

# This presentation premiered at WaterSmart Innovations

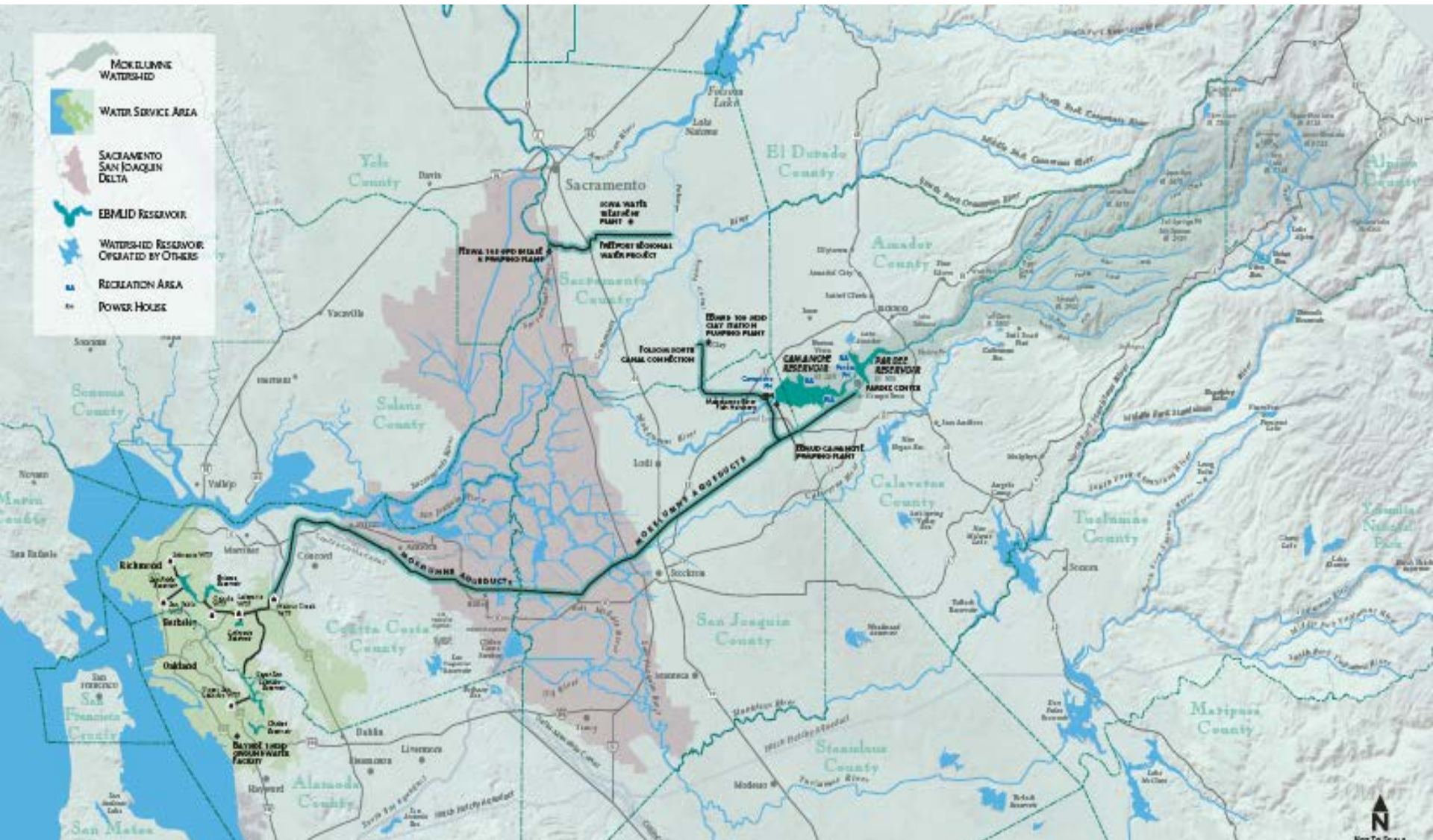
[watersmartinnovations.com](http://watersmartinnovations.com)



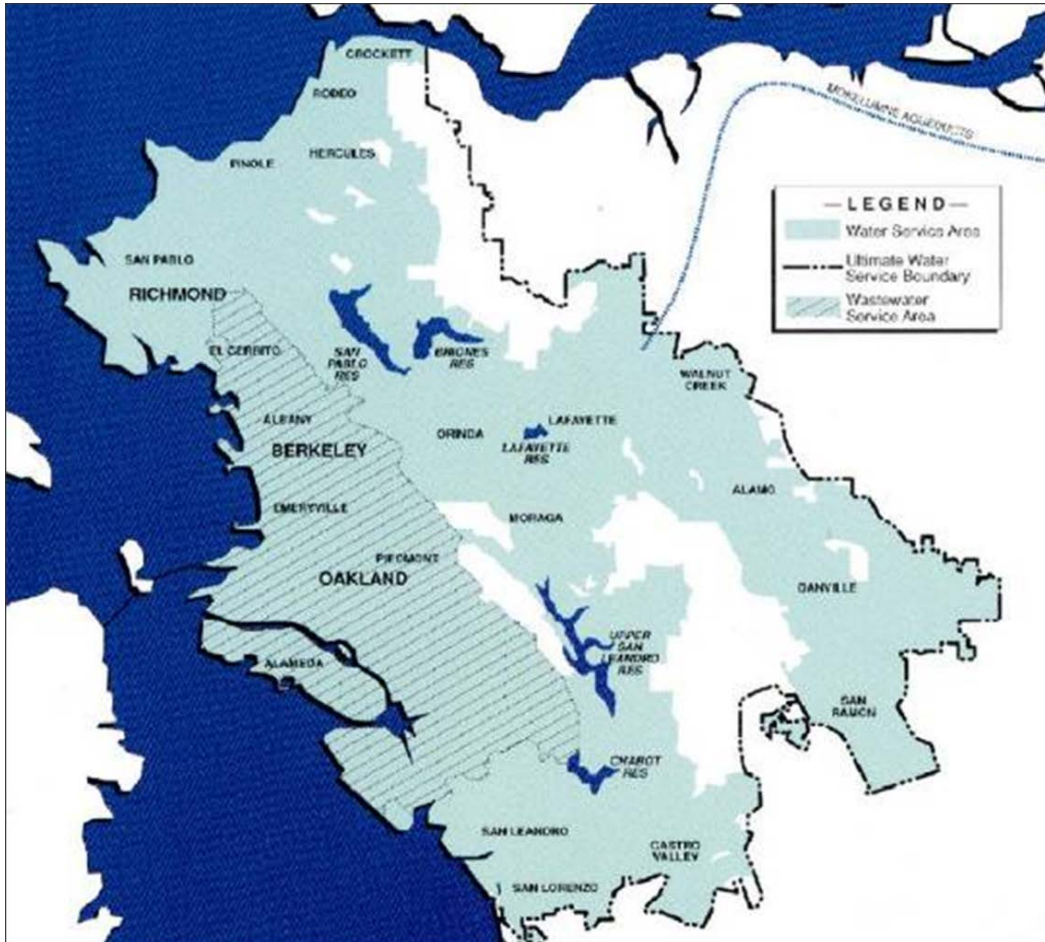
# Unmeasured Flow Study:

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EBMUD Water Conservation

# EBMUD System



# EBMUD Water and Wastewater



## Water

- 1.4 million customers
- 190-210 MGD demand
- 35 communities
- 330 sq.mi service area
- >4,000 miles of pipe
- 382k water meters

## Wastewater

- 650,000 customers
- 75 MGD Avg. Flow
- 83 sq.mi service area
- 100% energy sufficient

