



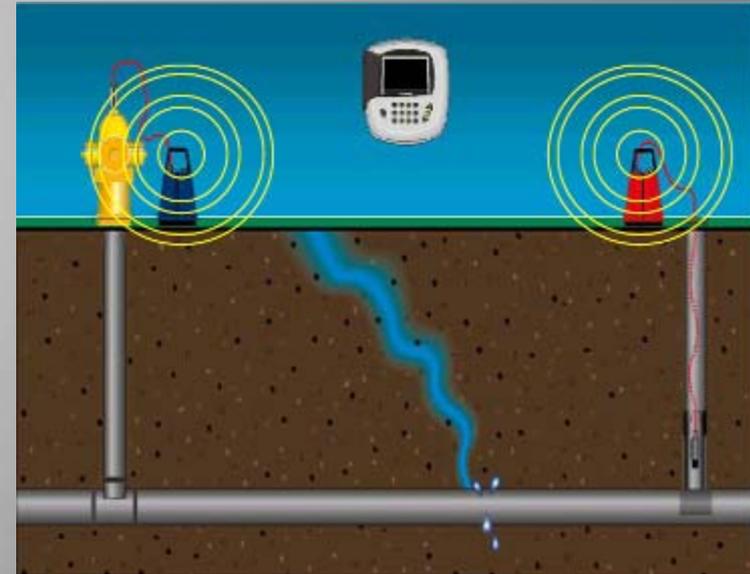
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What Side of the Meter Are You On?



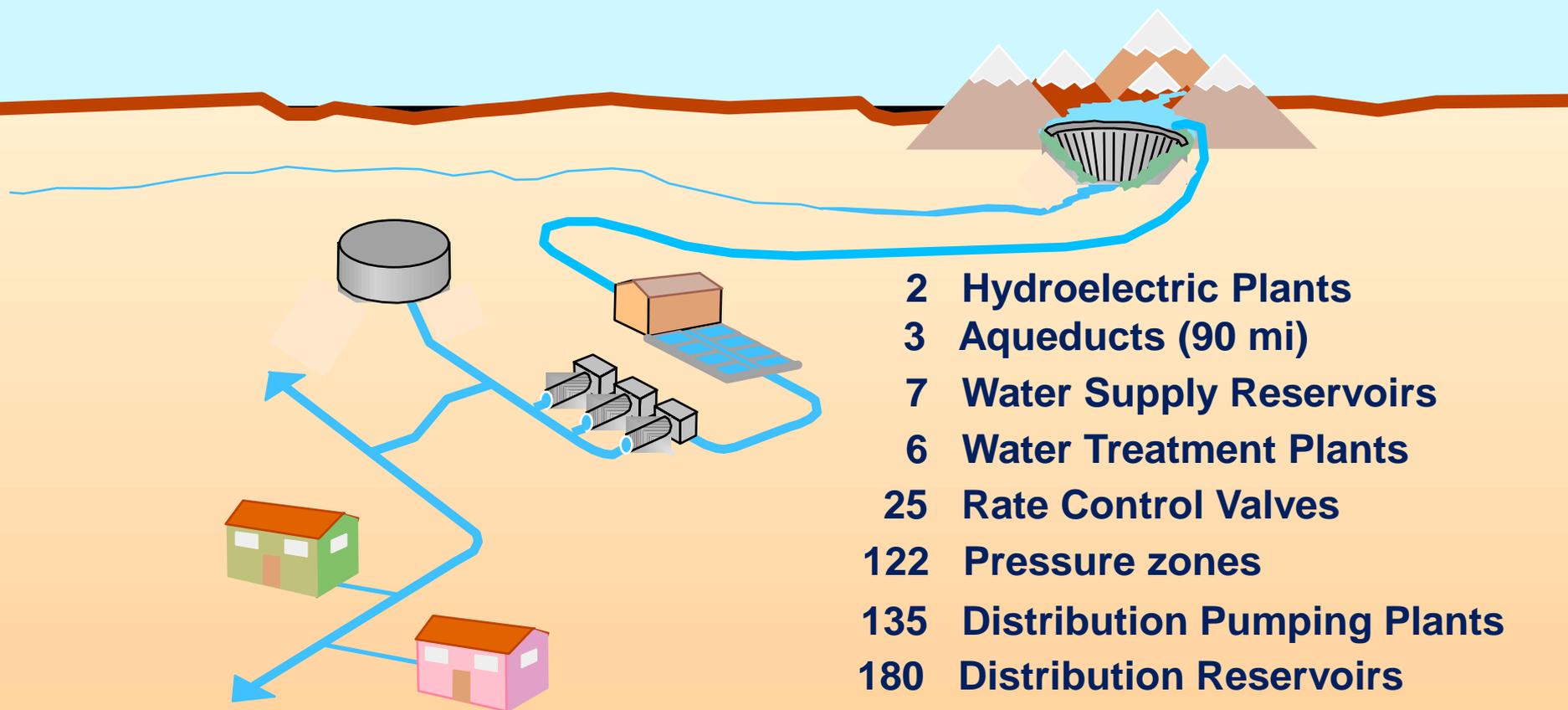
Proactively Looking and Listening for Leaks on Pipes and Aqueducts

**Richard Harris
David Wallenstein
William Cain**

**2010 Watersmart Innovations
Conference & Exposition**



EBMUD Water System Facilities



- 2 Hydroelectric Plants
- 3 Aqueducts (90 mi)
- 7 Water Supply Reservoirs
- 6 Water Treatment Plants
- 25 Rate Control Valves
- 122 Pressure zones
- 135 Distribution Pumping Plants
- 180 Distribution Reservoirs
- >4,000 Miles of Distribution Pipeline
- Elevation: MSL – 1,450 ft

1.34 Million customers

2007 Water Production = 210 MGD

Summary of Leak Detection Practices



- Pinbars have been used for 100s of years
- During the '77 drought began foot surveys of 330 square mile service area
- Using correlators for about 20 years
- Ground Microphones about 15 years
- Logger lift and shift method for about 10 years
- Permanent logger deployment in limited areas

Two Projects Being Evaluated



Large Diameter Pipeline Leak Detection

- Evaluate permanent deployment of loggers vs. lift and shift
- Help determine how much water is lost by leaks
- Determine how long leaks flow before surfacing
- Help determine cause of leaks
- Reduced unplanned pipe repairs
- Save Water
- \$300K grant from U.S. Bureau of Reclamation

Two Projects Being Evaluated (Cont.)



