Unidirectional Flushing

Water Main Flushing

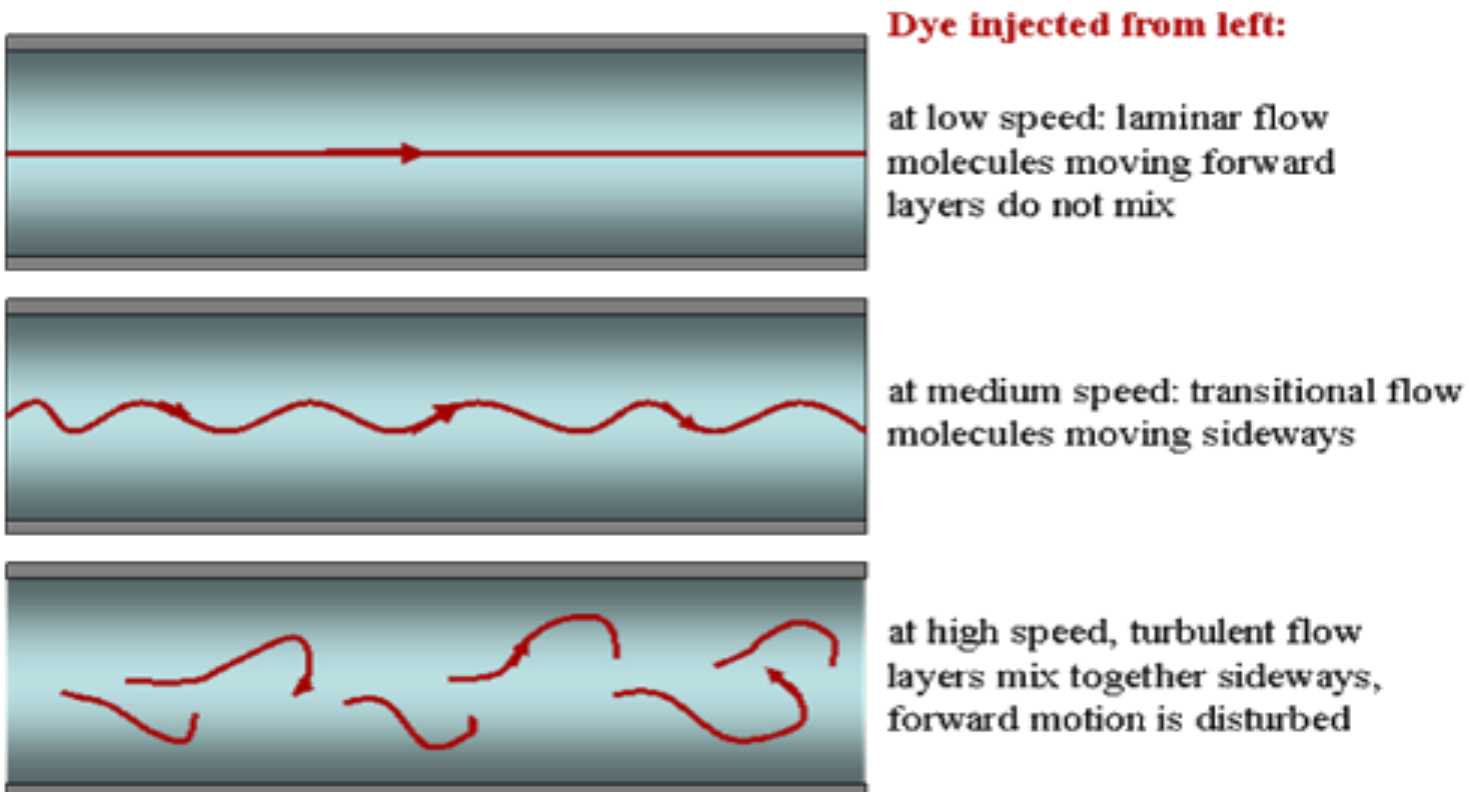
- The AWWA states that:

  Water main flushing is the best maintenance procedure to maintain water quality in a distribution system.

- Helps ensure clean fresh water is found throughout the system
- Helps remove debris and biofilms from distribution piping and reservoirs
- Helps operators locate isolation valves and understand the layout and flow pattern of the water system
- Helps with maintaining a chlorine residual at the ends of the water system
- Helps with reducing taste and odour complaints from water system users

Water Quality Concerns

- During regular use, water flow follows a laminar motion and allows sediment or debris to build up in pipes
- Only at high flow rates is a turbulent flow pattern achieved



Water Main Flushing

- Flushing can take many forms and can include:
  - Regular flushing of dead ends
  - Hydrant maintenance
  - Dedicated flushing procedures
  - Uni Directional Flushing
  - Swabbing
- Each flushing procedure has its advantages and disadvantages
- To be effective any flushing procedure should have clear goals and objectives

Unidirectional Flushing

- Unidirectional flushing takes the procedures and steps of a dedicated flushing program and tries to make them more efficient

- Flushing is done is a planned order to maximize flow velocities and ensure water is flowing in one direction only while flushing is occurring

Unidirectional Flushing

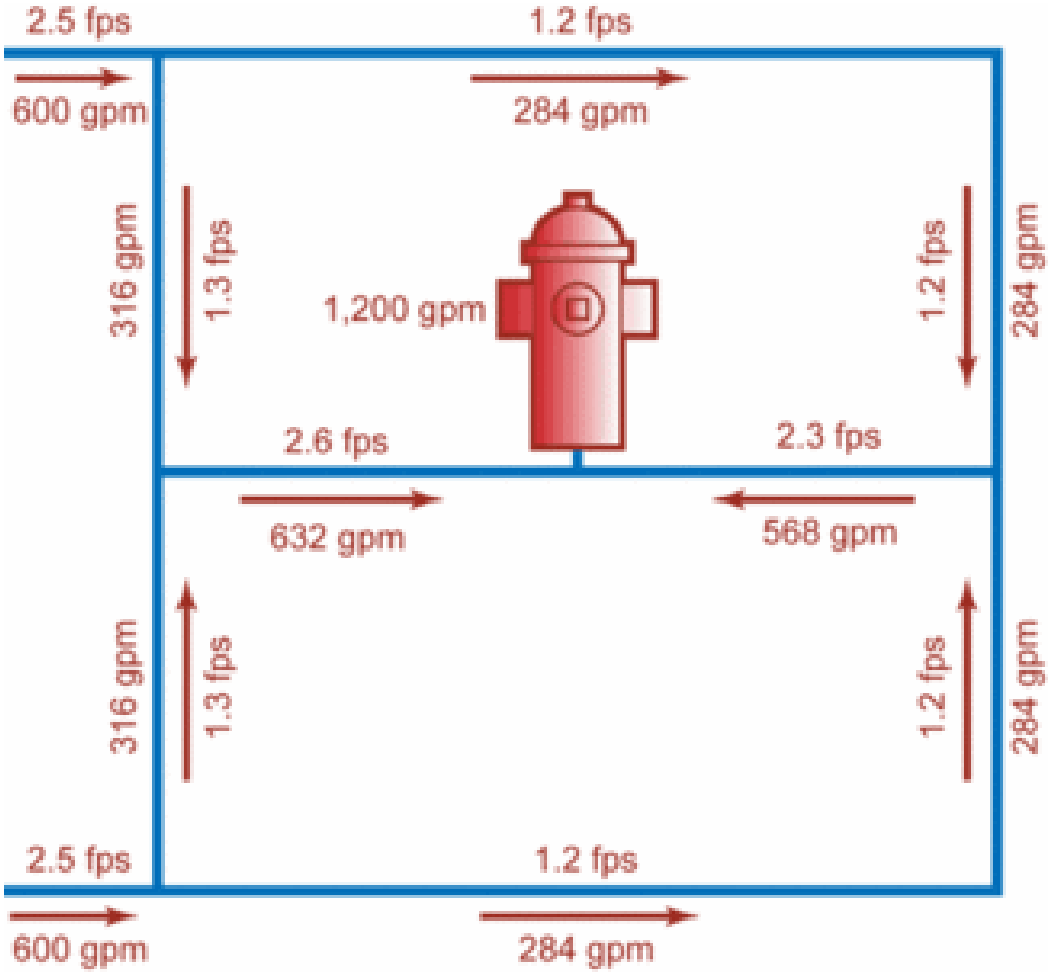
- Unidirectional flushing takes the same planning steps and requires the same equipment as a regular flushing program.

- The difference is that the unidirectional plan takes steps to ensure that:
  - Water flows in one direction only
  - Maximum scouring velocities are achieved

  - AWWA recommends minimum velocities of:
    - 0.91 m/sec (3.0 ft/sec) to remove sediment
    - 1.5 m/sec (5 ft.sec) to remove biofilm

Flushing Procedures

- Recommended flushing velocities may not be achieved during flushing due to the flow pattern taken by the water
- Water quality concerns may not be met due to inadequate flushing
- Debris may be pushed around the system without being removed



Unidirectional Flushing - Planning

- Planning and executing a unidirectional flushing plan for the first time can take a lot of effort.

