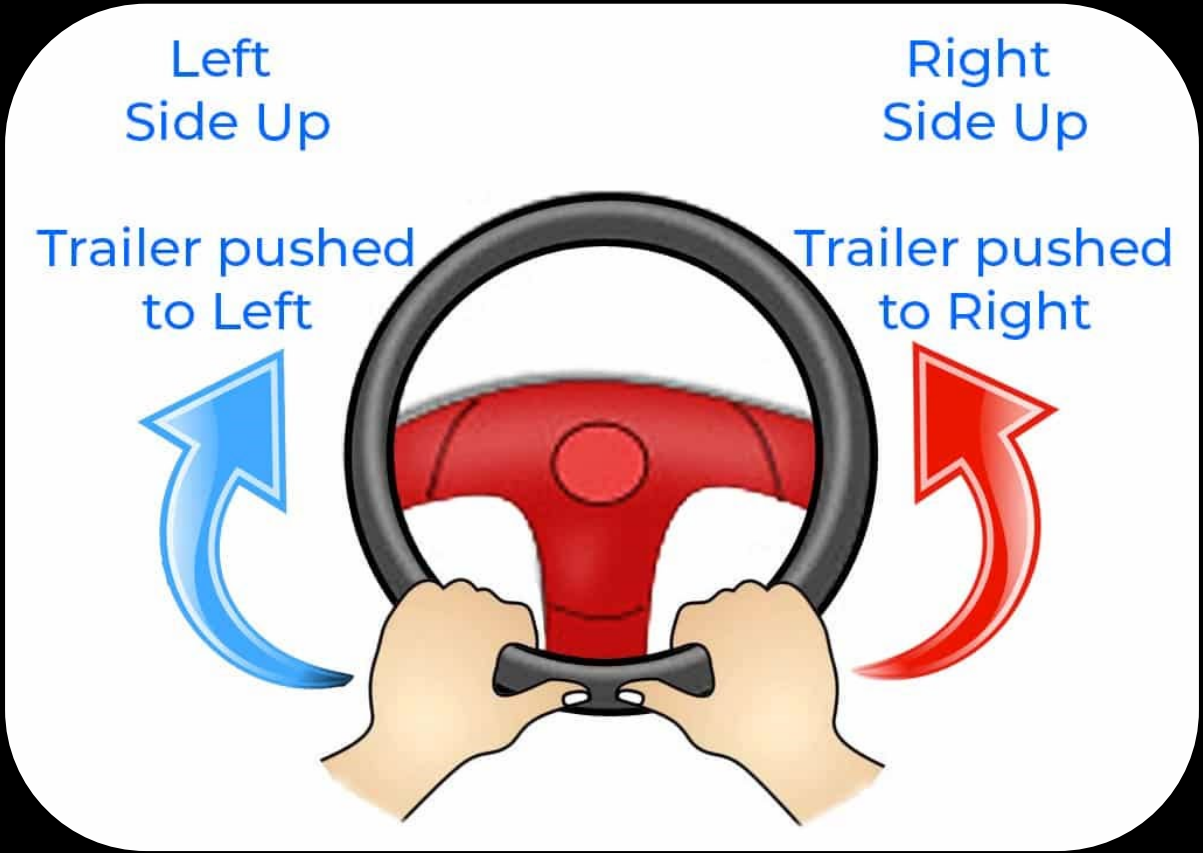
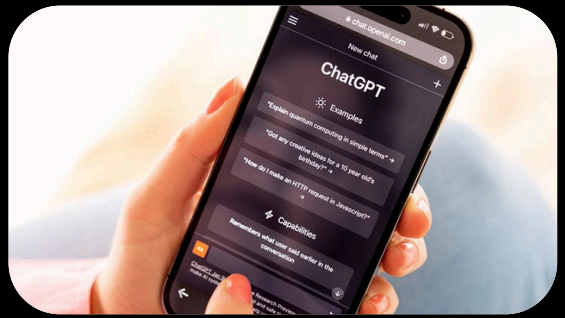
Teaching Old Pipes New Tricks


Parker


Left
Side Up
Right
Side Up
Trailer pushed
to Left
Trailer pushed
to Right



Do this homework problem for me, but make my professor believe that a student did it.

Artificial

Intelligence

Artificial

Intelligence

20th CENTURY TIMELINE

100 YEARS

Witness the most significant events of the last century.

1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000

Source: 20th Century Timeline

20th CENTURY TIMELINE

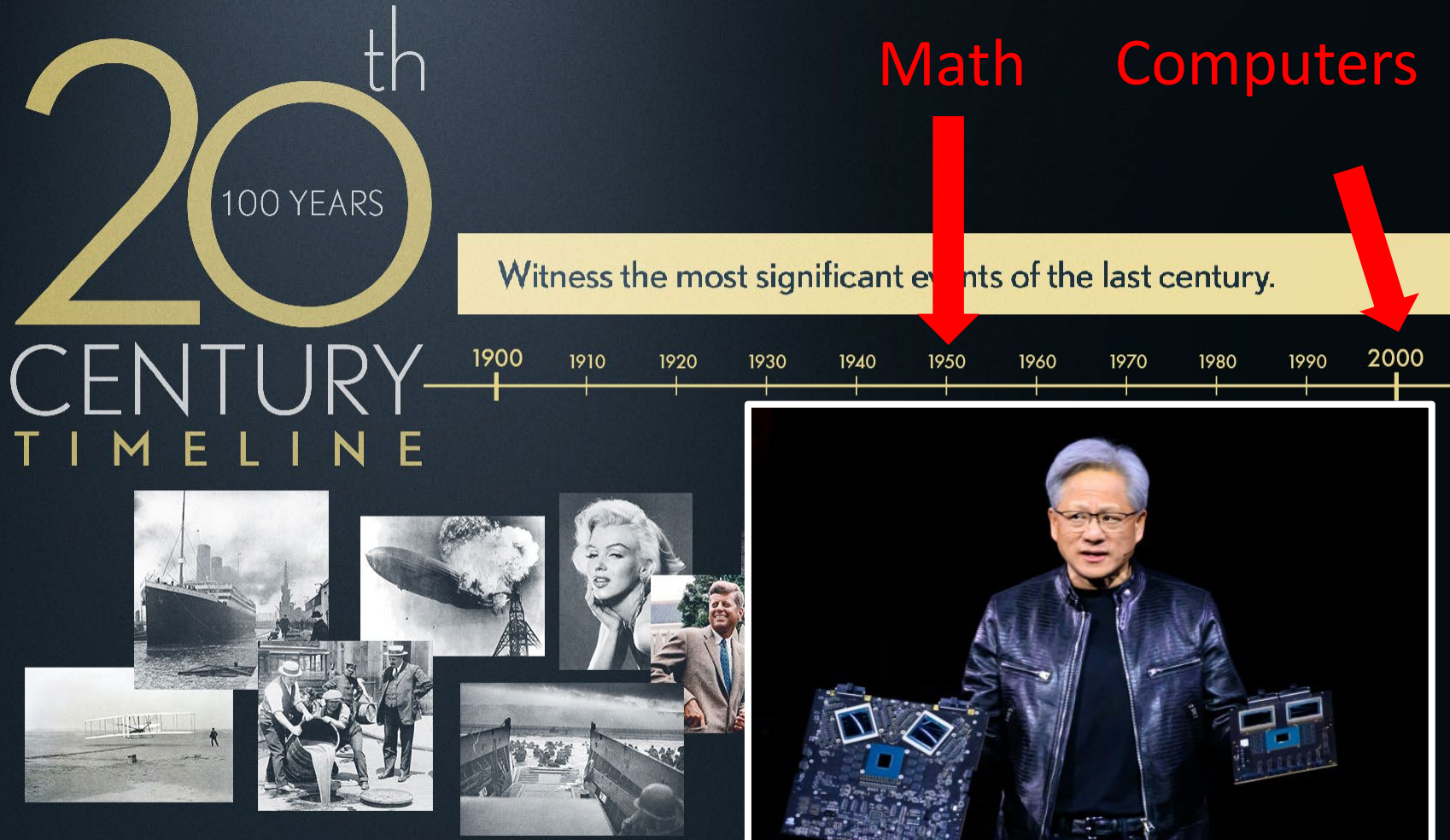
100 YEARS

Math

Witness the most significant events of the last century.

1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000

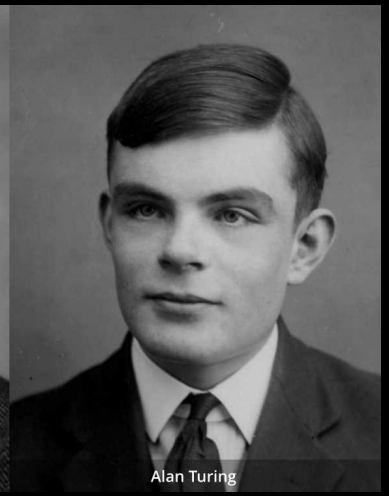
Math Computers



1956

John Mccarthy

Marvin Minsky



Alan Turing

A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug. 16

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if

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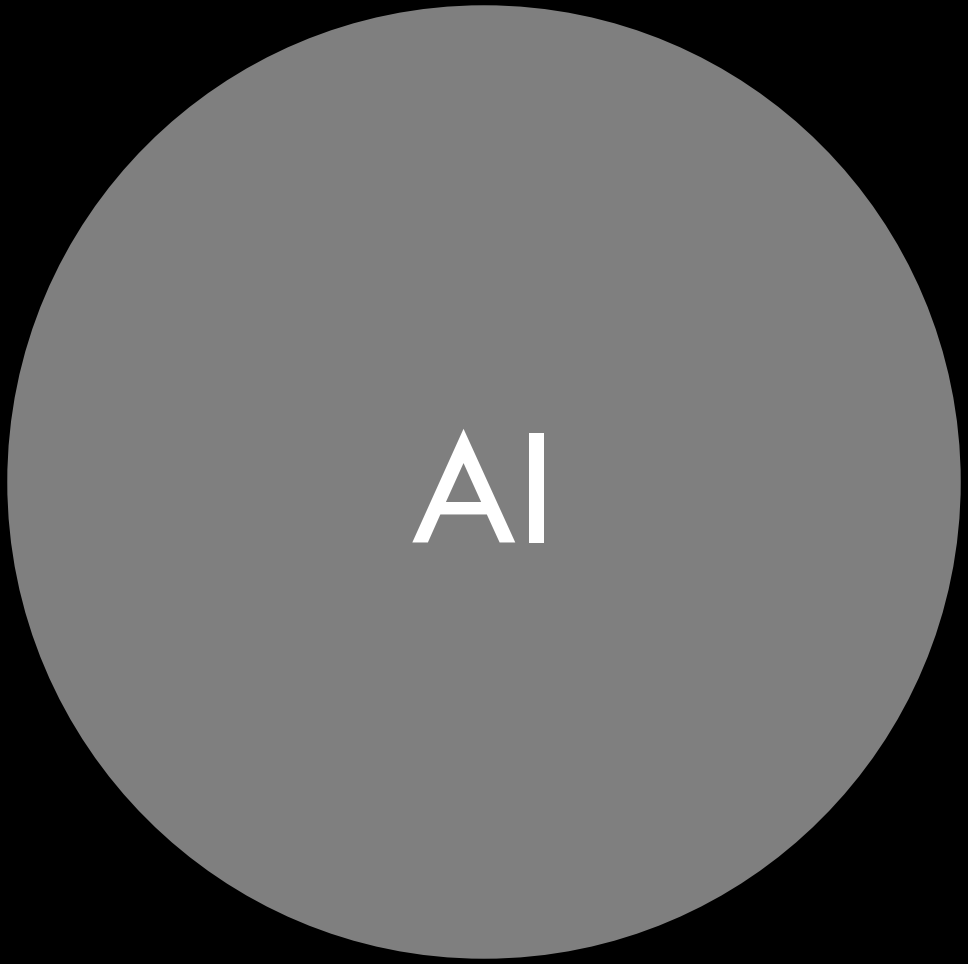
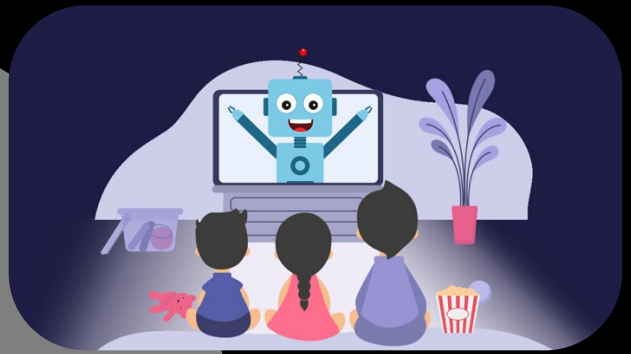
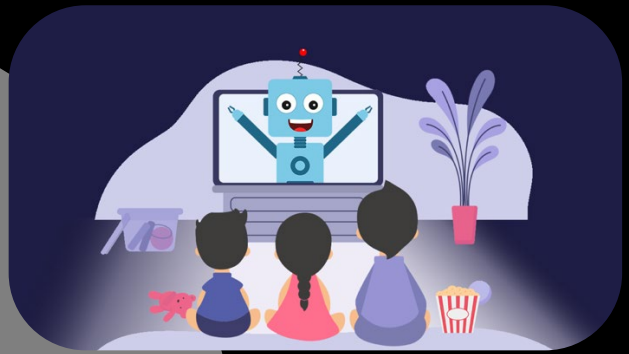

