RCAP Asset Management Webinar Series

Completing a Preventative and Predictive Maintenance Plan

Presented by

Wayne Cannon, Sr. Rural Development Specialist

Bud Mason, Sr. Rural Development Specialist

Your Speakers Today

Wayne Cannon

Bud Mason

Today's Class is sponsored by

Ohio EPA

Division of Drinking & Ground Waters

Today's session is being recorded.

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RCAP Asset Management Webinar Series

Sept 8	**Completing an Asset Inventory**
Sept 15	**Completing a Condition Assessment**
Sept 22	**Completing a Capital Improvement Plan**
Sept 27	**Completing a Preventative & Predictive Maintenance Plan**
Sept 29	**Budgeting for P&P, CIPs & Sustainability**

Each webinar is from 10 AM – 11 AM.
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Asset Management Webinar Series

Preventive and Predictive Maintenance Plan

Bud Mason – Ohio RCAP Rural Development Specialist
Wayne Cannon – Ohio RCAP Rural Development Specialist

Better management will be needed to achieve our AM Goals.

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- **1st Goal** – Maintain assets to achieve their maximum useful life. **IMPROVED MAINTENANCE!**
- **2nd Goal** – Systematically plan for asset replacement. **Escrow Reserve Funds.**

Cost of infrastructure replacement

Water Distribution $15,000 per customer	$15,000,000
Source and Treatment	$4,500,000
Total	$19,500,000

Financed over 30 yrs. at 3.29% interest = $84 customer / month for debt only

Run-until-failure is not a cost effective management strategy.

New MISSION is Sustainability. Managing remaining useful life…

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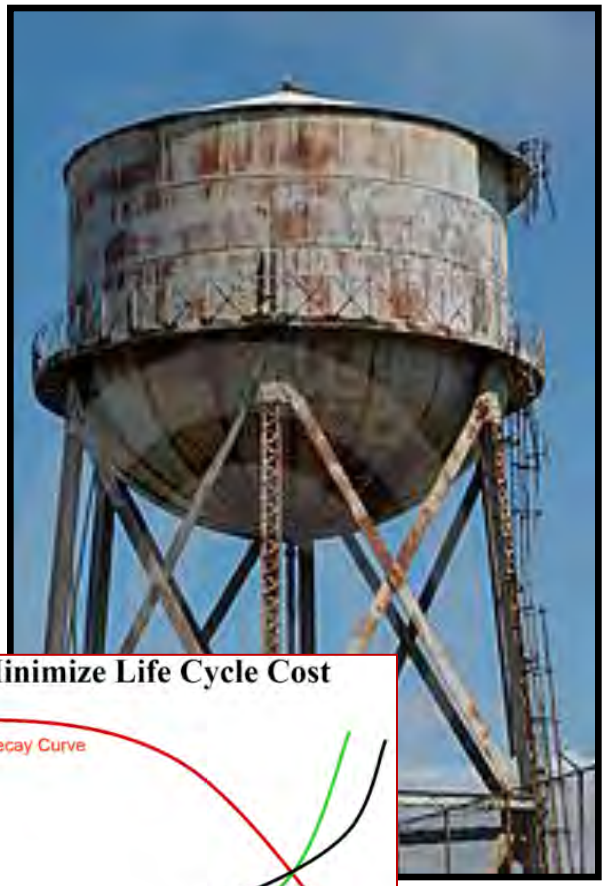

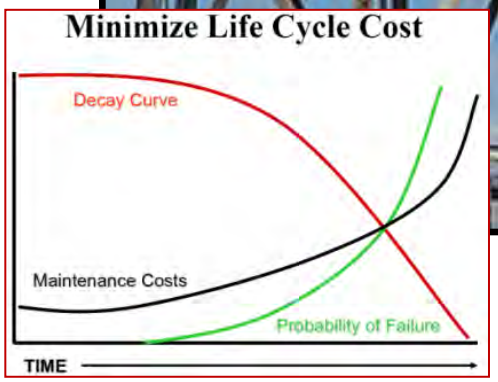

- Minimize lifetime ownership cost through improved **preventative maintenance** and timely **predictive maintenance** (asset rehabilitation).
- History show that **scheduled maintenance cost 1/3 less** than emergency repairs for the same task

1st Goal – Maintain assets to achieve their maximum economic life.

O & M Strategies
Preventive / Predictive / Reactive

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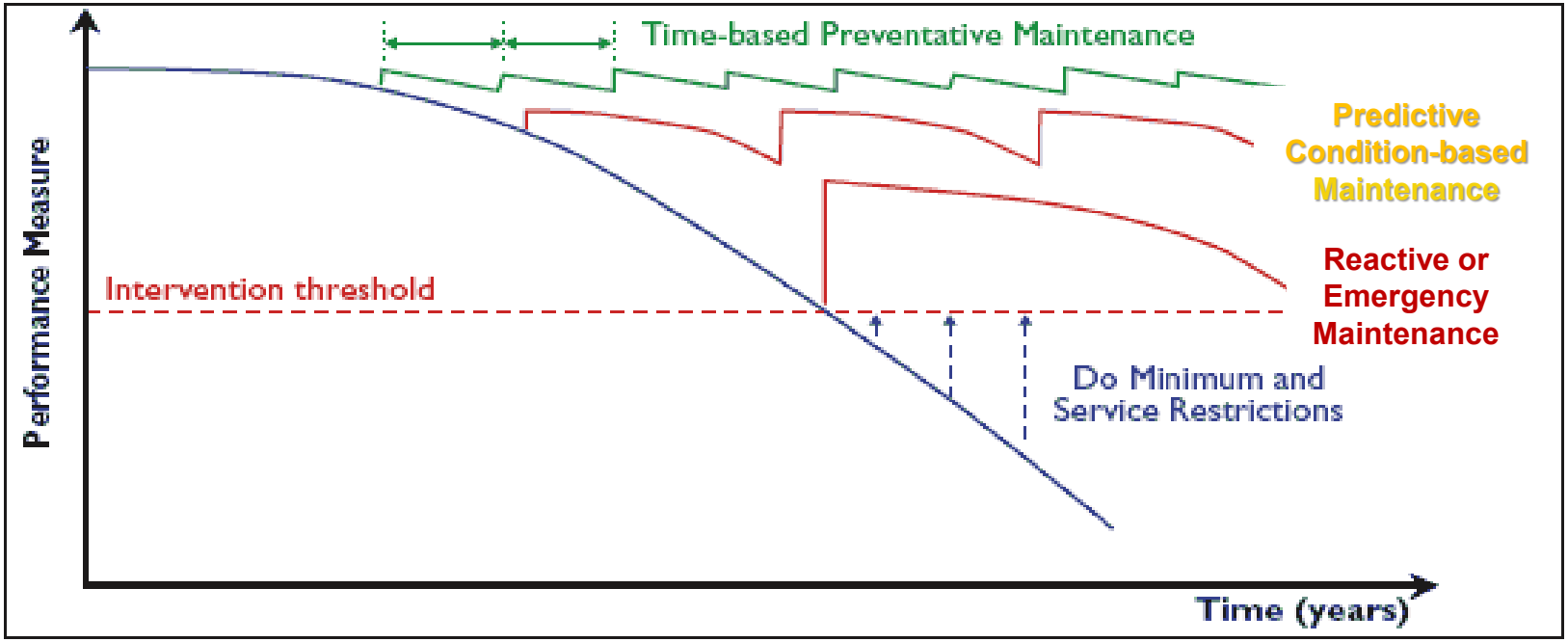

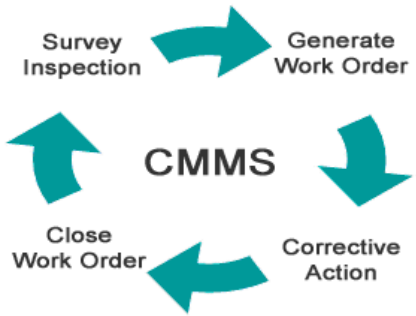

The best strategy for O&M varies by asset, criticality, condition and operating history.

