# Lake County West Distribution System

**SYSTEM THEORY AND DESIGN**
**AND**
**EXAMPLES OF LAKE COUNTY O&M**
**OTCO-D13350-OM**
**1 CONTACT HOUR**
**11/5/2019**

1840 Lake

Lake County, Ohio

LAKE COUNTY STATE OF OHIO

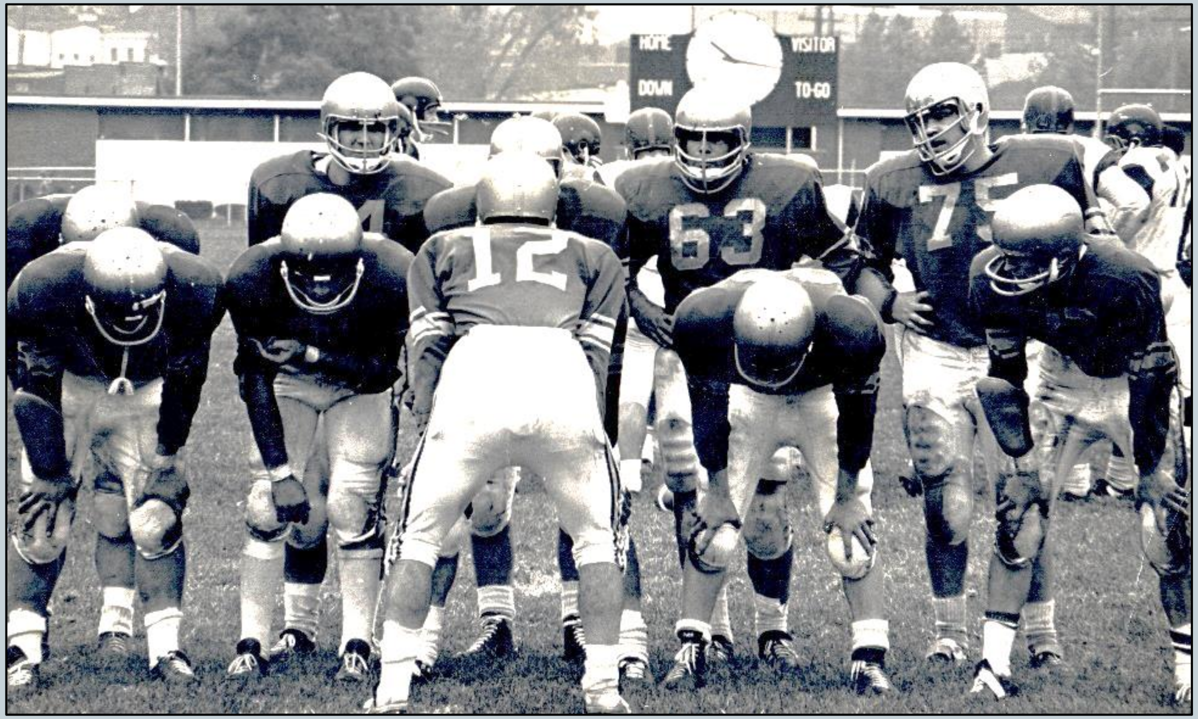
# The Distribution Operator

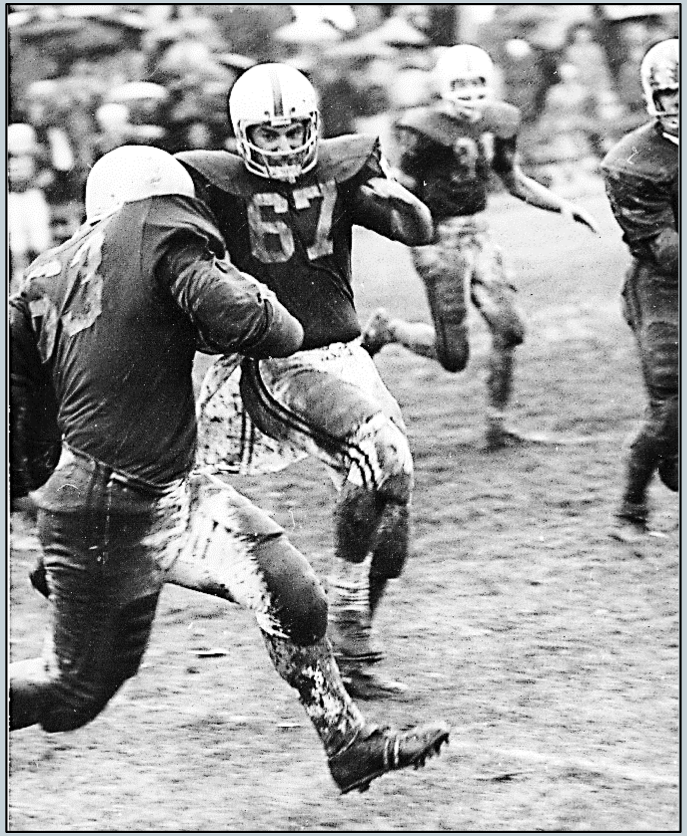
A DISCUSSION OF WHAT THE CULTURE IS, AND HOW IT DIFFERS FROM PLANT OPERATOR CULTURE

# Cultural Analogy - Operators vs. Football Players

**WTP OPS/Off Line – clean, neat, orderly – takes orders, follows rules, part of group**

**DIST OPS/Linebacker– loves the mud, disruptive – works alone, makes his own rules**





# Distribution System Operator Optics

- In most public water systems, the distribution operator is the face of the utility
  - They tend to come into contact with the public more than any other employee
  - The public is judgmental – like it or not, they will form opinions of the utility based on the appearance and work habits of the distribution crews
  - Should be trained to know what to say and what not to say to the public – the public will take what you say and run with it
- What the distribution operator does or doesn’t do always affects other jobs at the utility

# PR Role of the Distribution Operator

- Distribution personnel are key to how the public perceives the utility
- Operators are highly visible when they are discussing water matters with the public
- To be effective, the operator must:
  - Be able to communicate effectively
  - Show that he or she cares about the customer's plight
  - Be polite and courteous
- This is not easy when you are working under pressure
  - You may have only one chance to get the needed information about a serious problem from the customer

# Distribution operator culture

- Traditionally, Distribution OPS are more oriented to "react" to problems rather than to "prevent" problems (can be a good thing)
  - But sometimes they feel that preventive measures often cause more work e.g. – don't want to exercise valves because they might break
- They work day shift – so to them, overtime usually means there is an emergency (as opposed to plant OPS who expect overtime)
- With aging infrastructures, its likely that staff will be busy reacting
  - Preventative tasks typically get put on the back burner

# Distribution System Theory

HOW SYSTEMS ARE DESIGNED

HOW THEY ARE OPERATED

HOW THEY ARE MAINTAINED

HOW THE MANUALS SAY IT OUGHT TO BE DONE

# Approach

**Theory**

- Distributions systems are complex and dynamic parts of the over all drinking water industry
- We can look at the theoretical design of them, and examine the best practices that are used as a whole

**Reality**

- We can then spend some time exploring in detail how a few of those theoretical approaches are put to use
- We'll use the Lake County, OH West Distribution System and staff as one example of those practices

# Distribution Systems

- A modern water distribution system provides a means of conveyance of safe, reliable drinking water to all of the Utility customers
  - It provides adequate volume and pressure for any of the system needs
    - Needs are determined by types of customers
- The State of Ohio provides regulations for the design and operation of distribution systems
  - There are requirements for the size of system components, the minimum pressure allowed, and the volume of water that must be provided for fire-fighting
  - There are requirements for the quality of that water, and the quality of the people who distribute it, and for the maintenance of that quality

# Origin of Supply Can Dictate System Layout

## Surface Water

- Medium and large sized systems usually employ surface supplies
  - Groundwaters are typically too small in quantity
  - A prime feature of surface supplies is that the water enters the distribution system on one side – think Lake Erie
    - Large diameter transmission mains are needed to carry water to the far sides of the system
    - Water quality is good, and that attracts industry that needs process water for cooling and incorporation into a product
    - The availability of good quality water promotes rapid growth spurts of the community, which in turn requires frequent additions to the DS

## Ground Water

- Available almost everywhere, but the amount is usually small
  - Rate of withdrawal can be limited by several factors
  - If the groundwater needs no special treatment, the system can be supplied by several wells on either side
    - There may not be a need for transmission mains because water flows into DS from many locations
  - If there is only one well,  if that well needs to be treated, then the system may be laid out like a surface system
  - Same applies to many wells being sent to one treatment facility to be polished then sent out

