VODA.ai

A Science-based Approach to Manage Water Mains, Wastewater & Lead Pipes

January 24, 2023

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WATERMAIN BREAK CLOCK.COM
Corrosion is not Sustainable

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Each day, 850 water main breaks occur in North America. Since January 2000, we have suffered:

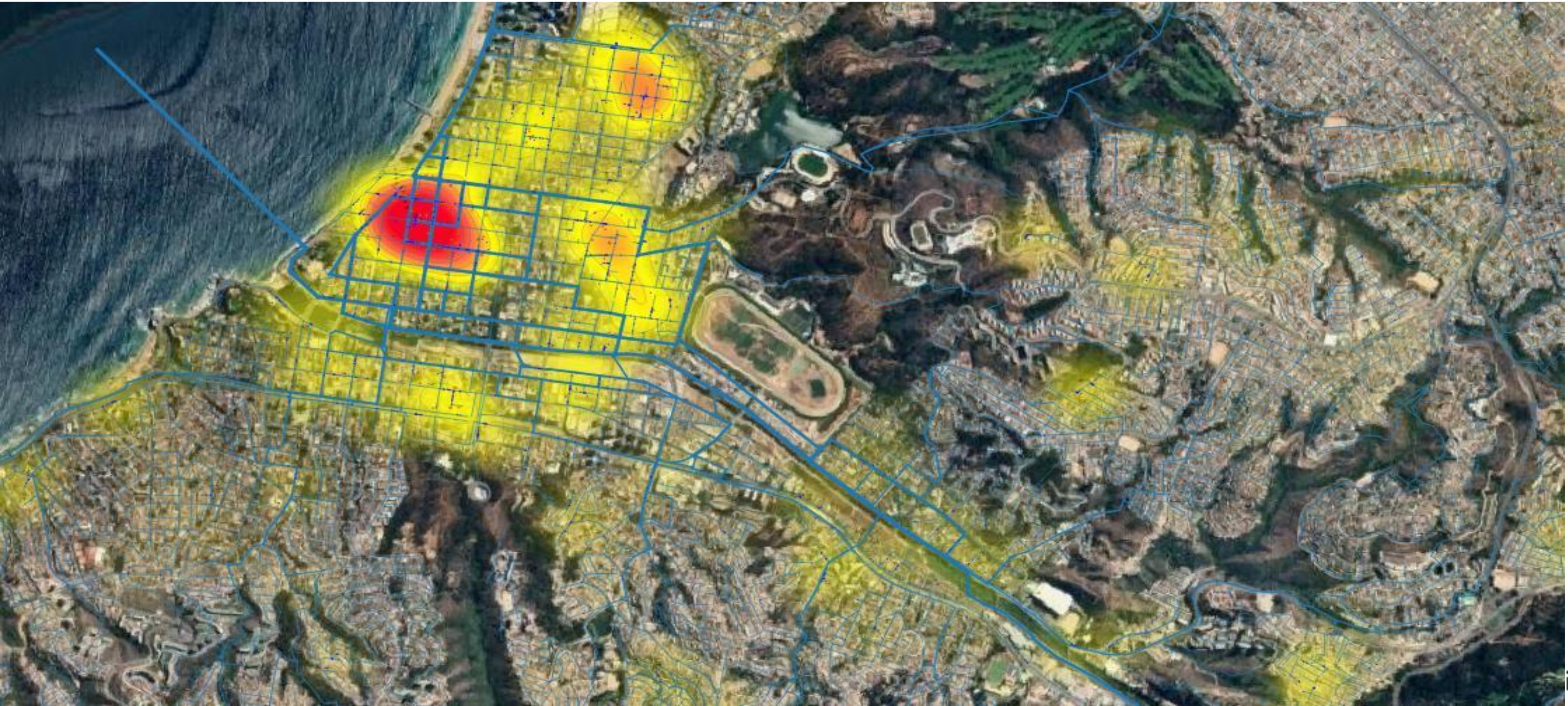
7,153,966 BROKEN WATER MAINS (INCLUDING **2,916** SO FAR TODAY).

$71,539,663,212 IN WATER MAIN REPAIR COSTS.

