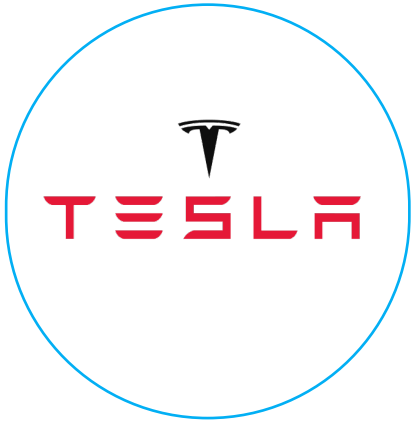
Manage Water and Sewer Infrastructure Proactively Using AI: Case Studies

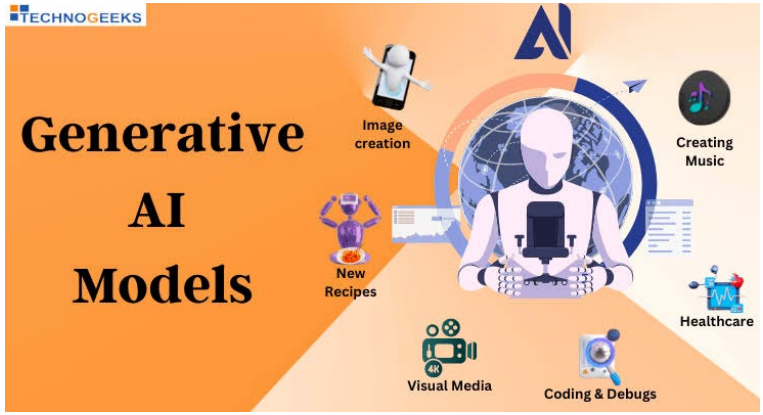
NWWC 2023 November 13, 2023

Copyright 2023

ARTIFICIAL INTELLIGENCE IS EVERYWHERE

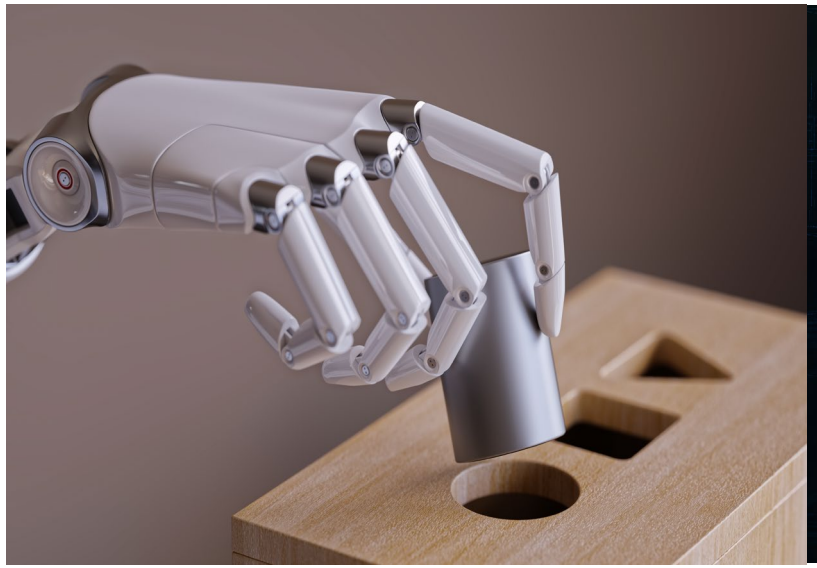


WAZE



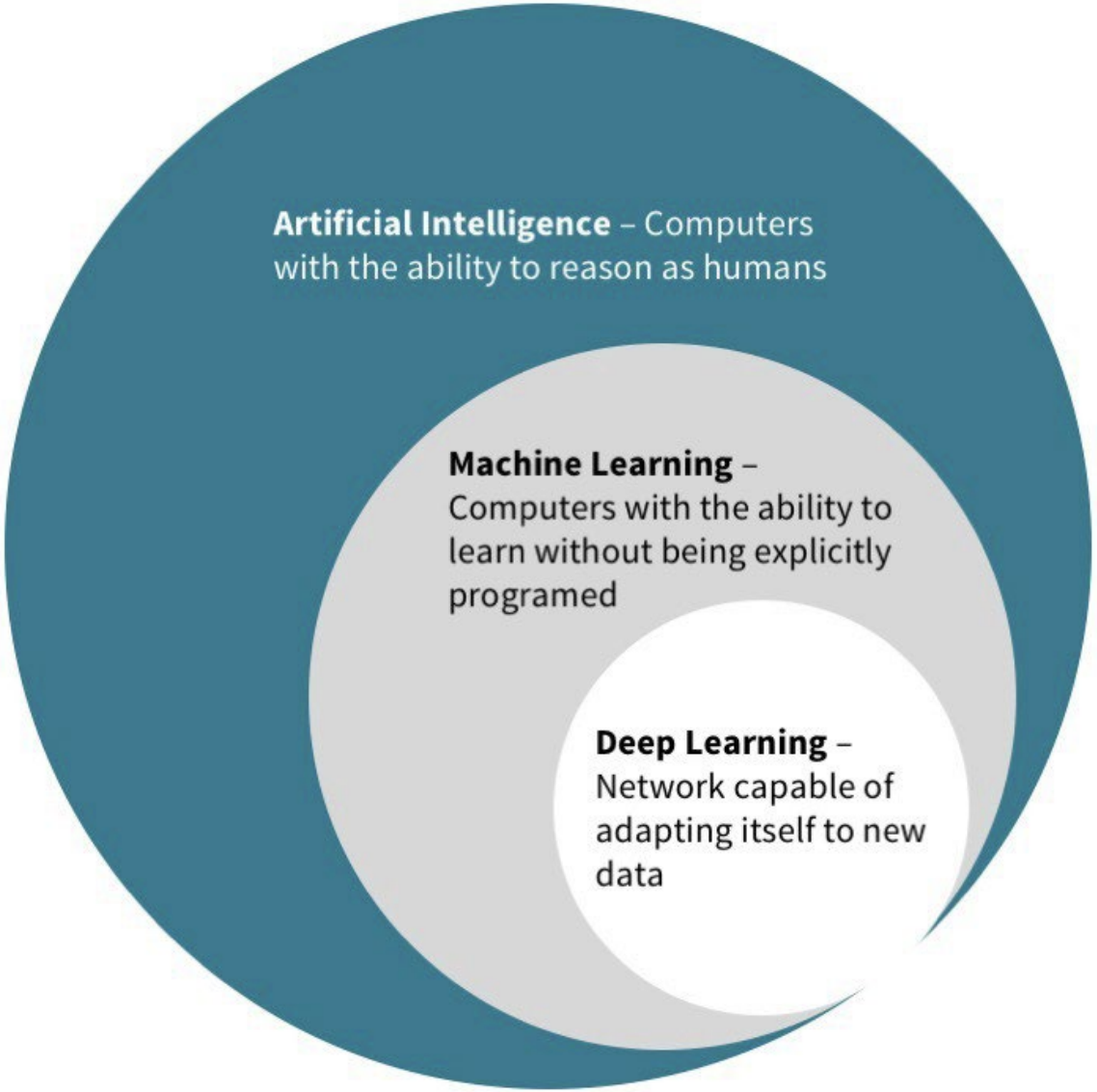
Reduce risks, improve results

“Artificial Intelligence” (AI) is not New



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

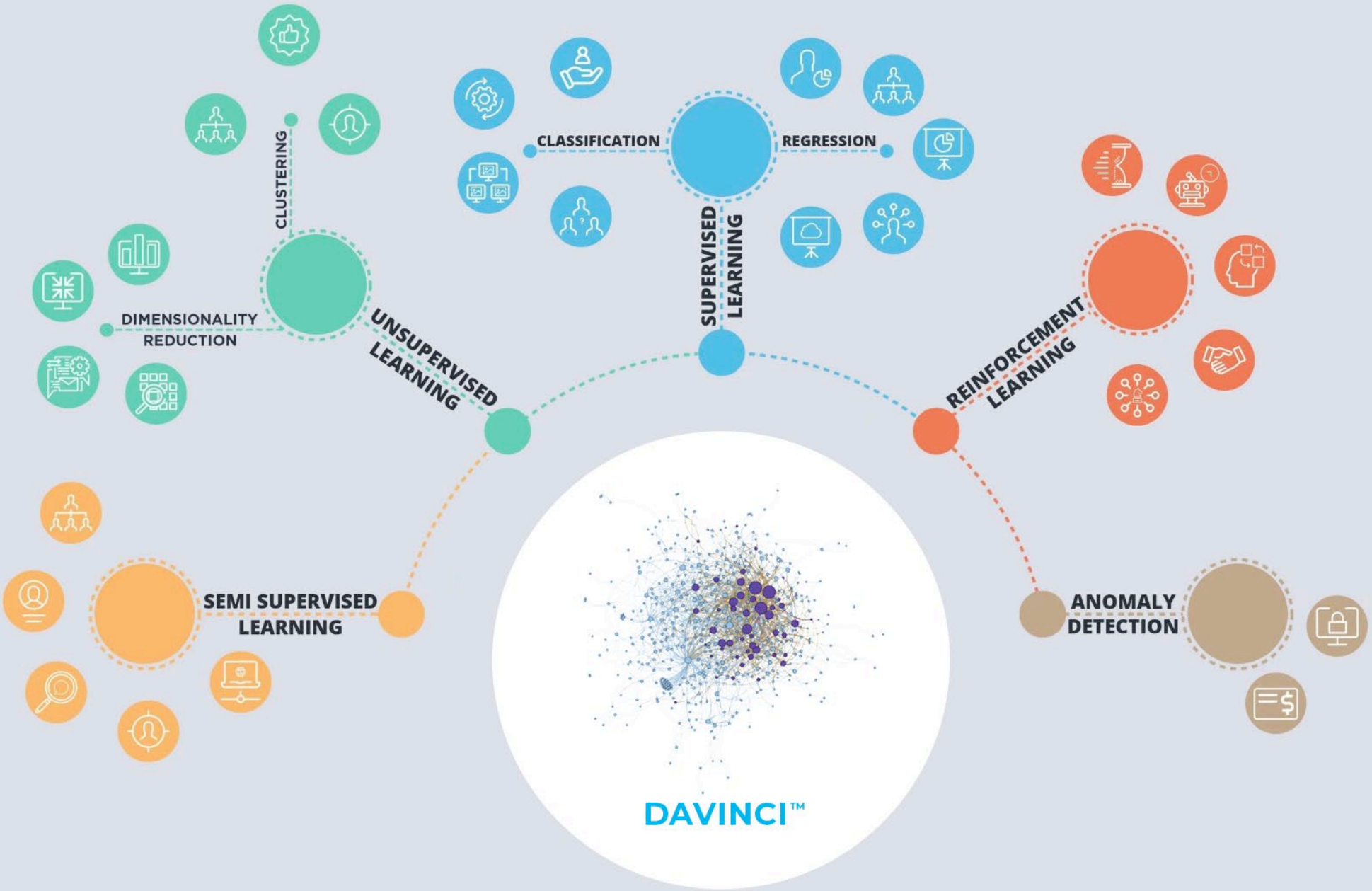
W hat is Machine Learning?



VODA.ai

Why Machine Learning Today?

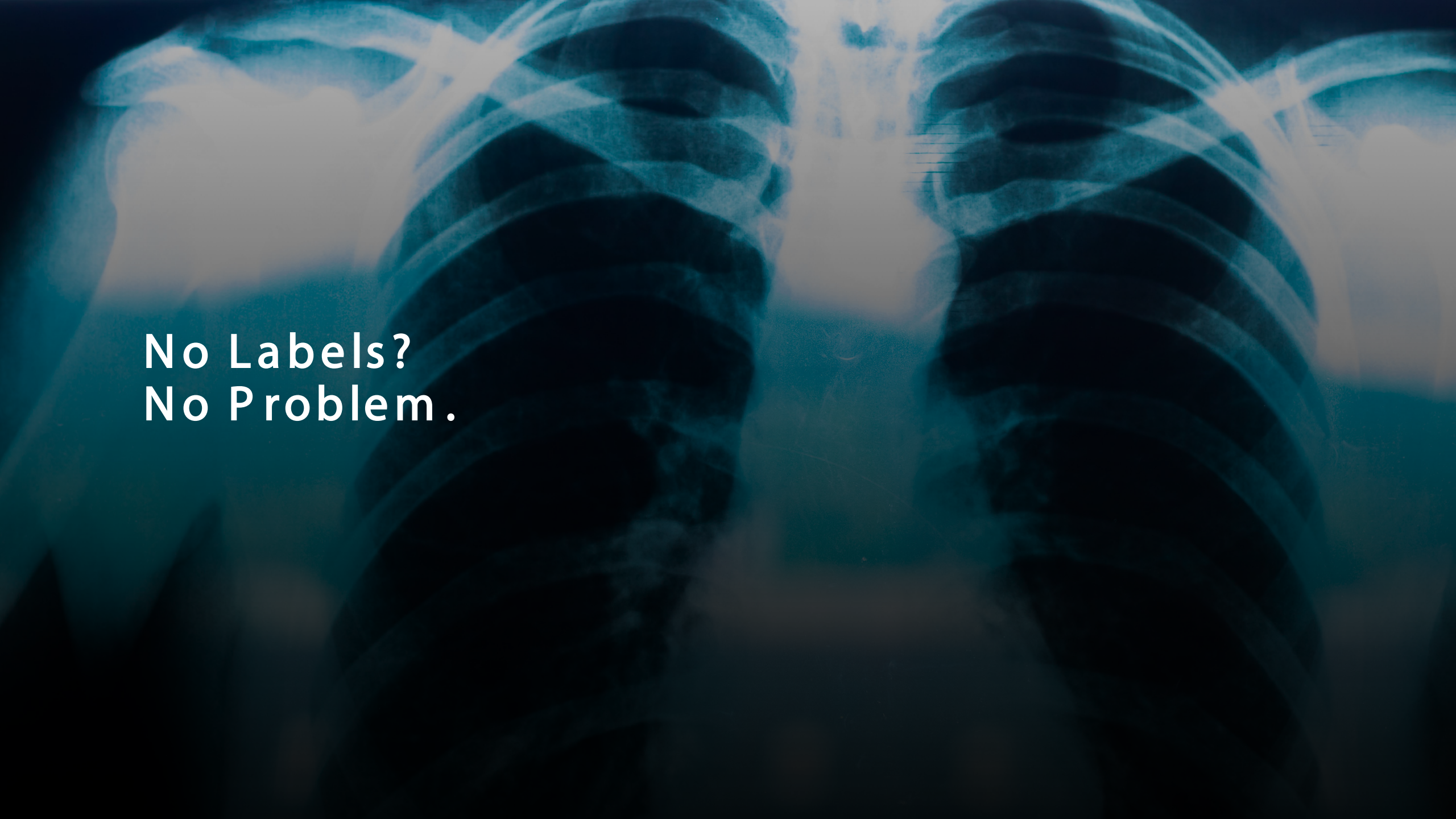
- Increased computing power
- Access to more data
  - Volume
  - Variety
  - Velocity
- New research

