

Not so long ago in a distribution system far,
far away...



Zero-Discharge Distribution System Mains Flushing Planning and Implementation

Alex Mofidi PE

Discussion Topics

-  Project Introduction and Key Issues
-  Flushing Background
-  Zero-Discharge (Closed-Loop) Flushing
-  Planning and Implementation
-  Summary and Next Steps



Discussion Topics

Project Introduction and Key Issues



Introduction

- ☾ State of California
 - 🏠 Severe State-Wide Drought
 - 🏠 Governor's EO: 25-Percent Use Reduction

- ☾ City of Oxnard
 - 🏠 60-miles Northwest of Los Angeles
 - 🏠 Need for Mains Flushing, Valve Exercising
 - It has been ~30 years
 - What to do?



Mains Flushing



Valve Exercising

Introduction

City of Oxnard

Sources

- SW
- Raw GW
- Desalted GW

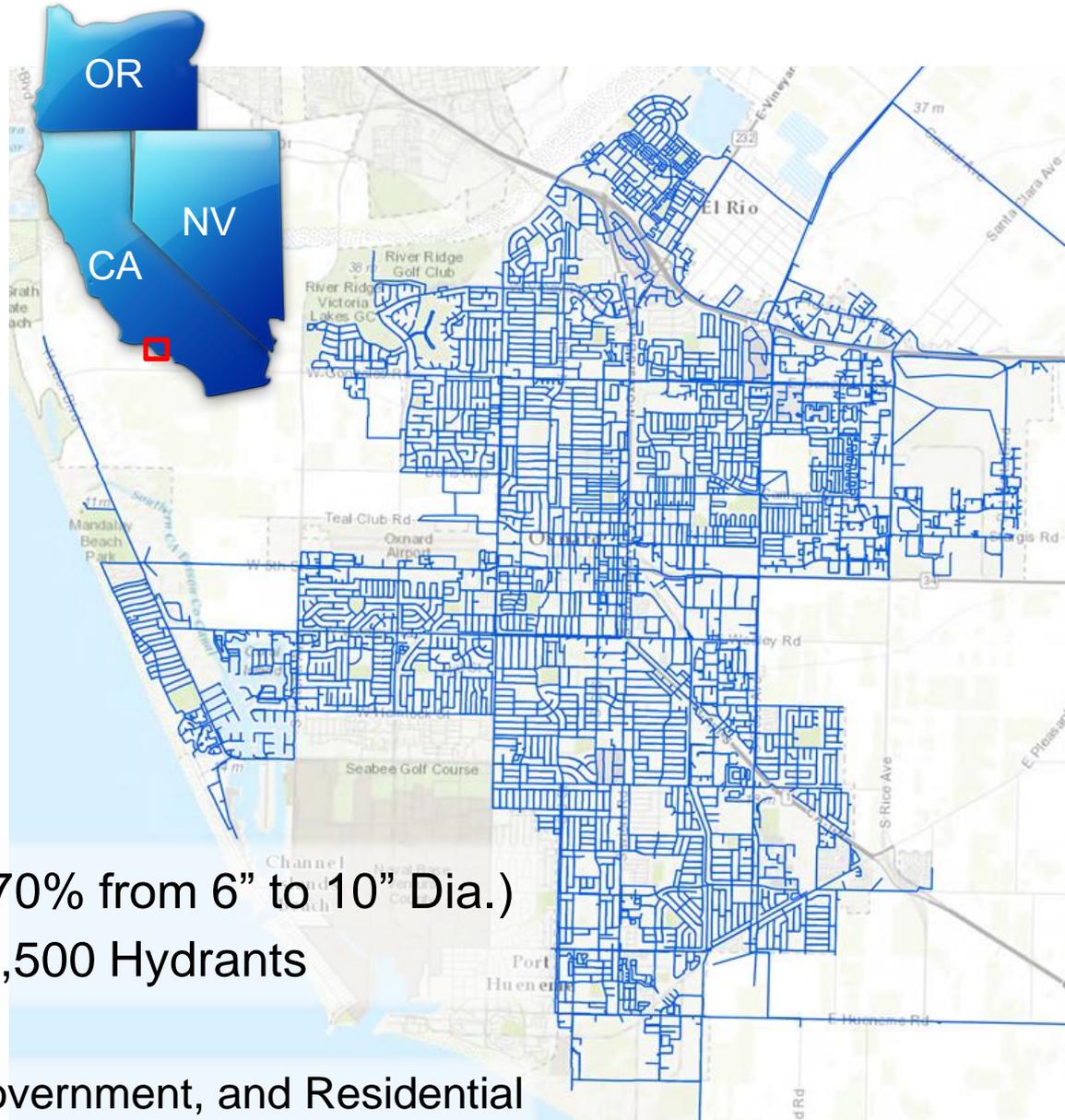
~30 square miles

614 Miles of DS Pipe (70% from 6" to 10" Dia.)

>16,000 Valves and >5,500 Hydrants

Customers

- Industry, Healthcare, Government, and Residential



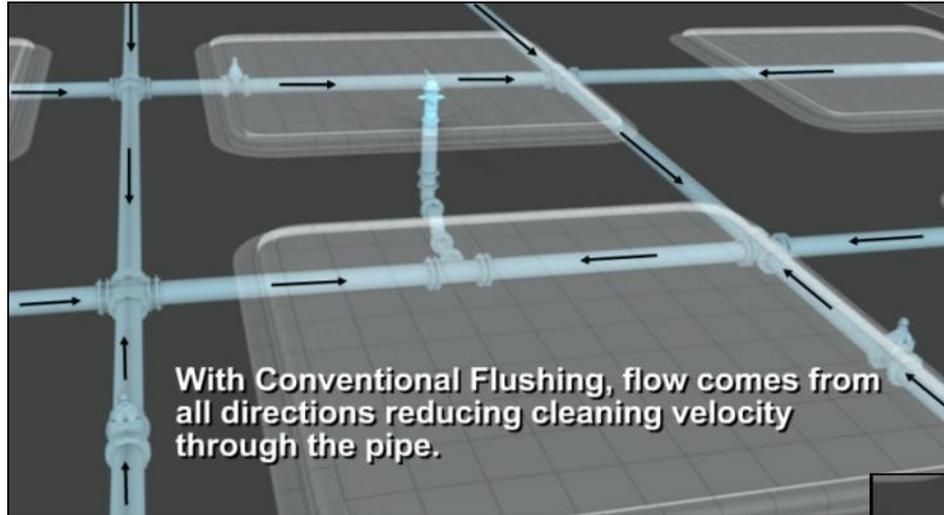
Discussion Topics

 Project Introduction and Key Issues

 Flushing Background

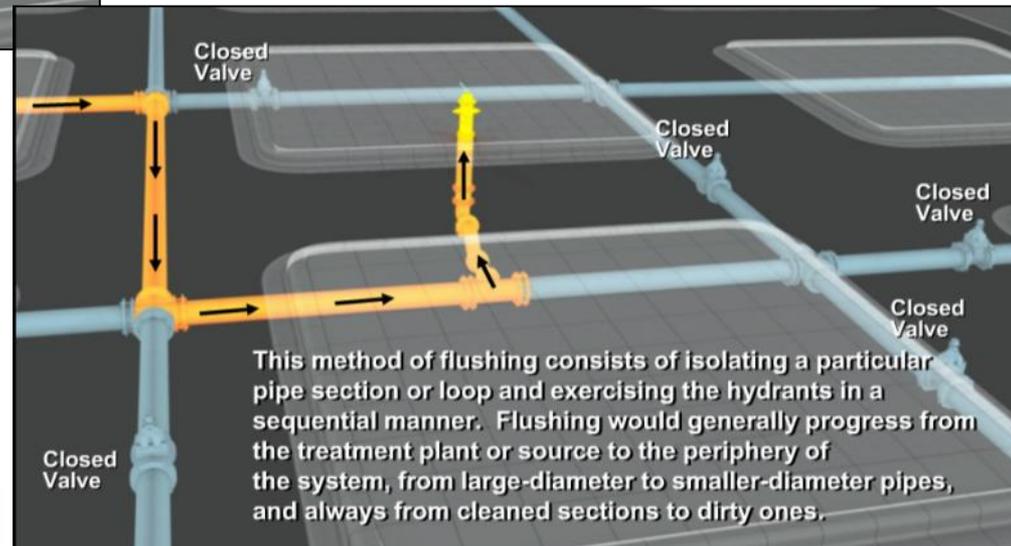


Flushing Background



Conventional Flushing

Unidirectional Flushing



Comparison of Flushing Techniques

Parameter	Conventional	Unidirectional	Closed Loop
Customer notification	Yes	Yes	Yes
Planning and modeling	Minimal	Yes	Yes
Achieves scour velocity	Difficult	Likely	Yes
Discharges water to curb	Yes	Yes	No
Impacts system pressures	Yes	Yes	No
Valve operations	Not typical	Yes	Yes
Special equipment required	No	No	Yes
Water quality sampling required	System Only	System Only	Equipment & system
Chemical dosing	No	No	Yes, chlorine
Traffic management duties	Minimal	Minimal	Increased

Discussion Topics

-  Project Introduction and Key Issues
-  Flushing Background
-  Zero-Discharge (Closed-Loop) Flushing



