*CSRMA* and
*Chris Ewers, P.E.*
*(Ewers Engineering)*

# FORCE MAIN CONDITION: WHAT HAVE YOU GOT?

Serve your customers well. Plan ahead.

**Recommended reading**

The following articles provide a range of data, including California and national statistical likelihoods of force main failure, California and national sanitary agency use of condition assessment practices, and projections of pressure pipe failure rates and tools for rehabilitation.

They're also available for free.

"Best Management Practices for Sanitary Sewer Overflow Reduction Strategies," Central Valley Clean Water Agency and Bay Area Clean Water Agency, Dec. 2009

"Buried No Longer: Confronting America's Infrastructure Challenge," AWWA, February 2012

2012 CSRMA Member Force Main Risk Management Survey Results, January 2013

*Inspection Guidelines for Ferrous Force Mains,* WERF report 04-CTS-6UR, 2007

State Water Resources Control Board Order No. 2006-0003-DWQ: Statewide General Waste Discharge Requirements for Sanitary Sewer Systems

If you have questions about condition assessment and its application, please contact me:

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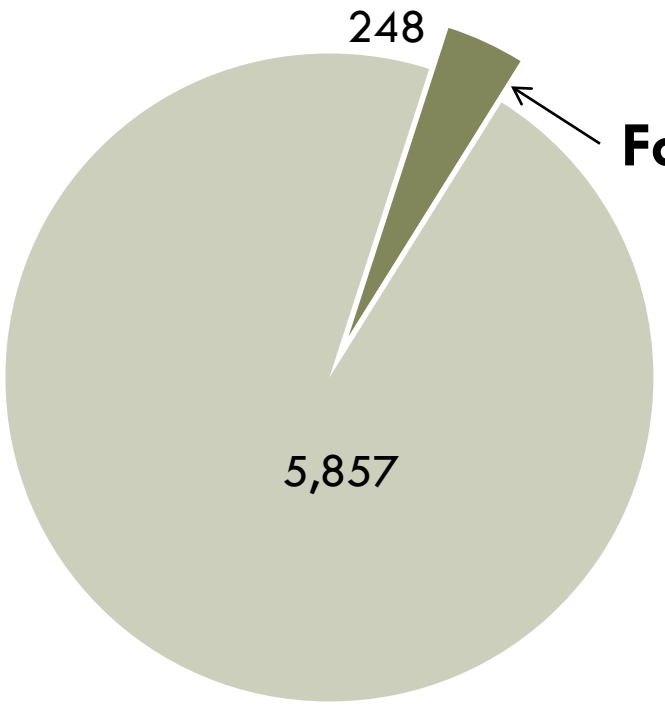
# Risk

The possibility of failure and consequent damage

# Likelihood of failure: 5-year record*

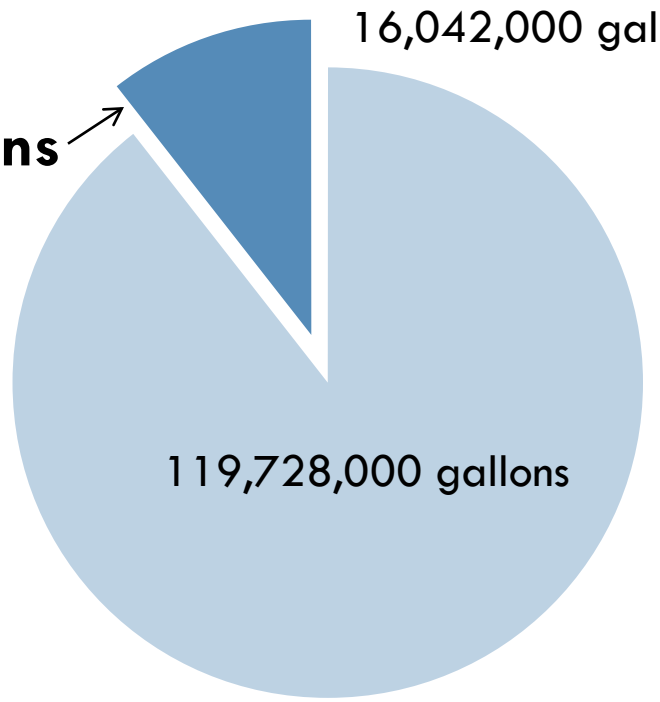
## Category 1 spills:

**Number**




**Force Mains**

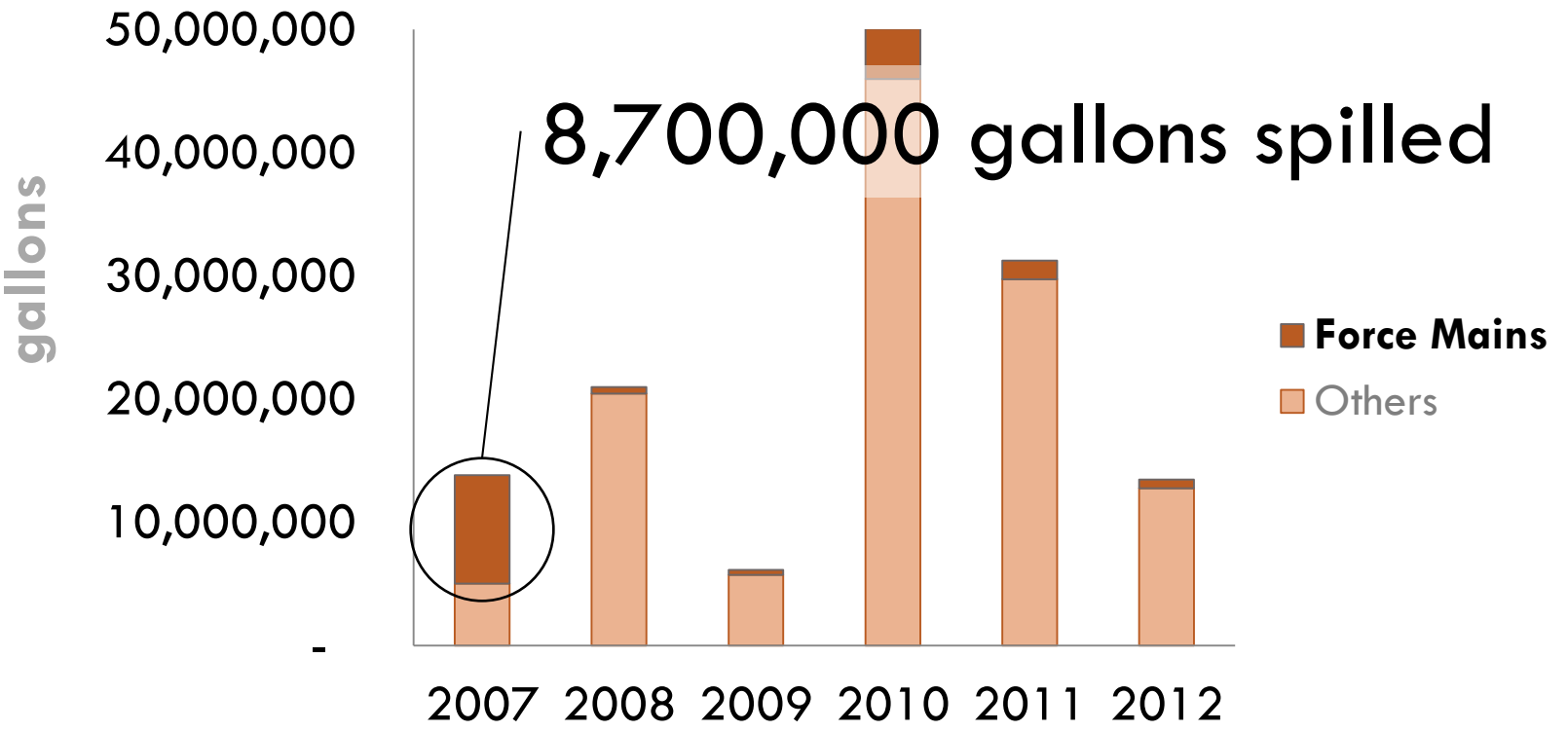
**Volume**




**California State Water Resources Control Board SSO database, 1/5/2013*

# Likelihood of failure: 5-year record*

*Category 1 spills by year*




*California State Water Resources Control Board SSO database, 1/5/2013

# Consequence of failure: Example 1

| | |
|---|---|
| Spill | 24” Force main rupture, 3/31/07-4/3/07 |
| Volume | 7,300,000 gallons into lagoon |

# Consequence of failure: Example 1

## Costs

| | |
|---|---|
| Construction | $4.4 Million |
| State fine | $1.1 Million |
| Lagoon | $0.5 Million |
| Staff/admin. | $ ? |
| Attorneys | $ ? |
| *Partial Total* | *$5.6 Million* |
| *Est. Pipe Cost* | *$3.2 Million* |

# Consequence of failure: Example 1

Time

| | |
|---|---|
| Cleanup-Construction | 4/2007-12/2012 |

*(5 years, 8 months of agency time)*

# Consequence of failure: Example 2

| | |
|---|---|
| Spill | Multiple system failure, flooding at WWTP, 1/2008 |
| Volume | 7,000,000 gallons into Pacific |

# Consequence of failure: Example 2

## Costs

| | |
|---|---|
| Construction, repairs (est.) | $50 Million |
| State fine | $2.3 Million |
| Staff/admin. | $ ? |
| Attorneys | $ ? |
| *Partial Total* | *$52.3 Million* |