# Origin of Supply Can Dictate System Layout

## Purchased Supply – satellite system

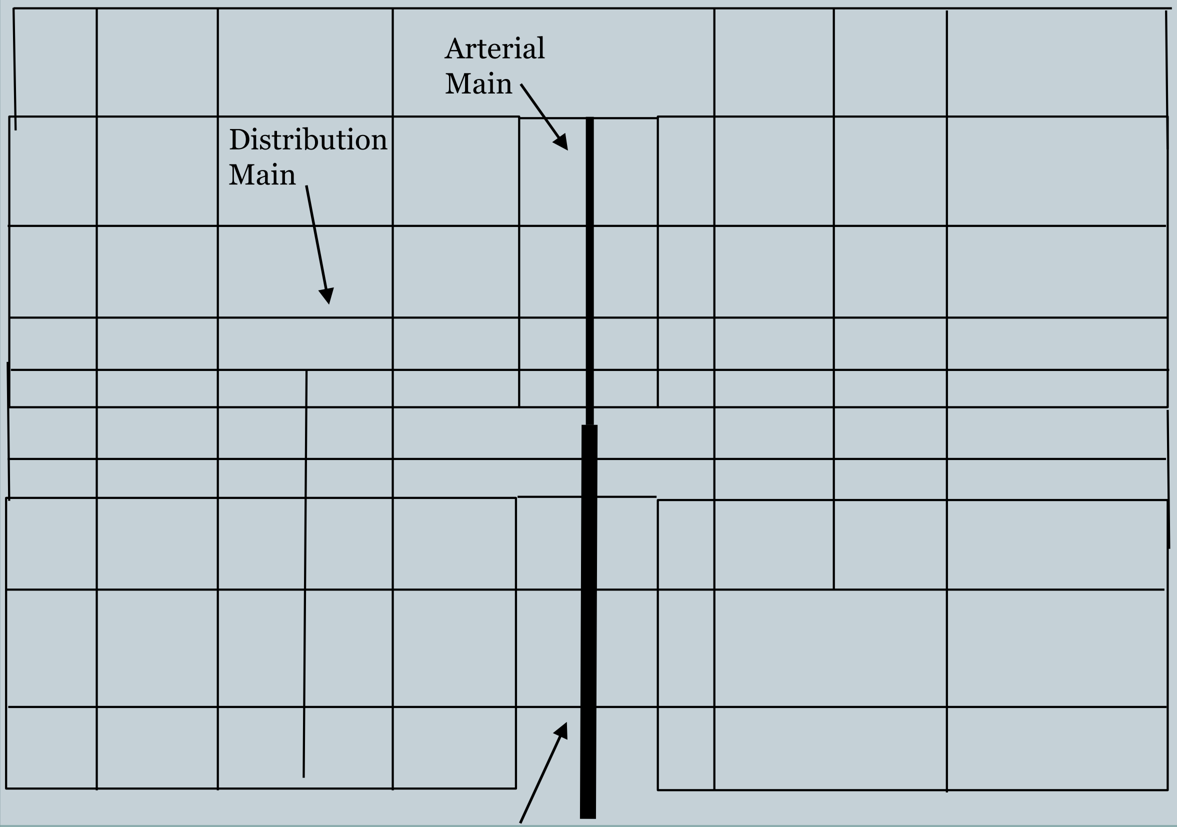
- Many small systems that started out with their own well had to eventually tie into a larger system due to the need of higher capacity, better quality, or because of regulatory pressure
  - These systems usually rely on large storage tanks which are a hedge against a broken supply line from the larger system
  - They will need to have good metering and accountability because all of the water use must be purchased, while much of it does not get bought by its customers – (unaccounted for water)

## Rural Water System

- These systems have developed in areas where surface and ground water is non-existent or quality is poor
- These systems have to run long mains across the country side to provide water to scattered homes and farms
- Will usually depend on plastic pipe, and have no hydrants
  - Water is supplied in limited amounts for domestic use
  - No design considerations for fire protection
  - Many don’t have storage tanks

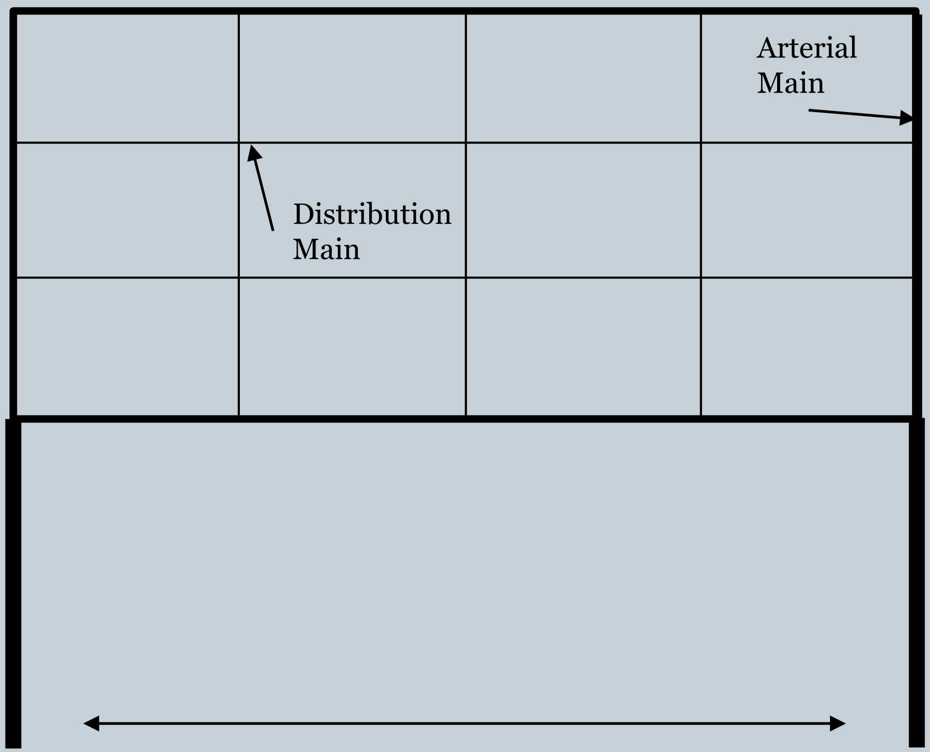
# Types of System Layout

## Grid System




Transmission Line

## Arterial Loop System



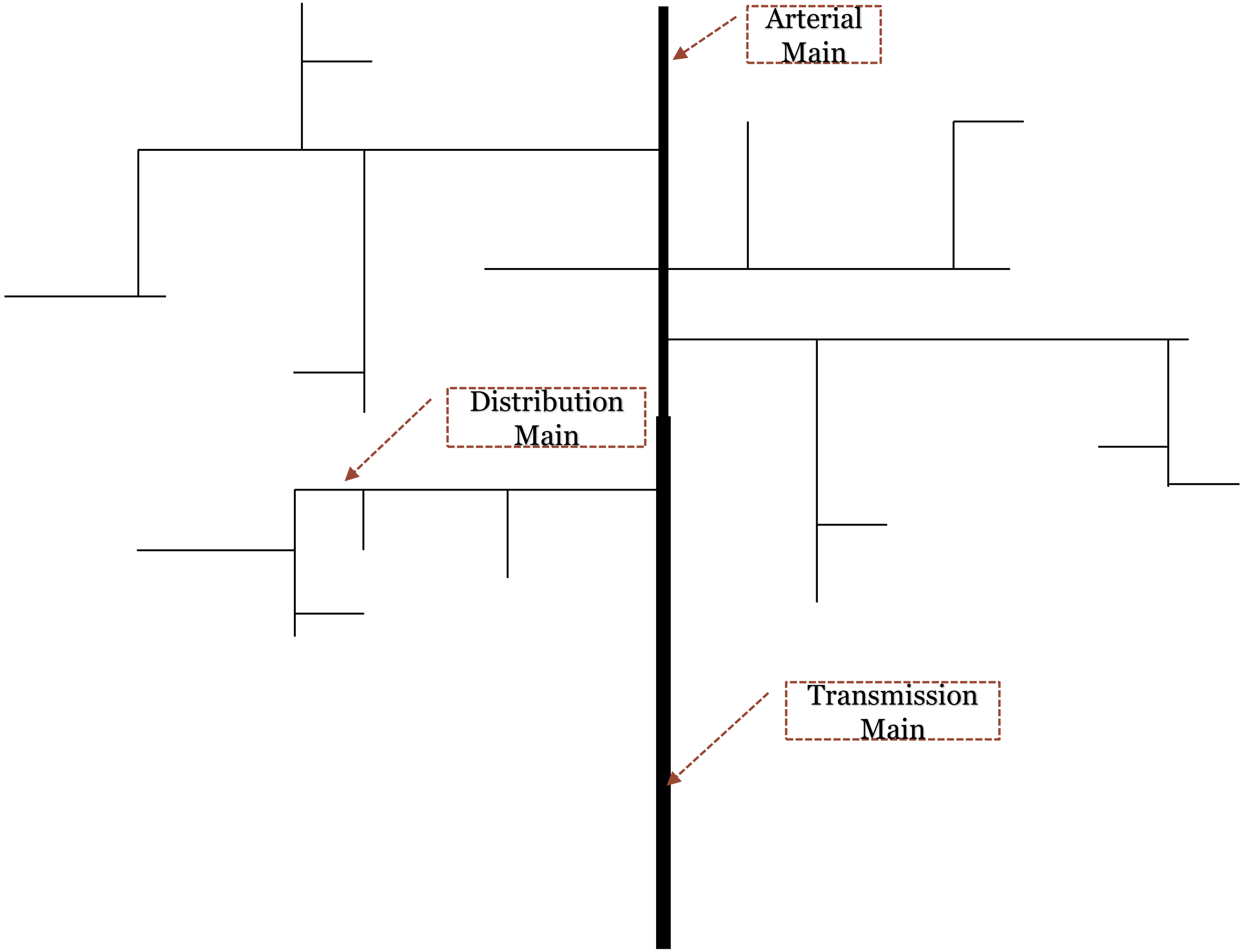

Transmission Lines

**Types of system layout**

Tree system

Thought to be the least advantageous system layout

Creates many dead end lines



# Pressure Districts or Zones

- Most systems with wide variation in elevations typically create pressure districts or zones – larger zones will often require an elevated storage tank
  - This allows for better choices in pump selection
    - Smaller pumps, back-up systems, redundancy, storage
    - More stabilized pressure within a relatively narrow range – important for customers
  - Also allows for easier management of infrastructure because components are generally smaller in size
  - Will require more storage and pumping facilities, therefore more maintenance efforts
  - Will create dead ends at the delineation of one district to the next