Zero-Discharge Closed-Loop Flushing

☾ Proprietary Equipment

☾ Growing Number of Users

🏠 Southwest US

🏠 Northeast US

☾ Pump – Filter – Chlorinate – Recirculate

🏠 Disinfect hydrants and equipment

🏠 Connect two hydrants up to 1,000 feet apart

🏠 Filtration to 1- μ m

🏠 Sodium hypochlorite for demand & free NH_3

🏠 Up to 1,700 GPM flow capacity

○ 12-inch Main @ ~5 FPS

○ 10-inch Main @ ~7 FPS



Zero-Discharge Closed-Loop Flushing, continued

☾ Health Department Acceptance

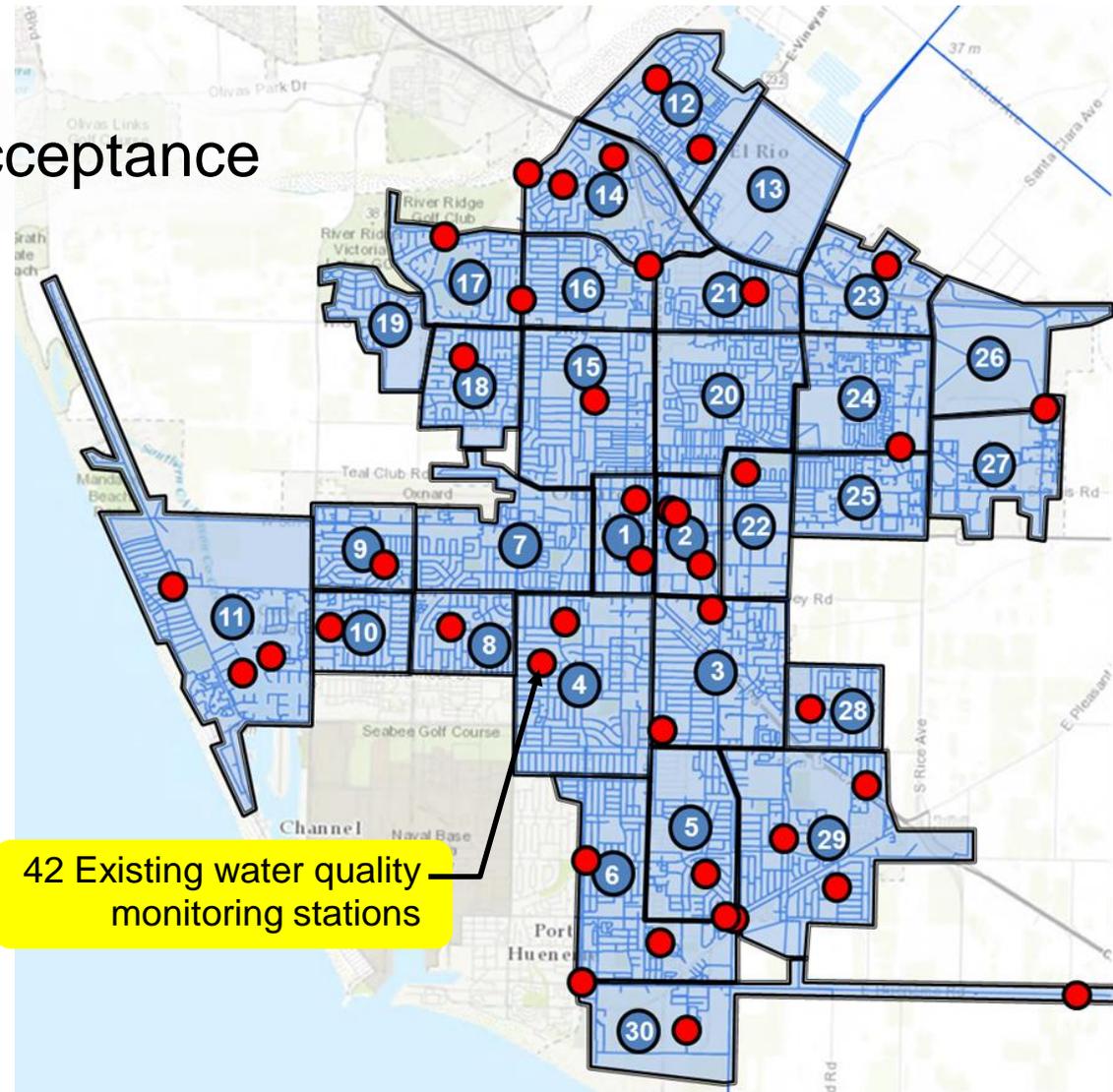
🏠 Flushing plan in place

🏠 Microbial sampling

○ Upstream & downstream

○ At flushing equipment

🏠 Chlorination practices

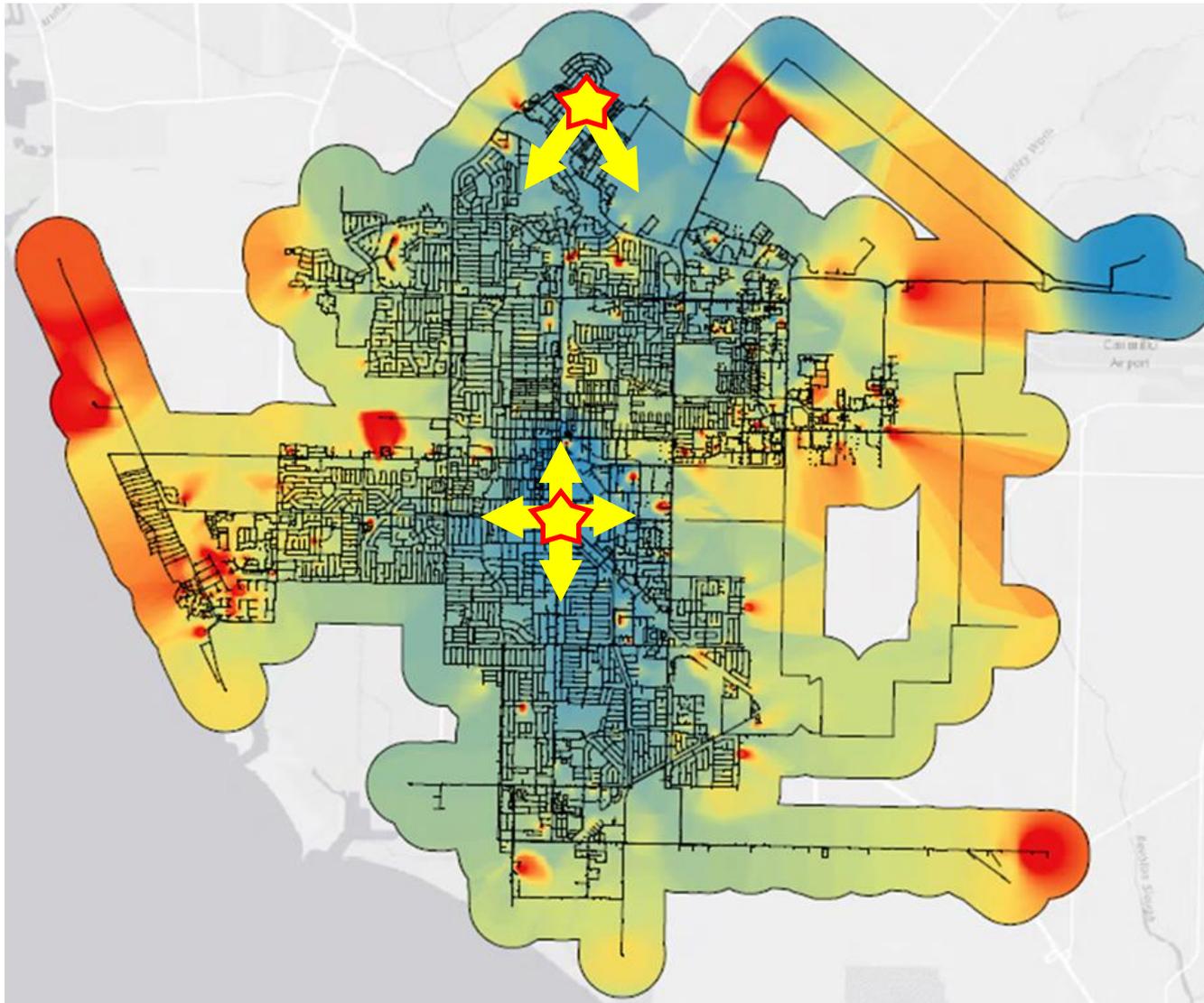


Discussion Topics

-  Project Introduction and Key Issues
-  Flushing Background
-  Zero-Discharge (Closed-Loop) Flushing
-  Planning and Implementation



Define The System: Water Age



☾ Start Flushing at Entrance to the DS

🏠 Blue = Entry

🏠 Red = End

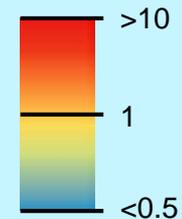
🏠 Focus flushing pipe ≤ 12 in. dia.

LEGEND

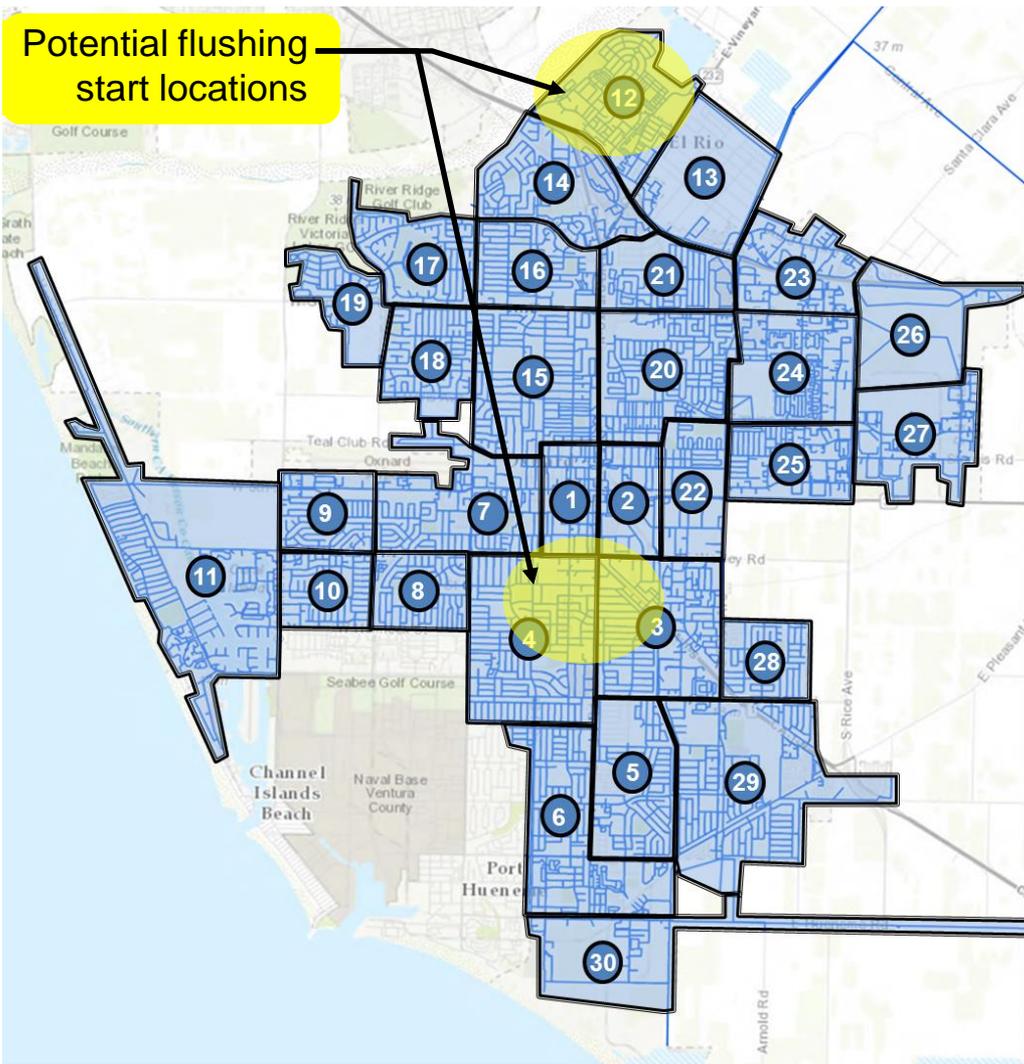
Potential Starting Flush Location



Water Age (Days)



Define The System: “Subsystem” Flushing Zones



Define Subsystems

Purpose

- Staffing & work planning
- Customer notification
- Progress through system from low to high water age
- Up to 2 weeks/subsystem

Boundaries

- Approximate
- Require various work crew confirmation/approval

Define The System: Extended Pipe Loops (EPLs)