# Consequence of failure: Example 2

Time

| | |
|---|---|
| Cleanup-Construction | 1/2008-today |

*(5 years and counting of agency time)*

# Goal

**Put you on the path to a healthy, well-managed system of force mains.**

# Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation

# Agenda: Condition Assessment

1. What we are doing
2. What we can do
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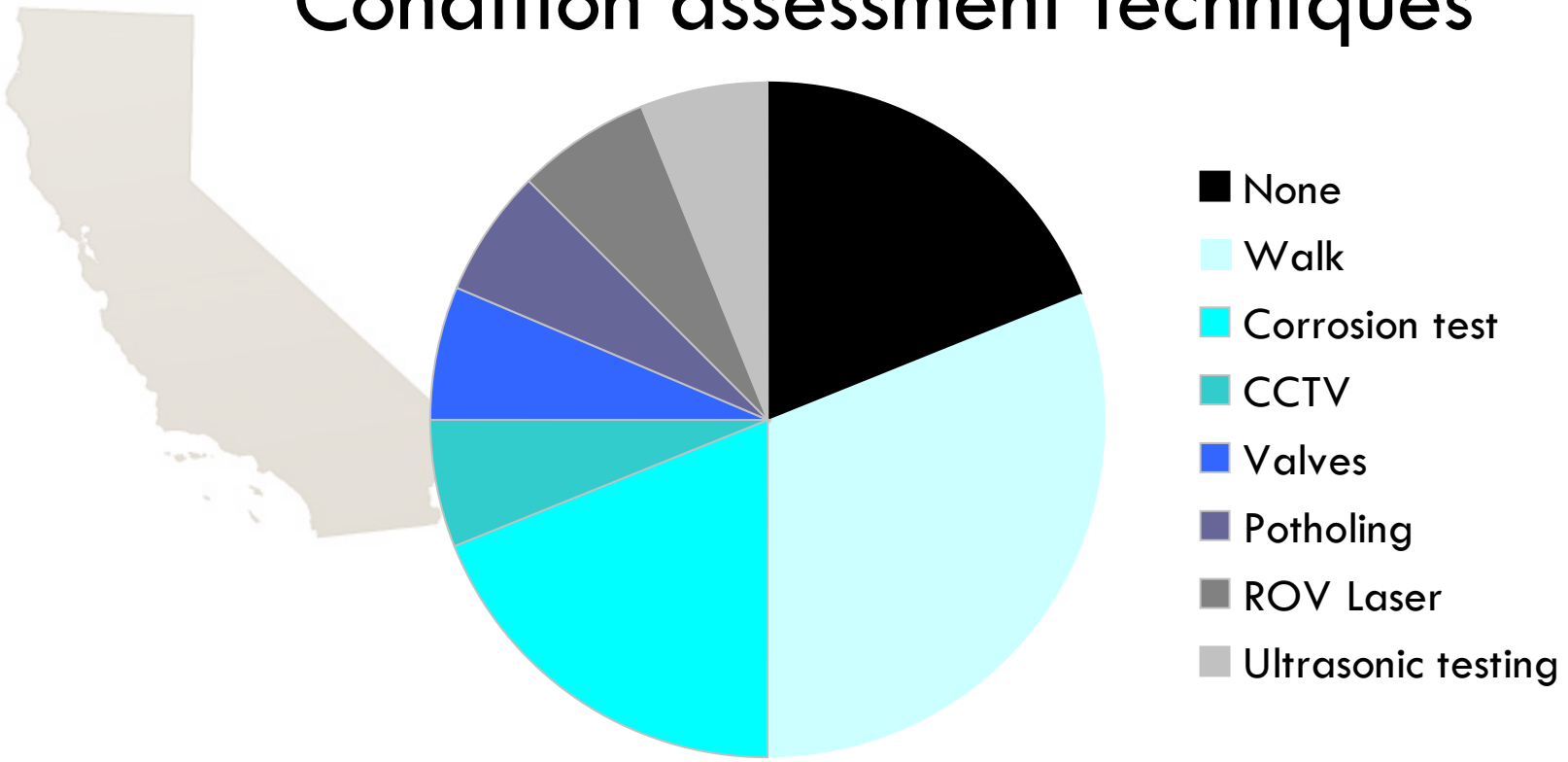
# Force Mains in California*



- Age
  - Average: 32 years
- Length per agency
  - Average: 15 miles

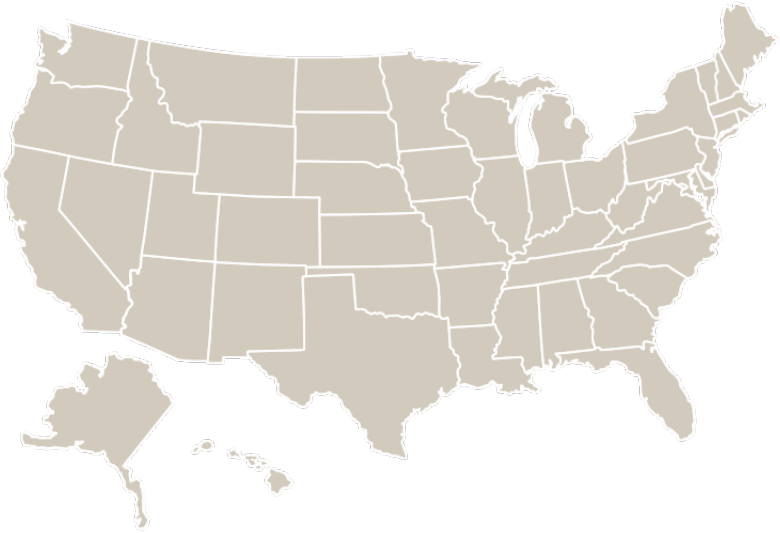
**CSRMA survey of member agencies on force mains, 12/2012*