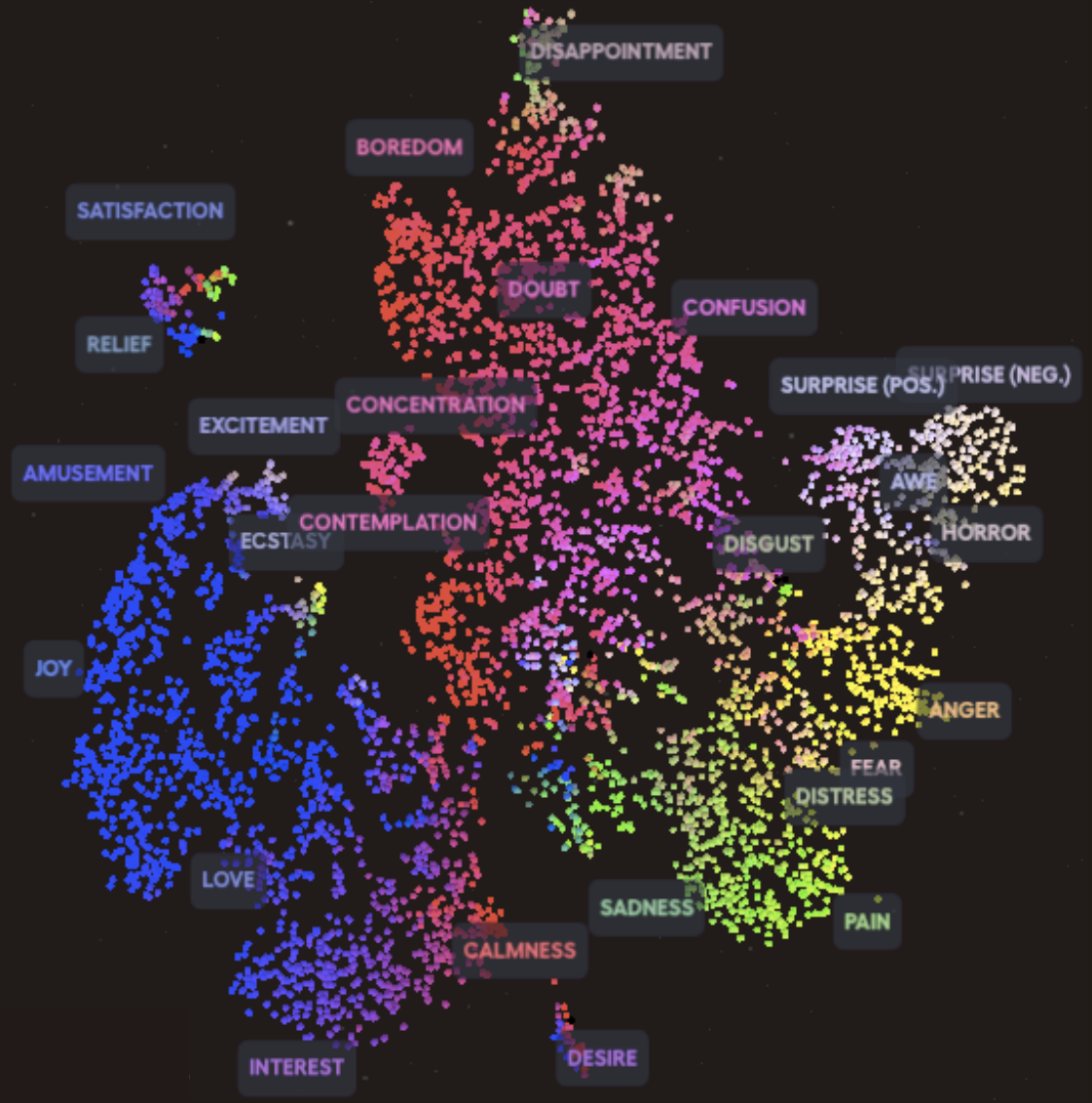

CLUSTERING
DIMENSIONALITY REDUCTION
UNSUPERVISED LEARNING
CLASSIFICATION
REGRESSION
SUPERVISED LEARNING
REINFORCEMENT LEARNING
SEMI SUPERVISED LEARNING
ANOMALY DETECTION
DAVINCI™

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


No Labels?
No Problem.



Detect Emotions.

ML consistently detects 37 emotions from facial expressions.

Benefits of ML

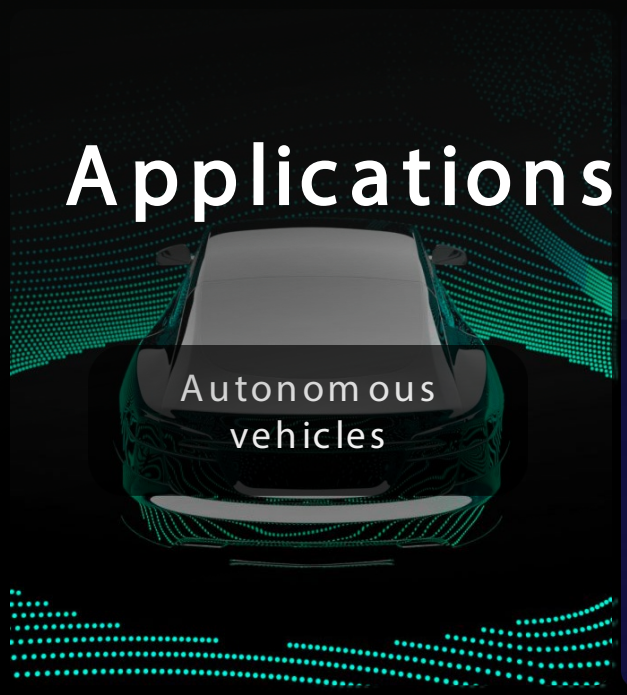
Data-driven decision making

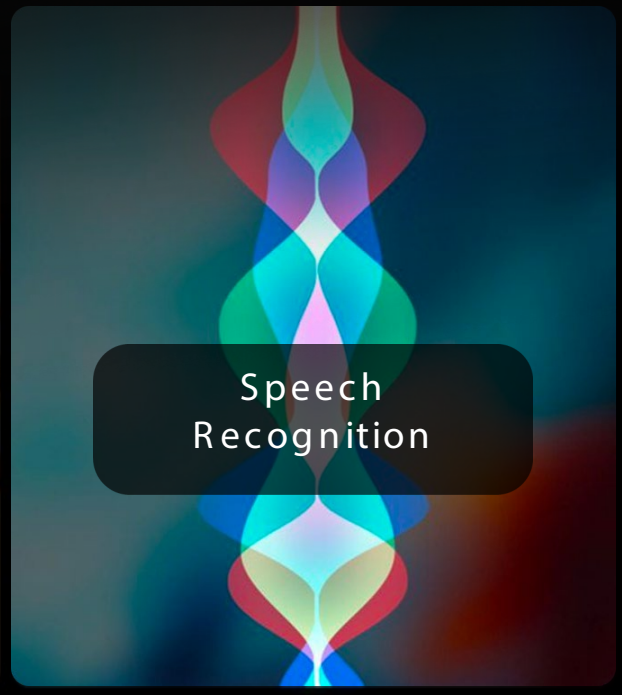
Optimize scarce resources

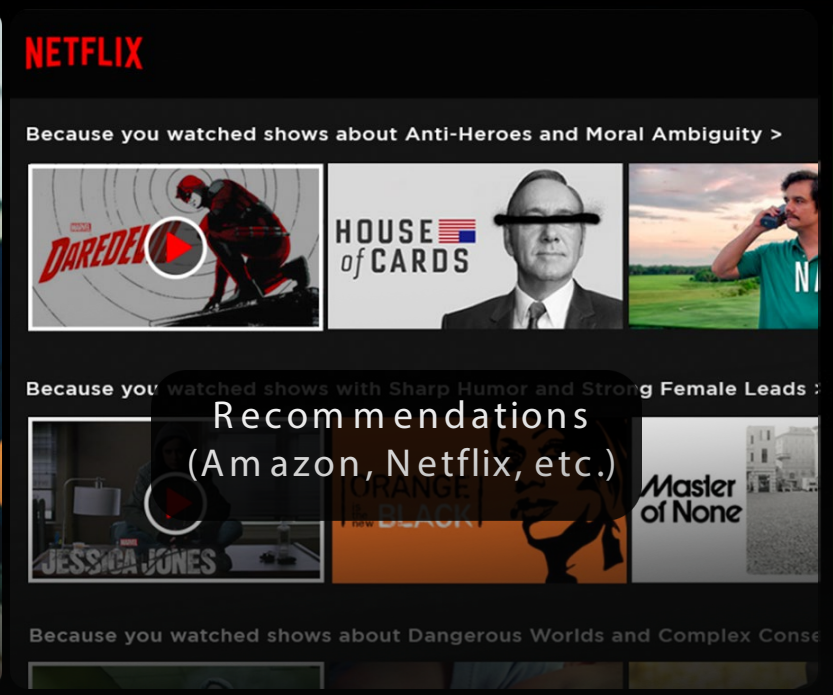
Enhance outcomes

Find patterns we can’t see

Applications of ML







TECHNOGEEKS

Generative AI Models

Generative AI

- Fraud Detection
- Customer Experience
- Supply Chain Optimization
- Optimized Operations
- Content Creation
- Training and Development
- Risk Management
- Predictive/Proactive Maintenance
- Enhance Customer Service
- Targeted Advertising

OK…

So how is AI/ML relevant to utilities?


850
Water main breaks just from today
$ 1Trillion in total corrosion costs

Do you proactively assess and manage water mains?

How do you choose which ones to

Inspect?

Monitor?

Repair or Replace?

Exercise Valves?

Install Sensors?