Planning

- Identify EPLs
- Identify valves
- Traffic management
- Sampling requirements
- Customer notification
- Staffing & work planning
- Customer notification

Exercise Valves

Flush

- Up to 2 weeks/subsystem
- Disinfect equipment
- Data and records keeping

Define The System: Extended Pipe Loops (EPLs)



Example: Subsystem 12

8 EPLs

Target 1-2 days/EPL

≤12-in. diameter pipe

<4 FPS average velocity

Exercise Valves First

Send valve crew between 2 to 4 weeks prior

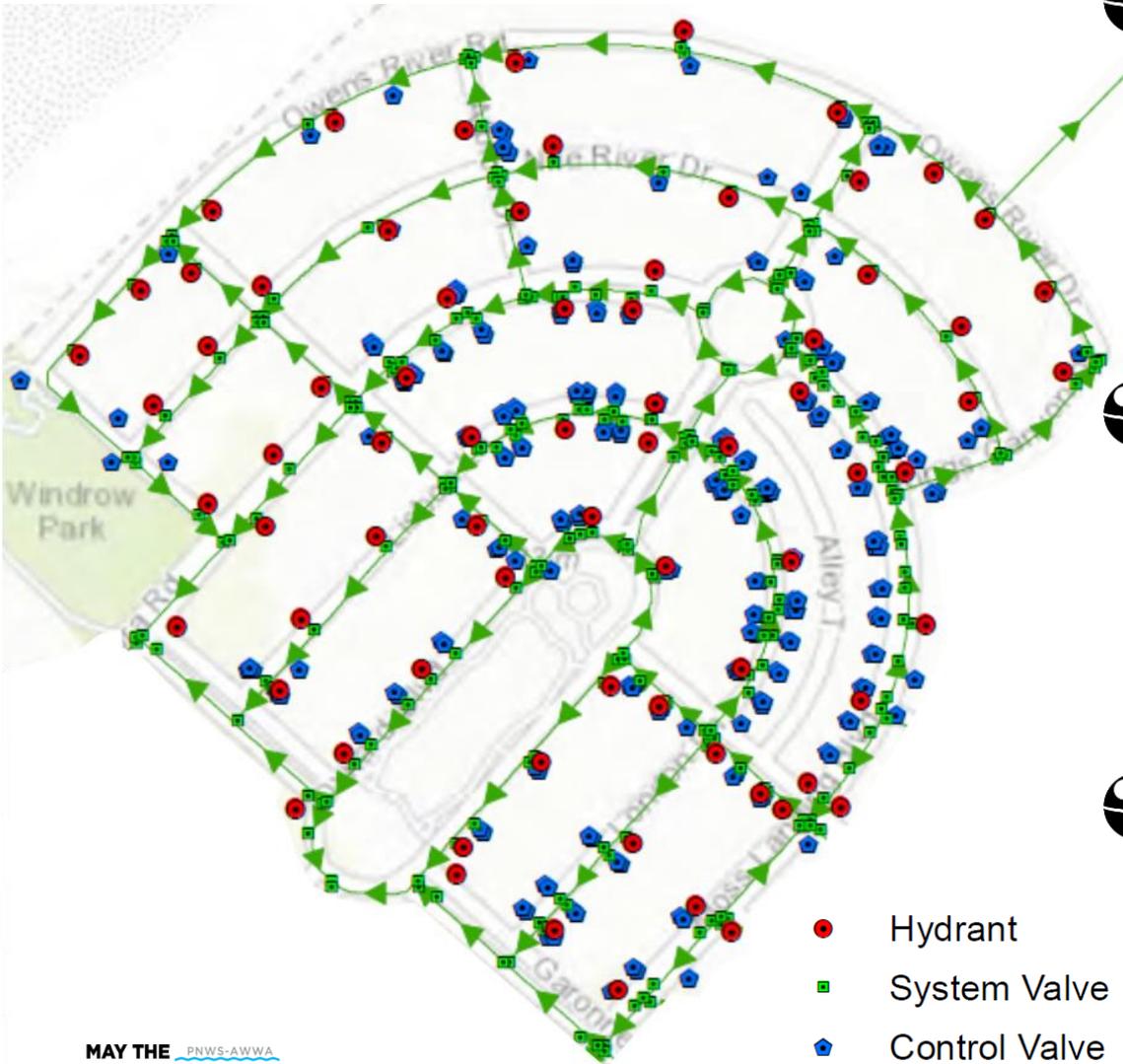
Locate, ID, exercise, order maintenance as needed

Set Flushing Targets

Average flow direction?

Average Magnitude?

Planning: Assess EPLs



Example: Subsystem 12

8 EPLs

Target 1-2 days/EPL

≤12-in. diameter pipe

<4 FPS average velocity

Exercise Valves First

Send valve crew between 2 to 4 weeks prior

Locate, ID, exercise, order maintenance as needed

Set Flushing Targets

Average flow direction?

Average Magnitude?

Planning: Assess EPLs

O-10129

O-10129	
SHAPE	Point
AncillaryRole	0
Enabled	1
FacilityID	O-10129
InstallDate	2/16/2007
Grid_No	O-10
Letter	O
Number_	10
Source	As Built
Drawing_No	06-50A
Sheet_Number	SHT # 34
LocationDescription	
Rotation	138.06597
LifecycleStatus	In Service
WaterType	Potable Water
Description	6" FIRE HYDRANT
AdministrativeArea	City of Oxnard
UNITID	10-OH29
COMPTYPE	Hydrant
COMPKEY	183632
HydrantType	H
HydrantNumber	H-29
Hydrant	H-29
PSI	
BARCODE	SHEET 34 OF 63
CREATEDBY	NOBEL
Make	
LARGE_DEMAND	Yes
GlobalID	{58D67483-D310-4634-A4FB-B5449876B2F1}
oldOID	2146

Directions: [To here](#) - [From here](#)

Imagery Date: 5/1/2015 34°14'46.07" N

Example: Subsystem 12

8 EPLs

Target 1-2 days/EPL

≤12-in. diameter pipe

<4 FPS average velocity

Exercise Valves First

Send valve crew between 2 to 4 weeks prior

Locate, ID, exercise, order maintenance as needed

Set Flushing Targets

Average flow direction?

Average Magnitude?

Planning, Continued

 Group / Widespread Notification

 Individual Notifications

 Hospitals

 Nursing homes

 Dialysis facilities & individuals

 Restaurants

 Laundromats

NOTICE: WATERMAIN CLEANING AND FLUSHING IN YOUR AREA

City of Oxnard Water Division crews will be flushing the **watermain**s on your street as follows:

Between: **Day, Month, Date** and **Day, Month, Date**

Weather Permitting

Please see below for answers to frequently asked questions and other information.

Why is the City 'flushing' the **watermain**s?

Flushing the **watermain**s improves water quality by removing sediment that slowly builds up at the bottom of the **watermain** over time. The sediment comes from internal pipe corrosion of the **watermain**s over many years.

What type of flushing is conducted and does it waste water?

The type of flushing that the City conducts is a very innovative, closed-loop flushing (CLF) approach. Where other utilities may typically discharge water to the curb via hydrants, the City has equipment which connects to one hydrant, flushes water through multiple filters at a high rate, and returns the water in a filtered, clean, sanitary fashion back to the distribution system pipeline through a second hydrant. This process wastes very little water (only when connecting and disconnecting hoses).

How will I know when the City is cleaning the **watermain**s in my neighborhood?

The City will inform residents before starting the flushing program by posting notices on its website and placing advertisements in local newspapers. You will receive a notice at your door at least one day before flushing starts. Also, during flushing activities, you will see signage on streets where flushing is taking place.

What should I do if my water is discolored after the City has flushed the **watermain**s?

It is normal for water to sometimes be discolored after **watermain** cleaning and flushing, but it is expected that this would not last long. You should avoid laundering clothing (to help prevent against and minimize staining) and also avoid use of hot water (to help prevent the possibility that sediment is drawn into your hot water tank). If you notice discolored water, it is recommended that you flush cold water from multiple taps in your home until the discoloration no longer observed.

How much does it cost me for the water I use if I flush the taps in my home?

The typical kitchen faucet delivers between 1 to 2 gallons per minute of water when it is fully opened to flush household plumbing. Therefore, it can be expected that the typical cost of conducting the expected flushing of household taps amounts to less than 5 cents (including any potential sewer charges) for every 5 minutes of flushing for each household tap flushed.

How long does it take to clean the **watermain**s on each street?

It may take approximately 60-minutes to flush **watermain**s on each individual street, and the work crews are expected to flush multiple mains each day.

Who do I contact at the Water Department if I have questions?

If you have further questions you may contact the City's customer service center at **ENTER PHONE NUMBER** or look online for more information at **ENTER WEBSITE ADDRESS**.

Planning, Continued

 Group / Widespread Notification

 Individual Notifications

 Valve Documentation & Maintenance

 Valve ID, position, max torque allowed

 Record turns open/close; pass/fail

 Maintenance and documentation

 Prepare/Disinfect Equipment

 Sampling

 Distribution system

 Equipment



Valve Inspection and Exercise Record

City of Oxnard - CLF Valve Exercise Program
Area / Sequence ID: _____ Date: _____

Valve Identification (Number / ID) _____

Valve Location (Address / Intersection / Side of Street) _____

Site Documentation / Recording Information

Valve Dimensions _____

Valve Condition _____

Other Pertinent Information about Valve or Site _____

Direction to turn valve to closed and open positions verified? (Y / N) _____

_____ ft-lb

_____ to apply to turn this valve? _____ (Open / Closed / _____ %)

_____ position was the valve found? _____

From fully closed, fully open the valve (complete a full close/open cycle) and document how many turns are required. Repeat this step over and over until the number of turns required to complete the cycle does not change from one cycle to the next (complete a minimum of 3 cycles).

Turning Cycle	Number of Turns	Maximum Torque Applied Per Cycle	Turning Cycle	Number of Turns	Maximum Torque Applied Per Cycle
1			10		
2			11		
3			12		
4			13		
5			14		
6			15		
7					
8					
9					

If turns/cycle do not match after 15 attempts, recommend that the valve is marked for follow-up maintenance.