Aqueduct Leak Detection Project

- Perform field condition assessments of selected large diameter pipelines ($> 24''\text{Ø}$)
- Develop a database of physical conditions of large diameter pipelines
- Develop methods to forecast large diameter pipeline renewal requirements
- \$300K grant from U.S. Bureau of Reclamation

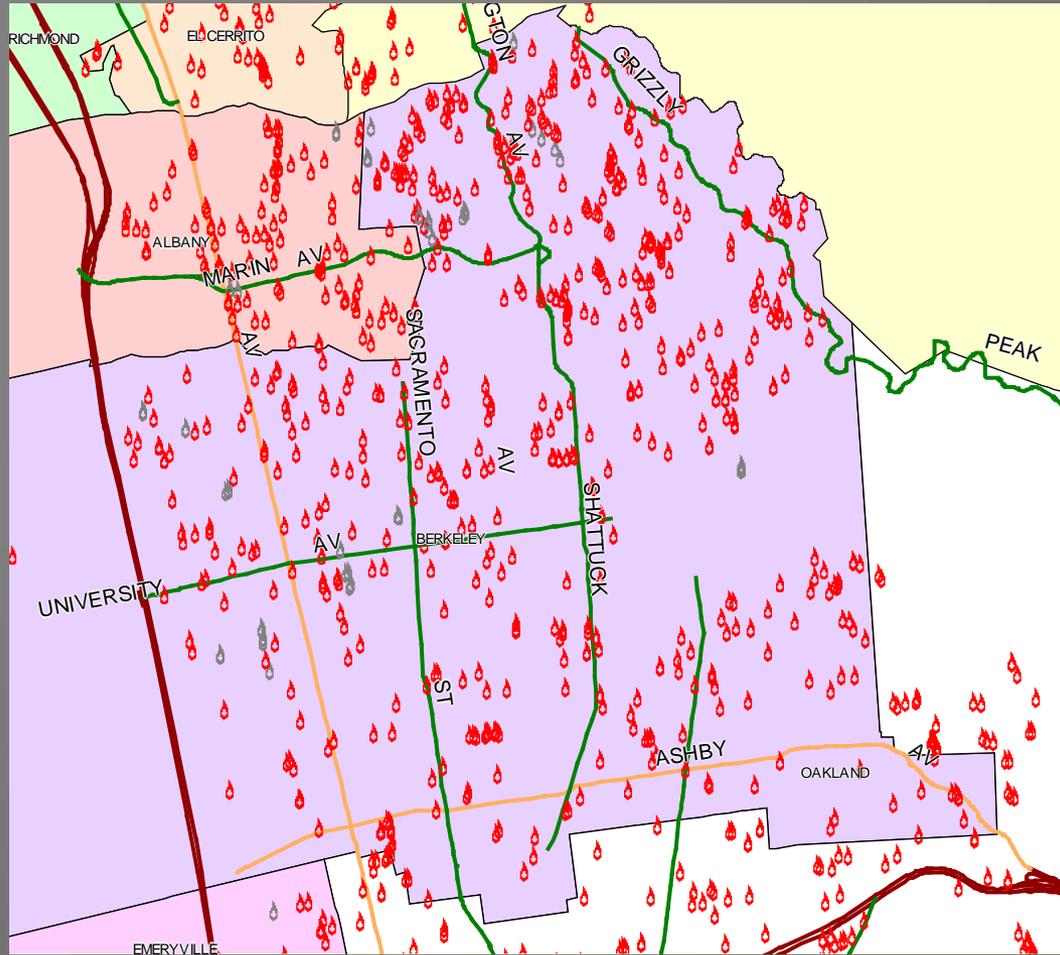
Large Diameter Pipe Project



Equipment

- 1,000 loggers (850 placed in City of Berkeley)
 - 200 loggers extension type for submerged use.
- Laptop, receiver, GPS system
- 3 Correlators
- 2 Ground Microphones

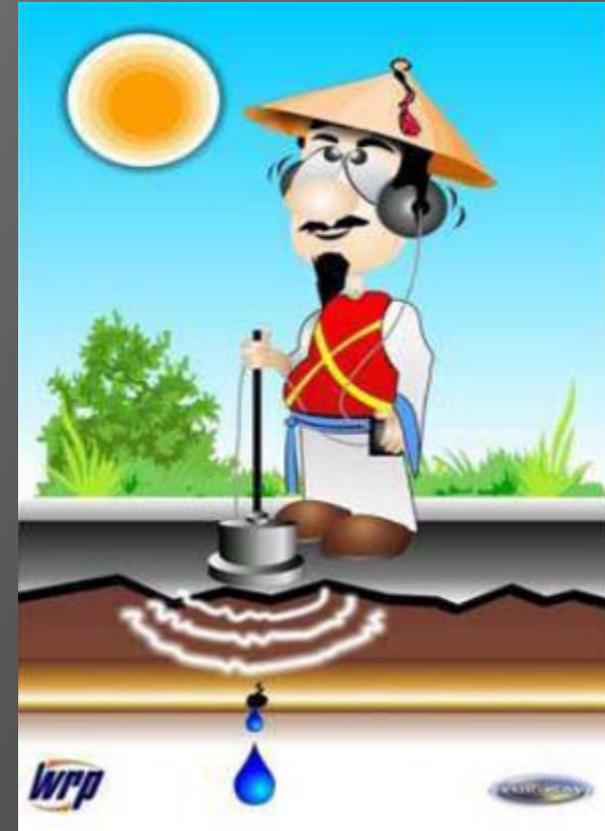
City of Berkeley



- Older pipes
- High no. of leaks
- Sizable area
- Numerous creeks
- Representative mix of pipe types, age, etc.