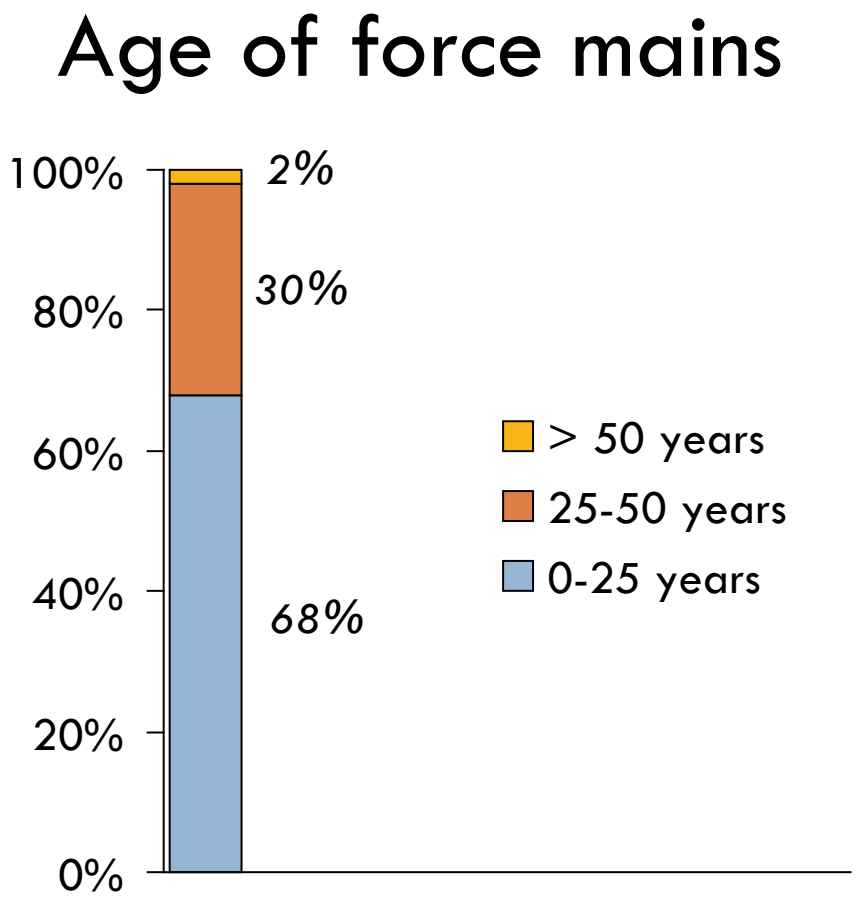
# Condition Assessment in California*




*CSRMA survey of member agencies on force mains, 12/2012*

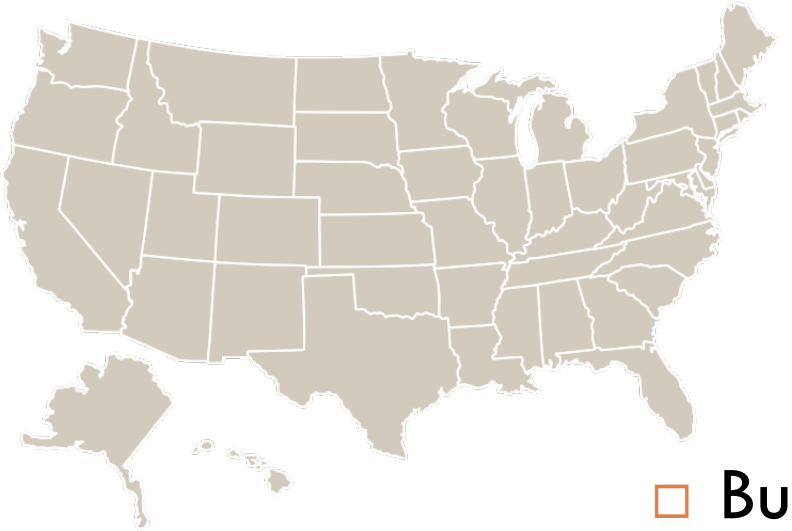
# Force Mains in the U.S. *






**WERF Final Report,* Inspection Guidelines for Ferrous Force Mains, *2007*

# Condition Assessment in the U.S.*

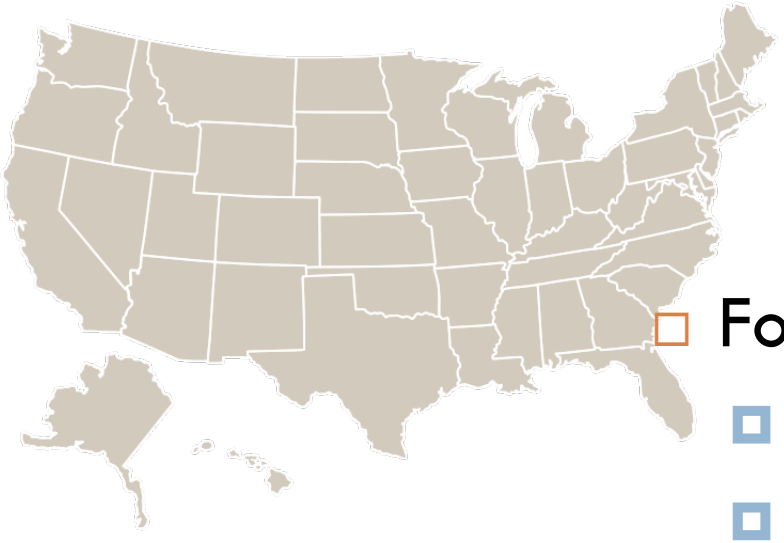


- Budget: $4.13/foot (average)
- Spent: $24.05/foot (average)

(Includes inspection, assessment, repair, and cleanup.)

**WERF Final Report,* Inspection Guidelines for Ferrous Force Mains, *2007*

# What we are doing: Conclusions



- Force mains
  - Small diameter (4”-20”)
  - Ferrous (DIP, CIP, Steel ~60%)
  - <<50 years old when replaced
- We underestimate repair and cleanup costs from failures.
  - Condition assessment is not effectively used.