Traditional Methods to Predict Issues

INTUITION

CLUSTER AREAS

FAILURE HISTORY

PIPE AGE

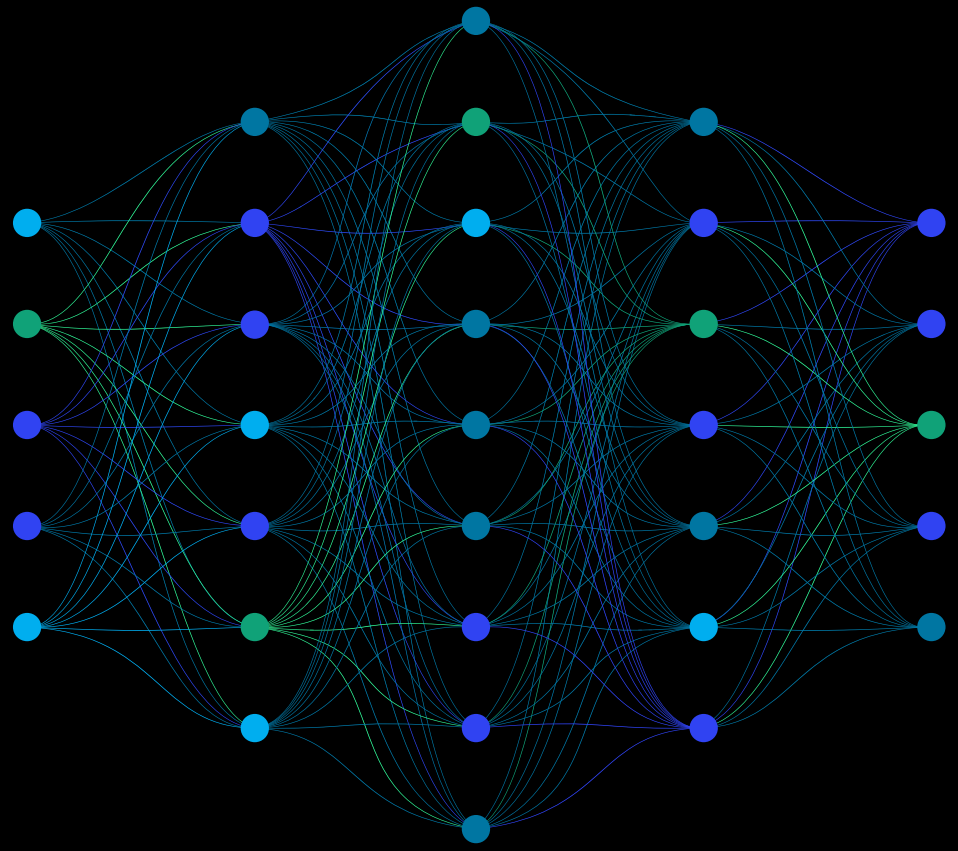
MATERIAL

SOME COMBINATION

A new way to prioritize with Machine Learning

65x

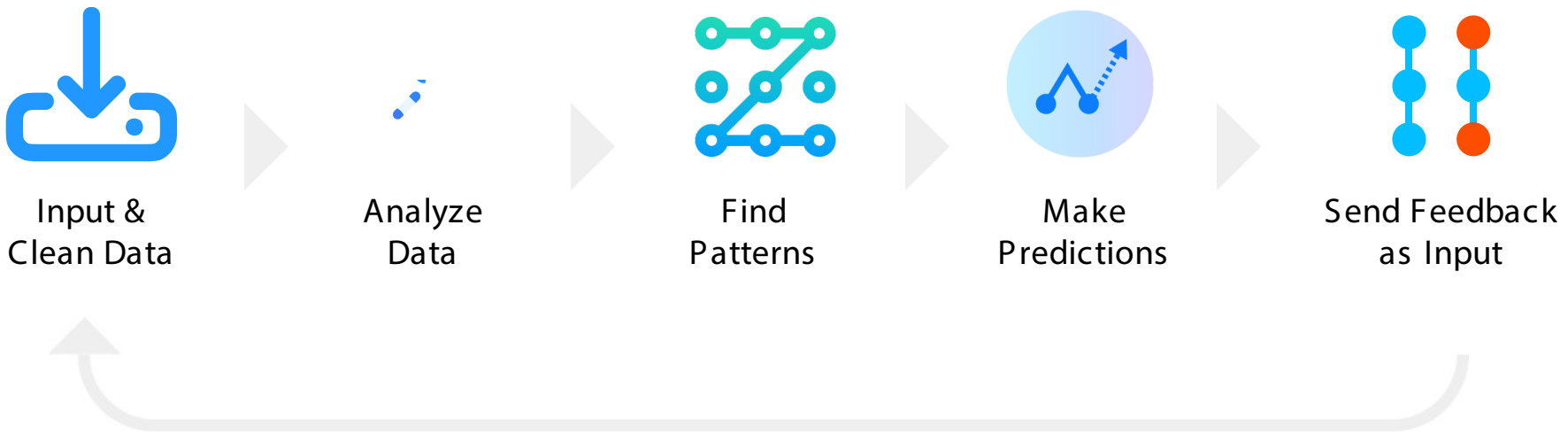
Improved Accuracy



TARGETED CAPITAL AND O&M SPEND

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

How does Machine Learning W ork?

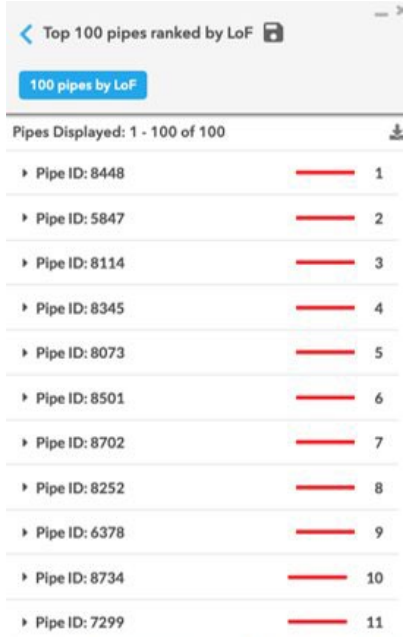


How Machine Learning "Learns"

Training data*

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

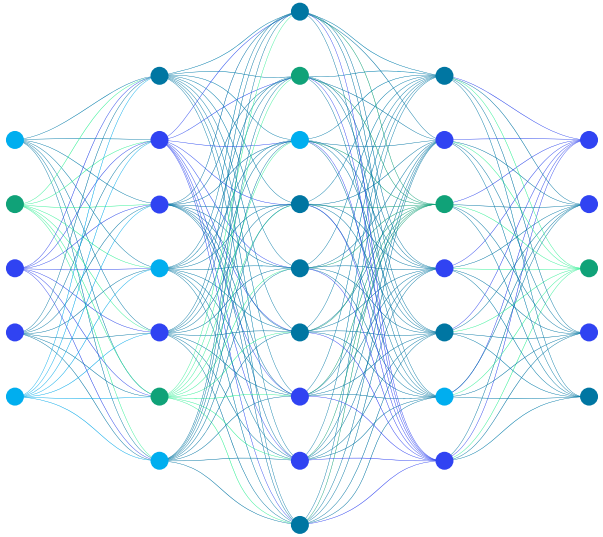
Results: patterns & knowledge

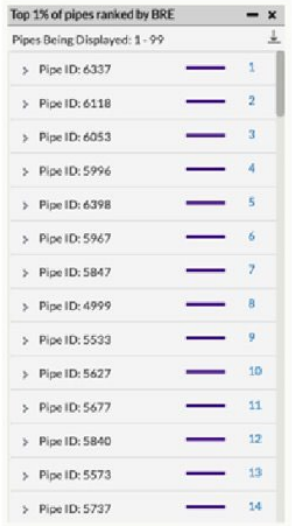


Instead of an engineer re-writing code every time there are new data, machine learning changes that algorithm on its own. It's self-learning.

VODA.ai

Process





DATA COLLECTION AND CLEAN UP

AI RISK ANALYSIS

PIPE RANKING

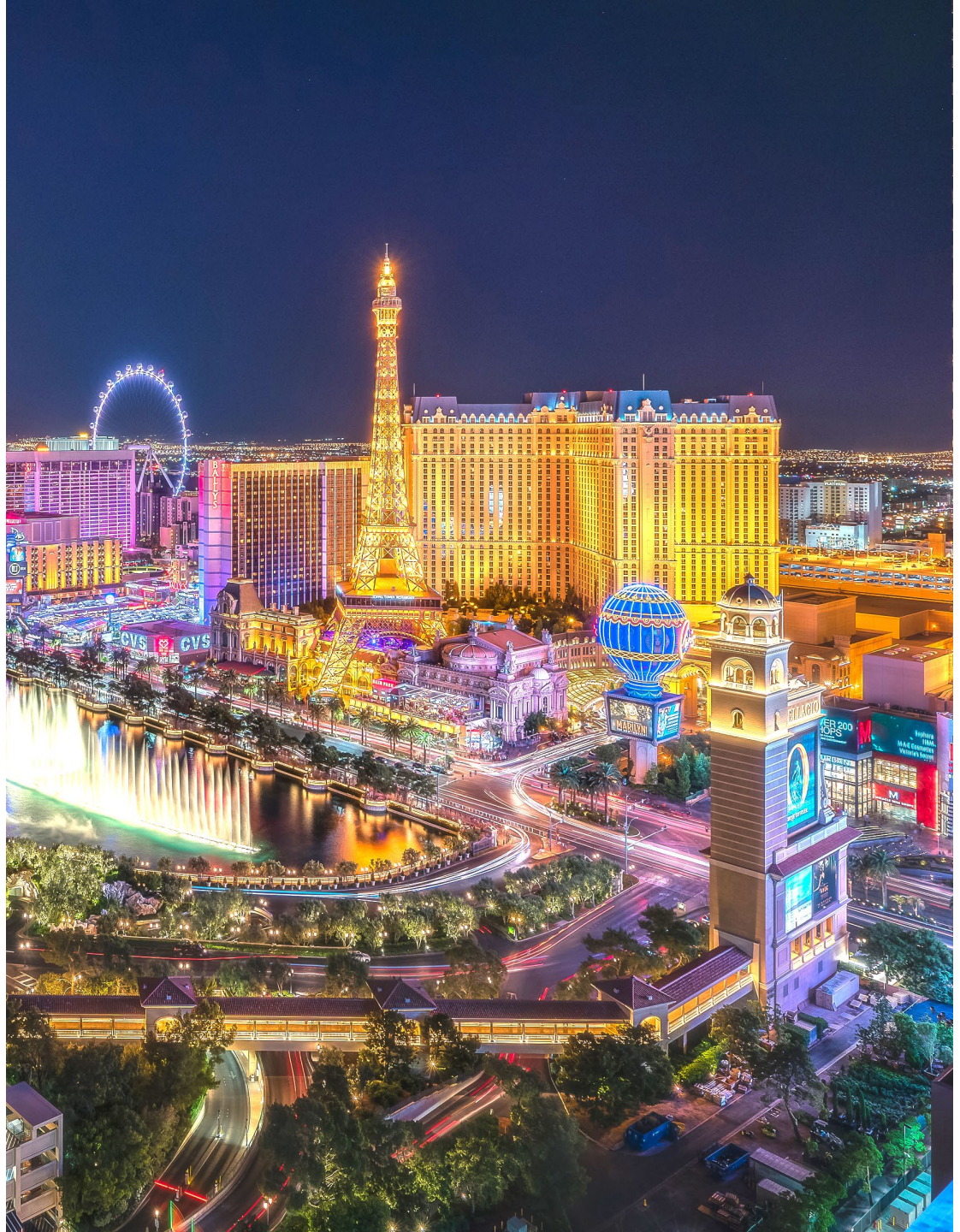
Case Studies

Case Study

Las Vegas, NV

5,000 miles of water mains

250,000 segments



Desktop Modeling had been used to prioritize decisions

Curiosity about machine learning led to a pilot with VODA.ai

COMPARING RESULTS: Within the Highest Risk 1%

Traditional Methods:

Prior Failure — found 11% of Failed Pipes

Pipe Age — found 12%

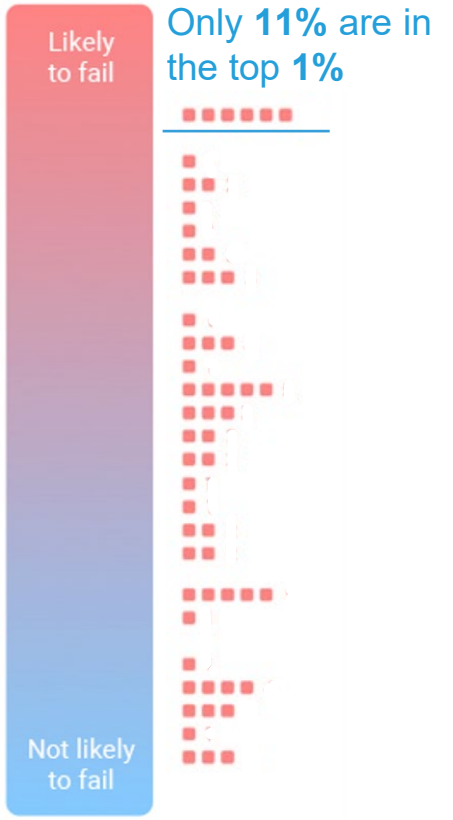
Desktop Statistical Model — ?

ML — 50%

Comparing Methods

Prior Failures

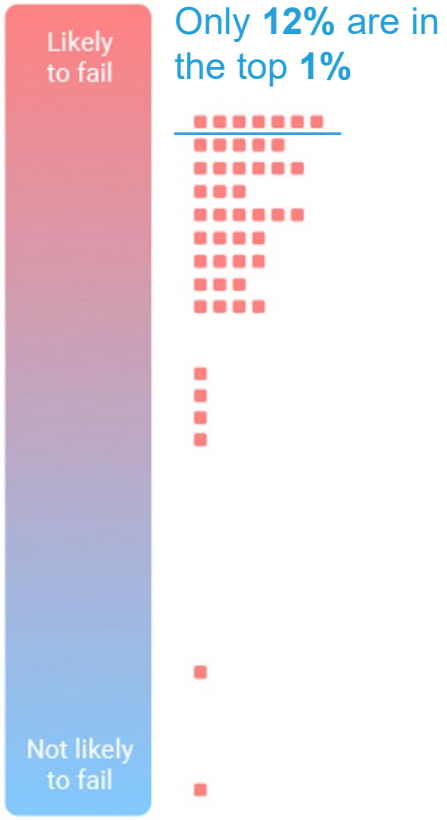
#1



Only **11%** are in the top **1%**

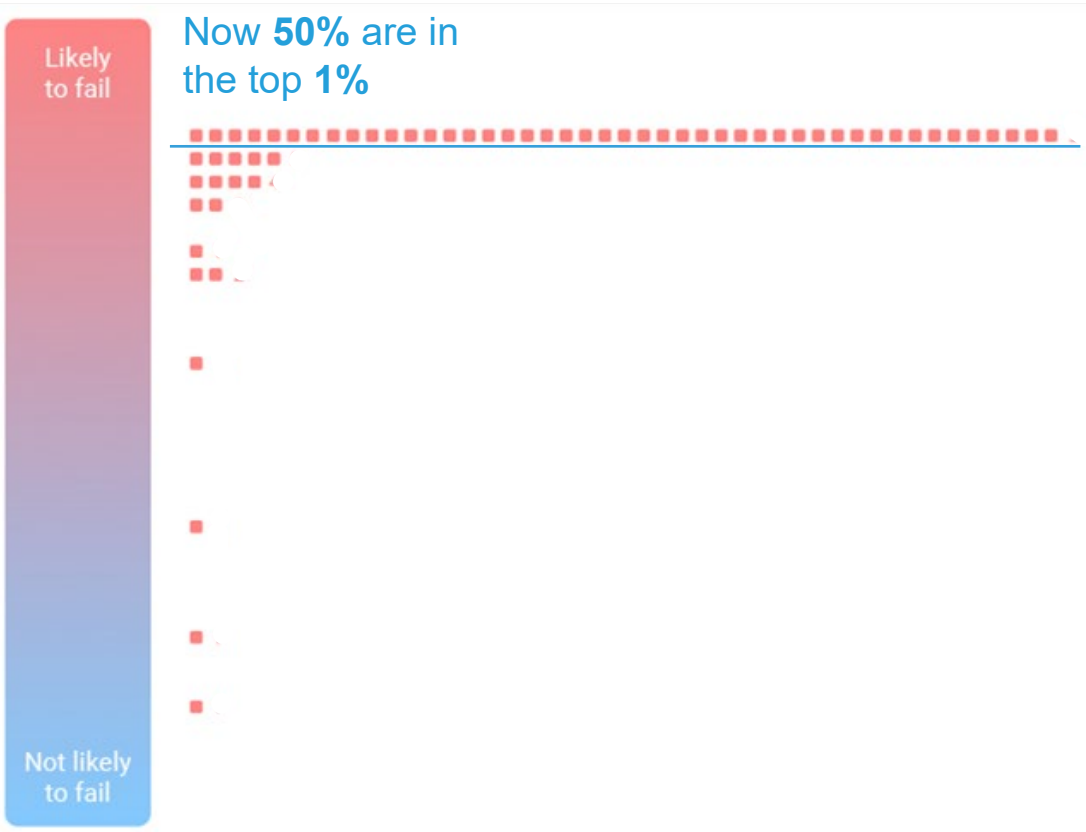
#250K

Age



Only **12%** are in the top **1%**

AI/ML



Now **50%** are in the top **1%**

VODA.ai

Case Study

Tucson, AZ

4,600 miles of water mains

230,000 segments

- In 2019, Tucson requested a ML pilot
- We asked for five years of data, but to withhold the most recent year (2018)
- We predicted the 2018 failures; Tucson validated the results
- Half failed for the 1st time!

TUCSON WATER
A proud part of the City of Tucson

CITY OF TUCSON FOUNDED 1775

AI/ML found 200% more failures than using traditional methods

50%

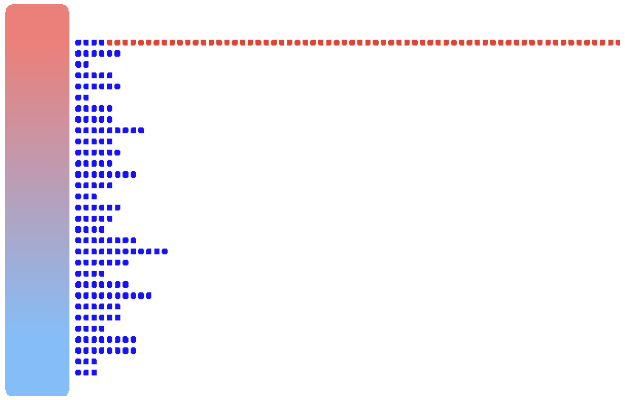
had no prior failures!