Type of Equipment Used

- **Loggers** that can find leaks
- **Correlators** that can pinpoint leaks
- **Ground microphones** that can verify leaks
- **Laptop and software** to store leak information
- **GPS system** to assist with downloading and tracking



How does a logger work?



- Magnetically attaches to valve pots
- Records sounds every 5 seconds (2-4 a.m; 2 hours = 1,440 reads daily)
- Based on distribution of leak sounds determines leak index from 0-100
- Loggers store leak numbers and graphical data
- Data recovered by a 2-way receiver
- Leak status announced on drive-by

How does a correlator work?



- Compares the sounds heard at 2 stations on either side of a leak
- Uses the sound velocity multiplied by time lag to calculate distance
- Sound velocity dependent on pipe:
 - Diameter
 - Material
 - Wall thickness
 - Pressure/Temperature-minor effects



Logger Operations



- Biweekly/monthly patrols takes 3 days
- Using GPS system and programmed route requires only 1 person
- Extension loggers installed on flooded pots
- Results reviewed and prioritized by Water Conservation and delivered to Operations



Data Zoom 13-0

0° (N)

Latitude N37° 54.040'

Longitude W122° 16.160'

0 ft 650

Name	Type	Active	Lock	Count	Date Modified	Directory
2nd Phase logger locations 8-27	Draw	<input checked="" type="checkbox"/>	<input type="checkbox"/>	191	Friday, September 05, 2008 12:10:32 PM	C:\DeLorme Docs\Draw\2nd Phase logger locatio...
handdrawn route (3)	Draw	<input type="checkbox"/>	<input type="checkbox"/>	117	Wednesday, August 27, 2008 10:16:44...	C:\DeLorme Docs\Draw\handdrawn route (3).an1

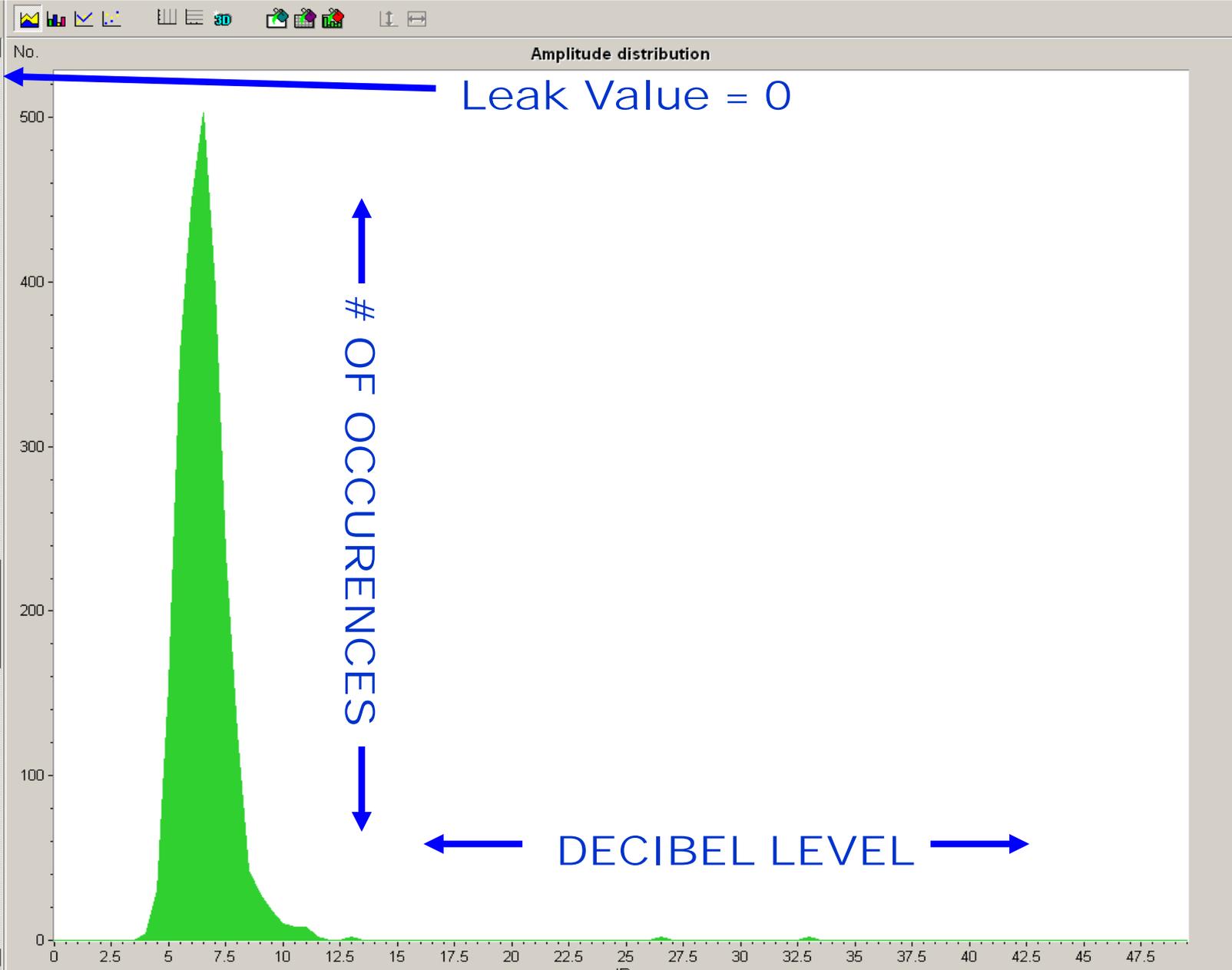
New Import... Save Export... Delete Copy To Done Less

