1.6: 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 032 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.

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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.

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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.

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 040 and 041.

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.
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.

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 \(\PageIndex{3}\): – Pump Station.

**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 “joins” 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.
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.

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.

**Fire Hydrants**

![Figure 6.9 – Fire hydrant.](image1)

![Figure 6.10 – Flushing a fire hydrant.](image2)

**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.

**Water Meters**
The information provided in this chapter (as with all chapters in this text) is a snapshot look into distribution systems. In Water 040 and 041 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 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 note of the meter read.

**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.