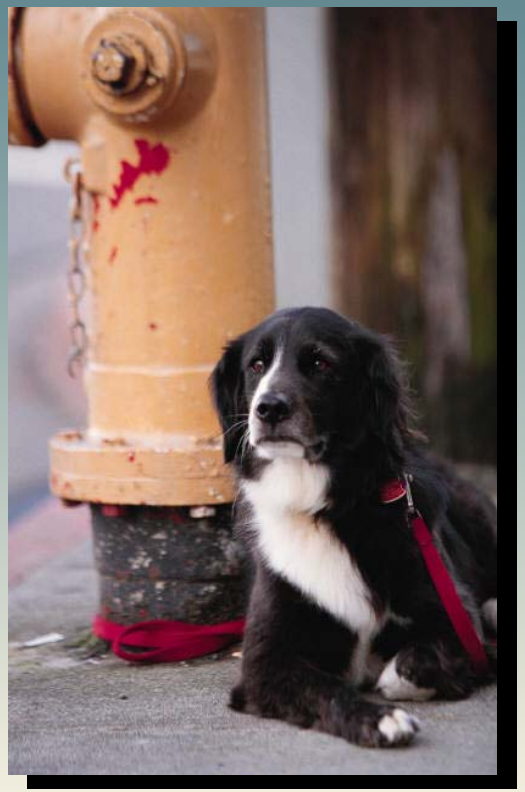
Developing and Implementing a Unidirectional Flushing Program

… And Why Bother



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Why Flush?

- **Key maintenance function in the "toolbox" for controlling water quality in distribution systems**
  - Pipe cleaning – remove accumulated deposits that can harbor microbes, exert chlorine demand, and degrade aesthetic quality, etc.
  - Remove stagnant or degraded bulk water
- **Is "available" to everyone with a distribution system and hydrants**

Why Flush?

- **Works in conjunction with – and not as a substitute for – other best practice "tools"**
  - Treatment (reduce solids loading)
  - System Operation (water age control)
  - Monitoring
- **Particularly valuable for small systems that lack source treatment or POE control of WQ**
  - Many small systems are groundwater-supplied and lack the "barriers" of filtration and/or secondary disinfection

Three-Step Approach to Developing a Flushing Program

Step 1

- Defining the Program:

  Appropriateness, Objectives, and Methods

Step 2

- Implementation:

  Planning, Coordination, and Field Activities

Step 3

- Evaluation and Refinement:

  Data Management and Response

Step 1: Defining the Program Appropriateness – Who Should Consider Flushing?

Indicators

- Frequent water quality customer complaints?
- Elevated levels of HPCs? Positive coliform results?
- Difficulty maintaining disinfectant residual in parts of system?
- Sediment accumulation in reservoirs/dead-ends?

Risk Factors

- Unfiltered system?
- Low-level loading of turbidity, Fe/Mn?
- Lots of old or corroded unlined iron pipe?
- Planning to implement a treatment change?

Step 1: Defining the Program
Is Flushing Feasible?

- **Are adequate resources available?**
  - UDF = labor-intensive
- **Is adequate water available?**
  - To support target velocities
  - "Fire-flow quantities" sustained
  - Can water be safely discharged?
- **Is flushing all or only part of the solution to the problem?**

Is Flushing Only Part of the Solution?

- **Suited to mains ≤ 12” diameter**
  - Alternative strategies for larger mains
- **May not work well on some deposits**
  - Coatings (e.g., Mn), corrosion scale
  - “Red water” equilibration response
- **More aggressive techniques may be warranted**
  - Pigging
  - Rehabilitation/relining
  - Replacement of old, deteriorated piping

Step 1: Defining the Program
Which Flushing Method to Use?

