# Opportunistic Watermain Inspection and Sampling Protocol

13 November 2023


Hamilton

Robinson Consultants

# Presenters:

**Kevin Bainbridge, C.E.T.**

Vice President, Robinson Consultants

**Muhit Tanveer, P.Eng.**

Senior Project Manager, Robinson Consultants

Hamilton

Robinson Consultants

# Presentation Overview

- City of Hamilton – Background Information
- Opportunistic Inspection & Sampling – Introduction
- Inspection & Sampling Methodology
- Inspection & Sampling Results
- Corrosion Risk Mapping
- Conclusion and Next Steps
- Questions

Hamilton Robinson Consultants

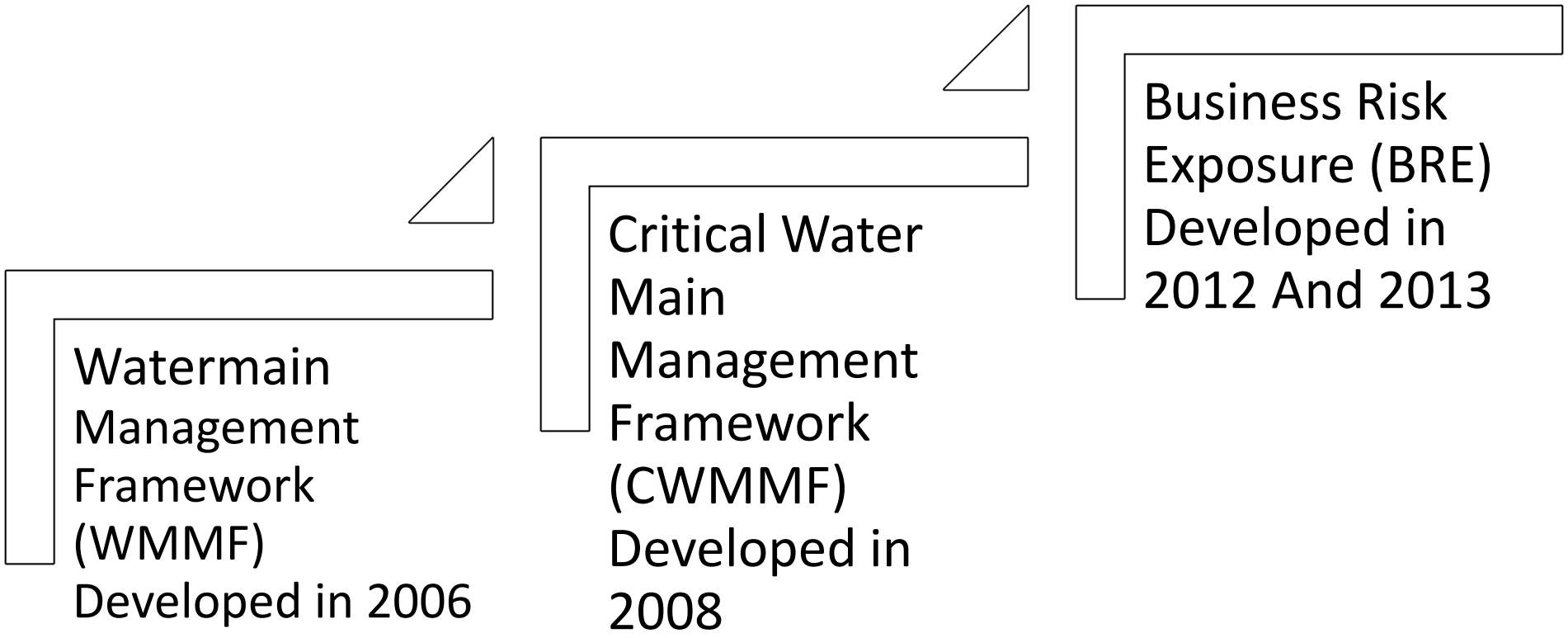
# City of Hamilton – Background Information

- Hamilton is located in Ontario, Canada, at the southwestern end of Lake Ontario
- Total area of 1,138 km$^2$ with an approximate population of 536,917 residents (2016 consensus)
- Operates and maintains 2100km of watermains;
  - 176 km of which are classified as a Criticality Level A/B (high/ medium consequence of failure)
- Actively developing and maintaining a critical watermain infrastructure management program for the past 13 years