# Where is Water Loss

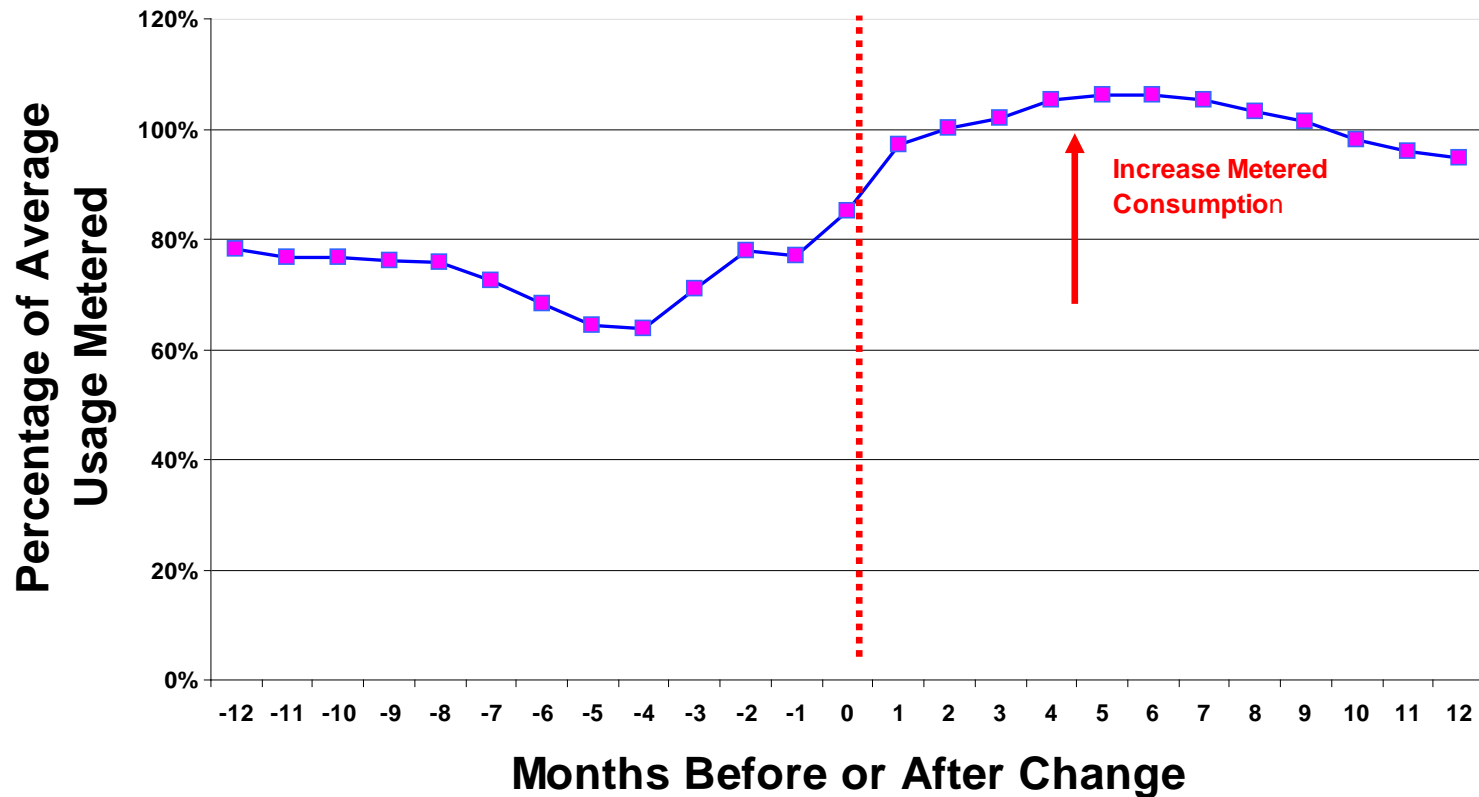


System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
		Real Losses	Data Handling Errors Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks Leakage on Service Connections up to point of Customer metering	

# Slow Meter Decay=Lost Revenue



## Average Meter Registration Before/After Changeout Based on 13,584 Stuck Meters



# Unmeasured Flow Study Goals



- To better understand customer usage rates.
- To assess the condition of existing meters.
- Evaluate revenue gains from new meters.
- To identify problem meters or conditions.
- To see leaks at even their lowest levels.
- Obtain consumption data for conservation.

# Considerations of Meter Accuracy



- AWWA standards down to 1/4 gpm
- Many NEW 5/8 meters can beat that
- Meters decay at the low end first
- Older meters often not accurate at low flows
- % of water used at low flows?
- Early studies suggest at least 5% less than 1/4 gpm.
- EBMUD has 345k 5/8-inch meters



# How much does an undetected leak really amount to?



Flow gpm	CF/Hr	GPD	CCF/mo	\$/mo*
1/32	0.25	45	1.83	\$8.16
1/16	0.5	90	3.66	\$16.3
<b>1/8</b>	<b>1.0</b>	<b>180</b>	<b>7.31</b>	<b>\$32.6</b>
1/4	2.0	360	14.6	\$65.3
1/2	4.0	720	29.3	\$130.6
1	8.0	1,440	58.6	\$261.1

*\* Assume water cost about \$4.46/unit or \$5.96 per thousand gallon*

¼ GPM



1/8 GPM



1/16<sup>th</sup> GPM



1/32 GPM



1/37 gpm (lower end of ability to measure)



1/150 gpm is still 10 gallons per day



# Unmeasured Flow Study Approach



- Replaced approximately 431 meters with Sensus Iperl Mag Meters and Metron M2 radios.
- Over 200 pulled meters tested at discrete flows  $1/32$ ,  $1/16$ ,  $1/8$ ,  $1/4$  and all the way up.
- Iperl Meters start registering at  $1/37$  gpm.
- Meter Resolution is 0.001 CF or about 1 ounce of water.
- Datalogging at 1 minute intervals.
- Two 11-day downloads per season.
- 55 million meter reads!





# Why the 5/8-inch meter only?



- EBMUD has 382k meters
  - 345k 5/8-inch meters
  - 35k other meters 3/4-16 inches
- 5/8-inch meters account for 54% of metered consumption.
- With more meters, more likely to have slow leaks
- No active replacement program
- Other meters to be studied later