# Theory of Pressure Districts

## Pressure districts with tanks

- Pump size chosen based in part on tank elevation and size
- Pumps send water into system
- Tank takes in water not used by customers
  - Altitude valve may be needed
- Tank handles demand periods
  - Reduces strain on pumps

## Pressure districts without tanks

- Pumps send water into "closed" system
- District is typically kept to small area
- May require pressure regulator
- May have stand-by source
  - Water supply, power

# Storage Tanks

- Storage tanks and reservoirs in the Distribution Systems serve to supply large volumes of water
  - for fire-fighting
  - for helping to equalize supply and demand
- Their ability to "fill and draw" as demand fluctuates helps to diminish the strain on high service pumping from the WTP and from Booster Stations, allowing the use of smaller pumps
- Unfortunately, tanks also provide greater opportunity and time for chlorine to come into contact with organic carbon in the water
  - Design engineers are tempted to over-emphasize the amount of water needed in storage
  - We refer to this increasing amount of residence time as "water age"

# Domestic Water Use Graphic – meeting peak demand

There is relatively heavy use in the morning as people get up and prepare for the day

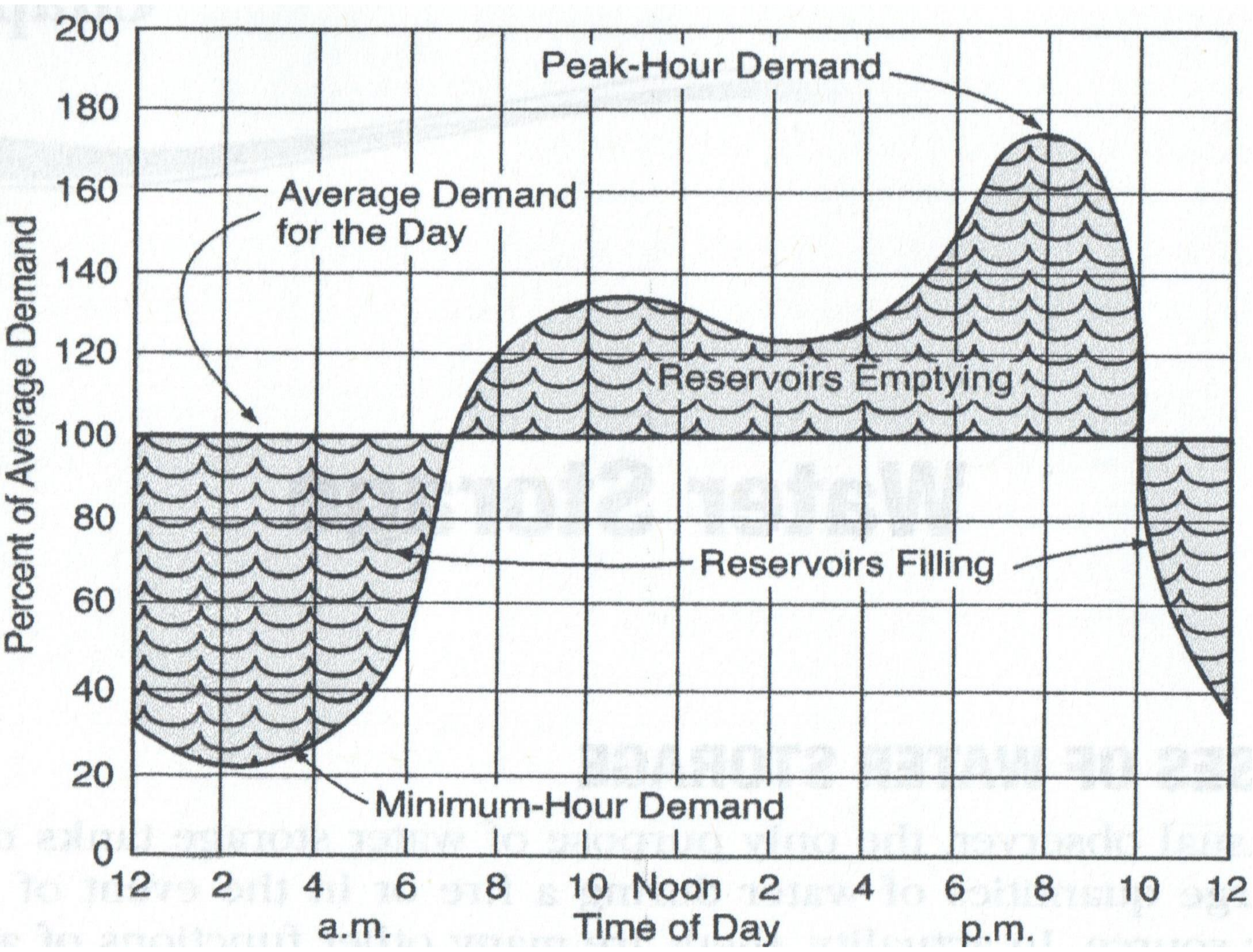
Use slacks off at mid-day

Increased use as supper time approaches

At about 10 pm, as people go to bed, the water demand slows down again

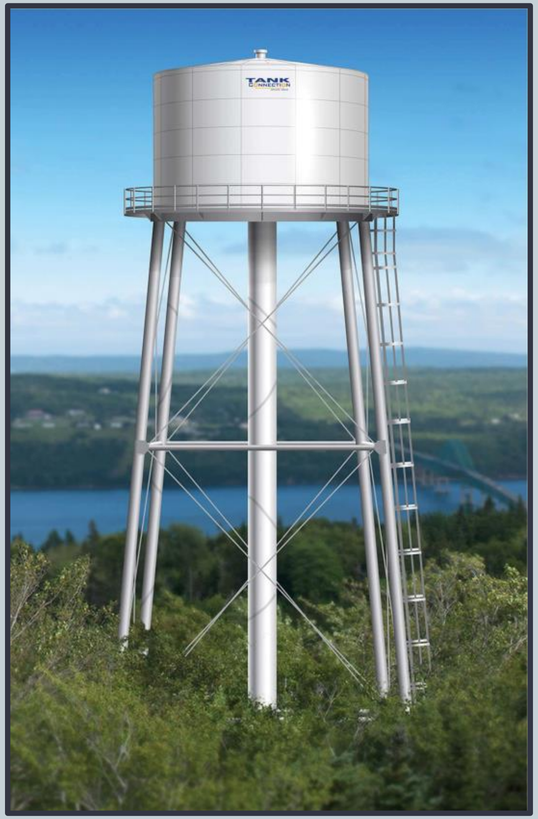
Note that peak hour demand is about 175% of average demand for the day.  If there was no storage tank, the plant capacity and pumps would need to nearly double

With tank, treatment becomes more uniform throughout the day



# Elevated Storage of Equal Volume

## Elevated tank – wider than it is tall



Has the advantage of holding a large amount of water and providing a narrow range of pressure variation

Can promote DBP formation if level not fluctuated properly

Can create a sudden loss of pressure if allowed to drain below the bottom of tank

## Standpipe – taller than it is wide

Lengthy storage provides the advantage of maintaining pressure during a power outage

Harder to “turnover” so can promote DBP formation if/when continually topped off

Considered to be ground-level storage by engineers

# Storage Tank Maintenance

- Storage tanks and reservoirs in the Distribution System must be maintained on a periodic basis
  - Sometimes will require emergency maintenance in spite of your best efforts
- Internal corrosion is minimized through cathodic protection program, but these in themselves require maintenance
- Some tanks will accumulate sand or grit and need to be cleaned frequently

# Boosters

- Booster Stations provide a means to:
  - fill elevated storage tanks
  - help fluctuate the water levels in the tanks to keep water as fresh as possible
- This is accomplished by dialing in the set-points at the pumps
  - These set-points specify a maximum and minimum level of water elevation that is to be maintained in the tanks, and therefore control the on-off events of the pumps
    - Systems utilize winter/summer set-points to minimize depletion of $Cl_2$
  - The set-points are also used to determine which pumps will activate, or whether multiple pumps will activate in any given scenario

# Valves and Hydrants - Recommendations

## Valves

- Valves should be spaced at frequent intervals so that areas may be isolated for repairs without putting too many people out of water
  - Ten States Standards calls for spacing of 500’ in business districts and 800’ in residential areas
  - Except for special circumstances, valves should be located at intersections opposite the right-of-way for the intersecting street (avoids most paving)
  - Mid-block valves should be located opposite an extended lot line (avoids most driveways)