Hamilton

Robinson Consultants

# City of Hamilton – Background Information




Hamilton Robinson Consultants

# City of Hamilton – Background Information

- Likelihood of overall exposure to risk based on:
  - Condition of pipeline (Pipeline Deterioration Factor) (PoF)
  - Consequence of pipeline failure (CoF)
- Business Risk Exposure (BRE) score – PoF x CoF
- 2012 - completed BRE ranking of critical PCCP watermain
- 2013 - completed BRE ranking of critical metallic watermain

Hamilton Robinson Consultants

# City of Hamilton – Background Information

- Trunk Watermains range in size from 400 mm to 2250 mm
- Condition assessments of the highest risk watermains through several ongoing programs:
  - Pre-stressed Concrete Cylinder Pipe (PCCP) Condition Assessment
  - Leak Detection
  - Steel Main Condition Assessment
  - Phase 2 Inspection on Two Pipelines
  - Opportunistic Watermain Inspection

Hamilton Robinson Consultants

# City of Hamilton – Background Information

- Since the inception, the City has inspected thirty-one (31) sites on nineteen (19) major trunk watermains
- Eight (8) involved cast iron pipe material, seven (7) were steel pipe, and seventeen (17) were Pre-stressed Concrete Cylinder (PCCP) pipe

| Site ID | Site Name | Pipeline | Pipe material |
|---|---|---|---|
| Site 01 | Tire Street Site | 55 | Cast Iron |
| Site 02 | Kenilworth Avenue Site | 55 | Cast Iron |
| Site 03 | Sherman Avenue Site | 18 | PCCP |
| Site 04 | Steam Museum Site | 18 | PCCP |
| Site 05 | West Gate 10 Site | 18 | PCCP |
| Site 06 | Upper Sherman Avenue Site | 33 | PCCP |
| Site 07 | Upper Ottawa Street Site | 28 | PCCP |
| Site 08 | Ainslie Avenue Site | 44 | PCCP |
| Site 09 | Charlton Avenue East and Catharine Street South | 113A | Cast Iron |
| | | 139 | Cast Iron |
| Site 10 | Greenhill D Site | 22 | PCCP |
| Site 11 | Justine Avenue & King Street Site | 54 | Steel |
| Site 12 | Central Avenue & Auburn Avenue | 54 | Steel |
| Site 13 | Kenilworth Access Site | 54 | Steel |
| Site 14 | Upper Ottawa Street and Queensbury Drive Site | 28 | PCCP |
| Site 15 | Rymal Rd. W | 106 | PCCP |

| Site ID | Site Name | Pipeline | Pipe material |
|---|---|---|---|
| Site 16 | Rymal Rd. W. | 106 | PCCP |
| Site 17 | Woodward Avenue | 62 | Cast Iron |
| Site 18 | Garner Rd. E. | 35 | PCCP |
| Site 19 | Stone Church Rd. E. | 31 | PCCP |
| Site 20 | Stone Church Rd. E. | 123 | PCCP |
| Site 21 | 275 Robert St Site | 111 | Cast Iron |
| Site 22 | Robert St & West Ave Site | 144 | Cast Iron |
| Site 23 | 27 Rutherford Ave & 198 Sanford Ave | 66 | Steel |
| Site 24 | Rutherford at Sanford Ave S | 74 | Steel |
| Site 25 | 168 Sanford Ave S | 74 | Steel |
| Site 26 | Barton Street East and Kenilworth Ave North | 61 | Cast Iron |
| Site 27 | Stonechurch Rd. W. | 123 | PCCP |
| Site 28 | Limeridge Rd E | 31 | PCCP |
| Site 29 | Upper Ottawa St. & Bowden St. | 28 | PCCP |
| Site 30 | 890 Limeridge Road East | 31 | PCCP |
| Site 31 | Delena Avenue South/North | 54 | Steel |

Hamilton

Robinson Consultants

# Opportunistic Inspection & Sampling - Introduction

- Valuable information during scheduled capital and maintenance not captured
- Establish a watermain inspection and sampling protocol - procedures for collection of soil and watermain samples, testing and analysis.
- Collect pertinent information while the pipe is exposed.
- Emergency repair, periodic maintenance, live connections, valve replacement etc.