Preventive Maintenance

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- The base level for preventive maintenance is defined in the owner's manual.
- Manufacturers recommendations can be supplemented by industry accepted best practices.
- **Annual expense item!**

Time Based Maintenance

(Date, Hours, Miles)

Preventive Maintenance

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- Industry accepted best practices are particularly important for distribution and collection systems because no owner's manual exist for this infrastructure.
- Condition assessment and performance monitoring are preventative maintenance task.

American Water Works Association

Dedicated to the World's Most Important Resource™

Water Environment Federation®
the water quality people®

ASCE American Society of Civil Engineers

Preventive Maintenance

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- The maintenance budget is often the target of budget cuts because maintenance can be delayed in the short-term with few consequences.
- Deferred maintenance usually results in higher "Life-Cycle Costs". **"Penny wise and dollar foolish"**

Predictive Maintenance

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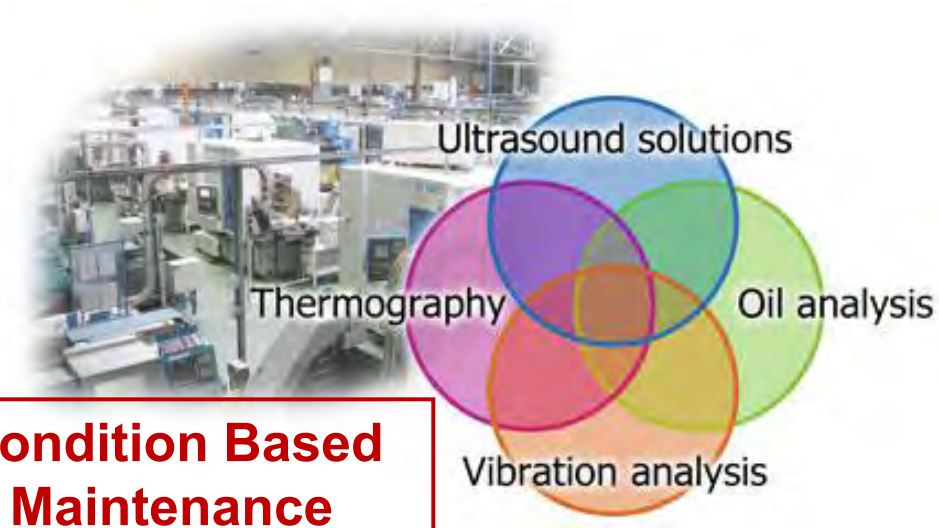
- Predictive maintenance activities are scheduled based upon monitoring and inspection report findings.
- Equipment is inspected and monitored for early warning signs of impending failure, such as vibration, leakage or reductions in performance and serviced accordingly.



Condition Based Maintenance

Predictive Maintenance

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The renewal and renovation of short-lived components of larger assets is predictable.

Examples include:

- Well Cleaning and Pump Maintenance
- Roof / HVAC Replacement
- Interior / Exterior Coatings on Storage Tanks
- Valves and Hydrants
- Meters

Escrow to savings for anticipated costs which are often 2 to 20 years into the future.

Reactive Maintenance (EMERGENCY or CORRECTIVE)

Reactive maintenance activities are scheduled when equipment fails or inspection activities reveal a problem that must be corrected to avoid an emergency situation.

This maintenance strategy is often referred to as Run-Until-Failure.

Preventive vs. Emergency (Reactive) Maintenance

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- Emergency maintenance cost 1/3 more than planned maintenance for the same task. Fix it right the first time!
- Emergency / reactive maintenance takes resources away from preventive maintenance and predictive monitoring task.
- When reactive maintenance becomes a predominant activity, personal may not be able to perform planned maintenance thus leading to more emergency / reactive maintenance situations.

Based on USEPA's assessment of Australia's advanced management practices, 20-30% future life cycle cost savings is achievable for most US water and wastewater utilities

Measuring the Effectiveness of Preventive Maintenance

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- Frequency and cost of emergency repairs relative to schedule maintenance is an indicator of maintenance program effectiveness.
- The CMMS system can be used to track the number and cost of work orders by asset and type.
- CUPSS Table 5.2 shows the cost and frequency of emergency and reactive maintenance upon work orders entered.

Table 5-2. Yellow Springs Sewer Emergency/Reactive Maintenance Expenses

Task Name	Cost($)	Frequency	Estimate Annual Cost
Total Emergency/Reactive Cost			0

The cost of emergency maintenance should not exceed 20% of total maintenance budget.

Improved Maintenance Program

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Drinking Water Distribution - Best Management Practices

Quick Reference Guide

Performance Monitoring

	General Recommendation	Supplemental Information	Budgetary Cost
System Wide Performance Monitoring	Daily, Monthly, Annually	System wide performance monitoring should be performed on an ongoing basis. This job is made easier by SCADA systems using flow data from the treatment plant and pump stations. System-wide performance monitoring will allow you to monitor gradual changes in the efficiency of water delivery.	Minimal - Requires better organization and understanding of existing information.
District Area Metering	Monthly, Annually	District Meter Area (DMA) management involves subdividing the distribution system into districts by manipulating of valves and measuring total water to metered consumption. The subsequent analysis of flow, particularly of the night flow, is used to calculate the level of leakage within the district. DMA flow monitoring is used to determine not only whether work should be undertaken to reduce leakage, but also to compare levels of leakage in the different districts to assess where it is most beneficial to undertake leak location activities.	District meters must be installed. Otherwise this effort requires minimal amount of additional work for analysis. Analysis can be automated using the SCADA and Billing System. Budget 5 to 10 staff hours monthly per district.
Water Audits	Annually	Audit results are more useful when the results are compared over time. The audit program will help producers to identify area in data collection and analysis. The industry is moving toward benchmarks based upon the volume water loss per service connection in densely populated urban situation and volume water loss per pipeline distance in sparsely populated rural systems. **Reference "The Water Audit Handbook for Small Drinking Water Systems - EFCN Smart Management for Small Water System Program"**	Budget 40 to 120 staff hours annually.

Condition Assessments

	General Recommendation	Supplemental Information	Budgetary Cost
Valve Exercising and Maintenance	All valves (such as distribution and transmission valves, air valves, and blow-offs) should be inspected and operated on a regular basis. (I could not locate any specific recommendations)	A valve exercising is a procedure that verifies proper location, operation, and material condition of valves, and initiates replacement as necessary. The physical operation of a valve and the documentation of the actions and procedures necessary to do so are equally important. The useful lifespan of valves at 40 years is less than half that of the pipe to which they are connected. Operational valves are necessary to fix water main breaks which are more likely to occur as the pipeline ages. Plan accordingly.	
Hydrant Testing and Maintenance	Hydrants should be inspected (flushed) twice a year, spring and fall.	The inspection and testing of fire hydrants is critical to determining the readiness of the hydrants to provide water at fire emergencies. The inspections shall verify the location, accessibility, proper mechanical operation, and water flow from the hydrant.	
Pipeline Condition Assessment	One factor used to quantify the occurrences of failing underground pipe is water main break rates. Water main break rates are calculated for all pipe materials used in the transport of water to create a measurement to judge pipe performance and durability.	The Average Age of Failing Water Mains is 47 years old. While pipe life can be estimated at over 100 years, actual life is affected by soil corrosivity and installation practices. Corrosion is a Major Cause of Water Main Breaks. One in four main breaks is caused by corrosion which is ranked the second highest reason for water main pipe failure. When failures rates of Cast Iron, Ductile Iron, PVC, Concrete, Steel, and Asbestos Cement pipes were compared, PVC is shown to have the lowest overall failure rate. "Water Main Break Rates in the USA and Canada: A Comprehensive Study - April 2012"	

Available online at : http://ohrcap.org/index.php?page=programs

Improved Maintenance Program

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- Today we going to highlight selected best maintenance practices to extend the useful life of your Water System.
- You are already familiar with many of these practices from emergency repairs. But how many of you use them in a proactive preventative maintenance program?
- Focus on how existing practices can be used for **Performance Monitoring** and **Condition Assessments**

Think about how to store the information obtained to avoid memory fade and personal changes that render it unavailable.