- **Conventional**
- **Unidirectional (UDF)**
- **Automatic Stations (AFS)**
  - Devices for dead-end blow-offs

Comparison of Flushing Methods

Conventional

- Hydrant draw without valving.
- Cannot control water source or velocity. Typically pulls water from multiple mains resulting in low velocities.
  - Deposits are stirred up. Some are removed while others are simply moved.
  - Can produce a long-term turbidity "bleeding effect".
- Mainly to displace bulk water (scour usually not achieved)
- Typically reactive and localized

Unidirectional

- Organized, sequential valve and hydrant operation pulls water thru a defined stretch of pipe.
- Start at clean water "fronts" and work towards system extremities.
- Control over the origin, direction, and velocity of water.
- Deposits are scoured & removed, and pipe is replaced with clean water.
- Can be targeted to specific areas or be system-wide (with area-specific frequencies)

Comparison of Flushing Methods

Conventional	Unidirectional
Limited WQ benefit (may actually create problems)	Greatest WQ benefit
Quick-fix response and minimal planning required.	Labor-intensive and requires extensive initial planning for smooth execution (though much of planning is one-time)

- Distinct tradeoff between level of effort and benefit achieved
- Both will continue to have a role, but strong industry push for UDF

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Unidirectional Flushing

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Description

From Wikipedia, the free encyclopedia

Unidirectional Flushing (UDF) is a utility maintenance function used to scour unwanted deposits and biofilm from the internal surfaces of water distribution system mains to improve drinking water quality. It involves passing clean water from a pressurized upstream source through a defined stretch or segment of piping and discharging through a fire hydrant or blowoff assembly. Valve exercising is used to isolate specific pipe stretches and provide control over the origin, direction, and velocity of the flow. Control over these variables is needed to ensure that adequate scouring forces are achieved and the pipe volume is replaced with clean water. Multiple pipe stretches (often referred to as loops) are flushed in sequence to achieve area-wide cleaning.

Step 2: Implementation of UDF Program
6 Essential Planning Elements

1. **Obtain updated and detailed system mapping**
   - Pipes/sizes, valves, hydrants, blow-offs (w/ asset ID tags)
   - Flow directions from hydraulic model
   - Create overlay with storm, sewer, and surface street maps
2. **Coordinate stakeholders and define responsibilities**
   - Internal: Program Manager, O&M, Engineering/GIS, Customer Service
   - External: Customers, Other Departments (Fire), Connected Systems
3. **Obtain field equipment and necessary permits**

Step 2: Implementation of UDF Program 6 Essential Planning Elements (Cont.)

4. **Develop and refine the "flushing loops"**
   - Part Art – Part Science – Part Iteration
     - Most time-intensive part of planning – but is "one-time"
   - Break system into small, manageable areas (1-10 miles each with a clean water source) that can be flushed independent of other areas
     - Provides flexibility for prioritizing certain areas for repeat flushing
     - Allows for better management of resources
   - Create "Field Cards" to document the loop details
     - One per loop
     - Makes operators happy

Step 2: Implementation of UDF Program
"Field Cards" Make Life on the Pavement Easier

Unidirectional Flushing SOP
Step 15 of 20

Location: Hydrant 3941-013, situated just northwest of the intersection of Tarwater Avenue and Schodde Street.
Objective: Clean west portion of Tarwater Avenue.
Pipe Type: 8 inches – Asbestos Cement.
Setup: Use 4.5-inch port.
Disposal: Dechlorinate and diffuse toward storm catch basin on northeast corner of Tarwater Avenue and Schodde Street.