Inspection and Exercise Results

Crew Member 1 _____

Crew Member 2 _____

Valve Passed Inspection? _____

If did not pass, indicate what reason that a follow-up inspection and/or maintenance is required: _____

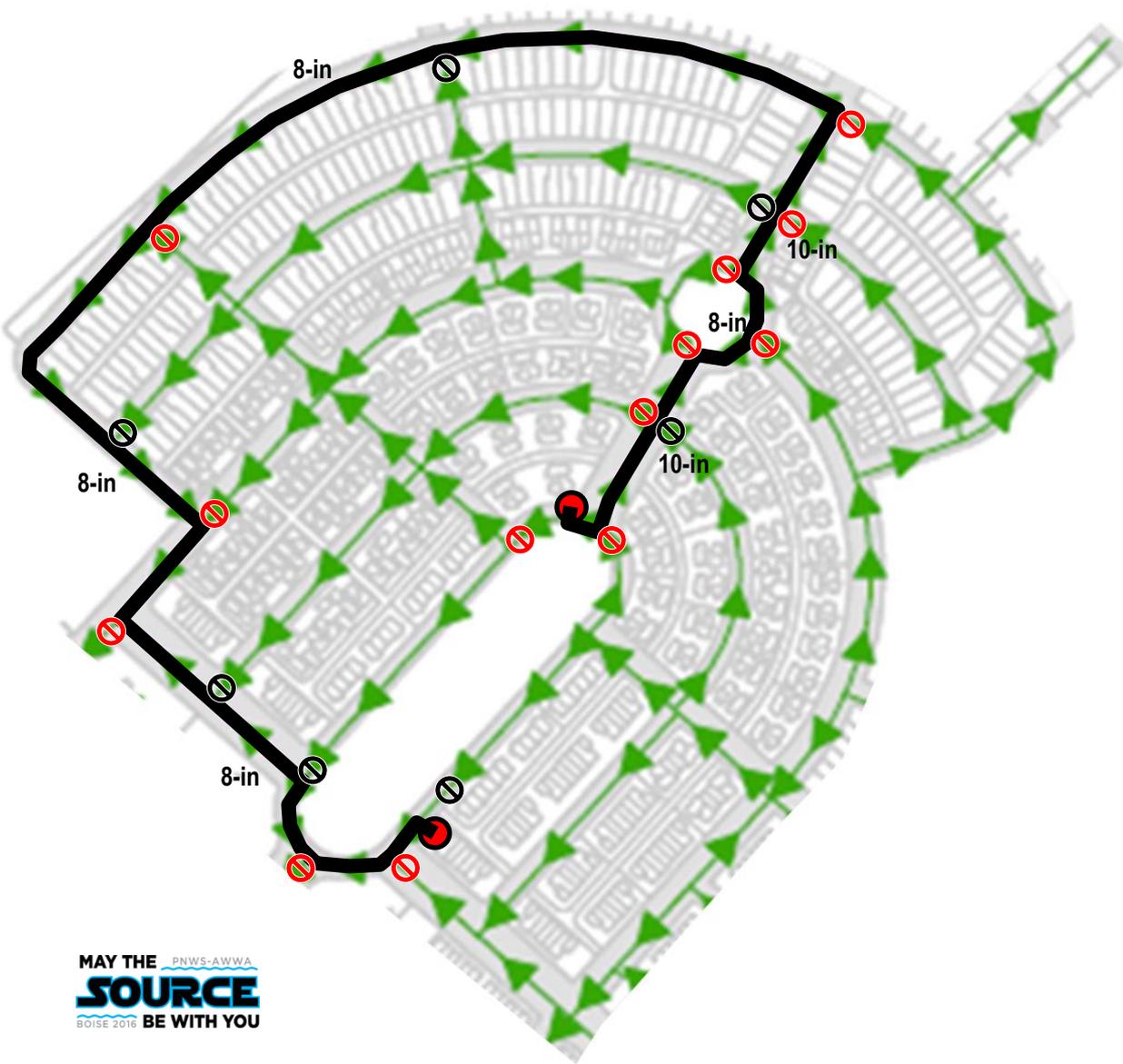
Attach photos of the valve and surrounding area:

Photo _____

Photo _____

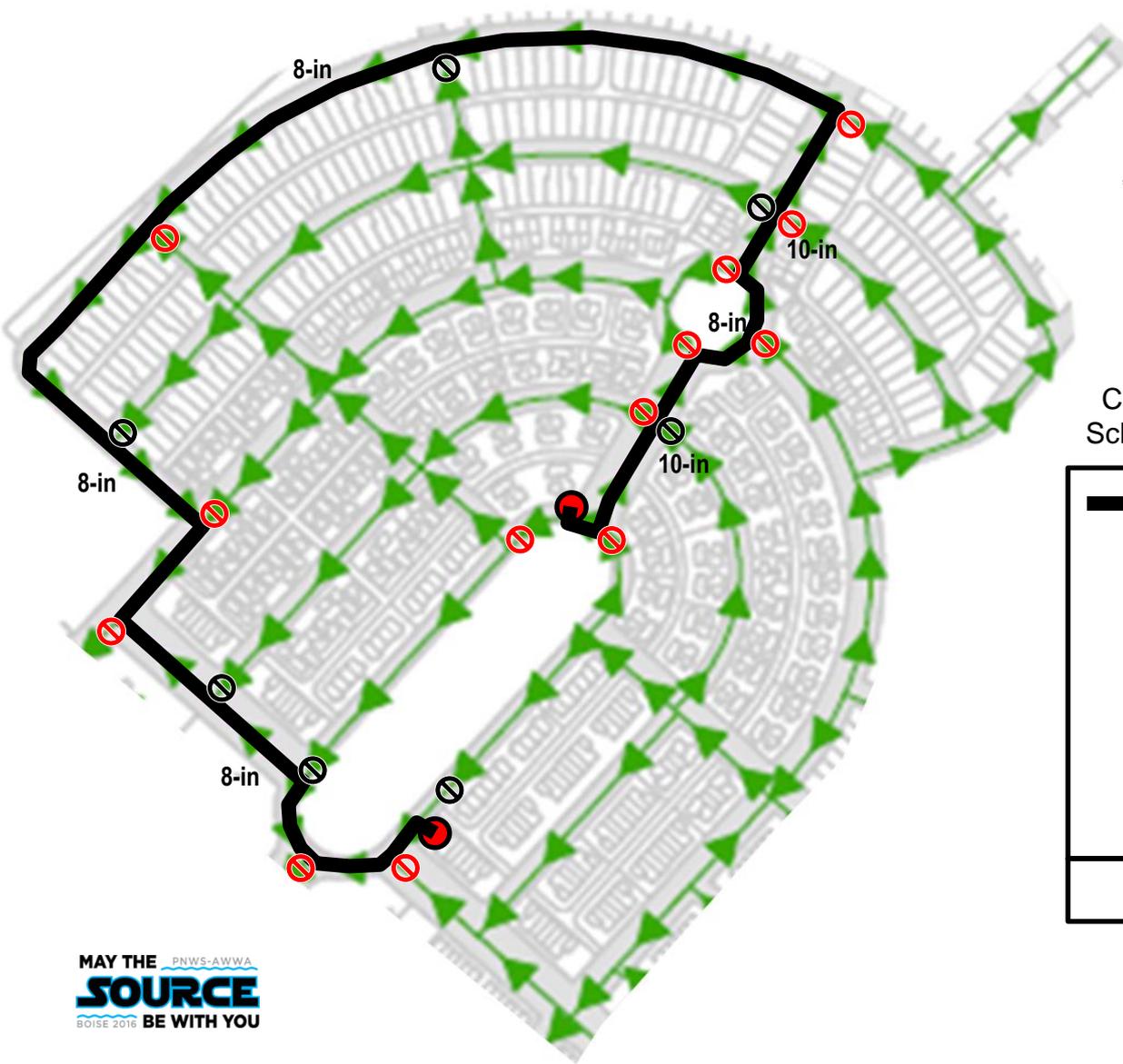
Photo _____

EPL Flushing Example



- Hydrant
- ⊘ Partially shut valve
- ⊙ Partially shut valve optional
- Pipe already flushed

EPL Flushing Example

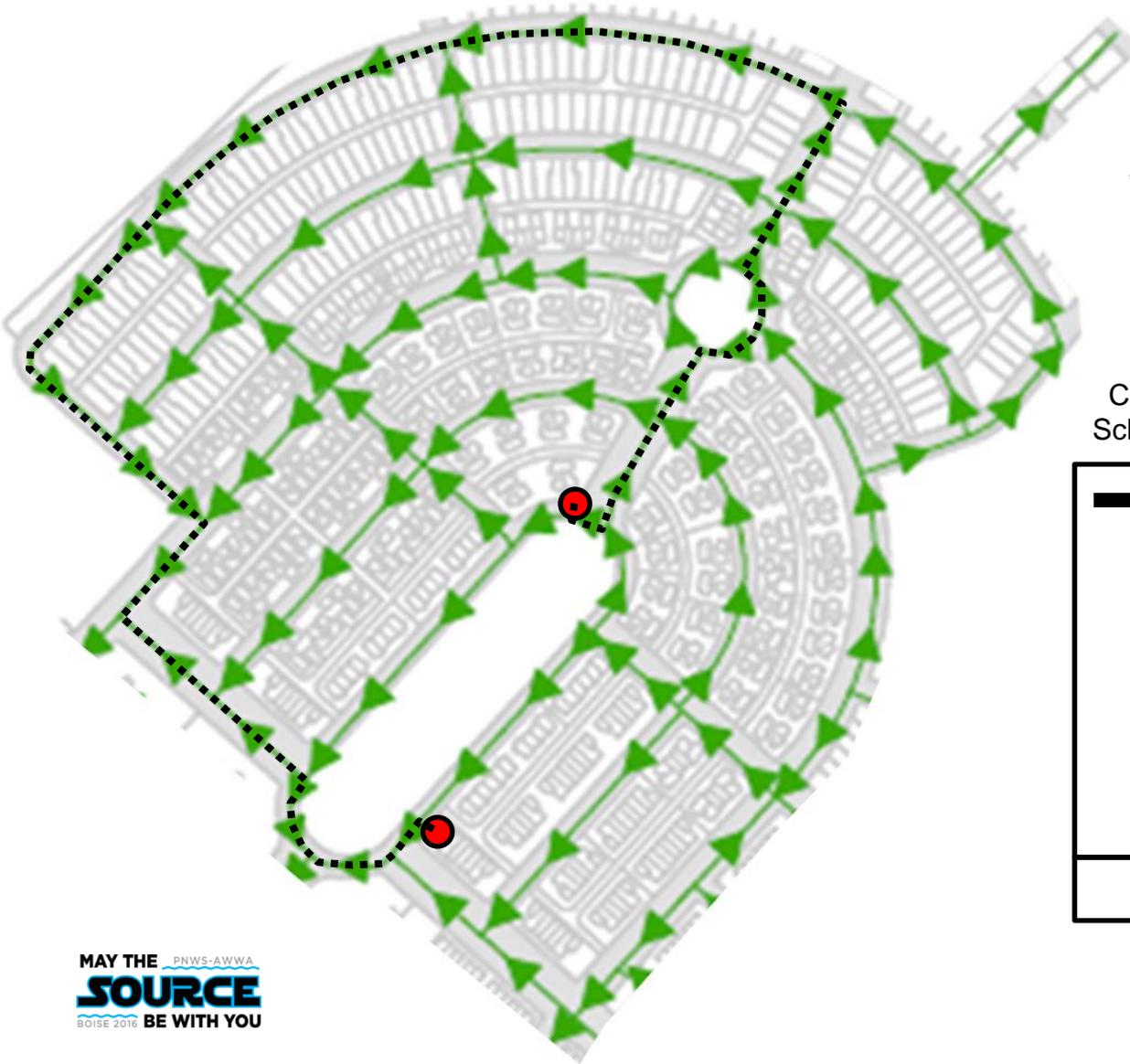


- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

● At 1470 GPM ● At 940 GPM
⊘ 2x vol = 21 min ⊘ 2x vol = 33 min
⊘ 10" = 6 FPS ⊘ 10" = 4 FPS
⊘ 8" = 9.5 FPS ⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20