Improved Maintenance Program

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- Poll Question
- What Maintenance Planning do you use?
  - Preventive / Predictable
  - Postponed / Put Off

Identifying Best Practices
Water Distribution

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- **Water Audits / Performance Monitoring**
- **Leak Detection (Active Leak Control)**
- **Valve Maintenance**
- **Hydrant (Pressure and Flow Testing)**
- **Clean pipe (Unidirectional Flushing)**
- **Maintain Records (GIS Mapping / CMMS Software)**

Condition inspection and performance monitoring should become an ongoing maintenance activity. Most utilities will need several years to inspect **ALL** of their assets.

Small communities often struggle with proactive maintenance practices due to limited staffing, equipment and knowledge.

Benchmarking Water Loss

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- Is **15% water** loss a good benchmark? Water is usually lost at the same amount every day no matter how much is pumped or metered.
- Nationwide water use is on the decline. If pumpage decreases from 200,000 gpd to 150,000 gpd the lost water percentage goes from 15% loss to 20% loss.
- However gallons of unaccounted for water is unchanged!

Perhaps water loss should be based upon a constant such as number of connections or miles of pipe.

“ Best Management Practice”
Annual Water Audit

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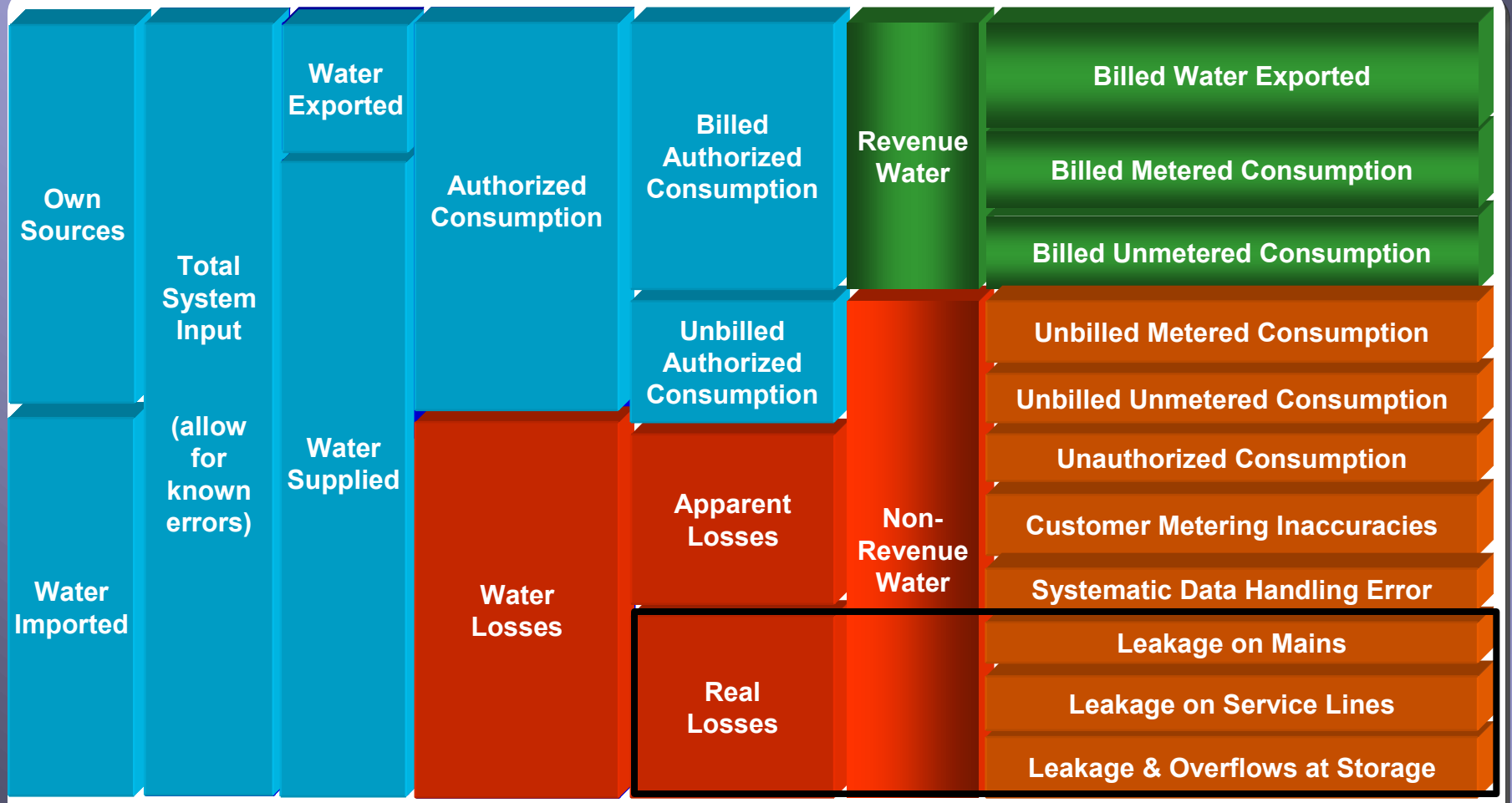

Focus on Real Losses: Mains, Service Lines, Overflows, etc.

Leak Detection Strategies

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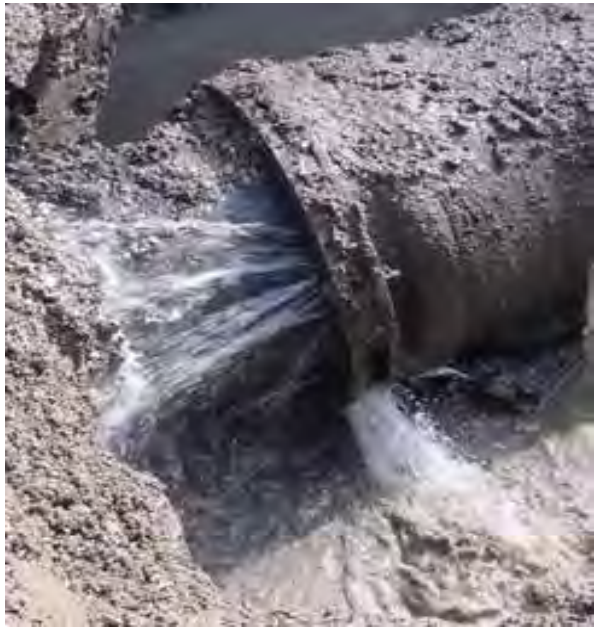
- Passive
  - Monitor Pumping / Pressures / Metered Usage
- District Metering
  - Step Testing
- Leak Surveys
  - In-house or consultant
  - Frequency
- Acoustic Monitors
  - Fixed or Lift & shift
- Correlation

It is NOT Lost!
We can find most of it!