Machine Learning Results

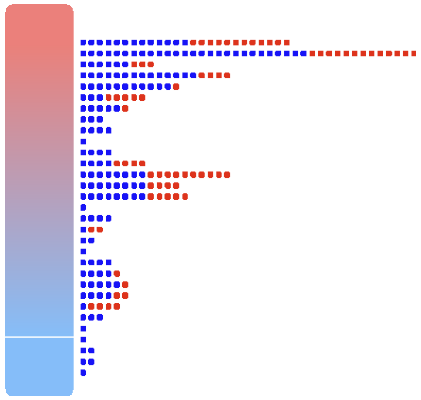
- ML found 55% of the pipe failures in the top 1% of risk rankings
  - 17 of the top 18 segments failed
  - Number 18 filed 2 months later
  - 18 of the ML top 18 failed within 14 months

Looking for the Bull's Eye

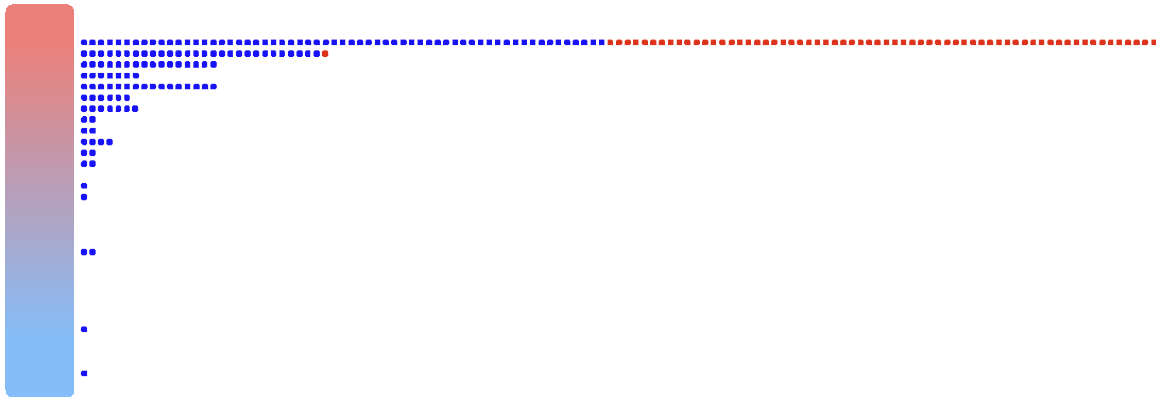
Prior Failures



Pipe Age



AI/ML



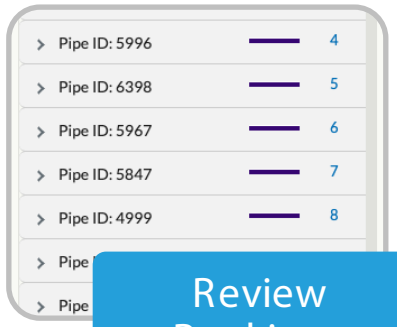
■ = Failed Pipes with No Break History

■ = Failed Pipes with Prior Breaks

AI/ML caught twice as many failures as the prior break model and 50% had never failed before