AI

AI

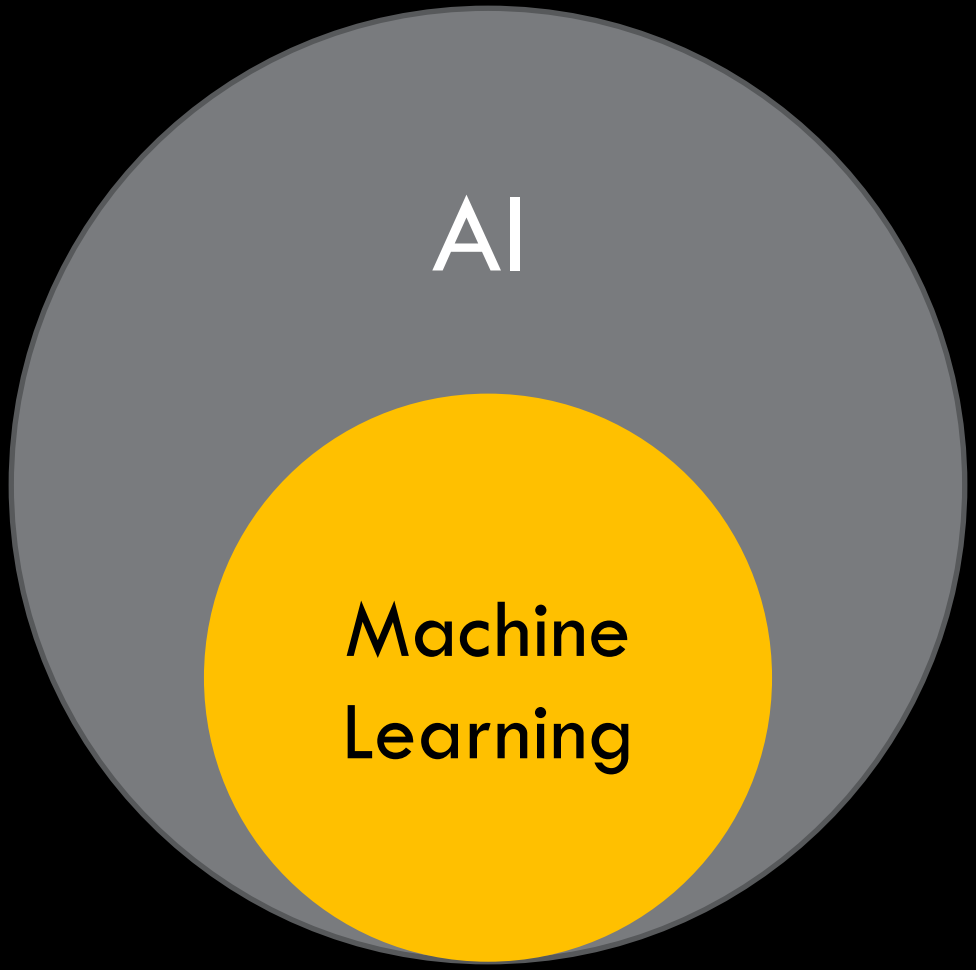
AI



AI



AI

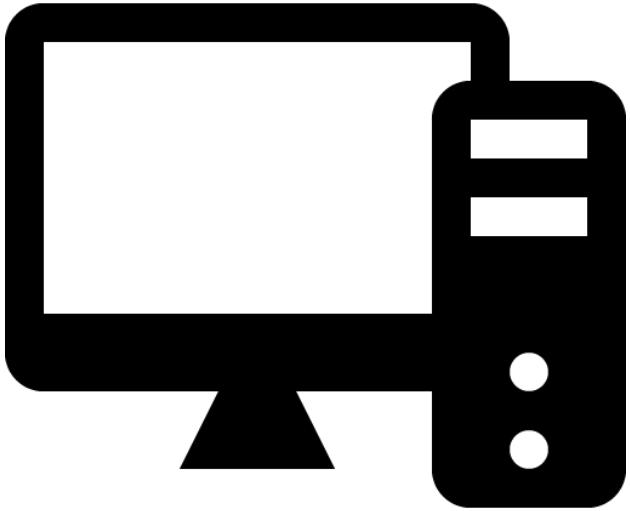

AI
Machine
Learning

Machine

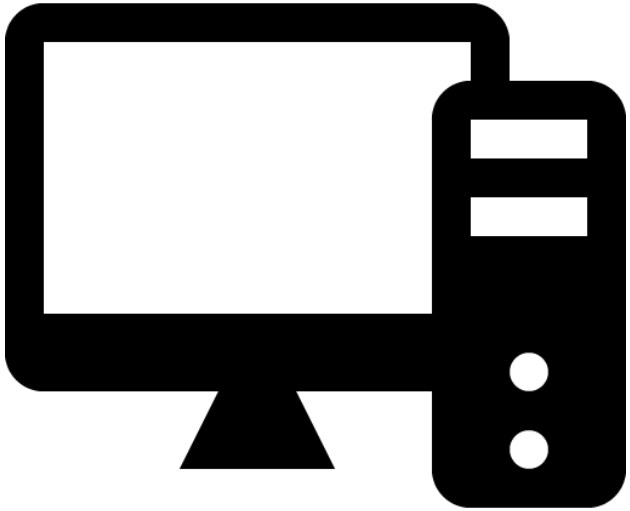
Machine

Machine

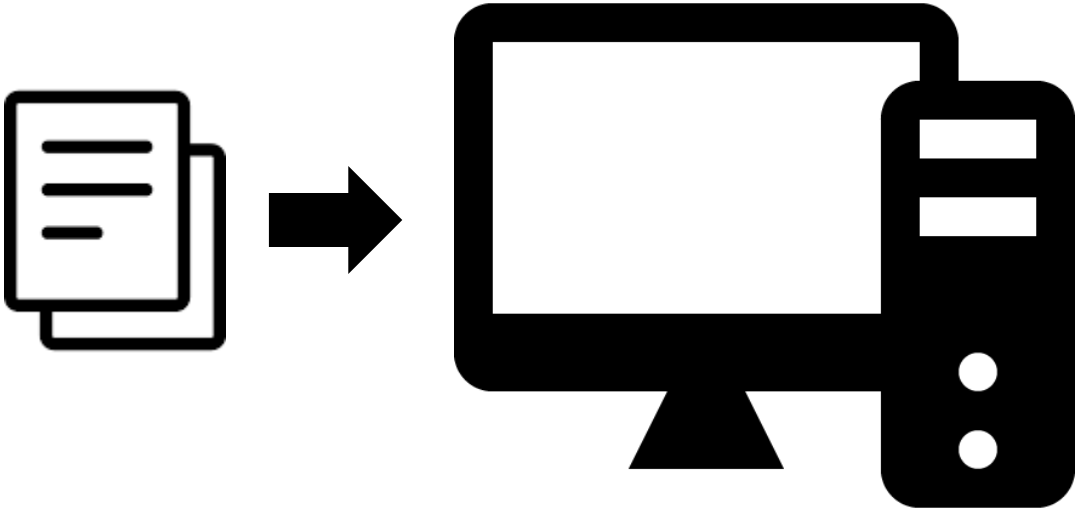
Machine



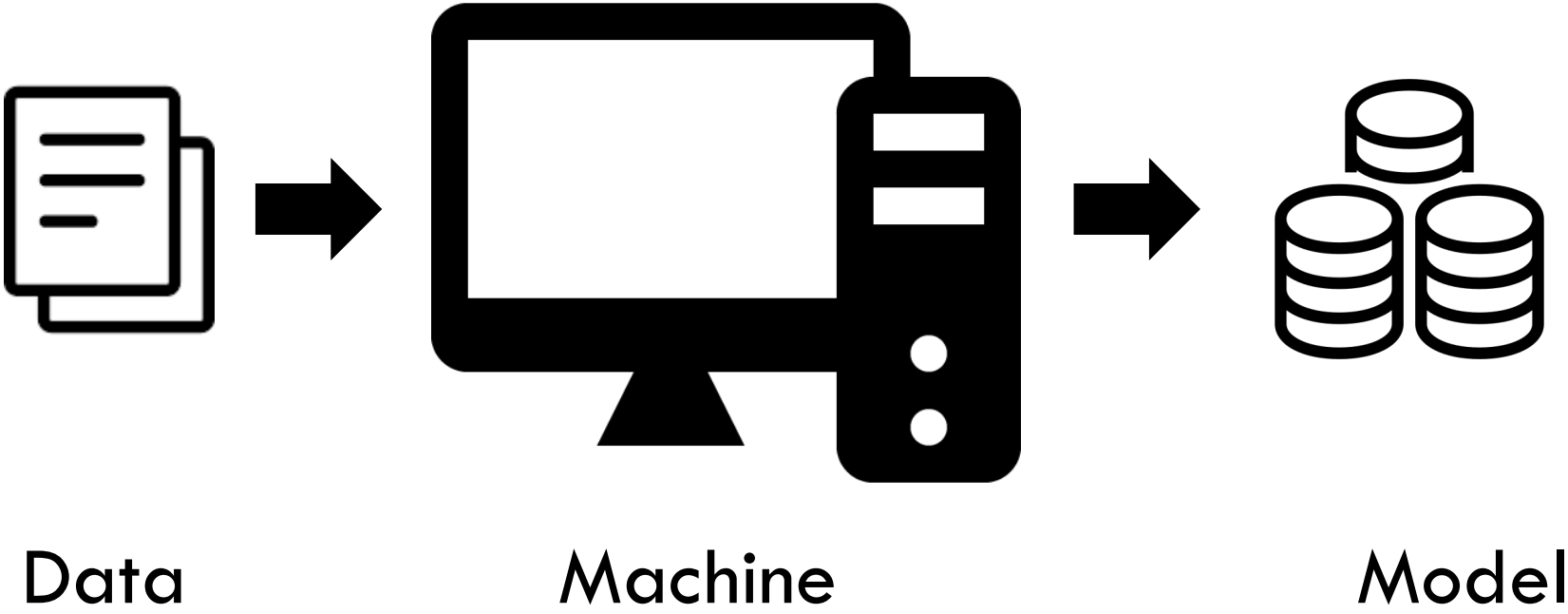
Machine

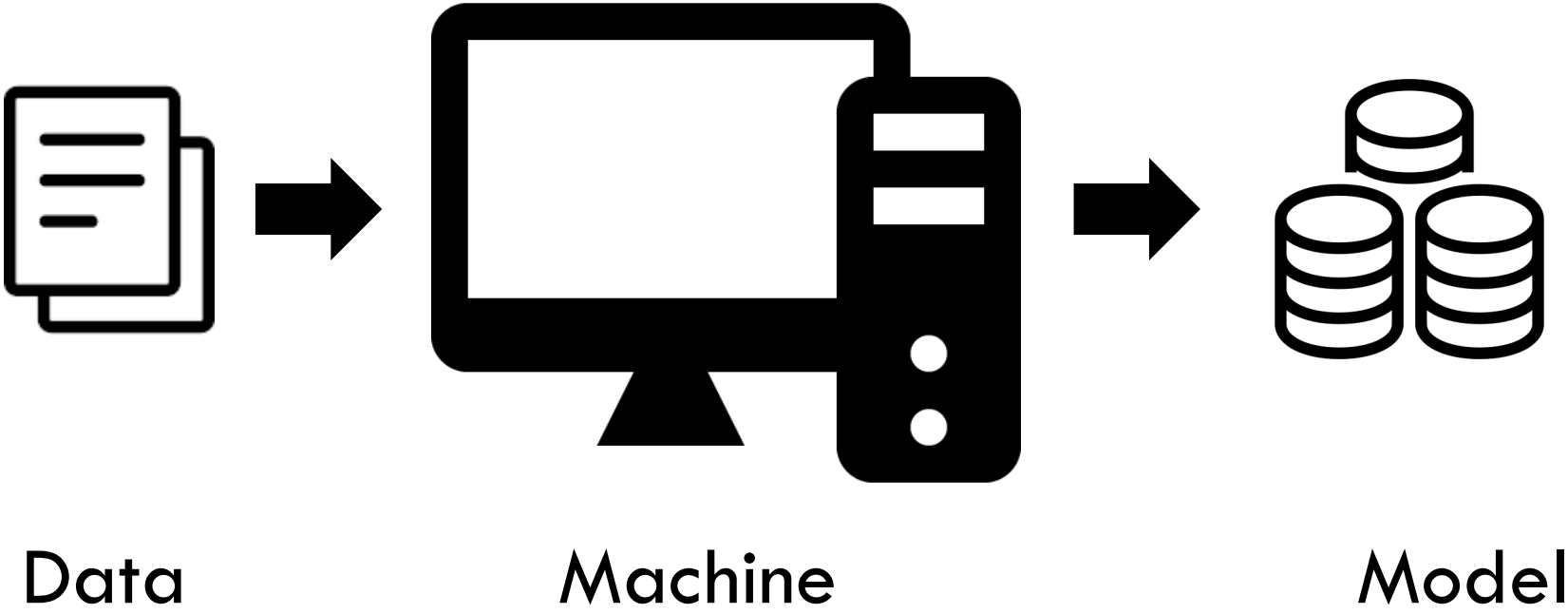


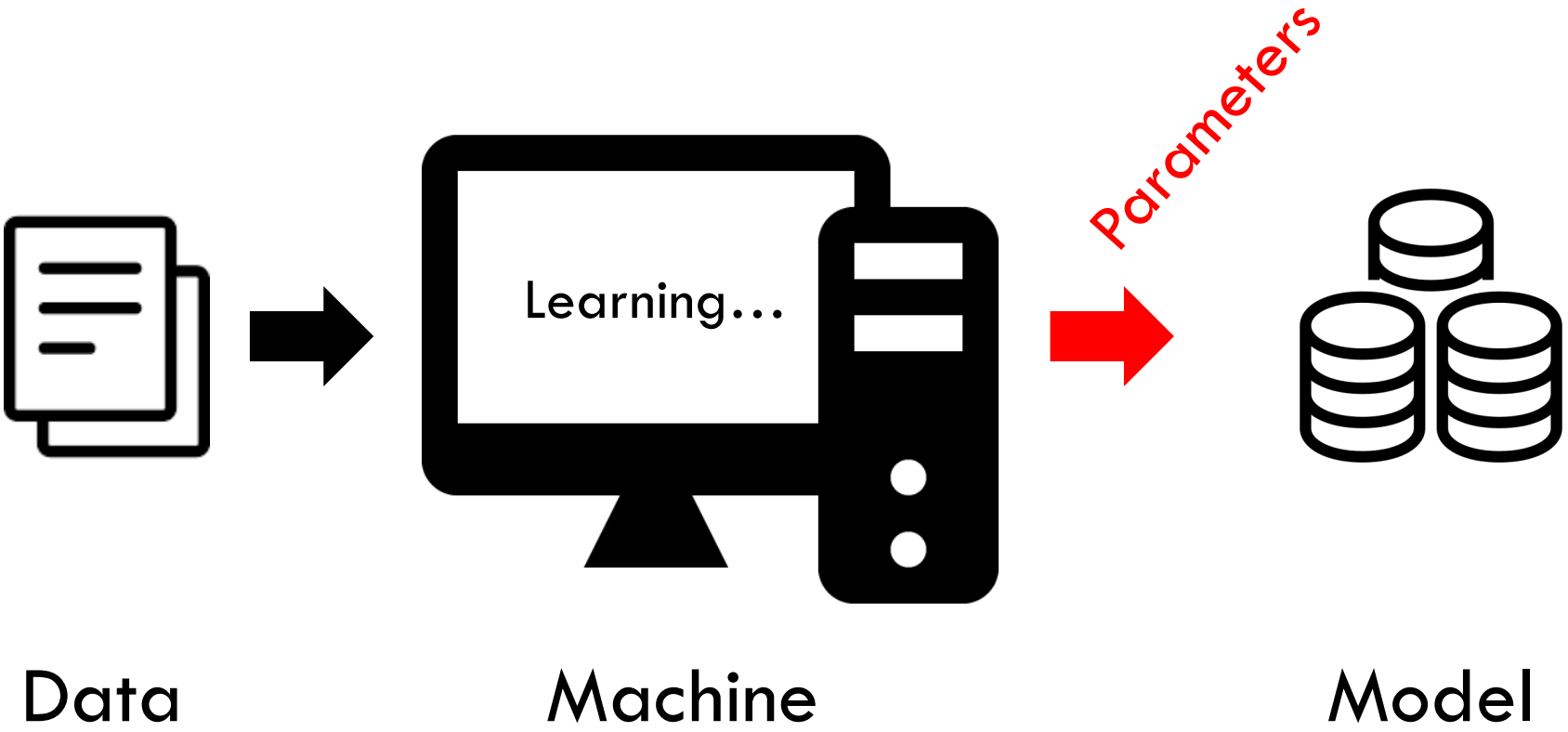
Machine



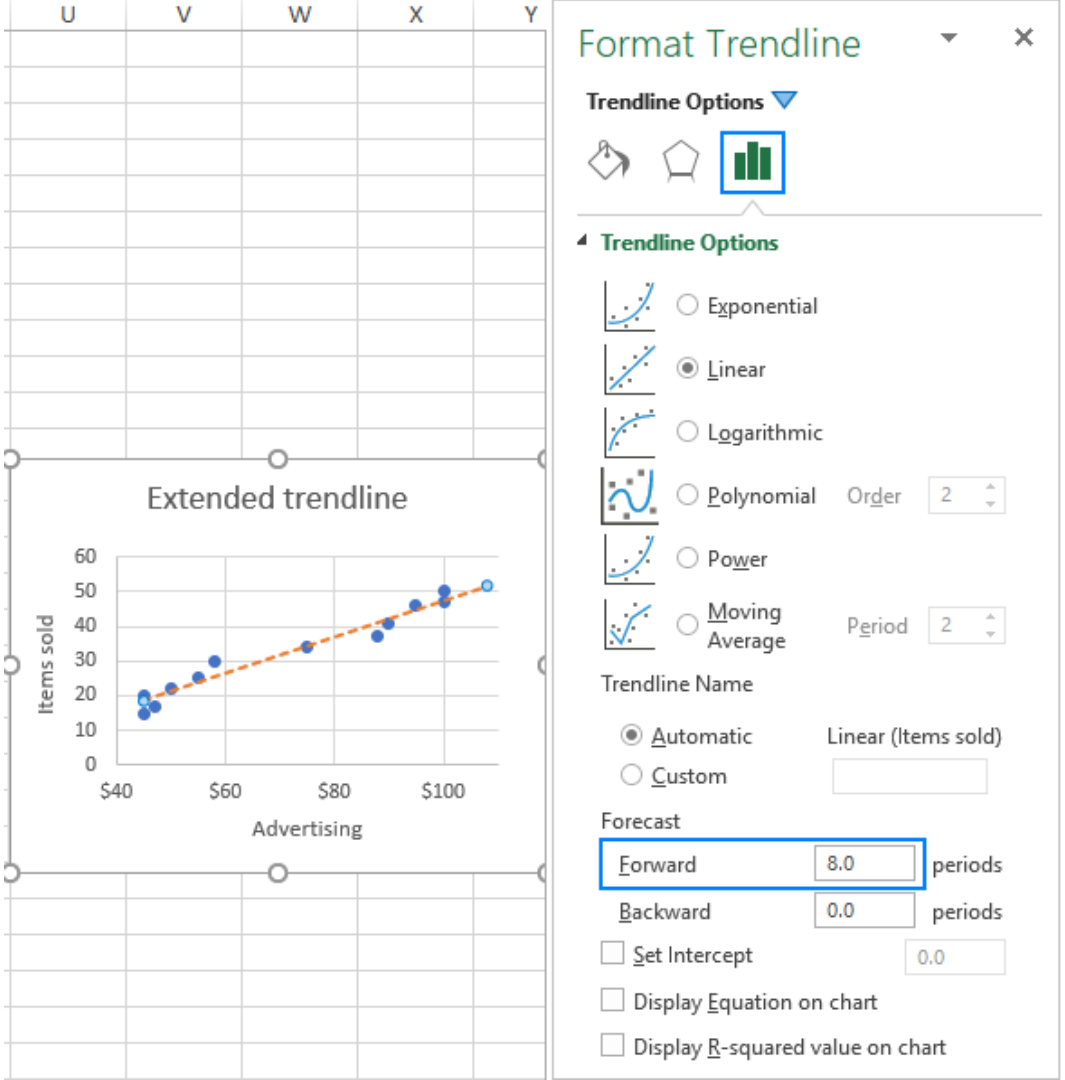
Data Machine

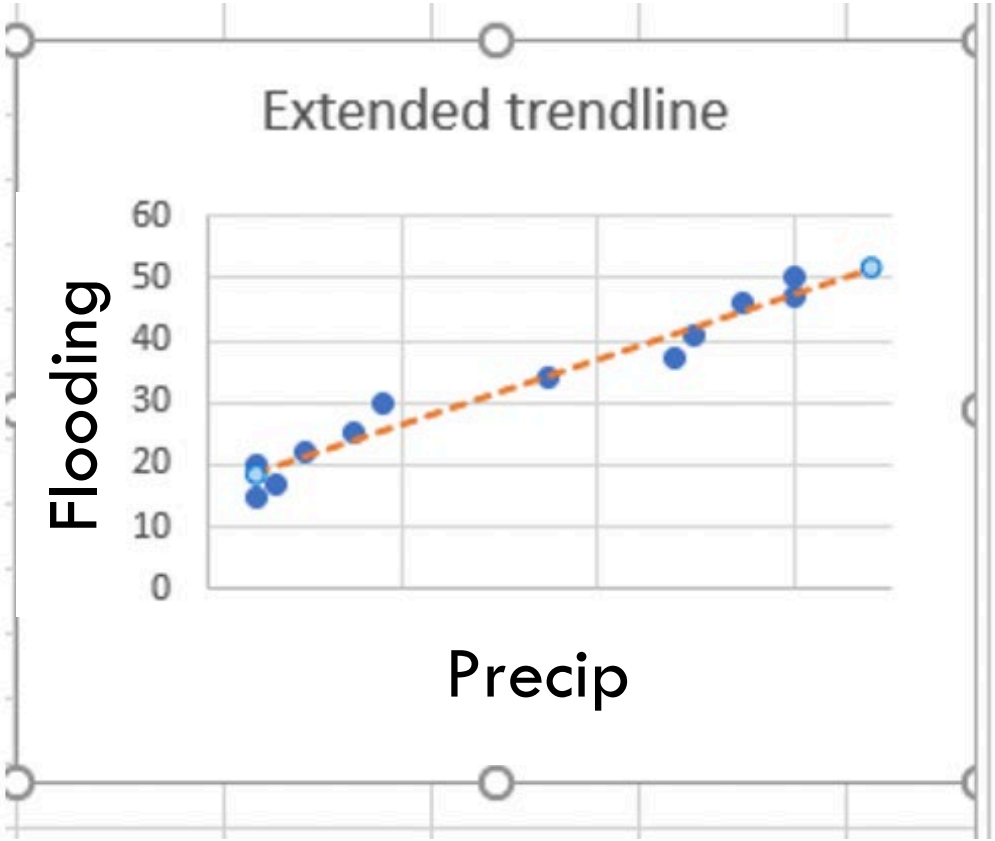

Data
Machine
Model

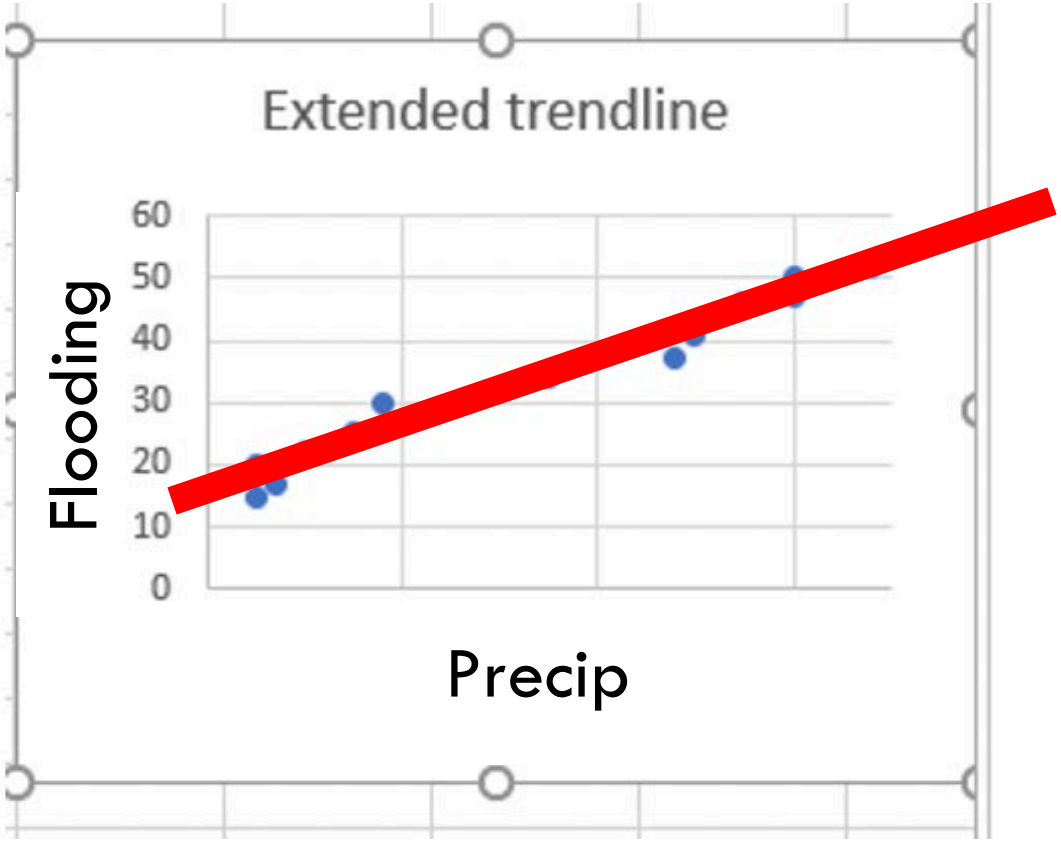

Data
Machine
Model

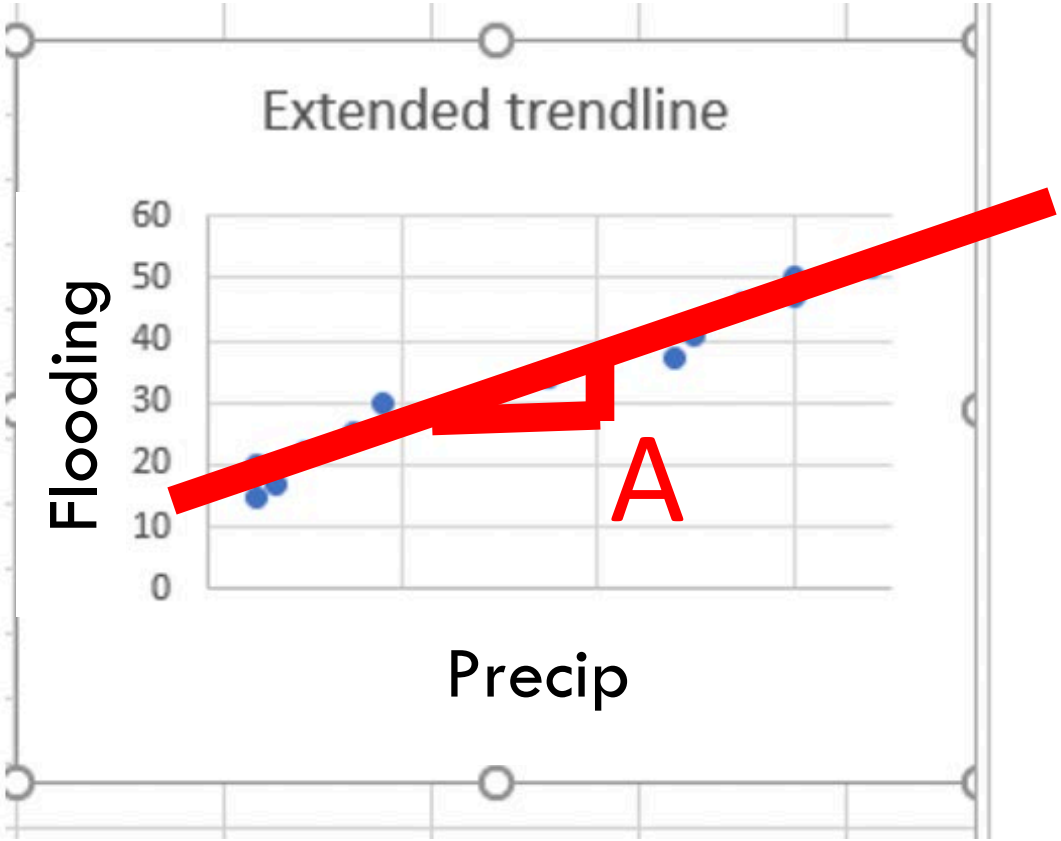

Learning…
Parameters
Data
Machine
Model

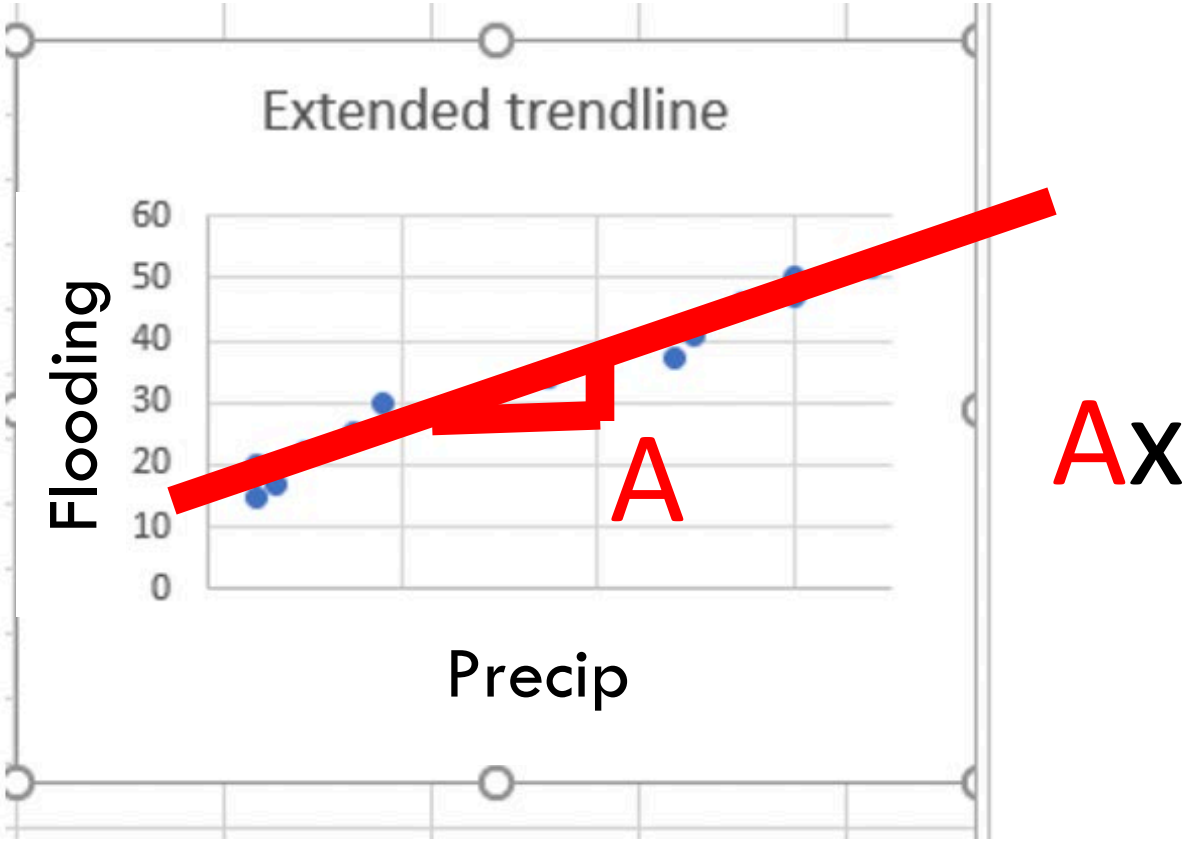
$$
\begin{aligned}
& p(y, \beta | X) \\
&= (2\pi)^{-(N+K)/2} |\det(\Sigma)|^{-1/2} \exp\left(-\frac{1}{2}\alpha^{\top}\Sigma^{-1}\alpha\right) \\
&= (2\pi)^{-(N+K)/2} |\det(A)|^{-1/2} |\det(\Sigma)|^{-1/2} |\det(A^{\top})|^{-1/2} \exp\left(-\frac{1}{2}\alpha^{\top}A^{\top}(A^{\top})^{-1}\Sigma^{-1}A^{-1}A\alpha\right) \\
&= (2\pi)^{-(N+K)/2} |\det(A\Sigma A^{\top})|^{-1/2} \exp\left(-\frac{1}{2}(A\alpha)^{\top}(A\Sigma A^{\top})^{-1}A\alpha\right) \\
&= (2\pi)^{-(N+K)/2} |\det(A\Sigma A^{\top})|^{-1/2} \exp\left(-\frac{1}{2}(A\alpha)^{\top}(A\Sigma A^{\top})^{-1}A\alpha\right)
\end{aligned}
$$