Tools of the trade

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High quality headphones

Extension Rod used to reach fittings or penetrated soft ground

Shielded ground microphone used on hard even ground surfaces

Tripod foot for uneven surfaces

Base unit – filters and displays noise

Overnight Correlators

Leak Noise Correlator

“Best Management Practice”
Active Leakage Control (ALC)

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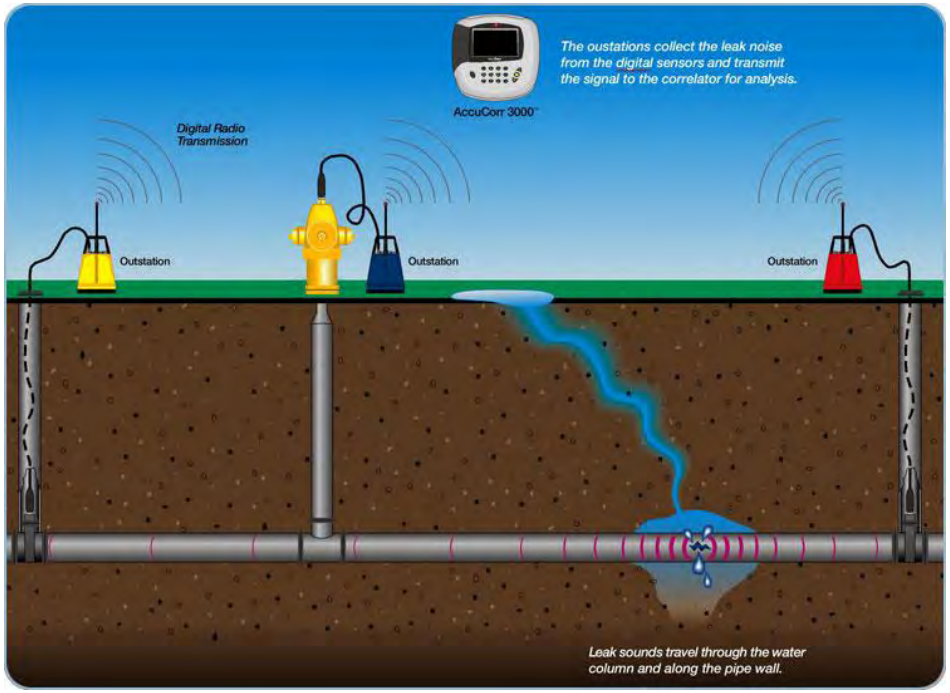
Active Leakage Control (ALC) is a proactive strategy to reduce water loss by locating and repairing non-visible leaks by technicians with specialized equipment.



ALC focuses on Unreported Leaks and Speed of Repair

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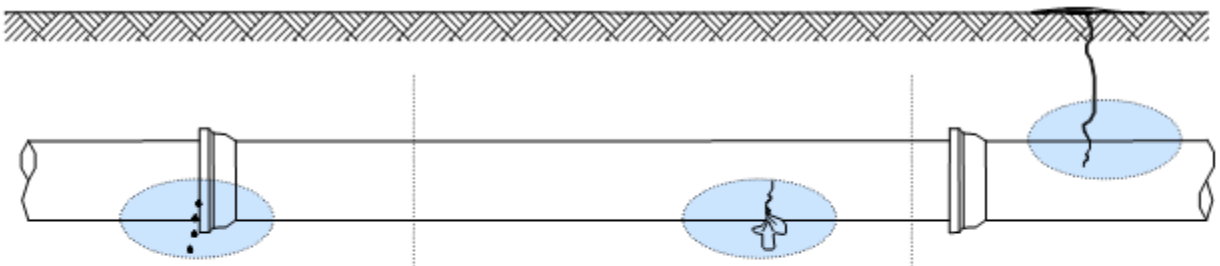
Unavoidable	Detectable	Observable



Background Leakage	Unreported Leaks	Reported Breaks
Unreported and undetectable using traditional acoustic equipment	Often does not surface but is detectable using traditional acoustic equipment	Often surfaces and is reported by the public or utility workers
Tools	**Tools**	**Tools**
• Pressure Stabilization • Pressure Reduction • Main and service line replacement • Reduction in the number of joints and fittings	• Pressure Stabilization • Pressure Reduction • Main and service line replacement • Reduction in the number of joints and fittings • Proactive leak detection and repair	• Pressure Stabilization • Pressure Reduction • Main and service line replacement • Reduction in the number of joints and fittings • Improve speed of repair

Small leaks are important!

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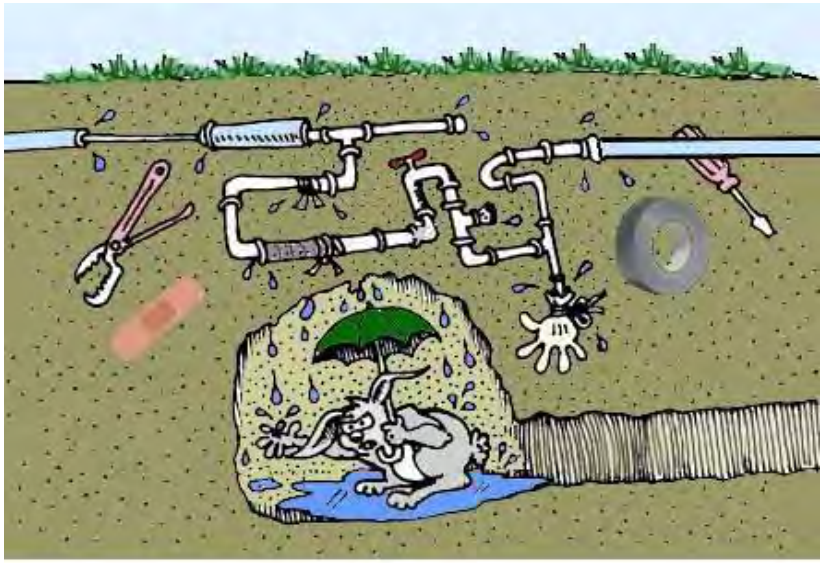
Research has shown that the constant flow of low level leaks that cause more water loss than the spectacular water main breaks.



Do the math!

1 gpm for 3 years = 1,576,800 gallons

10 gpm for 45 days = 648,000 gallons.

500 gpm for 4 hours = 120,000 gallons.

Valve Maintenance Equipment

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Why Exercise Valves?

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- Needed to control flow and address emergencies
  - Main breaks must be isolated
  - Speed of shut-off important in limiting damage
- Will deteriorate over time if not used.
  - Corrosion
  - Sediment deposits
- Valves can be lost!

"A valve that doesn't work is just a piece of pipe."

Step 1 – Gather and organize valve information

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- Distribution system maps and as-built drawings
- Valve location and depth
- Manufacturer
- Type and size
- Pipe and valve materials
- Operation and maintenance records
- Identify what information is missing that can be obtained in the field.

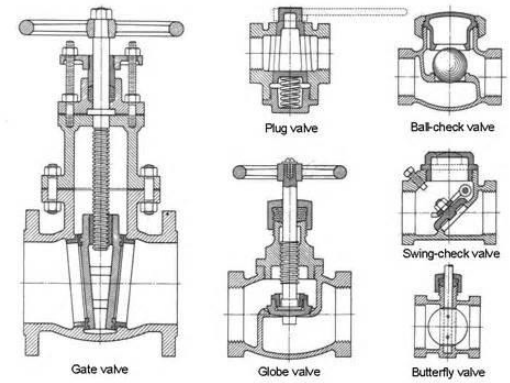
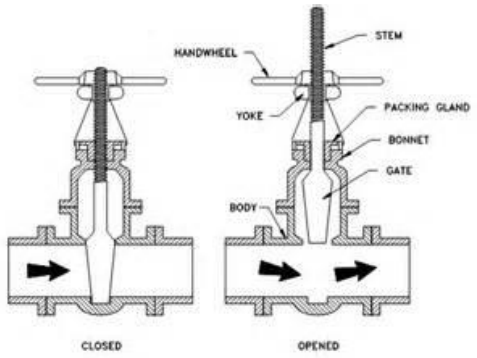


FIG. 10 Valves. The sectional drawings show their construction.