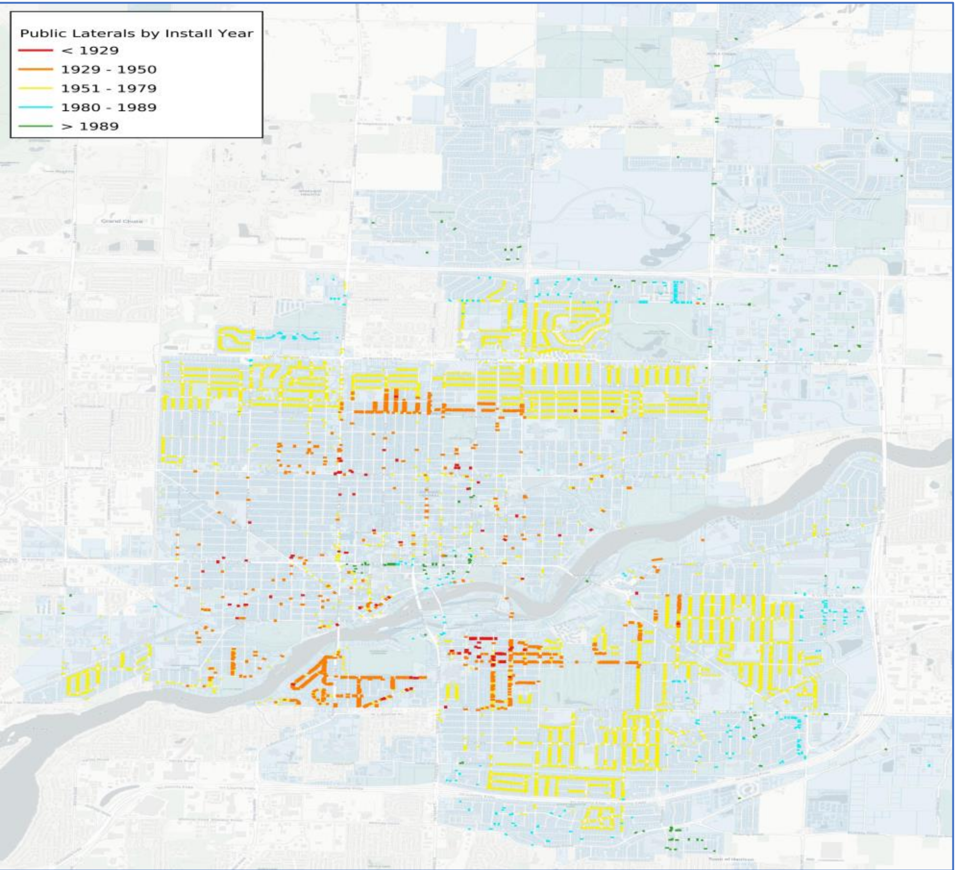
According to a 2002 congressional study, corrosion costs U.S. water and waste water systems over $50.7 billion annually. Since January 2000, the price tag for this epidemic in the United States is:

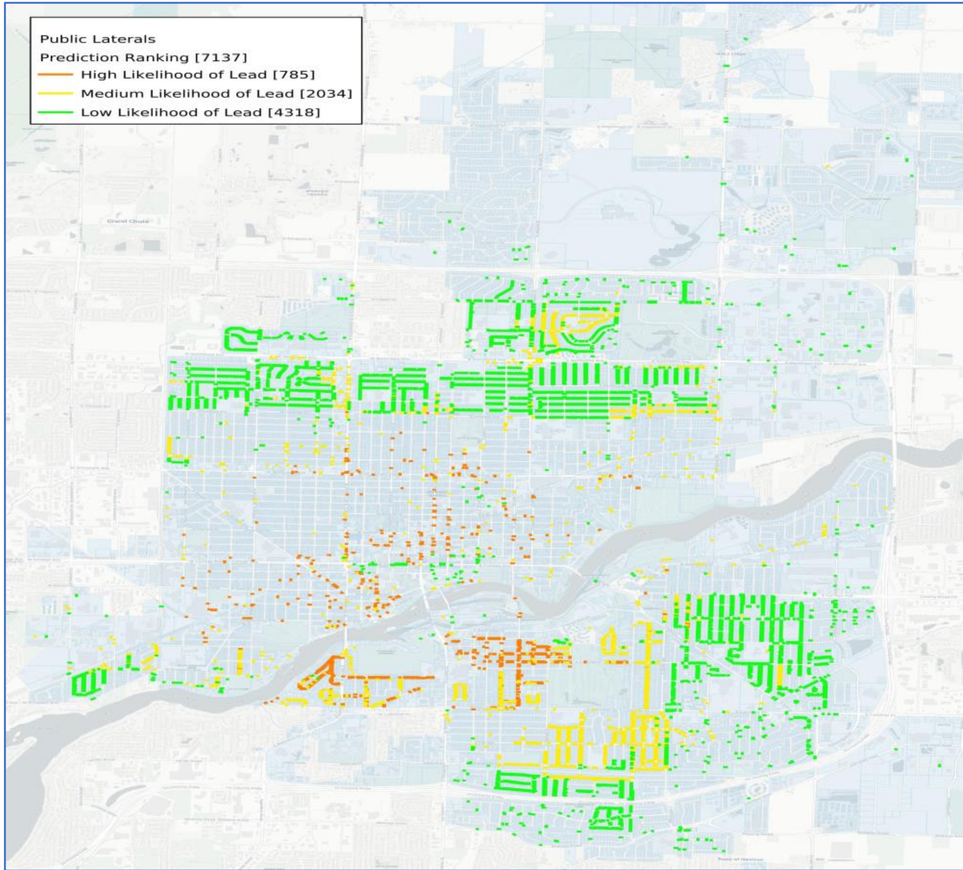
$930,181,379,227 IN TOTAL CORROSION COSTS.