# Inspection & Sampling Methodology

- A visual inspection with accompanying photographs.
- Cleaning of the exterior surface of the pipe
- Photos taken for any surface defects identified
- Scraping of the pipe surface
- Collection of soil bedding and backfill samples.
- If available, collection of pipe sample for material testing.

Hamilton Robinson Consultants

# Inspection & Sampling Methodology

Opportunistic site inspection – scheduled maintenance, emergency repair, live connections, valve replacement etc.

Hamilton Robinson Consultants

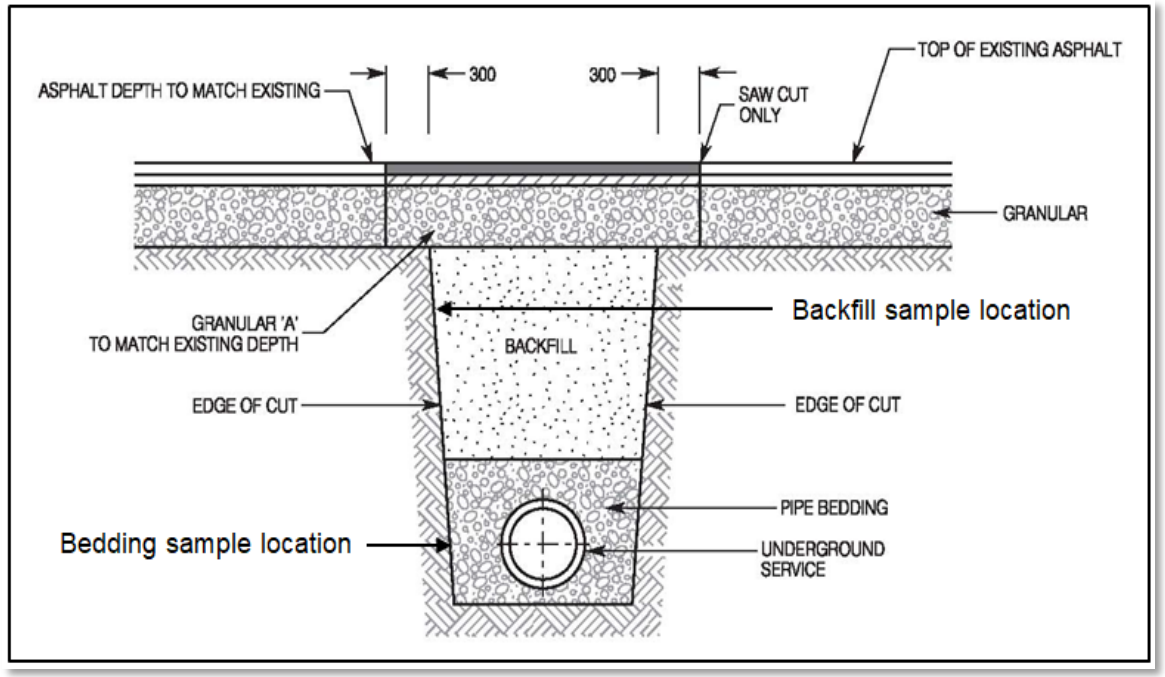
# Inspection & Sampling Methodology

Opportunistic site inspection – scheduled maintenance, emergency repair, live connections, valve replacement etc.

Hamilton Robinson Consultants

# Inspection & Sampling Methodology

- Four (4) soil samples, two (2) of each soil zones - stored in a polyethylene/glass container.
- **Backfill:** two (2) representative backfill samples, 250 mL in size.
- **Bedding**: two (2) representative bedding samples, 250 mL in size.
- Where a pipe sample is removed, a segment of 0.5m to 1m in length.