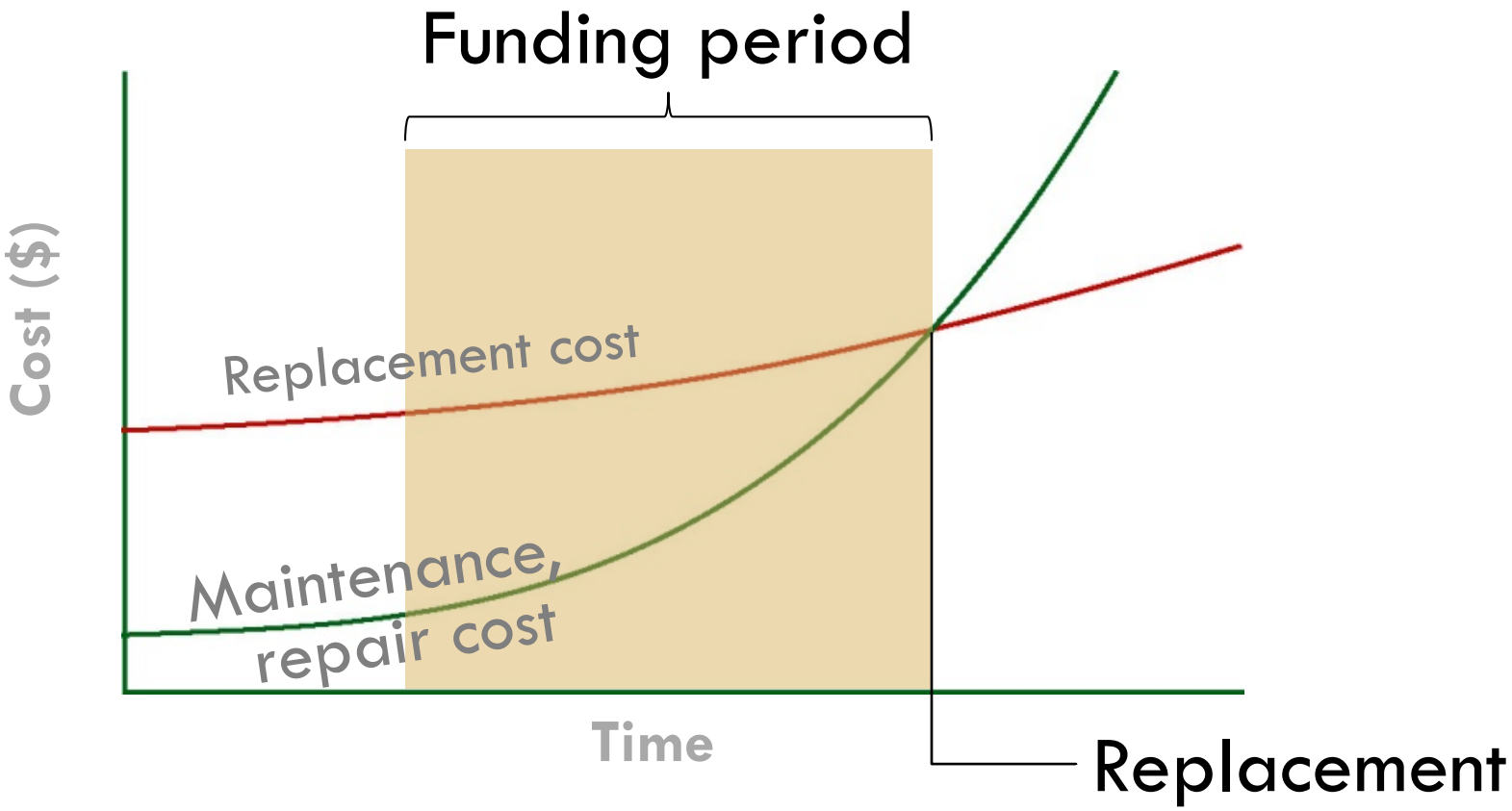
# Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation

# Goal of Condition Assessment

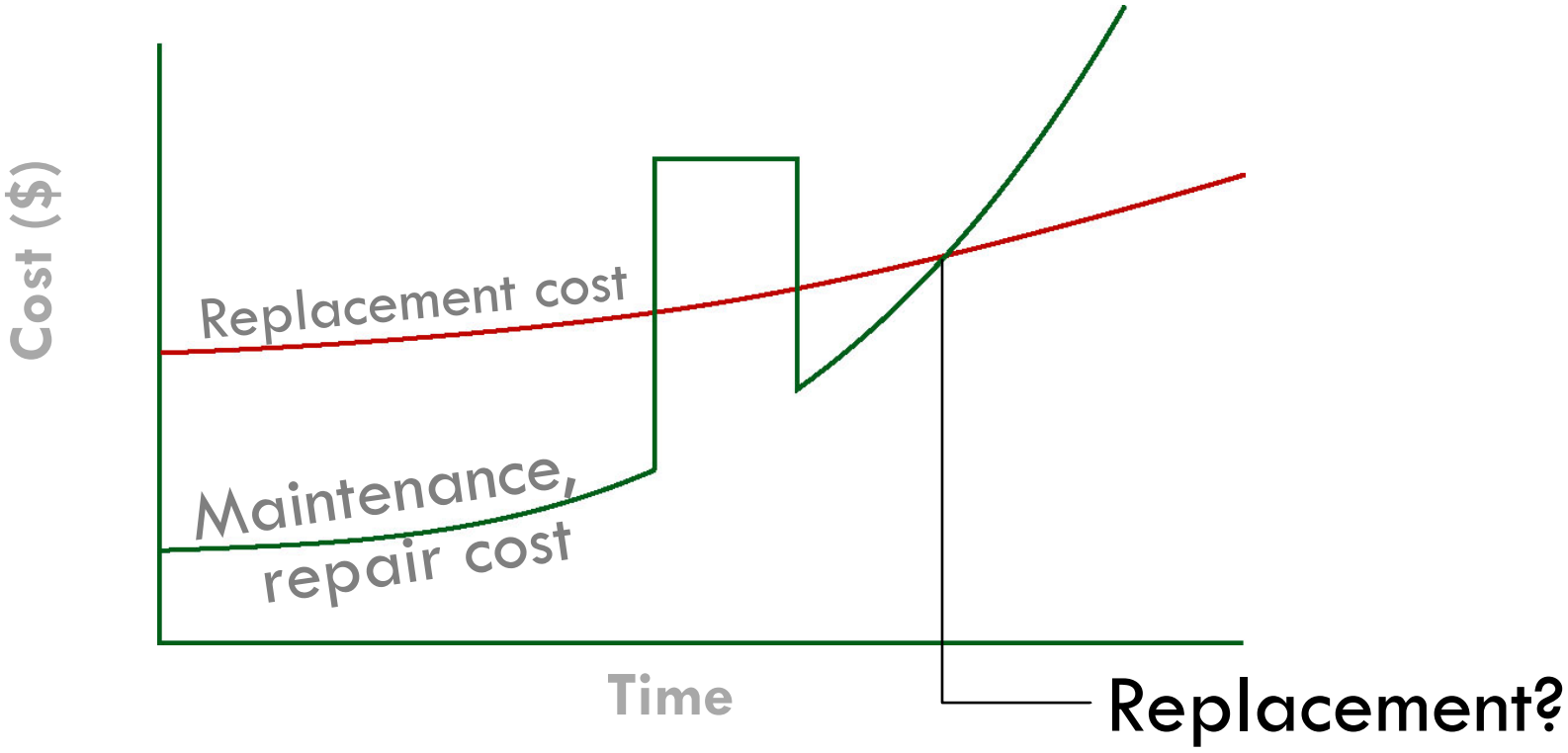
- Determine likelihood of failure:
  - Know where and when to repair and maintain
  - Know how long to maintain until replacement
  - Use time until replacement to set aside funding

