

# **Establishing Site-Specific Flushing Velocities [Project #2606]**

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**PRINCIPAL INVESTIGATORS:**

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**OBJECTIVES:**

Utilities need guidance related to appropriate flushing velocities in order to achieve a balance between water quality improvements, demand for O&M resources, and water conservation. The objective of this project was to determine the range of flushing velocities required to dislodge and remove various accumulated materials from water distribution mains based on site-specific conditions.

**BACKGROUND:**

Historically, utilities have flushed water mains in response to customer complaints or following maintenance work. Today, many utilities are implementing regular, structured flushing programs as part of a multifaceted strategy to maintain water quality in the distribution system. The more common objectives of flushing are (1) replacing stale water, (2) removing loose deposits, and (3) scouring (i.e., cleaning) the internal pipe surface. The focus of this study was on the latter two objectives.

**HIGHLIGHTS:**

The highlights of the project included the following:

- A computational fluid dynamics (CFD) model and resultant graphics were developed to determine the fractional area of pipe cleaned, based on flushing velocity, pipe condition, and particle specific gravity (for loose particles only).
- A detailed field protocol was developed for collecting particle samples using hydrant nets and bulk water samples during flushing.
- Primary and secondary variables were identified to help establish likely particle type (i.e., loose, compacted, adhered) and quantity.
- A Flushing Velocity Decision Tree Tool was developed to determine the most appropriate site-specific velocity.

**APPROACH:**

The project was broken into five tasks: (1) an evaluation of existing information through a literature review, utility survey, and utility case studies; (2) characterization of accumulated materials; (3) CFD modeling and pilot studies using pipe sections removed from distribution systems, as well as seeding a test rig with various particles; (4) field testing of low and high velocities at 12 different utilities with varying water quality concerns; and (5) development of site-specific velocity recommendations. After completing the first task, it became apparent that little published information was available on materials characterization, and that additional field sampling would be needed. Therefore, tasks 2 (characterization of accumulated materials) and 4 (field testing) were completed concurrently.

**RESULTS/FINDINGS:****Particle Occurrence and Type**

- Iron was the primary constituent measured in most samples, regardless of finished water quality, pipe type, or flushing velocity.
- The average specific gravity of particles removed from various distribution systems was 2.9, for both the low and high velocity flushes.

- Pipe material has a stronger influence on particle composition and quantity than finished water quality.

#### **Flushing Approach**

- Utilities that had never flushed before using a unidirectional approach benefited significantly from flushing at a high velocity, e.g.,  $\geq 5$  feet per second (fps).
- Utilities that had recently flushed (within 4 to 6 years) using a unidirectional approach received little benefit from flushing at a high velocity ( $\geq 5$ fps), versus the lower velocity (2 to 4 fps).
- Dead-end flushing is not effective unless the hydrant or blow-off is located at the pipe terminus.

#### **Velocity Recommendations**

- Loose particles, including corrosion particles, iron sludge, sand, and iron floc, are removed from smooth or slightly tuberculated pipes at low velocities (2 to 4 fps).
- Universal contaminant-specific velocities could not be recommended because other factors such as time since last flush, flushing approach, routine flow velocity, pipe condition, and finished water quality tend to control whether the particles are loose, compacted, buried, or adhered.

#### **IMPACT:**

##### **Labor and Water Savings**

- Lower velocities (2 to 4 fps) can remove nearly all loose deposits from smooth and slightly tuberculated mains.
- Distribution systems may contain miles of “self-cleaning mains,” i.e., smooth or slightly tuberculated mains with routine velocities between 2 to 4 fps. These mains can be identified and placed as a lower priority for routine flushing.
- Iron particles were present in every sample, regardless of the pipe material that was flushed. Unidirectional flushing removes particles from the system and reduces particle transport to other mains. Unidirectional flushing should reduce the frequency of flushing needed.

#### **PARTICIPANTS:**

Twelve utilities from three countries (United States, United Kingdom, and Australia) participated in this study.

#### **RESEARCH PARTNER:**

Kiwa