## Hydrants

- Hydrants should be spaced at intervals of 350’ to 650’ based on density, and valuation of the area being served
  - They are best located at street intersections
  - Where blocks are long, additional hydrants should be located at mid-block
  - Should be painted for easy identification, and by class to signify the available flow amounts

**Approximate number of turns to operate <u>double-disk valves</u> in system**

Large gate valves are equipped with geared operators so the number or turns is greater than shown here.  Also, butterfly valves are different, so you must rely on the tables that manufacturers supply to you

| Valve size, inches | # of turns | Valve size, inches | # of turns |
|---|---|---|---|
| 2 | 7 ½ | 12 | 38 ½ |
| 4 | 14 ½ | 14 | 46 |
| 6 | 20 ½ | 16 | 53 |
| 8 | 27 | 18 | 59 |
| 10 | 33 1/2 | 20 | 65 |

## AWWA Standard Color Classifications

Standard color classifications recommended for hydrant tops based on flow capacity

Hydrants assumed to have >40 psi under normal conditions and 20 psi residual pressure

| Class | Color | Flow Capacity, gpm |
|---|---|---|
| AA | Blue | 1,500 or greater |
| A | Green | 1,000 – 1,500 |
| B | Orange | 500 – 1,000 |
| C | Red | Less than 500 |

# Theoretical Operational Practices

**WHAT ARE THE MAJOR PERFORMANCE CATEGORIES FOR WATER DISTRIBUTION SYSTEMS?***

*Water Distribution Operator Training Handbook, AWWA Fourth Edition, 2013

# Performance Categories (PC)

1. Maintain water quality from the point of entry into the distribution system to the point of use
2. Deliver sufficient water quantity and pressure to reliably satisfy customer demands and meet fire-fighting requirements
3. Control water losses and reduce energy use

# PC - Maintaining Water Quality

- **Water has to meet the requirements of the Safe Drinking Water Act and Ohio EPA**
  - Your ability to maintain that water quality throughout the system will dictate how you are judged by the regulators, the public, and your administrators
  - To do this, you must monitor the water each day to determine if it is compromised, and if your efforts are sufficient or lacking
    - Changes in water quality either through your own neglect or from outside contamination must be eliminated or reduced
    - Practices include: corrosion control, main flushing, cross-connection control, customer complaint response, maintaining disinfectant residual, DBP control, sediment control, water age control, storage control, and water sampling

# PC - Managing System Reliability

- The most reliable systems tend to:
  - Integrate their system components
    - Adequate storage for evening-out demand fluctuations without water quality deterioration, integration of water-main network, use of construction standards, have looped water mains, and right-size the mains
  - Make use of alternate power sources
    - Ability to go “off the grid” to run pump, disinfection facilities, and telemetry as well as the use of interconnects with other systems, all backed-up by a contingency plan
  - Possess redundant equipment
    - Spare parts and components, and cross-trained staff

# PC – 7 Operations and Maintenance Practices

1. Main breaks management
    1. Frequency must be addressed, water loss must be controlled, and PR needs to be present
    2. Performance indicators: main breaks per mile of pipe, number of breaks per month, etc.
2. Emergency repairs
    1. A system must be in place that ensures experienced staff are available, SOPs are followed, valve exercise programs can help make certain that there is little confusion when trying to shut the break down
3. Hydrant and Valve Maintenance
    1. See above - a main break is NOT the time to find that a valve won't work – record keeping is vital
4. Pipeline rehab and replacement
    1. Newer and rehabbed mains are less problematic than older mains

# PC – 7 Operation and Maintenance Practices cont…

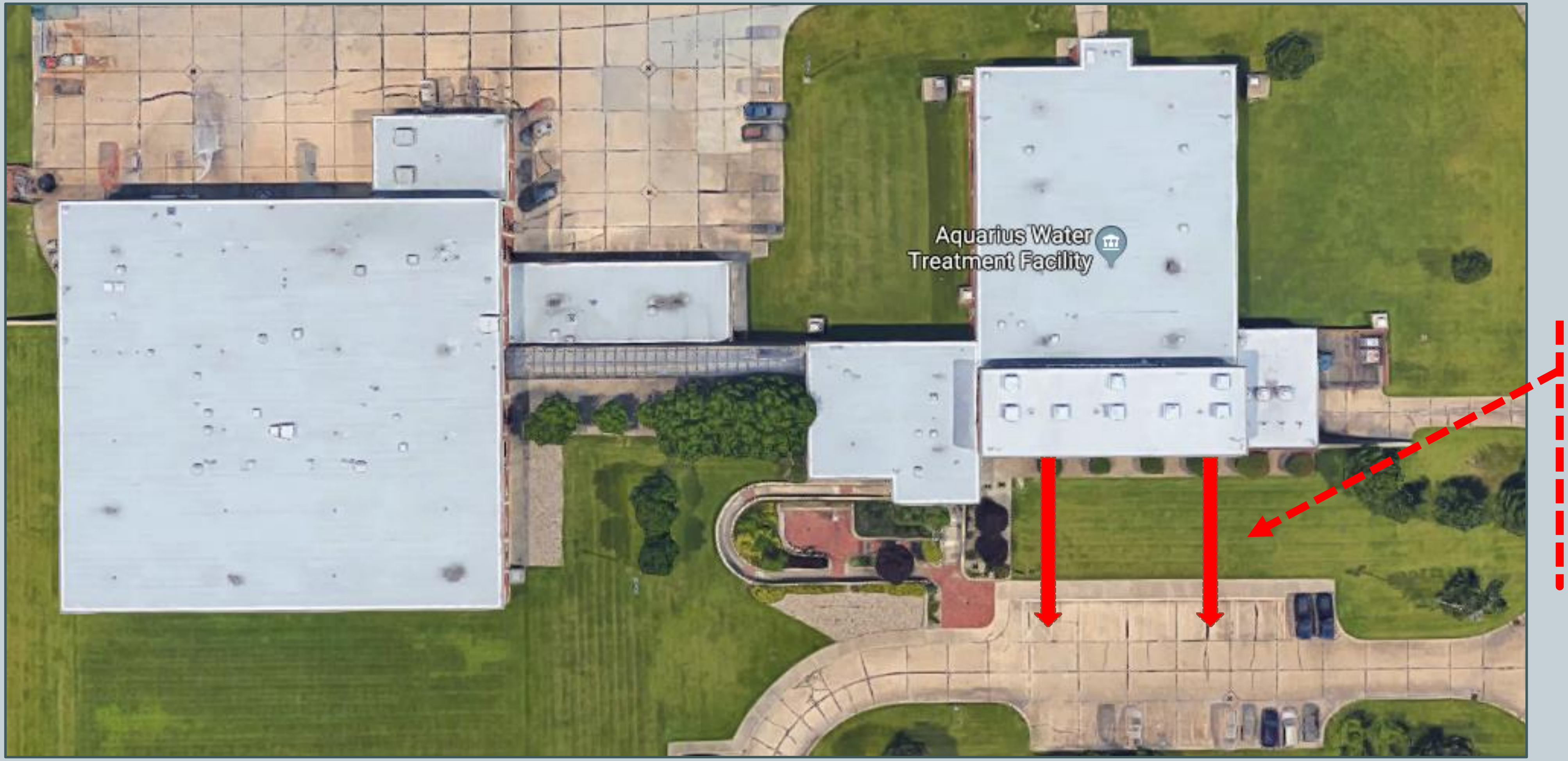
5. Pressure management
   1. Considered to be the most fundamental activity of a distribution operator. Pressure variation is typically a good sign of pending or existing disaster
6. External corrosion control
   1. Pipe walls weaken over time – external corrosion control makes them last longer
7. Security and surveillance practices
   1. Field observation by humans coupled with online sensors help determine system contamination

# Example System: the Lake County, OH West Distribution System

**AN ARTERIAL SYSTEM FOR THE MOST PART, WITH GRID SECTIONS SCATTERED THROUGHOUT**

**HOW ITS DESIGN AND QA/QC PROGRAM FOLLOW THE THEORETICAL PATTERNS WE JUST DISCUSSED**

# Lake County West WTP and beginning of distribution system




Two transmission mains

# West Service Area Description

**The West WTP and System serves the Western portions of Lake County**

**Areas served are:**

- Eastlake
- Willoughby
- Willowick
- Wickliffe
- Willoughby Hills
- Timberlake
- Lakeline