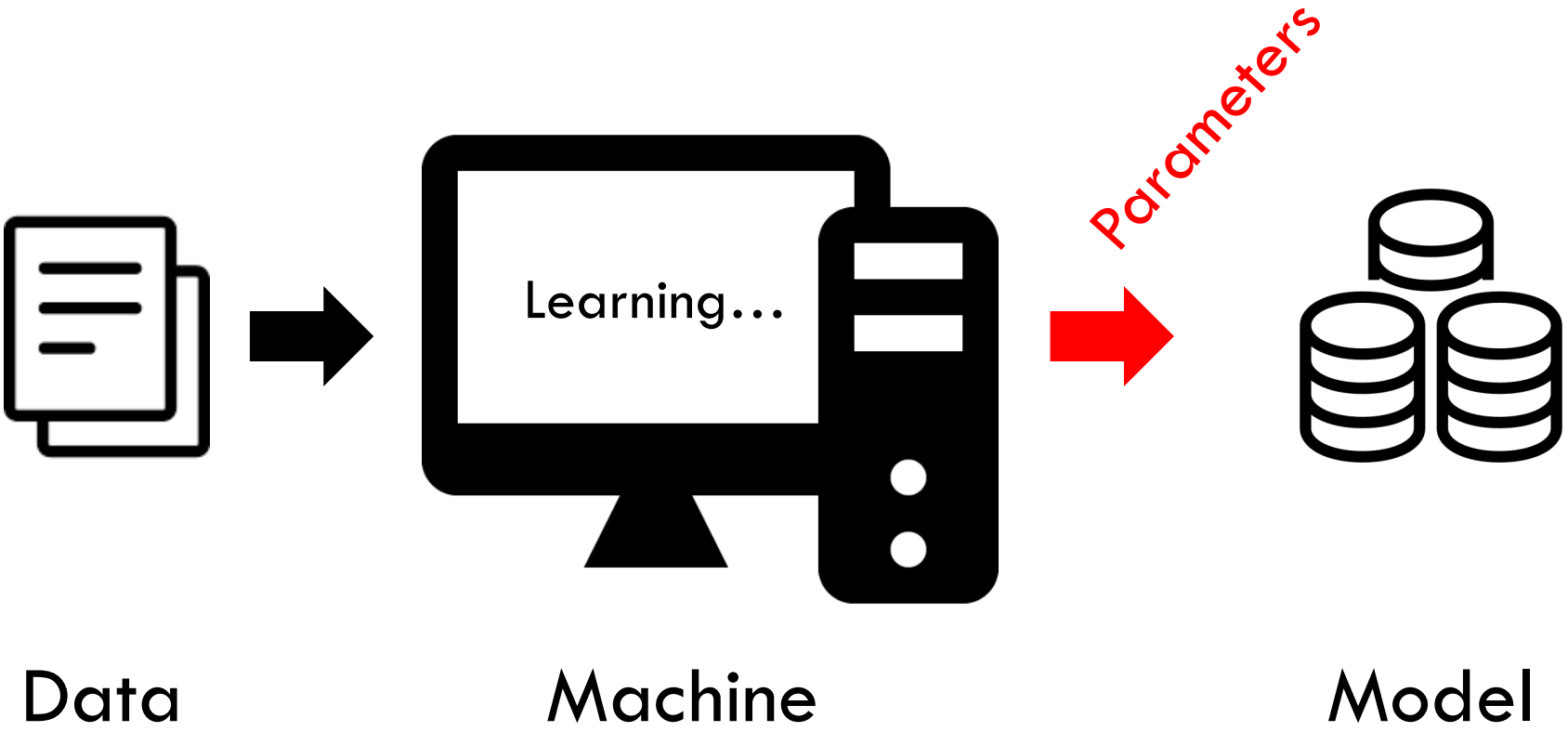

U
V
W
X
Y
Extended trendline
60
50
40
30
20
10
0
Items sold
$40
$60
$80
$100
Advertising
Format Trendline
Trendline Options
Trendline Options
Exponential
Linear
Logarithmic
Polynomial
Order
2
Power
Moving Average
Period
2
Trendline Name
Automatic
Linear (Items sold)
Custom
Forecast
Forward
8.0
periods
Backward
0.0
periods
Set Intercept
0.0
Display Equation on chart
Display R-squared value on chart

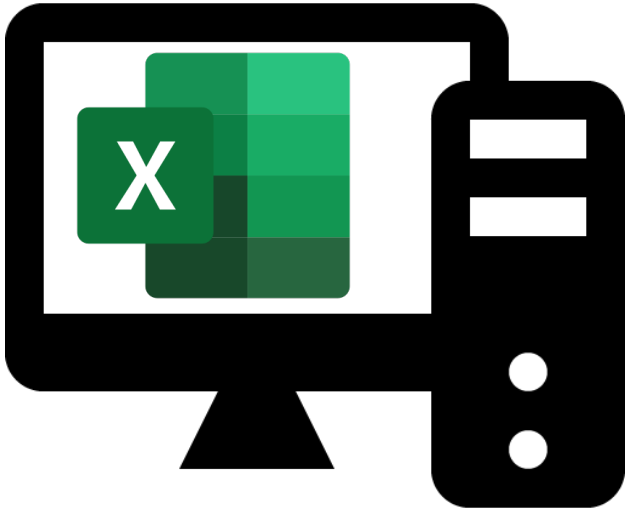

Extended trendline
60
50
40
30
20
10
0
Flooding
Precip


Extended trendline
60
50
40
30
20
10
0
Flooding
Precip

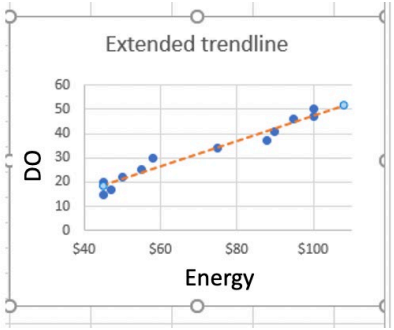

Extended trendline
60
50
40
30
20
10
0
Flooding
Precip
A


Extended trendline
60
50
40
30
20
10
0
Flooding
Precip
A
Ax


Learning…
Parameters
Data
Machine
Model



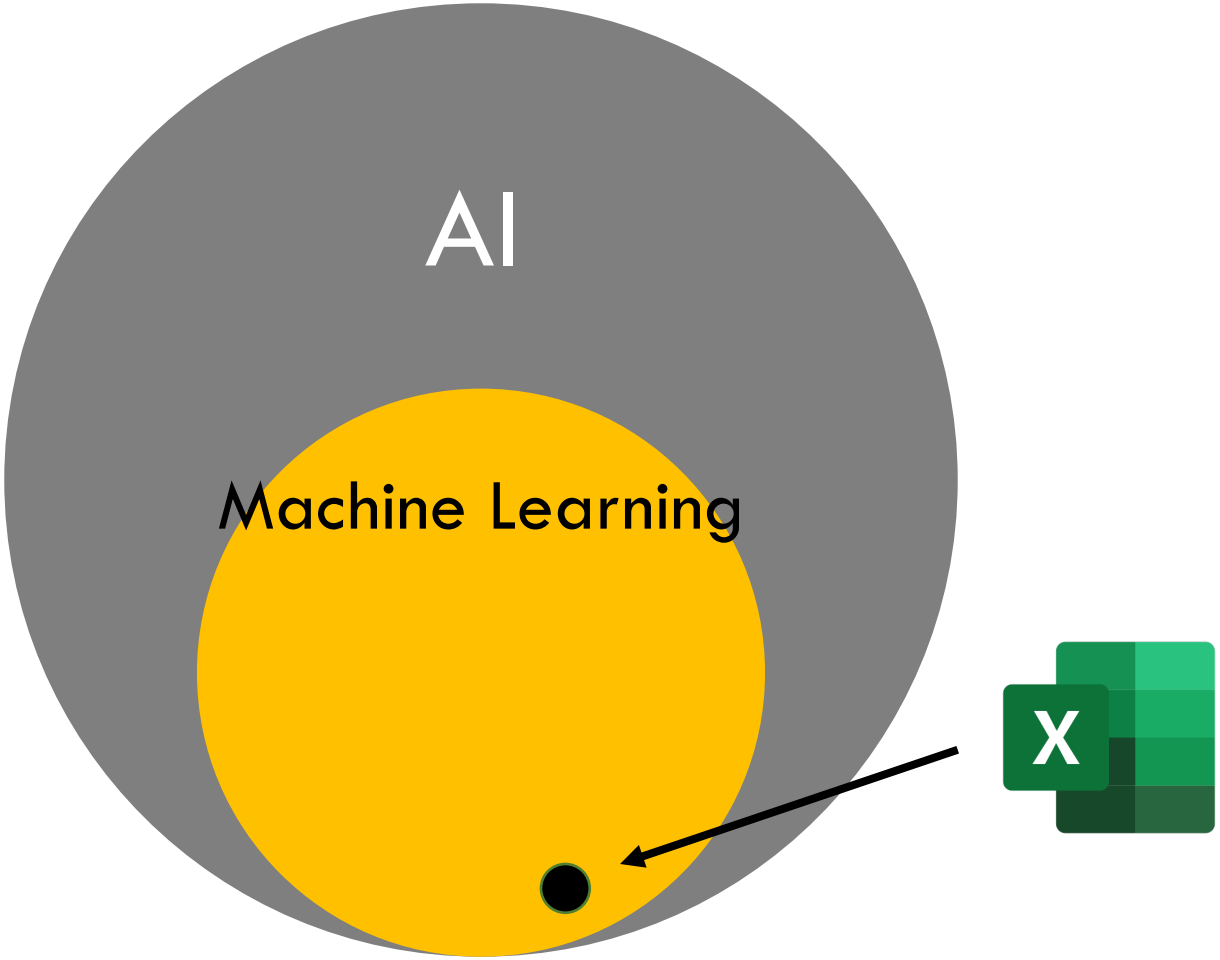
Ax



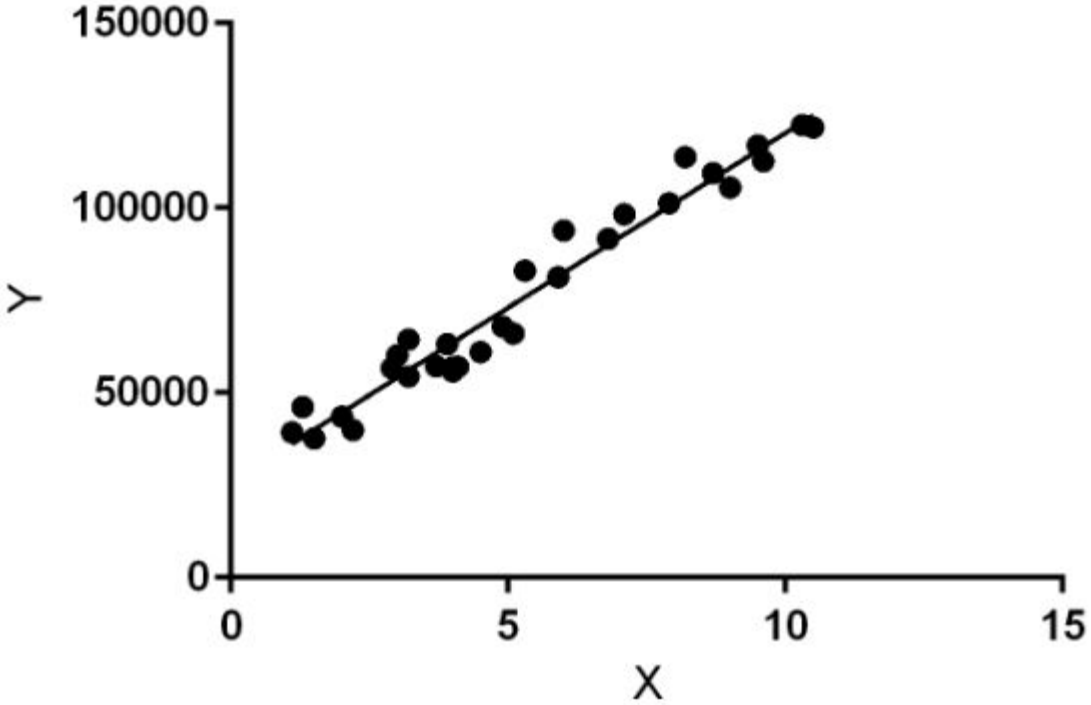
Data

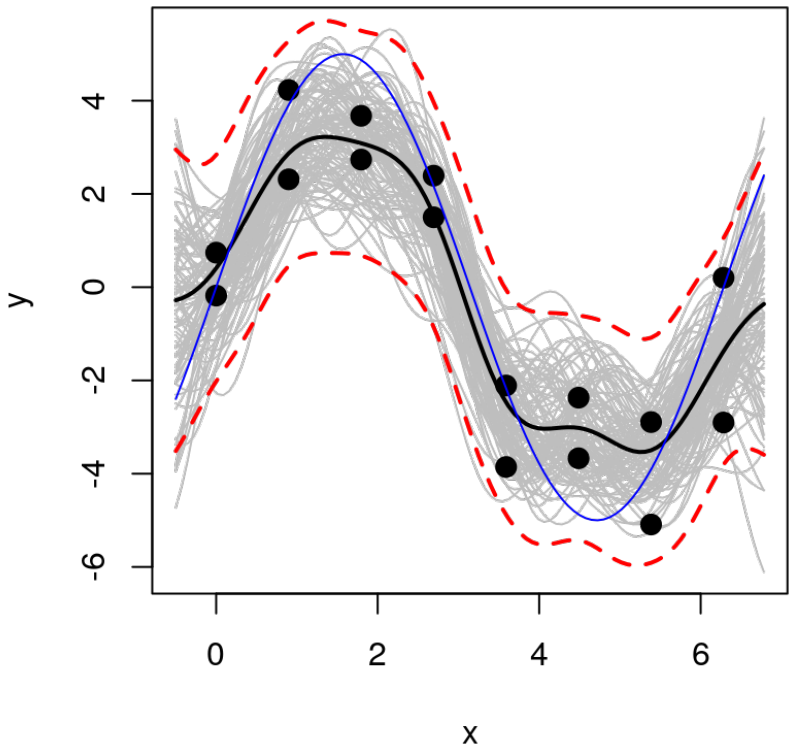
Machine

Model

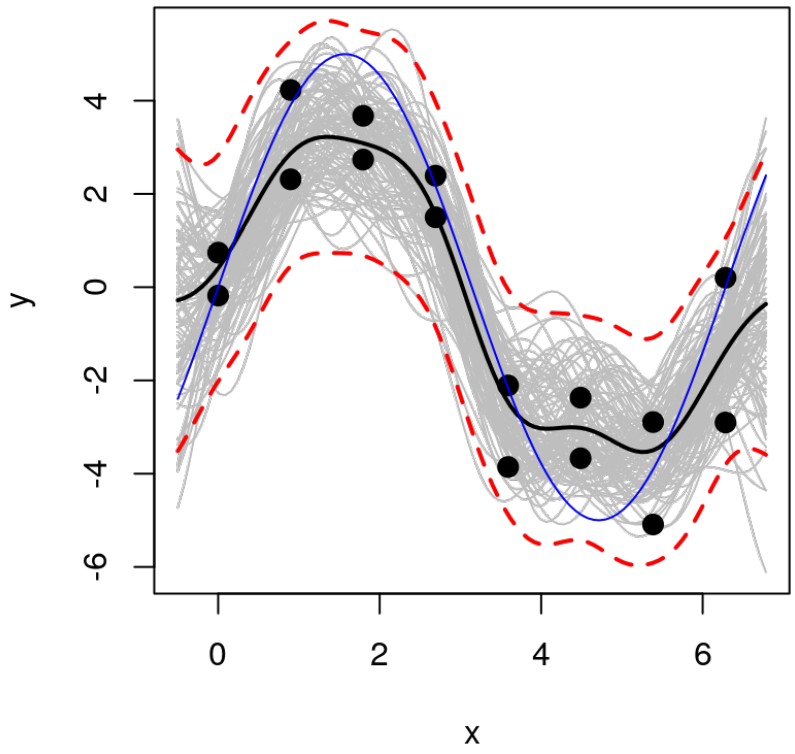

AI
Machine Learning
X

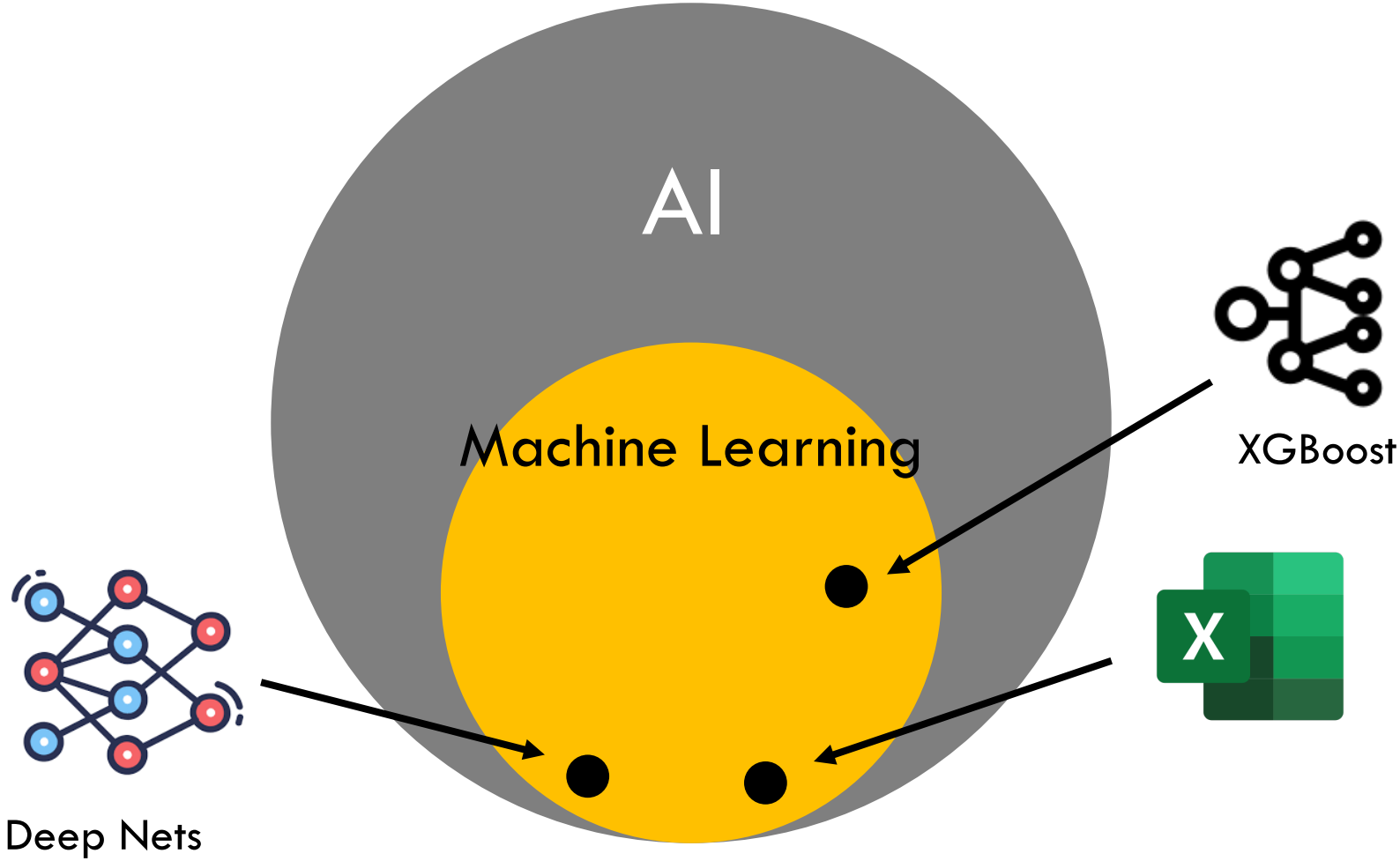
Regression

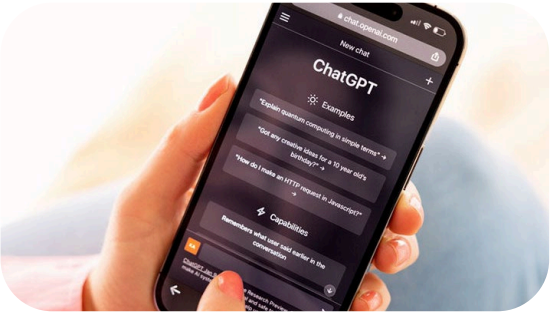



y
4
2
0
-2
-4
-6
0
2
4
6
x

“Larger” Regression Model




AI
Machine Learning
XGBoost
Deep Nets



Do this homework problem for me, but make my professor believe that a student did it.