Hamilton Robinson Consultants

# Inspection & Sampling Methodology

## Watermain Pipe Sampling summary

| Sample | Location | Quantity | Description | Method | Tests and Analysis* |
|---|---|---|---|---|---|
| **Watermain (Metallic)** | Segment | 500mm to 1m | Exposed end, segment or coupon | Rotary cutters or Snap cutters (where possible) | External corrosion characteristics and analysis: Nominal diameter, Wall thickness Pit depth characteristics (max depth, growth rate, and wall penetration) Estimation of the rate of corrosion and age of watermain |
| | | | | | Internal tuberculation characteristics and analysis Inside diameter, Height Cross-Sectional Area |
| | | | | | Internal corrosion characteristics and analysis: Nominal diameter, Wall thickness Pit depth characteristics (max depth, growth rate, and wall penetration) |
| **Watermain (PCCP)** | Segment | 500mm to 1m | Exposed end, segment or coupon | Rotary cutters | PCCP pipe sample characteristics and analysis: Nominal diameters, Core thickness Can thickness Reinforcing wires thickness Reinforcing wires spacing Mortar thickness Compressive strength of mortar Chloride levels in mortar Porosity of mortar |

Hamilton Robinson Consultants

# Inspection & Sampling Results

Soil Samples were evaluated for Corrosion Indicators:

Chloride Concentration

| Soil Parameter | Range of Values | Degree of Corrosivity |
|---|---|---|
| Chloride Concentration (ppm) | Above 5,000 | Severely Corrosive |
| | 1,500 - 5,000 | Very Corrosive |
| | 600 - 1,500 | Moderately Corrosive |
| | Below 600 | Mildly Corrosive |

| Soil Parameter | Range of Values | Degree of Corrosivity |
|---|---|---|
| Chloride Concentration (ppm) | Above 600 | Very Corrosive |
| | 201 - 600 | Moderately Corrosive |
| | 50 - 200 | Mildly Corrosive |
| | Below 50 | Non Corrosive |

A.W. Peabody, Control of Pipeline Corrosion – Second Edition, p. 91, (2001).

Chloride effects on PCCP pipes

Chloride effects on Metallic pipes

Hamilton Robinson Consultants

# Inspection & Sampling Results

Soil Samples were evaluated for Corrosion Indicators:

pH Levels

| Soil Parameter | Range of Values | Degree of Corrosivity |
|---|---|---|
| pH | Below 5.5 | Very Corrosive |
| | 5.5 - 6.5 | Moderately Corrosive |
| | 6.5 - 7.5 | Neutral |
| | Above 7.5 | Alkaline |

A.W. Peabody, Control of Pipeline Corrosion – Second Edition, p. 91, (2001).

pH effects on PCCP and Metallic pipes

Hamilton Robinson Consultants

# Inspection & Sampling Results

Soil Samples were evaluated for Corrosion Indicators:

pH Levels

| Soil Parameter | Range of Values | Degree of Corrosivity |
|---|---|---|
| Soil Resistivity (ohm-cm) | Below 500 | Very Corrosive |
| | 500-1,000 | Corrosive |
| | 1,000-2,000 | Moderately Corrosive |
| | 2,000-10,000 | Mildly Corrosive |
| | above 10,000 | Progressively Less Corrosive |

A.W. Peabody, Control of Pipeline Corrosion – Second Edition, p. 88, (2001).

pH effects on PCCP and Metallic pipes

Hamilton Robinson Consultants

# Inspection & Sampling Results

Soil Samples were evaluated for Corrosion Indicators:

Sulphate Concentration

| Soil Parameter | Range of Values | Degree of Corrosivity |
|---|---|---|
| Sulphate Concentration (ppm) | Above 10,000 | Severely Corrosive |
| | 1,500 - 10,000 | Very Corrosive |
| | 150 - 1,500 | Moderately Corrosive |
| | Below 150 | Mildly Corrosive |

G.A. Chandler, WWD, Sulphates and Concrete in the Winnipeg Area, Part 2, 1968, p.11.