Key Challenges – Wastewater Incidents, Overflows



Key Challenges – Lead Finder™





Proactive Pipe Management

- Identify high risk mains
- Target top 5% for inspection, monitoring, condition assessment, repair
- Target worst 1% for replacement

Asset Management Decisions with Machine Learning

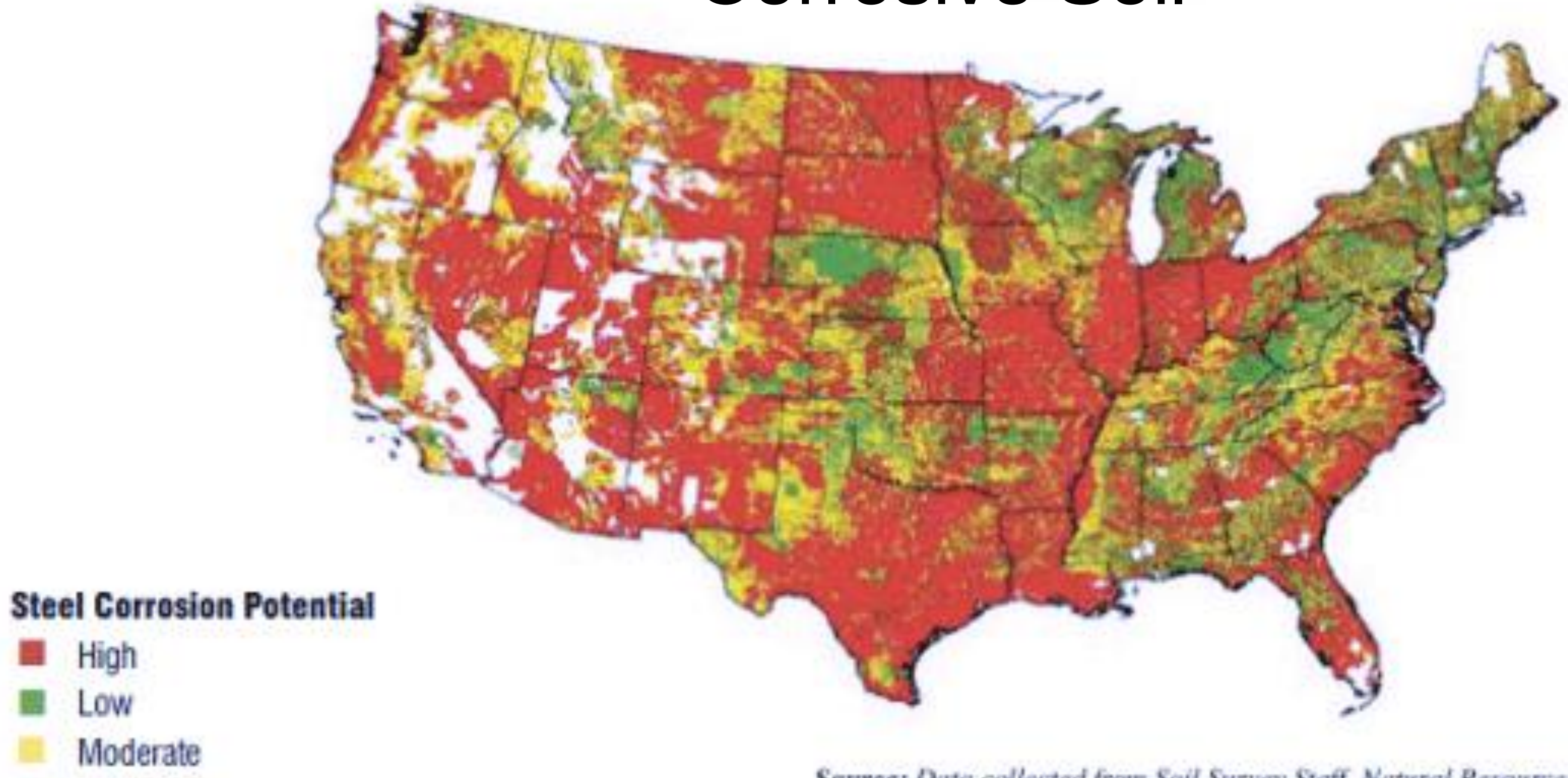
Do you proactively assess water mains?
How do you choose which ones to

- Inspect,
- Monitor,
- Exercise Valves
- Repair or Replace
- Where to put Sensors?