Dog :: Puppy

Dog :: Puppy

Cat :: _____

Dog :: Puppy

Cat :: Kitten

Language

(lots of text)

"Comparing a dog to a puppy is like comparing cat to a kitten."

Language
(lots of text)

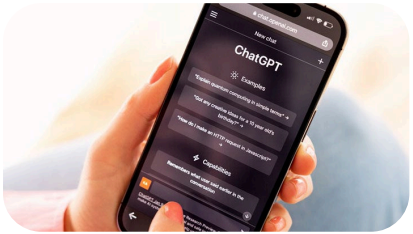
"Q: What do you call a little cat?
A: Kitten."

Language

(lots of text)

Language
(lots of text)

Large
Model

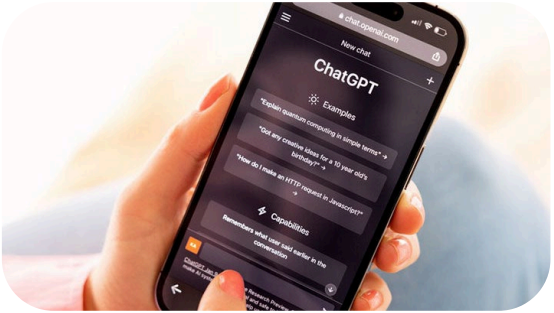


Language
(lots of text)

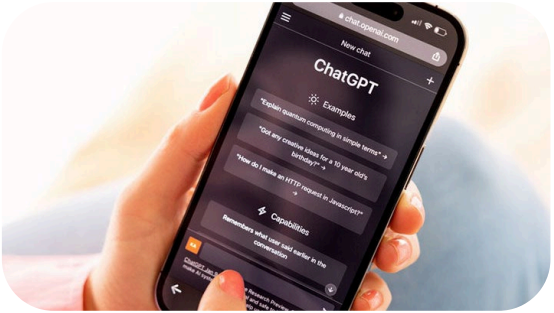
Large
Model

Large language
model

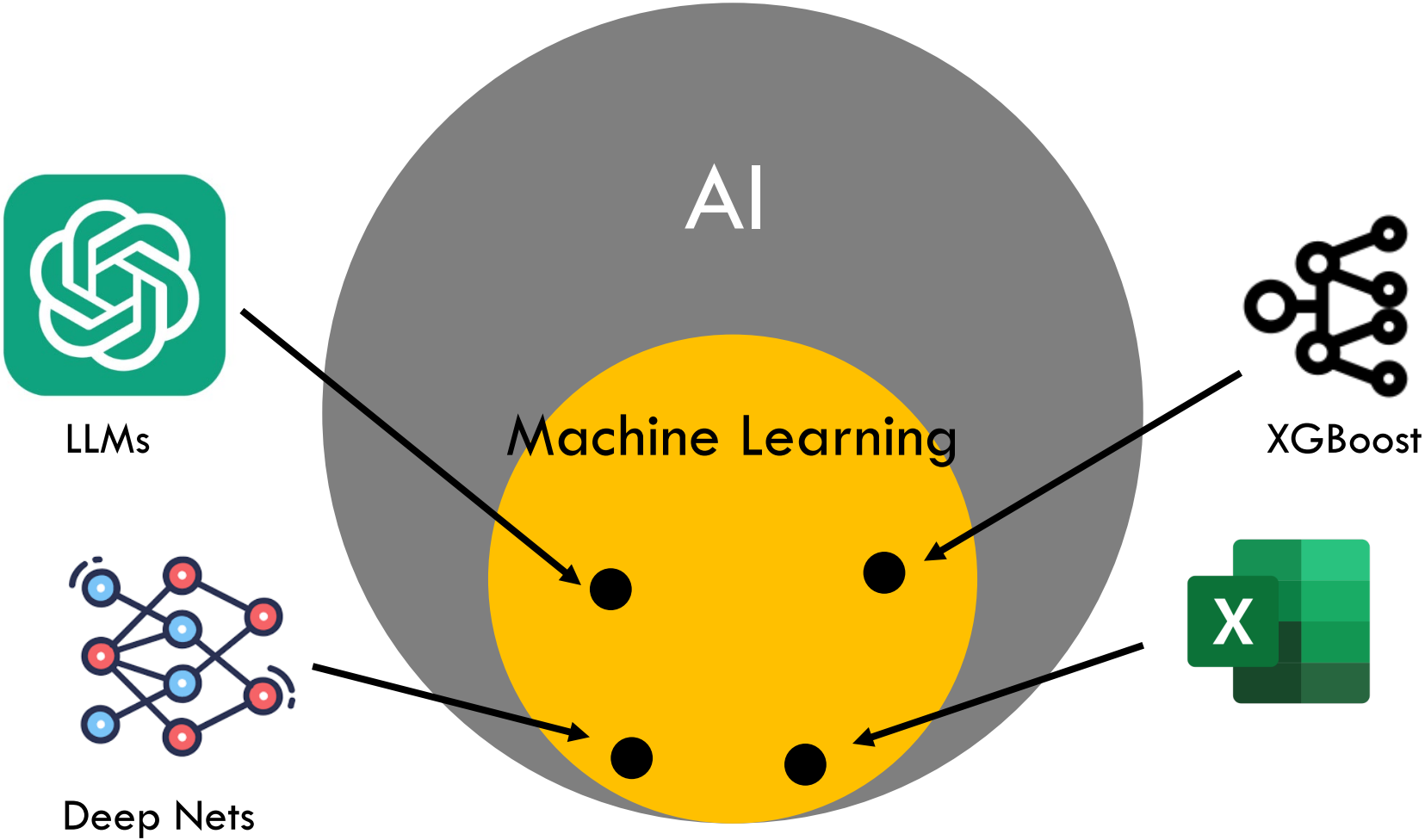
Q: A perfect water management plan ensures that every drop of rainwater _____

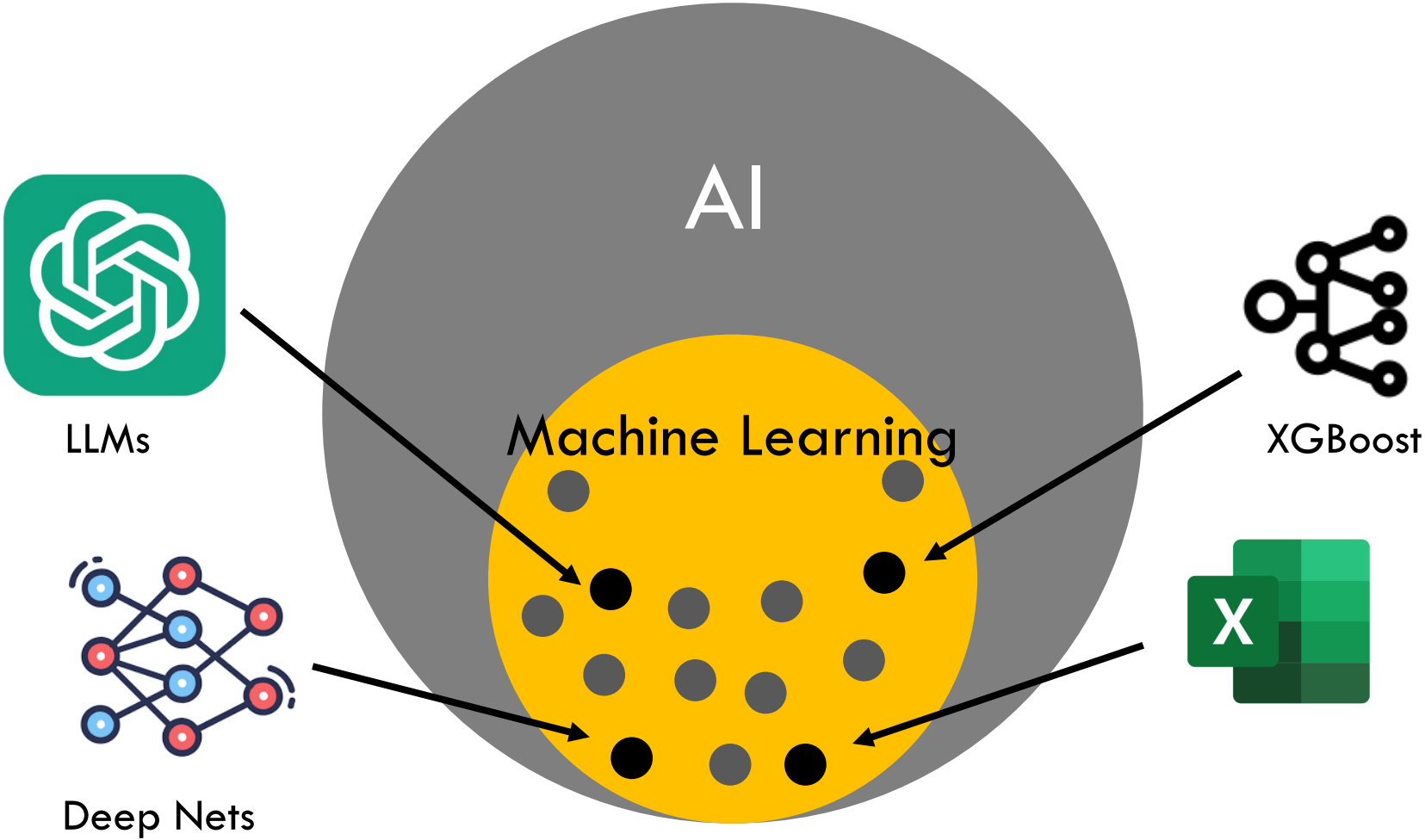


Q: A perfect water management plan ensures that every drop of rainwater _____



A: …waits for public comment before flowing downhill.


AI
Machine Learning
LLMs
XGBoost
Deep Nets


AI
Machine Learning
LLMs
XGBoost
Deep Nets

AI

$\neq$

digitalwaterlab.org


CRAVER

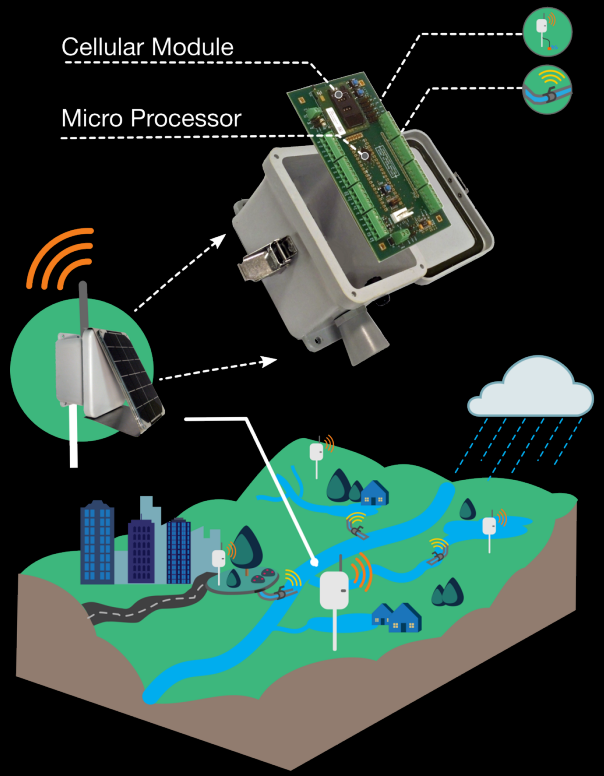
digitalwaterlab.org

digitalwaterlab.org


LEFT REARWARD VEHICLE CAMERA
MEDIUM RANGE VEHICLE CAMERA
RIGHT REARWARD VEHICLE CAMERA
MOTION FLOW
LANE LINES
LANE LINES
ROAD FLOW
IN-PATH OBJECTS
ROAD LIGHTS
OBJECTS
ROAD SIGNS