Name	Comment	URL	Date Modified	Type
			8/27/2008 2:46:36 PM PDT	Line
			8/27/2008 2:16:08 PM PDT	Line
			8/27/2008 2:44:13 PM PDT	Line
093			8/27/2008 11:11:07 AM PDT	Symbol

Measurement View

Logger: 200992

Date	Leak value	Batt.
6/1/08	0	
6/2/08	0	
6/3/08	0	
6/4/08	0	
6/5/08	0	
6/6/08	0	
6/7/08	0	
6/8/08	0	
6/9/08	0	
6/10/08	1	
6/11/08	8	
6/12/08	9	
6/13/08	22	
6/14/08	23	
6/15/08	21	
6/16/08	26	
6/17/08	31	
6/18/08	31	
6/19/08	31	
6/20/08	28	
6/21/08	31	
6/22/08	28	
6/23/08	33	
6/24/08	37	
6/25/08	57	
6/26/08	69	
6/27/08	49	
6/28/08	88	
6/29/08	96	
6/30/08	97	
7/1/08	100	
7/2/08	100	
7/3/08	0	
7/4/08	0	
7/5/08	0	
7/6/08	0	
7/7/08	0	
7/8/08	0	
7/9/08	0	



EBMUD Leak Analysis Database



Update General Work Order

[Close this Window](#)

Order #	Status	Status Date	Last Updated By	Last Updated On	Total Hours	Closed By
1347225	COMPLETED	10/07/2009	TBEREL	10/07/2009 00:00	28.3	TBEREL
Entered By: DWASHING		Entered On: 10/02/2009		Service No: 4061335	Construction status: <input type="text"/>	
Bldg	Fract	Street		Apt	City	Cross Street
911		<input type="text"/> CRAGMONT	<input type="text"/> AVE		BER	MARIN AVE
186	ft	<input type="text"/> S	of	MARIN AVE	on	<input type="text"/> E
Map	1488	512	Tap # 309169	Thomas Bros: Page: 609	Grid: H5	From Org: 722
CS Flag:	<input type="text"/>	GWO FEMA Code:	<input type="text"/>	Service Improvement Nu: <input type="text"/>		
Water Discharge?	<input checked="" type="checkbox"/> Y	Est Flow Rate GPM	7	Discharge to storm drain?	<input checked="" type="checkbox"/> Y	FMP Used? <input checked="" type="checkbox"/> Y
Cause	CORRECTIVE MAINTENANCE		Priority	4	Pipe Ext	E-22784
Problem Description	STREET LEAK>>USA EXP DATE 10/30/09 UPDATE BY 10/28/09					
Damage Rpt?	<input type="checkbox"/> N	Shut Down?	<input type="checkbox"/> N	USA#	308291	USA Notif. Due Date/Time
Permit #	<input type="text"/>	OT Code	<input type="text"/>	# of Surveys Issued	<input type="text"/>	

Current Tasks

Action	Device	Device #	Assign To	Org	Issue Date	Comp Date	Pgm/Proj	Est. Hrs	Act. Hrs	
REPAIR	MAIN	E-22784	DGUARAGL	723	10/02/2009	10/06/2009	5761	28	27.5	
Size	6	Comments: REPAIR FULL CIR BREAK ON 6" CI MN W/ 6 X 7.5 FULL CIR CLAMP					Qty	1	Delete	<input type="checkbox"/>
Action	Device	Device #	Assign To	Org	Issue Date	Comp Date	Pgm/Proj	Est. Hrs	Act. Hrs	
INVESTIGATE			HWELCH	722	10/02/2009	10/02/2009	5729	0.5	0.8	
Size		Comments: LEAK ON THE 6 IN CI MN					Qty	1	Delete	<input type="checkbox"/>



03.05.2008 12:40



03.05.2008 12:03



Logger Analysis and Findings



- 127 investigations defined
 - 16 customer leaks
 - 56 False positives due to logger malfunction
 - 47 real water leaks
 - 16 on distribution mains
 - 31 on appurtenances (service lines, hydrants, meters)
- 14 additional leaks tracked and eventually repaired

Review of Fixed Leaks



- 116 Repaired Leaks
 - 76 times no loggers heard the leaks
(no change in leak index after repair)
 - 36 times the loggers heard the leaks
(decrease in noise index)
 - 4 times the data was inconclusive