Traditional Methods to Predict Issues

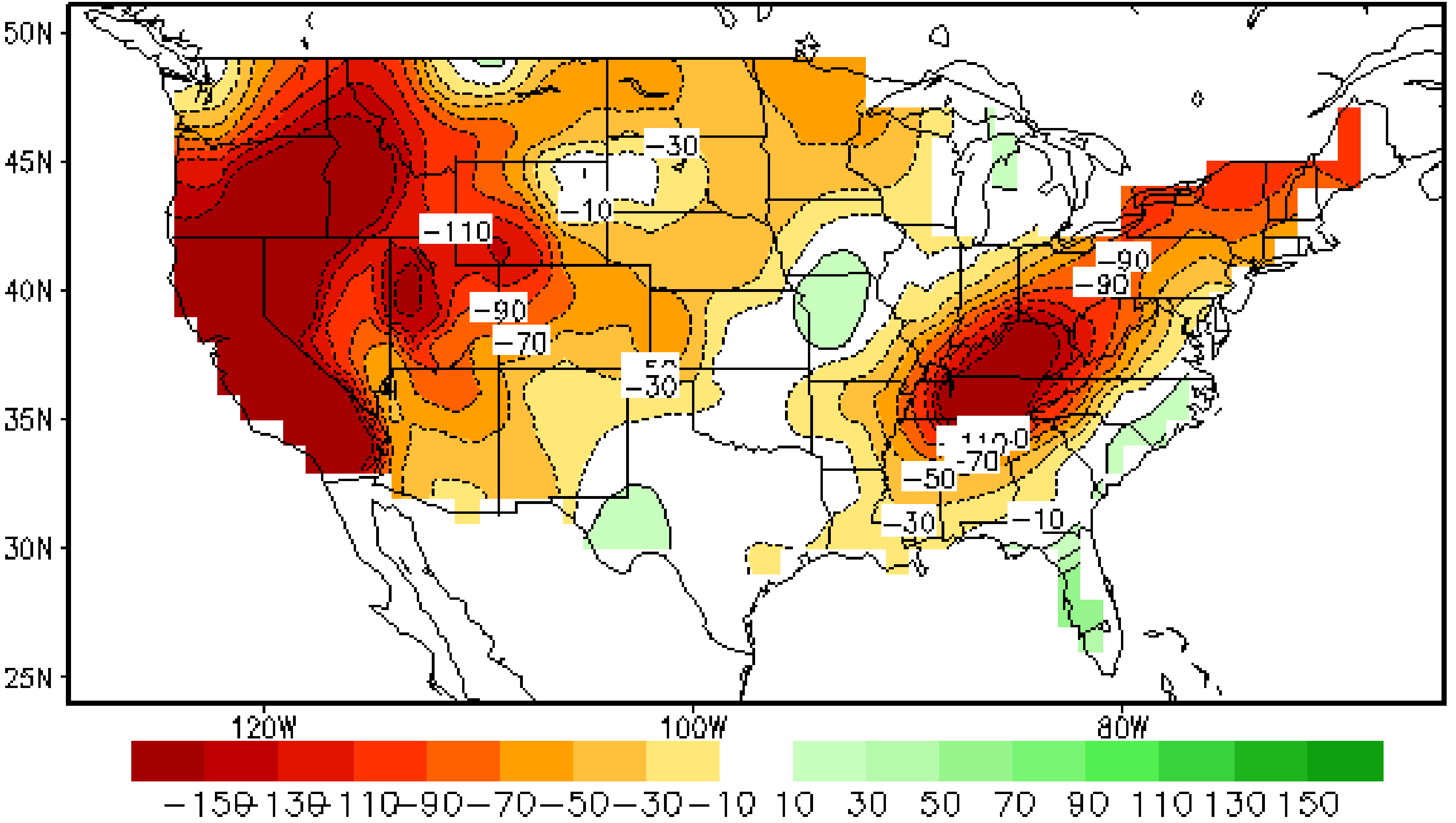
- Pipe Age
- Failure History
- Material
- Cluster Areas
- Intuition
- Some Combination of Above

Corrosive Soil



Source: *Data collected from Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture Soil Survey Geographic Database.*

Lagged Averaged Precipitation Outlook for NOV 2022
units: anomaly (sdX100), SM data ending at 20221024



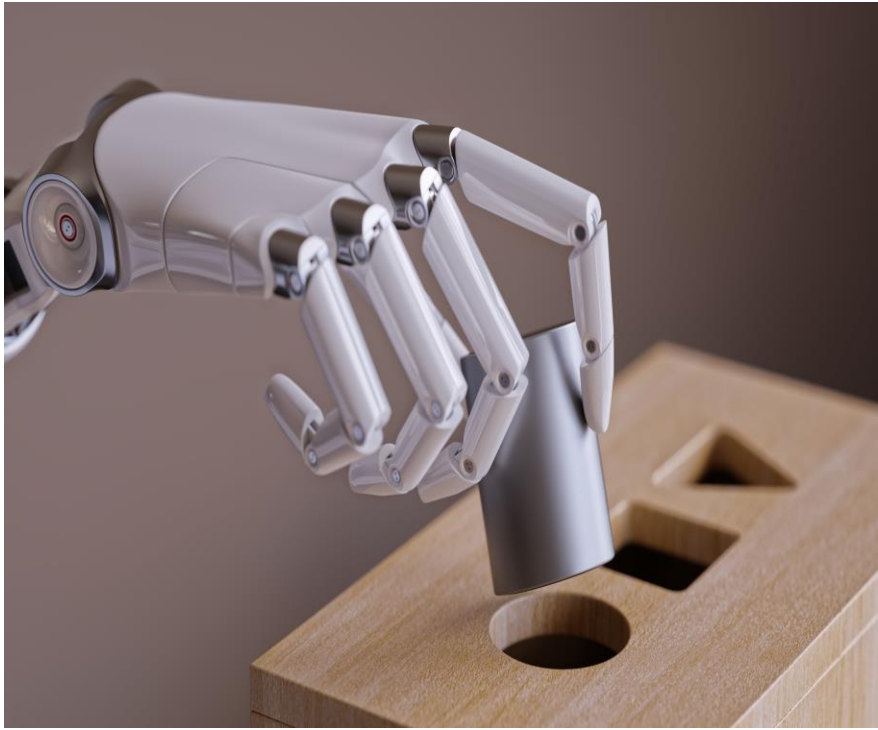
Other Variables

- Proximities
  - Highways
  - Railroads
  - Bridges
  - Lakes
- Seismic Activity
- Land Use
- Restaurant Clusters
- 100s of Variables