eve system-level
benefits

digitalwaterlab.org



Measure

Rain

Depth

Soil Moisture

Water Quality

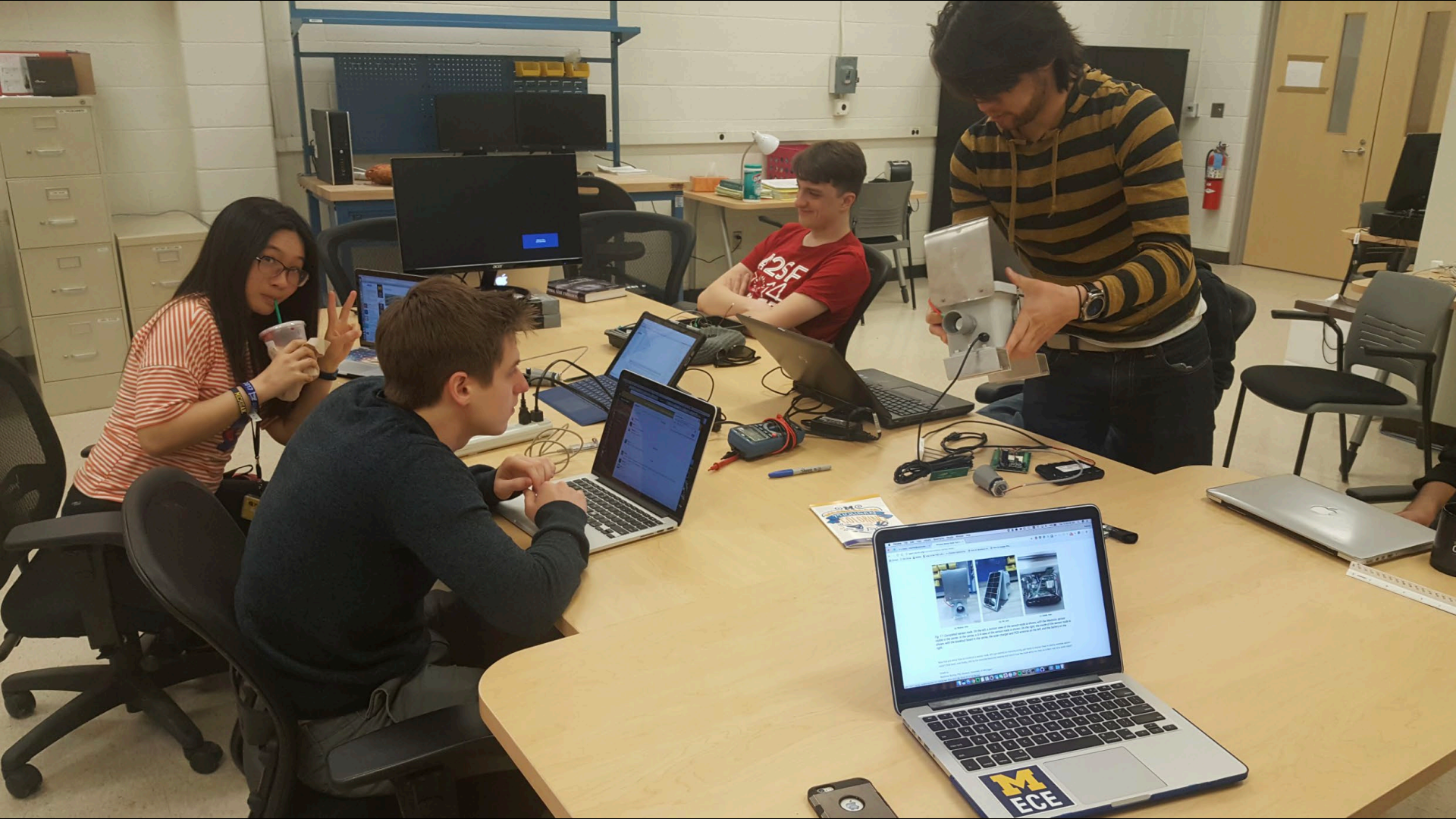
Control

Valves

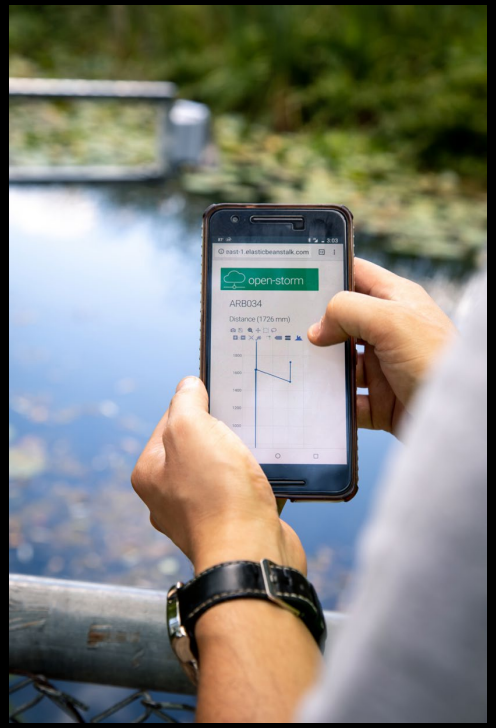
Gates

Automated Samplers

digitalwaterlab.org

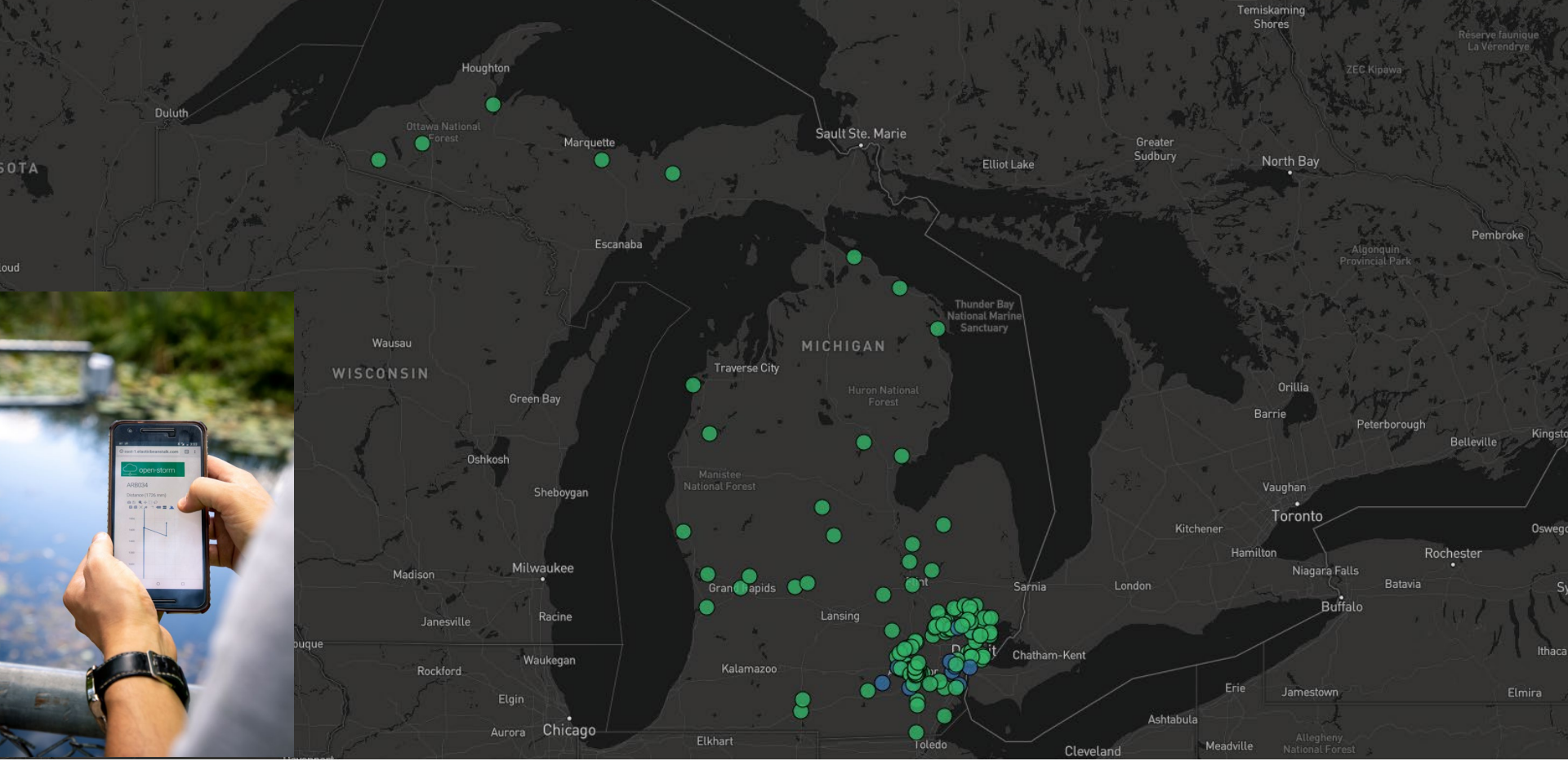

M
ECE

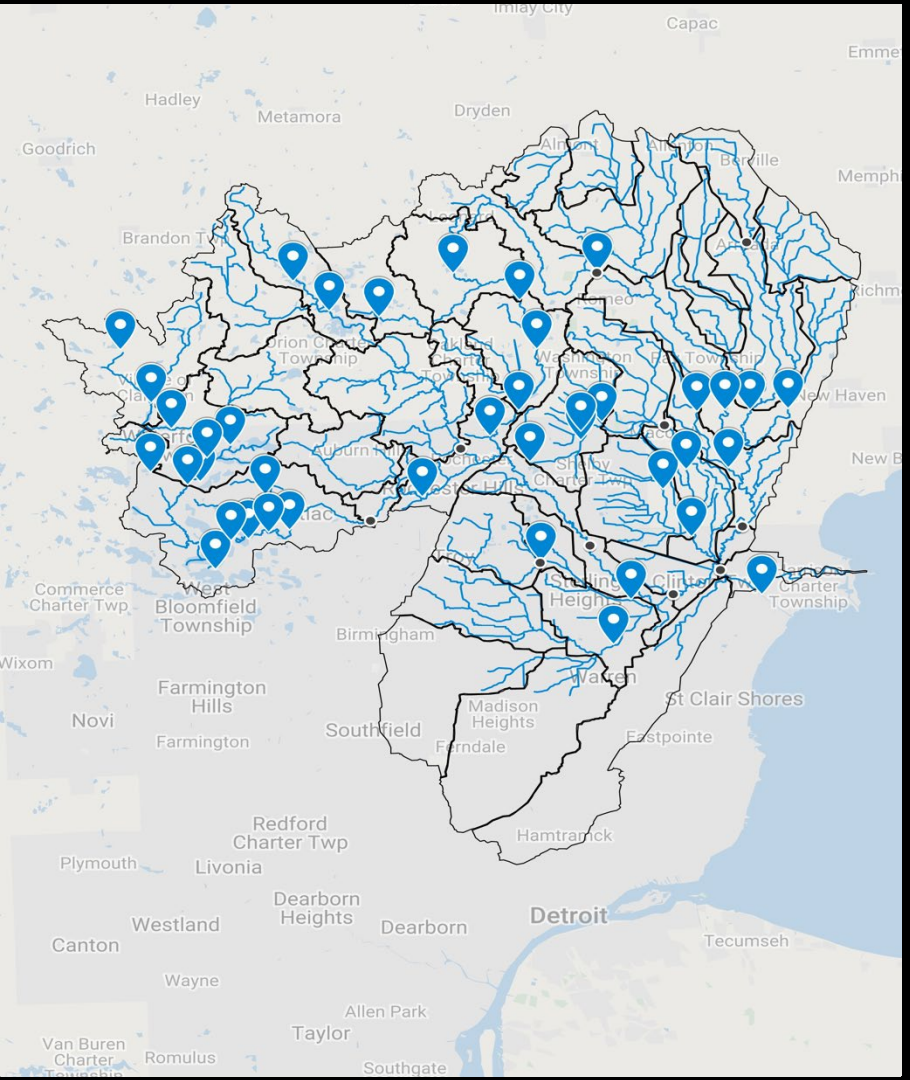
digitalwaterlab.org

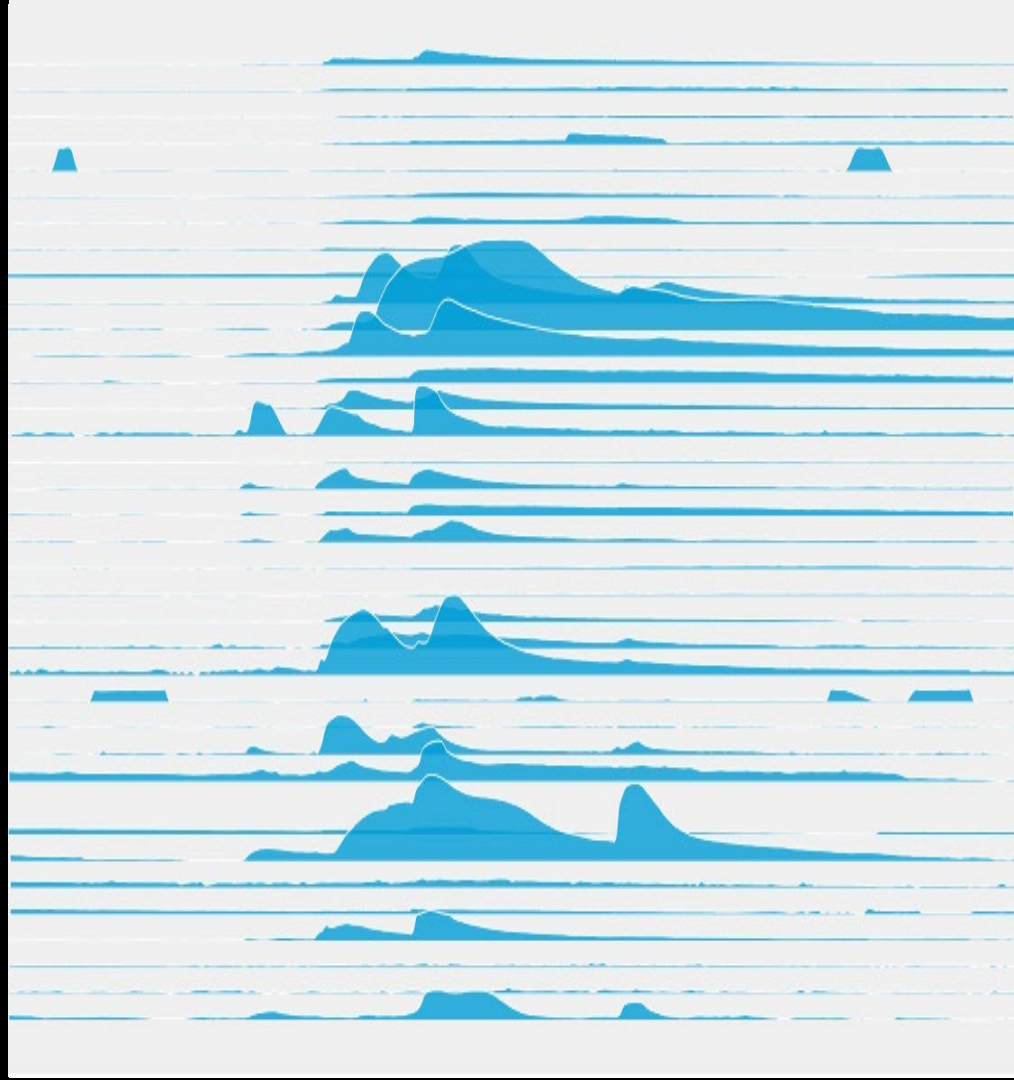


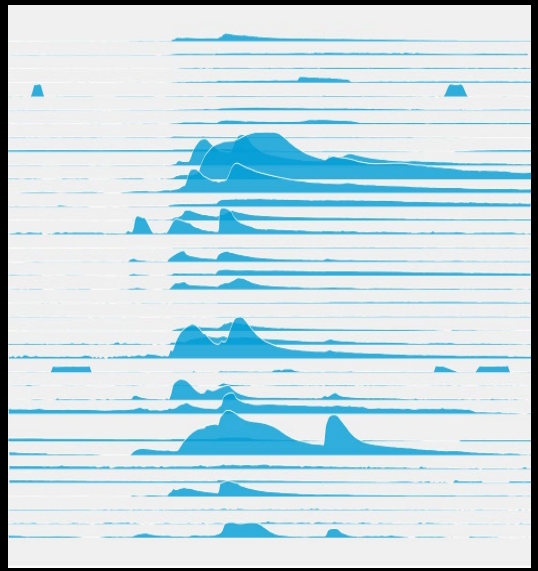
digitalwaterlab.org

digitalwaterlab.org


Temiskaming Shores
Réserve faunique La Vérendrye
ZEC Kipawa
Houghton
Duluth
Ottawa National Forest
Marquette
Sault Ste. Marie
Elliot Lake
Greater Sudbury
North Bay
Escanaba
Pembroke
Algonquin Provincial Park
Thunder Bay National Marine Sanctuary
Wausau
WISCONSIN
MICHIGAN
Traverse City
Huron National Forest
Green Bay
Orillia
Barrie
Peterborough
Belleville
Oshkosh
Manistee National Forest
Sheboygan
Vaughan
Toronto
Kitchener
Hamilton
Rochester
Niagara Falls
Batavia
Madison
Milwaukee
Grand Rapids
Sarnia
London
Buffalo
Janesville
Racine
Lansing
Chatham-Kent
Ithaca
Rockford
Waukegan
Kalamazoo
Erie
Jamestown
Elmira
Elgin
Ashtabula
Aurora
Chicago
Elkhart
Toledo
Cleveland
Meadville
Allegheny National Forest


Capac
Hadley
Metamora
Dryden
Goodrich
Brandon Twp
Orion Charter Township
Auburn Hills
Rochester
Rochester Hills
Shelby Charter Twp
New Haven
Commerce Charter Twp
West Bloomfield Township
Birmingham
Wixom
Farmington Hills
Novi
Farmington
Southfield
Madison Heights
Ferndale
Warren
St Clair Shores
Eastpointe
Redford Charter Twp
Plymouth
Livonia
Hamtramck
Dearborn Heights
Dearborn
Detroit
Westland
Canton
Tecumseh
Wayne
Allen Park
Taylor
Van Buren Charter Township
Romulus
Southgate





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open-storm
ARB030
Depth (0.005 Feet)
1.2
1
0.8
0.6
0.4
0.2
0

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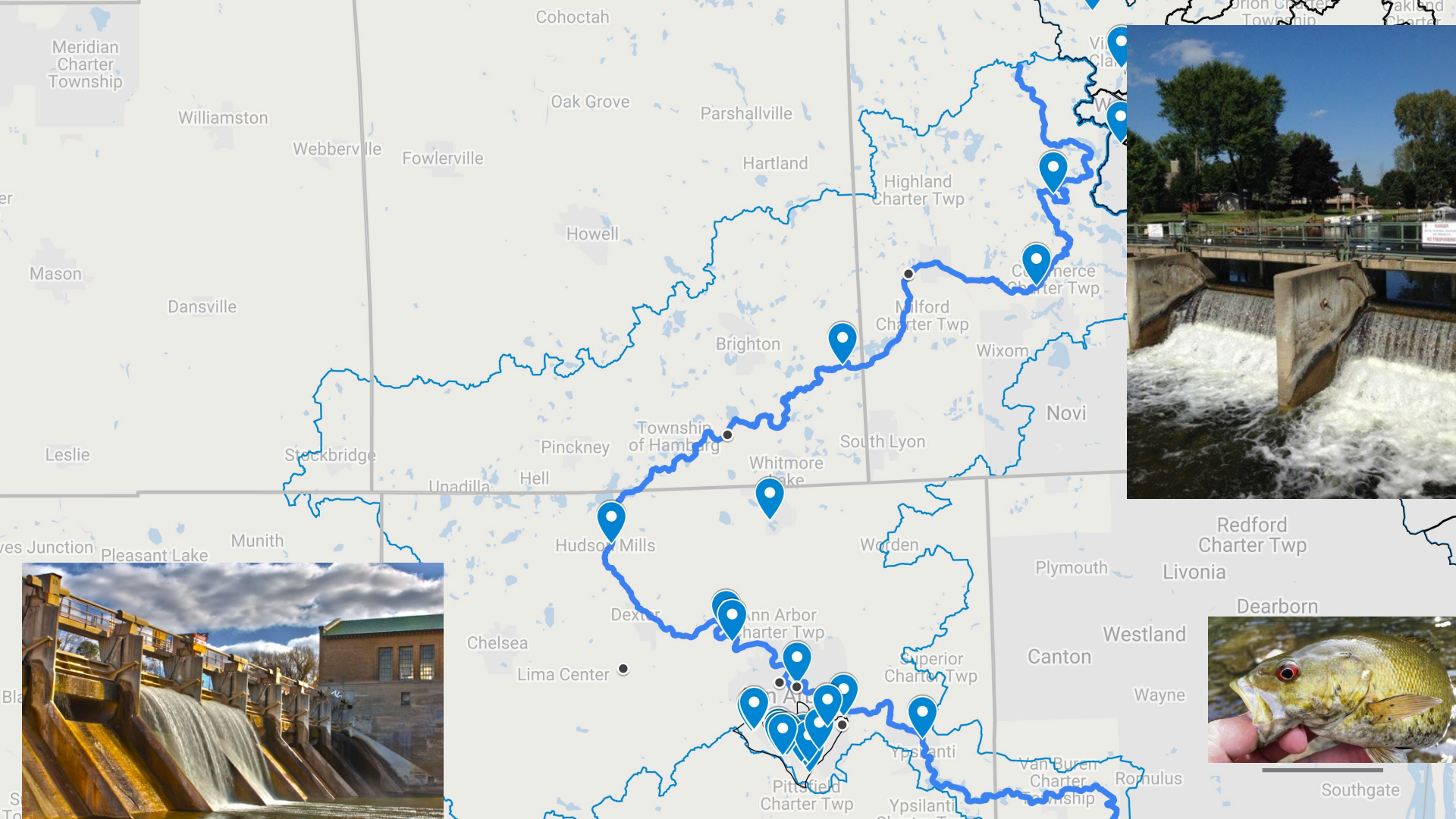

Meridian Charter Township
Cohoctah
Williamston
Oak Grove
Parshallville
Webberville
Fowlerville
Hartland
Highland Charter Twp
Howell
Mason
Dansville
Commerce Charter Twp
Milford Charter Twp
Brighton
Wixom
Novi
Township of Hamburg
Pinckney
South Lyon
Leslie
Stockbridge
Whitmore Lake
Unadilla
Hell
Munith
Pleasant Lake
Hudson Mills
Worden
Redford Charter Twp
Plymouth
Livonia
Dexter
Ann Arbor Charter Twp
Chelsea
Lima Center
Superior Charter Twp
Canton
Westland
Dearborn
Wayne
Ypsilanti
Van Buren Charter Township
Romulus
Pittsfield Charter Twp
Ypsilanti
Southgate