Review of Fixed Leaks

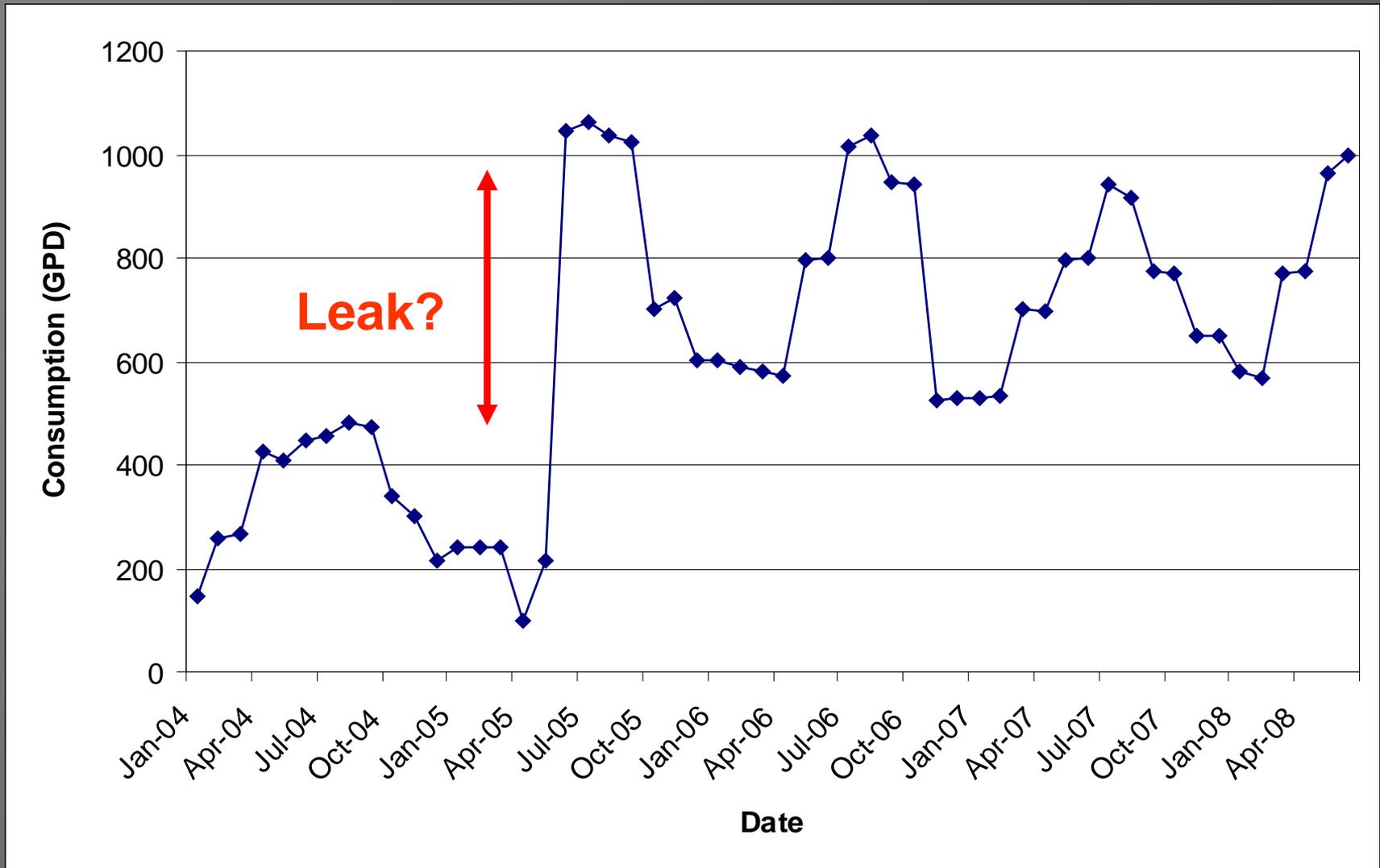


- Non heard leaks are either:
 - Background noises screens out leak noise
 - Loggers too far from leak depending on material (1,000 ft. spacing)
 - Loggers not attached to metallic pipe (dirt intrusion)
 - Logger malfunction
 - Data mishandling due to logger changeouts

Leak repaired by customer



Leak had been going - 3 years?



Conclusions



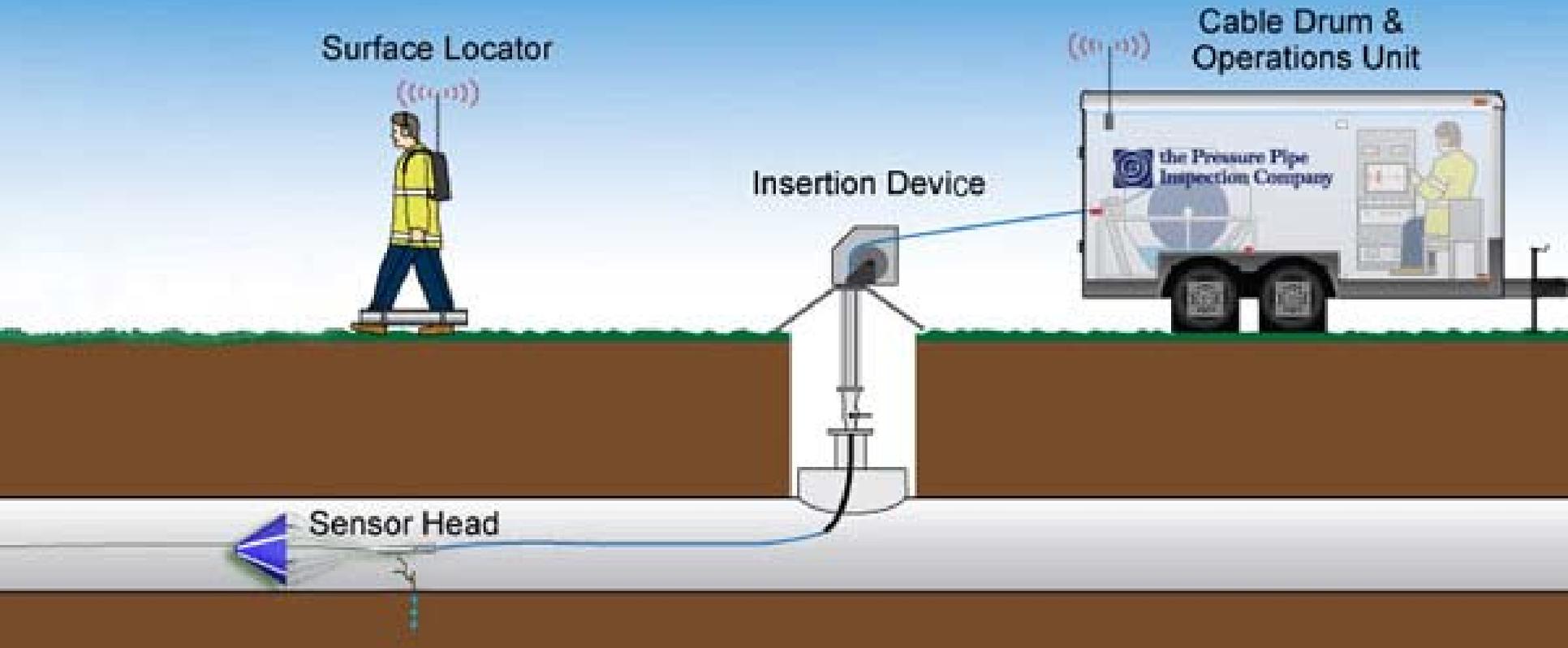
- Loggers currently spaced 1,000 feet apart; for reliable correlation recommend 500 feet spacing
- Loggers not currently as effective in detecting leaks as hoped (50% instantaneous and 50% took a long time developing)
- Accurate data analysis hindered by incomplete recordkeeping; need more accurate leak flow rates and notation if leak identified through program
- Semi-permanent deployment ok in select problem areas, not recommended as general practice