Step 2 – Develop an action plan

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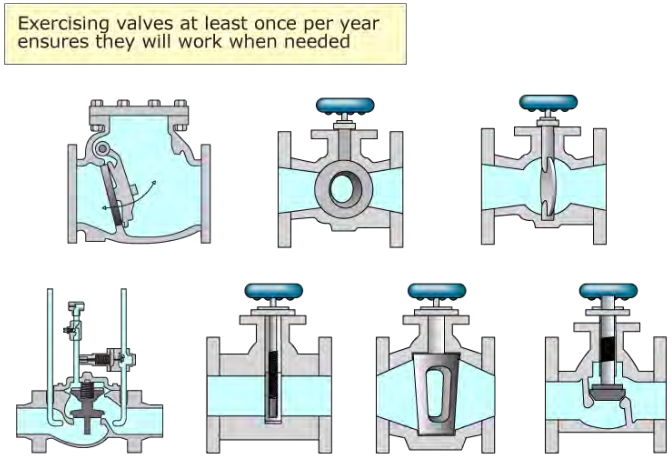
- Frequency
  - Exercise critical valves annually
  - 12” or larger every year
  - Smaller valves every three years
- Identify Critical Valves
  - Size, Age, Etc.
  - Serve critical facilities (Hospitals)
  - Proximity to main intersection on busy street
- Schedule by Map Section or Zone



Step 3 – Field locate and document the valve location

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- Field Verification
  - May require the use of metal detectors or magnetic locators
- Note precise location
  - GPS or Traditional Survey
  - Measure based on two or more permanent objects
- Take digital picture showing valve and surrounding area
- Mark the valve box lid with blue paint
  - Consider painting valve lids before going to the field.

Don't lose the valve once you have found it!

Step 4 – Examine and operate the valve

- Clean-up the valve box
  - You can't inspect what you can't see.
- Examine the existing state of the valve
  - (open, partially open, closed)
- Operate the valve
  - Use lowest torque setting possible – Don't force the valve
  - Count the number of turns down and up. They should match.
  - Don't close the valve completely the first cycle.
  - Open and close slowly to prevent water hammer
  - Listen for changes in flow.
  - Rule of thumb – Number of turns / 3 + 1 or 2 is the valve size

Develop Standard Operating Procedures for Valve Operation

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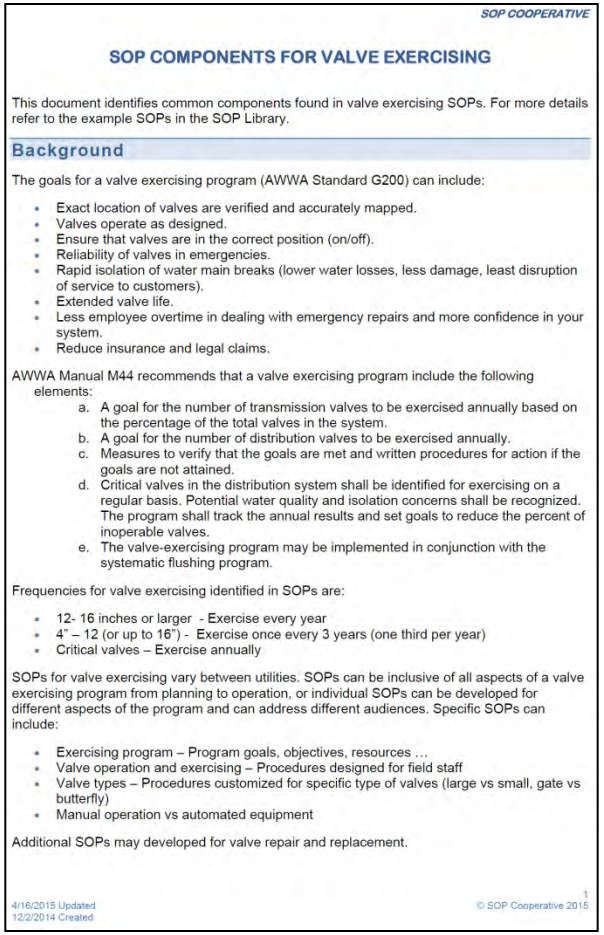
- Remove valve cover
- Visually inspect valve box
- Clean if necessary
- Insert valve key
- Check to see if the valve is open
- Fully close the valve and count the turns
- Exercise up and down 2 to 3 cycles
- Fully open valve
- Close 1 to 2 turns
- Inspect for leaks
- Replace cover
- Collect tools and safety equipment



SOP COOPERATIVE

SOP COMPONENTS FOR VALVE EXERCISING

This document identifies common components found in valve exercising SOPs. For more details refer to the example SOPs in the SOP Library.

Background

The goals for a valve exercising program (AWWA Standard G200) can include:

- Exact location of valves are verified and accurately mapped.
- Valves operate as designed.
- Ensure that valves are in the correct position (on/off).
- Reliability of valves in emergencies.
- Rapid isolation of water main breaks (lower water losses, less damage, least disruption of service to customers).
- Extended valve life.
- Less employee overtime in dealing with emergency repairs and more confidence in your system.
- Reduce insurance and legal claims.

AWWA Manual M44 recommends that a valve exercising program include the following elements:

a. A goal for the number of transmission valves to be exercised annually based on the percentage of the total valves in the system.
b. A goal for the number of distribution valves to be exercised annually.
c. Measures to verify that the goals are met and written procedures for action if the goals are not attained.
d. Critical valves in the distribution system shall be identified for exercising on a regular basis. Potential water quality and isolation concerns shall be recognized. The program shall track the annual results and set goals to reduce the percent of inoperable valves.
e. The valve-exercising program may be implemented in conjunction with the systematic flushing program.

Frequencies for valve exercising identified in SOPs are:

- 12- 16 inches or larger - Exercise every year
- 4" – 12 (or up to 16") - Exercise once every 3 years (one third per year)
- Critical valves – Exercise annually

SOPs for valve exercising vary between utilities. SOPs can be inclusive of all aspects of a valve exercising program from planning to operation, or individual SOPs can be developed for different aspects of the program and can address different audiences. Specific SOPs can include:

- Exercising program – Program goals, objectives, resources …
- Valve operation and exercising – Procedures designed for field staff
- Valve types – Procedures customized for specific type of valves (large vs small, gate vs butterfly)
- Manual operation vs automated equipment

Additional SOPs may developed for valve repair and replacement.

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SOP may vary based upon local conditions and management directives.

“Best Management Practice”
Hydrant Testing

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Residual Hydrant
- Static Pressure
- Residual Pressure
- Test evaluates water available at this location

Flow Hydrant
- Pitot Pressure

Why Maintain Hydrants?

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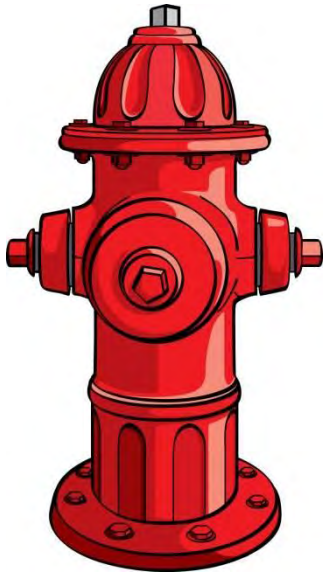
- Improve Water Quality (Flushing)
  - Reduce water age
  - Expelling sediment and contaminants
  - **Scouring and cleaning of pipes – Unidirectional Flushing**
- Condition Monitoring Site
  - Static Pressure
  - Flow – GPM
  - Residual Pressure
- Fire Protection
  - Impact on hazard insurance ratings
  - Reduce liability from non-operating hydrants



