences can serve to connect your old job to the job you are applying for.
    - A concluding paragraph that thanks the organization for its time and gives your email and phone number is helpful. Finishing off with a sentence such as, "I look forward to speaking with you in person to discuss my qualifications and experience" is a nice closing.

  There is a fine line between being concise and not providing enough information to interest the organization. There are plenty of sample cover letters on the Internet. Be sure to do your research on crafting and writing a cover letter and also on the company you are applying with.

- **Specific to the job you are applying for** – A generic cover letter and resume indicate a sign of laziness. Much of your cover letter can be "generic." It can have the same heading and components of the introduction and closing can be similar. However, tailoring your cover letter to the specific job you are applying for shows the organization that you have at least put some thought into this application process. Here is an example of a cover letter introduction:

Please accept this cover letter and resume as serious interest in the position available with your company. I think I will be a good fit.

Or

Please accept this cover letter and resume as serious interest in the position of Water Quality Specialist with XYZ Water District. I believe my qualifications and education will set me apart from others applying for this position.

Identifying the position and the agency shows that you have taken time to write a cover letter.

Lastly, we will look at formatting. Organizing and formatting your cover letter is also very important. Take your time writing contact information on the top of your cover letter and resume. It should include your name, address, phone number, and email address. It shouldn't be too fancy but it should also stand out so that it is recognizable at a glance. Here is an example:

John Doe
1234 Water Way, Spring Town, USA
111-222-3333 jdoe@yahoo.com

You should provide a phone number that you typically answer or check regularly. You should also use an appropriate email address. Many times, people have what they consider to be funny or clever email addresses. If you are one of these people, then create an email account specifically for looking for a job. A prospective employer is not interested in contacting "hotdogjimmy@coolemail.com" or "ilovecats@awesomeemail.com" for an interview. A simple first initial, last name or first name, last initial is an appropriate email address to list on all your contact information when searching for employment. Lastly regarding format, make your cover letter look clean and professional and be sure to personally sign it. If you are submitting your information through email or online, print the document, sign it, scan it, and then submit it.

RESUME

Your resume should contain a summary of your work and education experiences. It should list each employer that you have worked for and the position you held with that organization. It should list your educational background and any related research work you may have participated in. There are various types of resumes and there is a ton of reference information that can be found online. Do your research and find the type of resume that fits best and enables you to express your experiences and education. In this section we will focus on three main resume types: Chronological, Functional, and Targeted (www.jobsearch.about.com).

Don’t worry if you do not have any work experience. Everyone has to have a “first” job. In situations where you do not have any work experience state this in your cover letter. Write a couple short sentences as to why you do not have any work experience and something like, “I am eager to start a career and gain on the job experiences.”

Sometimes applicants have work experience, but not directly related to the job they are applying. Perhaps you have experience in aerospace or computers or something completely different. In these instances, be creative.

There are a couple of general rules regarding resume content. Typically, you should include the following information:

- **Summary of Qualifications** – a summary of qualifications is not always necessary in a resume, especially if you provide this type of summary in your cover letter. However, if you have some specific skills that are required by the job you are applying for, it can’t hurt.
- **Work Experience** – listing your prior work experience is very important. It shows your prospective employer that you are employable and that you have a track record of good standing.

Chronological Resume

This type of resume shows your work experience and educational experience in chronological order, starting with your most recent experience. This is probably the most common type of resume and is often preferred by employers. It is an easy way for an employer to see what you have done and the various times you have done it. This type of resume can be problematic if you have large gaps in employment. Large gaps in employment can be a red flag for employers. Sometimes there are perfectly acceptable reasons for gaps in employment but you don’t want to alarm a prospective employer before you have the chance to explain. If you do have gaps in employment and you have specific reasons for the gaps, it might be a good idea to discuss those briefly in your cover letter. For example, if you decided to stop working to go back to school or maybe you stopped working to have children. These are understandable reasons for having some gaps in employment. Regardless of the reason, you want to be able to explain it during an interview and you do not want your resume to be passed over without having the ability to explain yourself. There are various thoughts on what you should list first, your work experiences or your educational experiences. The best answer is probably to lead with whatever is stronger. For example, you might be a recent college graduate with very little work experience. In this situation, you may want to list your education first.

Functional Resume

This type of resume focuses on skills and experience. When there are big gaps in your employment history, it is sometimes better to focus on the specific skills and experiences you might have for the job you are applying for. This type of resume is very common for people who are changing careers. For example, you may have been an auto mechanic for 15 years and decided to change career paths. You took some time off to study water systems technology. Several years have passed without any employment history and you are now applying for a maintenance mechanic position with a water agency. Instead of listing your employment history with a gap while you were in school, focus on your experiences as a mechanic and relate those to the position of maintenance mechanic. During the interview, if you are asked about the gap in employment you can explain that at the time it was your desire to change careers and go back to school.

Combination Resume

As the name implies, a combination resume includes both experience and employment history. You can focus on the specific skills and experiences related to the job you are applying for and list the employment history as a reference for the employer. This is a very common approach when applicants have a combination of experience and work history but neither one is strong enough on its own merit.

There are many examples of the various types of resumes online. It is strongly recommended that you research the type and style that would fit best.

APPLICATIONS

It may seem fairly straightforward how and why you should complete an application but many times the application is the crucial document that will either bring you to the next level or result in the dreaded, “Thank you for your interest in employment with ABC Water Company but you have not met the minimum requirements for the position.” Quite often, especially when there are hundreds of applicants, there is an application screening process and the simplest of errors on the application can result in being disqualified. Or, sometimes in smaller agencies, your application can be put on the bottom of the list based on sloppiness, misspellings, missing information, etc. Completeness and neatness are two key elements to a successful application.

Many job descriptions will state minimum requirements to help filter out what can at times be hundreds of applicants. Maybe a certain certification level is required or perhaps a specific degree? Depending on the agency, you may not need ALL the minimum requirements at the time of applying. While others will disqualify your application if you do not meet everything stated in the description. Below are a couple job description requirements and what is recommended for an acceptable application submission:

> **Meter Reader - Minimum Requirements**
> *Associate of Science Degree from a two-year college is required. One year general work experience and Water Distribution Operator Grade D1 certificate from Division of Drinking Water preferred.*

Let’s say that you will receive your AS in one month and you meet the minimum “general work experience” requirement. Remember, the D1 is not a requirement. Some agencies may look at your application and accept the fact that your official graduation date is in one month and allow your application to be processed for an interview. Other agencies may disqualify you because you will not be in possession of the degree at the time the application is due.

While looking at this job requirement scenario, the questions below may have come to mind:

> *What if you don’t have an AS degree but you have a D1 certificate?*
> *What if you have both an AS degree and a D1 certificate?*

They are excellent questions and cannot be fully answered because each water utility will have different requirements and standards for their application review process. However, your chances of progressing through the application process are probably better if you meet the minimum and preferred requirements.

> **Water Quality Specialist - Minimum Requirements**
> *This position requires a 2-year degree in Biology, Chemistry or related field and 2 years of experience in a water laboratory environment. A Water Treatment Operator T2 certificate is required.*

The requirements for this job are a little more stringent and most agencies would probably disqualify you if you did not meet them. However, if you have completed and passed the T2 exam and you are just waiting for your certificate, you might be allowed to progress through the application process.

Regardless of your skills, experience, education, and background, you should not be discouraged from applying for jobs even if you think you are not qualified. Each agency is different and there are a variety of circumstances. Just make sure you are well prepared and provide neat and complete cover letters, resumes, and applications before you apply. Something not discussed in this chapter or text is the interviewing process. Interviewing is as much a skill as an art. The following are simple tips to help you prepare for an interview. However, the best preparation is practice. Try video recording yourself or practice in a mirror. You can also ask a friend or family member to ask you specific questions in a mock interview.

INTERVIEW TIPS

1. Dress for Success but don't over dress for the job. First impressions mean a lot. If you walk into an interview wearing jeans and a t-shirt, the first impression might disqualify you before you even say a word. Likewise, if you are applying for a construction-related position, it might not make sense to show up at the interview in a suit. Nice slacks and a button-down shirt or blouse should be acceptable for most field-related water positions. You can add a jacket or blazer if you wish. It is important to not seem too overdressed for a field position but you don't want to seem underdressed either. And, of course, your clothes should be clean and unwrinkled.
2. Improve your interview technique. Practice is the best way to improve. Getting caught off guard with a certain question might be the difference between you and the next person. However, you should also not be afraid to say you don't know or ask if they could repeat the question. Try to be relaxed and take time to think before answering.
3. Take time to say thank you. Always be polite and thank the interviewers. It is also recommended to write a thank you letter after the interview.

4. Networking is always helpful. Knowing someone in the organization or if you know common acquaintances can always help your chances to separate you from the next person.
5. Research the company. Researching the company is not only helpful with preparation of your cover letter and resume, it also helps during the interview process.

CHAPTER 5: WATER QUALITY

One of the most important responsibilities of a water utility is to provide SAFE drinking water. "Safe" can be a confusing word for water utility customers. At times the safety of drinking water is confused with its aesthetic qualities such as taste, odor, and color. Sure, no one wants to drink water that is discolored, has an odor, or tastes bad. However, most of the time the water is safe to drink regardless of how it looks, tastes, and smells. Now, this doesn't mean that water utilities are supplying customers with aesthetically unpleasing water. It simply means that often the safety of the water has little to do with its aesthetic quality. This is why there are both PRIMARY and SECONDARY drinking water regulations. Primary standards deal with health-related issues while secondary standards focus on aesthetic qualities of the water supply. Although water utilities strive to supply the best water possible, there are times when the water might be unpleasant from aesthetic characteristics. This chapter will discuss both primary and secondary water quality regulations, providing examples of both, as well as a discussion of various job opportunities within this discipline of the water utility industry.

Almost everyone is concerned with the quality of their water. It is typically the top complaint from customers, with the exception of high water bills. Since tap water is usually colorless, odorless, and, for the most part, tasteless, as soon as something changes, customers want to know why. Water quality is also a top concern of water professionals. Water quality professionals are responsible for the treatment, disinfection, testing, and compliance of the water served to their customers. Every year water utilities collect thousands of water samples and have them analyzed by laboratories to ensure compliance with water quality regulations. In addition to collecting samples, water utility operators conduct preventive maintenance, routinely inspect facilities, and respond to customer complaints to prevent and/or correct any water quality problems.

WATER QUALITY REGULATIONS

Current drinking water regulations are very complex and include many different requirements. President Gerald Ford signed the Safe Drinking Water Act (SDWA) in 1974 under growing pressure from newspaper articles, documentaries, and the general public's skepticism that drinking water might not be safe. The Environmental Protection Agency (EPA) conducted a national reconnaissance study to assess the concentrations, sources, and potential danger of certain contaminants in municipal drinking water supplies. In 1977, the national safe drinking water standards went into effect across the country. These standards included microbiological contaminants, ten (10) inorganic chemicals, six (6) organic pesticides, turbidity (or cloudiness), and radiological contamination. Among other things, the regulations also included a provision for the States to assume primary enforcement responsibility.

Since the enactment of the Federal Safe Drinking Water Act, there have been two (2) amendments. In 1986, the first amendment was passed. Some of the new requirements with this amendment increased the number of regulated contaminants, required certain filtration processes for surface water supplies, added disinfection requirements for some groundwater systems, and prohibited the use of lead solders, flux, and pipes in public water systems. Ten (10) years later the 1996 amendment was passed. This added a provision in the SDWA referred to as the Unregulated Contaminant Monitoring Rule (UCMR). The UCMR requires the EPA to provide a list of potential contaminants every five (5) years to water utilities so that their drinking water supplies can be analyzed. The EPA will then use this data to prepare future water quality standards. The amendment also created distribution and treatment operator certification requirements and a funding system for states needing financial help to comply with drinking water quality regulations. This funding is referred to as the Safe Drinking Water Revolving Loan Fund.

It is important to note that although there are federal drinking water regulations, many states have their own drinking water standards. In California, the regulatory agency is the Division of Drinking Water (DDW) under the State Water Resources Control Board (SWRCB). The DDW is responsible for enforcing the California Safe Drinking Water Act (CSDWA). Many states create their own regulatory agencies to help enforce the Safe Drinking Water Act.

Drinking water quality standards can be broken into two main categories: Primary Drinking Water Standards and Secondary Drinking Water Standards. Each set of standards has a list of contaminants that must be monitored by municipal water utilities and they must be below levels considered safe. These safe levels are referred to in the regulations as Maximum Contaminant Levels (MCL). Each constituent has a separate MCL that cannot be exceeded in the water supply or else some action must be taken. An action can be as stringent as taking the source of supply (i.e., groundwater well) immediately out of service. Or it may increase the amount of sampling requirements for a particular constituent. Exceeding an MCL may also require some type of notification to customers. The goal is to protect the public from unsafe levels of potential contaminants in water supplies.