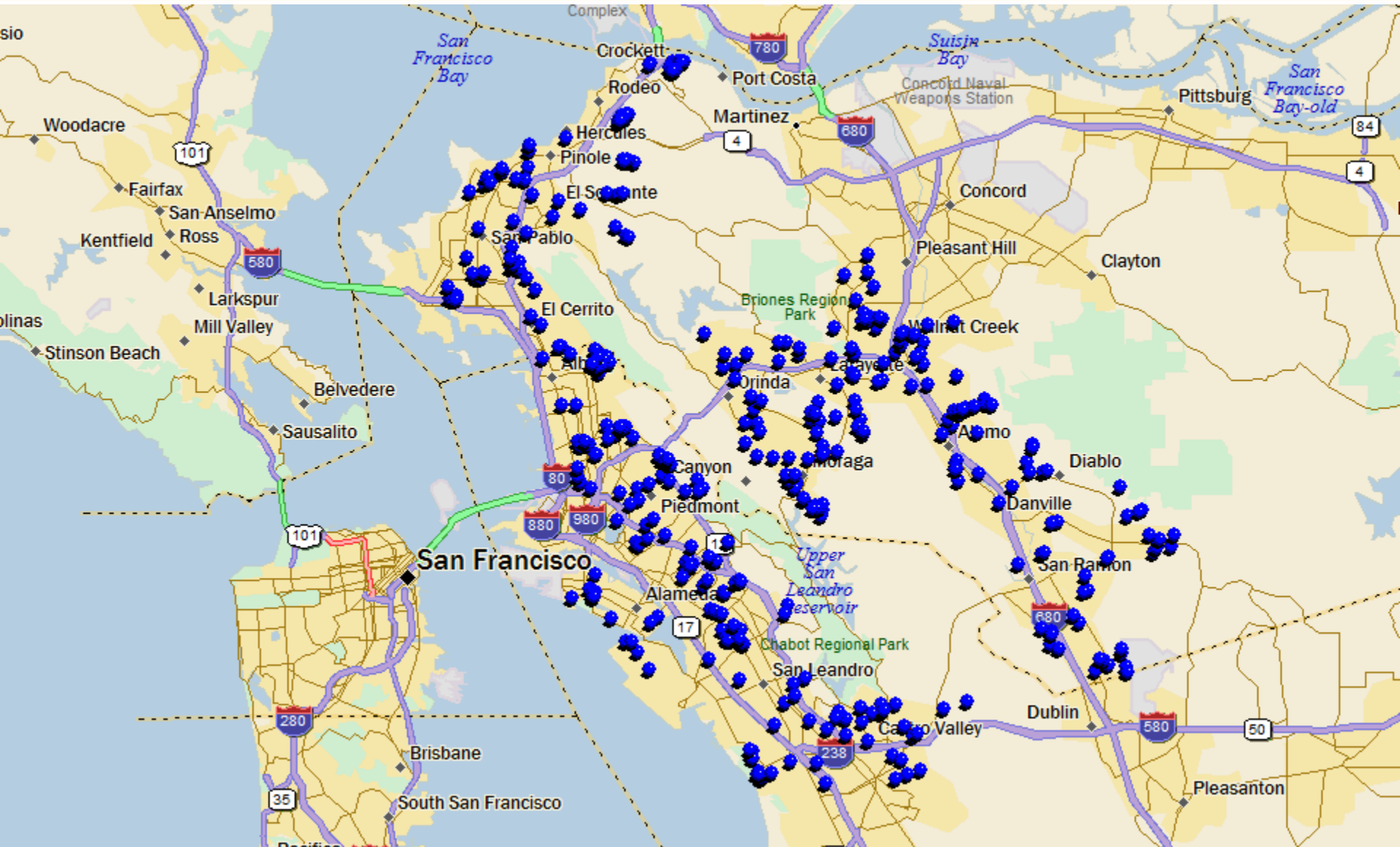


# Meter Selection and Installation

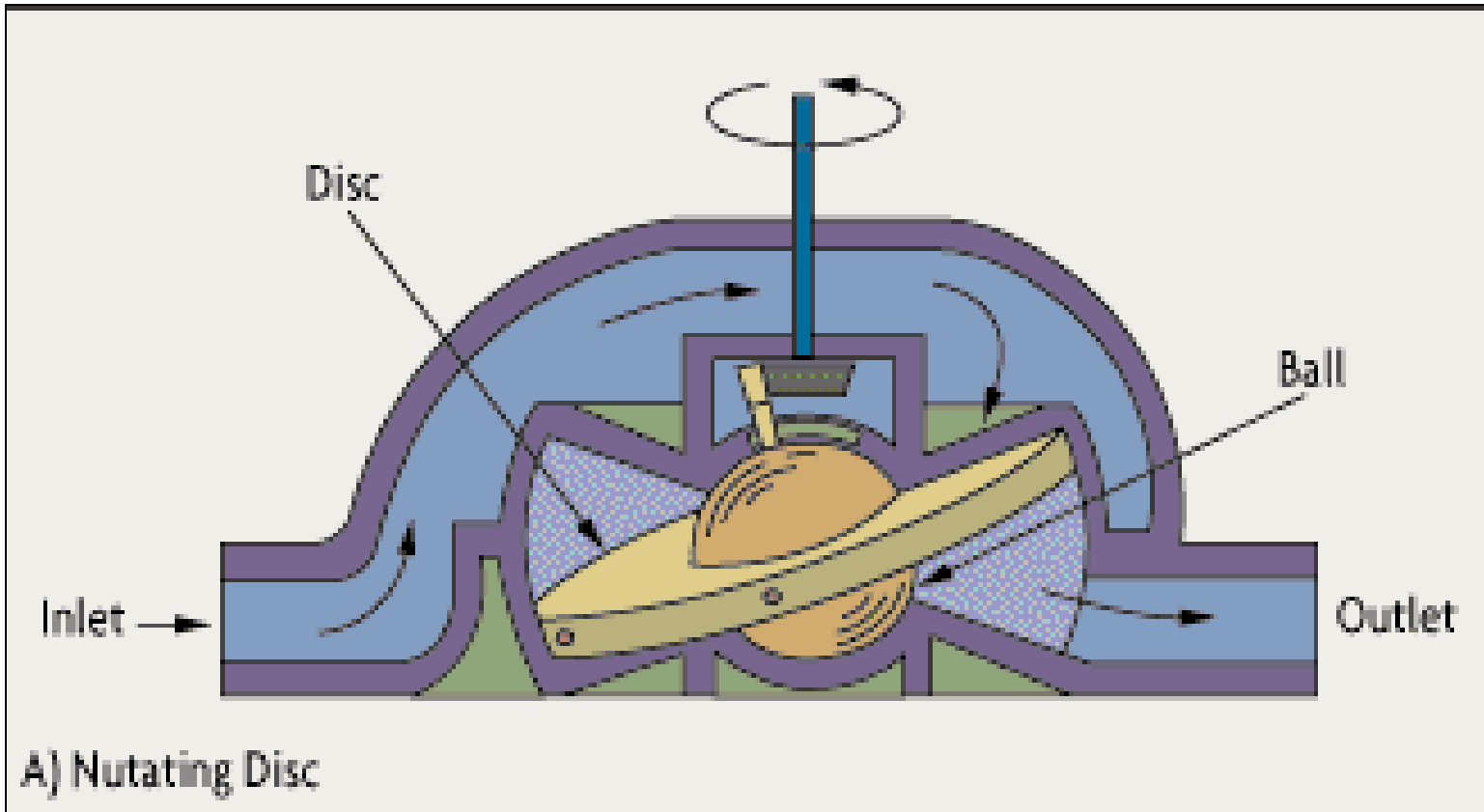


- Meters were installed Aug 2011 through July 2013
- Study period Sept 2013 to Sept 2014
- Meter selection based on convenience.
  - Meter raise project, 2000 meters replaced.
  - Selected meters geographically proportionally.
- Skipped stuck or questionable meters.
- Selected to be proportional to number in city.
- 2011 average 5/8-inch, 236 gpd.
  - Among selected accounts was 293 gpd