Life in a day…

Water Operator

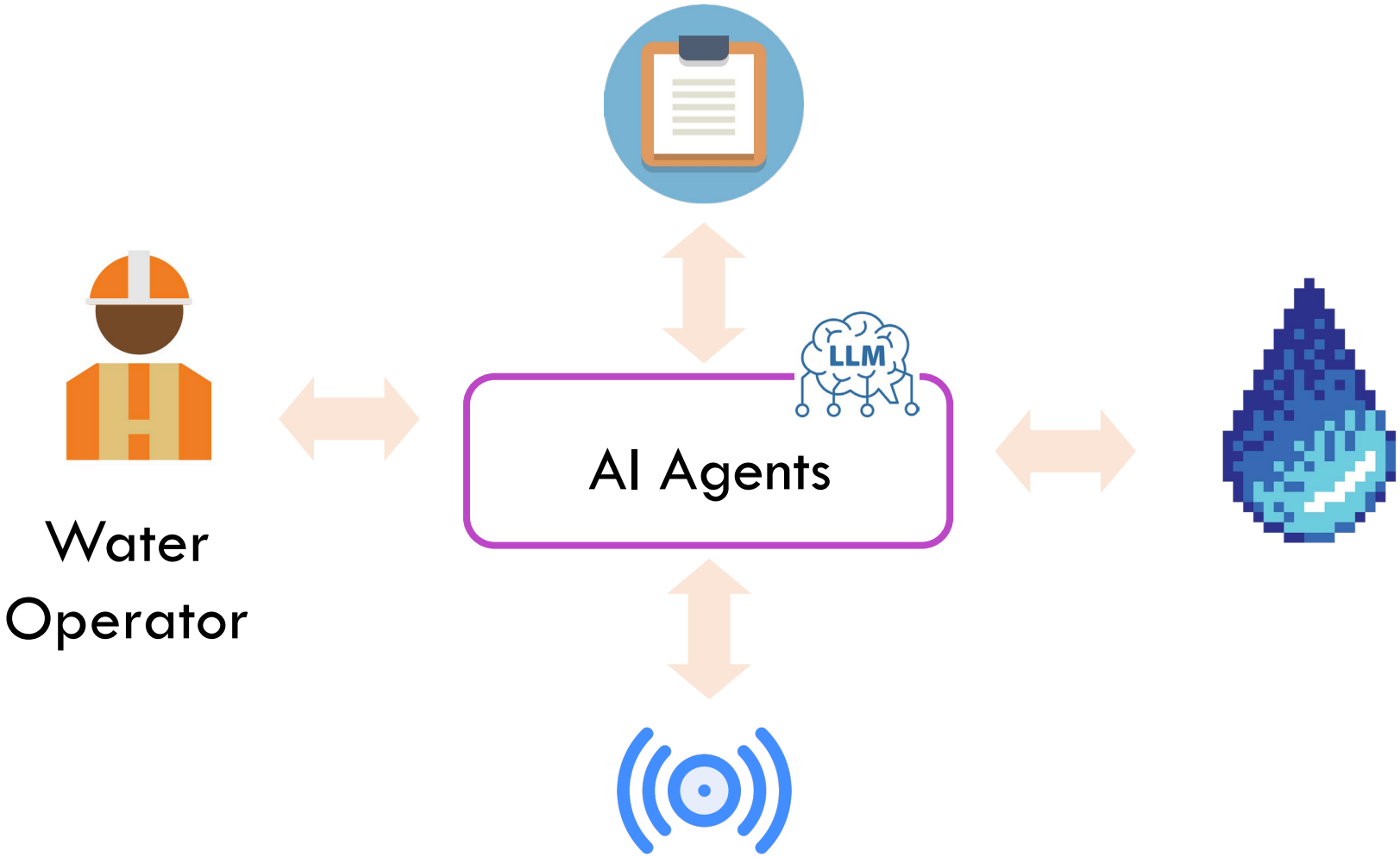
Water Operator

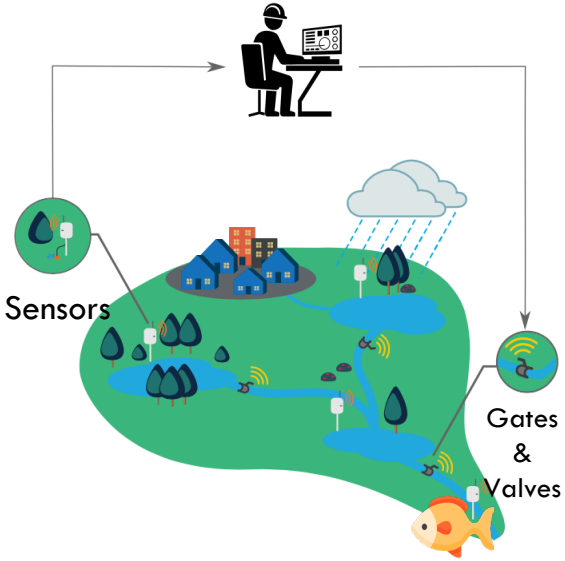
Water Operator

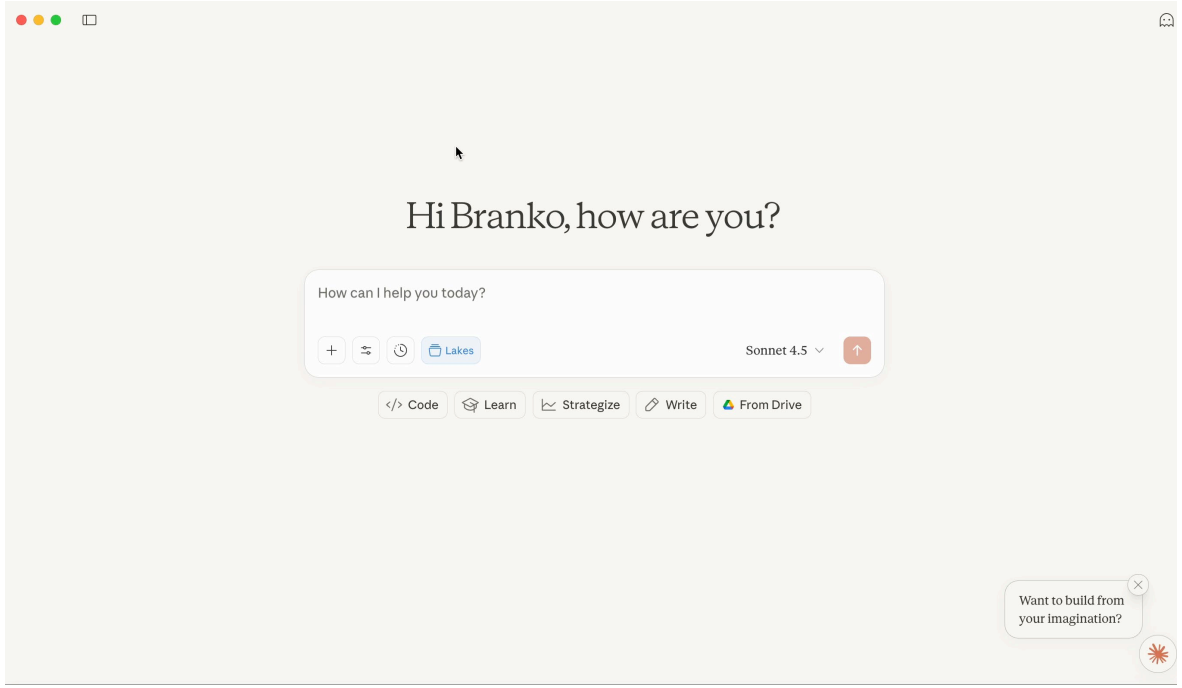
Water Operator

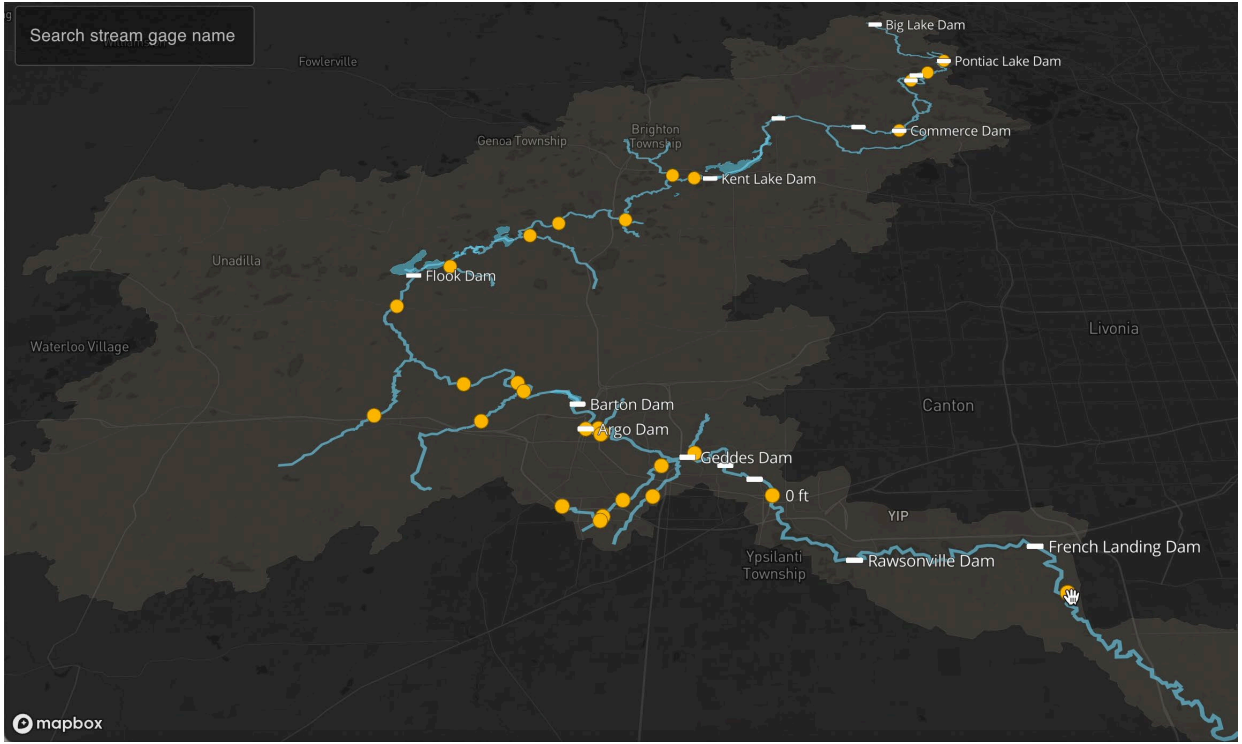
Water
Operator

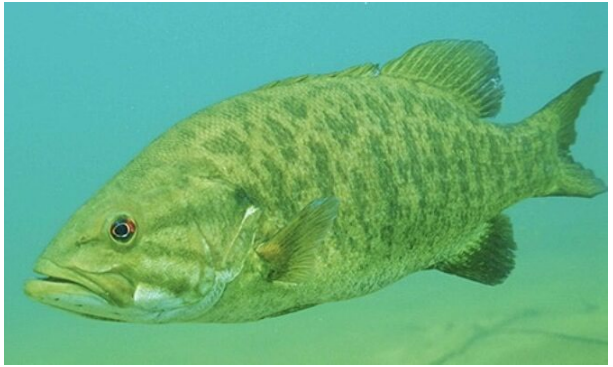
Water Operator


LLM
AI Agents
Water
Operator


Sensors
Gates
&
Valves


Hi Branko, how are you?
How can I help you today?
Lakes
Sonnet 4.5
Code
Learn
Strategize
Write
From Drive
Want to build from your imagination?


Search stream gage name
Big Lake Dam
Pontiac Lake Dam
Commerce Dam
Kent Lake Dam
Fowlerville
Genoa Township
Brighton Township
Unadilla
Flook Dam
Waterloo Village
Livonia
Canton
Barton Dam
Argo Dam
Geddes Dam
0 ft
YIP
Ypsilanti Township
Rawsonville Dam
French Landing Dam
mapbox

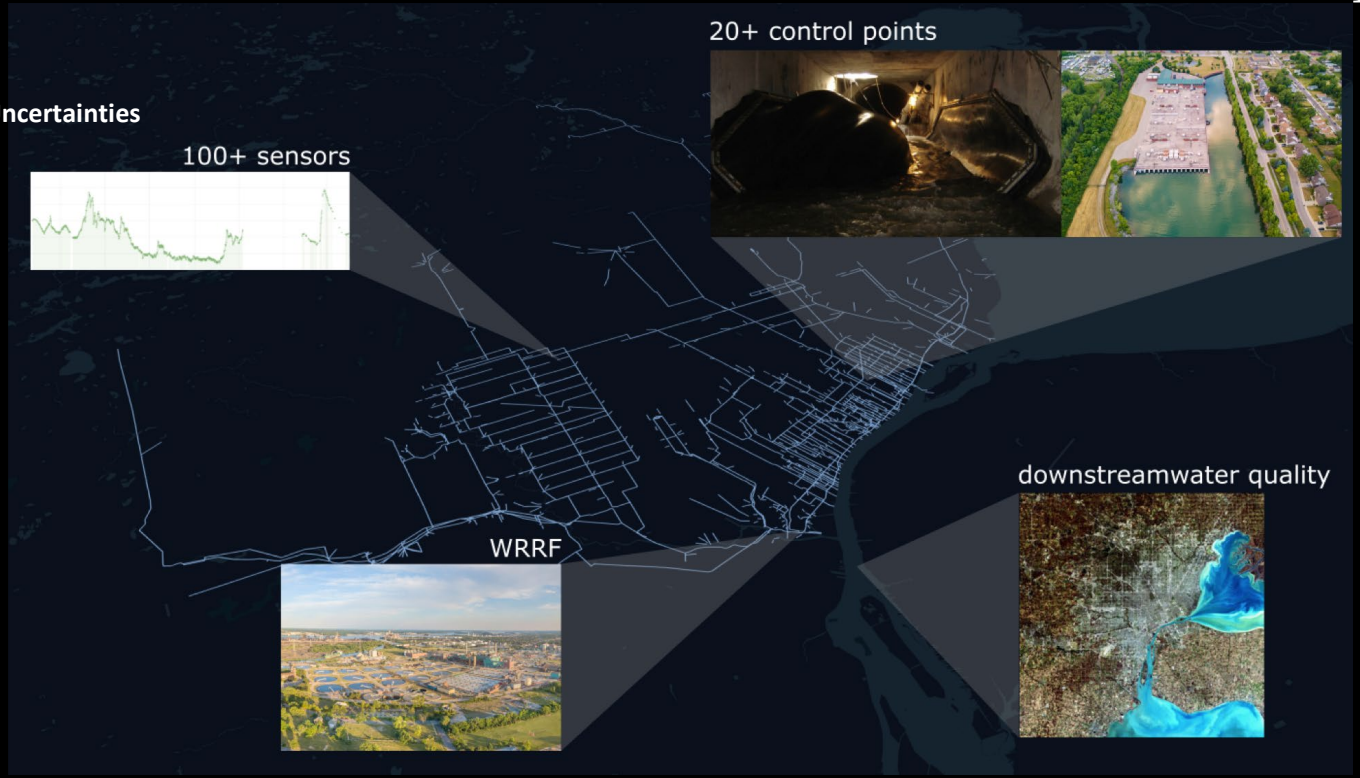


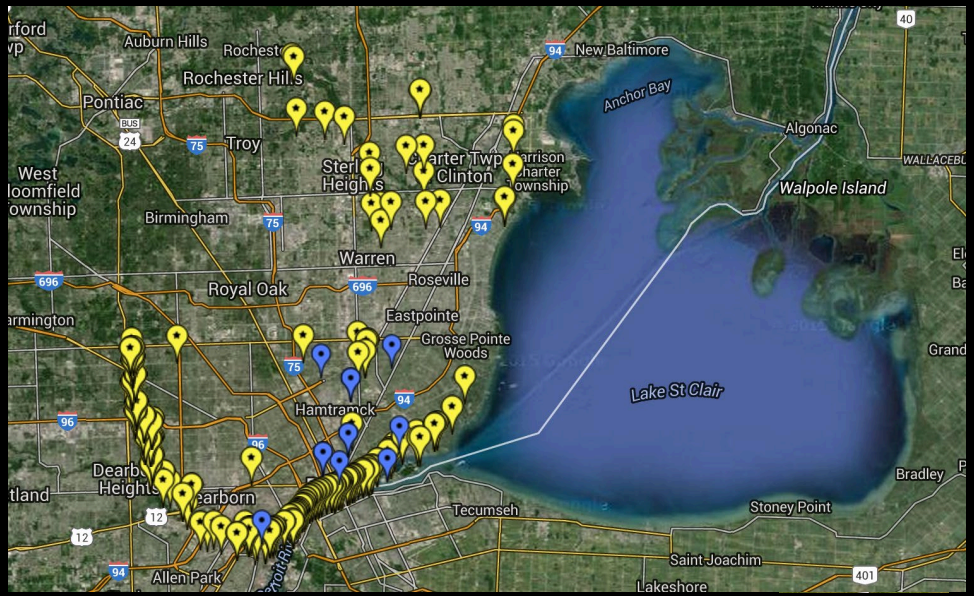
digitalwaterlab.org

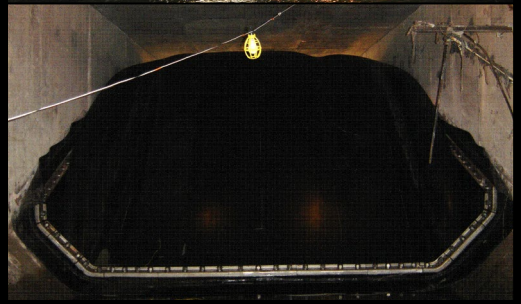
Southeast Michigan, USA, servicing 4 million people

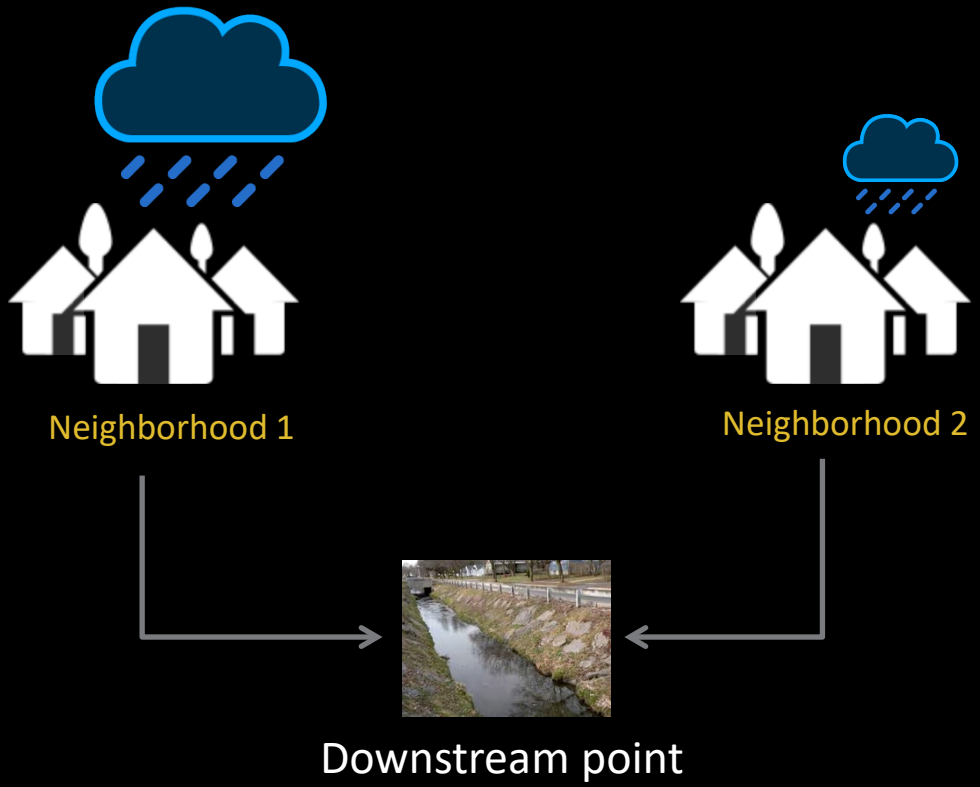
Large Solution Space $\approx 10^{40}$

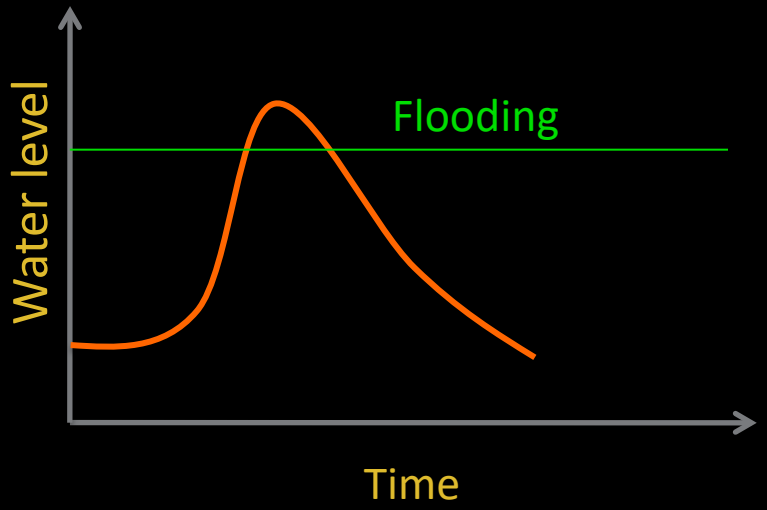
Rainfall Uncertainties

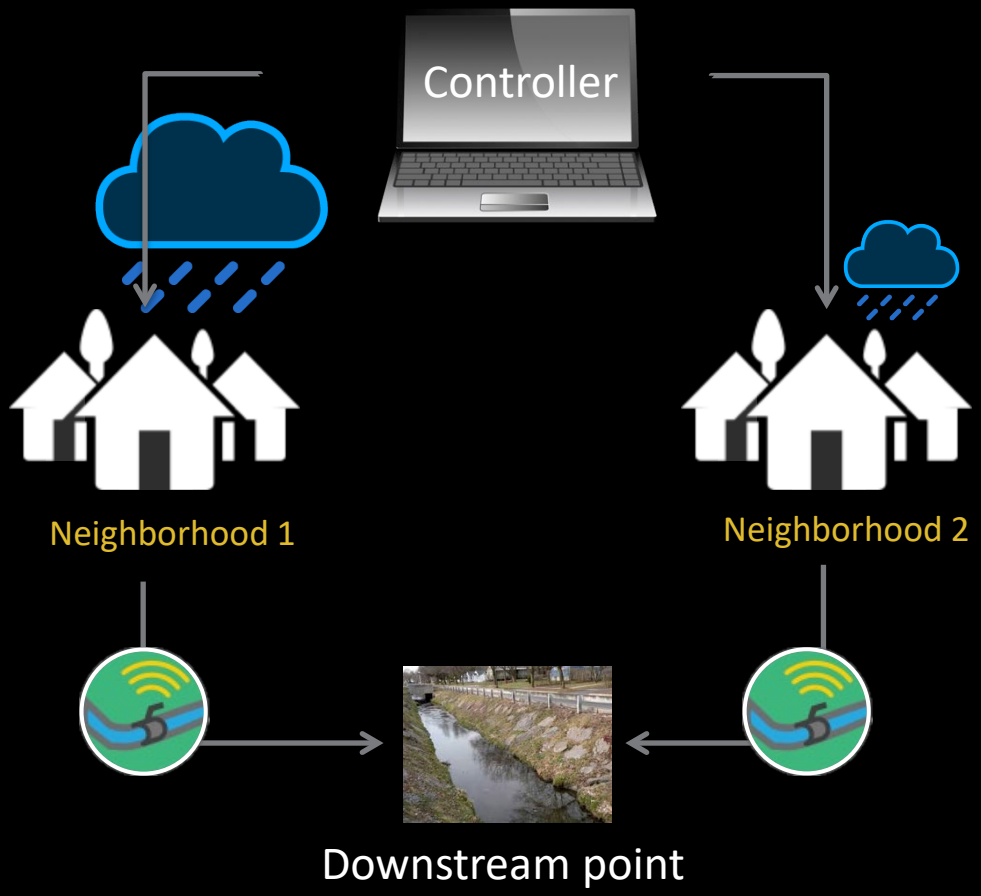


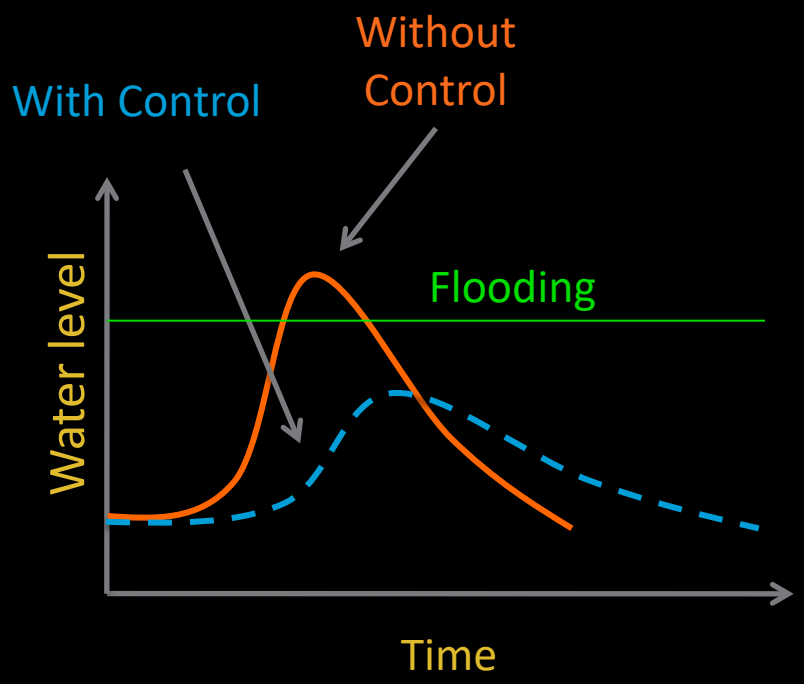

Auburn Hills
Rochester Hills
Pontiac
Troy
West Bloomfield Township
Birmingham
Warren
Royal Oak
Roseville
Eastpointe
Grosse Pointe Woods
Hamtramck
Dearborn Heights
Dearborn
Allen Park
Tecumseh
Lakeshore
Saint Joachim
Stoney Point
Bradley
Lake St Clair
Anchor Bay
Walpole Island
Algonac
New Baltimore
Clinton
Sterling Heights
Charter Twp
Harrison Charter Township