Effect of Sulphate on PCCP

Hamilton Robinson Consultants

# Corrosion Risk Mapping

Corrosion Risk Matrix

- The sample with the highest risk level was the governing risk factor for the site.

| Corrosion Risk Matrix | |
|---|---|
| Very Corrosive | 1 |
| Corrosive | 2 |
| Moderately Corrosive | 3 |
| Mildly Corrosive | 4 |
| NO DATA | N/A |

Hamilton Robinson Consultants

# Corrosion Risk Mapping

Soil Corrosivity Risk level : Site 1 - 13

| Site ID | Site Name | Pipeline No. | Corrosion risk Level | | |
|---|---|---|---|---|---|
| | | | Backfill | Bedding | Combined |
| Site 01 | Tire Street Site | 55 | *4* | *2* | **2** |
| Site 02 | Kenilworth Avenue Site | 55 | *4* | *2* | **2** |
| Site 03 | Sherman Avenue Site | 18 | *4* | *1* | **1** |
| Site 04 | Steam Museum Site | 18 | *4* | *1* | **1** |
| Site 05 | West Gate 10 Site | 18 | *4* | *1* | **1** |
| Site 06 | Upper Sherman Avenue Site | 33 | *3* | *1* | **1** |
| Site 07 | Upper Ottawa Street Site | 28 | *4* | *2* | **2** |
| Site 08 | Ainslie Avenue Site | 44 | *4* | *4* | **4** |
| Site 09 | Charlton Avenue East and Catharine Street South | 113A | *1* | *1* | **1** |
| | | 139 | *3* | *1* | **1** |
| Site 10* | Greenhill D Site | 22 | *N/A* | *N/A* | **N/A** |
| Site 11 | Justine Avenue & King Street Site | 54 | *3* | *4* | **3** |
| Site 12 | Central Avenue & Auburn Avenue | 54 | *4* | *4* | **4** |
| Site 13 | Kenilworth Access Site | 54 | *4* | *4* | **4** |
| *Note: No soil sample for Site 10 and Site 17 | | | | | |

Hamilton Robinson Consultants

# Corrosion Risk Mapping

Soil Corrosivity Risk level : Site 14 - 26

| Site ID | Site Name | Pipeline No. | Corrosion risk Level | | |
|---|---|---|---|---|---|
| | | | Backfill | Bedding | Combined |
| Site 14 | Upper Ottawa Street and Queensbury Drive Site | 28 | *2* | *4* | **2** |
| Site 15 | Rymal Rd. W | 106 | *2* | *3* | **2** |
| Site 16 | Rymal Rd. W. | 106 | *3* | *1* | **1** |
| Site 17* | Woodward Avenue | 62 | *N/A* | *N/A* | **N/A** |
| Site 18 | Garner Rd. E. | 35 | *2* | *1* | **1** |
| Site 19 | Stone Church Rd. E. | 31 | *3* | *3* | **3** |
| Site 20 | Stone Church Rd. E. | 123 | *3* | *3* | **3** |
| Site 21 | 275 Robert St Site | 111 | *3* | *3* | **3** |
| Site 22 | Robert St & West Ave Site | 144 | *1* | *1* | **1** |
| Site 23 | 27 Rutherford Ave & 198 Sanford Ave | 66 | *1* | *1* | **1** |
| Site 24 | Rutherford at Sanford Ave S | 74 | *1* | *1* | **1** |
| Site 25 | 168 Sanford Ave S | 74 | *1* | *3* | **1** |
| Site 26 | Barton Street East and Kenilworth Ave North | 61 | *1* | *1* | **1** |
| *Note: No soil sample for Site 10 and Site 17 | | | | | |