# Goal of Condition Assessment



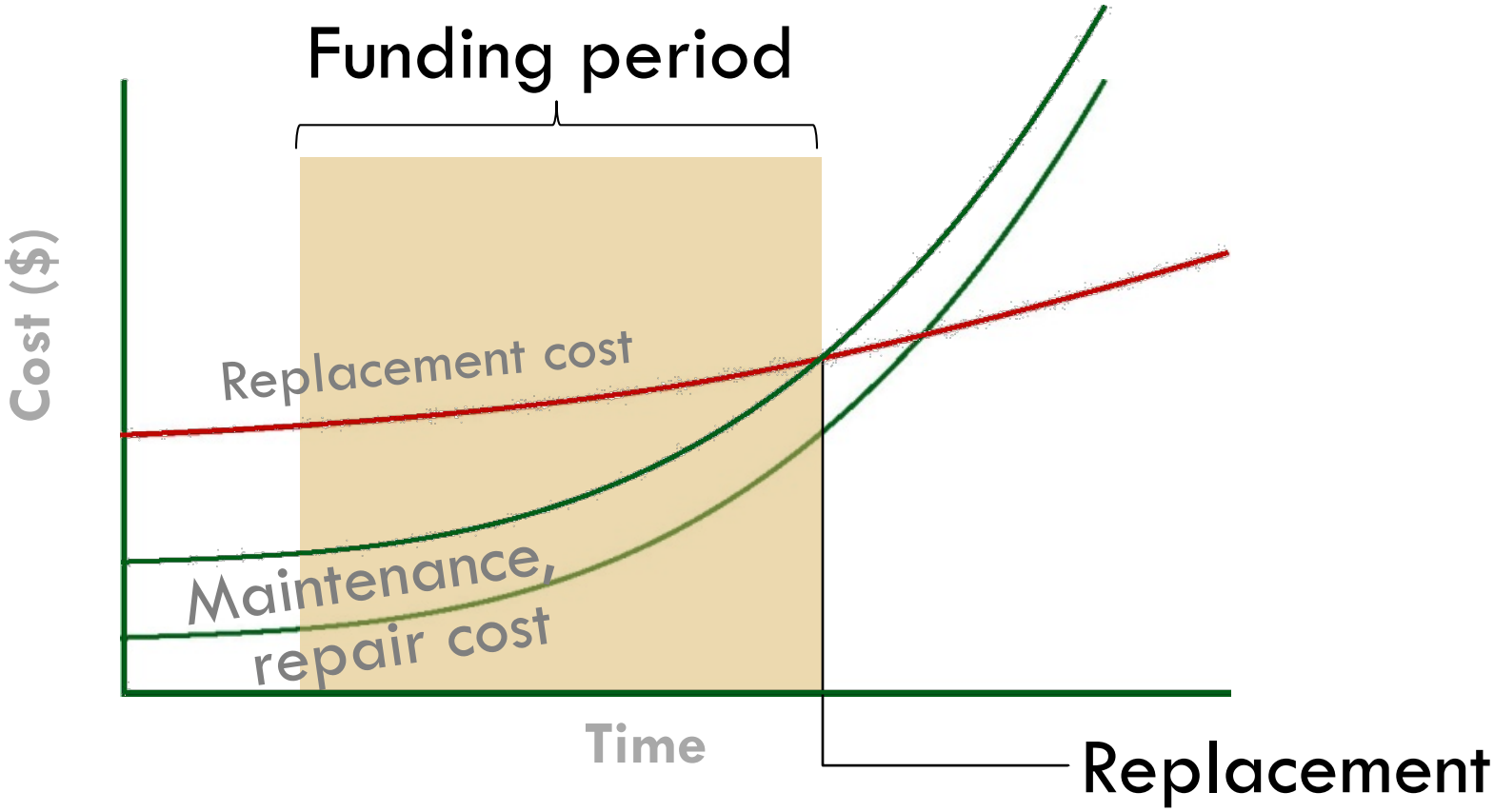
# Goal of Condition Assessment

Third-party construction emergency!



# Goal of Condition Assessment

Force main corrosion



# Indirect condition assessment tools

# Inventory

**Know what you have to get started.**

- Identify and map
  - Pumping facilities
  - Force mains and valves
  - Access points
- Materials, diameters, age of pipe, repair history

- Preparation: Minimal
- Cost: Staff time

# Site visit

**Know what you have to get started.**

- Verify mapping, diameter, materials
- Evaluate air release/air vacuum valves
- Signs of leakage, construction disturbance

- Preparation: Minimal
- Cost: Staff time

# Performance tests

**Know what you have to get started.**

- Lift station: pressure/flow
- Pressure: Transient max.?
- Corrosion test stations

- Preparation: Minimal
- Cost: Staff time, equipment

# Visual inspection: CCTV

**Know what you have to get started.**

- Requires force main out of service for extended duration
- Access may require construction
- Dark pipe reduces value
- Look for seepage into dewatered pipe

- Preparation: Depressurize, dewater, install or use access
- Cost: Staff time, equipment ~ $3/foot

# Leak and gas pocket detection

**Know what you have to get started.**

- Technology: Acoustic sensing
  - In-line
    - Tethered: Sahara hydrophone
    - Free-swimming: SmartBall hydrophone
  - Acoustic field testing

# Leak and gas pocket detection

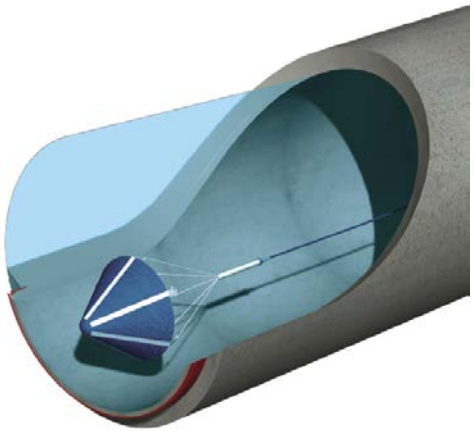
Technology: Acoustic sensing (hydrophone)

- Aided by high pressure, high flow (Re≥1,000)
- Sound of wastewater passing gas pockets permits their detection

# Leak and gas pocket detection

Technology: Acoustic sensing (hydrophone)

- Field hydrophones
  - Attach hydrophone to live pipeline
- Sahara
  - Tethered: Refined, repeatable location (≥0.25 gpm leaks)



- Smartball
  - Free-swimming: Accommodates long intervals at 3 mph min.

# Leak and gas pocket detection

| | In-Line | | Field |
|---|---|---|---|
| | Sahara | SmartBall | Field hydrophones |
| Technology | Acoustic | Acoustic | Acoustic |
| Material | All | All | All |
| Sizes | ≥ 4" | ≥ 6" | All |
| Preparation | Access: 2" tap | Access: 4" port | Access: Pipe wall or appurt. |
| Cost (mobilization/$/mi.) | $35,000/$35,000 | $25,000/$12,000 | Equipment |

# Direct condition assessment tools

# Structural integrity assessment

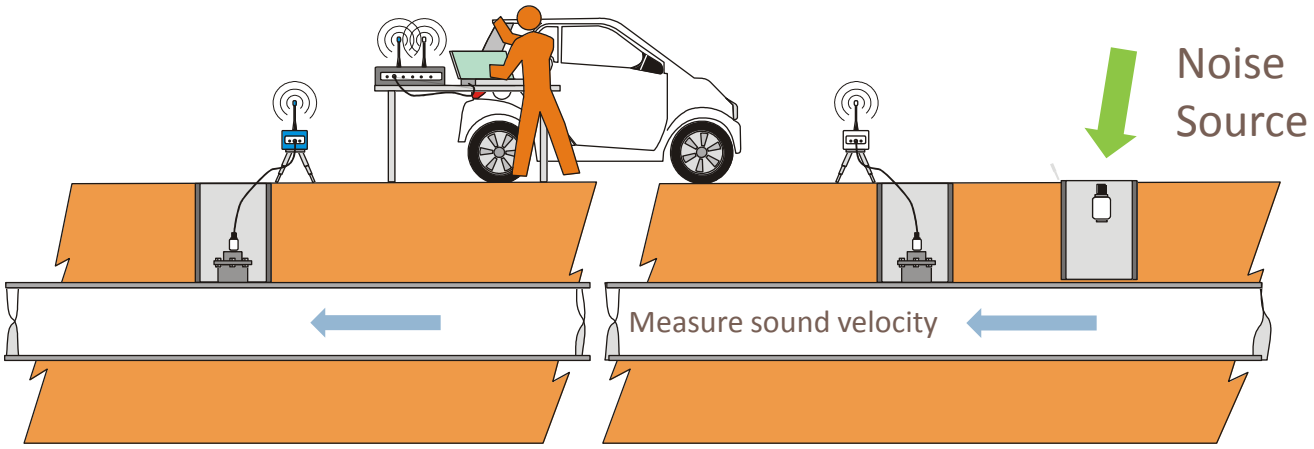
**Combine acoustic tools to assess pipe wall thickness**