A Science-Based Approach to Decision-Making

Artificial Intelligence

Machine Learning



ARTIFICIAL INTELLIGENCE IS EVERYWHERE

WAZE

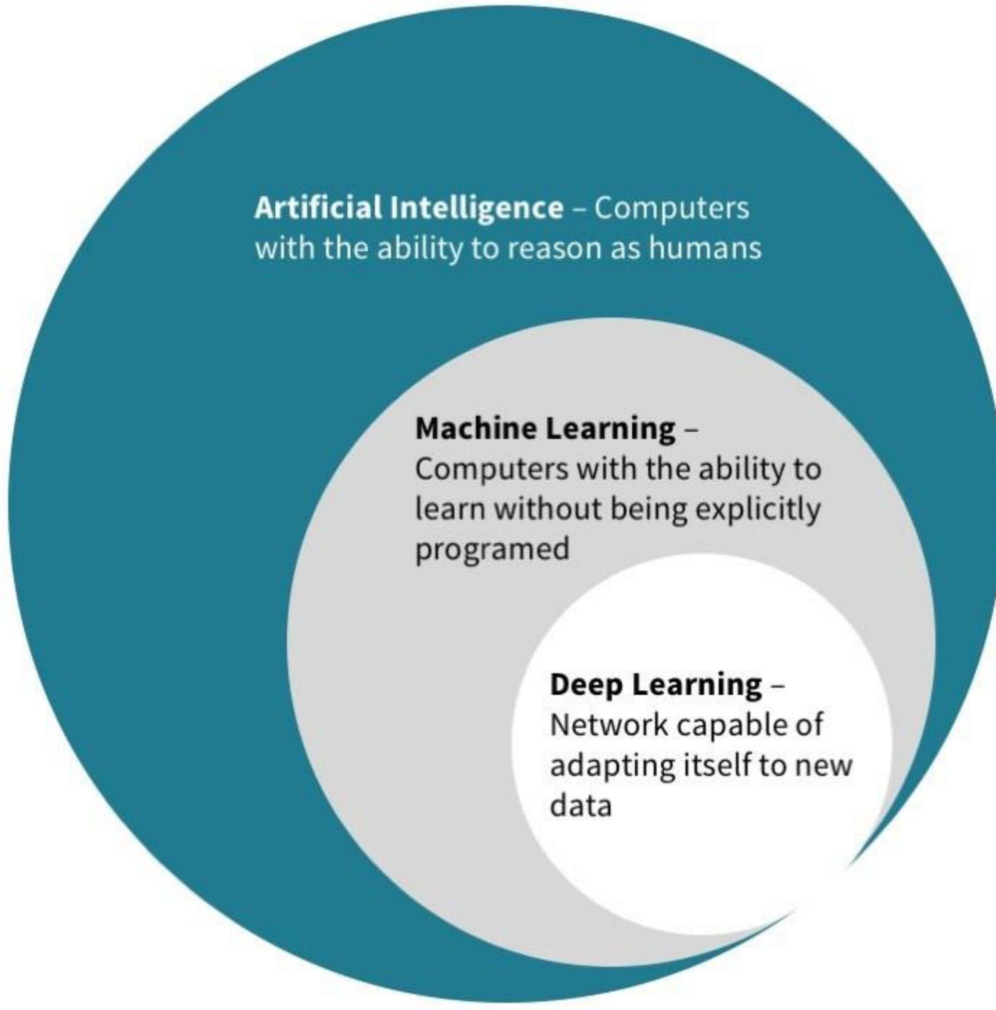
It helps reduce risks, improve results

Artificial Intelligence (“AI”) is not New

- Coined at Dartmouth College in 1956
- Machines acting rationally (like most people)
- Machine Learning (ML), subset of AI, uses algorithms & models for improving outcomes

Why Machine Learning?

- Increased computing power
- Access to more data
  - Volume
  - Variety
  - Velocity
- New research



ML Detects Emotions

Consistently detects 26 emotions from facial expressions

Applications of ML

GPS (routing, arrival time)
Recommendations (Amazon, Netflix, etc.)
Autonomous vehicles
Weather forecasts
Credit assessment
Medical diagnosis
Credit card fraud
Medicare fraud

Chess and GO
Speech recognition
Facial recognition
Detecting emotions
Predict pipe failures
Find lead pipes
Predict wastewater incidents
Sensor placements
Improve data quality
Pump failure prediction

Benefits of ML

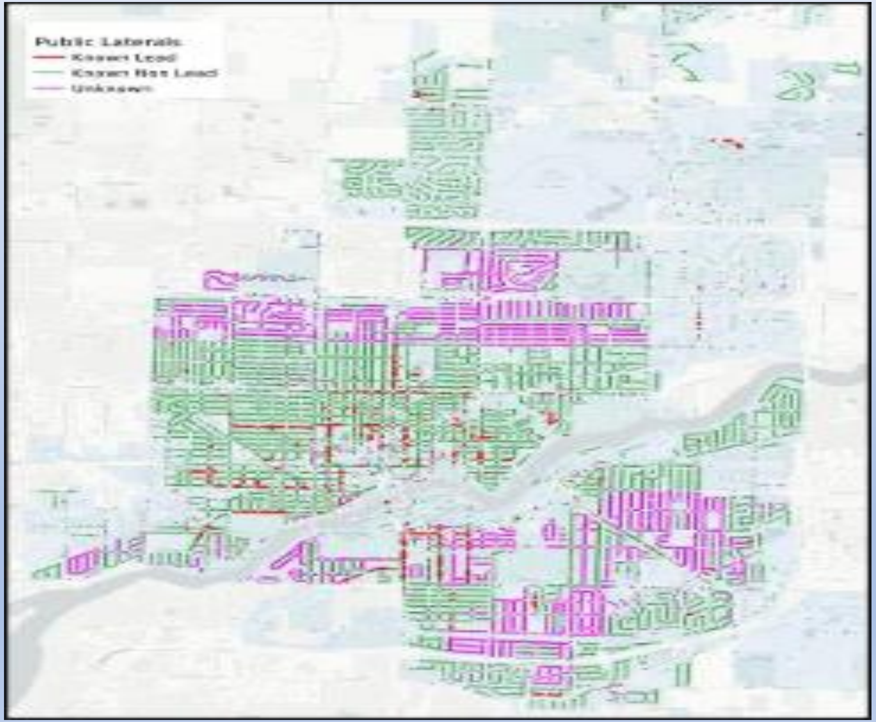
- Science-based decision making to:
  - Optimize scarce resources
  - Enhance outcomes and customer experiences
  - Find patterns we can't see