Hamilton Robinson Consultants

# Corrosion Risk Mapping

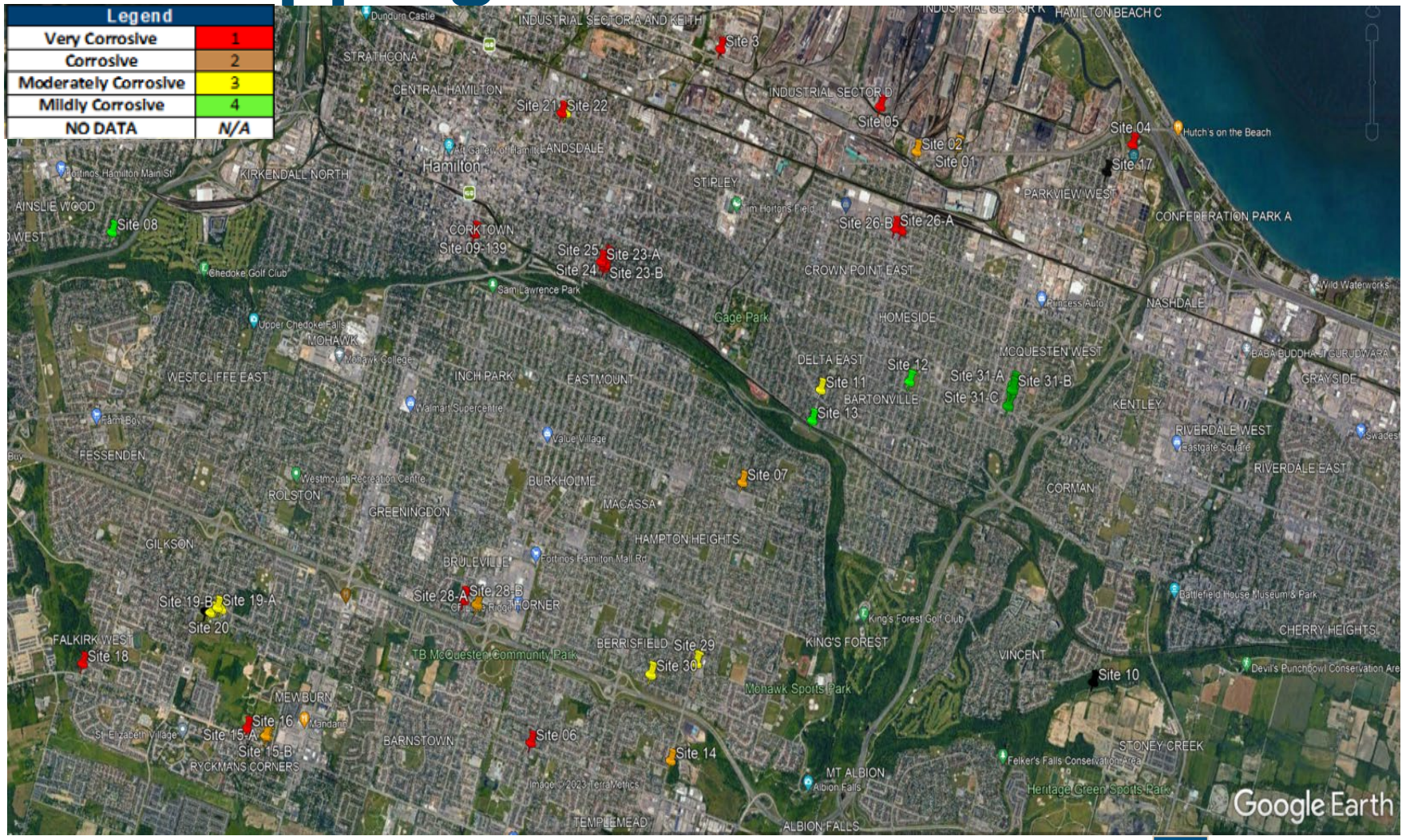
Soil Corrosivity Risk level : Site 27 - 31

| Site ID | Site Name | Pipeline No. | Corrosion risk Level | | |
|---|---|---|---|---|---|
| | | | Backfill | Bedding | Combined |
| Site 27 | Stonechurch Rd. W. | 123 | *N/A* | *N/A* | **N/A** |
| Site 28 | Limeridge Rd E | 31 | *2* | *1* | **1** |
| Site 29 | Upper Ottawa St. & Bowden St. | 28 | *4* | *3* | **3** |
| Site 30 | 890 Limeridge Road East | 31 | *3* | *3* | **3** |
| Site 31 | Delena Avenue South/North | 54 | *4* | *4* | **4** |

Hamilton Robinson Consultants

# Corrosion Risk Mapping

Corrosion risk level map generated based on using site specific risk table.




Hamilton

Robinson Consultants

# Conclusion & Next Step

- Relatively cheaper exercise (during emergency repair, periodic maintenance, live connections, valve replacement etc.)
- Helped identify any trend in the data set
- Prioritization of spending in the management of critical mains
- Continue gaining data and incorporate in corrosion mapping
- Utilize in validation of criticality ranking of PCCP and Metallic watermains

Hamilton Robinson Consultants

Robinson
Consultants


# Thank You!

Kevin Bainbridge
Muhit Tanveer

**www.rcii.com**

Hamilton

Robinson
Consultants