Flow Requirements

Target Velocity: 4 ft/s
Target Flow Rate: 627 gpm
Target Pitot Pressure: 14 psi

Sample Collection

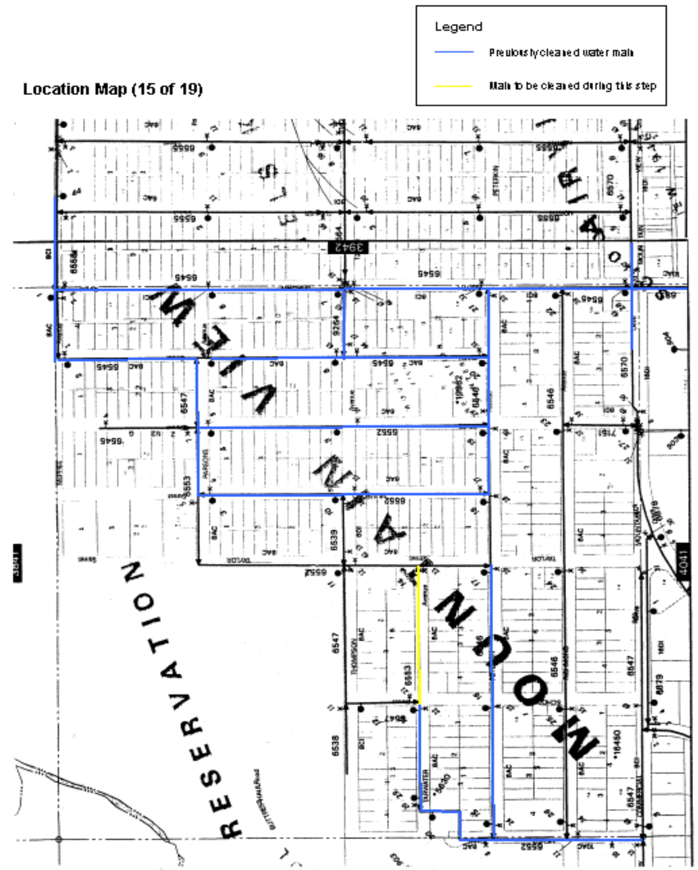
	4 fps	6 fps
Immediately	○	○
Midpoint	○	○
Completion	○	○

Pre-Flush Valve Sequencing

(1) Open valve 3941-019.
(2) Open valve 3941-020.
(3) Close valve 3941-022.
(4) Open hydrant 3941-013.

Post-Flush Valve Sequencing

(1) Close valve 3941-020.



Step 2: Implementation of UDF Program
6 Essential Planning Elements (Cont.)

5. Perform valve/hydrant pre-inspection and maintenance as-needed

- Field "walk-through" several weeks before actual flushing
- Inspect and exercise every valve and hydrant in the target area – not just those operated in loops
- Critical to smooth implementation of flushing activities
  - Has caught (or would have caught) potential major issues
  - Also used to assess feasibility and constraints for loops
- … also provides enforced asset inspection activities
  - AWWA recommended
  - Many utilities otherwise don't get around to doing

Step 2: Implementation of UDF Program
6 Essential Planning Elements (Cont.)

6. Public and customer notification

- Highly visible activity (lots of water, discolored, etc.)
- Educate the public regarding need for program
  - Can prevent complaints and tons of questions
  - Can strengthen customer-service image of utility
- Advanced notification to customers in affected area
  - Timeframe for activities
  - FAQs and answers
  - Variety of notification media
- On-site signage to inform general public

Step 2: Implementation of UDF Program
3 Key Technical Aspects of Field Activities

- **Flushing Velocity**
- **Duration of Flush**
- **Monitoring and Data Collection**

Step 2: Implementation of UDF Program
Role of Flushing Velocity

- **Flushing velocity determines scouring force**
- **Target velocity depends on "cleaning objective" and site-specific conditions**
  - Pipe material and condition (tuberculated?)
  - Time since and method of last pipe cleaning

Velocity Range	Typical Objective/Benefits
2 – 4 fps	• Bulk water turnover • Remove loose sediment
6 – 8 fps	• Scour scale and tubercles • Thin biofilm layers • Remove Mn coatings

- **Use "stepwise test" to determine your optimum**
  - Flushing at sequentially increasing velocity (4→7→10 fps) on a given loop accompanied with WQ monitoring or particle capture