# Unmeasured Flow Study

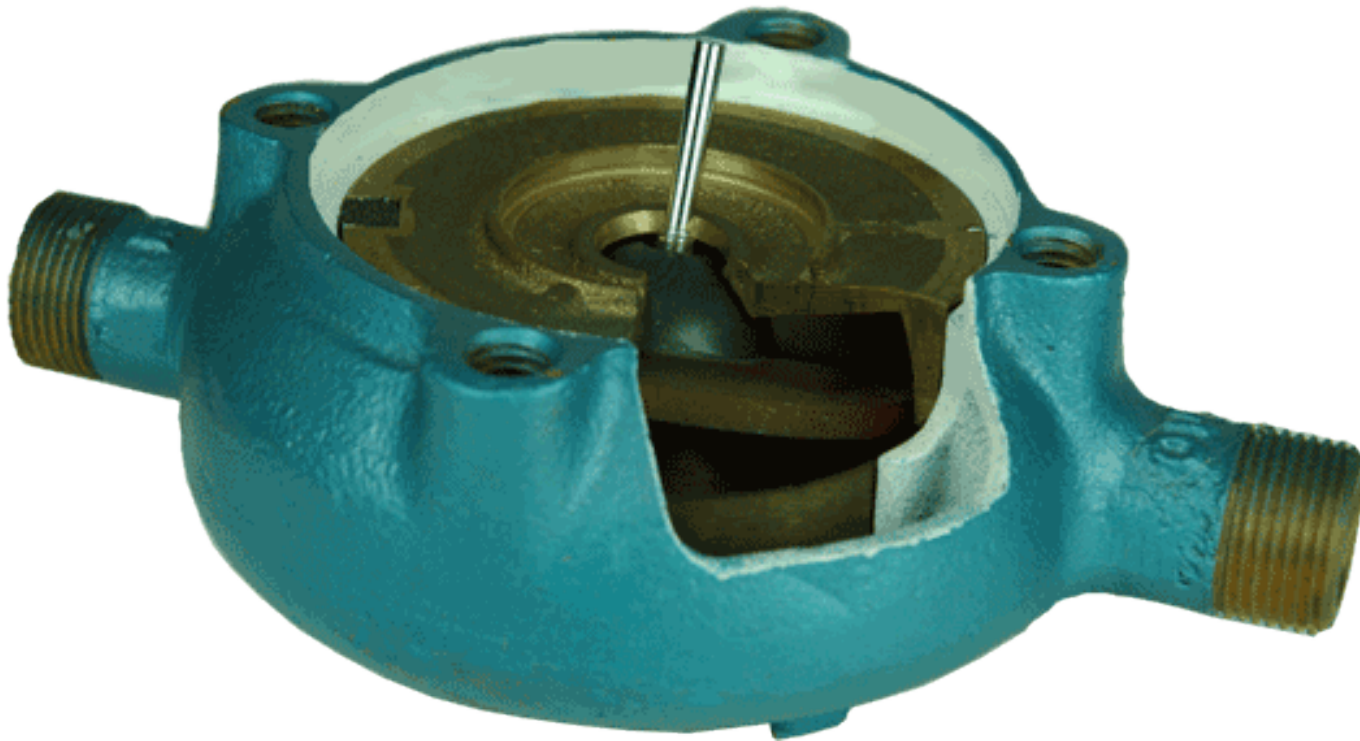


# Nutating Disc-Most Common in U.S.



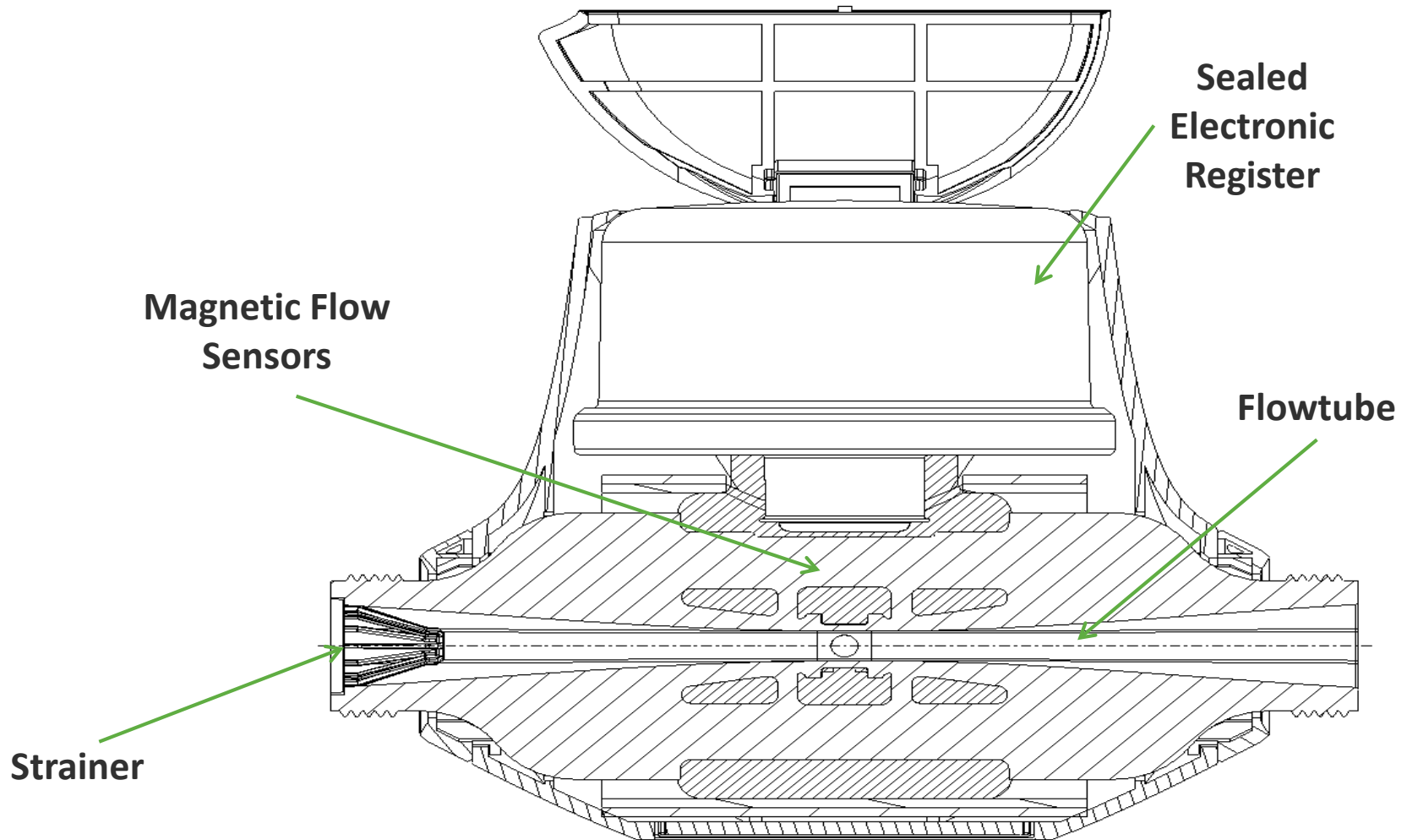
Source: OMEGA Complete Flow and Level Measurement Handbook and Encyclopedia®, OMEGA Press, 1995.