Drinking water quality regulations are not the only water quality regulations water utilities must comply with. There are many water quality regulations protecting the environment. These regulations are part of the Clean Water Act (CWA). The CWA regulates and permits the sampling and monitoring of discharges to “navigable waters of the United States.” Navigable waters are defined by the US Army Corps of Engineers as waters that are subjected to the ebb and flow of tides, and those inland waters that are presently used, or have been used in the past or may be susceptible to use in interstate or foreign commerce. This definition can be interpreted by water utility operators as any body of water wet or dry that discharges can flow into. Common water utility discharges include, but are not limited to flows from:

- Fire hydrant and dead-end flushing
- Water main flushing
- Meter testing
- Water leaks
- Storage tank overflows
- Water sample collection

Although water utilities are required to discharge water for a number of these activities, they must still comply with the CWA and the various State and Local regulatory agencies responsible for implementing the requirements set forth in the CWA. Much of the requirements involve preventing chlorinated water from entering a water body or preventing debris from gutters and storm drains being washed into a water body.

PRIMARY DRINKING WATER STANDARDS

Primary Drinking Water Standards are for contaminants that pose a health threat when detected in water supplies above an MCL. In order to establish an MCL, the EPA will take into consideration several different factors. They will examine the prevalence and exposure of the contaminant in the environment and in water specifically. A contaminant that isn't found in water supplies often would find a place low on the EPA priority list. However, a contaminant that is widespread would be at the top of the list. The EPA also looks at health effects. If it is a widespread contaminant but has little to no known health effects to humans then an MCL would not be very probable. However, if the contaminant is toxic or a known carcinogen then an MCL would be very likely. Another consideration is in regards to the analytical methodology. There has to be a statistically reproducible laboratory analytical method in order for the EPA to consider an MCL. If a laboratory cannot detect the contaminant readily and statistically accurate, then having an MCL would be very difficult. Lastly, an economic evaluation is completed. Typically, the cost benefit analysis looks at all the previously reviewed material.

Millions of dollars a year are spent by water utilities in efforts to comply with Primary Drinking Water Standards. It is one of the most important responsibilities of water professionals. There are a host of treatment technologies that are used to inactivate or remove contaminants from water. Thousands of samples are collected and analyzed to determine the level of each contaminant. Reports are prepared and filed with public health agencies to demonstrate compliance with the regulations.

Primary Drinking Water Standards are commonly broken up into four (4) main categories:

1. Bacteriological
2. Inorganic Chemical
3. Organic Chemical
4. Radiological Compounds

There are multiple constituents within each broad category and it is the utility's responsibility (with the assistance from the regulatory agencies) to understand the requirements for complying with these contaminants. Below is a brief description of each category, the predominant health effect associated with each, and various treatment methods.

Bacteriological

This group consists of not only bacteriological contamination, but also viruses, protozoa and various other microorganisms that pose a health threat. Most of the health effects associated with microbiological contamination in water are gastrointestinal. Symptoms include vomiting, diarrhea, headache, fever, etc. Many of the symptoms are similar to influenza. However, to various sub-populations, for example the very young or old or people with compromised immune systems, the health effects can be deadly.

Because of the vast number of microorganisms and the difficulty and cost of trying to analyze all of them, an indicator organism group is used for analysis. This group is known as the total coliform group. Coliforms are a group of bacteria that indicate the presence or absence of disease-causing microorganisms. The Total Coliform Rule (TCR) is a set of regulations that cover this wide range of contaminants.

Although there are various treatment techniques for the removal and inactivation of microbiological contamination, disinfection is the most common method. Drinking water treatment facilities and distribution systems both use disinfectant chemicals (primarily chlorine) for maintaining the health and safety of drinking water from microorganisms.

Inorganic Chemicals

There are many different chemicals found in drinking water supplies that fall under this broad category. Fortunately, most of them are naturally occurring and are considered safe. For example, minerals such as calcium and magnesium are commonly found in drinking water supplies. Although these may pose aesthetic problems for consumers (discussed later in this chapter), they pose no health effects. However, contaminants such as nitrate, arsenic, and chromium can also be found as naturally occurring elements in drinking water and these can pose health problems if ingested at levels above the MCL. In addition to being found naturally in the environment, these and many others are the result of some type of contamination.

- **Nitrate** – The primary source of nitrate contamination is from some type of fecal contamination. Agricultural farms and leaking septic systems both contribute to nitrate contamination. The main health effect is related to infants six (6) months and younger. If nitrate is ingested at levels above the MCL by this sub-population, a condition known as metheglobinemia (Blue Baby Syndrome) can occur. This results in suffocation when nitrogen displaces oxygen in the bloodstream.
- **Arsenic** – Arsenic has been used as a wood preservative resulting in contamination and is also naturally occurring. The primary health effect associated with drinking water containing arsenic at levels above the MCL are cancer-related.
- **Chromium** – This chemical got its spotlight from the movie Erin Brockovich. An oxidized form of chromium known as "Chrome6" or hexavalent chromium was brought to everyone's attention when PG&E was accused of contaminating the groundwater supply in Hinkley, California. This contaminant also causes cancer-related health effects.

Inorganic chemicals are not commonly found in drinking water supplies above their respective MCL. However, if they are, there are several treatment techniques that can remove these and many other contaminants from the water supply, ion exchange being one of the most common.

Organic Chemicals

The most commonly found organic chemicals found in drinking water supplies fall under the category of VOCs. VOC stands for volatile organic compound and are present in drinking water typically from the result of some type of contamination. Some of the more common VOCs found in drinking water include:

- Trichloroethylene (TCE)
- Tetrachloroethylene (PCE)
- Methyl Tertiary Butyl Ether (MTBE)

These chemicals come from various sources including degreasing agents, dry cleaners, and fuel additives respectively. These are considered "volatile" because of their propensity to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding atmosphere. Therefore, one of the more common treatment techniques to remove VOCs from drinking water is granular activated carbon in combination with packed air towers. The primary health effect from drinking water containing VOCs at levels above the MCL is cancer.

Radiological Compounds

The primary source of radiological compounds in drinking water is from naturally occurring sources. Geologic formations can contain uranium, radium, strontium and other radiological compounds. In rare cases, radiological contamination can result from a nuclear facility accident. However, this is not very common. As with many drinking water contaminants the primary health effect is cancer-related. Common treatment for radionuclides is ion exchange.

In addition to the treatment techniques previously mentioned, blending is a type of "treatment" technique that DDW may approve. However, blending is typically only approved for contaminants that do not pose an acute (immediate) health risk. The previous examples are not a complete list of potential contaminants in drinking water, nor is the information provided an exhaustive explanation. It is a glimpse into drinking water quality providing the reader a background overview.

SECONDARY DRINKING WATER STANDARDS

Although Primary Drinking Water Standards are the most important regulations for water professionals, aesthetic quality is still a significant challenge and focus of drinking water providers. Making sure water is safe to drink is critical but if customers do not like the taste, odor, or color of the water they are likely to think that the water is unsafe and not fit for cooking and drinking. Therefore, it is important for water utilities to respond and take seriously all customer complaints, have a good preventive maintenance program, collect samples routinely and comply with all regulatory requirements. However, even the most diligent utilities can experience aesthetic water quality problems. Some aesthetic quality problems can be addressed by routine flushing and preventive maintenance programs, but some are the result of certain naturally occurring conditions and can only be removed through treatment and/or blending.

With varying sources of supply, comes varying water quality. Aquifer formations made up of limestone would tend to have higher levels of calcium, while other geologic formations might contribute other minerals such as magnesium, sodium, and potassium to name a few. Therefore, the quality of water in Los Angeles can be completely different than the water quality in Phoenix. However, in the United States all water must meet the minimum federal and state drinking water standards.

Common Aesthetic Issues with Drinking Water

Although the United States has some of the safest drinking water supplies in the world, sometimes little effort is focused on the aesthetic qualities. A crystal clear glass of water may not be safe to drink because it can have harmful tasteless and colorless contaminants in it. At the same time, discolored water with a bad smell and taste can be perfectly safe to drink. Everyone wants safe water to drink but it is usually the aesthetic qualities that determine if we will drink the water. Many times, when people are asked why they drink bottled water instead of tap water, their answer is usually "because it tastes better."

So why does some water look, taste, and smell bad? There are various things that can cause aesthetic issues with drinking water. The following scenarios provide just a few common issues facing water utilities. Please note that each scenario only reflects typical responses to common problems. They are meant as examples only.

- **Scenario 1** - A customer calls their local utility complaining of a slight yellow color to the water. What can cause this discoloration? What should the utility tell the customer? As mentioned previously, all water quality complaints should be treated with concern and taken seriously. A common first response from a water quality professional might be, "Is the discoloration coming from all the faucets in the home?" This simple question will help determine if the problem is coming from the customer's internal plumbing system or if it is coming from the water being served by the utility. If the discoloration is coming from all faucets, then the next step would be to check the water coming into the home. Sometimes the utility will send someone out to investigate, while other times the homeowner can be asked to flow the water at the front hose bib to check for discoloration. Usually the answer from the customer is the discoloration is only coming from a certain faucet or area in the home. A common source of the discoloration is from older galvanized internal plumbing systems. Sometimes a bathtub or sink is not used very often and iron from the internal plumbing system can leach out and cause a brown/yellow discoloration. A common suggestion to the homeowner would be to run the faucet for a while until the discoloration clears up.

- **Scenario 2** - A customer calls complaining of cloudy water. Cloudiness or "milky" looking tap water is commonly entrapped air in the water. A test that water quality professionals ask the customer to try is to fill up a clear glass and set it on the counter. If it is air then the cloudiness will begin to clear from the bottom of the glass up. This is because the air bubbles will rise into the atmosphere.

- **Scenario 3** - Sometimes customers will call and complain about odors. Customers will often call saying their water smells like a “pool.” Chances are something has changed in the distribution system or with the disinfection process. Drinking water is commonly disinfected with chlorine or chloramines. The switch from one to the other can cause “pool” chlorine type of orders. Or if water usage demands in the system have changed these same odors can be present for a short period of time.

No matter what the customer complaint is, all water professionals need to be honest, provide specific detail and help, and if they are ever uncertain of the solution to the customer’s concern, tell them they will need to investigate the issue and will provide them with a response as soon as possible.

As you can see, drinking water quality regulatory compliance is a complex and detailed area of the drinking water industry. However, regulations are readily available and government regulators are typically very helpful and responsive to questions from utilities. Water professionals and regulators alike should have the same goal of providing the public with a safe and reliable supply of drinking water.

CHAPTER 6: WATER DISTRIBUTION SYSTEMS AND OPERATIONS

Drinking water comes from a variety of different sources. As water makes its way through the hydrologic cycle, it comes back to land in the form of precipitation (rain, sleet, snow, etc.). Some of it is captured in lakes and rivers, while some of it percolates into the earth's surface and becomes groundwater. Groundwater can be pumped back up through groundwater wells and surface water can be treated and delivered to customers. In order for water to continue to flow out of the faucet when it is turned on by customers, it requires a network of pipes, pumps, storage, and other components which make up a distribution system. The water distribution system is the focus of this chapter. We will identify how water enters, travels through, and leaves a distribution system. Some of the focal points for discussion are storage, pipes, pumps, and various appurtenances. Appurtenance is a general term used to describe things such as valves, fire hydrants, meters, among other things. There are various names which refer to a company which distributes water to customers. Some examples include, water retailer, water utility, water district, water agency, water purveyor, and water supplier. These terms may be used throughout this text with the understanding they all virtually mean the same thing.

SOURCES OF SUPPLY

Water 132 Water Supply is a full semester course covering the details of sources of water supply. For this course, we will touch on some of the general aspects of water supply. As mentioned in the introduction to this chapter, most water supplies come from either surface water sources or groundwater sources. All surface water must go through treatment before it can be used for domestic purposes. A water supplier operating a distribution system must either operate their own drinking water treatment plant or purchase water from a drinking water treatment plant if they intend to use surface water as a source of supply. Let's look at a couple of local Southern California examples. The Los Angeles Department of Water and Power (LADWP) is one of the largest water suppliers in the country. They are an example of a utility which owns and operates a drinking water treatment plant as well as distributes water to its customers. In contrast, Las Virgenes Municipal Water District purchases all of its water from a water wholesaler. This wholesaler is the Metropolitan Water District (MWD) of Southern California. MWD owns and operates drinking water treatment plants but is referred to as a wholesaler because they do not serve domestic customers directly. They sell water to water suppliers who then sell directly to the end user customer. Surface water is carried through pipelines, aqueducts, and canals to the treatment plants for processing before being delivered to customers.

The other primary source of drinking water supply comes from underground aquifers. An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials from which groundwater can be extracted. Groundwater is extracted using wells. Wells can also be owned and operated by a water supplier or they can be owned and operated by a wholesaler who sells the water to a supplier.

DISTRIBUTION SYSTEMS

Once the source brings the water to the water supplier, it must make its way through a network of pipes, facilities, and various appurtenances in order for water to get to the customer. Below is a breakdown of the primary components of each of these.

Pipelines

1. Transmission Mains
2. Distribution Mains
3. Service Laterals

Facilities

1. Storage Structures
2. Pump Stations
3. Pressure Reducing Stations

Appurtenances

1. Valves
2. Angle Joints
3. Fire Hydrants
4. Meters

This list is by no means exhaustive, but it provides a basic overview of a distribution system.

Pipelines

Pipelines are arteries and veins of a water distribution system. They are in a variety of lengths and sizes and deliver water throughout a wide range of areas. They are commonly referred to as transmission, distribution, and service mains/pipes.