Flushing to Capture Deposits

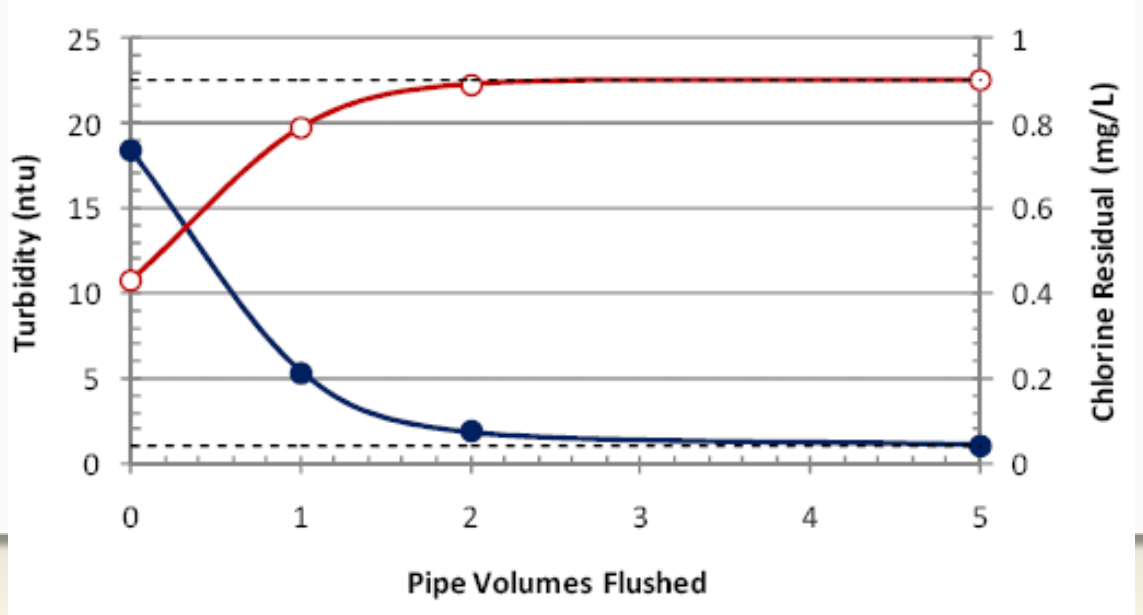
Special socks can be used to capture solids from hydrant flushing events.

Other “Solids” from Flushing

- Leaves, dirt and bark chips
- Rocks and pebbles
- Cat carcass

Step 2: Implementation of UDF Program Duration of Flush

- **Disposal constraints (flooding)**
- **Use "flush-terminating" criteria**
  - Monitor discharge water quality
    - Restore turbidity and disinfectant residual to clean water value
  - Turn-over at least 2 pipe volumes
    - Simple field calculation based on length of main and velocity
  - Don't just rely on visual appearance



Step 2: Implementation of UDF Program Value of Monitoring and Data Collection

- ✓ Quantify WQ benefits of flushing
- ✓ Determine when to terminate a flush
- ✓ Explore effectiveness of differing velocities
- **Establish end-of-flush (new baseline) WQ conditions**
  - Can be used with routine and diagnostic DS monitoring results (inc. customer complaint response monitoring) to determine when to flush again and to establish area-specific UDF frequencies
- **Manage data for effective decision-making**

Step 3: Program Evaluation and Refinement

- **Address some basic questions**
  - Were water quality improvement objectives met?
  - What was the level-of-effort and costs?
    - Consider one-time v. repeat labor efforts
  - Were there positive secondary aspects?
    - Decreased customer complaints (may take time to tell)
    - Increased system performance and reliability
    - Updated mapping and system understanding
    - Improved asset management
  - Were there negative secondary aspects?
- **Assess pros/cons and costs/benefits and refine the program as appropriate**

Step 3: Evaluation and Refinement

- **Use Indicators and Risk Factors to determine "where" and "how often" for prioritization of future UDF**

Group	Parameter	Examples, Recommendations
Indicators	• Customer complaints	Geospatial tracking; follow-up monitoring for color, turbidity, T&O, bacteria, disinfectant residual.
	• Routine and response monitoring	Disinfectant residual (grab samples and online analyzers), HPC, coliform, turbidity, Fe/Mn.
	• Historical practices	Track UDF history; identify chronically bad areas.
Risk Factors	• Proximity to unfiltered source	Turbidity, Fe/Mn deposition.
	• Pipe material and condition	Prioritize areas with unlined iron and corroded or encrusted older pipes.
	• Hydraulic conditions	Prioritize low-flow and dead-end areas.
	• System changes	New treatment, piping mod's, construction work. Perform impact assessment prior to change.

Conclusions

- **An effective UDF program requires significant resources and planning for smooth implementation**
- **Flushing has many "system- and site-specific" elements, including velocity effectiveness and optimum frequency of repeat future efforts**
  - Data collection and management are critical
- **If you are going to flush, it is worth the time and money to tailor the program to meet your utility's objectives and constraints**
  - A pilot UDF program conducted in a portion of a system is a proven and popular way to provide tailored program startup, technical support, and staff training.

Questions?

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