Aqueduct Leak Detection Technologies Tested



- Pressure Pipe Inspection Company "SAHARA" System
 - Tethered acoustic sensor drawn by parachute
 - Capability to 5,000 feet/run or 270 degrees of bends
- Pure Technologies U.S. Ltd. "Smart Ball"
 - Free-rolling Ball (not tethered)
 - Capable of 12-15 hours at about 90% of water velocity (>1 ft/s)
 - Can pass through "some" obstructions
- Echologics Engineering "Leakfinder RT"
 - Acoustic and auto correlation functions
 - Capable of 300-5,000 foot spans in steel pipe

PPIC "SAHARA" Acoustic System



Sahara - Components & Tracking



Acoustic
Sensor

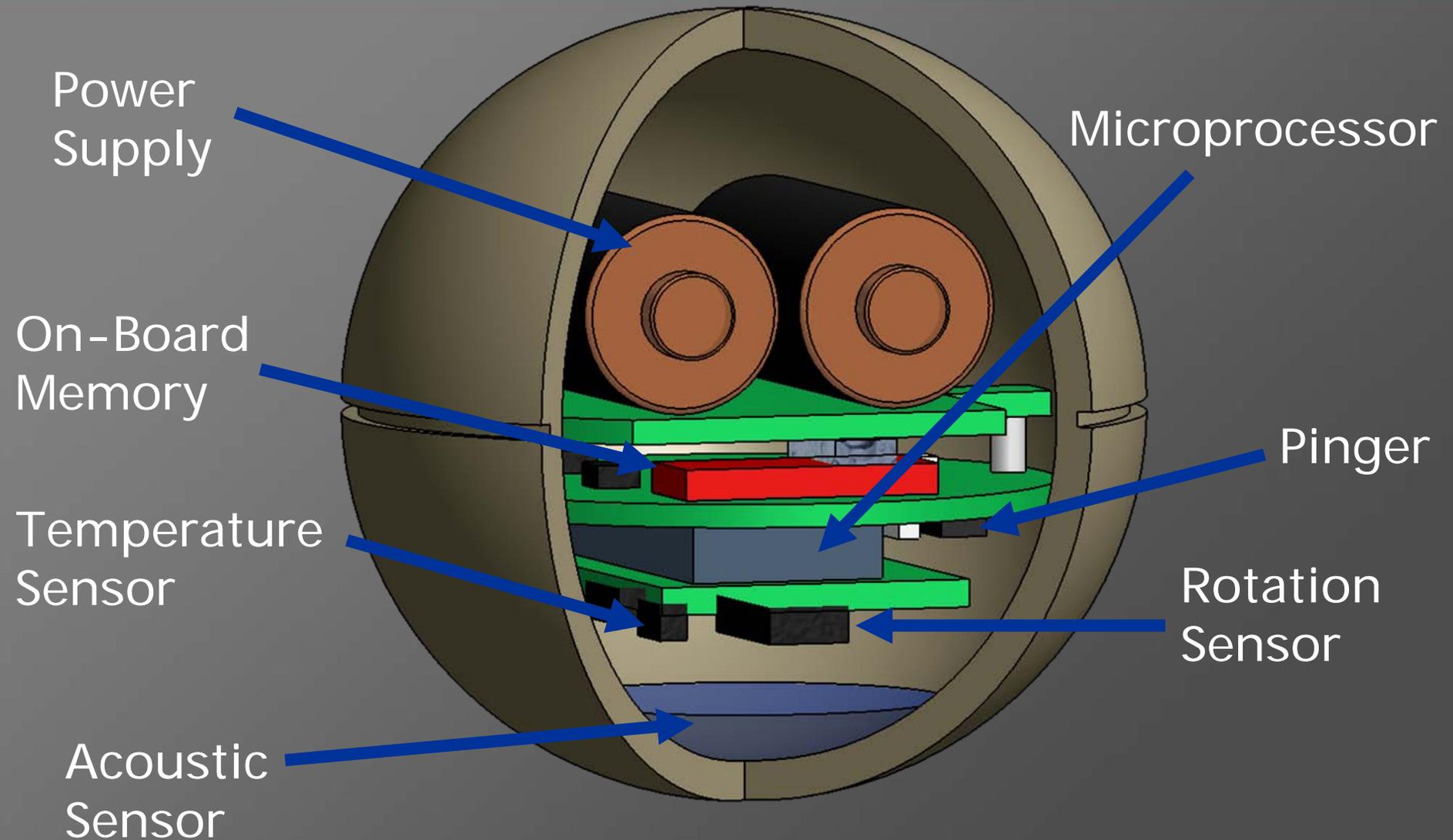


Parachute

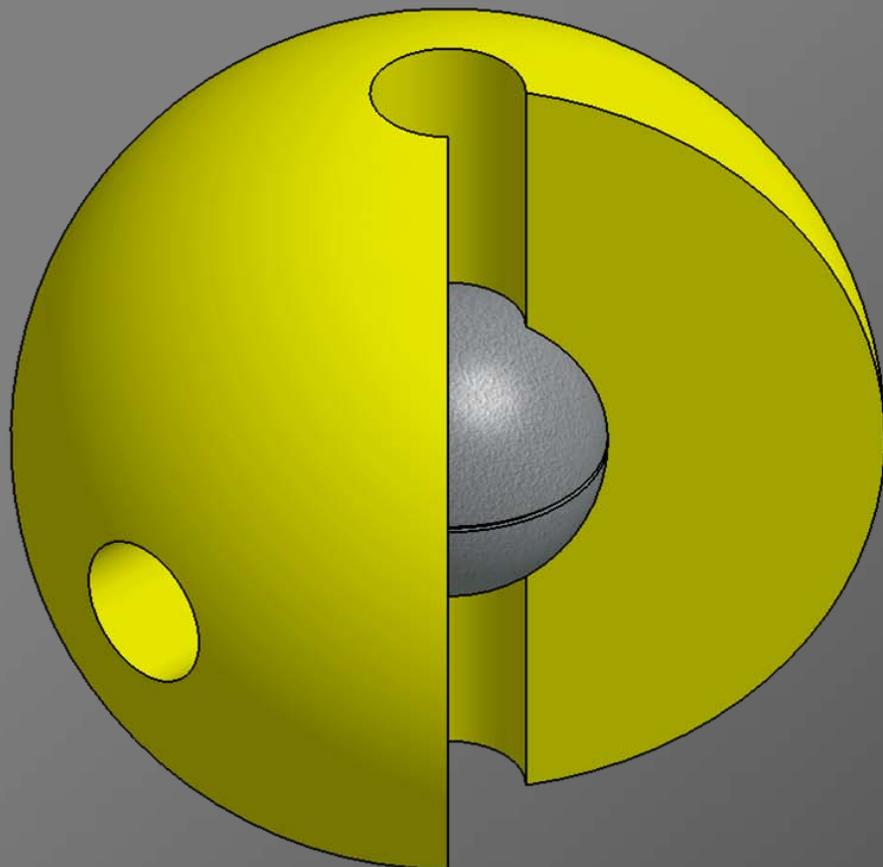


Surface Tracking

Pure Technologies "Smart Ball"