The WHO and WHEN of hydrant inspection and maintenance

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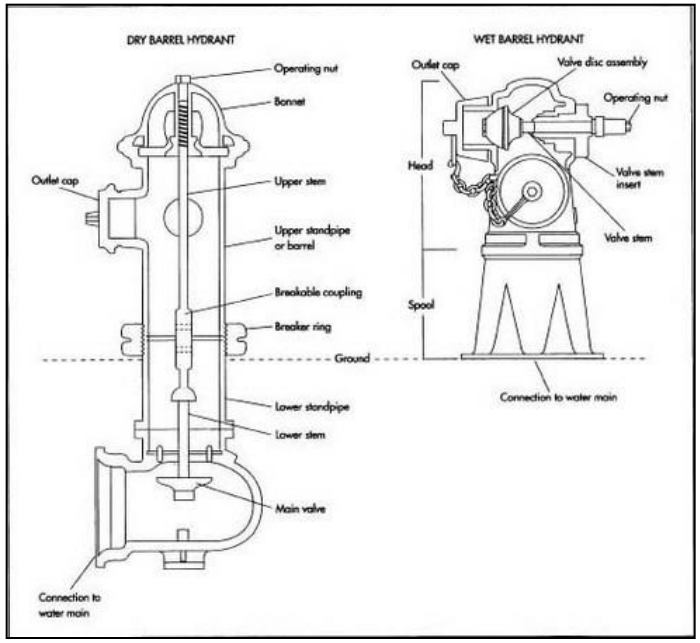
- Who conducts the program?
  - Water Utility – Flushing and Distribution System Maintenance
  - Fire Department – Fire Protection
- Frequency of Inspection
  - Wet barrel - Inspected annually
  - Dry barrel – Inspect twice annually
  - After each use



Fire department and water department view hydrants differently.

Fire Flow Standards

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NFPA defines Fire Flow as: "The flow rate of water measured at 20 psi residual pressure that is available for firefighting." The NFPA standard calls for bonnets and caps to be color-coded. **NFPA 291, Chap. 3**

Class C	**Less than 500 GPM**	**Red**
Class B	500-999 GPM	Orange
Class A	1000-1499 GPM	Green
Class AA	1500 GPM & above	Light Blue

Liability Issue:

Because it looks like a fire hydrant does not make it a fire hydrant!

Hydrant Maintenance & Testing

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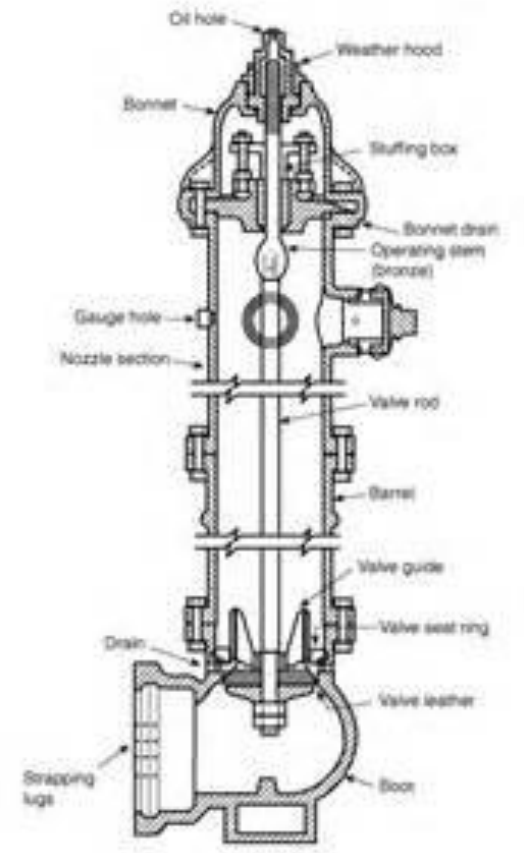
How do I inspect and maintain a hydrants?

1. Inspection
2. Operate hydrant
3. Check hydrant valve
4. Schedule Repairs
5. Recordkeeping



More information is available online.

Step 1 - Inspection

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- Look for visible signs of damage
- Verify hydrant data
- Digital picture
- Remove caps, inspect gaskets, chains
- Check for water in the hydrant, leakage
- Lubricate

Step 2 - Operation

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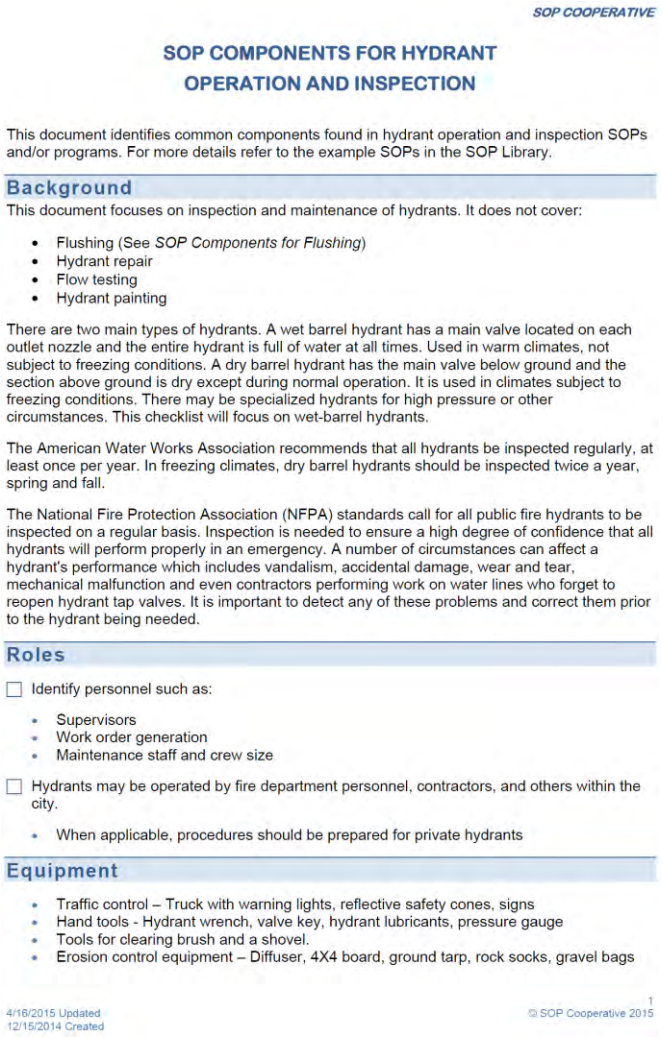
- Install pressure gauge on one nozzle
- Slowly open hydrant, bleed out air, check pressure
- Shut down hydrant and make sure it drains

Follow SOP established by utility.

"If you open it, you own it."



SOP COOPERATIVE

SOP COMPONENTS FOR HYDRANT OPERATION AND INSPECTION

This document identifies common components found in hydrant operation and inspection SOPs and/or programs. For more details refer to the example SOPs in the SOP Library.

Background

This document focuses on inspection and maintenance of hydrants. It does not cover:

- Flushing (See *SOP Components for Flushing*)
- Hydrant repair
- Flow testing
- Hydrant painting

There are two main types of hydrants. A wet barrel hydrant has a main valve located on each outlet nozzle and the entire hydrant is full of water at all times. Used in warm climates, not subject to freezing conditions. A dry barrel hydrant has the main valve below ground and the section above ground is dry except during normal operation. It is used in climates subject to freezing conditions. There may be specialized hydrants for high pressure or other circumstances. This checklist will focus on wet-barrel hydrants.

The American Water Works Association recommends that all hydrants be inspected regularly, at least once per year. In freezing climates, dry barrel hydrants should be inspected twice a year, spring and fall.

The National Fire Protection Association (NFPA) standards call for all public fire hydrants to be inspected on a regular basis. Inspection is needed to ensure a high degree of confidence that all hydrants will perform properly in an emergency. A number of circumstances can affect a hydrant's performance which includes vandalism, accidental damage, wear and tear, mechanical malfunction and even contractors performing work on water lines who forget to reopen hydrant tap valves. It is important to detect any of these problems and correct them prior to the hydrant being needed.

Roles

☐ Identify personnel such as:

- Supervisors
- Work order generation
- Maintenance staff and crew size

☐ Hydrants may be operated by fire department personnel, contractors, and others within the city.