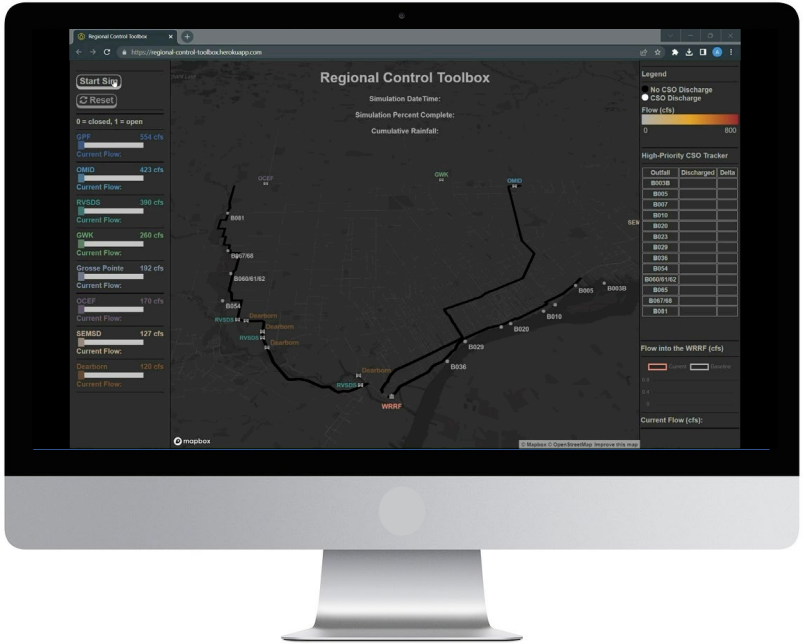








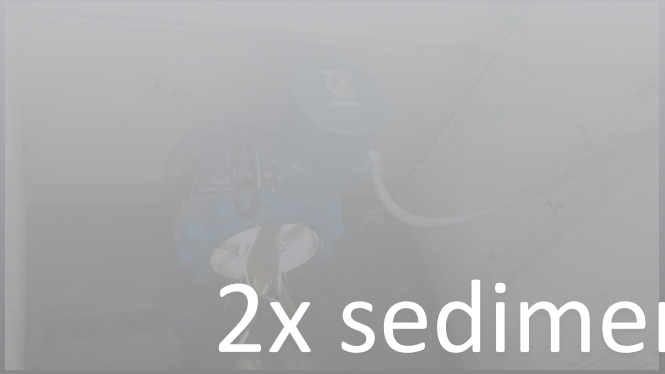
digitalwaterlab.org


Regional Control Toolbox
Start Sim
Reset
0 = closed, 1 = open
Simulation DateTime:
Simulation Percent Complete:
Cumulative Rainfall:
Legend
No CSO Discharge
CSO Discharge
Flow (cfs)
High-Priority CSO Tracker
Flow into the WRRF (cfs)
Current Flow (cfs):
WRRF
mapbox

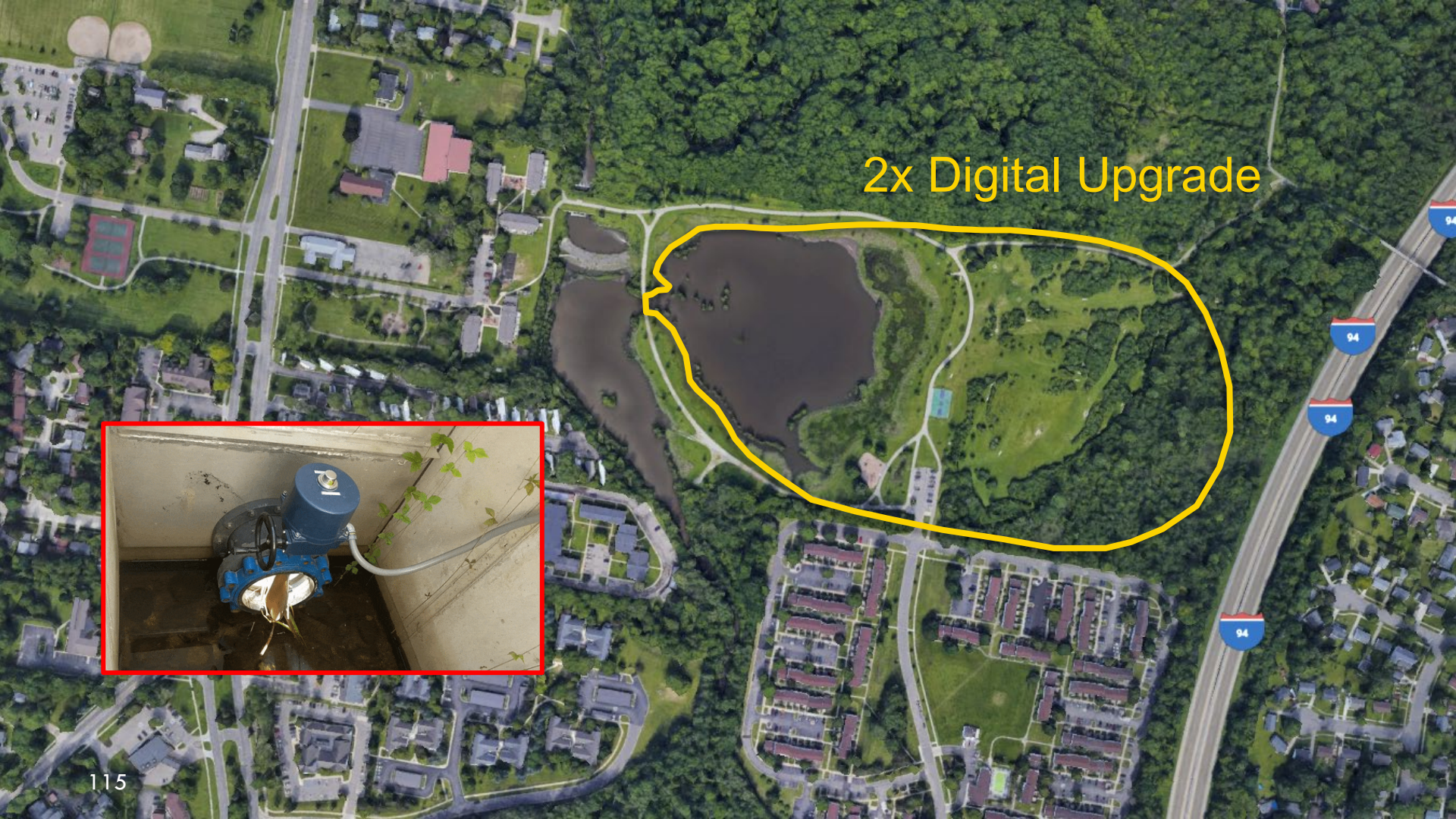
=

$0.5 Billion

digitalwaterlab.org



2x sediment capture
6x dissolved nutrient capture


2x Digital Upgrade
94
94
94

University Testbeds

digitalwaterlab.org

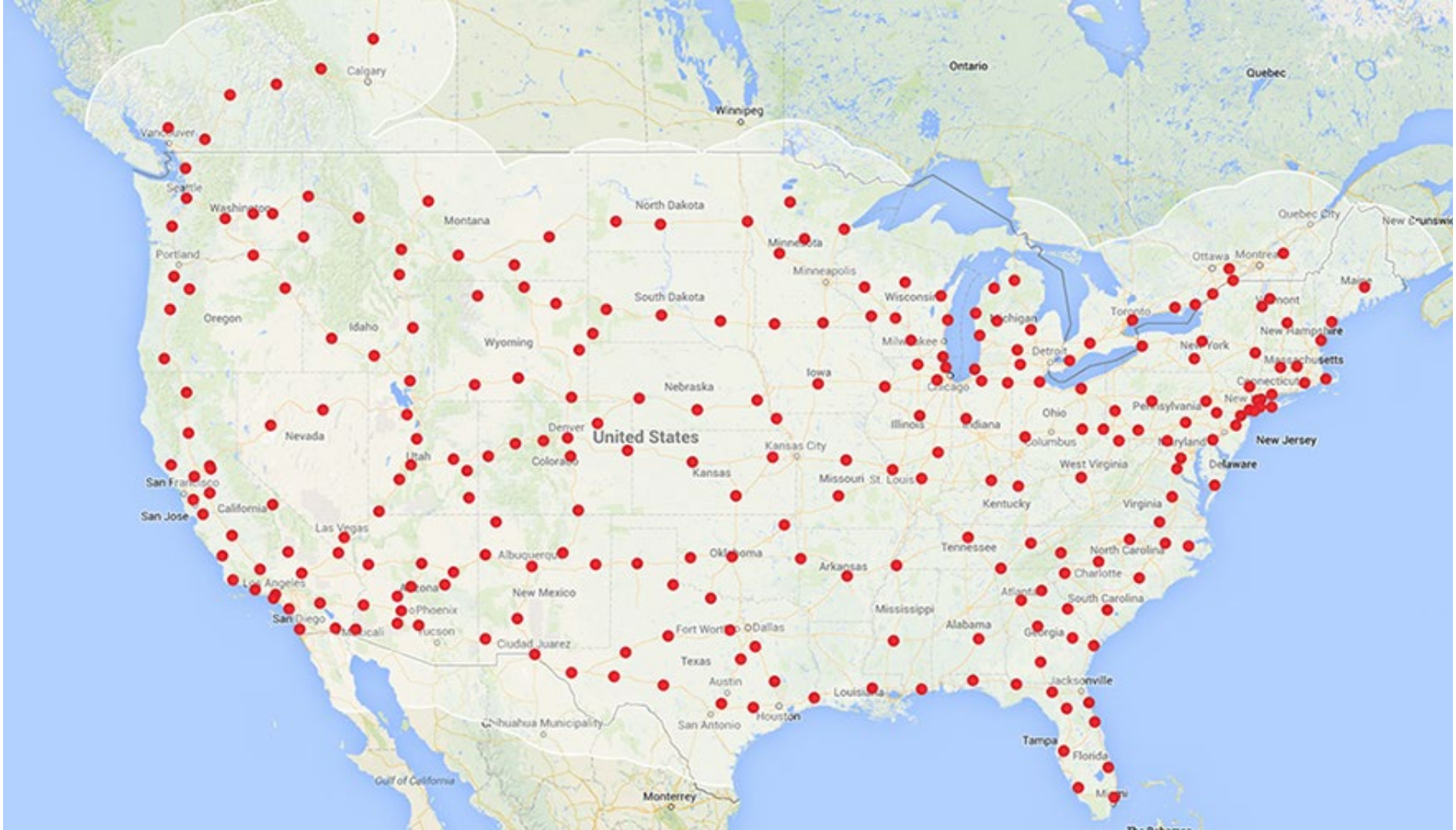







22

Verizon Disaster Resilience Prize
WINNER
hyfi
verizon
GreenBiz group
Atlantic Council
Adrienne Arsht-Rockefeller Foundation Resilience Center


Calgary
Ontario
Quebec
Winnipeg
Vancouver
Seattle
Washington
Montana
North Dakota
Minnesota
Minneapolis
Portland
Oregon
Idaho
South Dakota
Wyoming
Wisconsin
Michigan
Milwaukee
Detroit
Toronto
Ottawa
Montreal
Quebec City
New Brunswick
Maine
Vermont
New Hampshire
New York
Massachusetts
Connecticut
New Jersey
Delaware
Maryland
Pennsylvania
Ohio
Columbus
Indiana
Illinois
Chicago
Iowa
Nebraska
Denver
United States
Nevada
Utah
Colorado
Kansas City
Kansas
Missouri
St. Louis
West Virginia
Kentucky
Virginia
San Francisco
San Jose
California
Las Vegas
Albuquerque
Oklahoma
Arkansas
Tennessee
North Carolina
Charlotte
Los Angeles
Arizona
Phoenix
Tucson
New Mexico
San Diego
Mexicali
Ciudad Juarez
Fort Worth
Dallas
Texas
Mississippi
Alabama
Georgia
Atlanta
South Carolina
Jacksonville
Austin
San Antonio
Houston
Louisiana
Chihuahua Municipality
Tampa
Florida
Miami
Gulf of California
Monterrey


FLOOD
GAUGE
FEET
5
4
3
2

Respond

Real-time

Respond
Real-time

Prepare
Day Ahead

Respond
Real-time

Prepare
Day Ahead

Maintain
Weeks Ahead

Respond
Real-time

Prepare
Day Ahead

Maintain
Weeks Ahead

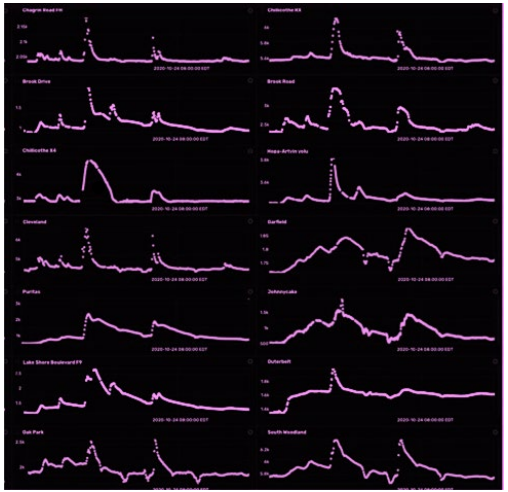
Plan
Years ahead

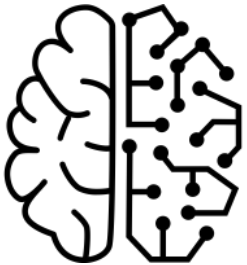
Respond
Real-time

Prepare
Day Ahead

Maintain
Weeks Ahead

Plan
Years ahead



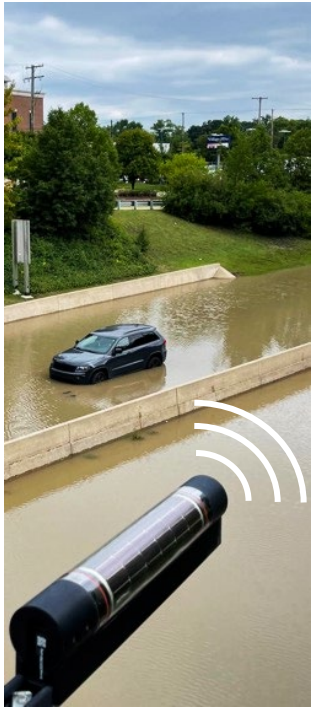


Respond
Real-time

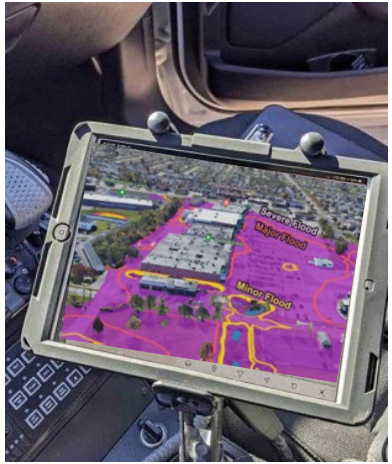
Prepare
Day Ahead

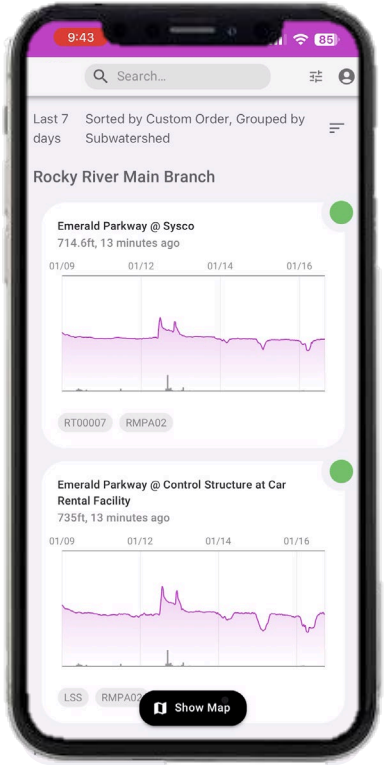
Maintain
Weeks Ahead

Plan
Years ahead

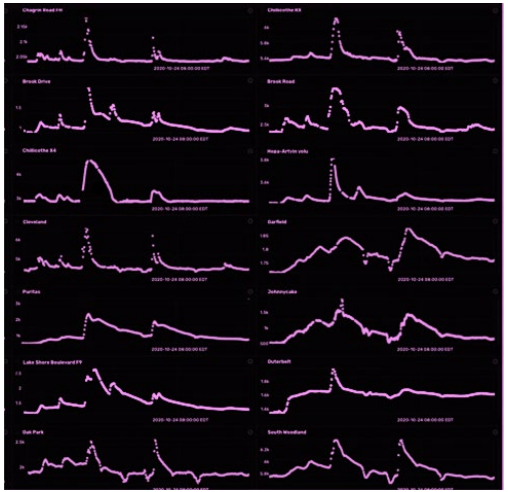


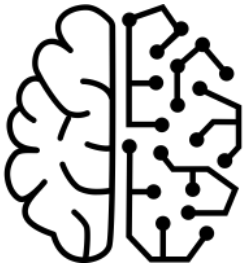

WEST HARTFORD


Severe Flood
Major Flood
Minor Flood


9:43
85
Search...
Last 7 days
Sorted by Custom Order, Grouped by Subwatershed
Rocky River Main Branch
Emerald Parkway @ Sysco
714.6ft, 13 minutes ago
01/09
01/12
01/14
01/16
RT00007
RMPA02
Emerald Parkway @ Control Structure at Car Rental Facility
735ft, 13 minutes ago
01/09
01/12
01/14
01/16
LSS
Show Map

hyfi.io



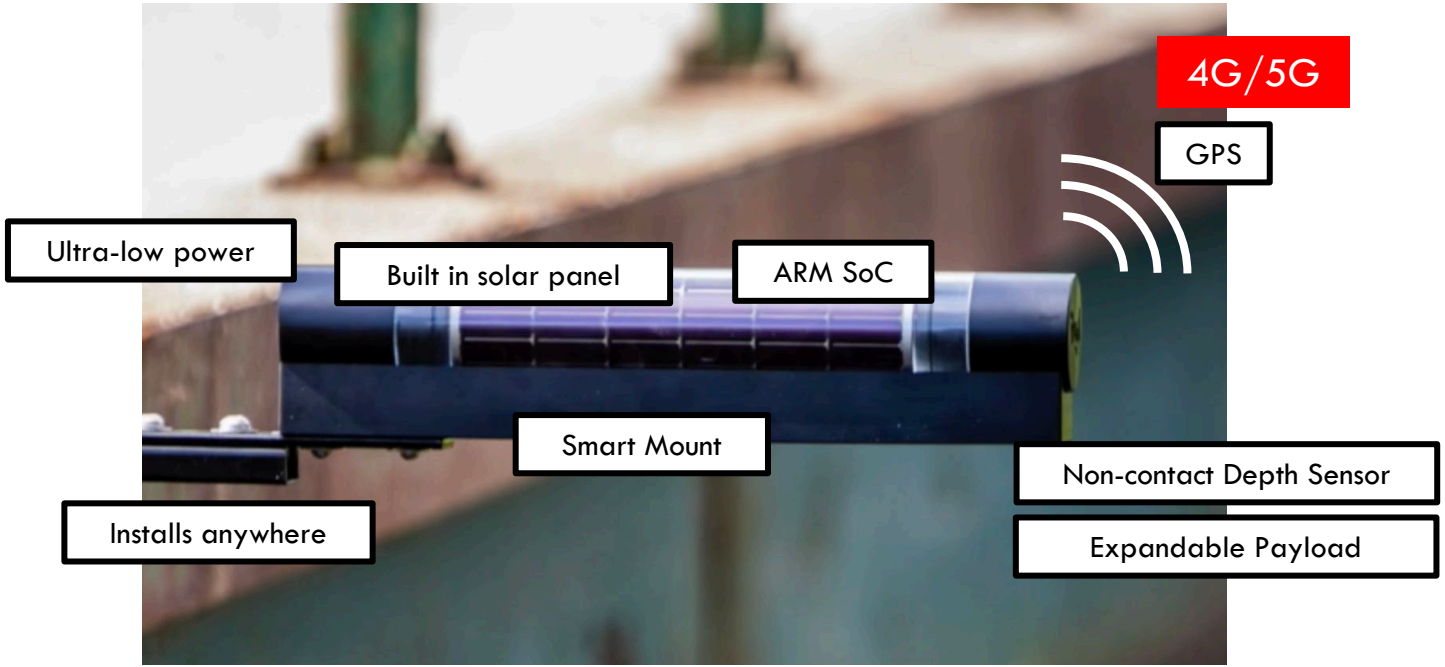


Respond
Real-time

Prepare
Day Ahead

Maintain
Weeks Ahead

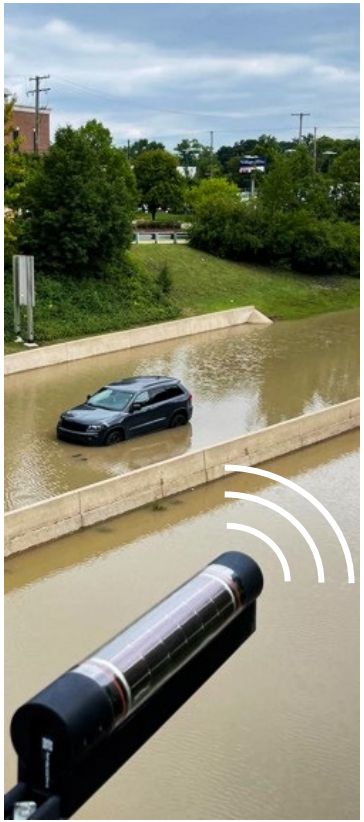
Plan
Years ahead


4G/5G
GPS
Ultra-low power
Built in solar panel
ARM SoC
Smart Mount
Non-contact Depth Sensor
Installs anywhere
Expandable Payload