Transmission Mains

As water is brought from a surface water treatment plant to a water supplier, or as water is pumped from the ground, it must be connected to piping to begin the distribution process. Many times, a surface water treatment plant and sometimes drinking water wells are located outside of the area where customers are being served. If this is the case, then transmission mains play an important role in bringing water to the distribution system. Transmission mains are large diameter pipes, which travel long distances carrying large volumes of water. Some transmission mains can exceed diameters of 10 feet (120 inches) or more. Not all water suppliers have transmission mains of this size and some may not travel long distances. Smaller water suppliers might have transmission mains around 24 inches in diameter and only travel a mile or less. Typically, there are no service connections to customers off transmission mains unless they are smaller in size and are located within a distribution system.

Transmission mains are commonly welded steel and ductile iron pipe.

Figure 6.1 - Four, 36-inch cast-iron pipes.[1]

Distribution Mains

As water makes its way into a distribution system the pipe sizes become smaller. Distribution mains typically range in size from 6 inches up to 24 inches in diameter. This is not to say there are never distribution mains larger than 24 inches in diameter, it is merely a general description. Unlike transmission mains, distribution mains have customer services connected to them. There are three common network structures distribution mains are laid out in: arterial, grid, and tree. The “tree” network is typically the least desirable since they result in multiple dead ends. A dead end is a pipeline, which ends without any connections on the end of it. For example, most cul-de-sacs are dead ends. A grid network is usually the most desirable because all the pipelines within the grid are interconnected. Distribution mains are most commonly ductile iron pipe. However, polyvinyl chloride (PVC) is also extensively used. Asbestos cement pipe is often found in older water systems and is not typically installed any more. These network layouts and pipelines in general will be discussed in more detail in Water 140 and 141.

Service Laterals

In order for water to get to each customer individually, pipes need to be connected to a distribution main and brought to the customers parcel. Service laterals are these pipes. They are typically made of copper or plastic and connect to a distribution main and run to the customer's parcel, connecting to a water meter. The picture below refers to the "distribution main" as a water main and the "service lateral" as a service line.

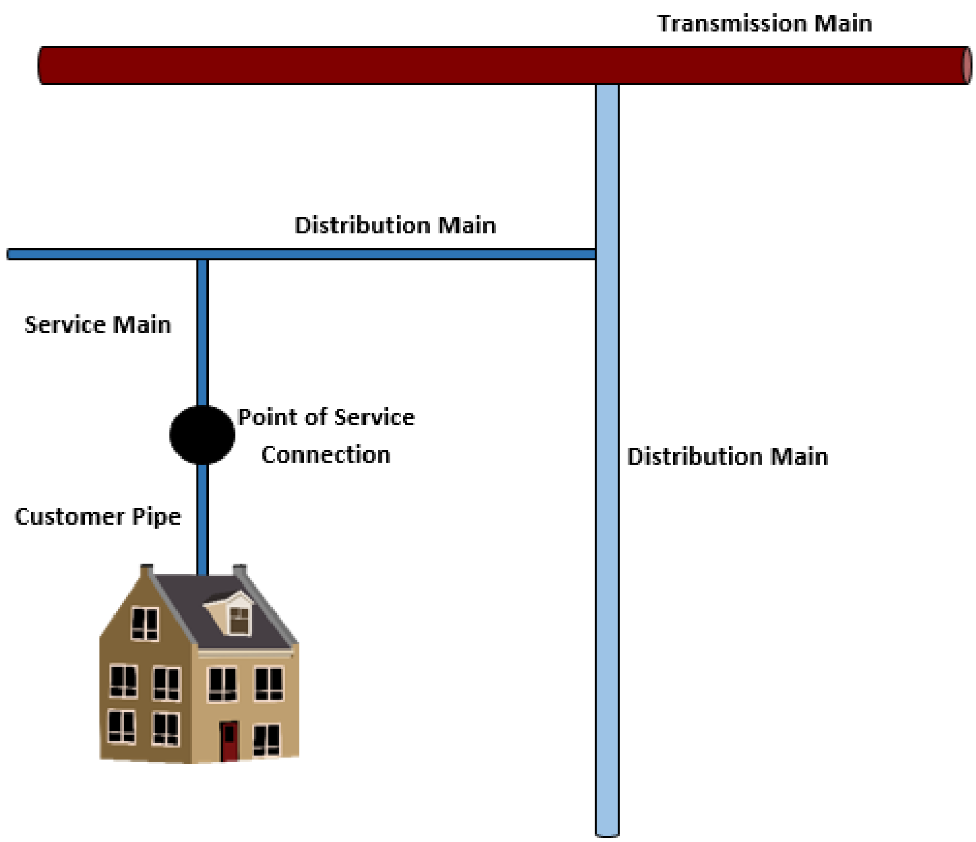


Figure 6.2 – Service laterals.[2]

It is also important to point out in this particular picture there is no water meter or valves connecting the pipes. However, it is a nice reference for illustration purposes.

[2] Image of house by rdevries is licensed under CC0 1.0 (modified by COC OER)

Facilities

A water supplier has a variety of facilities to store and move water through the distribution system. The information below is not a complete list of facilities but it is a basic overview of common facilities within a distribution system. Storage structures, pumps, and pressure control valves are common among most water distribution systems.

Storage Structures

Storage is an important requirement for distribution systems. Storage provides pressure and water demand for daily operations, maximum day demands, and enough flows for putting out fires. In order for water to flow through pipes there needs to be pressure. If pumps are not running, then something else needs to provide the pressure. This is where storage structures come into play. Next time you drive around the Santa Clarita or San Fernando Valleys look up on the surrounding hills and you will see tanks scattered around. These cylindrical shaped tanks are above ground water storage tanks. Above ground storage tanks are not the only type of distribution storage, but they are the most common in California. Depending on the topography of the area, the tanks might be placed at various heights throughout the system. Some might be at lower elevations and others at higher elevations. These varying elevation differences are referred to as “pressure zones.”

Pump Stations

A pump station is used to pump water from lower elevations to higher elevations. In order for water to get to these storage structures, pumps are needed to do the lifting. If a community were completely flat there might not be a need for pump stations. Groundwater wells could possibly provide enough pressure to lift water to elevated storage tanks. In areas where there are varying elevation differences, pumps are needed to lift water to the different pressure zones. This is not to say pumps are only providing water to storage tanks. However, the level of water in a tank is commonly used to determine when a pump needs to be turned on and off. Look at the example below. Imagine homes scattered around the line between the pump and tank too. When the level in the storage tank gets low, the pump would need to be turned on to refill the tank. While the tank is filling, customers might be connected to the pipe leading to the tank and use some of the water while it makes its way to the tank. Once the tank is full the pump would then be turned off.

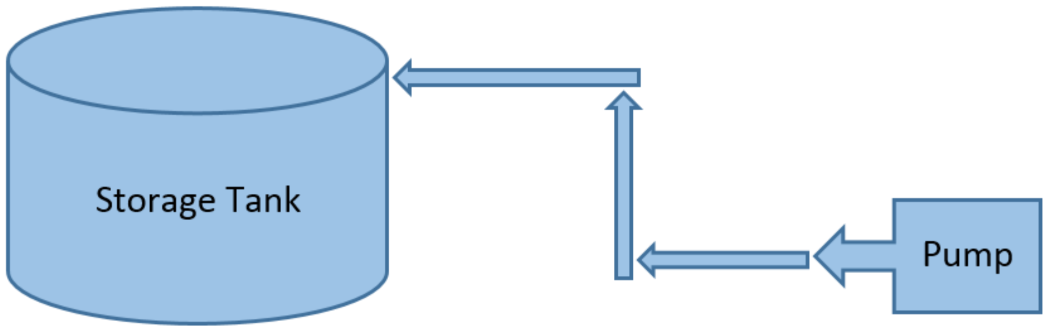


Figure 6.3 – Pump Station.[3]

Pressure Reducing Stations

Sometimes, the distance between the storage tank and a customer can be so great that the pressure the customer receives is too high for normal plumbing systems. In this case a pressure reducing station can be installed to reduce the pressure down to acceptable levels. Acceptable pressure values vary from water supplier to water supplier but a general range of 40 pounds per square inch (psi) to 140 psi is very common. These pressure reducing stations are very similar to a "pressure regulator" you might have at your home. Generally speaking, the maximum acceptable pressure inside a home is around 80 psi. Therefore, since water suppliers can have pressures up to 140 psi or more, it is common for customers to also have pressure regulating devices. Water supplier pressure reducing stations can also be designed to allow water to flow from higher pressure areas to lower pressure areas if pressures in the lower pressure area drop below a previously determined set point.

Appurtenances

Appurtenance is a generic term and commonly used for miscellaneous components throughout a distribution system. They are the "joints" and parts used to hold the distribution system together, monitor flows, allow to flow, and to stop water from flowing. In this section we will briefly discuss valves, angle joints, fire hydrants, and meters.

Valves

The primary purpose of a valve is to stop the flow of water. These are installed throughout water distribution systems to stop the flow of water, especially when there is a break in a pipe. As with pipelines, valves come in various sizes. For example, if a water main is 12" in diameter, then the valve is usually 12" in diameter. There are valves on transmission mains, distribution mains, and service laterals. There are also shut off valves connected to most customer meters.

When a repair needs to be made or some modification to an existing system needs to be performed the flow of water needs to be stopped. Therefore, valves are a critical component to a water distribution system. Valves connecting a distribution main to a service lateral are commonly referred to as corporation stops (corp stop). Valves located at meter connections are typically referred to as angle, curb, and meter stops. Below are a couple examples of valves.

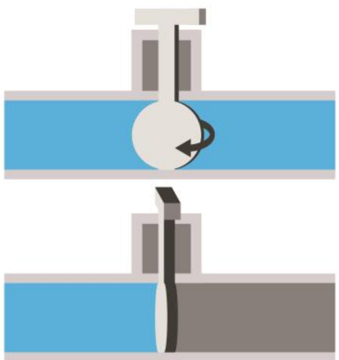


Figure 6.4[4]

Figure 6.5[5]

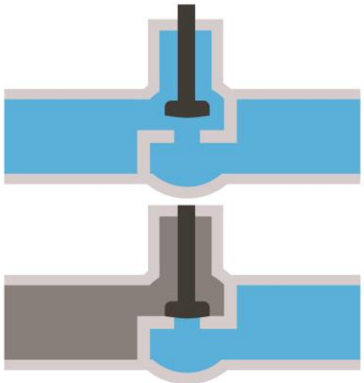


Figure 6.6[6]

Angle Joints

An angle joint is very similar to a joint in your body. Its use is to allow a pipe to change directions. If a pipe is installed in a street and the street turns to the right, the pipe needs to turn to the right too. If the turn is a 90 degree turn, then the angle joint would be referred to as a 90° elbow. There are a variety of different angle joints. The more common ones are at the following angles: 90°, 45°, and 22 ½°. If pipes coming from different directions need to be connected, then a “tee” or a “cross” would be used. See the examples below.

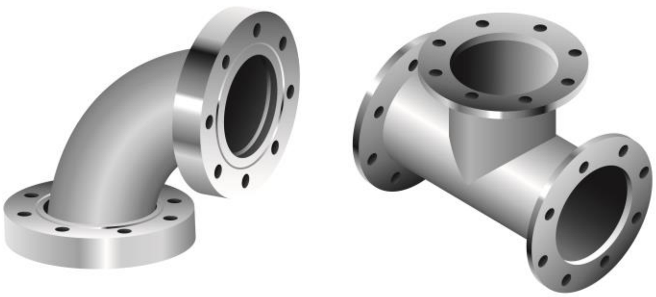


Figure 6.7 – Angle joint.[7]

[4] Image by Ian Joslin is licensed under CC BY 4.0
[5] Image by Alloy Valves is licensed under CC BY 3.0
[6] Image by Ian Joslin is licensed under CC BY 4.0
[7] Image by Ian Joslin is licensed under CC BY 4.0

Fire Hydrants

Fire hydrants are critical appurtenances in a distribution for putting out fires and keeping insurance costs lower. Fire hydrants allow water to flow at high volumes in order to help fight fires. Fire hydrants are also used to flow water for cleaning out sewers, provide water to trucks for dust control, and as a means to "flush" a distribution system for water quality purposes. Water sitting in pipelines for long periods of times without being used can become stagnant and discolored. Therefore, from time to time fire hydrants can be used to "flush" out a system. If a fire hydrant is broken or for some other reason "out of service", it is important that it is identified as not working. Therefore, if the fire department needs to put a fire out they are not wasting any time connecting to a not functioning hydrant.

Figure 6.9 – Fire hydrant.[8]

Figure 6.10 – Flushing a fire hydrant.[9]

Meters

The last appurtenance we will discuss in this text is a water meter. Meters are very important for tracking the amount of water traveling in, out or through a distribution system. Meters are commonly placed on pump stations and wells to track the water being pumped into a distribution system. Or, if the pump station is boosting water to a different zone, it is important to track the amount of water entering a particular zone. The most common location for water meters is at the customer service connection. Especially in areas where water is scarce, it is extremely important to be able to track the amount of water a customer uses in order to accurately charge them for the cost of water. Meters also come in various sizes and types depending on the amount of flow needed for the respective service connection.