- There are numerous steps that need to be done before any results are seen. It is best to assign one person to be in charge of the program and then have that person look after or delegate the required tasks.

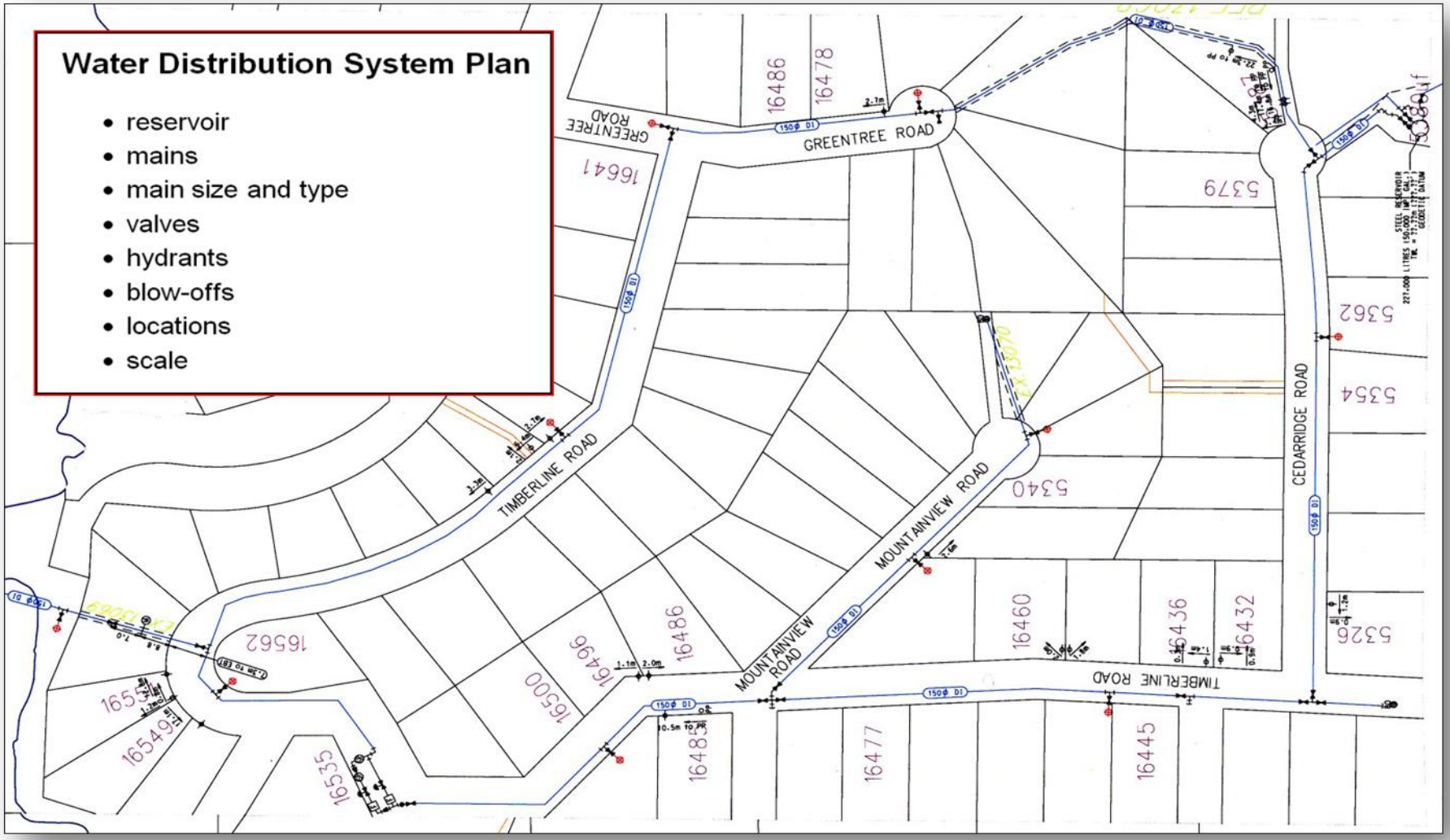
- A unidirectional flushing plan is always changing and evolving as the priorities, regulations, and infrastructure of the water system change

Unidirectional Flushing - Planning

- Additional staffing and time will be required to do tasks such as:
  - Writing up procedures for the flushing program
  - Writing up the required flushing runs
  - Locating and ensuring isolation valves are operational
  - Servicing flushing points
  - Collecting and organizing field data
  - Assessing the flushing plan and making adjustments

System Maps

- Good system maps are essential to planning a unidirectional flushing program
- Maps may need to be updated with field data before the program is put in place
- Flushing program may assist with locating missing valves or blow offs. It may also help with planning new installations
- Maps should be of the comprehensive type and show all valves, hydrants, and inline control valves.


Water Distribution System Plan
reservoir
mains
main size and type
valves
hydrants
blow-offs
locations
scale
GREENTREE ROAD
GREENTREE ROAD
TIMBERLINE ROAD
MOUNTAINVIEW ROAD
MOUNTAINVIEW ROAD
CEDARRIDGE ROAD
TIMBERLINE ROAD
16486
16478
16641
5379
5362
5354
5340
16562
16549
16535
16500
16499
16486
16460
16436
16432
5326
16483
16477
16445

System Maps

- When looking at the maps, you can start a plan for flushing from the source to the ends of the lines.
- The initial plan should focus on making sure the water is flowing in one direction. Flows can be measured in the field and the plan adjusted if scouring velocities are not achieved.
- The closing of valves should not result in any customers being without water for the duration of the flushing. People may experience a pressure loss but system pressure should remain above kPa (20 psi)
- Plan may have to be adjusted after running through it once to prevent loss of pressure in some parts of the system

Valve Exercising

- All system valves should be located and operated. Valves can then be found when needed and will function when needed, especially in an emergency
- Undertaken annually (AWWA recommendation)
- Number of turns for gate valves is:
  - approximately 3 full turns x diameter of pipe in inches + 3
  - 150 mm (6 inch) pipe = 3 x 6 + 3 = 21 turns
  - 200 mm (8 inch) pipe = 3 x 8 = 3 = 27 turns

Flushing Runs

- When looking at the maps and making an initial plan you must consider items such as
  - Different pressure zones
  - Different water sources
  - Flow of water in and out or reservoirs
- The plan should be broken down into groups of flushing runs that can be completed in one day
- Flushing runs sequenced to move water from clean areas to dirty ones
- Each flushing run should be less than 600m of pipe length to be effective
- The same flushing point can be used for multiple flushing runs depending on the valve configuration

Flushing Runs – General Rules

- When setting up your flushing runs keep in mind some of the general rules of effective flushing:
  - Flush from cleaner mains to dirtier mains
  - Flush from larger mains to smaller mains (flushing is not effective in mains over 300mm)
  - Flush from higher pressure area to lower pressure
  - Shorter to medium sized runs are more effective (600m max)
  - Flush long enough to do two turnovers of water in the pipe
  - Flushing until water quality is acceptable
  - Retain at least 140 kPa (20psi) in the water system
  - Customers should not lose water service due to flushing

Flushing Runs

- Flushing runs also need to take into consideration the needs of the high water consumers such as
  - Schools
  - Hospitals
  - Nursing homes
  - Commercial users such as car washes, dry cleaners, etc.
  - Industrial users

- Flushing may have to be scheduled for nights or weekends to minimize the impact on some users

System Maps - GIS

- GIS mapping systems may be able to set up a recommended flushing order
  - Information should be checked to ensure it is correct
- GIS may give expected flow at certain points in the system and recommended flushing times
  - Field data can be sent back to the GIS system to make it more accurate
- There are software packages that focus on unidirectional flushing programs and can offer assistance to larger systems