EPL Flushing Example

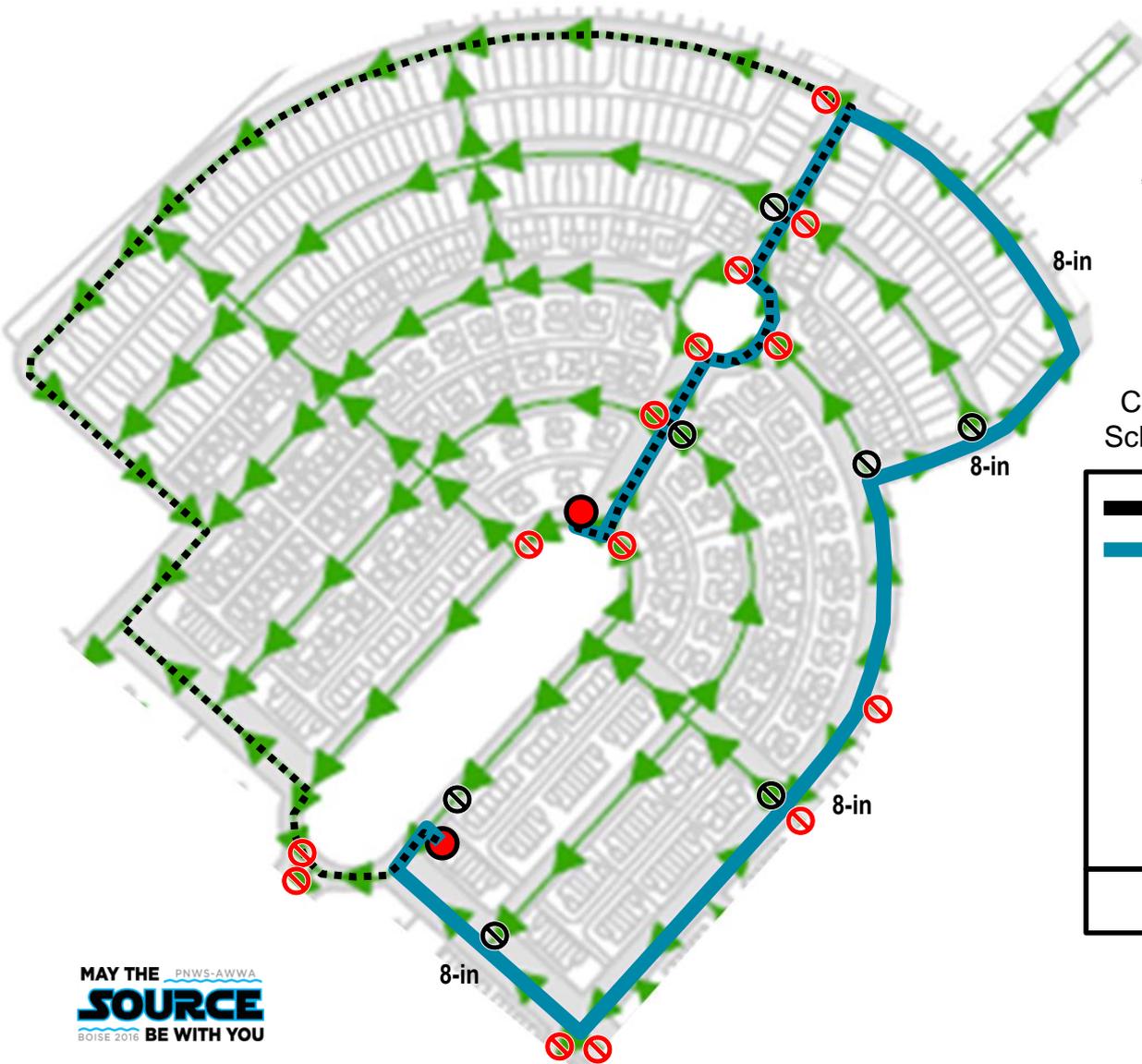


- Hydrant
- Partially shut valve
- Partially shut valve optional
- Pipe already flushed

● At 1470 GPM ● At 940 GPM
🚰 2x vol = 21 min 🚰 2x vol = 33 min
🚰 10" = 6 FPS 🚰 10" = 4 FPS
🚰 8" = 9.5 FPS 🚰 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20

EPL Flushing Example

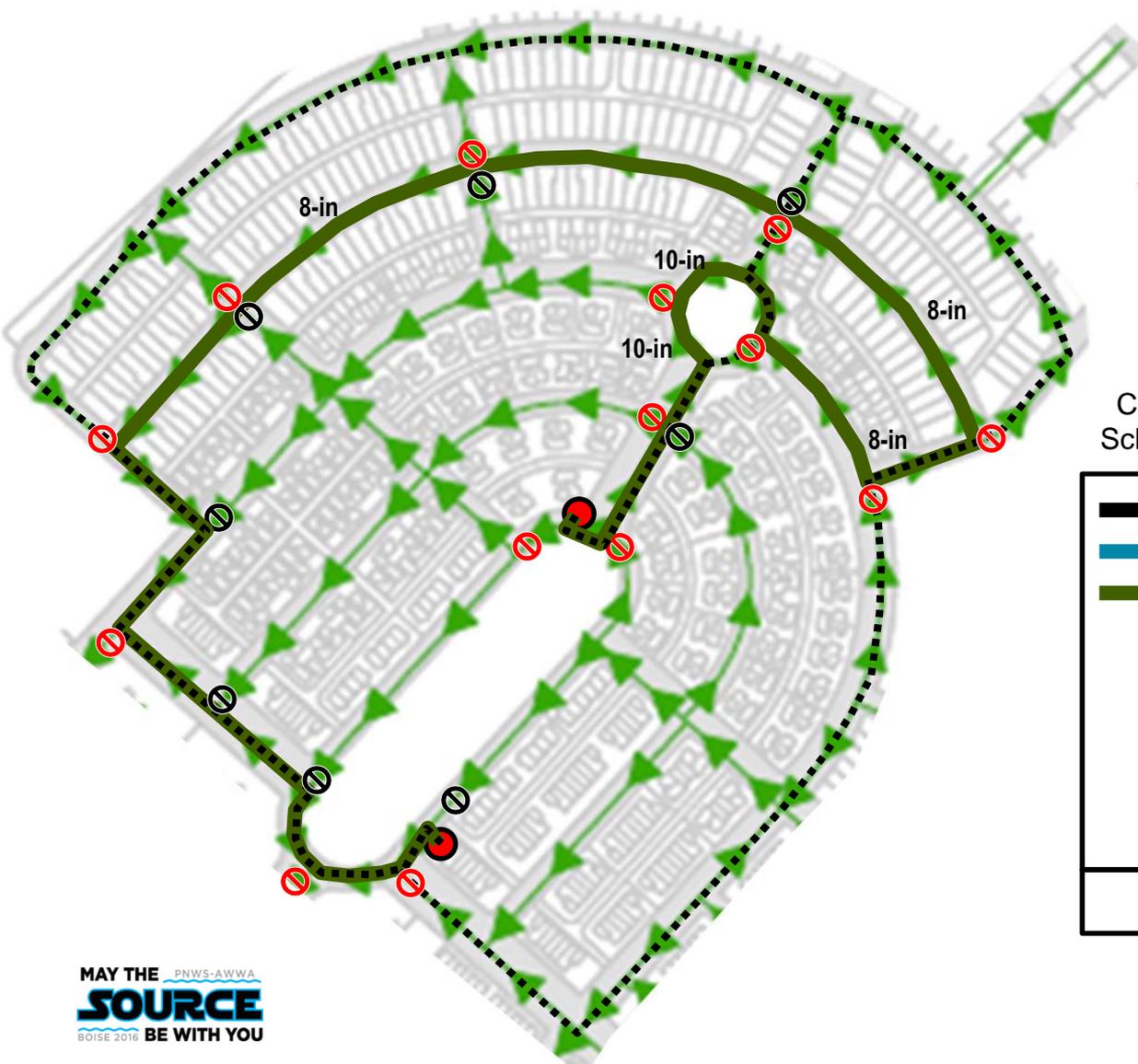


- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

⊘ At 940 GPM
⊘ 2x vol = 19 min
⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20
█	3,500 ft	-	21