[8] Image on Pixabay

[9] Image by Barksdale Air Force Base is in the public domain

Figure 6.11 – Meter.[10]

Figure 6.12 – Meter.[11]

The information provided in this chapter (as with all chapters in this text) is a snapshot look into distribution systems. In Water 140 and 141 of the Water Systems Technology program, you will take a more in depth look at this and more water distribution information.

CAREERS IN DRINKING WATER DISTRIBUTION

There are a variety of career opportunities working for a water distribution supplier and depending on the size of the organization, there can be multiple levels of each position with multiple departments. A large organization such as Los Angeles Department of Water and Power (LADWP) has over 4,000 employees. They have multiple departments with very specific tasks and responsibilities. For example, they might have a meter reading crew that only reads meters. Whereas in a smaller water utility, a meter reader might also be responsible for leak inspections at the meter service, hanging shut-off notices for non-paying customers, and other functions. In even smaller agencies, an employee might read meters one day, fix a leak the next day, and conduct well and pump maintenance on another day. Below is a list of some of the more common job opportunities and a brief description of some of the responsibilities.

Meter Reader

Responsible for reading water meters for customer billing persons. Typically requires walking from service to service, bending down to lift a meter lid, and making notes of the meter read.

[11] Image on Pixabay

Customer Service Representative

Responsible for assisting with sending out water bills, answering customer calls, processing customer payments, and creating work orders based on customer complaints.

Water Quality Technician

Responsible for the collection of water quality samples, reading and interpreting water quality results, writing reports, and ensuring the water being served to customers is in compliance with drinking water quality regulations.

Well and Pump Maintenance

Performs daily visits to well and pump sites to ensure proper operation. Collects meter reads, changes oil, monitors and maintains disinfection systems, keeps sites clean, and various other maintenance responsibilities.

Managers and Supervisors

There are various department managers and supervisors for both field and office staff. Their responsibilities range from organizing and assigning work tasks, creating and monitoring budgets, report writing, and other specific tasks related to their department.

This is only a small snapshot of possible opportunities within a water distribution utility. There are many more areas of specific focus such as engineering, human resources, administration, accounting, and construction, just to name a few. However, it is a good list to give a person some perspective on the operations of a distribution system.

CHAPTER 7: WATER TREATMENT FACILITIES AND OPERATIONS

Water treatment is one of the most critical steps in the drinking water process. It is critical to remove unwanted particles, inactivate harmful organisms, and treat to a level that complies with the Safe Drinking Water Act (SDWA). Most water treated within drinking water treatment plants comes from surface supply sources. As snow melts and rainfall moves along the ground surface into rivers, streams, and lakes, particles are picked up along the way. Therefore, ALL surface water to be used for domestic drinking water purposes must be treated. Surface water is also more susceptible to contamination because much of this contamination comes from "runoff". Every time it rains or as snow melts, water is washed down from mountains, hillsides, roads, and other areas, picking up anything along the way. For example, imagine a farm next to a stream that feeds a local lake used as a drinking water storage reservoir. There is a potential for animal waste among other things making its way to the storage reservoir. Just the sediment from a lake's hillside and the natural organic matter in a lake makes the water not suitable for drinking. Therefore, there are regulations within the Safe Drinking Water Act called Surface Water Treatment Rule (SWTR), which specifically addresses surface water treatment requirements. There have been several iterations of this rule to improve the quality of drinking water. The SWTR is crafted to prevent waterborne diseases caused by microorganisms. The rule requires water systems to filter and disinfect water from surface water sources to reduce the occurrence of unsafe levels of disease-causing microbes.

One of the primary constituents the SWTR requires treatment and monitoring for is turbidity. Turbidity is the cloudiness or haziness seen in water samples and prevents the performance of filtration systems. Low turbidity requirements are used to protect against certain microbial contaminants, in particular *Cryptosporidium*. *Cryptosporidium* is a protozoan that can cause gastrointestinal illness in humans, which is similar to many disease-causing microorganisms. The lower the turbidity levels, the less likely there will be disease causing microorganisms. The SWTR also requires disinfection to protect against these pathogens. Disinfection chemicals, such as chlorine, are used to inactivate (kill) pathogens during the treatment process through a required residual present in the water throughout the distribution system.

Surface waters also have to be treated for aesthetic qualities. An aesthetic quality doesn't typically have an effect on public health. These types of qualities are usually related to the appearance and palatability of the water. Does the water taste good, look good, and smell good? Taste, odor, and color are three qualities surface water quality is treated to improve.

PARTICLES IN WATER

Particles in water can be broken into three (3) general categories: suspended solids, colloidal compounds, and dissolved solids. Microorganisms fall under the colloidal compound category. One of the main goals of a surface water treatment plant is to prevent the outbreak of disease from microorganisms. These disease-causing agents are referred to as pathogens. The three main pathogen categories are distinguished as bacteria, virus, and protozoa. In drinking water quality, these organisms are not specifically analyzed in samples. Specific organisms, viruses, and protozoa can be very costly and require extensive sampling techniques. Some of the more common pathogens, which can be found in water, are:

- Bacteria – *Escherichia coli (E. coli)* and *Vibrio cholera*
- Viruses – *Enterovirus* and *Coronavirus*
- Protozoa – *Cryptosporidium parvum* and *Giardia lamblia*

Instead of analyzing for these organisms specifically, a class of organisms called *total coliforms* (TC) is used analyzed instead. TC is referred to collectively as indicator organisms. The *presence* or *absence* of TC bacteria indicates the presence or absence of pathogens. The analytical test is easy, inexpensive, and very effective. Microorganisms are one class of "particles" removed or inactivated from water. Microorganisms are difficult to remove from water, therefore they are usually destroyed or inactivated through the treatment process.

In contrast to colloidal compounds, suspended solids are more easily removed. Much of the suspended material found in surface water supplies is referred to as turbidity. This turbidity comes from decaying plant material and soil as water runs across land and makes its way to streams and lakes. While suspended solids are not typically associated with disease, they can shield microorganisms from treatment processes and provide an overall poor quality to the water supply.

Dissolved compounds are the most difficult to remove because they are dissolved in the water. Think about sugar or salt mixed in a glass of water. Once it dissolves and mixes in the water, a treatment process is needed to remove it from the water. These treatment processes are more complex than the standard drinking water treatment plant. There are a variety of processes including things such as ion exchange, membrane filtration, chemical absorption, and others. If the dissolved compounds do not pose a health threat or if they are below their corresponding Maximum Contaminant Level (MCL), they are not typically treated for in the drinking water treatment process.

PRE-STORAGE

Prior to entering a drinking water treatment plant, water is typically held in large storage reservoirs. These "reservoirs" (lakes) provide an area for large amounts of water to collect so the treatment plant has a constant source of supply. These reservoirs can also allow for some settling of solids and many double as a recreation space for fishing, boating, and water-skiing, etc.

ENTERING THE TREATMENT PLANT

As discussed in earlier chapters, surface water used for drinking is commonly stored in above ground lakes. These storage reservoirs are sometimes used for recreation such as fishing, boating, and water skiing. This recreational use is an important part of the economy and public use. However, they can add additional water quality problems for the water treatment plant. Water leaving these storage reservoirs needs to be free of large debris such as plants fish, trash, wood, etc. In order to take water from the storage reservoir and leave the larger debris behind there are "intake" structures. A surface water intake structure is a screened structure to let water through and keep larger items from entering the treatment plant. The screen size can vary depending on the use of the storage reservoir and the quality of the raw water. Raw water is the term used to identify water before treatment. The picture below shows an example.

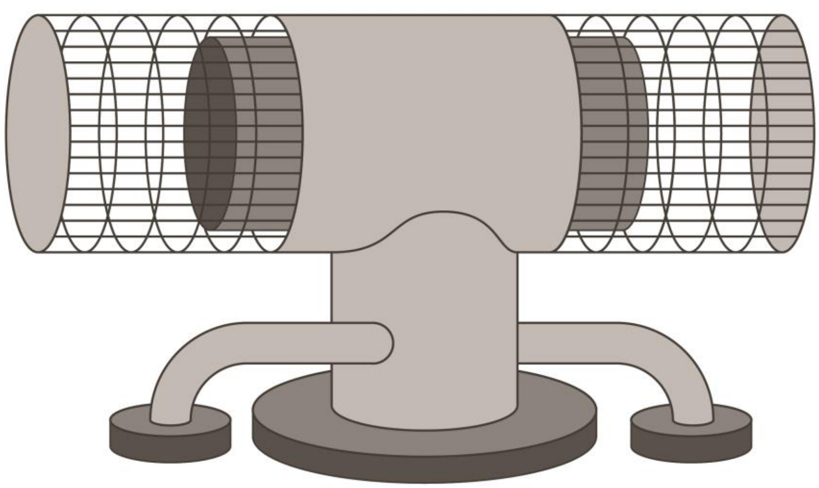


Figure 7.1 – Surface water intake structure.[12]

The water entering the intake structure can either be pumped or can flow by gravity to the treatment plant depending on the location of the plant compared to the storage reservoir.

[12] Image by Ian Joslin is licensed under CC BY 4.0

Valves can be used to adjust the flow into the plant and the water is sometimes kept in an onsite storage tank leading into the plant.

INSIDE A WATER TREATMENT PLANT

Pre-Disinfection

Once raw water enters a treatment plant there may be a pre-disinfection process. Some plants use a disinfectant to kill pathogens and other microorganisms prior to the water going through the treatment process. This can be done to prevent certain organisms from entering the plant and having an effect on the various treatment processes. Or it can be done to remove precursors, such as total organic carbon, to prevent disinfection by-products from forming. Newer treatment plants will use ozone as the disinfectant primarily because it is an effective oxidizer and it does not leave a residual in the water throughout the treatment process.

Ozone is a trivalent form of oxygen. Simply put, it is a compound of three (3) oxygen molecules (O_3). If you have ever smelled an electrical spark or a lightning strike, chances are it is ozone that you smelled. It must be used at the point of generation. Unlike chlorine, which can be processed at a chemical plant (for example), a treatment plant using ozone must generate it on site. Ozone has a number of benefits over chlorine.

Ozone Compared to Chlorine

1. Stronger disinfectant
2. Does not contribute to disinfection by-products
3. Kills a wider range of organisms
4. Achieves removal of unwanted tastes and odors
5. Reactions are more rapid

However, as mentioned previously, ozone does not leave a disinfectant residual in the water. This might be a good thing for a treatment plant, but ozone is not used in distribution systems because a residual is needed.

Conventional Treatment vs. Direct Filtration

There are two main types of drinking water treatment plants. There are conventional treatment plants and direct filtration plants. Each has benefits and drawbacks. All of which will be discussed in this text. It is important to remember that this text is an introductory text for a very general overview of the waterworks industry. Therefore, details of each treatment process discussed may be omitted and are provided in more specialized courses. The basic difference between a conventional water treatment plant and a direct filtration water treatment plant is a sedimentation basin. A conventional drinking water treatment plant has a sedimentation basin and a direct filtration plant does not. So, why would one be used over another? Below is an example of some of the "pros" and "cons" of a sedimentation basin.

Sedimentation Basin Pros

- Allows solids to settle out of the water prior to entering the filtration process
- Reduces the amount and duration of backwashing filters

Sedimentation Basin Cons

- Sedimentation basins are large and require a bigger treatment plant
- The sludge at the bottom of a sedimentation basin needs to be removed from time to time.

We will now look at the other processes typically found in a conventional and direct filtration drinking water treatment plants.

Coagulation

Coagulation is the process of chemical addition such as "Alum" to the water supply in order for small suspended particles to "stick" together forming floc. The chemicals added produce positive charges to neutralize the negative charges on the particles. The particles stick together becoming larger and larger during this process.

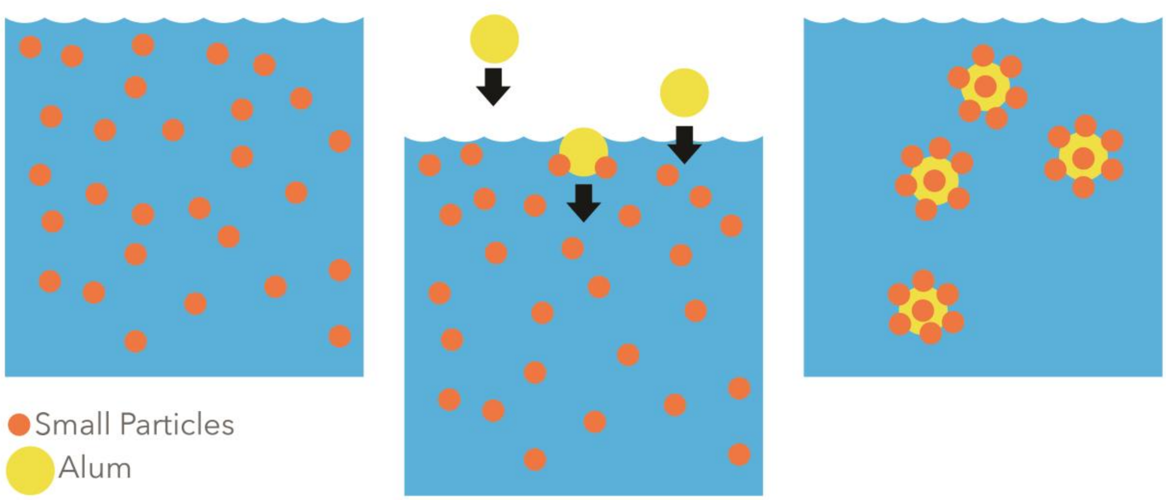


Figure 7.2 – Coagulation.[13]

[13] Image by Ian Joslin is licensed under CC BY 4.0

Flocculation

As the particles begin to stick together, the water is then sent through a series of tanks with "paddles." These paddles are designed to slowly mix the water, bringing the particles together to form larger and larger particles called "floc." The mixing process must be gentle enough to not break apart the floc back into smaller particles.