- When applicable, procedures should be prepared for private hydrants

Equipment

- Traffic control – Truck with warning lights, reflective safety cones, signs
- Hand tools - Hydrant wrench, valve key, hydrant lubricants, pressure gauge
- Tools for clearing brush and a shovel.
- Erosion control equipment – Diffuser, 4X4 board, ground tarp, rock socks, gravel bags

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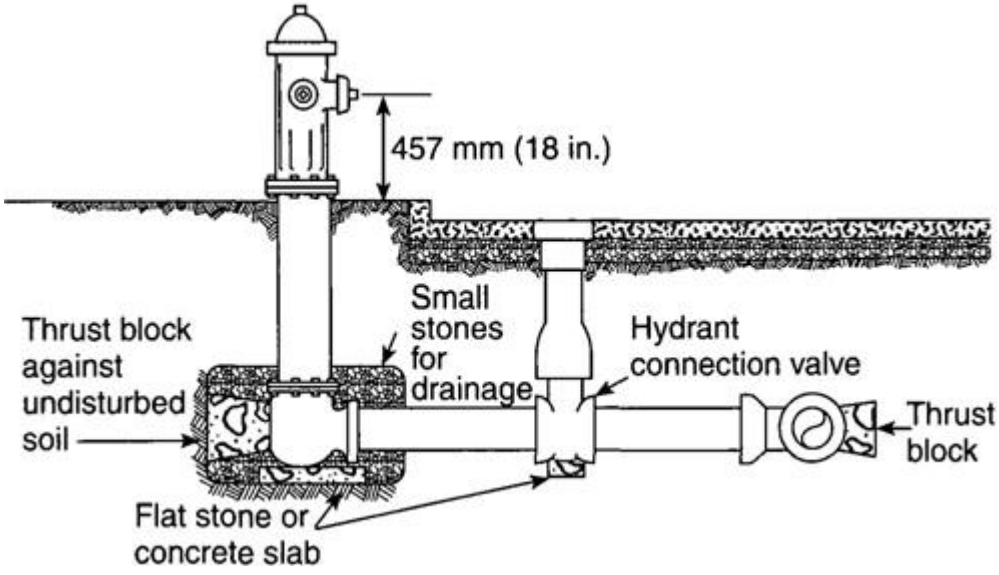
Step 3 - Check hydrant valve

- Locate hydrant valve
- Operate valve
- Ensure that flow stops completely
- Open hydrant valve to flush hydrant line



Step 4 – Repairs

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- Inspect then repair or schedule for repair.
- Notify the fire department if out of service

Step 5 - Recordkeeping

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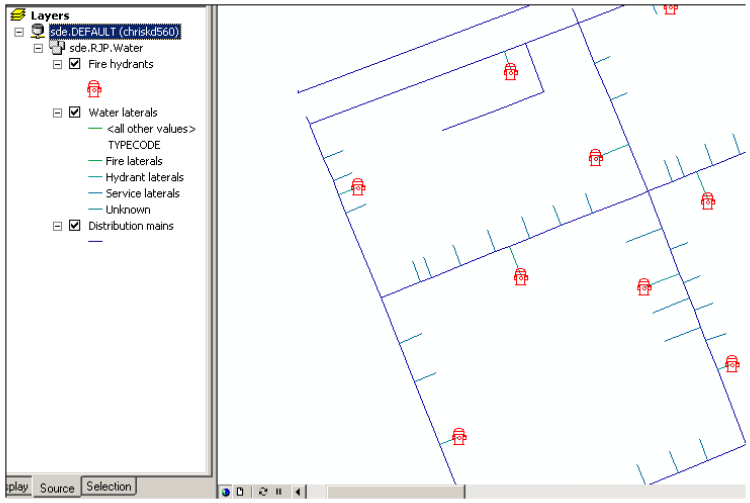
- Inspection checklist
- Hydrant data cards
- GIS records



HYDRANT RECORD

Location Saddle Brook Estates #1 — No. 1 — Color Code G

Type Fire Hyd. — Make

Number Outlets ___ 2-1/2" ___ 4-1/2" — In Service yes

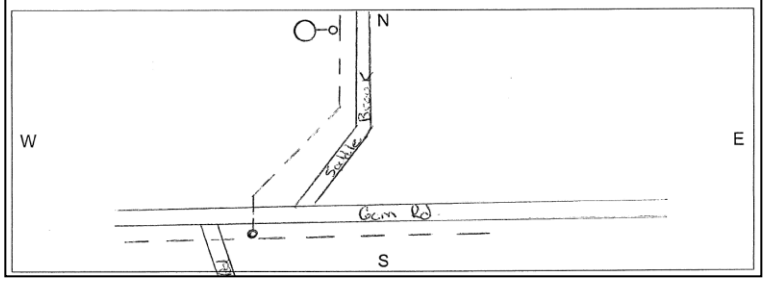
Size of Main 6" — Size of Riser 6"

Static Pressure 124 — Flow Pressure

Provided with Street Gate Valve? yes — Discharge 1350 (Gallons per minimum)

Annual Inspection Report

Date	Flushed	Lubricated	Painted	Repaired	Cap & Chain	Checked by	Remarks
10-13-09	✓	✓			✓	JP	
8-17-10	✓	✓			✓	W.W.	



Clean Pipe

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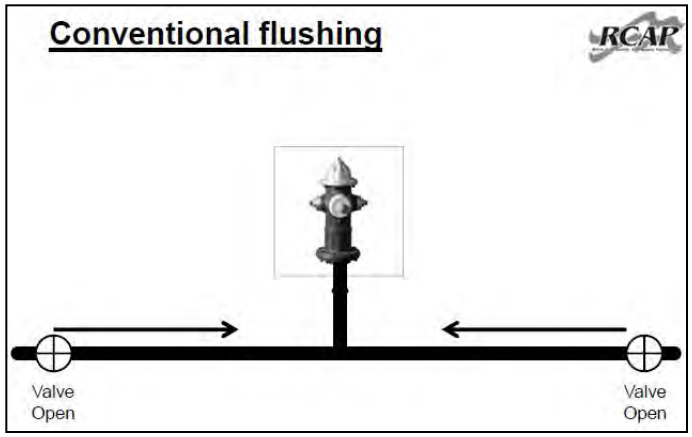
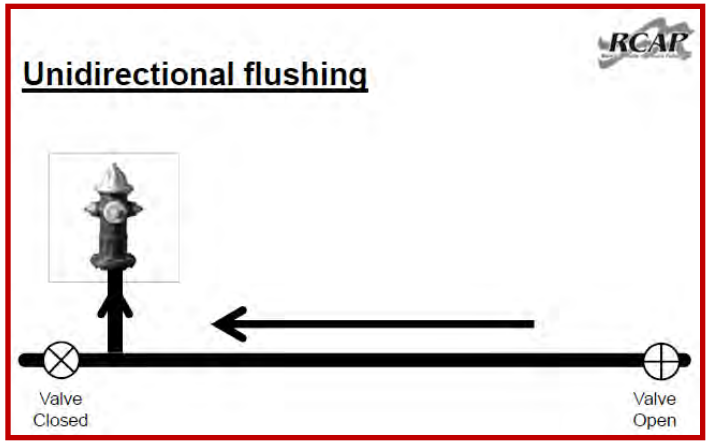
Conventional – Reactive



Expulsion of poor quality water.

Unidirectional – Proactive



Maximizes scouring velocities

- Unidirectional flushing maximizes cleaning velocities.
- Unidirectional flushing lowers water use for maintenance.
- Unidirectional flushing requires operational valves.