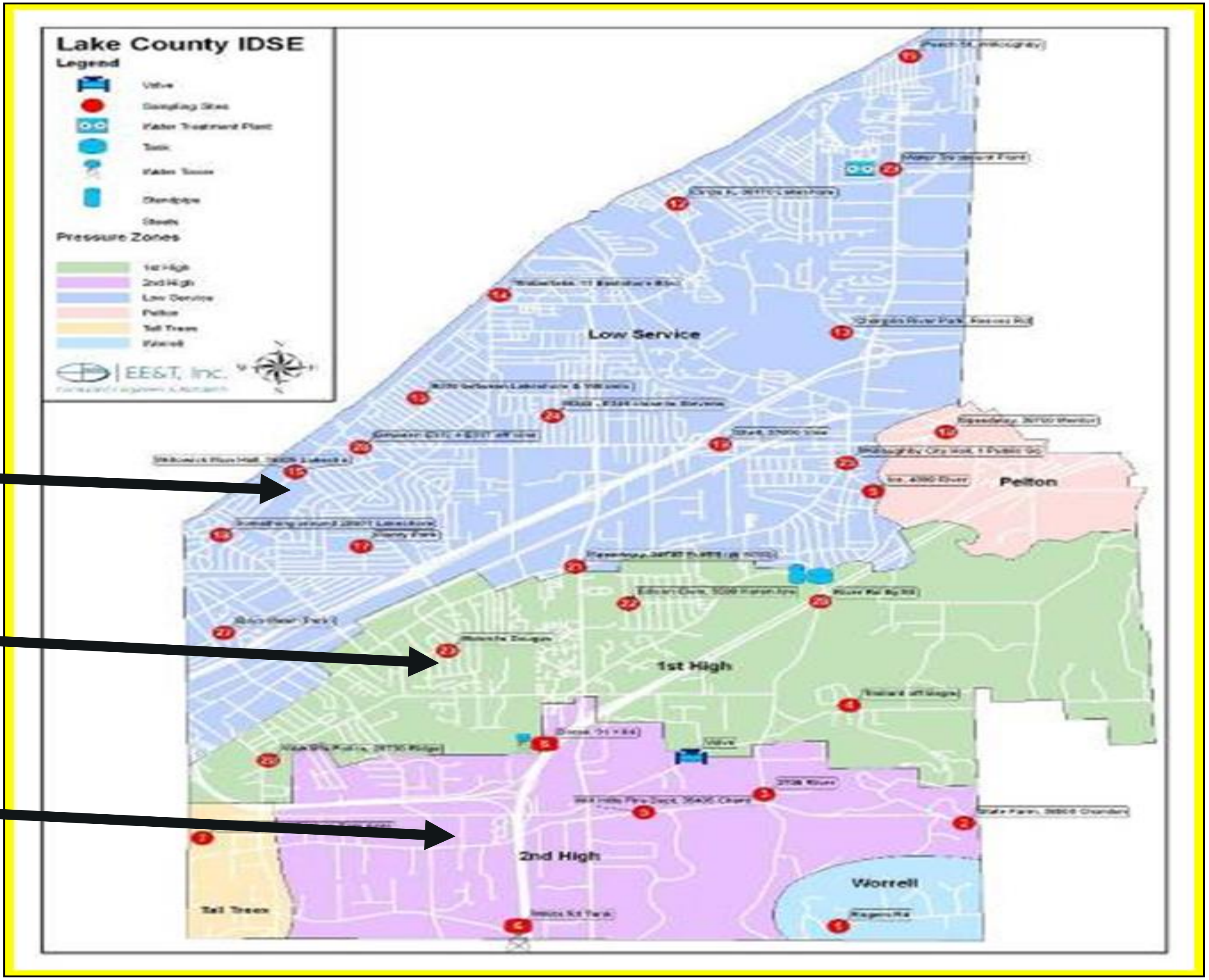
## There are three main pressure districts:

- **Low Service**
  - Pressurized by pumps at WTP
  - They send water out through two 30 inch transmission mains and to the below and above ground reservoirs in Low Service
- **First High Service**
  - Supplies water to system and an elevated tank
  - A booster district within
- **Second High Service**
  - Supplies water to system and elevated tank
  - Several booster districts within

# The Service Districts in West End of Lake County

Three main pressure districts:

- Low service
- First High
- Second High



# Topographic Map of portion of West System

Key feature - General area around the Dome and the ET is highest point in LS

These contours range from a low of about 700' to the high point of 800'

Lake County utilized the highest point available on which they built the Dome and ET

# Low Service

- Low service is fed directly from the plant pumps through two 30 inch transmission mains
  - Water going through the Eastern 30 inch main heads into Willoughby
    - It ends up in the BGR and the Route 174 & 84 standpipe
  - Water going through the Western 30 inch main covers low service areas
    - It ends up in the 5 MG reservoir known as “the Dome” located at Route 91 & 84

# Low Service Elevations Explain the Choice of HS Pump HP Sizes

1st and 2nd high service booster pumps at the Dome are housed in this building

They move water into the ET and White Rd Tank

Elevation of Lake Level – 570’
Elevation at AQ WTP full clear well – approx. - 615’
Elevation at Dome low level – 784’
Elevation at Dome high level – 816’
Elevation at ET overflow – 915’

AQ HS Pumps were designed at 260’ TDH

# West End Storage and Boosters

## MOVING WATER THROUGH THE SYSTEM

# The Dome Storage Tank

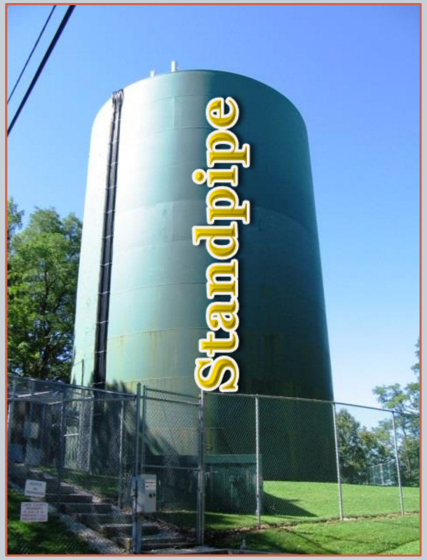
- As mentioned, the Dome is a 5 MG reservoir that takes in water from low service
  - Therefore, its level is controlled by the action of the High Service Pumps at the Plant – (can be confusing – HS Pumps feed into Low Service)
- The Dome works in tandem with the Below Ground Reservoir (BGR) and the Standpipe located at Route 174 and 84
- Together, these storage units help to maintain pressure and volume for the low service district
  - Average day for system is around 9MG, but peak hour is 14MG.  Dome alleviates the need for bigger pumps.

# Storage of the Low Service System

## The Dome


Approximately 8 MG can be stored in these tanks

## BGR and standpipe




BGR

# BGR and Standpipe

- The BGR and Standpipe at Routes 174 & 84 are an older part of the system which was obtained in the takeover of the Willoughby Water System
- Like the Dome, these facilities ride on the Low Service District and supply pressure and volume to it
  - The BGR consists of two side-by-side 1 MG tanks operated in parallel
  - The Standpipe has a volume of 1 MG. There are two 650 gpm pumps located at the BGR. Normal operation is for these two pumps to draw water from the BGR and put it into the LS District
  - The pumps can also be used to fill the Standpipe when necessary. Operators can control these pumps from the WTP

# BGR and Standpipe

**BGR**

**Standpipe**

# Pumps at Dome

- All water going into First High and Second High comes from the low service Storage
- There are two sets of pumps located in a building just north of the Dome
- This pump station boosts pressure into 1$^{st}$ high and into 2$^{nd}$ high and fills the two tanks associated with them
  - Standby power generation comes on automatically