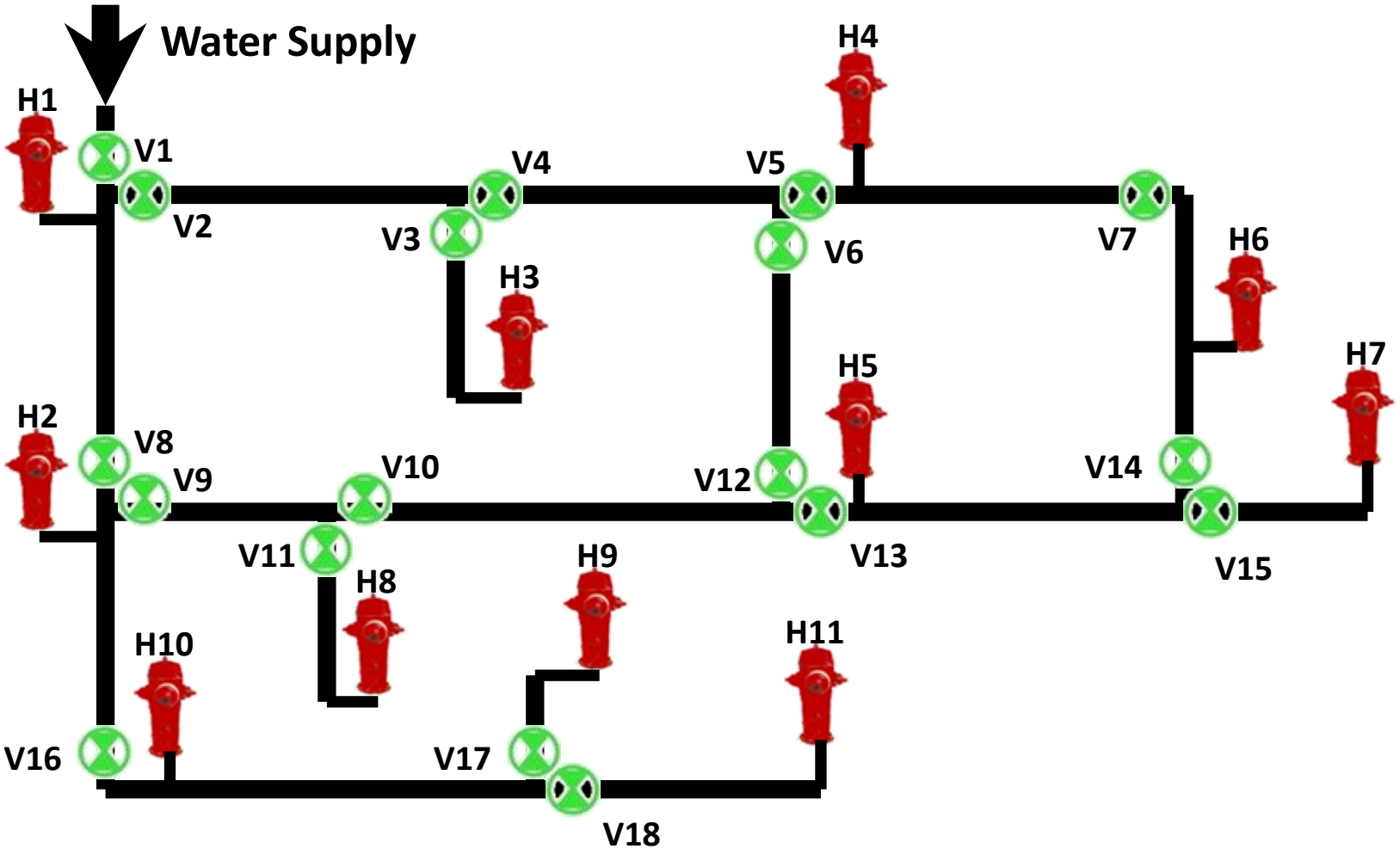
Initial Unidirectional Flushing Plan

- The initial unidirectional flushing plan does not have to have a lot of detail. Focus on the main components such as:
  - What valves need to be located and operated.
  - What hydrants or blow offs are going to be used for flushing.
  - Where static and dynamic pressure readings are going to be taken.

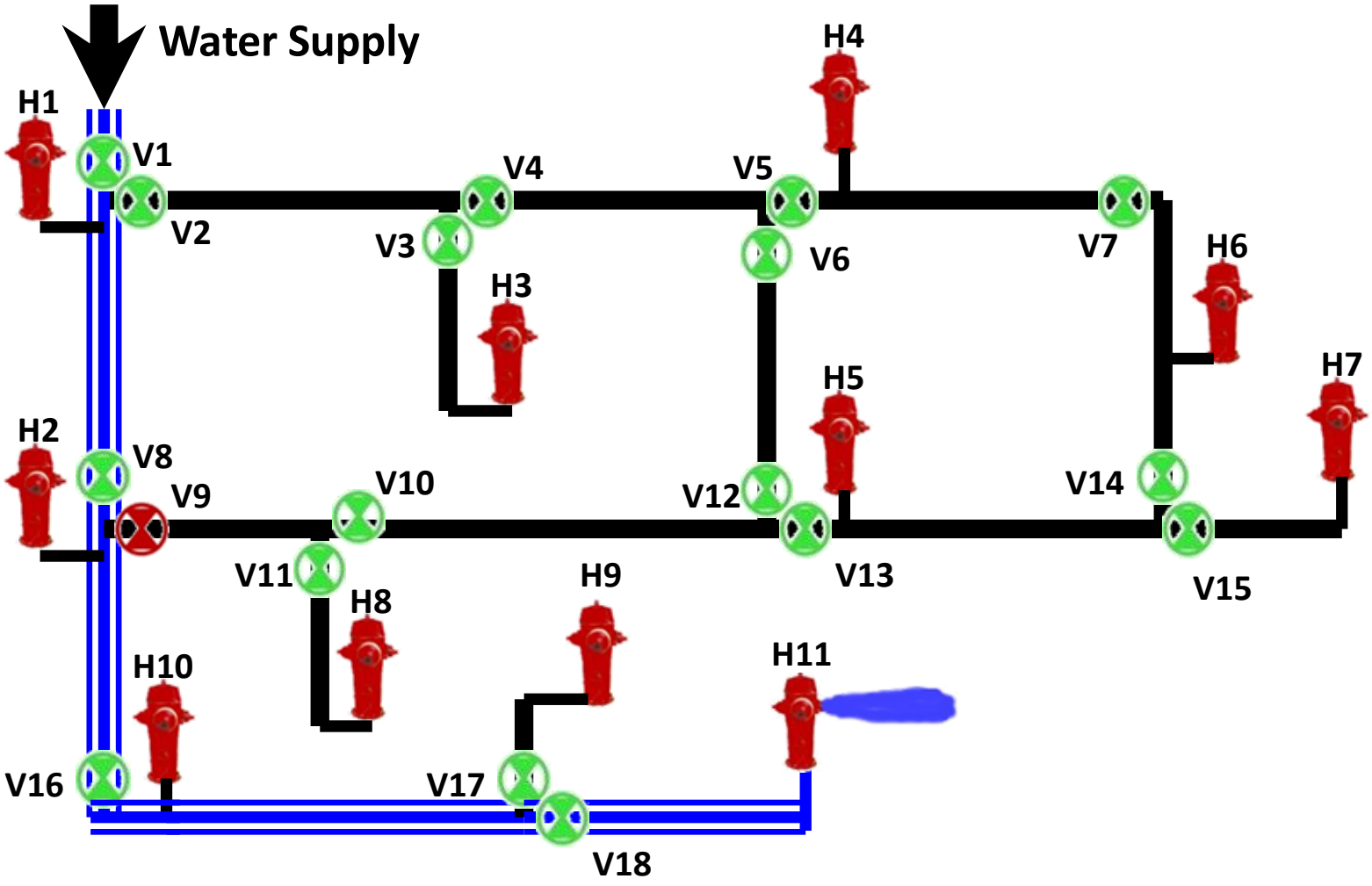
Initial Unidirectional Flushing Plan

- Plan can be as simple as making some notes on paper.
  - Run #1 – Close valve at corner of Fir and Cedar Rd. Flush from hydrant #2 at end of Cedar Rd.
  - Run #2 – Close valve at corner of Cedar Rd and Arbutus Rd. Flush from hydrant #4 at end of Arbutus Rd. Possible low pressure on Cedar Rd?
- As you work out the plan you can highlight the flushing runs on a copy of the system map.
- You are done when all the mains on the map have been highlighted.