# Nutating Disc-Most Common in U.S.

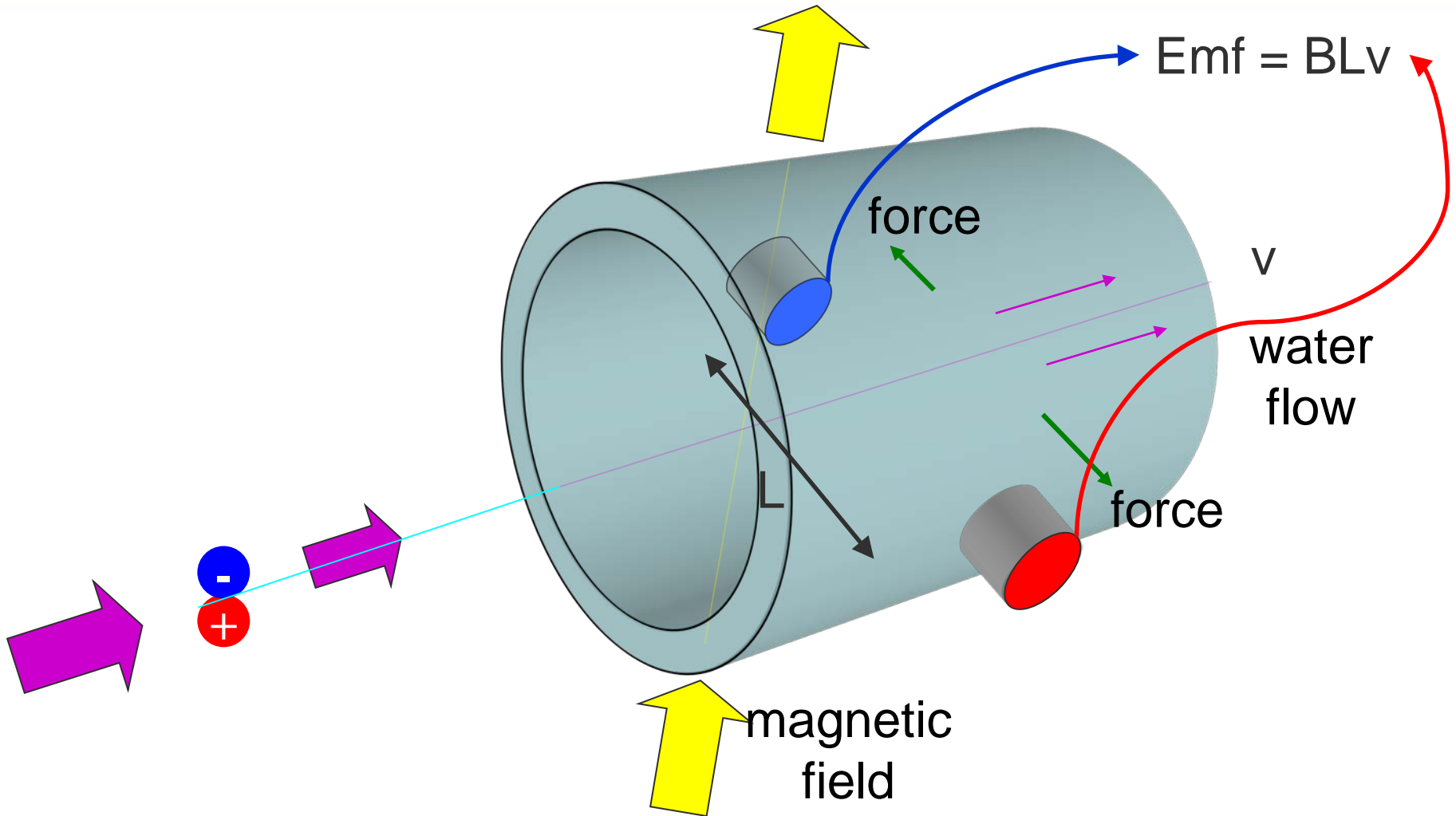


*Source: Neptune Meter.*

# Magnetic Meter



# EMF Theory: In Motion



# What does a small leak look like?

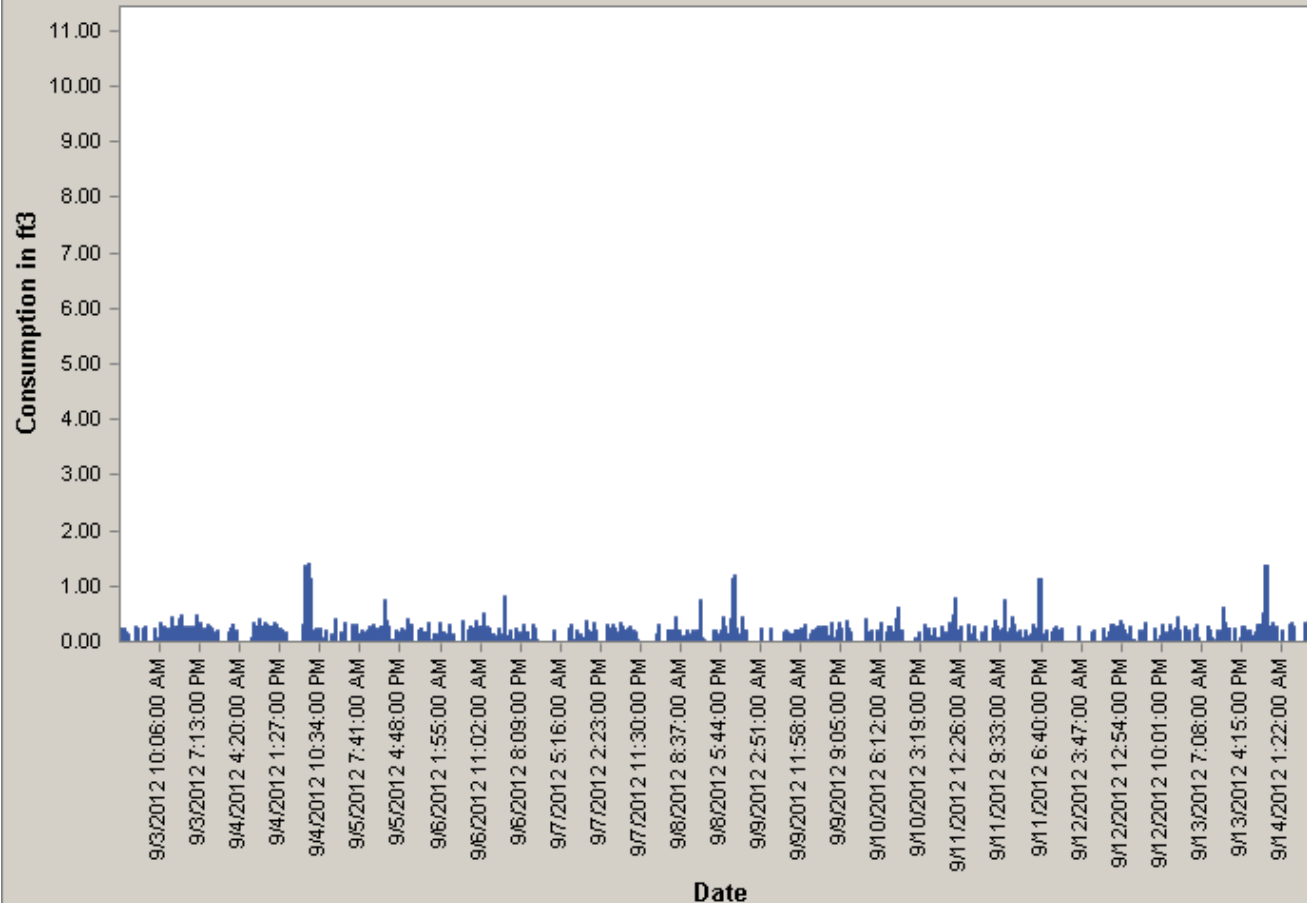


Route database: C:\T2 G2\Database\EBMUD.mdb

Graph Export View



446934



9/3/2012 1:00:00 AM	0.00
9/3/2012 1:01:00 AM	0.00
9/3/2012 1:02:00 AM	0.00
9/3/2012 1:03:00 AM	0.12
9/3/2012 1:04:00 AM	0.24
9/3/2012 1:05:00 AM	0.25
9/3/2012 1:06:00 AM	0.08
9/3/2012 1:07:00 AM	0.02
9/3/2012 1:08:00 AM	0.06
9/3/2012 1:09:00 AM	0.04
9/3/2012 1:10:00 AM	0.15
9/3/2012 1:11:00 AM	0.07
9/3/2012 1:12:00 AM	0.00
9/3/2012 1:13:00 AM	0.06
9/3/2012 1:14:00 AM	0.00
9/3/2012 1:15:00 AM	0.00
9/3/2012 1:16:00 AM	0.00
9/3/2012 1:17:00 AM	0.01
9/3/2012 1:18:00 AM	0.00
9/3/2012 1:19:00 AM	0.01
9/3/2012 1:20:00 AM	0.00
9/3/2012 1:21:00 AM	0.00
9/3/2012 1:22:00 AM	0.00
9/3/2012 1:23:00 AM	0.25
9/3/2012 1:24:00 AM	0.01