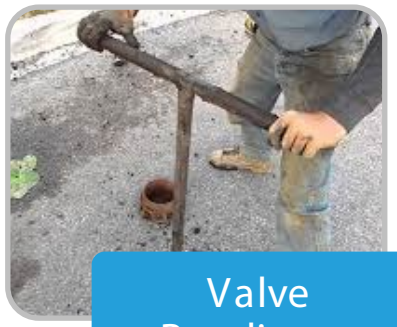
VODA.ai

ML Assists Operations



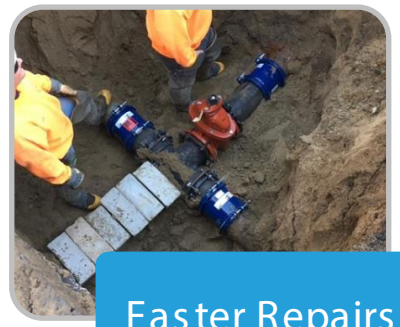
Review Rankings

Check for Leaks



Valve Readiness

Material Availability



Faster Repairs

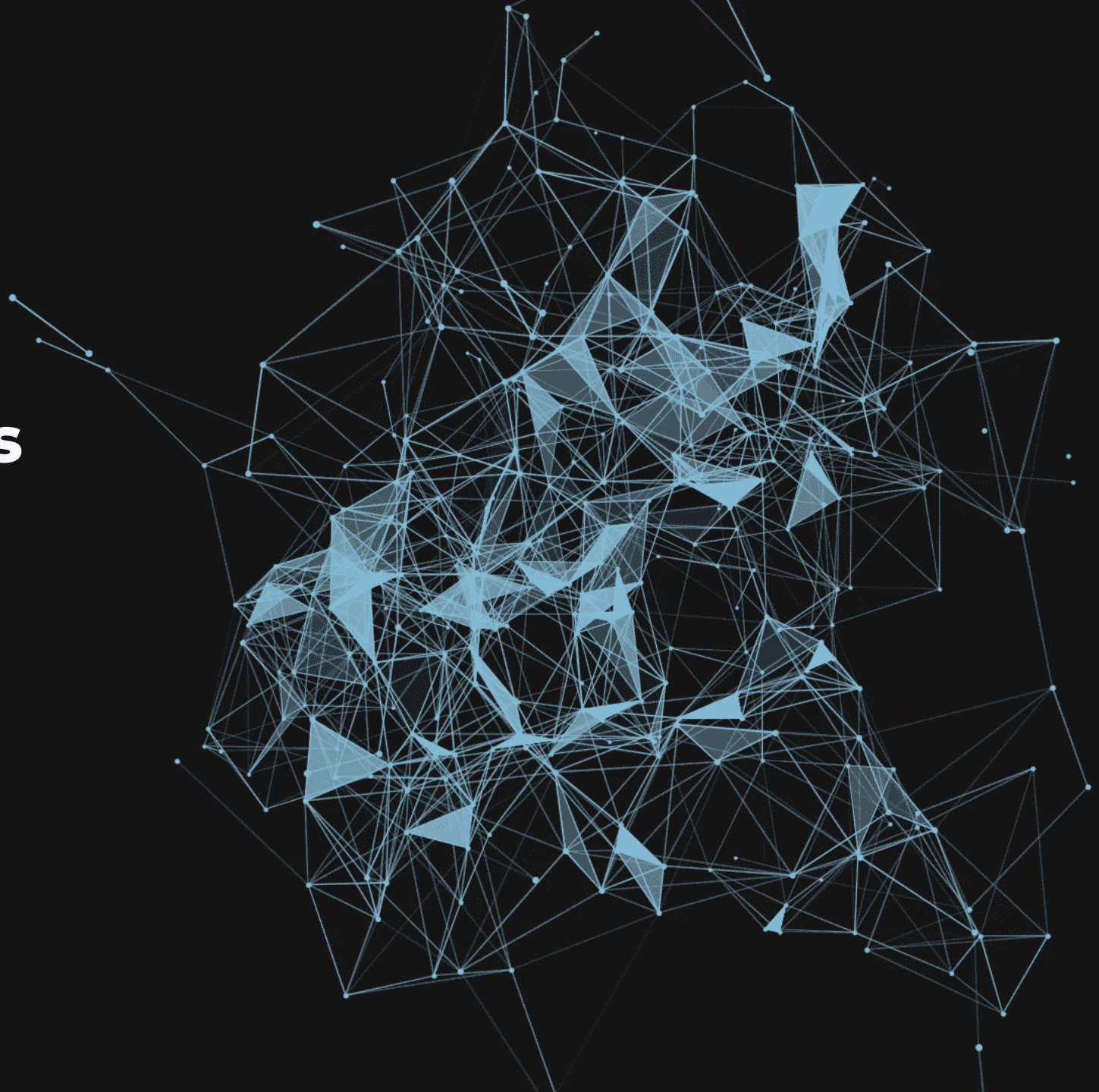
Planning

Replace more of these

And less of these

Machine Learning Finds Lead

A powerful engine created for utilities



Challenges

Missing service line data

Unknown pipes are a problem

Visiting every location is costly

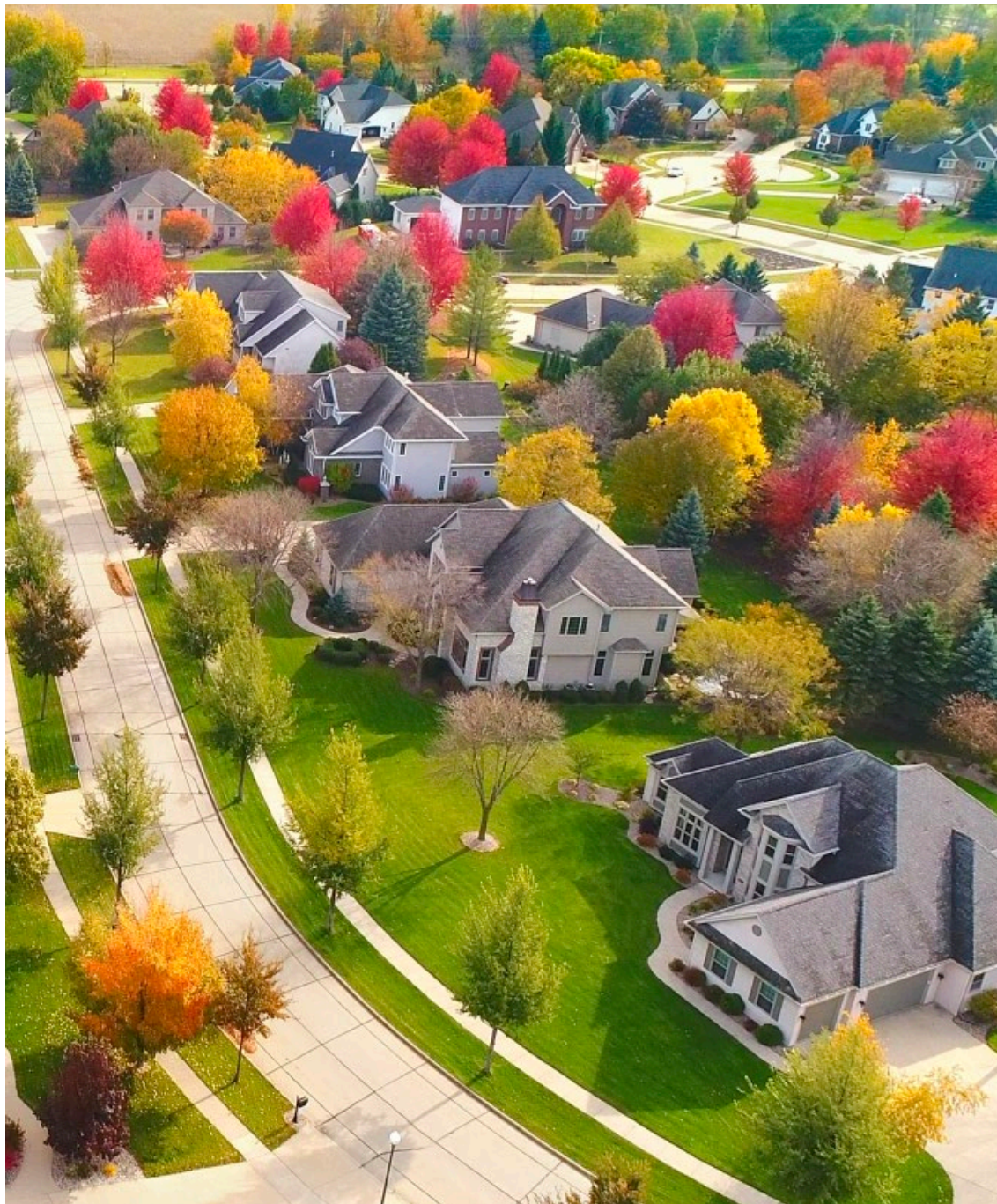
LCRR deadlines

VODA.ai

Case Study

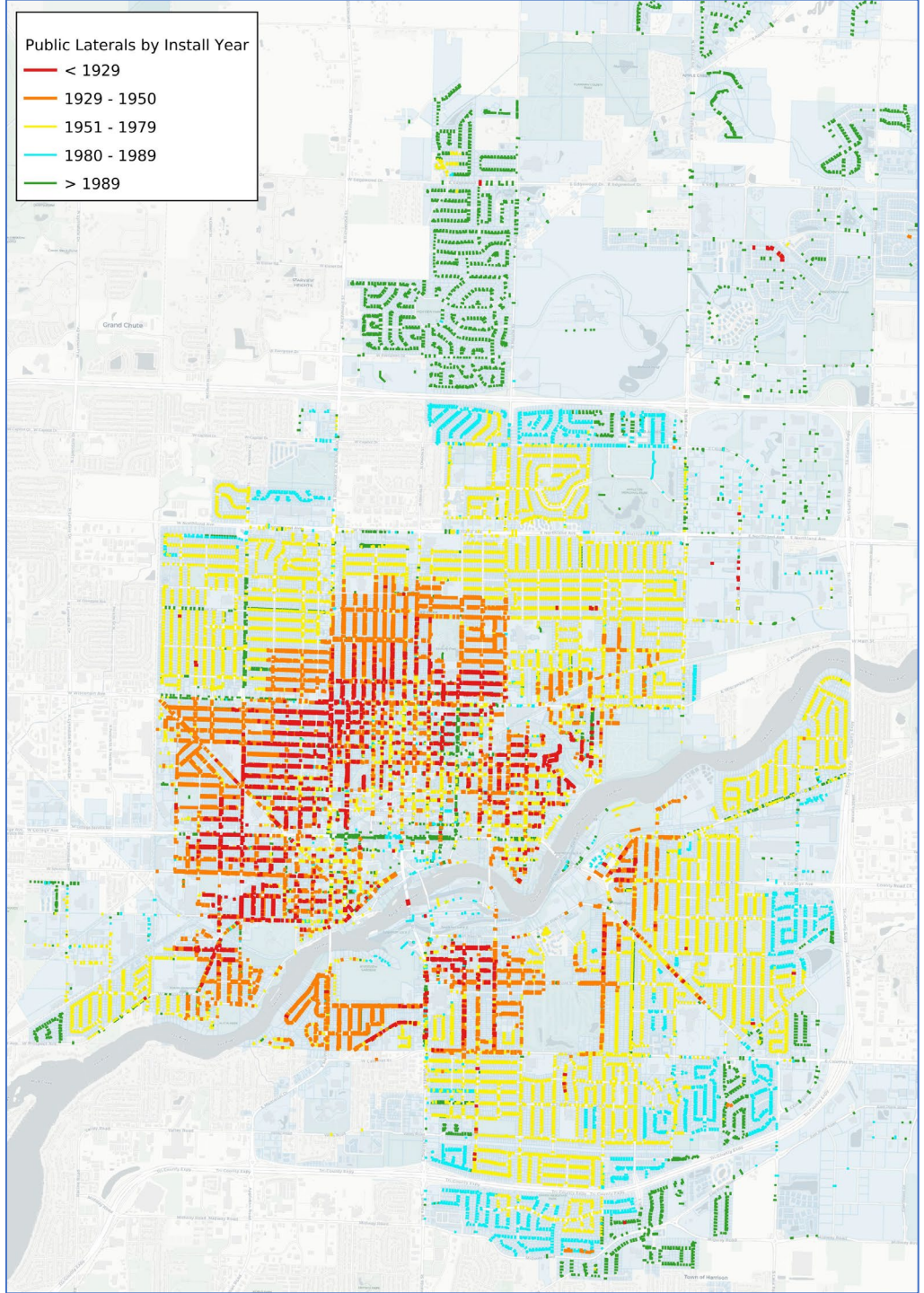
Appleton, Wisconsin

29,000	73	15,000
Service Lines	Confirmed Lead	Unknown Material