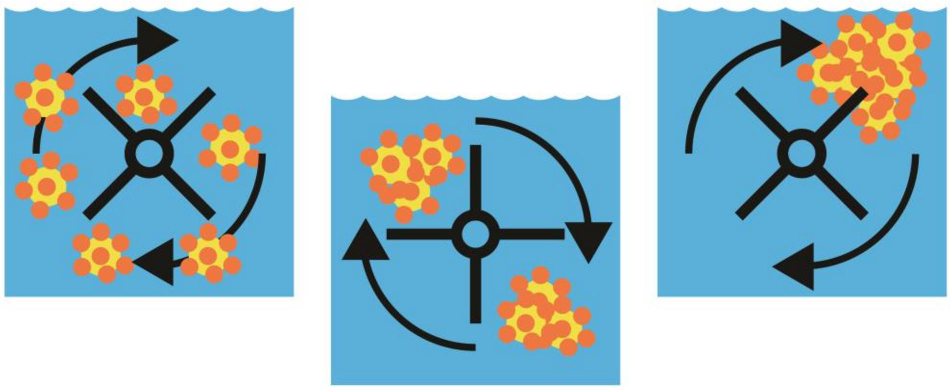


Figure 7.3 – Flocculation.[14]

Sedimentation

In conventional drinking water treatment plants, the sedimentation process allows for the forces of gravity to allow the floc to "settle" to the bottom of the basin. Not all the floc will settle. As you might expect, the large particles settle more rapidly than small particles. Also, the slower the water moves through the basin the more particles will settle out. Water in a direct filtration plant moves straight from the flocculation tanks to the next step…filtration.

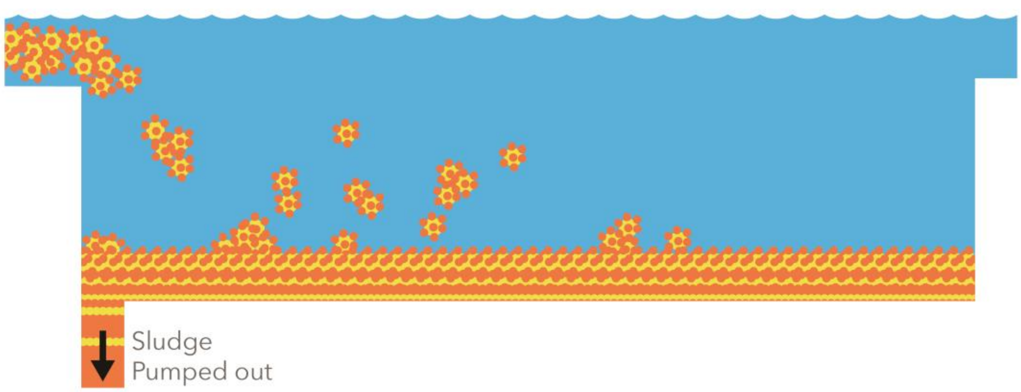


Figure 7.4 – Sedimentation.[15]

[14] Image by Ian Joslin is licensed under CC BY 4.0
[15] Image by Ian Joslin is licensed under CC BY 4.0

Filtration

The filtration process is one of the most critical steps. Filters are commonly constructed in concrete boxes and contain sand and gravel. Sometimes other filter media is used, but many times sand is sufficient enough to remove the remaining suspended particles. The purpose of the gravel is to support the sand and prevent it from leaving the filter. Under the gravel is a structure called an “underdrain.” The purpose of the underdrain is to allow clear filtered water out of the filter while supporting the gravel and sand filter media. The process of backwashing will be discussed later.

Post-Disinfection

Prior to the water entering the distribution system, it is usually disinfected with a chlorine-based disinfectant. Chlorine gas was and still is commonly used to provide a “free” chlorine residual throughout the distribution system. However, because of the water quality risk of disinfection byproducts, many water treatment plants are using a “total” chlorine residual by mixing chlorine and ammonia together. This disinfection process is referred to as chloramination.

How much disinfectant is required before water can be provided to customers for domestic use?

There are two “standards” when it comes to disinfection. There is a maximum residual disinfectant level (MRDL) and a minimum disinfectant level, which should be provided to the furthest areas within a distribution system. The MRDL is 4.0 mg/L and this level should not be exceeded in the water entering a distribution system. Typical free (chlorine) and total chlorine (chloramination) levels in water leaving a treatment plant can vary, but are commonly between 2.5 and 3.5 mg/L. The minimum residual level, which should be maintained in the furthest areas of a distribution system is 0.2 mg/L. Since microorganisms have the ability to multiply, a “residual” helps prevent regrowth and keeps the water free of pathogens. The previously mentioned dosage values typically provide enough disinfectant to kill/inactivate (disinfectant demand) remaining microorganisms and allow for a constant and minimal residual within the distribution system. The previous sentence used three (3) common terms associated with disinfection; dosage, demand, and residual.

1. **Dosage** – is the amount of a disinfectant added.
2. **Demand** – is the amount of disinfectant “used up” by the disinfection reducing agents in the water (microorganisms, organic matter, etc.)
3. **Residual** – is the amount of disinfectant left in the water supply.

Therefore, the following formula is commonly used.

Dosage = Demand + Residual

The amount of disinfectant added to a water supply (dosage) minus the amount "used up" (demand) equals the amount remaining, which is referred to as the residual.

Storage

In order for treatment plants to provide large quantities of water to distribution systems, a large amount of storage is commonly required and provided at the treatment plant. This "post" storage can and often times be in the millions to tens of millions of gallons. Therefore, treatment plants require large areas of land for the entire treatment process and storage.

Additional Treatment Processes

If the influent quality of water coming into a treatment plant or if the water supply a distribution system is producing, (often times from groundwater wells), is contaminated and not within drinking water standards, the water will require additional treatment. Some of these processes include but are not limited to, ion exchange, membrane filtration, and air stripping. Ion exchange, for example, is the process of removing ions using water with opposite charged ions. In Water 050 and 052, you will take a more in depth look at each process and analyze the benefits and challenges a water treatment operator might encounter.

CAREERS IN DRINKING WATER TREATMENT

Because many drinking water treatment plants are wholesale water providers, meaning they sell water to various water agencies, the extent of career opportunities and paths can be quite extensive. They can have careers ranging from field technicians, maintenance workers, treatment plant operators, engineers, water resource professionals, as well as a variety of office and policy related opportunities. For example, Metropolitan Water District (MWD) of California deliveries is one of the largest wholesaler water suppliers in the country. MWD provides approximately 1.7 billion gallons of water per day and is the largest contractor of the State Water Project. In addition to the responsibilities associated with operating a water treatment plant, MWD has an extensive distribution system. They also have the important task of securing sources of supply to ensure there is always enough water for the water retailers who purchase water from them. They have additional responsibilities in the areas of water conservation, legal matters, public relations, human resources, finance, administration…the list goes on and on. They employ almost 2,000 people with jobs ranging from laborers to scientists, to engineers and more. As you can imagine, trying to list and discuss the vast amount of opportunities for an organization like this would be a lengthy process. For an introductory course like this one it would be impractical. Therefore, we will just look at a smaller example of a drinking water treatment plant and focus on career opportunities available for students such as you.

Treatment Plant Operator

Water Treatment Plant Operators (WTPO) typically work various assigned shifts. It is not usually a typical "8 to 5" type of job. After all, treated, safe drinking water needs to be available to customers 24 hours a day, 7 days a week. Therefore, WTPO need to work around the clock to make sure the treatment process is functioning efficiently. Below is a list of some of the more common tasks and responsibilities of a WTPO.

- Ensure the treatment plant is operating
- Perform biological, chemical, and physical laboratory tests on water
- Interpret test results
- Monitor and read gauges, meters, charts, and other treatment performance indicators
- Monitor and inspect treatment process equipment and instrumentation
- Make adjustments and take corrective action on treatment process equipment
- Maintain operational and water quality records
- Prepare reports
- Participate in training programs

In addition, other responsibilities may include cleaning and disinfecting storage tanks, flushing pipelines, and conducting public tours of the treatment plant. Often, plants will have a variety of automated processes and the WTPO will monitor these processes on a computer screen, making adjustments through a Supervisory Control and Data Acquisition System (SCADA).

Experience and educational qualifications will also depend on the size of the facility, but many entry level positions will require a minimum of a Grade 3 Treatment Operator certification (T3) or a Grade 2 Treatment Operator certification with the ability to obtain a T3 within a year of employment. Since treatment plants may also have an associated distribution system to get water to the utilities purchasing water from them, a Distribution Operator certification may also be required. The more education and experience you can obtain will always help your chances in landing a job. An associate's or bachelor's degree is sometimes listed as a "desirable" qualification.

Water Treatment Plant Maintenance Worker

Just as a distribution system needs maintaining, a water treatment plant also requires maintenance. Pumps and motors can malfunction. Pipes can leak. System process and equipment can breakdown requiring repairs or replacement. Therefore, most treatment plants will have a maintenance crew as part of the staff.

Water Quality and Laboratory Staff

Many water treatment plants will have their own drinking water laboratory to analyze samples throughout the treatment process ensuring proper function and for adjusting chemical doses. The staff might be in charge of collecting samples and running analytical instrumentation in the lab. They might also be responsible for writing reports and keeping track of water quality data for regulatory compliance.

CHAPTER 8: WATER SUPPLY

We have already discussed our water supply in several chapters. Remember, the two main sources of supply for use are surface water supplies and groundwater supplies. And, as you will see in Chapter 10 there are other sources of water used to supplement these two main sources. If you recall, surface water receives its supply from precipitation in the form of rain, sleet, snow, etc. Moist warm air rises and condenses on upward slopes. On the west coast, rain falls mostly on the westward facing mountains and as dry air drops a rain shadow effect occurs on the east facing slopes. Much of this precipitation runs off into streams, rivers, and lakes. Evaporation occurs condensing water back into the atmosphere. Some of it percolates into the ground and becomes groundwater. Plant roots also take up some water and transpiration occurs. The process of water transpiring and evaporating back into the atmosphere is referred to as evapotranspiration. When precipitation occurs, the entire cycle is continued. This cycle is known as the hydrologic cycle.

Most of the water on earth is salt water. In fact, 97% of the earth's water is seawater and only 3% is fresh water. This means of all the water on the planet, we get our fresh water from 3% of it. The story continues. Approximately 69% of all freshwater is in the form of glaciers and icecaps. Groundwater is approximately 30% and surface water is less than 1%. This is fairly startling considering much of the water we use every day comes from a fraction of the freshwater on earth. The vast majority of this small fraction is found in lakes. Some of these lakes are natural and some are man made storage reservoirs behind dams. Much of the water that supplies California sits in these "manmade" storage reservoirs as the water moves through several aqueduct systems.

CALIFORNIA SURFACE WATER

California's diverse climate and geography presents an interesting situation when it comes to water supply. Approximately 2/3 of the state's rainfall occurs in the upper 1/3 of the state, while 2/3 of the usage occurs in the lower 1/3 of the state. In other words, water is used more in areas where it doesn't naturally fall from the sky. Therefore, surface water supplies are plumbed thousands of miles across California. There are 6 main aqueduct systems providing surface water throughout the state. They include:

- State Water Project
- L.A. Aqueduct
- Colorado River Project
- Hetch Hetchy Aqueduct
- Mokelumne Aqueduct

These aqueduct systems originate in the central to northern portion of the state and are operated by a variety of agencies.

State Water Project

The California State Water Project (SWP) originates from the tributaries of Lake Oroville, north of Sacramento. It runs a distance of approximately 600 miles and includes twenty-nine (29) dams/storage reservoirs, eighteen (18) pumping plants and five (5) hydroelectric power plants. It passes through the California Bay Delta. The Bay Delta is one of the nation's largest and most complex water delivery system and is known for its agricultural productivity, ecological diversity, and complexity. The SWP also includes the world's largest water lift. The Edmonston Pumping Plant at the base of the Tehachapi Mountains pumps (lifts) water 2,000 feet over this mountain range. More than 2/3 of Californians receive water through the SWP. The California Department of Water Resources (DWR) operates the State Water Project.

Los Angeles Aqueduct

In contrast, the Los Angeles Aqueduct is owned and operated by the Los Angeles Department of Water and Power. In the early 1900s, William Mulholland and Fred Eaton traveled north to find additional sources of supply for Los Angeles. What they discovered was the Owen's Valley, which had more water than the area knew what to do with. They built an aqueduct approximately 223 miles from the Valley diverting water down to Los Angeles. The unique thing about this aqueduct system is it flows entirely by gravity. The book and movie titled *Cadillac Desert* documents the vast undertaking by William Mulholland.