How Machine Learning “Learns”

Training data*

$$
\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \vdots \\ m \end{array}
\begin{array}{c}
\begin{array}{cccc} 1 & 2 & \ldots & n \end{array} \\
\begin{bmatrix}
a_{11} & a_{12} & \cdots & a_{1n} \\
a_{21} & a_{22} & \cdots & a_{2n} \\
a_{31} & a_{32} & \cdots & a_{3n} \\
\vdots & \vdots & \vdots & \vdots \\
a_{m1} & a_{m2} & \cdots & a_{mn}
\end{bmatrix}
\end{array}
$$

Results: patterns & knowledge



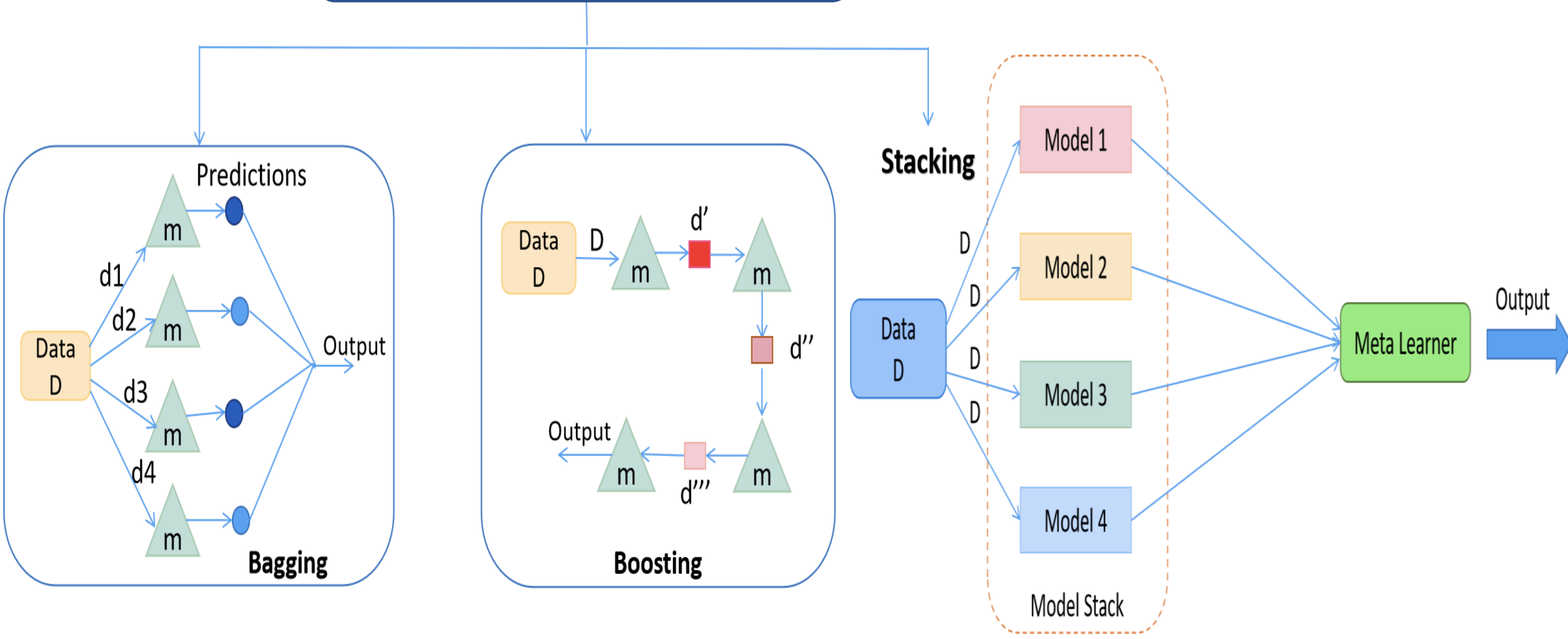
*Matrix (mathematics). (2022, September 18). In *Wikipedia*.
https://en.wikipedia.org/wiki/Matrix_(mathematics)

Multiple Algorithms & Models Optimize Results

Decision trees
Bagging
Boosting
Random forest
k-NN
Linear regression
Naive Bayes
Artificial neural networks
Logistic regression
Relevance vector machine
Support vector machine

Supervised learning
Unsupervised learning
Deep learning
Clustering
Dimensionality reduction
Structured prediction
Anomaly detection
Artificial neural network
Reinforcement learning
Human collaboration

Ensemble Learning



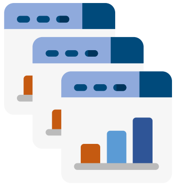
TARGETED CAPITAL AND O&M SPEND

- Targeted Leak Detection & Monitoring
- Targeted Valve Maintenance
- Targeted Inventory
- Remaining Useful Life
- Faster Repairs to **reduce risk**

How it works

Three-step process

01

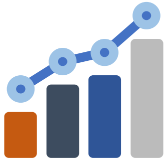


Gathering data

02

Cleaning data

03



Predicting risk

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Step 1 The Data

Material
Install Year
...