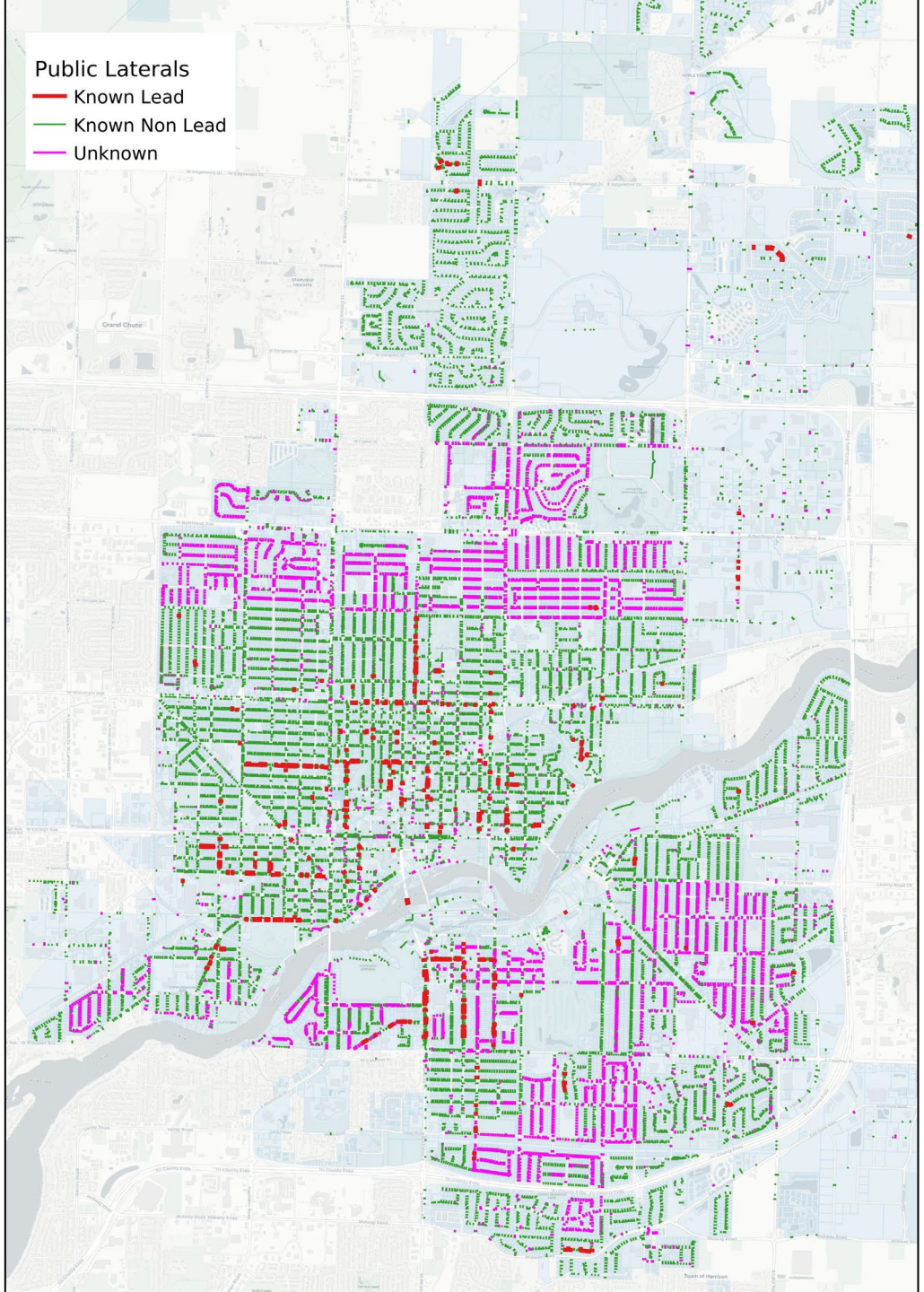
VODA.ai

Public service lines – likely lead pipes using installation year



VODA.ai

Public service lines – likely lead pipes using known & unknown material



VODA.ai

ML model using 5% of known lead found 80% of lead lines

5%

of private & public lines

80%

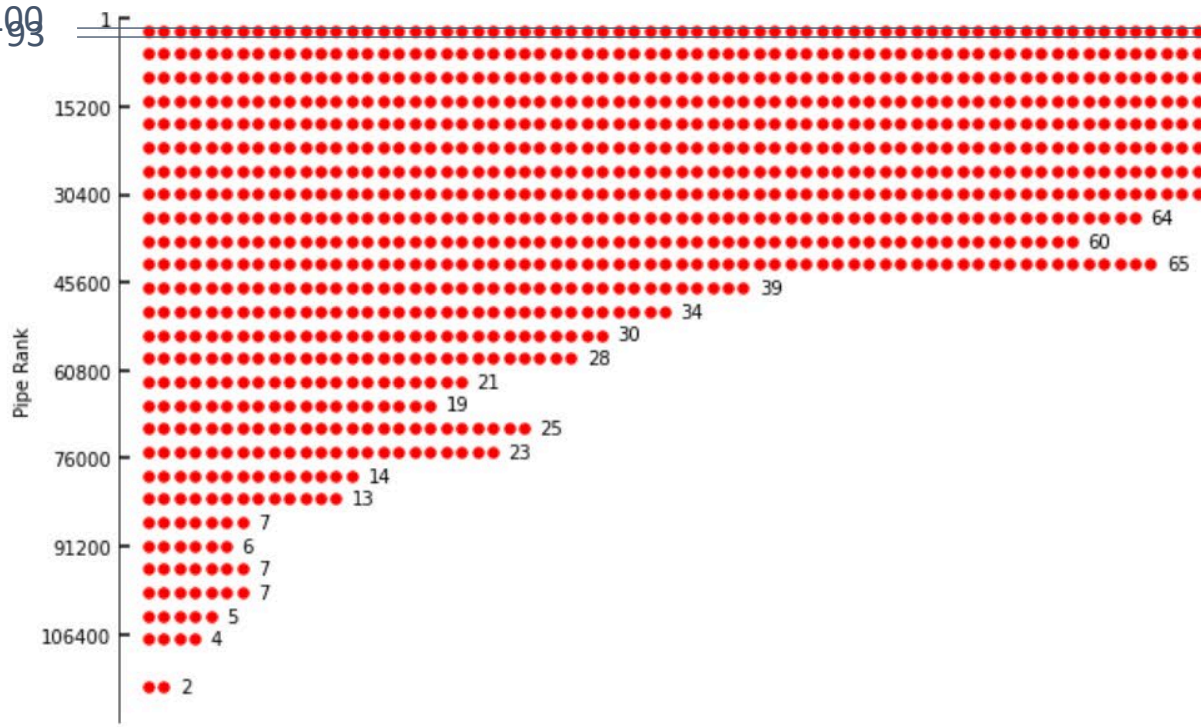
of lead found


VODA.ai
100%
more accurate than
installation year alone

Wastewater Santiago, Chile

Prioritizing Infrastructure

Wastewater Results – Chile, South America



Size of network: **6.485 km**

Number of pipe segments: **121.434**

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

VODA.ai accuracy score: **93**

In first 500 pipes…

484 Failures!