Colorado River Aqueduct

The Colorado River Aqueduct begins at Parker Dam along the Colorado River and travels approximately 242 miles west into California. There are two (2) storage reservoirs along the way and five (5) pumping stations to traverse the desert. The Metropolitan Water District of Southern California holds the priority water rights on the Colorado River Aqueduct.

GROUNDWATER

Underground aquifers hold a vast amount of water. Pores in the soil and fractures in rock formations hold millions of gallons of water beneath the earth's surface. As rain falls and snow melts, rivers fill with water and recharge these underground storage basins. There are three (3) main types of aquifers, each with unique geological characteristics. An unconfined aquifer can be very shallow, around 20 feet below the earth's surface to several hundred feet deep. These aquifers are commonly made of alluvium deposits consisting of porous, water-bearing materials of sand and gravel. These aquifers are capable of yielding large amounts of water and relying on annual recharge to keep them full of water. Beneath unconfined aquifers are confined aquifers. These aquifers are separated by an impermeable layer of soil (commonly clay) with porous sand and gravel beneath the clay. This impermeable layer acts as a barrier between the soil sediments above acting as a protective shield. Confined aquifers are less susceptible to surface contamination because of this impermeable layer. Fractured rock aquifers are not very common, but they can exist in mountain regions where there are cracks or fissures in the underlying rock. Water from precipitation can then make its way into the cracks and can be withdrawn by wells. Most wells require a pump and motor to get the water from below the ground to the surface. However, where recharge zones are higher than the elevation, the water can flow out without any help. These types of aquifers are referred to as artesian.

Groundwater banking or aquifer storage and recovery (ASR) is becoming increasingly popular, especially in areas prone to experience drought. Water can be pumped into an aquifer through injection wells or spread across acres of land allowing the water to percolate into the aquifer. This type of water storage is often done using surface supplies when water is plentiful. Instead of allowing the surface water to flow to the ocean, it can be diverted into an underground storage "bank".

WHAT IS WATER?

When discussing water, sometimes we often overlook the very unique qualities of this vital resource. Water is composed of three (3) atoms. There are two (2) hydrogen atoms attached to one (1) oxygen atom. The bonding of these atoms to form a water molecule is what truly gives water its amazing characteristics. A water molecule is a polar compound, meaning it has the hydrogen ion bonds angled away from the oxygen atom. The oxygen atom has an affinity for positively charged ions while the hydrogen atoms attract negatively charged ions. This polarity allows water to bond with a variety of compounds making water a "universal" solvent. Water is found in three different phases; liquid, solid, and gas.

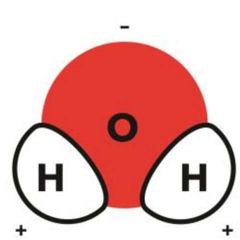


Figure 8.1 –Water molecule.[16]

[16] Image by Ian Joslin is licensed under CC BY 4.0

The ability of water to attract other water molecules is called cohesion. This characteristic creates surface tension of water. A simple experiment to see surface tension in action is to float a paperclip on water. Fill a glass and gently place a paperclip on the water. The surface tension among the water molecule bonds allows the paper clip to float. Adhesion is the ability of water to attract other molecules. This attraction to other molecules can be seen by the meniscus in a cylinder. Water attaches to the sides of the cylinder causing it to "creep" up the sides. Some substances are not attracted to water molecules preventing them from dissolving in water. For instance, fats and oils are considered hydrophobic because they do not dissolve in water. Conversely, hydrophilic substances such as salts and sugars dissolve quite easily in water.

WATER RIGHTS

Does everyone have a right to water? Well, on the surface this seems like an easy answer. Everyone should have the right to a safe, clean, and affordable water. However, this isn't always the case. Water rights laws are very complex and simply stating that everyone has the right to access drinking isn't always enough. Typically, in highly populated cities, the "right" to water isn't a big issue. However, accessing a safe, clean, and reliable supply in rural areas isn't always possible, let alone feasible. In 2012, California enacted Assembly Bill 685 establishing a state policy that every Californian has a human right to safe, clean, affordable, and accessible drinking water. This sounds great, but making this a reality is very difficult to accomplish, especially in very rural areas where the infrastructure doesn't exist to provide the water. Who actually "owns" the water we use every day?

Water rights are held by a variety of different private and public entities. Individual farmers can own water rights as well as large municipalities. Water rights are commonly land-based rights. Rights can be allocated based on land ownership or possession. Another type of water right is termed "riparian" rights. This type of land-based right gives the owner of land adjacent to the bank of a water body the right to the water flowing next to their property. Water rights can be also based on use. Use-based rights grant the user certain rights based on the amount of water previously used. Use is given for certain beneficial uses. This can also be for municipalities serving a certain population. Most water rights are associated with surface water supplies. Groundwater is often left to the people owning groundwater wells and pumping water out of the underlying aquifer system. At times this can be contentious if one entity is considered to be pumping more water than others deem is appropriate for the area and or use. This type of contention can result in something called adjudication. Adjudication is a legal process to determine who has a valid right to the water and how much of it can be used by each entity.

CHAPTER 9: WATER USE

It is amazing what water is used for and how much is used on a daily basis. We tend to not think about all the daily activities we do which requires the use of water. We turn on the faucet in the morning without giving it much thought. We flush the toilet, make coffee, and shower without the consideration of where or how the water comes out of our tap. If we think about the simple and obvious water uses, we might list washing our face and hands, taking showers or baths, brushing our teeth, making coffee, boiling pasta, washing dishes and clothes, flushing toilets. However, the list of water use goes on and on. In addition to the obvious uses (i.e., drinking, bath, irrigation, etc.) millions of gallons are used in the manufacturing and processing of everything from semiconductors to beer and everything in between. Water is a vital resource for public health and safety and plays a significant role in our economy. One of the largest water uses in California is the agriculture industry. According to the Pacific Institute's 2009 report titled *Sustaining California Agriculture in an Uncertain Future*, approximately 17.2 million acre-feet of water is used for agriculture annually. In addition, a large portion of the state's water supply is undeveloped and used for environmental purposes.

Water use can be broken down into several different categories: geographic, socioeconomic, availability, reliability, and quality. Geographically where water is plentiful very little is used for outdoor irrigation and sometimes use isn't even tracked. In contrast, in areas of the world where precipitation is low and water is scarce, it is treated differently and very little is used for outdoor irrigation. In poorer areas of the globe, water is a vital resource for survival. Approximately one (1) billion people lack safe and adequate water. In these regions people are not concerned with keeping a lawn green with water. They are worried about surviving. Availability, reliability, and the quality of water also play an important role in usage patterns. Industrialized countries tend to have water readily available, with reliable infrastructure, and of high quality. However, as we have seen in recent years, in certain areas, such as Australia and California, long droughts can occur, jeopardizing water availability, reliability, and quality. The point of this introduction is not to memorize facts and figures; it is to illustrate the vast amount of water uses and variability of supplies throughout the world. The remainder of this chapter will focus on common water uses primarily in California. As mentioned above, water plays an important role in the manufacturing of items. The following table is an example of how much water is needed to prepare certain items.

ITEM	GALLONS OF WATER
Pair of Jeans	1,800
Cotton T-Shirt	400
Barrel of Beer (32 gallons)	1,500
Single Board of Lumber	5.4
Gallon of Paint	13
Individual Plastic Bottle of Water	1.85

UNITS OF WATER

Whenever we discuss water we talk in volumes. However, there are various units to measure volumes of water. Each unit has its own purpose and are commonly interchanged with each other. Below is a partial list of units and the common use for reporting.

USE	UNIT
Meter Reads	Cubic feet (cf) Hundred cubic feet (HCF / CCF)
Groundwater Well Flow	Gallons per minute (gpm)
Daily Production	Million gallons per day (MGD)
Annual Production	Acre-feet per year (AFY)
Per Person	Gallons per capita per day (GPCD)

Understanding the terminology and units used in any industry is very important. The water industry uses a variety of different units and has a lot of terms not used in any other industry. As you start taking more classes in this field and begin your career in water you will become acquainted with the “language” of the industry.

As shown in the above table, the common unit of measure to track water use on a per person basis is “gpcd”, which is gallons per capita (per person) per day. This is the amount of water used by one person per day. It is typically calculated by taking the total water demand (use) for the year and dividing it by the total population served. This will give you the amount of water each person uses for one year. Dividing it by 365 (the number of days in a year) will yield the gpcd, the gallons per person (per capita) per day. This number and unit were not used very often in the industry prior to 2009. In 2009, the governor of California passed legislation for conserving water and one of the parameters used to measure the required amount of conservation required by water suppliers is gpcd. Senate Bill X7-7 requires water suppliers to conserve at least 20% of their water demand by the year 2020. Hence, the bill is commonly referred to as 20x2020 (20 by 2020).

In order to conserve water, it is important to identify water use. Where is the water being used? This may seem like an obvious statement, but being able to identify where the most water is being used can help in targeting specific areas for conservation. For example, gpcd includes both indoor and outdoor water use from residential customers. As previously stated, it is simply the total amount of water used divided by the total population. However, it doesn't distinguish between indoor or outdoor water uses. It also doesn't discern between other uses such as business or industry (these will be discussed later in the text.) In the next section we will analyze and assume the entire population of the first few examples is a residential community. Therefore, the gpcd would be for all residential water use both inside and outside the home.

GPCD

Water usage varies from person to person, city to city, state to state, and more importantly climate to climate. Geography and socioeconomic status also play an important role with water use. Little irrigation water is needed in areas with high amounts of precipitation. However, sometimes in areas with very little precipitation, little is used for outdoor irrigation too. For example, the gpcd for someone living in an area where there is a lot of annual precipitation will more than likely have a lower gpcd than compared to someone living in a warmer climate. Socioeconomic status will also have an effect on water use and gpcd. A single person living alone in a small apartment will probably have a lower gpcd than someone living in a Beverly Hills mansion with a large yard. Someone with high efficiency appliances, low flow toilets and faucets would tend to have a lower gpcd than someone with access to these types of things. Below is an example of the differences between geographic regions and the respective gpcd values.

Average Daily per Capita Water Use in Several Major U.S. Cities[17]

Metropolitan Area	GPCD
Phoenix, AZ	115
New York, NY	78
Seattle, WA	52
Sacramento, CA	280
San Diego, CA	143

Before even looking at the actual gpcd values in the above table, you could probably guess which city would have the lower and which would have the higher average gpcd values. The only city which may have tricked a few people could possibly be Phoenix, Arizona. Phoenix is a very hot and arid city and one might expect a very high gpcd. However, the gpcd value is considerably lower to a similarly hot and arid Sacramento community. Why is this? If you have ever traveled to Phoenix and Sacramento, the difference between most of the homes in Sacramento compared to Phoenix is the type of landscaping at an average-sized single-family home. In Phoenix, many homes have "native" or natural landscaping such as rocks and cactus. In contrast, many Sacramento homes have grass (turf) for landscaping. There are other reasons why Sacramento has a higher gpcd than Phoenix, but this is one of the more obvious reasons. Water use is dependent on availability, reliability, and quality.

Let's now take a look at a hypothetical gallon per capita per day (gpcd) calculation to work with as an example to identify water use. Typically, when a gpcd is calculated it is not done based on individual water usage. It is commonly calculated based on total annual consumption divided by the total population served. Assume a population of 5,000 people uses 1,120 acre-feet of water in one year. What would be the gpcd for this hypothetical community? Using the formula "total gallons divided by total population", converts to a gpcd of approximately 200 (see below).

1 AF = 325,829 gallons
1,120 AFY × 325,829 gallons = 364,928,480 gallons per year
364,928,480 gallons ÷ 5,000 people = 72,986 gallons per person per year
72,986 gallons per person per year ÷ 365 days = 200 gpcd

[17] The information shown in the table is provided by the non-profit organization Circle of Blue

This type of calculation will be discussed in more detail in the Water 131 Advanced Waterworks Mathematics course. Therefore, you will not be required to perform this type of calculation in this course. It is used as an example and to help explain how water use is calculated and identified. Now that we have an example gpcd, let's break down the actual usage.

CALIFORNIA

Among all the countries in the world, the United States has the highest average daily water use per person. In fact, on average, the U.S. uses approximately 410 billion gallons of water per day. The majority of this water use comes from surface supplies; about 80% and the remaining 20% comes from groundwater. Thermoelectric power is responsible for approximately half of all U.S. water demand. Irrigation (agriculture) and public water supply makes up just about all the remaining.

California water use is strongly dependent on the Mediterranean climate throughout much of the state. However, California also has some very tall mountain ranges with subarctic conditions. The lower flatland areas of California consist of long dry summers, cool evenings, and mild rainy winters. This is why so many people flock to areas in Southern California. A summer day in Santa Monica or San Diego is almost the perfect climate condition; warm (not hot) days and cool evenings. Many of the mountain areas throughout the state experience a more traditional four-season year with snow lasting from November to April. However, because California is a coastal state, the climate is also dependent on the conditions of the Pacific Ocean. This means, there can be times of significant drought and also high amounts of rainfall during weather conditions such as El Nino.