"Best Management Practice" Unidirectional Flushing

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- Increased friction from sedimentation and/or encrustation can significantly reduce the available pressure and flow. Maximizes scouring velocities. Uses up to 40% less water!
- Can be combined with other maintenance activities (valve exercising, hydrant operation, performance monitoring)
- Provides long-term improvements and performance baseline for future comparison. Hydrants should periodically undergo flow testing to provide data on distribution system performance and fire flow capabilities.
- Record start time, static pressure, sustained rate of flow, length of time of flushing, and discharge pressure.
- Discharge water pressure to must be maintained above the minimum operating pressure of 20 psi.

General guidelines for an effective flushing program.

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- Flush all water distribution mains that are less than 12 inches in diameter. Transmission mains typically have enough flow velocity to be cleaned continuously.
- Start at the plant and work outward, larger pipes to smaller pipes (easier to create high velocity). Flush from cleaner pipe to dirty pipe (clean source)
- Identify sequence for opening and closing valves in advance. Size work orders for completion by the flushing crew in 1 day. Limit flush lengths to an average of 1,500 ft.
- Always open the hydrants fully, never leave them open partially. This is a manufacturer's recommendation to properly lubricate the threads, to fully cleanse the drain holes, and to allow all foreign material to pass properly.

Time and velocity of flush necessary to clean water lines.

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- The amount of water in the main, and therefore the amount that must be flushed out, can be calculated by simple pipe volume formulas, such as:

  Length of Pipe x [pi x (Diameter^2/4)] = cubic feet, so; for
  1,000 linear feet of 6-inch diameter pipe (6”/12 inches per foot = 0.5 feet diameter):
  1,000 linear feet x [3.14 x (0.5^2/4)] = 196 cubic feet

  There are 7.48 gallons per cubic foot of volume, therefore:
  196 cubic feet x 7.48 gallons per cubic feet = 1,469 gallons.

- The hydrant should remain open long enough to move twice the storage capacity at a minimum flushing velocity of 5 ft. per second.
- Chlorine levels should be tested to document effectiveness of the flush and insure water freshness.

Pipeline Condition Assessment and Performance Monitoring

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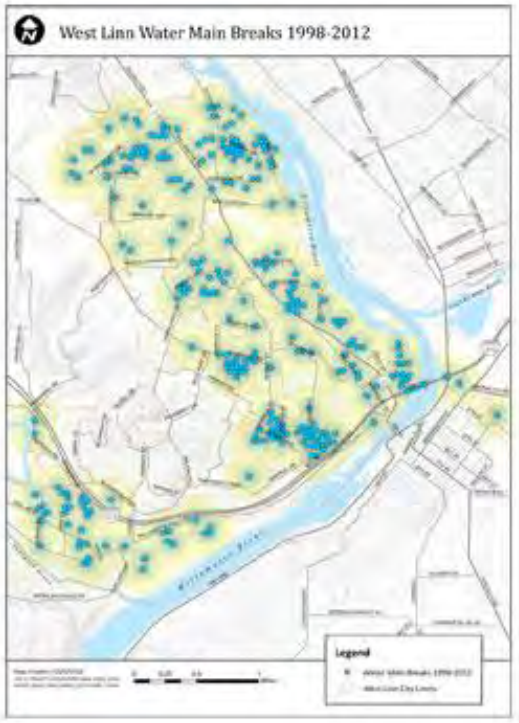
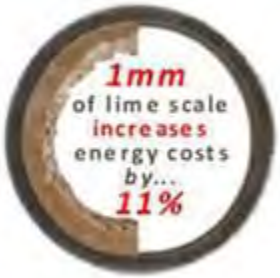
- Track water main breaks
  - Location
  - Cause of Failure
  - Condition of Pipe (Scale)
- Monitor Pressure and Flow
- Real Water Loss





Benefits of this approach!

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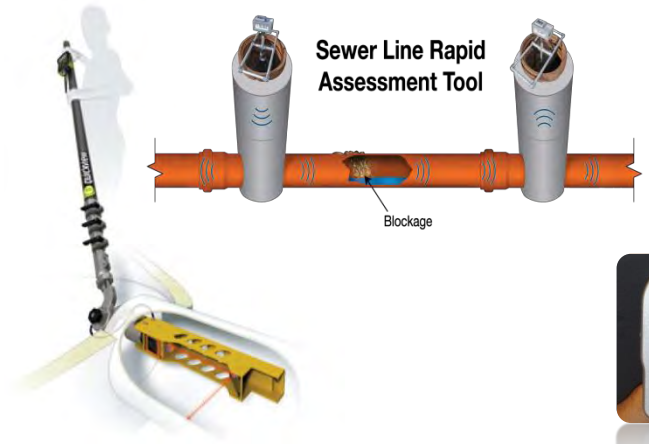
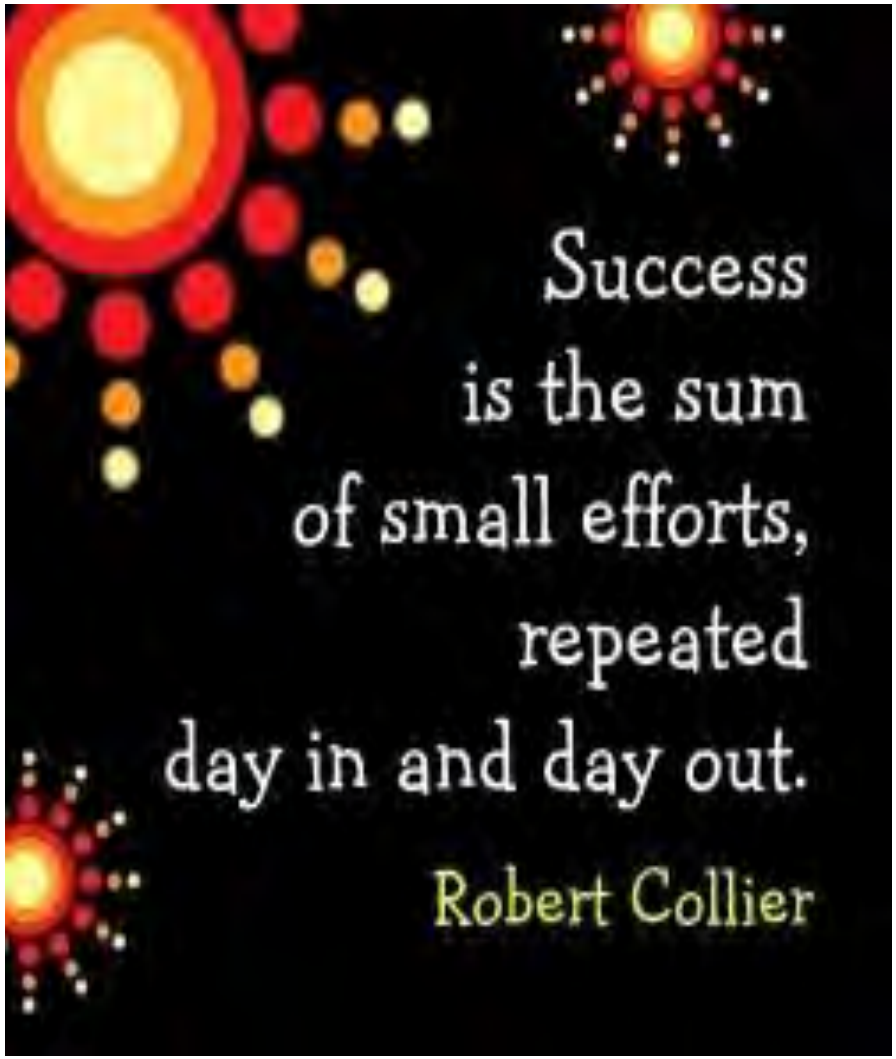
- Emphasize sustainable maintenance solutions over unaffordable capital projects.
- Address the REAL cause of asset failure.
- Reduce the waste of precious capital resources.



Improve reliability and sustainability of utility systems in small rural communities cutting edge technology.

Questions



Questions?

Upcoming Webinars

Friday Sept 29th

Budgeting for Sustainability