In last 5000 pipes…

0 Failures!

Wastewater Results - Chile

Events caught at top 1% of ranked segments

Comparison

	Age method	Prior breaks method	VODA.ai method
Full area (all regions)	12	245	**787**

3X

Improvement

Water Failure Predictions

Wastewater Condition Assessment

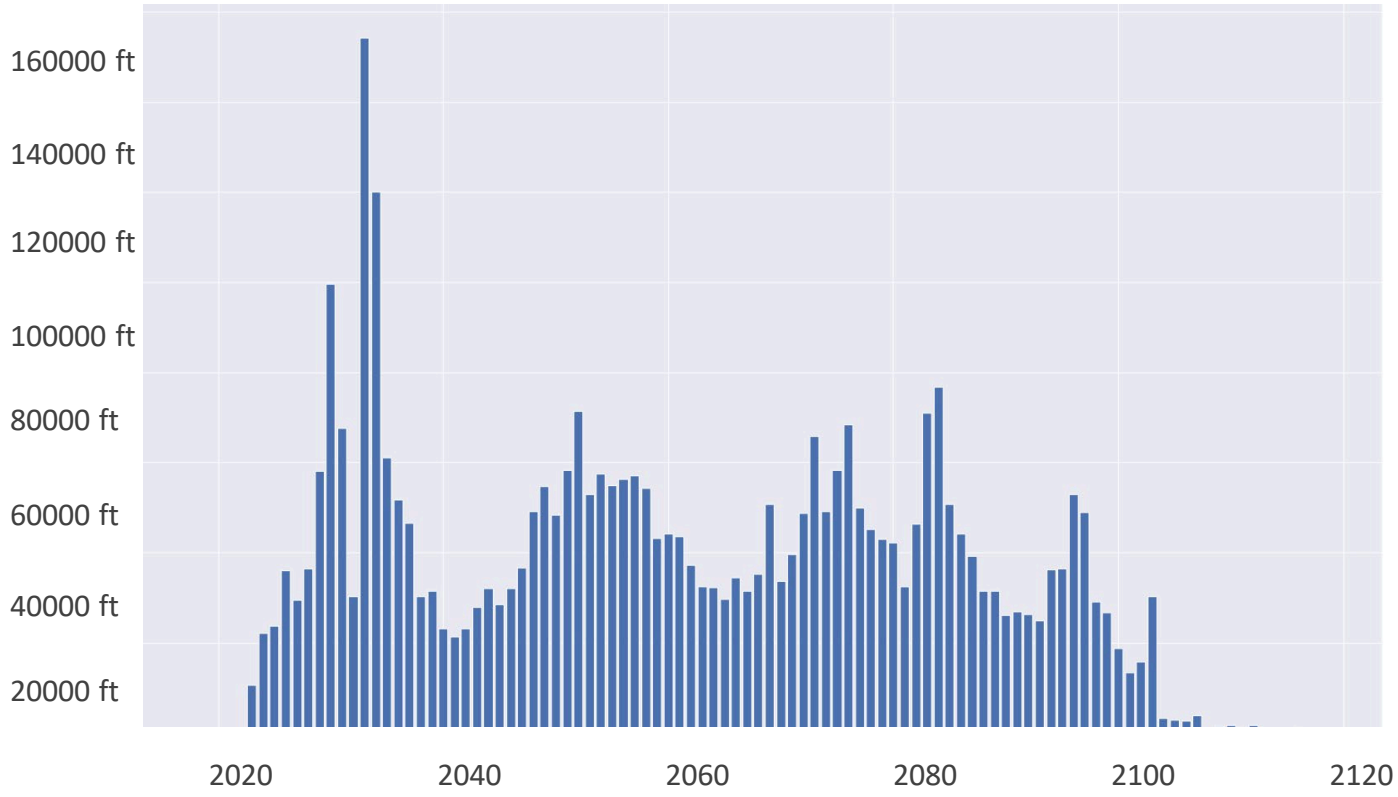
Wastewater Incident Predictions

Lead Pipe Finder

AI/ML Based Remaining Useful Life

RUL

- AI-RUL is calculated using AI/ML
- Understand investment needed to avoided large increases in future failures



VODA.ai

VODA.ai®

Prioritizing Infrastructure™

Are you ready for the next step in your digital transformation?

Contact: Jim
Jim@voda.ai

50 Milk Street | Floor 15 | Boston, MA 02109