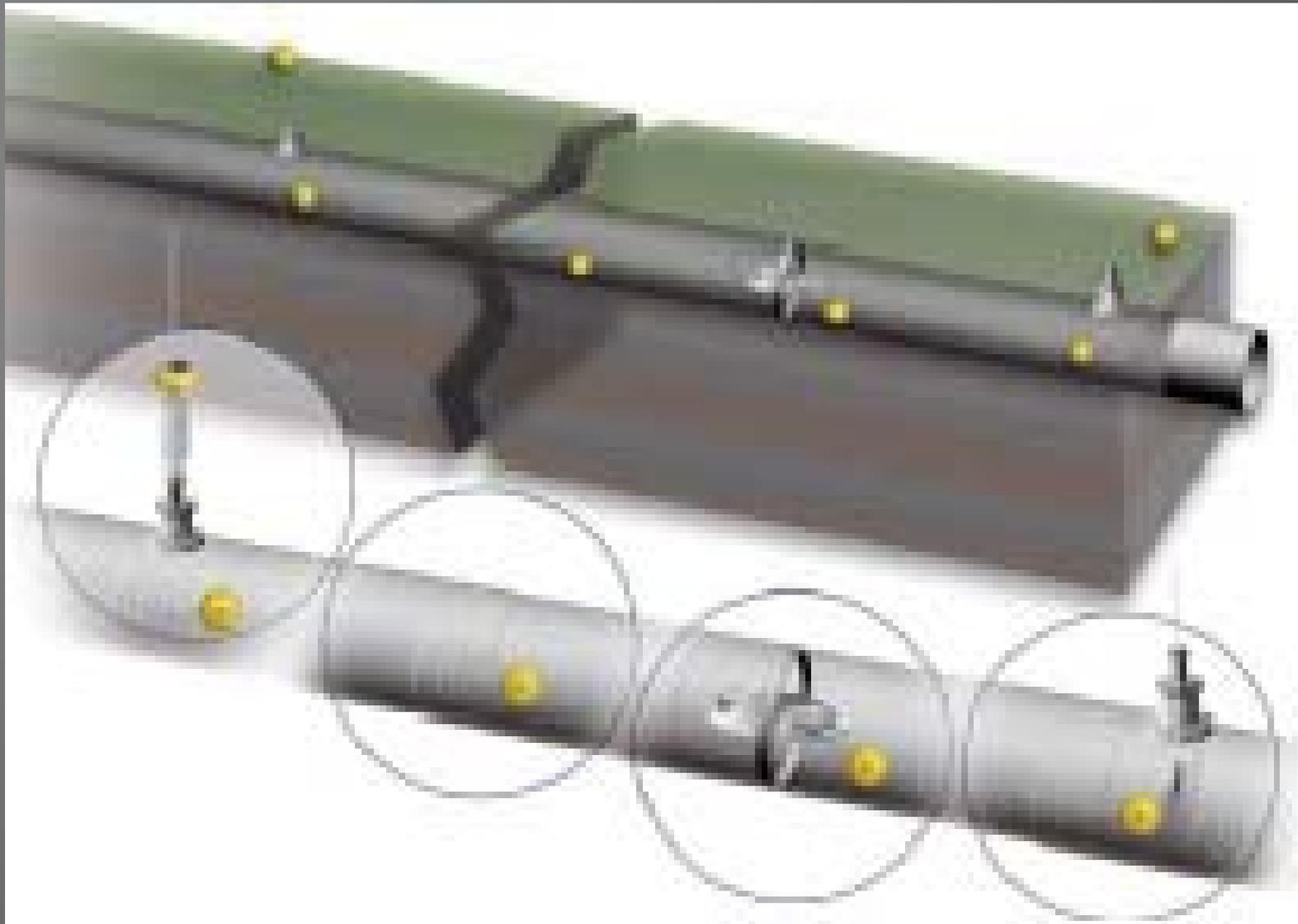
Smart Ball & Foam Covering



Pure Technologies “Smart Ball”



Pure Technologies “Smart Ball”



Echologics Engineering “Leakfinder RT”

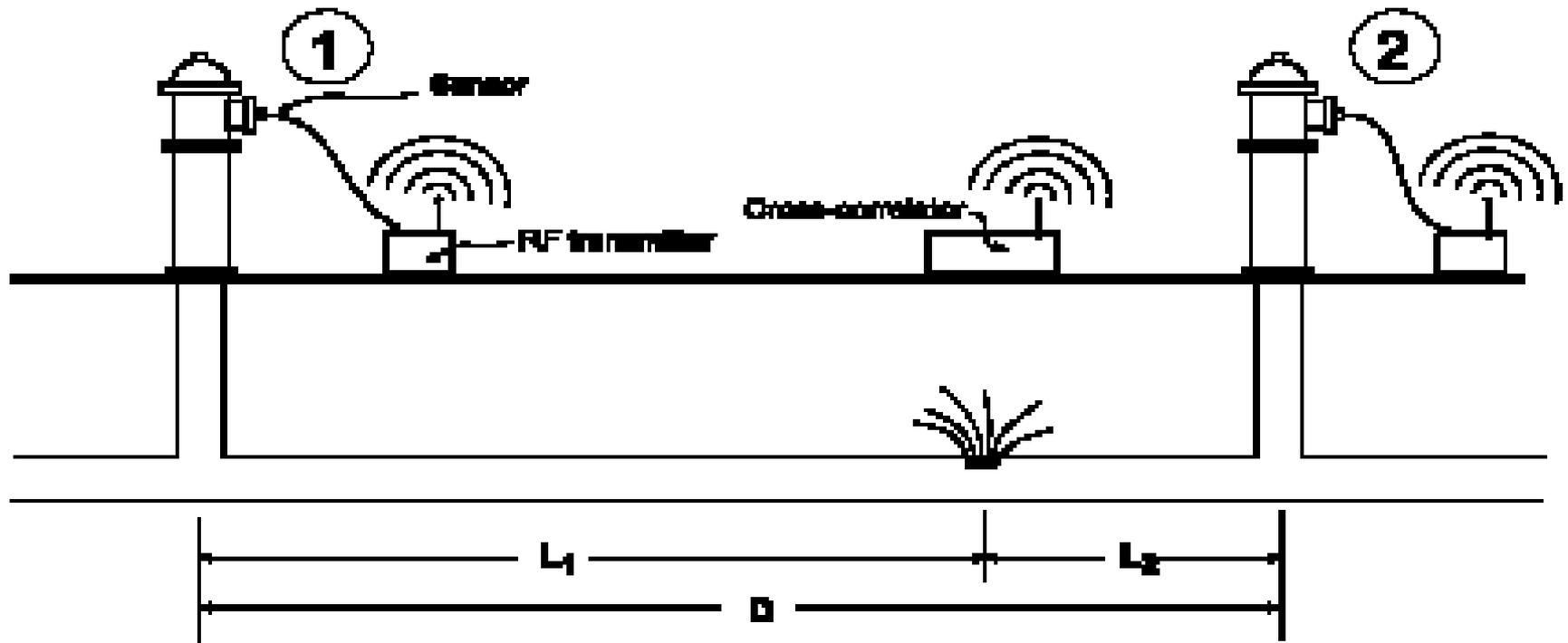


Figure 1 Schematic illustration of the cross-correlation method

Echologics LeakFinderRT



Aqueduct Leak Detection Phase 1 Preliminary Findings



- Phase 1 (\$150K) head-to-head test complete
- Each vendor/technology found all known and simulated leaks
- Precision of locating leak: 0.1 - 5.0 ft
- Speed of surveys: 1,000 - 8,000 feet per day
- Length of pipe surveyed: 9,500 - 114,000 ft
- Total per foot cost: \$0.55 - \$8.22
 - District cost: \$0.11 - \$3.09
 - Vendor cost: \$0.44 - \$5.13

Aqueduct Leak Detection Conclusions



- Use of technology dependent on:
 - pipeline and field conditions
 - desired accuracy in locating leaks
 - length of survey desired
 - available budget
- Likely to use a combination of technologies in future

Aqueduct Leak Detection Next Steps



- September 2010 Phase 2 (\$150K) initiated w/Echologics LeakFinder RT
- November 2010 Survey add'l 63 miles of pipe
- December 2010 Final report to USBR

- For more information please contact:

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