# Pumps at Dome

## 1st High Service

## 2nd High service

# VFD Equipment

## Control Panel

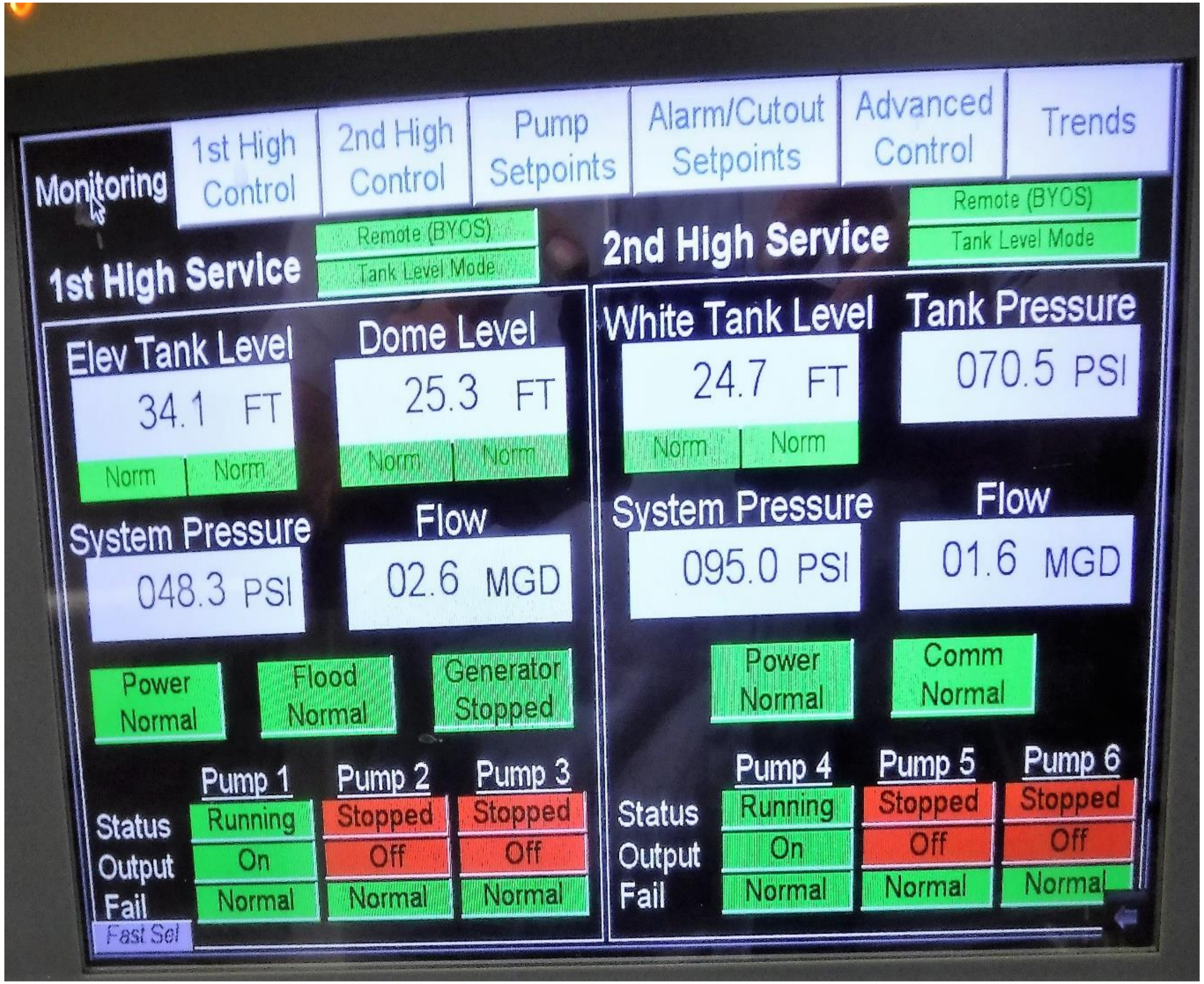

## One of the 6 controllers

# Control Panel at Dome

The Control Panel provides information as to levels in the tanks, and which pumps are operating.

It also shows flow rates and pressures, and allows control of components at the Dome.

It provides trending capability also – **important tool.**



The Dome has stand-by power generation capable of running the station in the event that power is lost

When normal power is interrupted, the generator automatically activates

This Transfer Switch reacts and allows power from the generator to feed the station demands


## Transfer Switch at Dome

# Booster Stations

- The West System has several booster stations that create specialized pressure districts apart from "low service"
  - First and second high pumps at the Dome
    - The pumps pull water from the Dome and send it into the two tanks
  - Pumps at BGR and Standpipe now have VFD
    - The pumps draw water from the BGR and put it into low service
  - **Tall Tree Booster** – created to break away from CWD – and maintain the service that this area was accustomed to experiencing
  - **Worrell Road Booster** – created to serve about 110 homes in a higher elevation
  - **Note – The Old Pelton Road Booster** - which was created to serve area around Kirtland Country Club – in now served from a waterline under the Chagrin River. The Booster does still run during high demand times

# First High Service

- First High Service is generally comprised of the portion of the Lake County system which is bordered
  - By route 271 and route 90
- There are three pumps located in the pump station at the Dome which are dedicated to the First High District System.
- Water is moved into the Elevated Tank – or "ET" – where is provides pressure and volume for first high service
  - Volume of ET is 0.5 MG

# The Elevated Tower (ET)

- The E.T. is a 0.5 MG elevated storage tank located on the same grounds as the Dome, and it provides pressure and volume for First High Service
- It is filled from a set of pumps located in the pump station at the Dome
  - 3 pumps @ 2,200 gpm

# Second High Service

- Second High Service is generally contained in those portions of the system south of Route 90
- There are three pumps located in the pump station at the Dome which are dedicated to the Second High Service district
- Water is moved up to the White Road Tank, which provides pressure and volume for second high service
- Within this district are two booster stations that serve specific parts of it
  - Tall Tree Booster – (uses majority of water in second high)
  - Worrell Road Booster

# White Road Tank

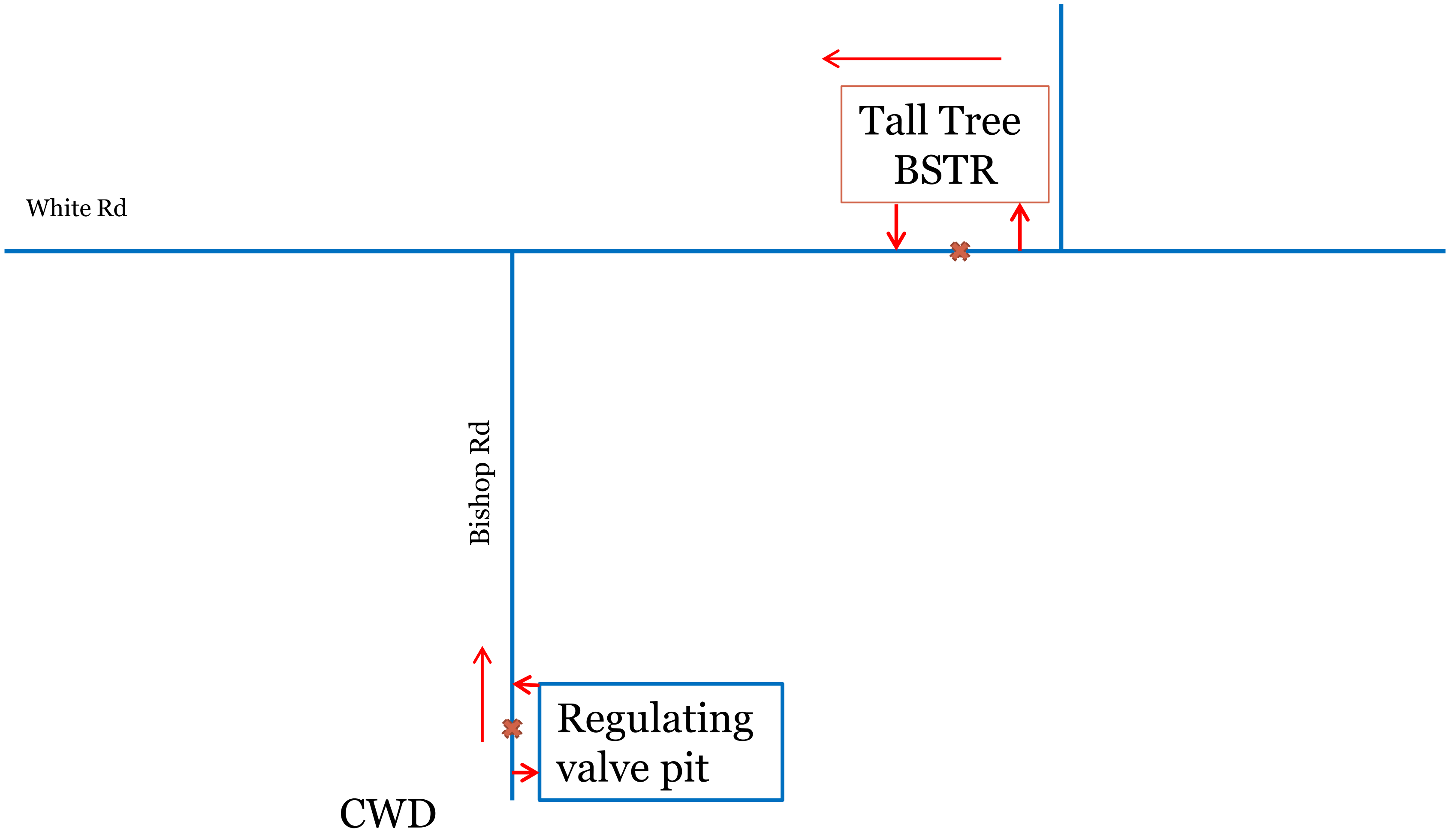
- The White Road Tank is a 0.75 MG elevated storage tank located on the West side of Route 271 on White Road, and it provides pressure and volume for 2nd High Service
- It is filled from a set of pumps located in the pump station at the Dome
  - 3 @ 1,150 gpm

# Tall Tree Booster District – specialized district with stand-by water supply from Cleveland

- Fed from Second High Service and White Road Tank
- The area it serves has an emergency connection with Cleveland Water in case of power outage
  - On Bishop Road – an 8 inch pressure regulating valve set to open at 110 psi