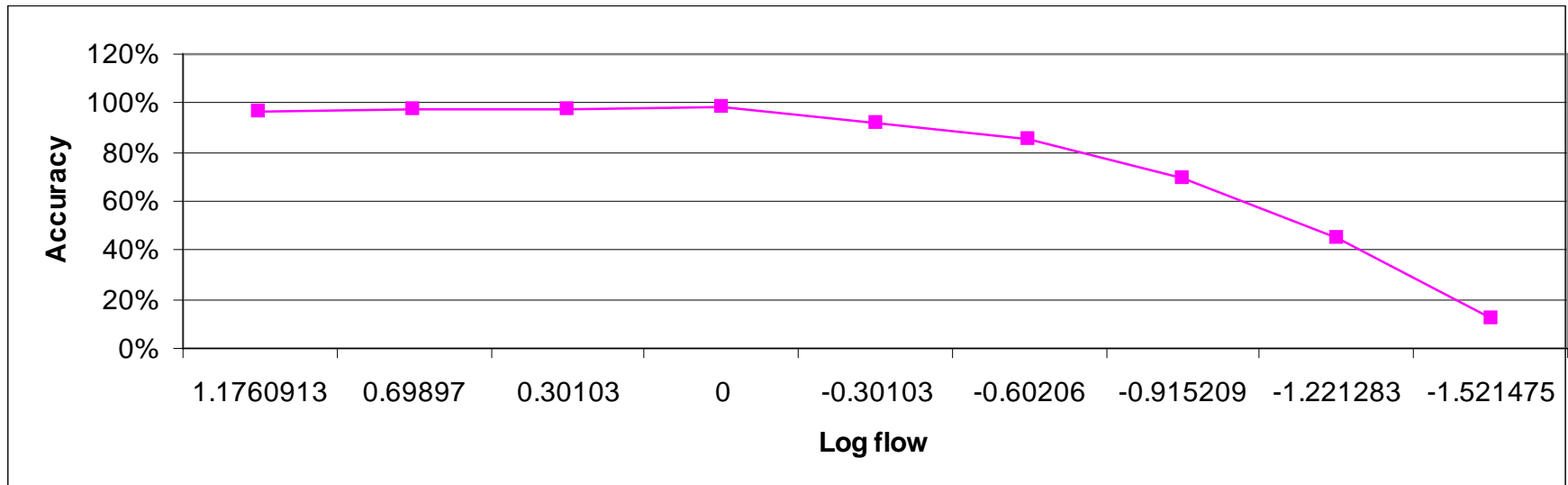


# Sample Accuracy Testing-Log Normal curve

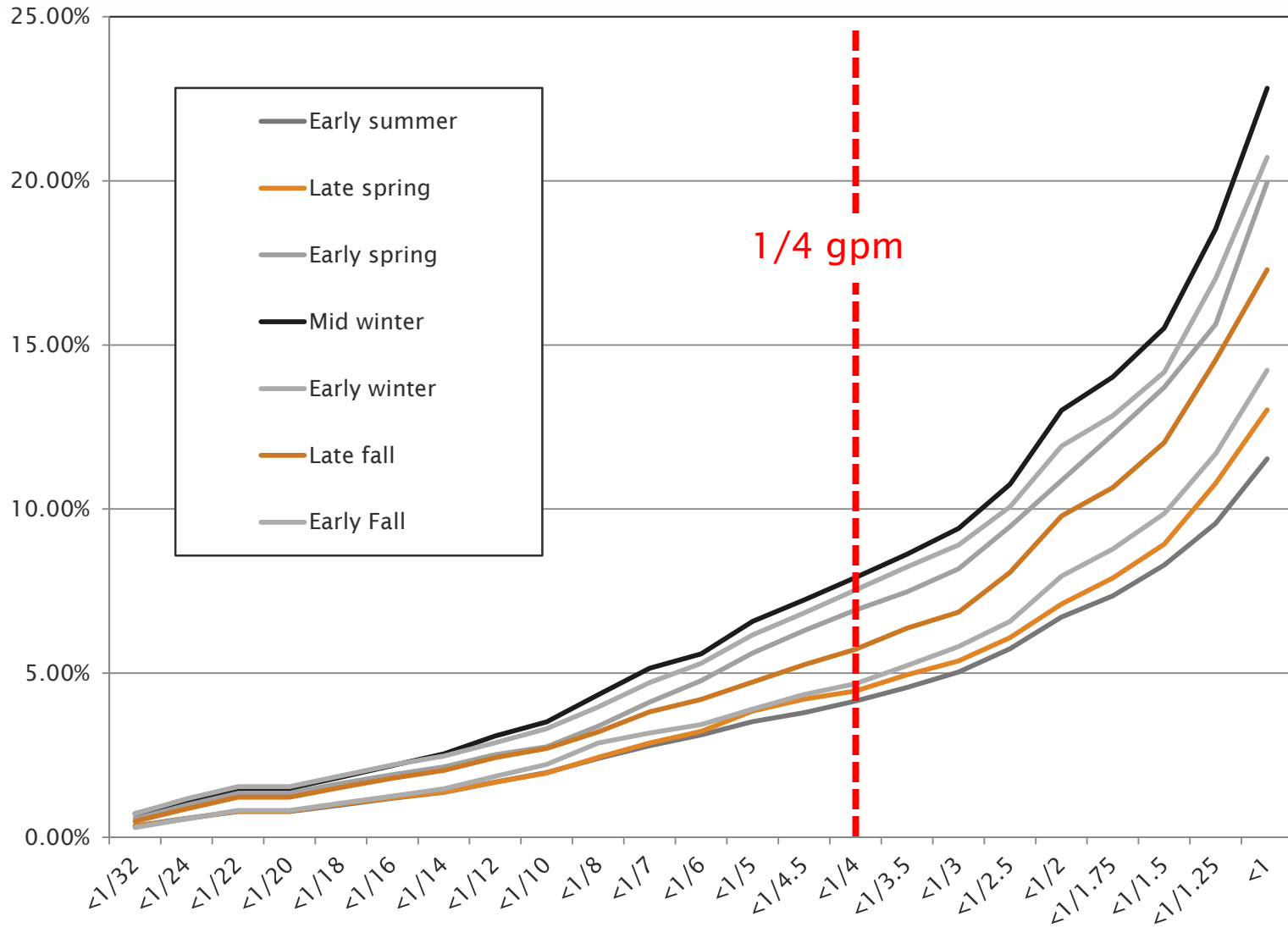


Flow gpm	15	5	2	1	1/2	1/4	1/8	1/16	1/32
% acrcy	97	98	98	98	92	86	69	45	12

**Log of Flow rate vs. tested Accuracy**



# Flow Rate Changes by Season



# Example Accuracy Calculations



Measured = sum[(%of flow)X(accuracy of flow)]

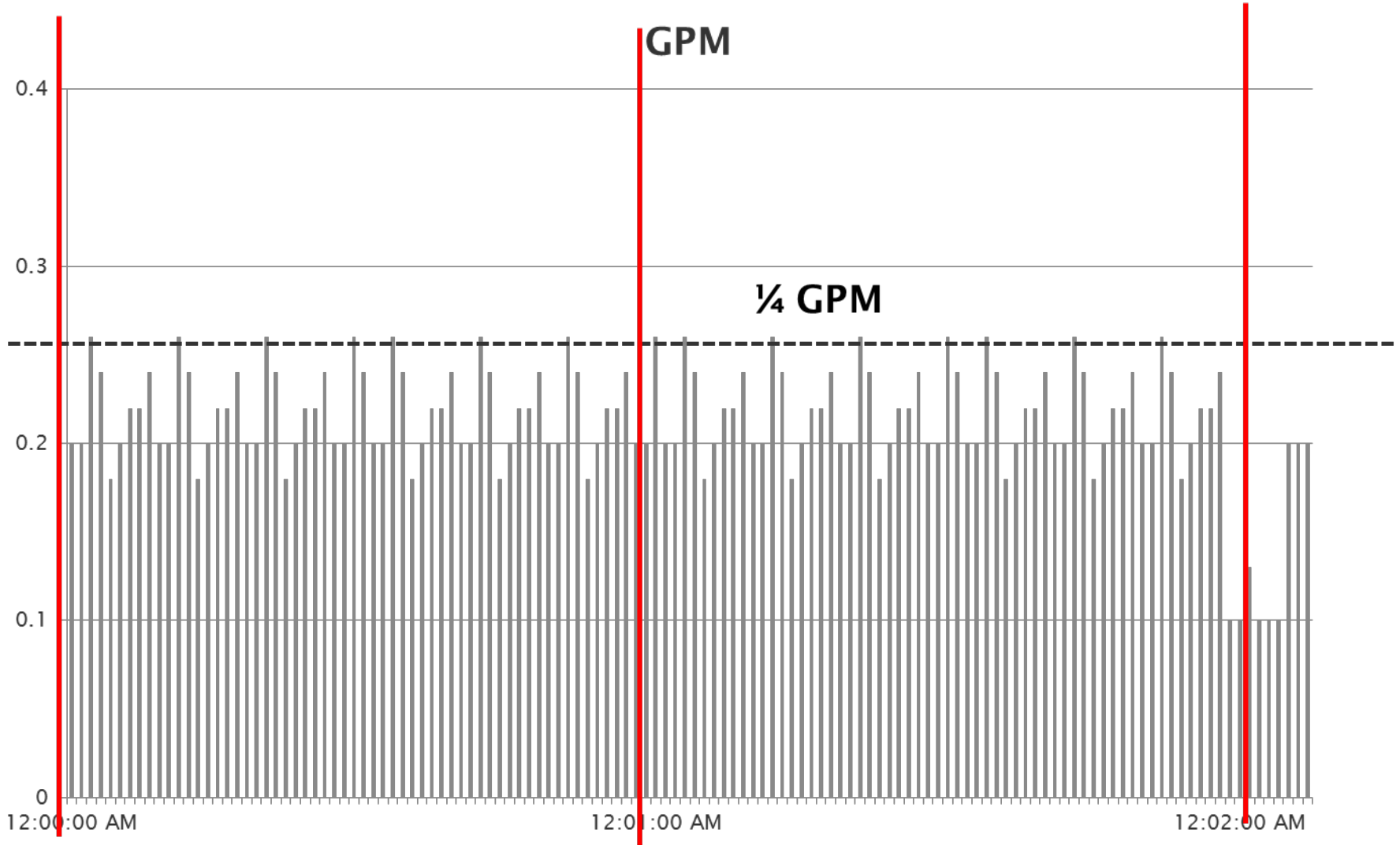
Range	Midpt	Log Midpnt	Accur acy	% of flow	% Measured
1/32-1/24	1/28	-1.447	20%	0.3	0.06
1/24-1/22	1/23	-1.362	29%	0.4	0.116
1/22-1/20	1/21	-1.322	34%	0.0	0.00
1/20-1/18	1/19	-1.279	38%	0.4	0.152
1/18-1/16	1/17	-1.23	44%	0.3	0.132
1/16-1/14	1/15	-1.176	48%	0.2	0.096