Because of California's unique size and location, there are four (4) main climate regions; Central Coast, Mountain, Central Valley, and Imperial Valley. These four (4) regions have very diverse climate conditions. The Central Coast has more mild than hot summers and milder than cold winters. Think of San Francisco as an example. The summers in San Francisco are not typically too hot and the winters are not extremely cold. The mountainous regions of California also have typically mild summers. However, in contrast the winters can be very cold with high amounts of rain and snow. The Central Valleys usually experience very hot summers and cool winters. The San Joaquin Valley for example can have summer temperatures, which exceed 100F and also see some snow in the winter. The Imperial Valley (e.g. Palm Springs) is very hot and dry in the summer and the winters are typically very mild with little to no rainfall.

Most of the rain and snow occurs in the eastern and northern portions of California. While most of the people live along the coast and southern portions of the state. This presents a unique distribution challenge for water professionals. Bringing water from where it is to where most of the people are is something California does quite well. However, during years of drought the ability to distribute water throughout the state can be costly and difficult. Most of the time there are ample supplies of water in California for all of the various uses. During extremely wet years, there is sometimes too much water and not enough storage and a lot of the supply ends up in the Pacific Ocean.

INDOOR WATER USE

In this section we will analyze some potential indoor residential water use and compare it to the 200 gpcd we calculated in the previous section. If indoor and outdoor uses are not metered separately, certain assumptions will have to be made to distinguish between the two main areas of use. A lot of research and study has gone on and continues regarding water use. In January 2010, the California Homebuilding Foundation published a document titled *"Water Use in the California Residential Home".* Many of the estimates used in this section were collected from this document. However, it is important to note that this is a "fluid" topic (pun intended) and regulations and policies are constantly changing when it comes to water use and conservation.

Now that we have established a 200 gpcd for this example community, we know how much water each person uses on an average per day. There are a number of variables affecting the actual use per individual, but this is the actual average gpcd for this example. Once the average gpcd is calculated you can break down the usage. First, let's identify typical indoor uses. There are a number of different indoor water uses. For example, flushing toilets, brushing your teeth, bathing, washing your hands, cooking, cleaning dishes, and cleaning clothes. In addition to these common uses a certain amount of water can be lost through leaks in the plumbing system. There are obvious leaks such as a broken pipe or fixture. However, some leaks can go undetected for days or possibly longer. Toilets are probably some of the more common areas where leaks occur. The slightest little crease or crack in the rubber seal in the toilet tank can cause water to slowly drip into the bowl without being noticed. This is just one example of leaks which can account for a high percentage of water use both indoors and outdoors. The list of indoor water use can be larger, but this is a good start. Look at the table below for some estimated amounts and volumes of indoor water use.

Use	Amount (%)	Volume Per Use	Time/Quantity of Use	Total Based on 200 Gpcd
Bathing	8%	2.5 gpm	8 min	16 gal
Toilets	3%	1.6 gpf	4	6.4 gal
Faucets (cooking/washing)	6%	2.2 gpm	5.5 min	12.1 gal
Clothes Washer	2%	1 load per week	25.5 per load	3.6 gal
Other/Leaks	8%			16 gal

Total Gallons per Day: 54.1 gpd

Based on the information in the above table, the indoor usage would account for approximately 27% of a person's usage with a 200 gpcd. This is to say 54.1 gallons of indoor water use divided by a total water use of 200 gpcd equates to about 27%. If 27% is identified as indoor water use, then the outdoor (or irrigation) usage would account for approximately 73% or 145.9 gallons per day.

In the space below, make a list of your various indoor uses and estimate how much water you use per day in your home.

Use	Time or Frequency	Volume

OUTDOOR WATER USE

Sticking with the same 200 gpcd example, the average outdoor water use equates to approximately 73% or 146 gpcd. In California, the average outdoor residential water use ranges from approximately 60 - 75%. Most of this water is used to keep lawns green. Drive around any single-family residential community in California and you'll see acres and acres of turf. This green lush landscaping requires significant amounts of water to keep it green, especially in some of the dry semi-arid inland communities across the state. However, in 2015, the State Water Resources Control Board (SWRCB) adopted water conservation regulations mandating urban water suppliers to reduce water consumption on average of 25%. In addition, new home building standards are becoming stricter making it almost impossible to install grass as the normal focal point in front and backyards throughout California. As usage patterns change, there are still millions of homes with front and backyards covered in grass. So, how much water is used to irrigate a lawn. New efficient drip, micro-spray, and irrigation systems are coming out every day, but many outdoor irrigation systems use standard "sprinkler heads." The amount of water sprayed out of a sprinkler head varies, but the average nozzle produces approximately four (4) gallons of water per minute. Let's look at a hypothetical example.

Assumptions:

- 1 sprinkler head produces four (4) gallons per minute
- 7 sprinkler heads per irrigation station
- 5 irrigation stations
- Each station operates for 10 minutes per day

Based on the assumptions above, let's calculate how much water this irrigation system produces in one day.

7 sprinkler heads × 4 gallons per minute per head = 28 gallons per minute
28 gallons per minute × 10 minutes = 280 gallons per station
280 gallons per station × 5 stations = 1,400 gallons per day

You can see by this example, the amount of water used for outdoor irrigation can add up in a hurry. In fact, based on the 200 gpcd example we used in the above example this would equate to a much higher gpcd. One other thing needs to be mentioned regarding the 200 gpcd. Remember, this is for one person. Someone with the irrigation system used in the above example may be from a family's home. So, let's assume the irrigation system is from a family of four (4) and they are not watering daily. Let's assume they are watering three (3) days per week. How does this look in terms of a gpcd?

First, take the 200 gpcd and multiply it by a family of four (4).

200 gpcd × 4 = 800 gpcd for this home

Next, take the 1,400 gallons per day, multiply it by three (3) days a week and then divide it by seven (7) days a week to get the per day amount.

1,400 gpd × 3 days = 4,200 gallons per week
4,200 gpw ÷ 7 days in a week = 600 gallons per day

The 600 gallons of outdoor water use is for the entire family of four. As a percentage, this equates to approximately 75%, which is consistent to the example given above.

Now, divide this by four (4) for the family.

600 gallons per day ÷ 4 people = 150 gallons per person per day

Therefore, in this example, one (1) person uses 200 gallons per day with 150 coming from outdoor uses and 50 from indoor uses. If you remember the indoor usage calculated in the earlier example it was 54.1 gallons, similar to the results in this exercise. Please note that this is just one example in a very complex and diverse world, but it should illustrate the point of how indoor and outdoor uses can be estimated.

OTHER WATER USES

This section will focus on other uses in California. The California Department of Water Resources (DWR) breaks down California's total water use into three (3) main broad categories: Urban, Agricultural, and Environmental uses. Urban use includes domestic residential use as previously described. In addition, urban water use includes commercial, industrial, and institutional uses. These three (3) categories make up a component of water use in California and throughout the world. In California, these use categories are defined by the DWR.

- **Commercial:** Water users that provide or distribute a service.
- **Industrial:** Any water users that are primarily manufacturers or processors of materials as defined by the Standard Industrial Classifications (SIC) Code.
- **Institutional:** Any water using establishments dedicated to public service. This includes schools, courts, churches, hospitals, and government facilities.

As you can imagine, the use percent for these three (3) categories can vary widely based on the area. For example, the amount of commercial, industrial, and institutional water use in a small "bedroom" community would be quite low. However, in a city such as San Pedro, California, where there are a variety of industries this component of usage can be quite high. In California, these categories only account for a small percentage of all urban water use.

AGRICULTURAL AND ENVIRONMENTAL WATER USE

In California, it is estimated that the agriculture industry accounts for approximately four (4) times as much water use as all urban water uses. This is not surprising since California's unique geography and Mediterranean climate have allowed the State to become one of the most productive agricultural regions in the world. California produces over 250 different crops and leads the nation in production of 75 commodities. California agriculture irrigates approximately 9.6 million acres of land. Environmental uses are identified as coming from developed and undeveloped water supplies. A developed water supply is one controlled and operated by someone. For example, the State Water Project is a developed water supply controlled and operated by DWR. It comes from natural runoff from precipitation and snowmelt runoff, but it has been developed into a supply for specific uses. In contrast, an undeveloped supply would be a “free” flowing stream or river which is not used for specific uses. Both of these supplies are used for and by the environment. Among other things, developed flows are needed to keep salinity levels lower in the Sacramento Bay-Delta area and to help keep cold, clean water needed for salmon migration and spawning. According to DWR, roughly 52 percent is used for agriculture, 14 percent for urban, and 33 percent for environmental uses.

CHAPTER 10: RECYCLED WATER, REUSE, AND CONSERVATION

Water is one of our most precious and vital resources on earth. Without it, life would not exist. However, at times we all take water for granted. Every time we turn on the faucet at home water comes flowing out. We have learned throughout this text where water comes from, how it is treated, and how it is distributed. We also learned about the hydrologic cycle and how water is transformed from one phase to another. But, what if part of this hydrologic cycle is interrupted? What if it doesn't rain? What if there is no snow in the mountains? In 2011 – 2015, California was faced with one of the worst droughts in the state's history. California has seen record low snowpack in the Sierra Nevada Mountains and historically low rainfall throughout the state. In January 2015, San Francisco recorded no rain for the first time in the city's history. The Governor and the State Water Resources Control Board handed down mandatory conservation regulations in 2015. Some water suppliers were asked to conserve as much as 36%. What if droughts continue for long periods of time? Will conserving water be enough?

Conservation is always a prudent approach to saving water, but sometimes it will not be enough to offset the potential loss of water during times of serious drought. Reuse is a term used often in the water industry to identify reusable sources of supply. Recycled (reclaimed) water is one of the most common reuses of water, but there are other sources of alternative reused supply including gray water, stormwater and desalinated water.

RECYCLED WATER

"Recycled Water" can be classified as any water which is reused and has not been processed for drinking purposes. For example, if you have a rain barrel and you collect rainwater and use it to irrigate your yard; this can be thought of as a type of recycled water. Storm water runoff can also be looked at as a type of "recycled water." As it rains and storm water is captured and reintroduced into a groundwater basin to recharge, an aquifer can be considered a form of recycled water. Greywater systems are also a form of recycled water. Grey water is the water collected after uses such as dish and laundry washing machines and reused as irrigation water. Although these previous examples can be thought of as "recycled water", most people think of recycled water as treated wastewater. Wastewater is solid and liquid discharges from all sources dumping into a municipal sewer system. Sometimes, storm water can enter the sewer system through manholes in the street. However, most storm water makes its way through a storm drain system and eventually flows to the ocean. This water is typically untreated. In contrast, wastewater goes through a series of treatment processes to remove solids, harmful pathogens, and other things to make it acceptable to be discharged back into the environment. The various wastewater treatment stages are referred to as primary, secondary, tertiary, and advanced treatment. Most wastewater used for recycled water purposes goes through at least tertiary treatment. Below is a brief description of each wastewater treatment process. These processes are covered in more detail in the Water 160 and 161 courses.

- **Preliminary Wastewater Treatment** - The removal of large, entrained, suspended or floating objects. The treatment process usually consists of large screens and cutting devices.
- **Primary Wastewater Treatment** - The separation of solids and greases through settling tanks and clarifiers.
- **Secondary Wastewater Treatment** - This step involves the removal of organic matter primarily through biological treatment.
- **Tertiary Wastewater Treatment** - Disinfection chemicals such as chlorine and ultraviolet light are used to remove pathogens (disease causing organisms) from the wastewater.
- **Advanced Wastewater Treatment** - If additional contaminants need to be removed sometimes advanced treatment is employed with the use of membrane filtration and/or additional chemical treatment processes.

When discussing recycled water, the main purpose is to reduce the burden on fresh water supplies by reusing water such as treated wastewater. Recycled water is commonly discussed in unison with water conservation. The idea is to **R**educe the amount of water used, **R**euse water supplies for various purposes, and **R**ecycling treated wastewater. The remaining sections of this chapter will discuss these “conservation” related topics and how the three “R”s are incorporated.

GROUNDWATER RECHARGE

Groundwater recharge is the process of water from the surface re-entering the ground becoming groundwater. Typically, groundwater aquifers are recharged through precipitation. Rain and melted snow make its way to an aquifer recharge zone and percolates deep into the soil becoming groundwater. However, there are other sources of water which can makes its way to a recharge zone can become groundwater. For example, if a fire hydrant gets hit and water flows into a storm drain which discharges to a dry riverbed with an underlying aquifer can percolate into the soil becoming groundwater. Another example is the treated effluent from a wastewater treatment plant. These types of examples are referred to as “incidental” recharge.

DIRECT POTABLE REUSE

Direct potable reuse is using a source of recycled wastewater directly as potable water. At the time this text was written, this is not an approved source of potable water. There are too many health concerns and unknowns regarding the quality

INDIRECT POTABLE REUSE

Indirect potable reuse is the process of reusing treated wastewater to recharge groundwater basins and aquifers and to augment various surface water supplies. This type of reuse can be something which is termed “incidental” or it can be a planned and constructed use. Anywhere wastewater is treated and discharged back into the environment has the potential to recharge an aquifer. For example, if a wastewater treatment plant is discharged into a dry river bed and this dry river bed has an underlying groundwater aquifer, this would be considered incidental recharge. If there are groundwater wells downstream of this discharge location, this “incidental” recharge would be a potential supply for these wells. Conversely, in Orange County, CA there is the Groundwater Replenishment District which takes highly treated wastewater and pipes it back up into the groundwater basin for recharge. They process enough water to serve approximately 600,000 people.