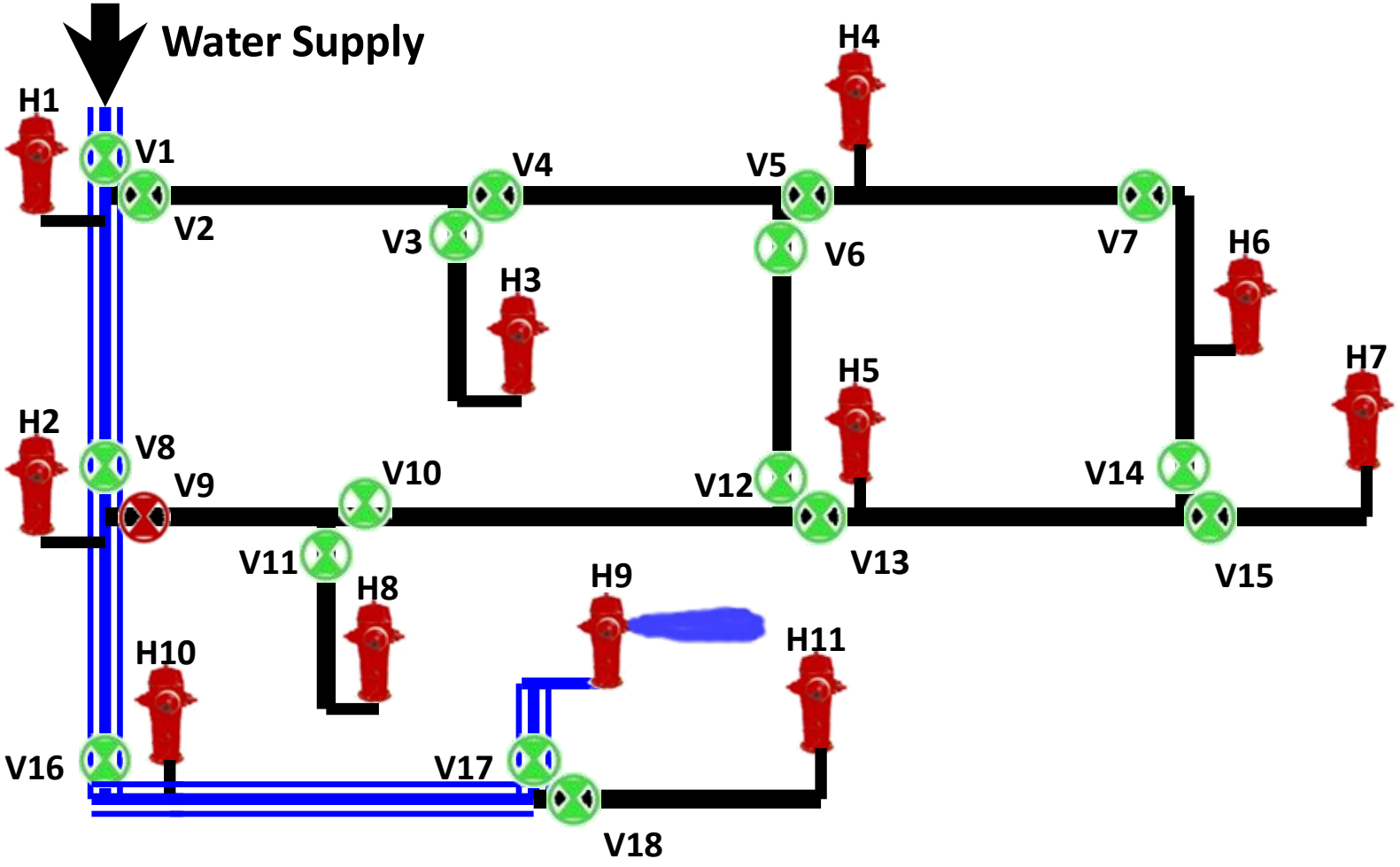
Unidirectional Flushing Plan



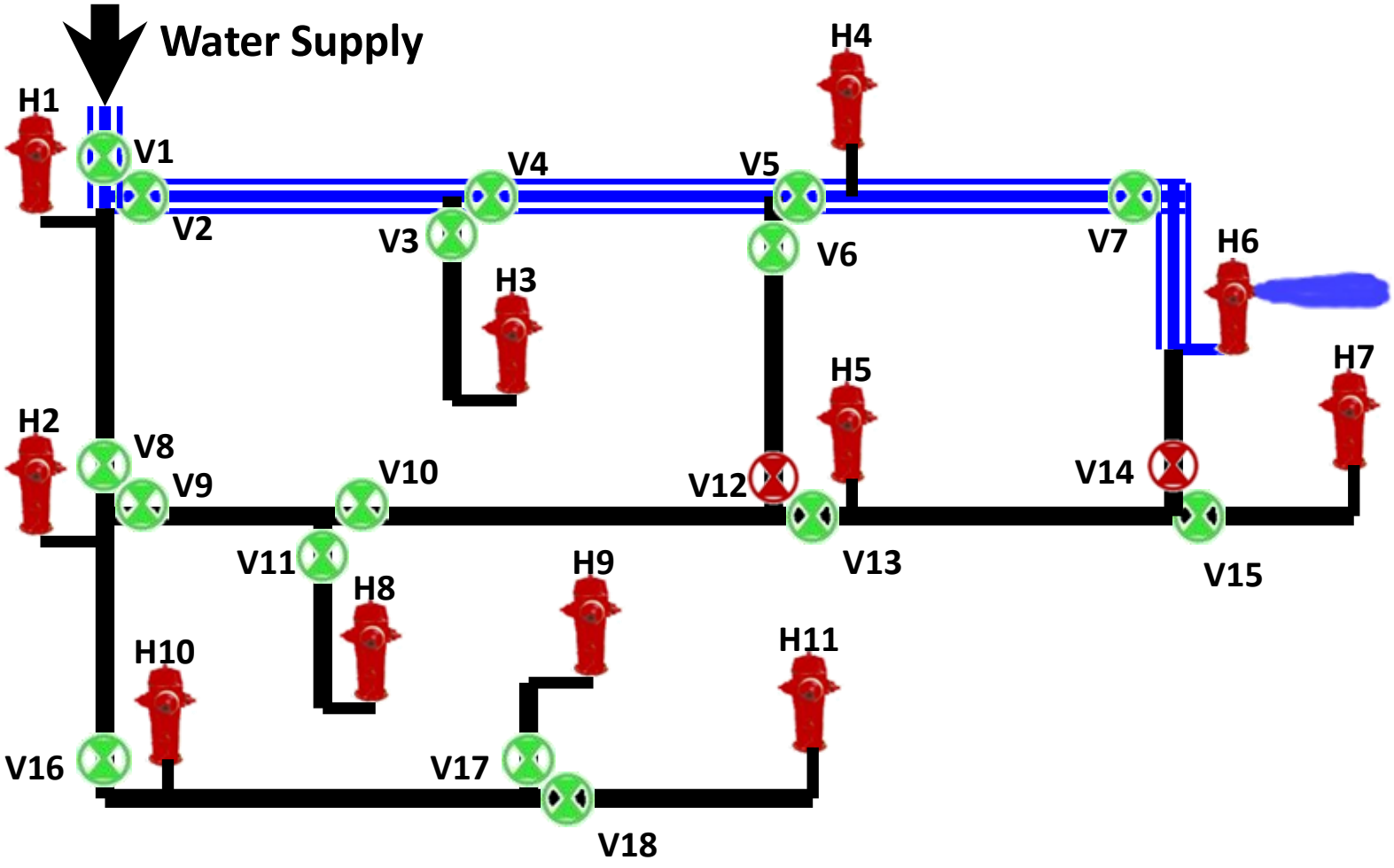
Example Run #1



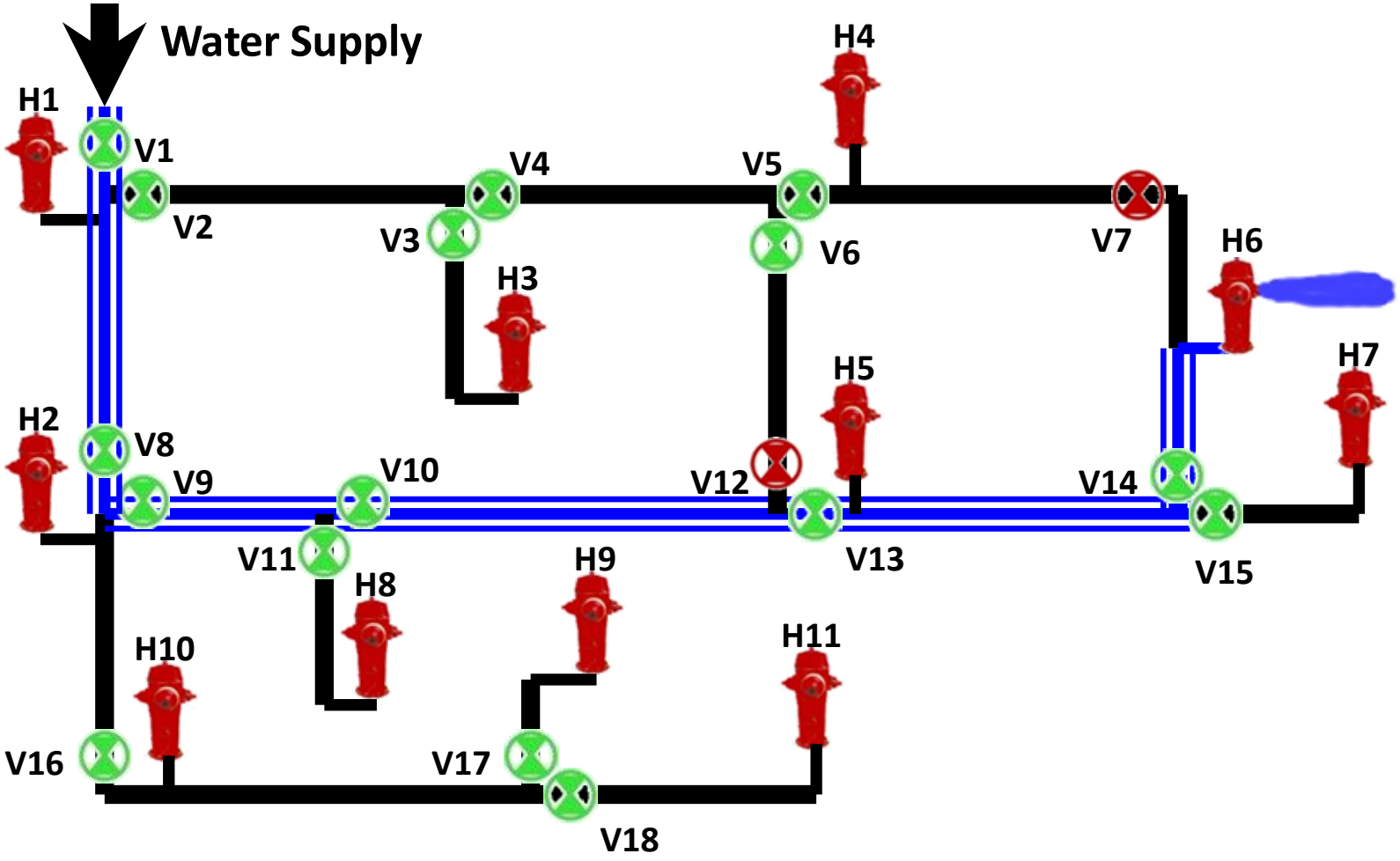
Example Run #2



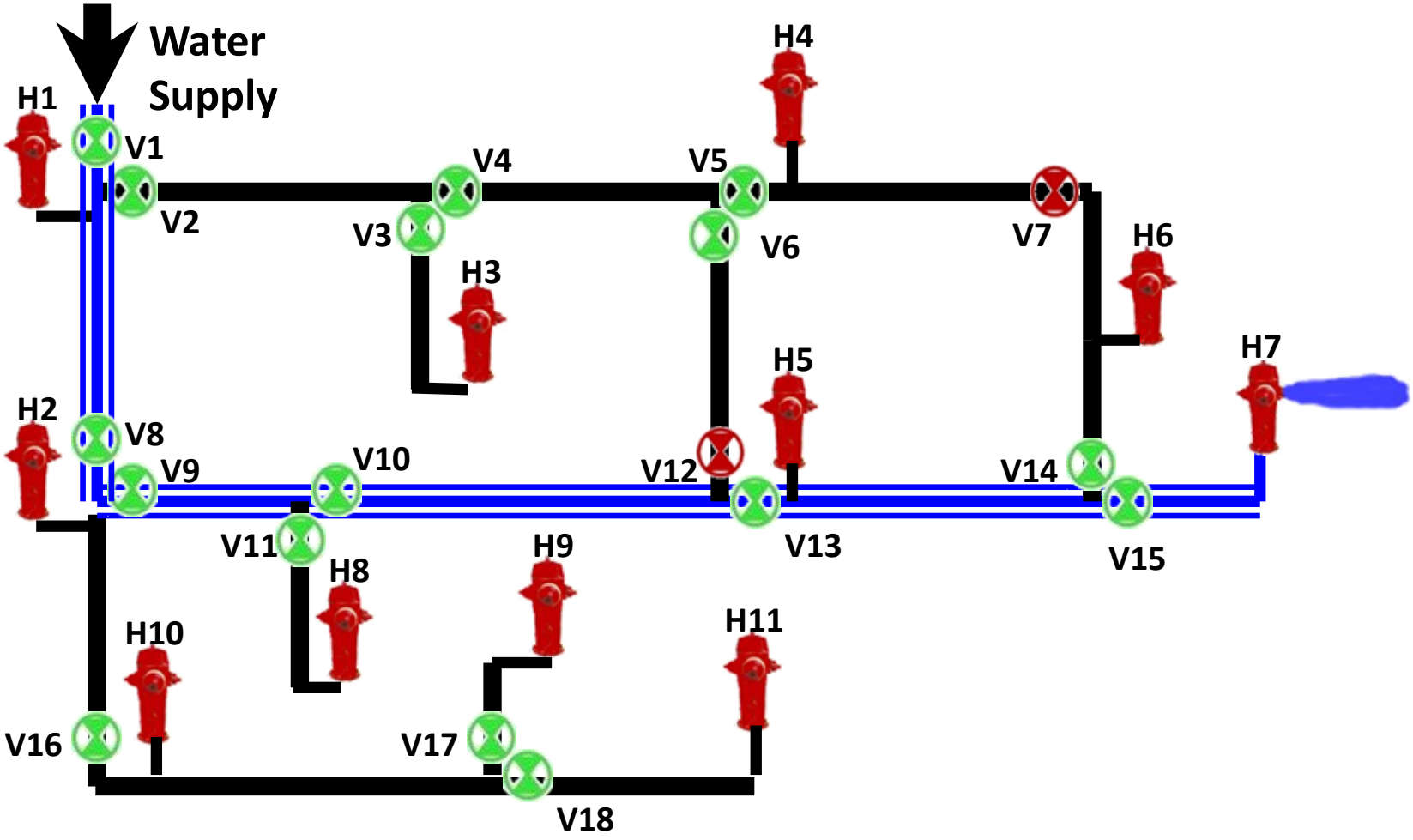
Example Run #3



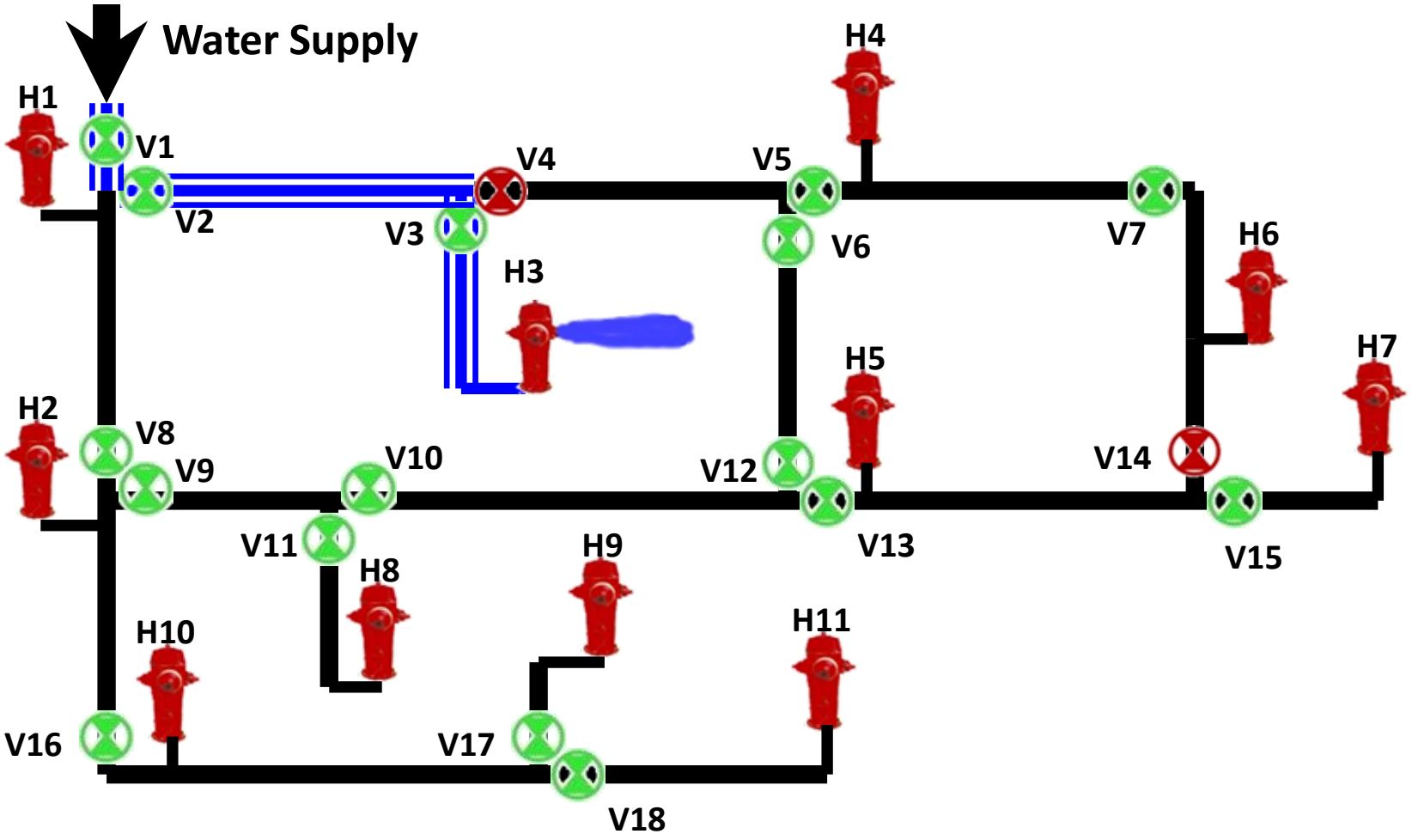
Example Run #4



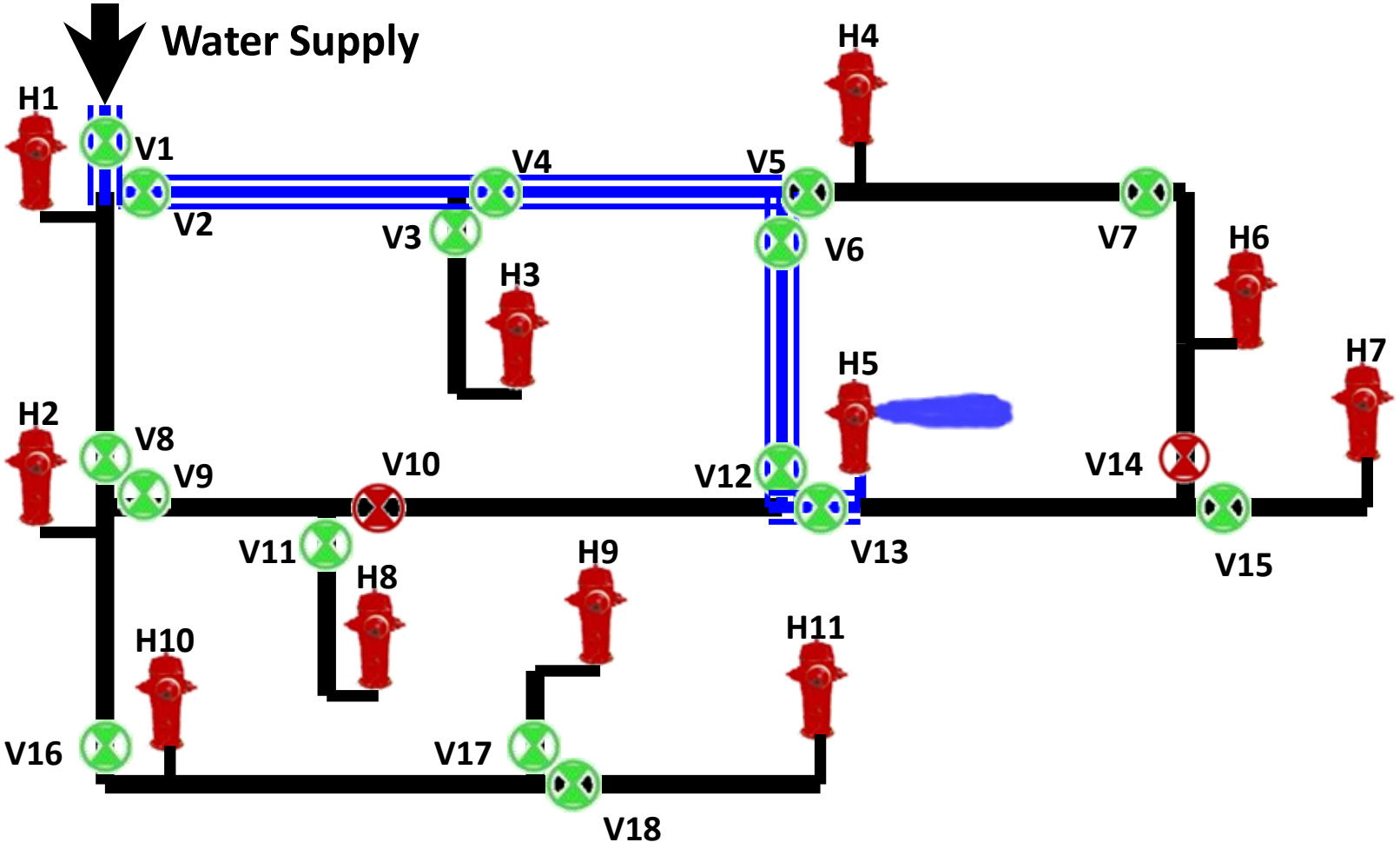
Example Run #5



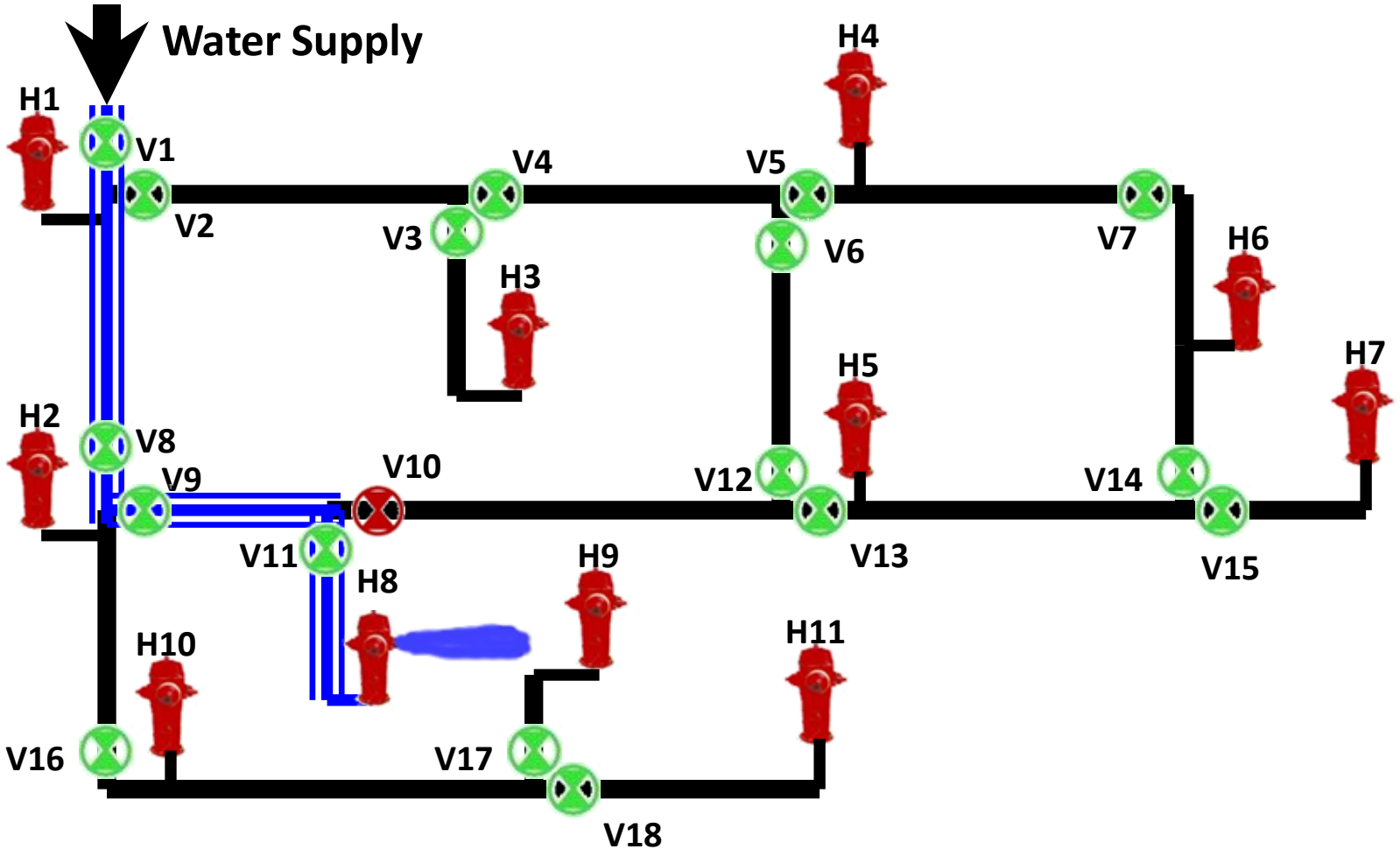
Example Run #6



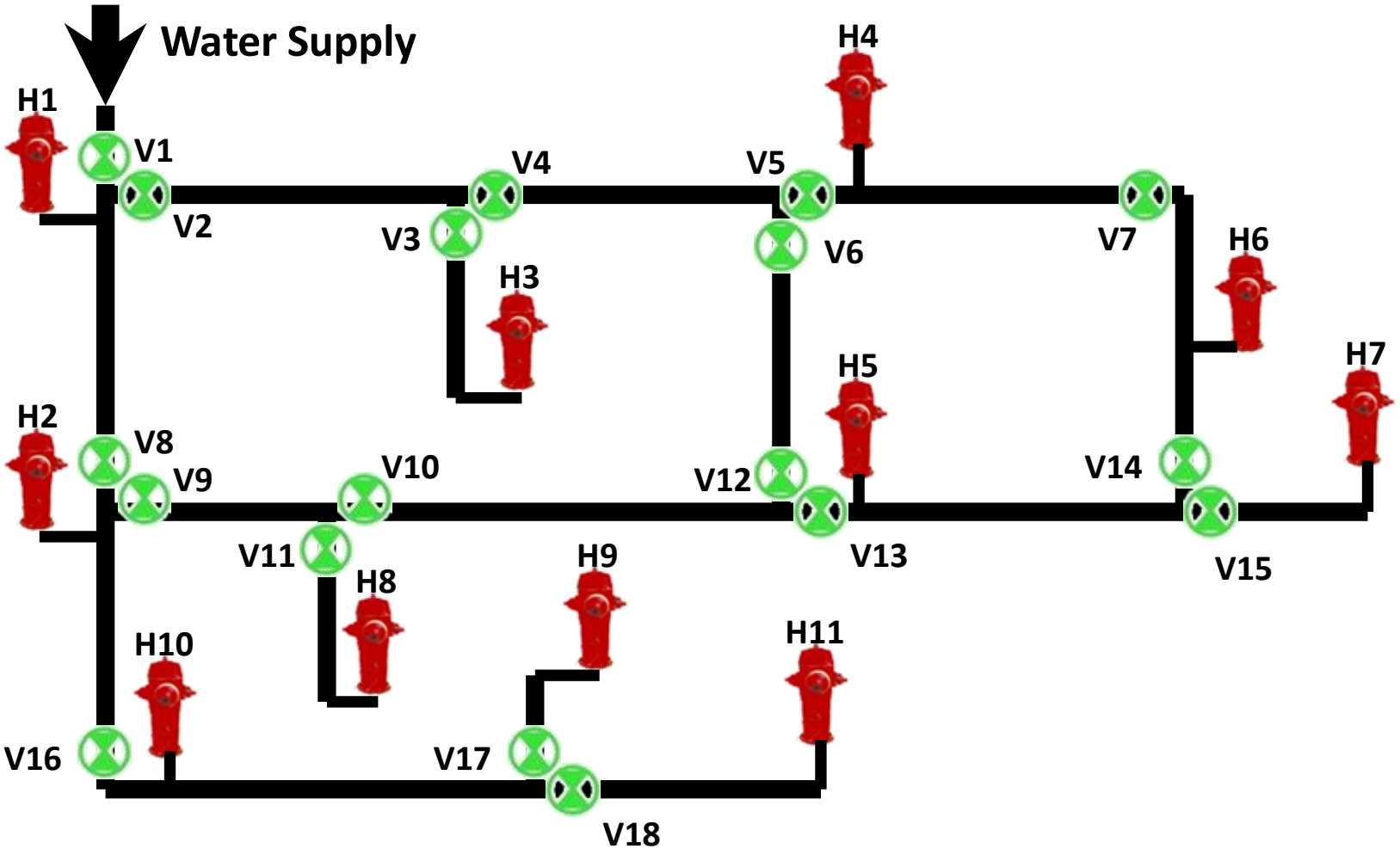
Example Run #7



Example Run #8



Unidirectional Flushing Plan



Initial Unidirectional Flushing Plan

- After finishing the initial plan, walk the system and locate all the required valves and flushing points.

- Asses each run for anything that may require additional work or a change in the plan.
  - Are the valves operational?
  - Is there infrastructure in the field that is not on the map?
  - Is there good drainage at the flushing point?
  - Are discharge hoses required?
  - Is traffic control required to complete the flushing?
  - Is there anything of concern that should be looked at while doing the flushing?

Initial Unidirectional Flushing Plan

- After doing the walkthrough you can make changes to the flushing plan.