# Sampling Time Issue

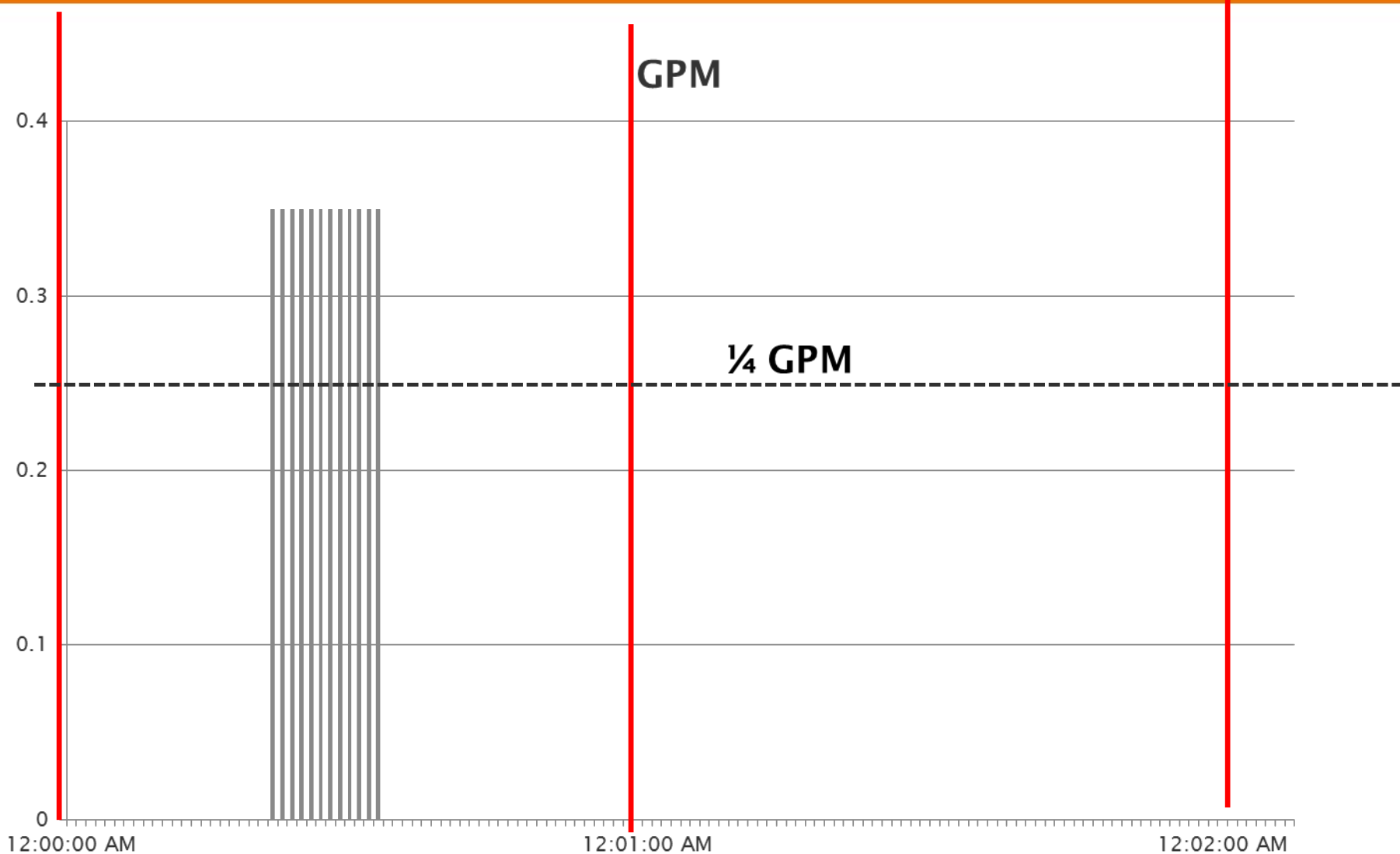


- We are logging 0.001 CF every 1 Minute.
- Some leak usage continuous low flow some periodic usage.
- Short duration high flow looks like low flow.
- A 2 gpm faucet will take 2 seconds to fill an 8 Oz glass. This will look like 1/16 gpm.
- Solution strike isolated low flow minutes of one or two minutes less than ¼ gpm.