- Technology: Acoustic sensing
  - Acoustic field testing

# Structural integrity assessment

Technology: **Acoustic sensing (hydrophone)**

- Hydrophone receives/correlates pipe noise
- Speed of wave reflects rigidity of pipe
- Bulk modulus of sewage needed for pipe thickness



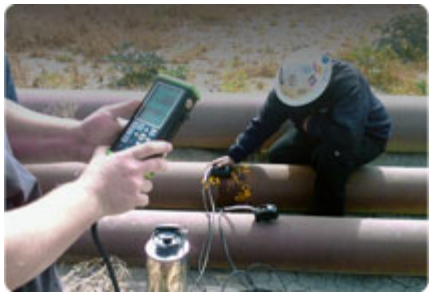
# Structural integrity assessment

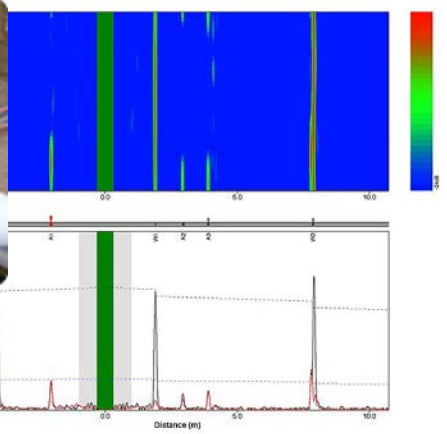
| | In-Line | Field |
|---|---|---|
| | Not yet commercially available | Field hydrophones |
| Technology | | **Acoustic** |
| Material | | All |
| Sizes | | All |
| Preparation | | Access: Three 6” pipe wall seats |
| Cost (mobilization/$/mi.) | | X/$30,000 |

# Structural integrity assessment

**Tried, proven tool for profiling pipe wall**

- Technology: **Ultrasonic Testing**
  - Coating removal, cleaning
  - Calibration with pipe wall required
  - Hand-held: B-Scan
  - Circumferential: Guided-Wave (50-500 ft.)





# Structural integrity assessment

**Hand-scan tool for detecting anomalies in ferrous pipes**

- Technology: **Broadband Electromagnetic Testing**
  - Scans through 2” coating
  - Uses eddy current sensing
  - Data interpreted in Australia
  - Slow process finds relative changes in wall

# Structural integrity assessment

| | Field | |
|---|---|---|
| Technology | Ultrasonic: B-Scan, Guided-Wave | Broadband Electromagnetic |
| Material | Ferrous | Ferrous |
| Sizes | ≥6“ | ≥6“ |
| Preparation | Access: Full diameter, remove coating | Access: Full diameter |
| Cost (mobilization/$/mi.) | $3,500/read | $3,500/read |

# Structural integrity assessment

**In-line tool with the finest resolution available for PCCP testing**

- Technology: **Magnetic Flux Leakage**
  - In-line, sized to match pipe
  - Scans through mortar coating
  - Requires full-diameter access
  - Characterizes PCCP strand damage, small pits in ferrous walls
  - Cracks are often not detected

# Structural integrity assessment

**Live-pipe, free-swimming test of PCCP pipe walls**

- Technology: **Remote Field Transformer Coupling (Pipe Diver)**
  - In-line, scans through mortar coating
  - Launch in live force main
  - Characterizes PCCP strand damage, ferrous pipe wall damage
  - Navigates bends, valves

# Structural integrity assessment

**Flooded-pipe platform that can test PCCP pipe walls**

- Technology: **SONAR, P-wave electro magnetics, CCTV, laser profiling, (robotic platform)**
  - In-line, tethered
  - Crawl 40 feet/min., ≤8,000 feet
  - Float ≤16,000 feet
  - Characterizes PCCP strand damage, profiles, visual assessment

# Structural integrity assessment

| | In-line | | |
|---|---|---|---|
| | Magnetic Flux Leakage Pig | Pipe Diver (free-swimming) | Robotic (tethered) |
| Technology | Magnetic Flux Leakage | Remote Field Transformer Coupling | P-Wave EM, laser, CCTV, etc. |
| Material | PCCP, BWP | PCCP, BWP | PCCP, BWP |
| Sizes | 8“-78” | 24“-96” | 18“-72” |
| Preparation | Access: Full inter. diameter | Access: 12” ports | Access: 14”x16” |
| Cost (mobilization/$/mi.) | $40,000/$40,000 | $40,000/$40,000 | $40,000/$40,000 |

# Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation

# Guidelines for implementation

- Watch out for big data.
- Pick the technology that fits your force main and budget.
- Start simple, invest more as you know more.
- Prioritize your efforts.

# Questions?

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