- You can also start to add in more detail to the plan and include items such as:
  - Any notes or observations from the walkthrough.
  - Field data that should be collected while doing the flushing.
  - Recommended flushing times to achieve two turnovers of the pipe volumes.
  - Directions on valve operation and drainage locations.
  - Equipment and signage required to complete the flushing program.
  - Space to make comments while doing the flushing.
- Plan should start to be written out in a more formal way. Use a format that is easily changeable as the plan will have to be re-assessed later.

Unidirectional Flushing Program

Flushing Run #5

Purpose: Flushing main along Mt. Newton X Rd and Tetayut Rd

Approx Pipe Length	260.0	m
Pipe Size	200.0	mm
Pipe Volume	8.2	m^3
Approx Flushing Flow	3.0	m^3/min
Recommended Flushing Time	8.2	min

Date _____

Step #	Action Required	Completed
1	Close 200mm valve at corner of Tsawout Rd and Tetayut Rd	
2	Close 200mm valve by H026	
3	Take Cl_2 Residual	
4	Flush From H025 (Townhouses on Tetayut Rd)	
5	Take Cl_2 Residual	
6	Open 200mm valve by H026 (Can be kept closed if proceeding to flushing run 7&8)	
7	Open 200mm valve at corner of Tsawout Rd and Tetayut Rd	

Cl_2 Residual before Flushing		mg/L