Soil
Land Use
...

Volume
Slope
...

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Planning

Replace more of these

And less of these

REAL WORLD RESULTS

Traditional Methods:
Prior Failure — 11%
Pipe Age — 12%

VS. 50%

W/ VODA.ai's ML

TUCSON WATER

A proud part of the City of Tucson

VODA.ai found 200% more failures than using traditional methods

50% had no prior failures!

Tucson Water

- 4,600 miles of pipe (230,000 pipe segments)
- In 2019, they engaged VODA.ai for a pilot project.
- We asked for at least five years of data, but to withhold the most recent year (2018), which we then predicted.
- Machine learning found 55% of their pipe failures in the top 1% of rankings by risk
- 17 of the top 18 segments ranked by LoF – failed
- The 18th pipe failed 2 months later
  (18 of the top 18 failed within 14 months)

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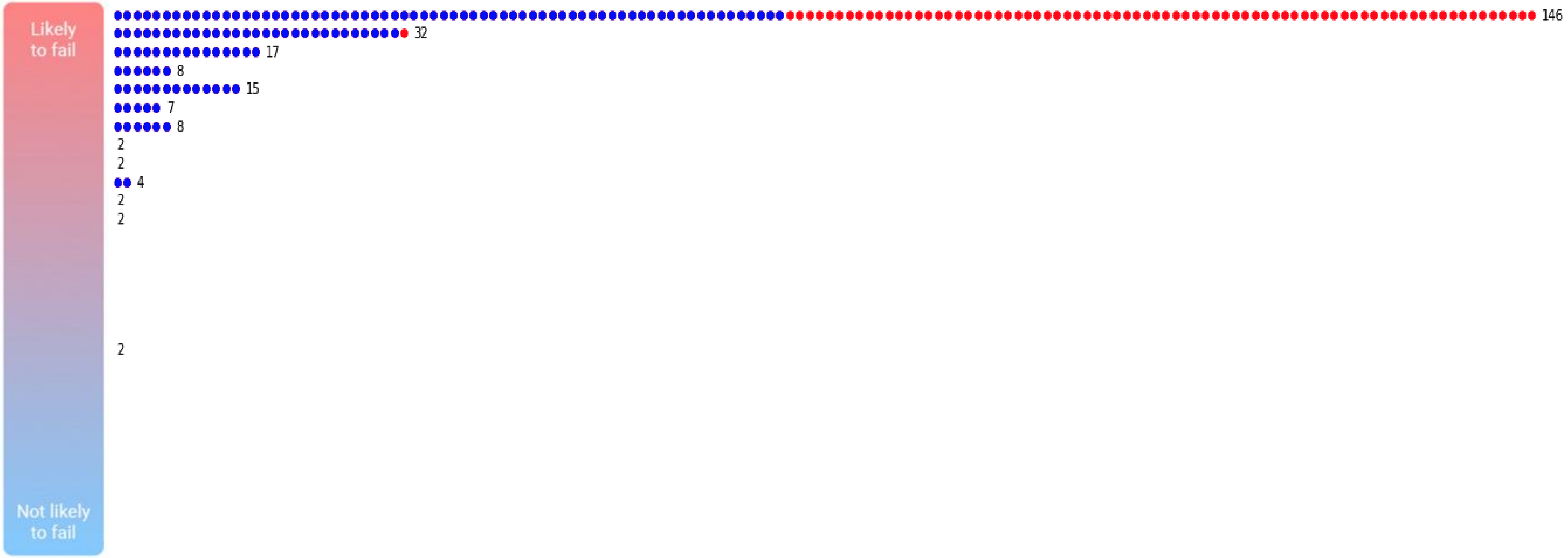
Looking for the Bull's Eye