Designed to put out high pressure

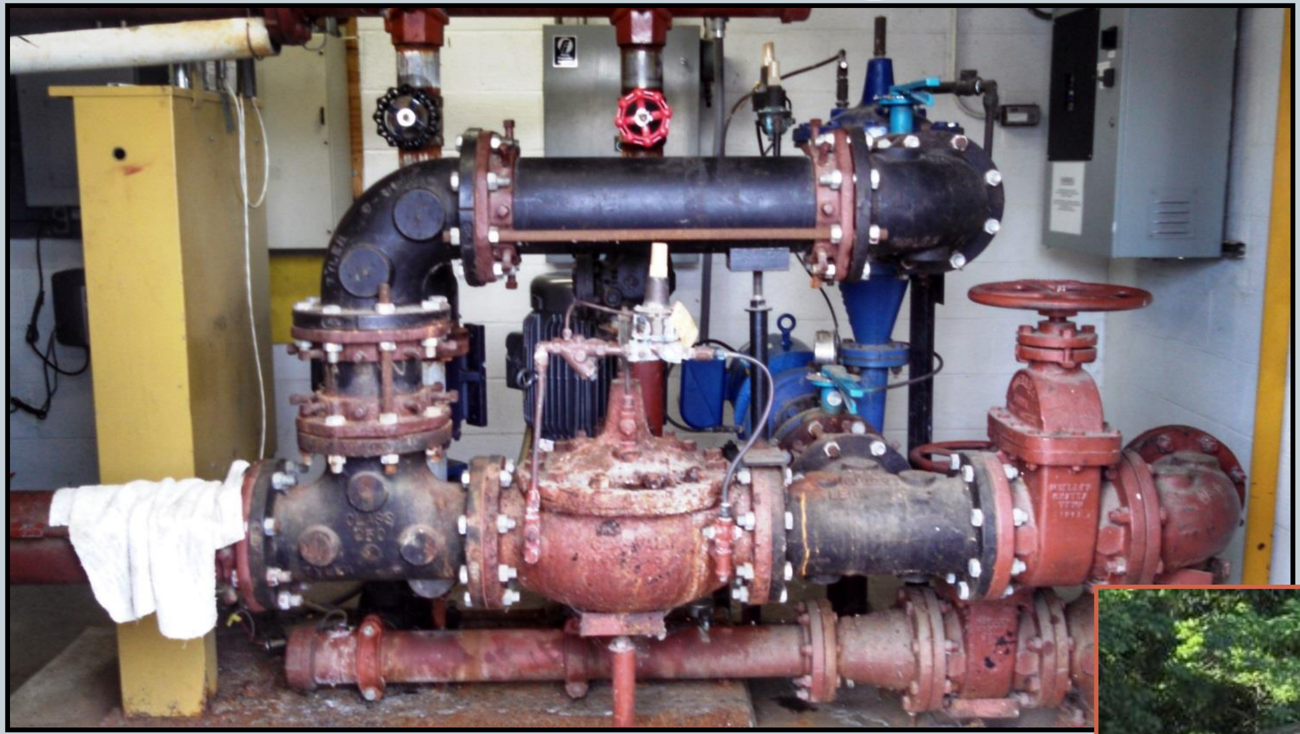
# Tall Tree Booster District



# Worrell Road Booster District

- Located at a far end of Second High Service

# Pelton Road Booster



# Altitude Valves

- The purpose of this type of valve is to control the height to which the water level will rise in the tank, without allowing the tank to overflow and waste water
  - Valve at Standpipe at 174 and 84
  - **No** valves at other tanks
- Valves need periodic maintenance

# Boundary Valves and Interconnects

- **Boundary valves** help to keep separate *the pressure districts* within the system – these create dead-ends
- **Interconnects** are valves and/or meters that allow the West System to provide water to, or receive water from, another water system, and serves to keep the systems separate

Boundary valves and interconnects are normally kept closed

# QA/QC Group Activities

KEEPING WATER FRESH

# System Storage, Water Age and Tank Turnover

- **Water Age** is minimized in the system partly by forcing the storage tanks to "turnover" as frequently as possible
- System storage:
  - The Dome– 5,000,000 gals
  - E.T. – 500,000 gals
  - White Road– 750,000 gals
  - BGR and Standpipe – 3,000,000 gals
- Q/A staff seeks a happy medium between fire protection, system pressure, and water quality

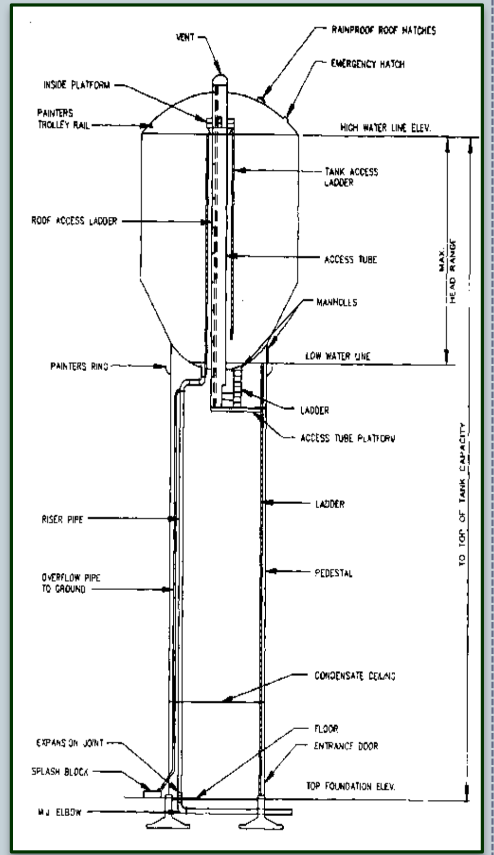
# Tank Turnover Calculation

## Tank Turnover percent example

- If tank bowl is 0' to 40'

***and***

- 10' is the drain/fill event
- 10'/40' = 25%
- Location of drain/fill area is important




## Determining the largest turnover percent in month

| Day | Drain/Fill | Day | Drain/Fill |
|---|---|---|---|
| 1 | 13 | 16 | 13 |
| 2 | 9 | 17 | 12 |
| 3 | 12 | 18 | 10 |
| 4 | 11 | 19 | 11 |
| 5 | 11 | 20 | 15 |
| 6 | 12 | 21 | 13 |
| 7 | 9 | 22 | 12 |
| 8 | 10 | 23 | 9 |
| 9 | 8 | 24 | 10 |
| 10 | 12 | 25 | 11 |
| 11 | 13 | 26 | 12 |
| 12 | 12 | 27 | 10 |
| 13 | 13 | 28 | 9 |
| 14 | 10 | 29 | 10 |
| 15 | 10 | 30 | 9 |

# System Storage Comparison – 3 Ohio Utilities

Average day demand compared to total storage for example systems classified as small, medium, and large in Ohio.

Comparison shows storage in distribution system only, not in clear wells at the WTPs.

| Utility/classification | Average Day Demand, MG | System Storage, MG* | System storage as % of average day demand |
|---|---|---|---|
| Cleveland / Large | 200 | 130 | 65% |
| Lake County West / Medium | 9 | 9.2 | 102% |
| Conneaut / Small | 1.2 | 2.2 | 183% |

*Total system storage with all tanks full - which may differ from actual operations

# Tank turnover discussion

- It makes a difference where in the tank the turnover is taking place
  - An easy way to think of it is to divide the tank into three equal sections:
    - The upper third
    - The middle third
    - The lower third
  - Displacing the water through the range of elevations for any of these "third" sections will provide a calculation of 33.3%
  - But the starting and ending point of that one-third turnover dictates the effectiveness of the event
  - Because of hydraulics, the displacement of water in the range of the middle third will provide a better mix than it will in the upper third

The effectiveness of the turnover will be influenced by seasonal temperatures

# Main Flushing

PROCESS BY WHICH THE QA GROUP REDUCES WATER AGE AND ELIMINATES BIOFILM ACCUMULATION

# Main Flushing

- The Lake County WEST System flushes all dead-end mains twice each year.
  - Good treatment at the plant becomes a wasted effort without a good flushing program
  - Main flushing improves water age and helps to remove biofilms
  - Can be designed to target problem areas
  - Especially important because Lake County uses phosphates to control Pb and Cu
- A unidirectional flushing program is used
  - The QA group follows the policy of flushing at a velocity of 2.5 fps

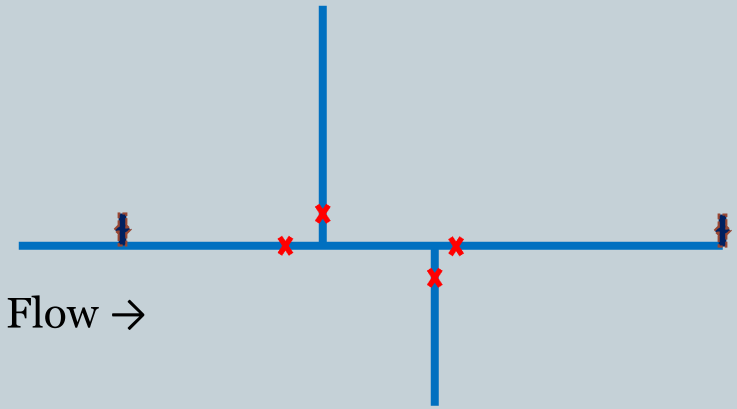
# Unidirectional Flushing

## Procedure

- Unidirectional flushing starts at the source of pressure and works outward
  - WTP, Boosters, Elevated Storage e.g.
  - Requires that valves be opened and closed so that the flow comes from one source only
  - Guideline: flush segments of 1,200 feet or less, flush for 3 detention times,

## Example

- Make sure all water comes from one direction and goes to one direction



# Flushing Velocity

- AWWA suggests using a 2.5 ft/sec velocity
  - Q = A * V
  - Example for a 12 inch main
  - Q = 3.14 x 0.5’ x 0.5’ x 2.5 ft/sec

    Q = 1.9625 $ft^3$/sec

    Q = 880 gpm

Assumes you can measure the flow!