Cl_2 Residual after Flushing		mg/L

Flushing Comments

Field Data

- While planning the unidirectional flushing program a decision must be made on what field data is going to be collected while the flushing is occurring. This may include but is not limited to:
  - Static and dynamic system pressure
  - Water flows and consumption
  - Pre and post flushing water quality
    - pH, chlorine residual, turbidity, conductivity, coliforms counts
  - Flushing time
  - Amounts of dechlorinator used

Flushing Equipment

- Equipment for flushing procedures includes:
  - Valve keys
  - Hydrant wrenches
  - Hoses and related equipment
  - Diffusers
  - Dechlorination equipment
  - Pressure gauges
  - Flow gauges
  - Signage and safety equipment

Diffusers

- Diffusers are used to reduce the energy of the water and protect landscaping from damage

- Can be combined with dechlorinating equipment or flow gauges

- Should be secured to ensure the flow goes in the desired direction

Pressure and Flow Gauges

- Pressure and flow gauges are required to obtain field data
- Flow gauges can be a part of the diffuser or independent pitot gauges can be used
- Pressure gauges are not required for flushing procedures but they do provide additional data or the water system

Static and Dynamic System Pressure

- Static pressure is the normal system pressure when water is not flowing.
  - Often taken as part of the hydrant maintenance program
- Dynamic pressure is the pressure when a large volume of water is flowing through the system.
- If possible, you should measure the system pressure at different points in the water system during the flushing events
- Pressure readings will help identify problem areas in the water system and data can be used for hydraulic modelling
- Readings can be taken manually or with the use of data loggers

Dynamic System Pressure

- Data loggers allow for a more accurate pressure reading to be taken
- Readers should be set up in the same zone that flushing is taking place
- Data can be downloaded into various other programs and used for hydraulic modelling
- Accurate time readings of flushing events is required to be able to correlate the data back to the data logger.

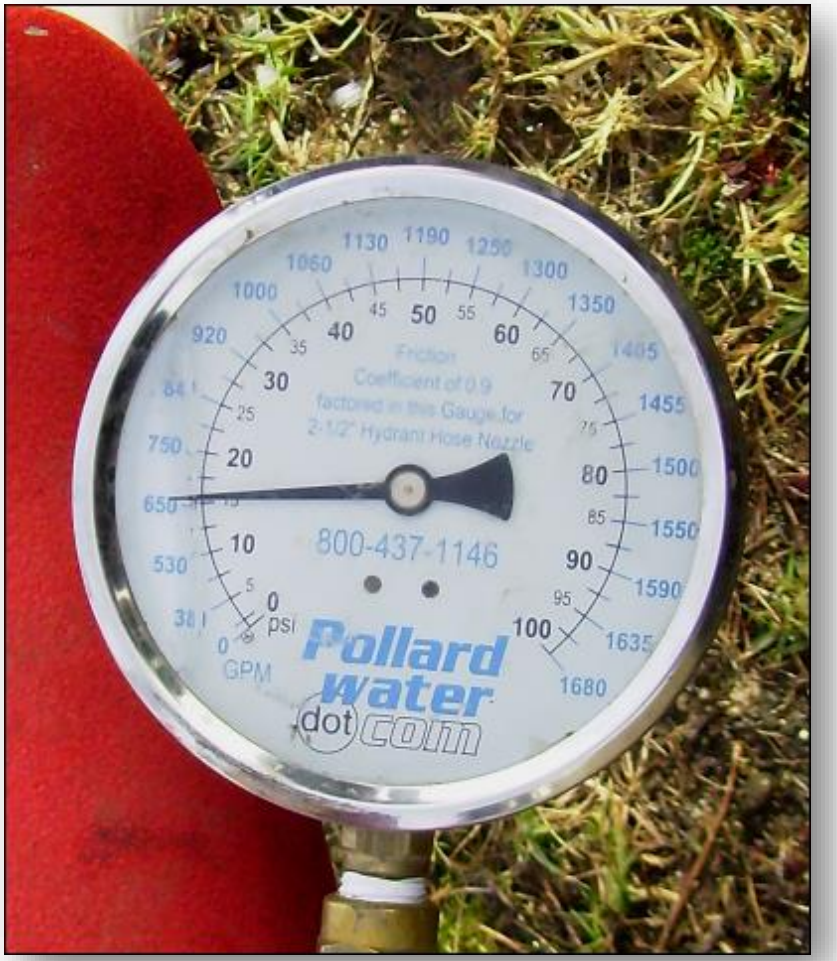
Dynamic System Pressure

Water Flow and Consumption

- Pitot gauges can be integrated into flow diffusers or be stand alone units
- Manufacturers instructions should be reviewed and followed to ensure accurate flow readings are taken