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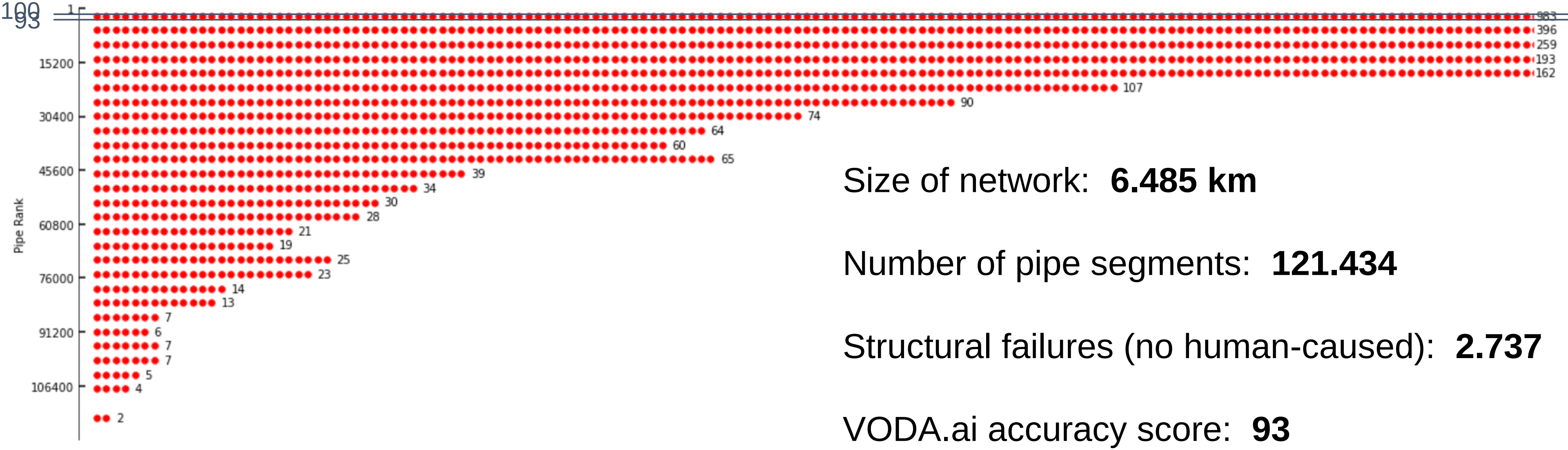
Case 1 – Comparing Methods

Wastewater Results 2020



Size of network: **6.485 km**

Number of pipe segments: **121.434**

Structural failures (no human-caused): **2.737**

VODA.ai accuracy score: **93**

NNWW Pilot Results

Top 50 Segments (0.1%)

13 Failures

NNWW Pilot Results

Bottom 20,000 Segments (51.5%)

4 Failures

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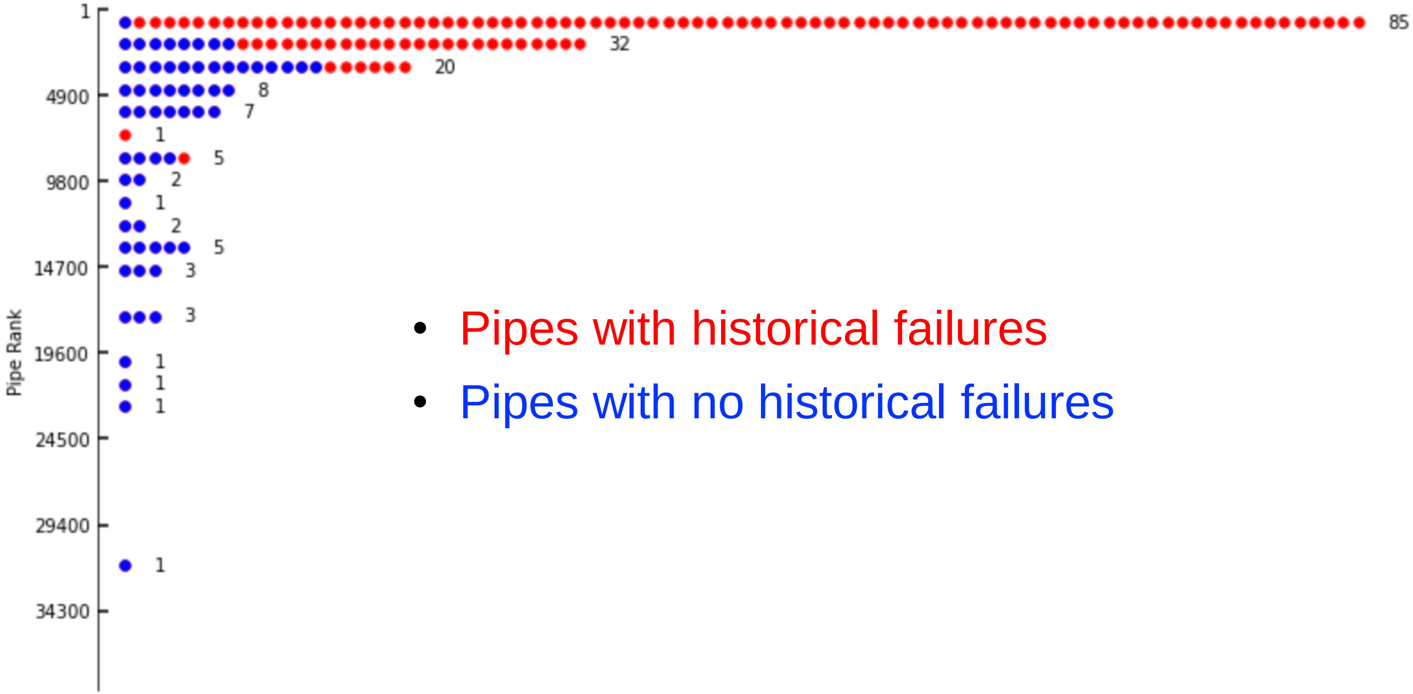
NNWW Results

Of the 50 highest risk segments, (0.1%), 13 failed.

In the lowest risk 50%, 4 failed.



Questions?

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Prioritizing Water Infrastructure

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