# Water Hammer must be managed when flushing mains

- Water hammer is a term for the shock wave which is created in water a main when water velocity changes abruptly (speeds up or slows down).
- In addition to the speed of the change, water hammer is a function of the type of piping material that is used.

| Type of Pipe | Wave speed ft/sec |
| --- | --- |
| Class 150 A/C | 3300 |
| Class 52 DIP | 4040 |
| Class 150 PVC | 1300 |

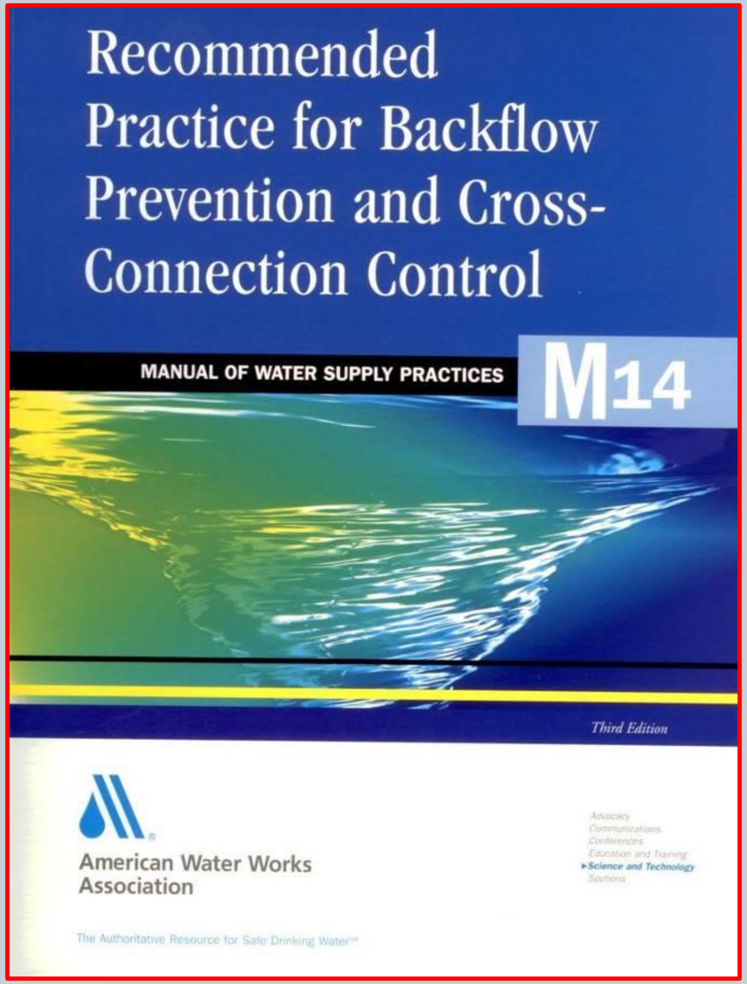
Pipe material affects speed of shock wave

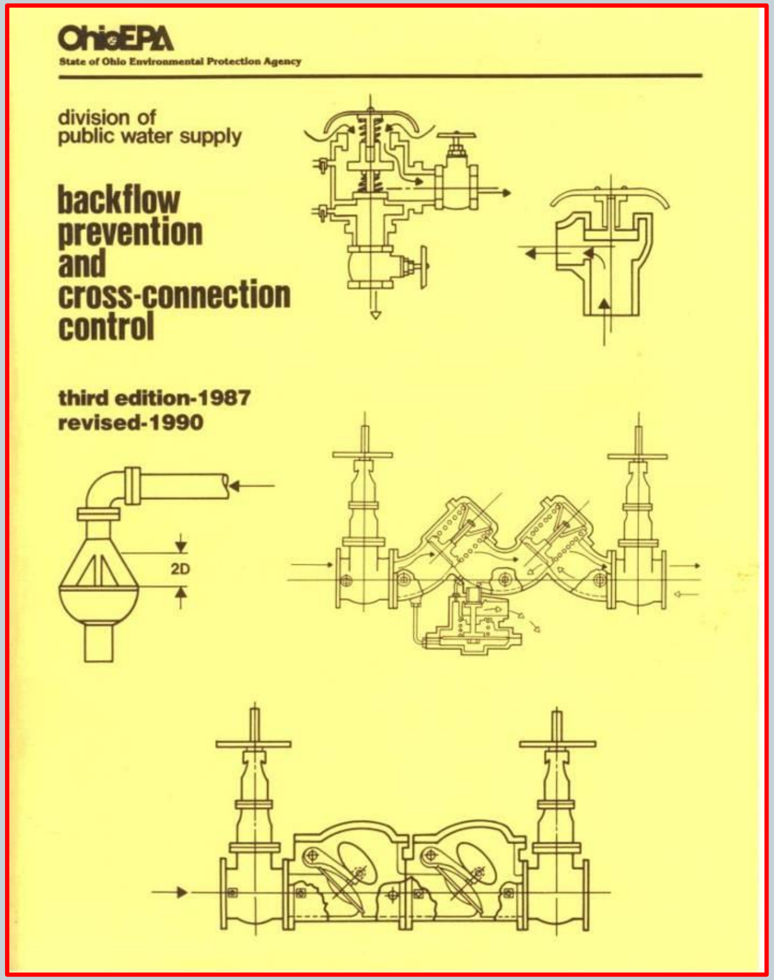
# Cross Connection Control

**KEEPING SYSTEM CONTAMINATION TO A MINIMUM**

**ADMINISTERED BY QA GROUP**

# AWWA M14 and Ohio EPA Manual



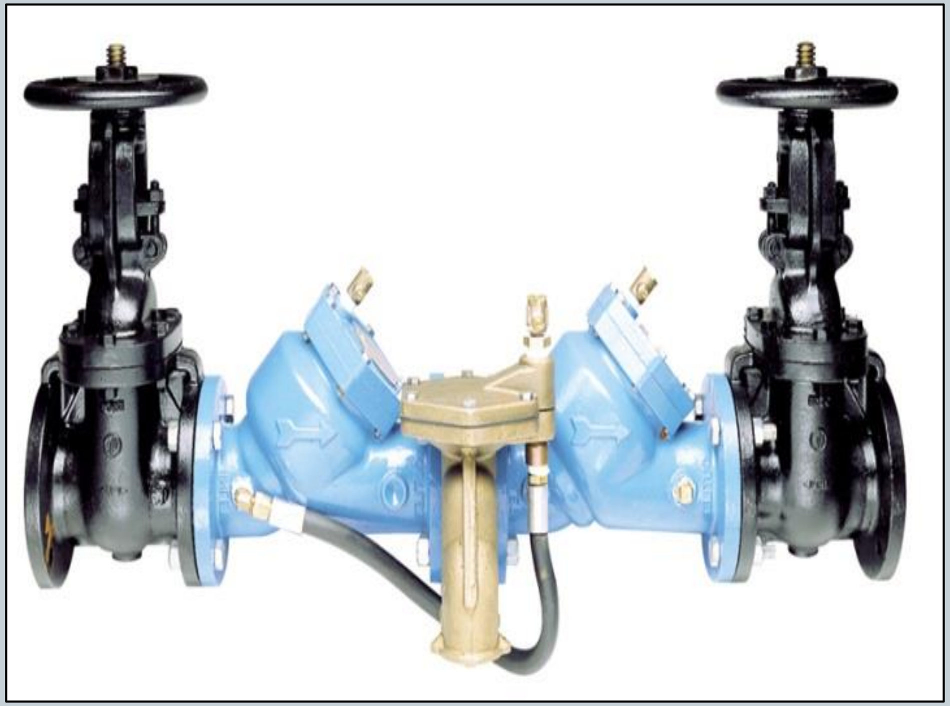
# Cross-Connection Control

- Lake County System follows the mandates of the Ohio EPA Cross-Connection Control Guidelines
  - The guidelines require that the water purveyor provide a working cross-connection program
    - They must cause inspections to be made
    - They must require backflow protection where needed
  - The guidelines require that water customers maintain working backflow devices
    - They must report the results to the water purveyor
    - They must make repairs when needed

# Two Causes of Backflow

| Back-pressure | Back-siphonage |
|---|---|
| • Pressure in the water user's premises becomes higher than public water system pressure<br>○ Can be caused by on-site pump, or hot water boiler, etc. | • A vacuum is created in the system causing water to flow backwards<br>○ Can be caused by water being drawn to quickly, or by flushing a large main from a small main |

# Backflow Devices

| Double Check Valve | R/P Device |
| --- | --- |
|  |  |

# Pressure Regulation

KEEPING AN EVEN DOWNSTREAM PRESSURE REGARDLESS OF THE UPSTREAM FLUCTUATIONS

# Pressure Regulation

- The Lake County West Distribution system has 4 working pressure regulators in its system:
  - Eagle Road, Willoughby Hills
  - Dodd Road, Willoughby Hills
  - Rodgers Road, Willoughby Hills
  - River Road (SR 174), Willoughby Hills
    - The units are on a regularly scheduled maintenance list, and must be kept in good working order or they will fail. For this reason, spare parts are kept on-hand, and staff is trained so that more than one person knows how to work on these units in an emergency.

# Example Regulator Assembly