EPL Flushing Example

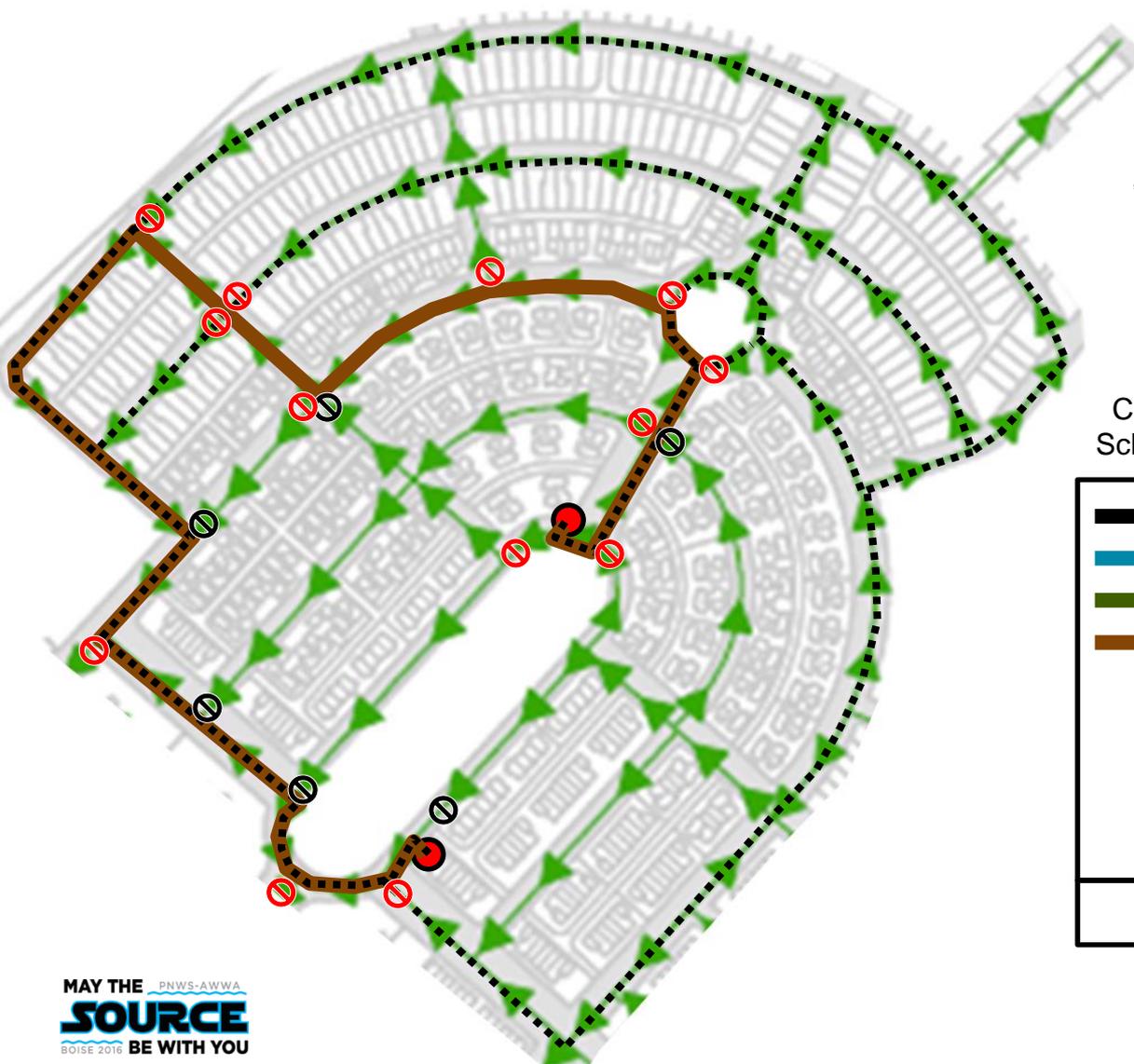


- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

● At 1470 GPM ● At 940 GPM
⊘ 2x vol = 15 min ⊘ 2x vol = 23 min
⊘ 10" = 6 FPS ⊘ 10" = 4 FPS
⊘ 8" = 9.5 FPS ⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
	4,500 ft	900 ft	20
	3,500 ft	-	21
	3,650 ft	300 ft	22

EPL Flushing Example



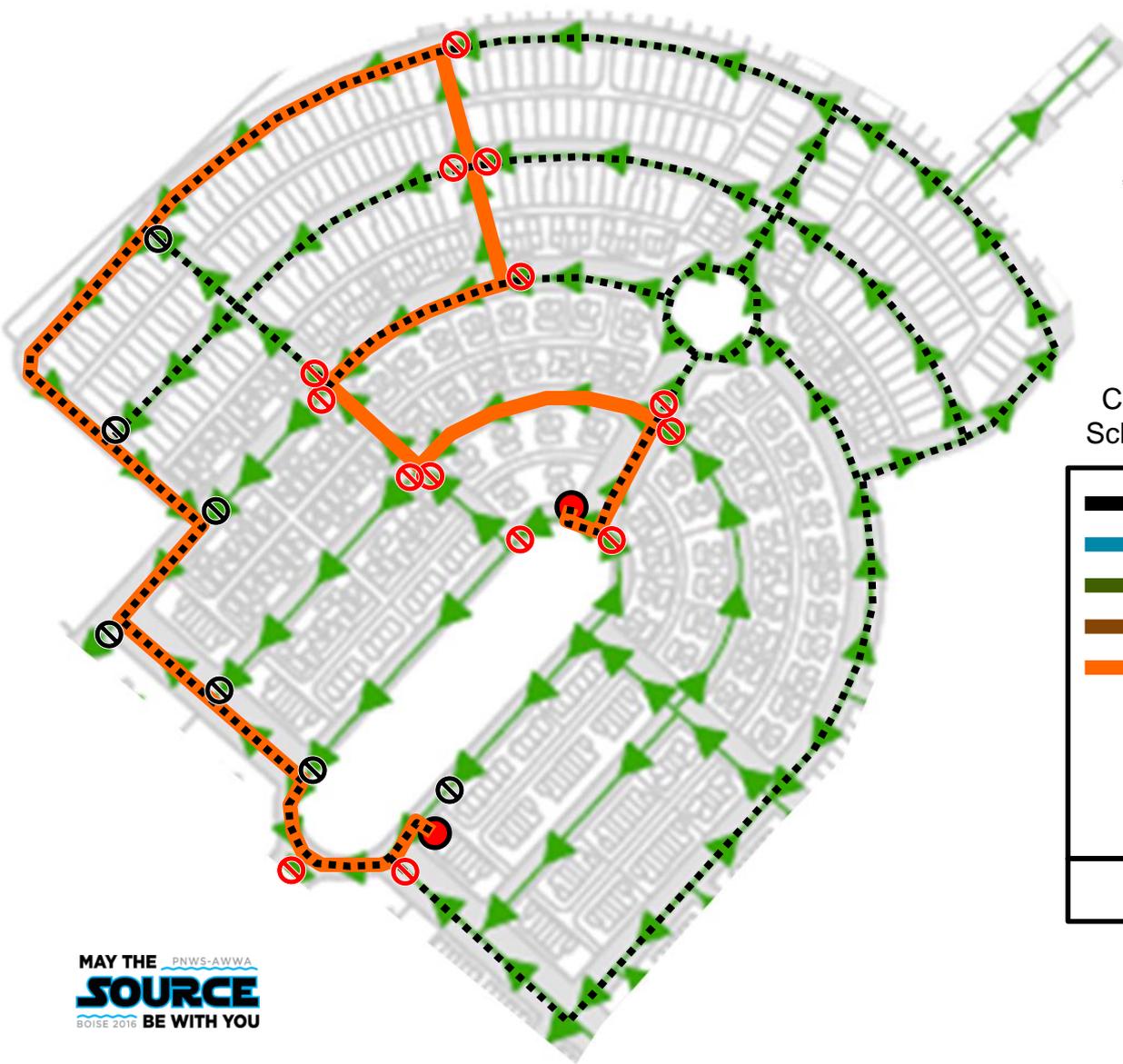
- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

● At 940 GPM

- ⊘ 2x vol = 8 min
- ⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20
█	3,500 ft	-	21
█	3,650 ft	300 ft	22
█	1,450 ft	-	19

EPL Flushing Example



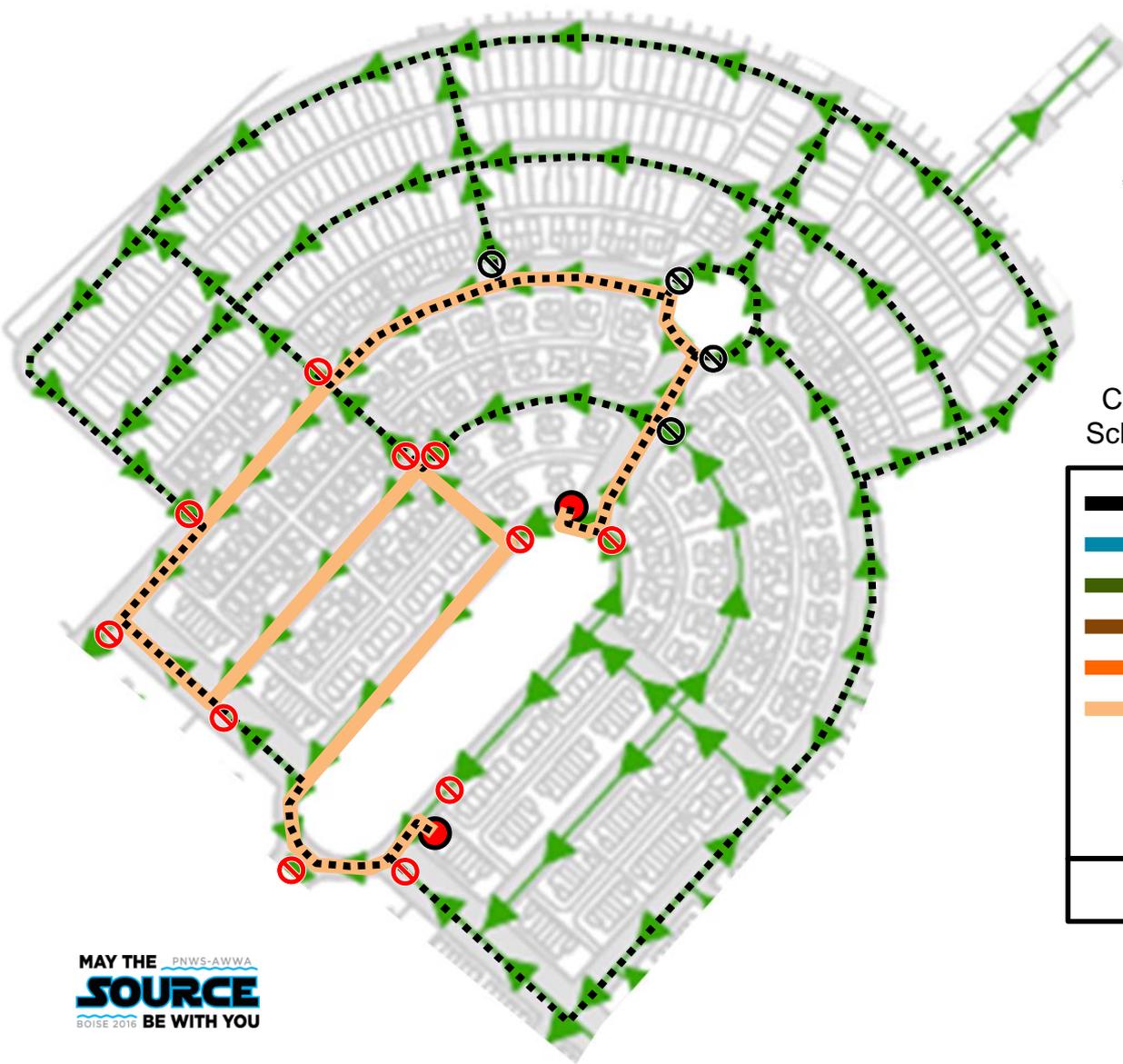
- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

⊘ At 940 GPM

- ⊘ 2x vol = 9 min
- ⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20
█	3,500 ft	-	21
█	3,650 ft	300 ft	22
█	1,450 ft	-	19
█	1,550 ft	-	21