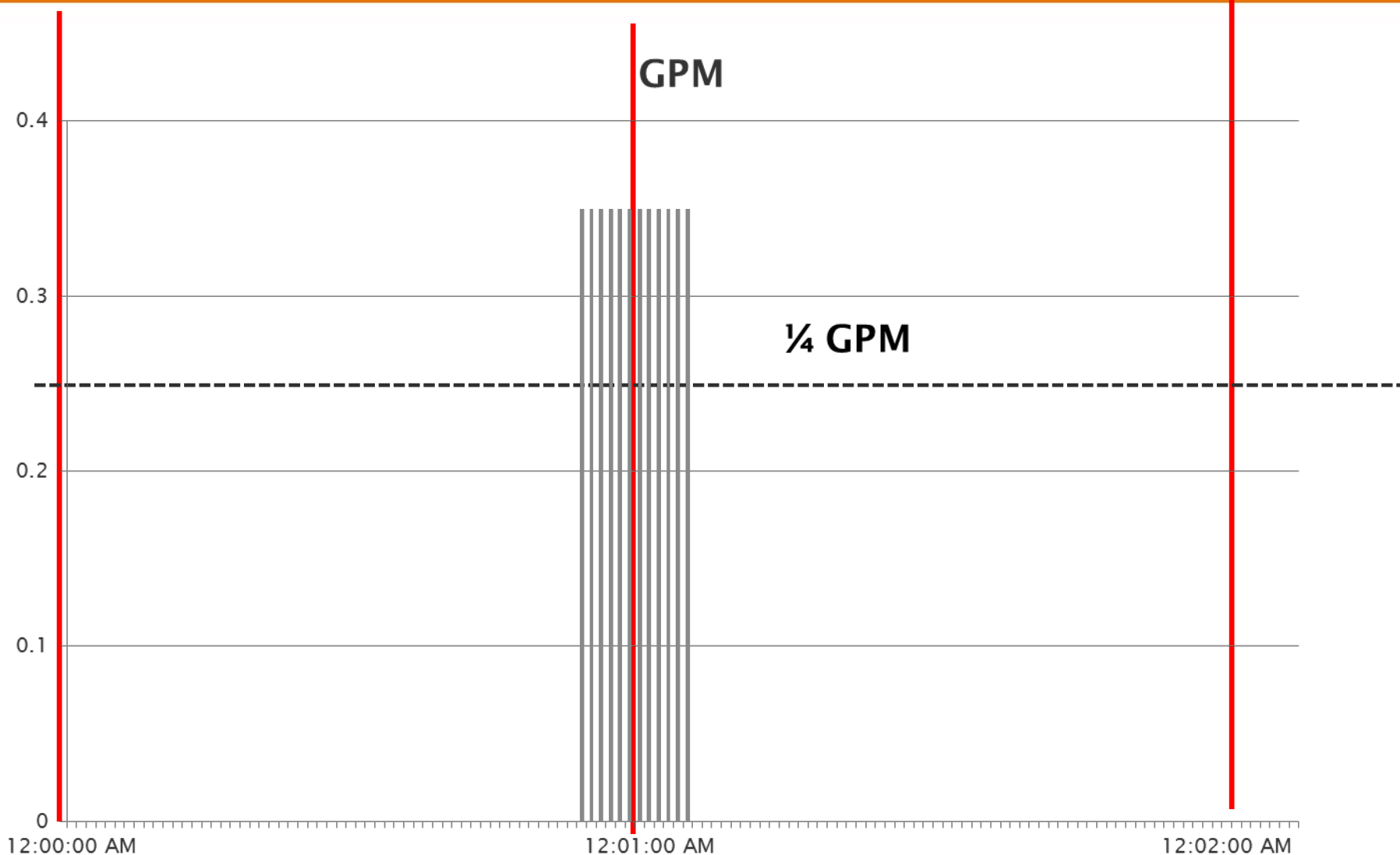
# GPM is Gallons in one Minute-60 seconds interval (average)



# Error if flow volume not same across minute



# Worse if flow volume between two minutes



# Sampling Time Issue-Correction



Minute	Registered Consumption in Cubic Feet	Corrected Consumption in Cubic Feet	Comments
1	0	0	
2	0.03	0	Deletes isolated minute
3	0	0	
4	0.03	0	Deletes isolated pair
5	0.03	0	
6	0	0	
7	0.03	0.03	Keeps all three minutes
8	0.03	0.03	
9	0.03	0.03	
10	0	0	
11	0.03	0	Deletes partial minute
12	2.5	2.5	
13	2.5	2.5	
14	0.03	0	Deletes partial minute
15	0	0	



# What are the results?

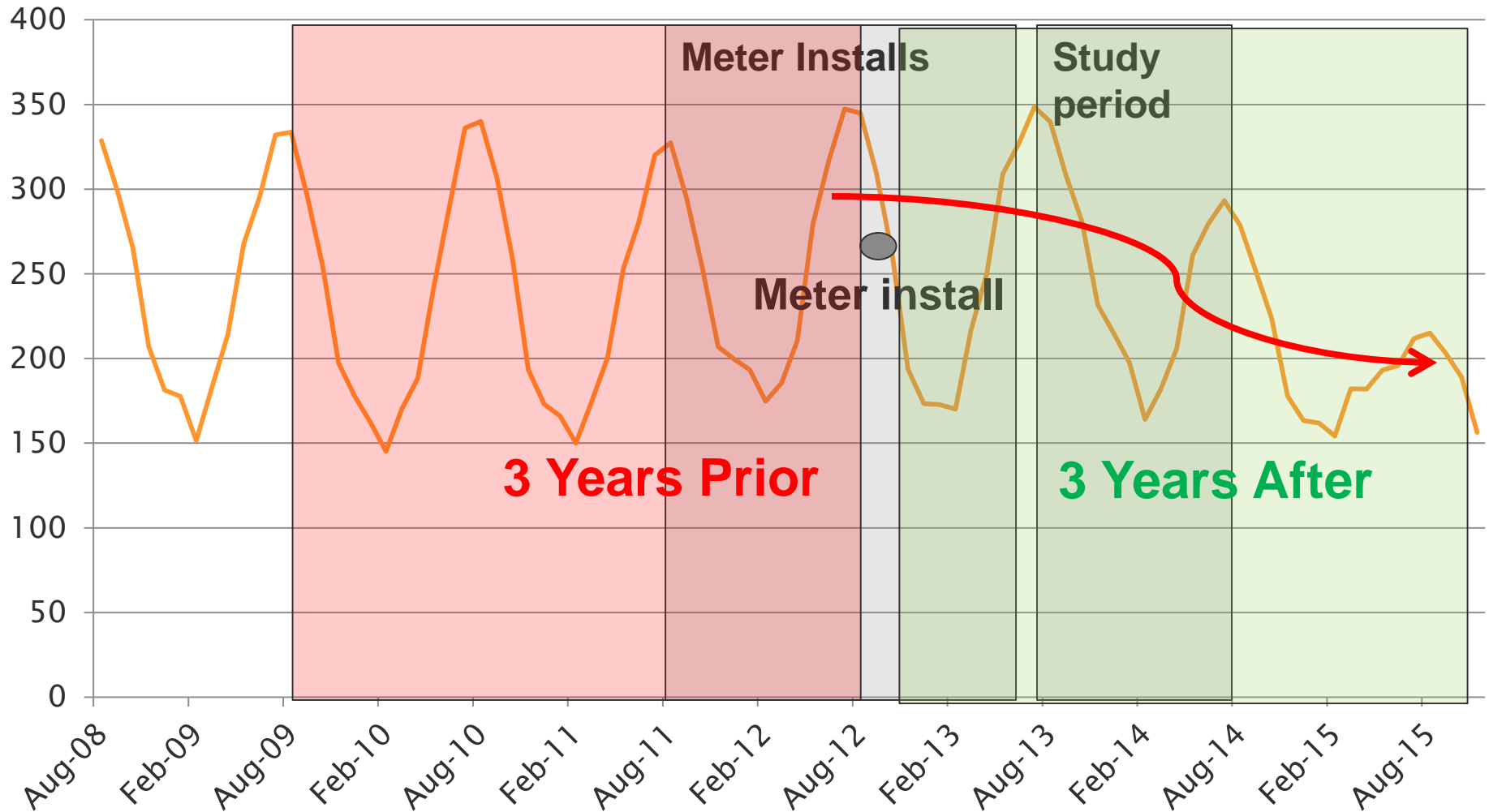


- Methodology indicates results are unmeasured flow is between 4 and 7% depending on
  - Treatment of unexpected stuck pulled meters
  - Treatment of stray water usage
- Consideration of accuracy of test meters

# Analysis challenge with drought



## Average GPD of 5/8 meters



# Analysis of Pre/Post Consumption



- New meters installed Aug 11 to Nov 12
  - 3 years Post/Pre new meter data up 2 %
- Control group consumption down -6 %
  - Net difference 3 year pre/post 8%
- Consumption increase slightly higher than method
- Less headloss?
  - Reduced irrigation demand, leaks are higher percentage

# General Observations



- Higher consumption in new meters.
- Low flow leaks found in older homes.
- 1/3 of all minutes had consumption.
- Observed flows up to 40 gpm-broken pipe.
- Many older meters performed pretty well.
- Many newer meters performed miserably.
- Apparent losses higher than we expected.

# Other lessons learned



- Low flow testing can be tricky.
- Unresolved issues with meter-radio communication.
- 1-minute data can lead to data overload.
- Different methodologies can lead to different results.
- Losses inversely tied to average flow rate.
- New low flow meter accuracy specification.



# Questions & Comments

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