Water Flow and Consumption

- Water flow at the flushing point can be measured used flow gauges and pitot gauges
- Portable or inline water meters can be used to measure the increase in water consumption caused by the flushing program
- Data can be compared to expected values from previous flushing events
- Flow meters can also give instantaneous flow measurements to determine if scouring velocities have been reached



Flow Volumes and Velocities

Pipe size Diameter	Velocity (0.91 m/sec) lpm	Velocity (3.0 ft/sec) gpm	Velocity (1.50 m/sec) lpm	Velocity (5.0 ft/sec) gpm
100 mm	445	118	720	196
150 mm	1000	264	1680	440
200 mm	1780	470	2880	784
250 mm	2780	734	4560	1224
300 mm	4000	1057	6720	1764

Flushing Time

- A minimum flushing time for the exchange of two water volumes should be included in the flushing plan
- The actual flushing time should be recorded. This is the time that it takes for the required water quality parameters to be met.
- This can be used to estimate the volume of water that has been discharged

$$Time = \frac{Volume}{Flow}$$

Flushing Time

- For the initial estimated flushing time you can use the minimum required flows from the previous chart.
- 150mm (6”) main requires 1680 lpm or 440 gpm to achieve a velocity of 1.5 m/sec or 5.0 ft/sec.
- Use online calculators for pipe volumes.
  - For example 100 meters of 150 mm pipe (328’ of 6”) holds 1,767 liters or 482 gallons.
  - Remember to double the volume to achieve good flushing!

Public Notification

- Public notification of a planned flushing procedure should be sent out well in advance of the actual event

- Notification should include:
  - When the flushing is going to occur
  - Why it is happening
  - What the customer may notice
    - Dirty water being discharged from hydrants or taps
    - Loss of pressure
  - Departmental contact information

- Notification can be done in numerous ways such as:
  - Newspaper ads
  - Customer mail outs or door to door notices
  - Radio Ads
  - Signage posted along major roadways

Conduct Flushing Program

- Flushing program may require in field adjustments
- All observations and records made in the field have to make their way back to the system administrator
- Data collection is required to measure the effectiveness of the program

Pre Flushing Water Quality

- Field data should be taken at or near the flushing point. Initial test should be completed before the flushing begins.
- Data such as pH, turbidity, conductivity, or chlorine residual can be taken at multiple times during the flushing run to get a profile of how it changes while the flushing is happening
- Final tests should start to be taken after the minimum flushing time is completed.

Unidirectional Flushing Program

Flushing Run #5

Purpose: Flushing main along Mt. Newton X Rd and Tetayut Rd

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Date _____

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Cl_2 Residual before Flushing		mg/L
Cl_2 Residual after Flushing		mg/L

Flushing Comments

Post Flushing Water Quality

- The same tests taken before flushing should be repeated after flushing
- Post flushing samples should be taken at the same point as pre flushing samples
- Data can be compared to field data collected during the year to track the improvement and/or deterioration of the water quality in the distribution system

Measuring Flushing Effectiveness

- Chlorine and Turbidity levels should be measured to determine if the flushing time is effective

- Turbidity levels can be directly measured or a large glass jar or bucket can be used. Flushing is done until the water is clear to the naked eye

Measuring Flushing Effectiveness

- Turbidity levels will spike during flushing
- Frequency of testing is a operational decision. Tests should be done after minimum flushing time and then at intervals to ensure levels meet the department goals.
- Maximum acceptable turbidity in a distribution system is 1.0 NTU
  - 5.0 NTU and dropping target can be used for flushing.

Measuring Flushing Effectiveness

- To help with tracking chlorine residuals through the system the chlorine dosage can be increased during the flushing procedure
- Increased chlorine dosages may be also required due to sediment being stirred up in pipes
- Canadian Drinking Water Guidelines recommend a free residual less than 2.0 mg/L

Measuring Flushing Effectiveness

- Increasing the chlorine dosage at the water source will make it easier to track through the system
- For example, if chlorine residuals are usually 0.5 mg/L, increase the dosage to achieve a 1.0 mg/L residual and use that as your flushing target.
- The chlorine demand of the water may also be increased due to the stirring up of debris and sediment in pipes and reservoirs.
- Chlorine residuals will slowly fall to normal levels after flushing is completed.

Post Flushing Assessment

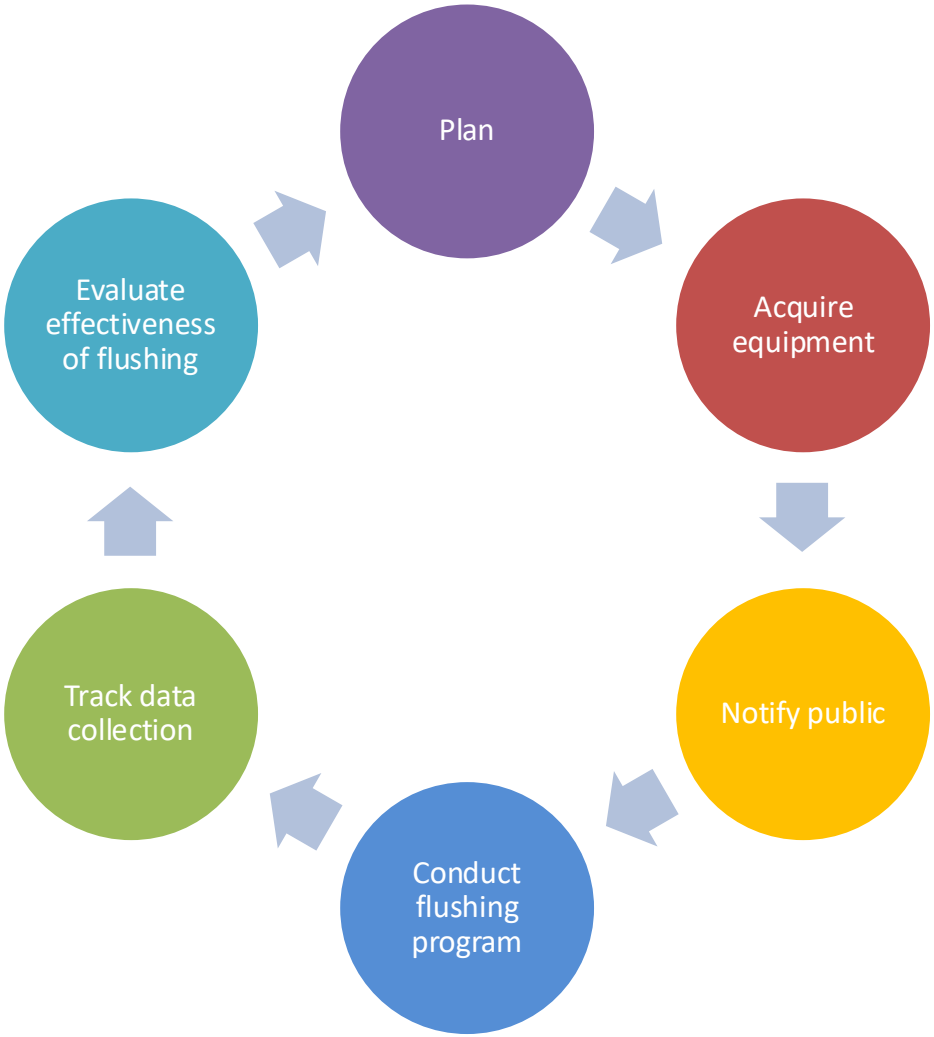
- Data collected during the flushing program should be compared to expected results and changes to the program be made
- Areas of low pressure need to be identified and adjustments to the flushing program or to the system operation can be made
- GIS modelling can be updated and made more accurate
- Flushing runs can be adjusted as required
- Changes may not work as anticipated and people must be willing to try new things and possibly make mistakes

Hydraulic Modelling

- Hydraulic models should be updated with information found in the field to make them more accurate
  - Static models are based on engineering formulas
- Numerous different models and can systems might not work for everyone
- Data can be used in GIS Interfaces
- Ability to evaluate multiple different scenarios quickly
- Data received from modelling system is only as good as the data that is put into it

Water Main Flushing

- All water main flushing programs should be a dynamic process. The program should evolve as the system and data changes from year to year



Unidirectional Flushing