There are however, several challenges when presenting these wastewater reuse strategies. Professionals within the water and wastewater industries have a good understanding of the various treatment and distribution processes of water making it safe and reliable for human use and for the environment. The general public typically has less of an understanding, especially when it comes to reusing wastewater. This lack of understanding usually results in a reluctance of the public. When terms such as “toilet to tap” are floated around the media, the public becomes skeptical. In addition to perception, there is a significant cost which goes along with all reuse options. A significant amount of infrastructure is needed to bring water from wastewater treatment plants to the various customers. Many times, miles of pipeline are needed as well as pumps and storage. The infrastructure costs can oftentimes be cost prohibitive. However, in new developing communities, the infrastructure costs can be greatly reduced by charging connection fees to developers and because it is much cheaper to install pipe lines in dirt than existing streets in asphalt.

There are multiple reasons why recycled water should be used. Since water can be a limited resource in many parts of the world, recycled water can be used for many different non-potable uses where potable drinking water is typically used. For example, an office building can be “dual-plumbed” so the restroom water for toilets is recycled water and the sink water is potable drinking water. By far, the most common use of recycled water is for irrigation. By using recycled water, we reduce the reliance of fresh water from sensitive ecosystems, reduce the dependence on importing water, and there is the potential for energy savings by reusing a local resource. These are just a few examples of recycled water uses and benefits from reusing treated wastewater. In addition to the public and costs issues with using recycled water, there are various permitting hurdles with Los Angeles Regional Water Quality Control Board (LARWQCB) and Division of Drinking Water (DDW). The LARWQCB is responsible for promulgating the federal Clean Water Act. As part of this act, it gives the authority of maintaining clean water in what is called "navigable waters of the U.S." Locally, a navigable water of the U.S. would mean the Los Angeles River and the Santa Clara River. All water discharged into these and other water bodies must meet certain water quality standards known as Basin Objectives. Each watershed can have different water quality objectives depending on the beneficial use of the water in the watershed. Since DDW is responsible for drinking water systems in California, they oversee recycled water use and water used for groundwater recharge. Their requirements involve the quality of the water and how long the water being discharged and subsequently pumped out through groundwater wells for domestic use. In addition, the agency responsible for treating wastewater may also have specific regulatory requirements. In Los Angeles, this would be the Los Angeles County Sanitation District. LA County Sanitation District has permits with the Regional Water Quality Control Boards for discharges and they have also set up specific requirements to use their treated wastewater as recycled water. These and other rules and regulations are not limited requirements, but they do require time for research, analysis, and permitting before recycled water can be used. Below is a list of some of the approved recycled water uses.

- **Groundwater Recharge** – certain LARWQCB and DDW rules and regulations apply. For example, the quality of the water used must meet certain LARWQCB Basin Water Quality Objectives and the quality and distance before the water is pumped out of the ground for domestic use must adhere to certain DDW regulations.
- **Lavatory Facilities** – if the plumbing system of a building is "dual-plumbed", meaning there are pipes specific for different uses, recycled water can be used for toilets, drainpipe priming, etc. There are specific DDW rules and regulations that apply. Currently (2015) dual-plumbed systems are not allowed in residential homes.
- **Industrial and Commercial** – certain business processes can use recycled water for non-potable purposes. Various regulations apply.

In addition to the regulatory requirements mentioned above, some of the specific requirements imposed on water suppliers before they can begin using recycled water are the following:

- Users must have a Site Supervisor. The water supplier is required to coordinate with the user training and assignment of an onsite supervisor.

- Annual visual inspections must be conducted. The Site Supervisor and the water supplier must coordinate these inspections.
- Pressure test inspections are also required every four (4) years. In addition to the Site Supervisor and water supplier, a State or County Health Department usually provides an inspector.

Locally in the greater Los Angeles area Valencia Water Company, Burbank Water and Power, and Los Angeles Water and Power serve recycled water.

CONSERVATION

Why should we conserve water? There are a number of reasons why someone would conserve water. During times of drought there may be regulatory requirements for water conservation. Some people may think it is just the right thing to do, since water can be a limited resource in certain parts of the world. Or, maybe you just want to try and save a little money. Water rates are always getting higher and higher and the less you use, means the less you will pay. Reusing water, whether it is recycled water for irrigation or recycled water used to recharge groundwater aquifers, is a prudent approach when it comes to water resources. However, water conservation or reducing the amount of water used is also an important tool when it comes to water supply resources. Reducing the amount of water we use will help ensure the availability of water in the future. As the cost of water continues to rise, it is also economically prudent to reduce the amount of water used.

In 2009, the governor of California signed into law Senate Bill x7-7. This bill is also known as 20x2020 and requires all water suppliers to reduce their water demand by 20% by the year 2020. The 20% reduction is calculated using the water suppliers' average customers daily use or gallons per capita per day (gpcd). Gpcd is calculated by taking the total water production and dividing it by the total population.

Daily Production = 9,600,000 gallons
Total Population = 40,000
9,600,000 gallons ÷ 40,000 people = 240 gpcd

A 20% reduction for this example would equate to a 192 gpcd. In this example, you might be thinking that this is a lot of water for one person to use in one day. However, if you recall from the Water Use chapter, the amount of water used can add up quickly. Regardless of the reasons you decide to conserve water, the bottom line is you will save money.

Let's go back to the 20% savings example above. A 20% daily savings of 48 gpcd for a family of four (4) will equate to over 70,000 gallons a year. Let's take a look.

48 gpcd × 4 people = 192 gallons per day.
192 gallons per day × 365 days = 70,080 gallons per year
Most utilities bill in hundred cubic feet (HCF or CCF) billing units
1 CCF = 748 gallons 70,080 gallons ÷ 748 = 94 CCF

Now, we need to make an assumption about how much a water supplier would charge for a CCF. Water rates vary, but averages in the southern California area range between $1.60 - $3.50 per CCF. Therefore, using the low and high of this range, this family of four (4) would save

94 CCF × $1.60 = $150.40 per year 94 CCF × $3.50 = $329 per year

I don't think anyone would turn down $150 a year let alone $329! So, regardless of the reason you might decide to conserve, there is the potential to save a lot of money.

How Do Water Suppliers Get Customers To Conserve?

Sometimes people are not aware of how much water they use. They might look at their monthly water and if it looks similar to the month before they do not think twice before paying their bill. Communication is the number one tool water suppliers have at their disposal to promote water conservation. Bill inserts, flyers, social media, and all good ways to communicate to the public about conservation. Some water suppliers may also use billboards and radio and television advertisements. Getting the word out is the first step. Many water suppliers offer a variety of incentive rebates to help people conserve water. Low flow toilets, efficient appliances, drip irrigation nozzles, and "turf" buyback programs are just a few rebate programs water suppliers use.

Sometimes water suppliers need to take a more aggressive approach, especially if there is a drought and regulations require conservation. If the public does not respond to outreach programs or rebates, utilities will often resort to increasing water rates and/or issue fines. This is not the most popular approach among customers, but sometimes it is a necessary tool to force customers to conserve water. It is also important to note that sometimes water suppliers will have to increase water rates because of conservation. The less water used means the amount of revenue a utility collects will decline. This is probably one of the most difficult things to communicate to customers. Water suppliers tell customers to use less water and then the water rates are increased anyway.

One of the last things a water supplier will use to get customers to use less water is to shut off their water service. This is not usually advisable, because a minimal amount of water is needed to maintain health and safety, but at times, people might have their water service discontinued for a certain period of time until they decide to use less water.

WATER RATES

There are various different rates structures water suppliers use. They include; flat rates, uniform single quantity rates, tiered rates, and water budgets. The type of water rate a utility will use is dependent on a number of factors and vary from area to area.

Flat Rate

Flat rates are the simplest rate design. The rate is the same or flat for every customer regardless of water use. This type of water rate is common in areas where use is relatively the same for everyone. For example, an area where outdoor irrigation is not needed because of ample amounts of precipitation and indoor use is the predominant use a flat rate might be used. However, some people might deem this type of rate unfair because a large family would essentially pay the same amount as a single person living in a home. This is a very easy rate structure for utilities. No meters are needed and the revenue amount every year is relatively constant.

Uniform Single Quality Rate

This type of rate structure is considered a more fair way to charge for water and the services associated with treatment and delivery. There is a single rate price for one unit of water. Therefore, if you use one unit (CCF) you only pay for one unit of water. Whereas if you use 100 CCF of water you pay for the 100 CCF you used. It is probably the most common rate structure. Each utility with this rate structure must make sure they review the income revenue often since a large reduction in use will translate to a large reduction in revenue. The amount of money a utility needs to operate is referred to as revenue requirements. This will be reviewed later in this chapter.

Tiered Rates

Tiered rates are becoming more common, especially in areas where use of hydrologic patterns can fluctuate, such as areas affected by drought. This type of rate structure can be used to encourage conservation. The cost of a unit of water increases the more you use. There can be as few as two tiers and some agencies have up to five tiers. A tier rate structure might look something like this:

Tier 1 = \$1.50 per CCF up to 10 CCF (1 – 10 CCF)
Tier 2 = \$2.00 per CCF for each unit over 10 CCF up to a certain amount (11 – 20 CCF)
Tier 3 = \$3.00 per CCF for anything used over 20 CCF (21 and up)

Let's see how this type of rate structure works. The following example is based on a monthly water usage of 30 CCF. The first 10 CCF of the monthly 30 CCF usage would be billed at the \$1.50 per CCF rate. Therefore, you would multiply 10 CCF by \$1.50.

10 CCF × \$1.50/CCF = \$15

The remaining CCF would be 20 (30 CCF - 10 CCF). The next 10 CCF of water used (11, 12, 13…20 CCF) would be billed at the second-tier rate of \$2.00 per CCF.

10 CCF (11 - 20 CCF) × \$2.00/CCF = \$20

The remaining usage up to 30 CCF is another 10 CCF. These remaining 10 CCF (21, 22, 23…30 CCF) would be billed at the third-tier rate of \$3.00 per CCF.

10 CCF (21 - 30 CCF) × \$3.00/CCF = \$30

All three total charges would be added together for a total monthly bill amount of \$65.

\$15 + \$20 + \$30 = \$65

This is a very simplistic look at a tiered rate structure, but it should illustrate how the cost of water increases based on the amount used. You can see how this type of rate structure might encourage conservation.

WATER BUDGETS

The last rate structure we will look at in this text is called water budgets. It is a similar structure to tiered rates. However, unlike tiered rates, water budgets provide a more fair and equitable way of charging for water use. In a straight tiered rate structure many people complain because of the subsidization issue. Large use customers pay much more and, in some instances, subsidize smaller users. This is because a traditional tiered rate structure is blind to parcel size. Water budgets are different. A water budget is an individualized rate structure based on each customer's specific parcel. For example, a customer with a large yard and multiple people living in their home will have a larger budget than a single person living in an apartment with no outdoor landscaping. Both customers would have a monthly allocation specific to their needs. Water budgets usually classify an indoor allocation of 50 - 60 gpcd and then specify an outdoor allocation based on actual landscape measurements or perhaps a percentage of the parcel size. All this information gets input into a formula to calculate the monthly budget. The formula typically includes a monthly evapotranspiration rate (ETo) and a coefficient for the specific type of landscape material. The evapotranspiration rate is the amount of water needed to sustain plants based on the current weather. For example, the ETo rate is higher in summer months than during the winter. Although this is a more equitable rate structure, it does require additional work by the water supplier and can sometimes be confusing for customers to understand.

Regardless of the rate structure, the utility must demonstrate that their rates are truly the cost of providing service. There have been lawsuits in the past and will continue in the future, challenging various rates structures and the amount being charged. Utilities must adequately identify why their rate structure is the needed amount for their specific revenue requirements.

SERVICE CHARGE

One last rate component should also be discussed. A service charge is a monthly (or bi-monthly) charge placed on each customer regardless of the amount of water used. This charge is a flat rate and covers some specified percentage of the water supplier's revenue requirement. It is sometimes referred to as a "readiness to serve" charge. It guarantees a certain amount of revenue every billing period allowing the utility to continue basic business functions without worrying about usage fluctuations.

REVENUE REQUIREMENTS

This term has been mentioned several times in the preceding sections. A revenue requirement is nothing more than the amount of money (revenue) a utility must collect to maintain their basic day-to-day service. Water rates and service charges are the primary source of revenue water suppliers receive. Well, what is a “revenue requirement”? A water supplier has certain expenses, which cannot be avoided. For example, water treatment is required in order to provide a safe drinking water supply to customers. For each gallon of water served it requires a certain cost for treatment. Likewise, there are electrical costs for pumping water, maintenance costs, salaries and benefits for employees, and costs for replacements and improvements to infrastructure. There are many expenses to operate a water utility, but this doesn’t mean there is no room to reduce costs to keep rates low. Each water supplier must determine what is necessary and what can be reduced or cut in order to maintain an efficient operation.

Water is a vital resource and the availability of fresh water varies throughout the world and is dependent on weather patterns. An El Niño weather pattern can bring much needed rain to parts of the world while creating devastating droughts in other parts. Understanding the use and need of water will help us all use it a little more wisely and will help professionals manage this important resource. There will always be a need for water professionals as long as clean, safe, and reliable drinking water is needed.