EPL Flushing Example

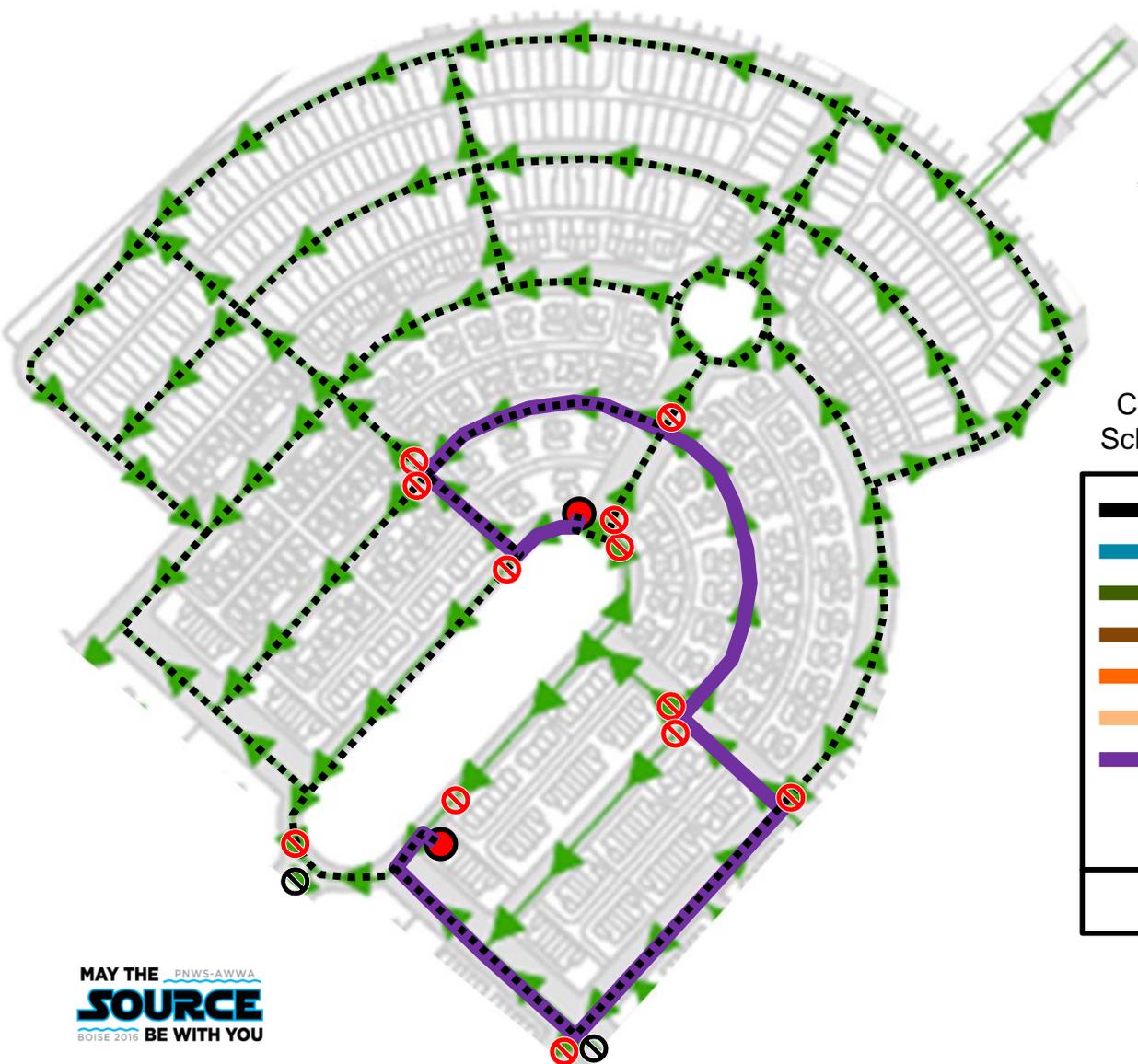


- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

⊘ At 940 GPM
⊘ 2x vol = 12 min
⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20
█	3,500 ft	-	21
█	3,650 ft	300 ft	22
█	1,450 ft	-	19
█	1,550 ft	-	21
█	2,150 ft	-	15

EPL Flushing Example



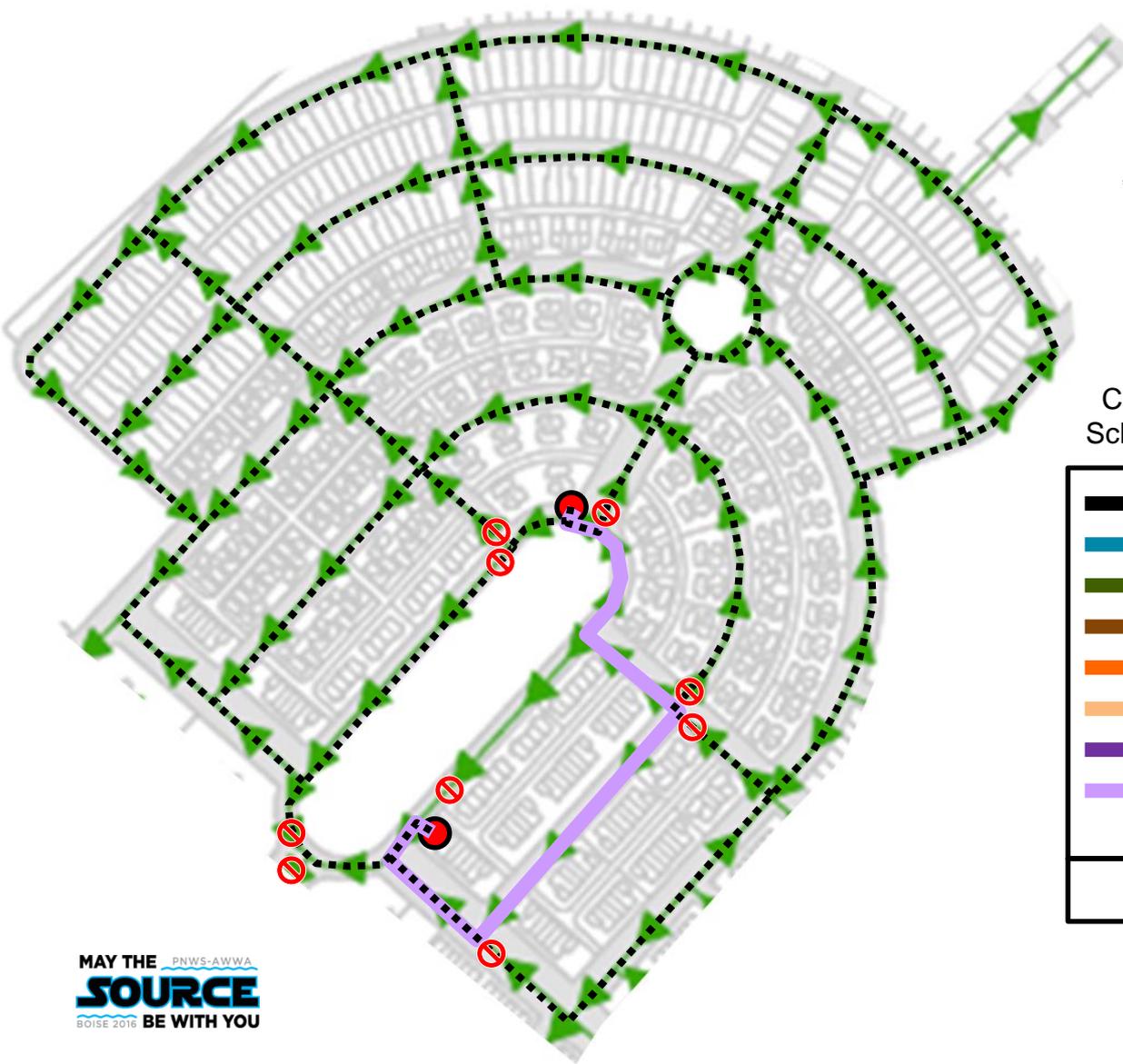
- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

At 940 GPM

- 2x vol = 6 min
- 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
	4,500 ft	900 ft	20
	3,500 ft	-	21
	3,650 ft	300 ft	22
	1,450 ft	-	19
	1,550 ft	-	21
	2,150 ft	-	15
	1,000 ft	-	14

EPL Flushing Example

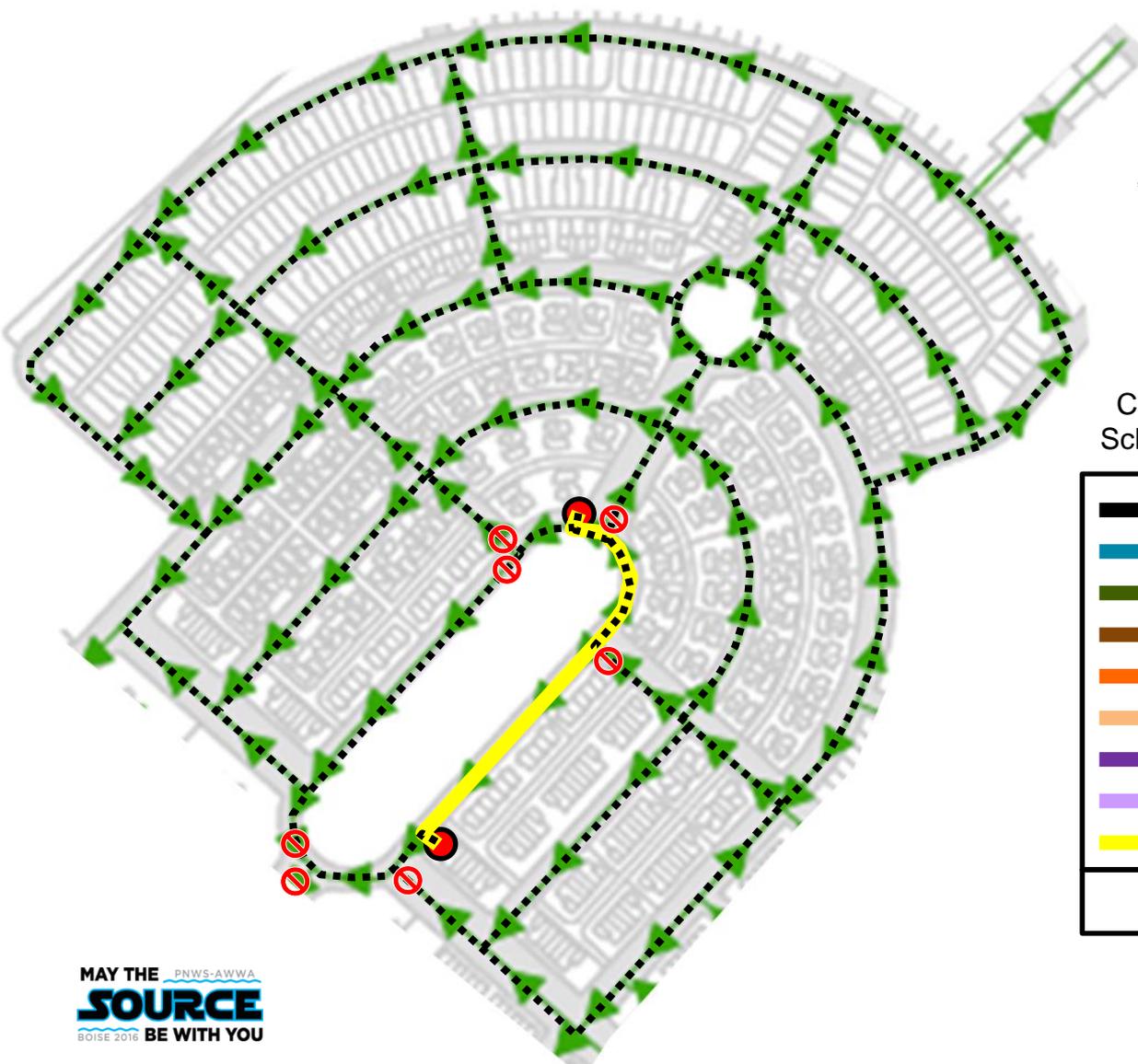


- Hydrant
- ⊘ Partially shut valve
- ⊘ Partially shut valve optional
- Pipe already flushed

⊘ At 1470 GPM	⊘ At 940 GPM
⊘ 2x vol = 5 min	⊘ 2x vol = 8 min
⊘ 10" = 6 FPS	⊘ 10" = 4 FPS
⊘ 8" = 9.5 FPS	⊘ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
█	4,500 ft	900 ft	20
█	3,500 ft	-	21
█	3,650 ft	300 ft	22
█	1,450 ft	-	19
█	1,550 ft	-	21
█	2,150 ft	-	15
█	1,000 ft	-	14
█	1,000 ft	300 ft	9

EPL Flushing Example



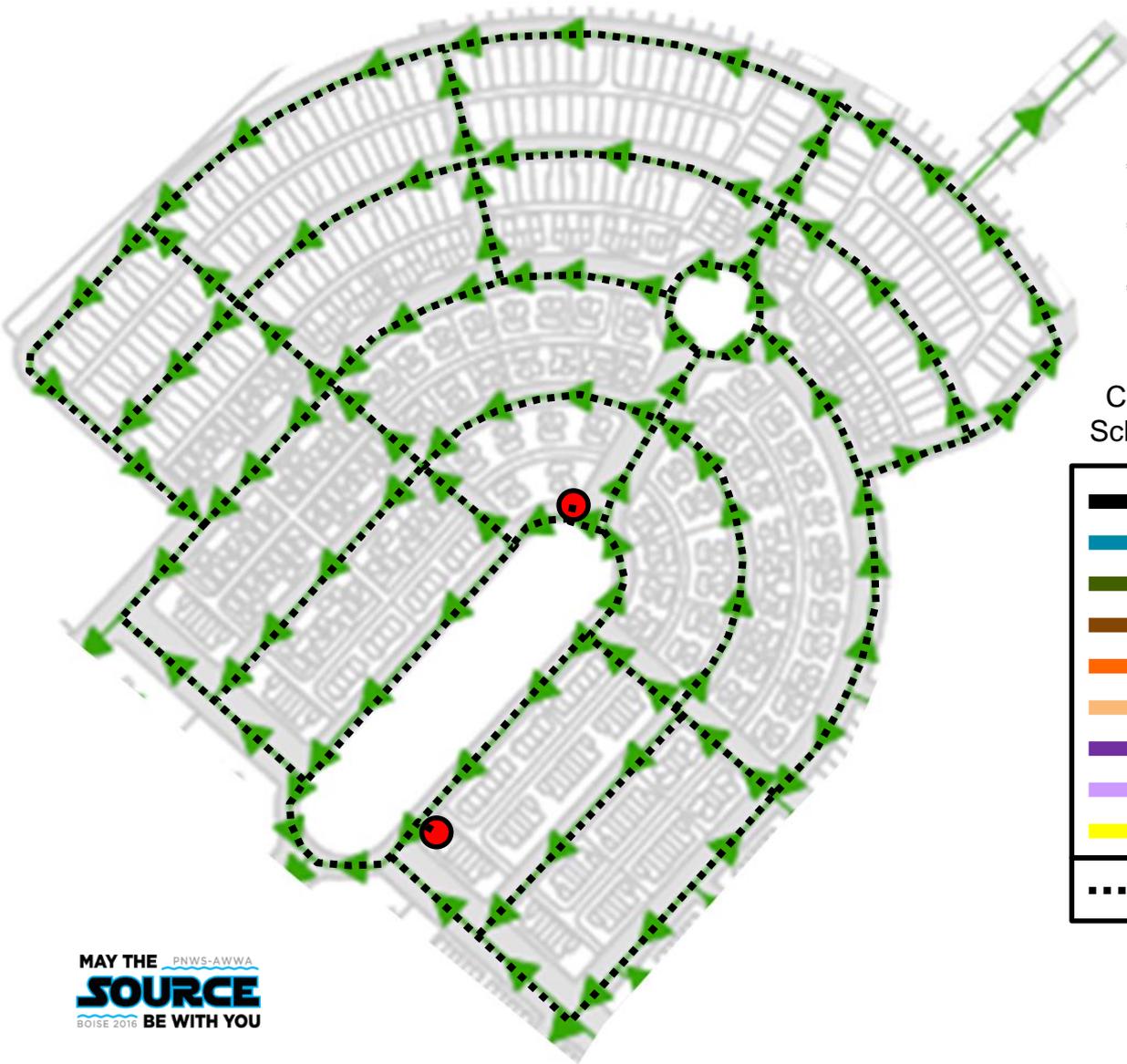
- Hydrant
- ⊘ Partially shut valve
- ⊙ Partially shut valve optional
- Pipe already flushed

● At 1470 GPM

- ⌚ 2x vol = 3 min
- ⌚ 8" = 6 FPS

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
Black	4,500 ft	900 ft	20
Blue	3,500 ft	-	21
Green	3,650 ft	300 ft	22
Brown	1,450 ft	-	19
Orange	1,550 ft	-	21
Light Orange	2,150 ft	-	15
Purple	1,000 ft	-	14
Light Purple	1,000 ft	300 ft	9
Yellow	-	570 ft	7

EPL Flushing Example



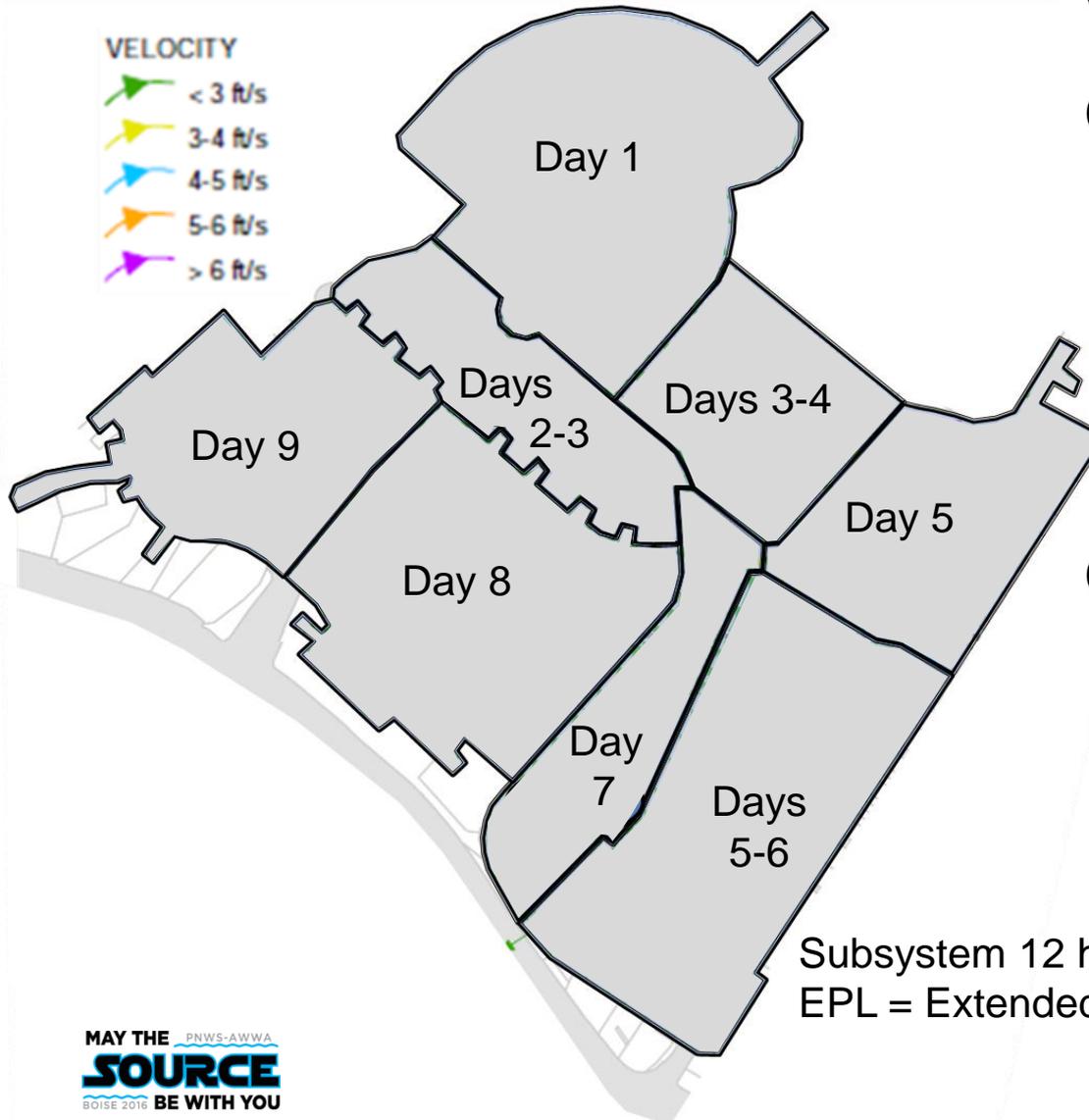
- Hydrant
- ⊗ Partially shut valve
- ⊗ Partially shut valve optional
- Pipe already flushed

- Flush time = 121 min max
- Valve turning time
- Time needed to setup, sample, and replace filters

Color Scheme	8-in Pipe Flushed	10-in Pipe Flushed	Valves To Close
	4,500 ft	900 ft	20
	3,500 ft	-	21
	3,650 ft	300 ft	22
	1,450 ft	-	19
	1,550 ft	-	21
	2,150 ft	-	15
	1,000 ft	-	14
	1,000 ft	300 ft	9
	-	570 ft	7
.....	18,800 ft	2,070 ft	148

Subsystem Flushing Summary

VELOCITY



Subsystem 12 has 8 EPLs
EPL = Extended Pipe Loop

 Target 1 EPL/day

 However.....

 Complexity may require connection at multiple hydrant locations

 Can take 2 days

 Benefit of EPLs

 Flushing reduced from ~4 years to ~2 years

 ~5 miles/week

Summary and Next Steps

Zero-Discharge, Closed-Loop Flushing

-  Proprietary equipment
-  No change in system pressure; no water loss
-  Can achieve excellent scouring (5 fps in 12-in dia. Mains)
-  Rapid progress through the distribution system (5 miles / week)

Appropriate for Chlorinated & Chloraminated Systems

-  Remove sediment
-  Precise chlorine addition meets demand; combines with free NH_3

Supports Distribution System O&M

-  Valve asset management
-  Mains cleaning



Summary and Next Steps, continued

Challenges

-  Pre- and continuous planning effort
-  Scheduling and customer notification
-  Sanitary working practices (disinfecting equipment, sampling)
-  Traffic management during flushing
-  Equipment purchase, storage, and O&M
-  Staffing: valve maint. (2 persons) and flushing crew (2 persons)

Current Status and Next Steps

-  Planning completed
-  Health Department approval given
-  Equipment to be purchased





Thank You!

Alex Mofidi PE