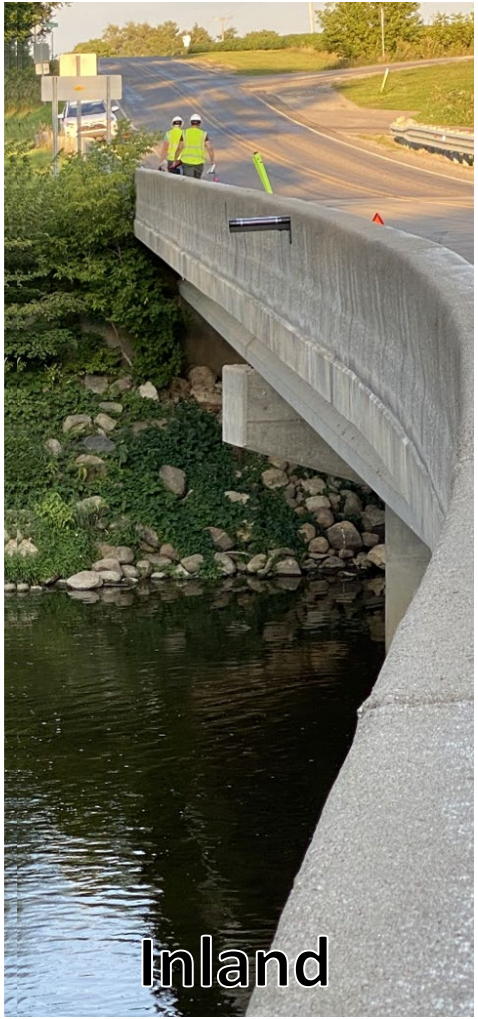

1. Click!


2. Twist!


3. Ready

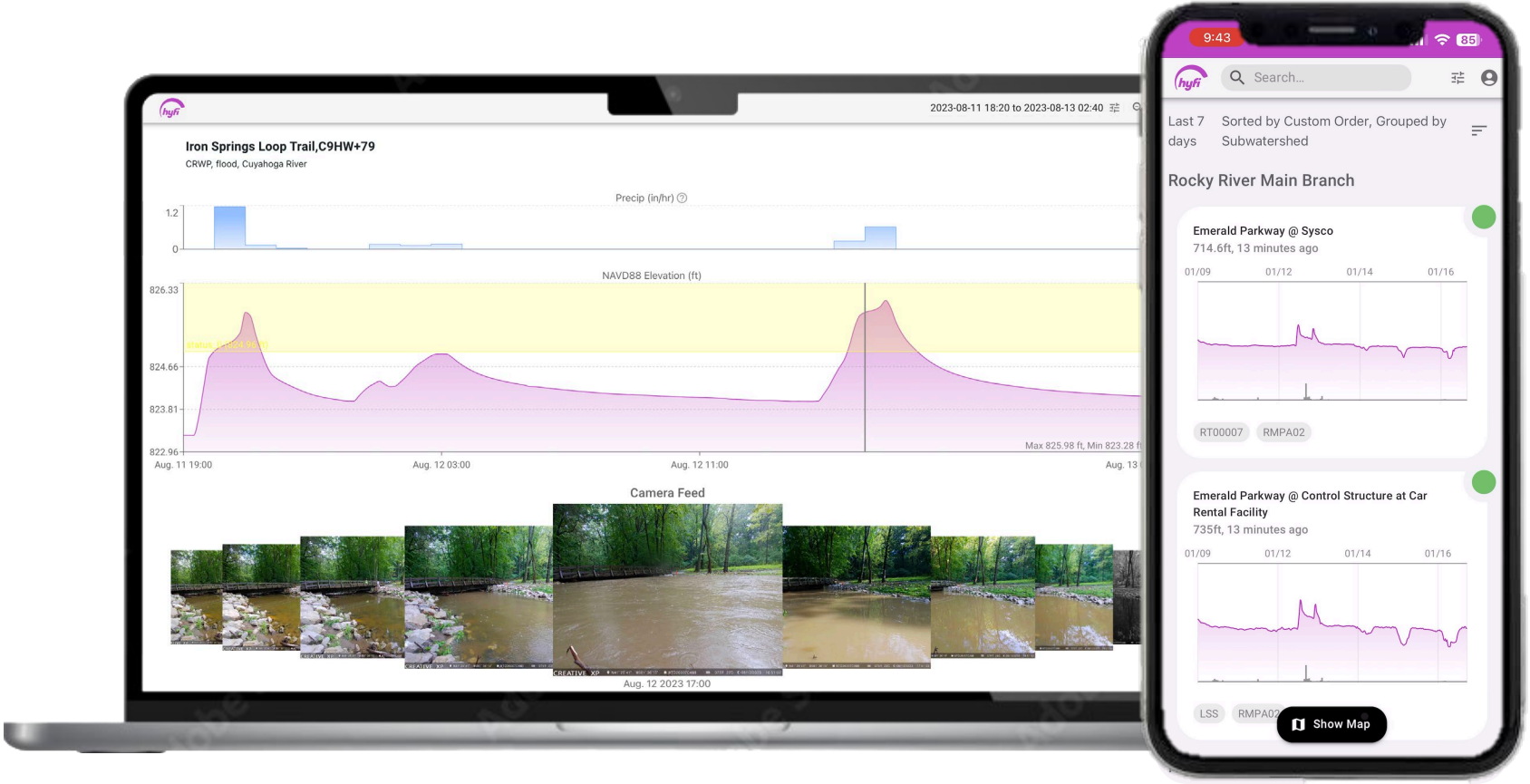



Coastal

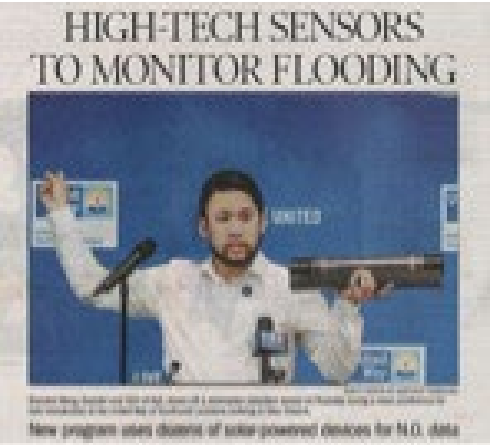

Inland


Street


Below


2023-08-11 18:20 to 2023-08-13 02:40
Iron Springs Loop Trail,C9HW+79
CRWP, flood, Cuyahoga River
Precip (in/hr)
1.2
0
NAVD88 Elevation (ft)
826.33
824.66
823.81
822.96
Aug. 11 19:00
Aug. 12 03:00
Aug. 12 11:00
Max 825.98 ft, Min 823.28 f
Camera Feed
Aug. 12 2023 17:00
9:43
Search...
Last 7 days
Sorted by Custom Order, Grouped by Subwatershed
Rocky River Main Branch
Emerald Parkway @ Sysco
714.6ft, 13 minutes ago
01/09
01/12
01/14
01/16
RT00007
RMPA02
Emerald Parkway @ Control Structure at Car Rental Facility
735ft, 13 minutes ago
01/09
01/12
01/14
01/16
LSS
Show Map

hyfi.io

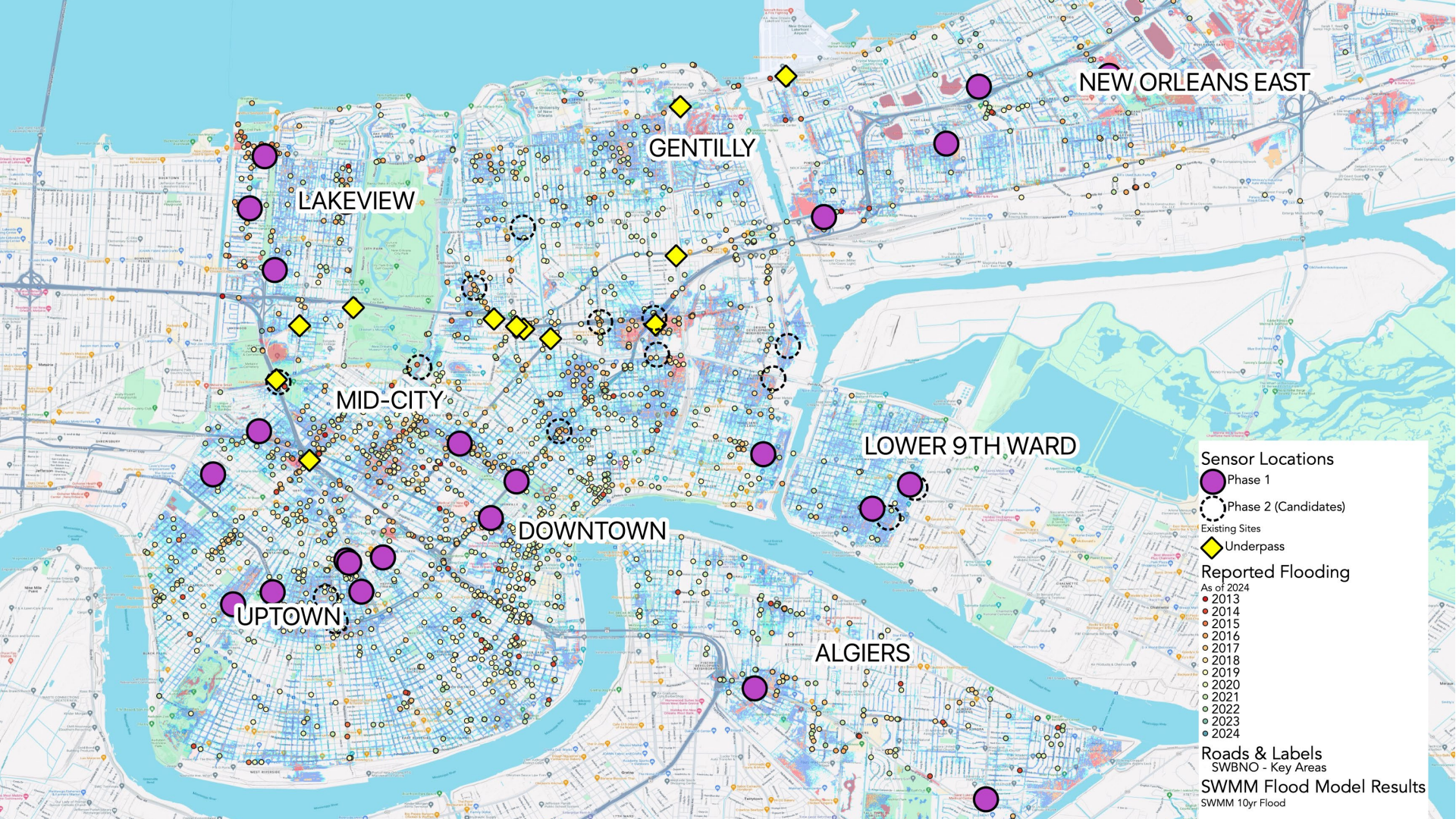


verizon

UNITED WAY
Southeast Louisiana

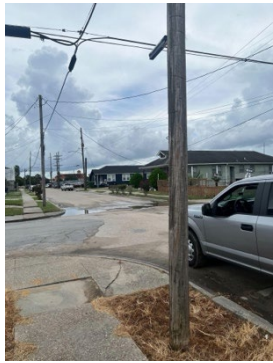
CITY OF NEW ORLEANS
MAYOR LATOYA CANTRELL

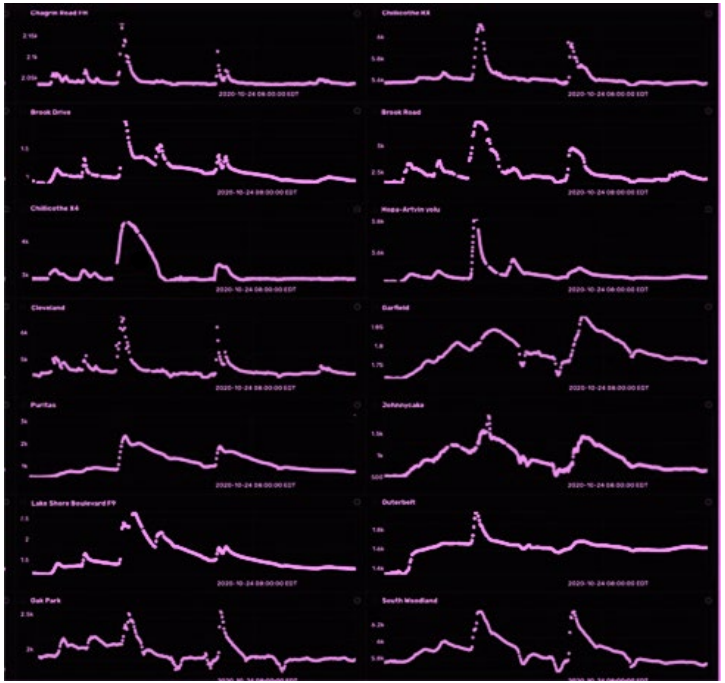
SEWERAGE & WATER BOARD
CRESCENT BOX
WATER METER
NEW ORLEANS, LA.


NEW ORLEANS EAST
GENTILLY
LAKEVIEW
MID-CITY
LOWER 9TH WARD
DOWNTOWN
UPTOWN
ALGIERS
Sensor Locations
Phase 1
Phase 2 (Candidates)
Existing Sites
Underpass
Reported Flooding
As of 2024
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Roads & Labels
SWBNO - Key Areas
SWMM Flood Model Results
SWMM 10yr Flood


Audubon
ONE WAY

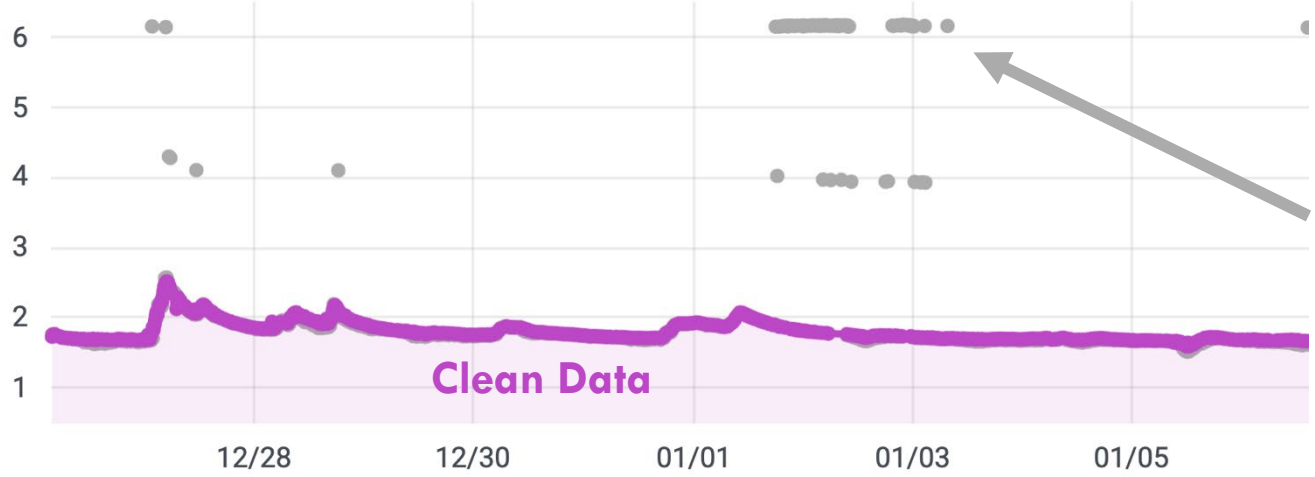

STOP



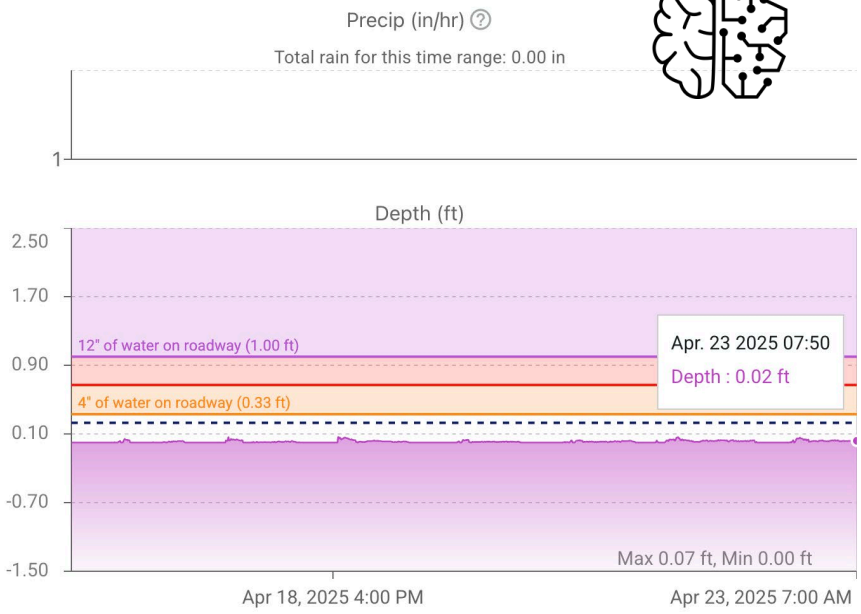

Chagrin Road FR
Chillicothe K8
Brook Drive
Brook Road
Chillicothe X4
Hope-Artvin valu
Cleveland
Garfield
Puritas
Johnnycake
Lake Shore Boulevard F9
Outerbelt
Oak Park
South Woodland

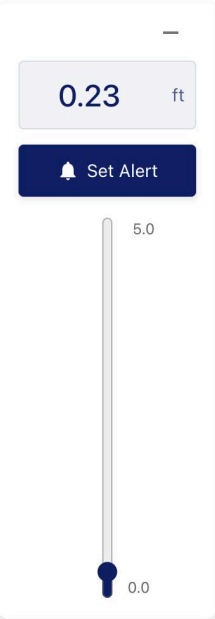

Audubon
ONE WAY

Obstacle Detection & Data Quality

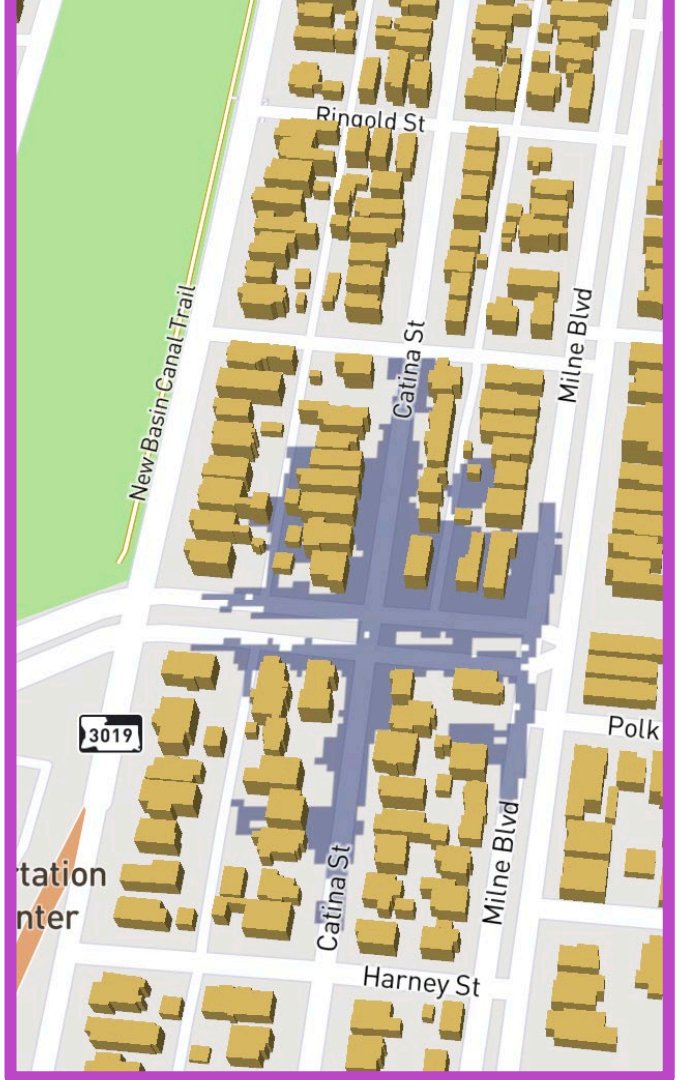


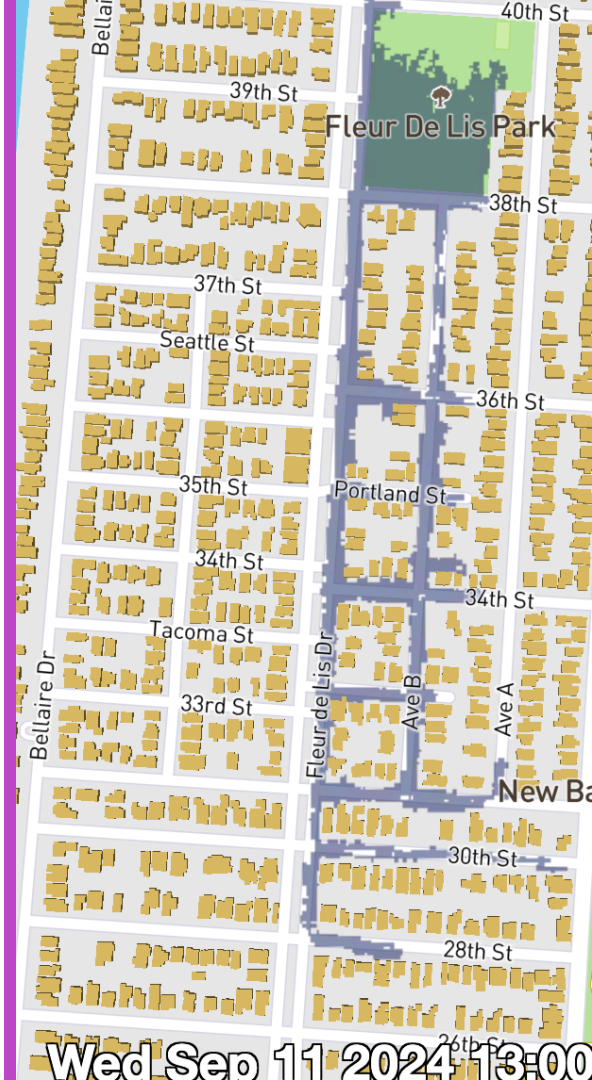
10 Fleur de Lis Drive & 34th St

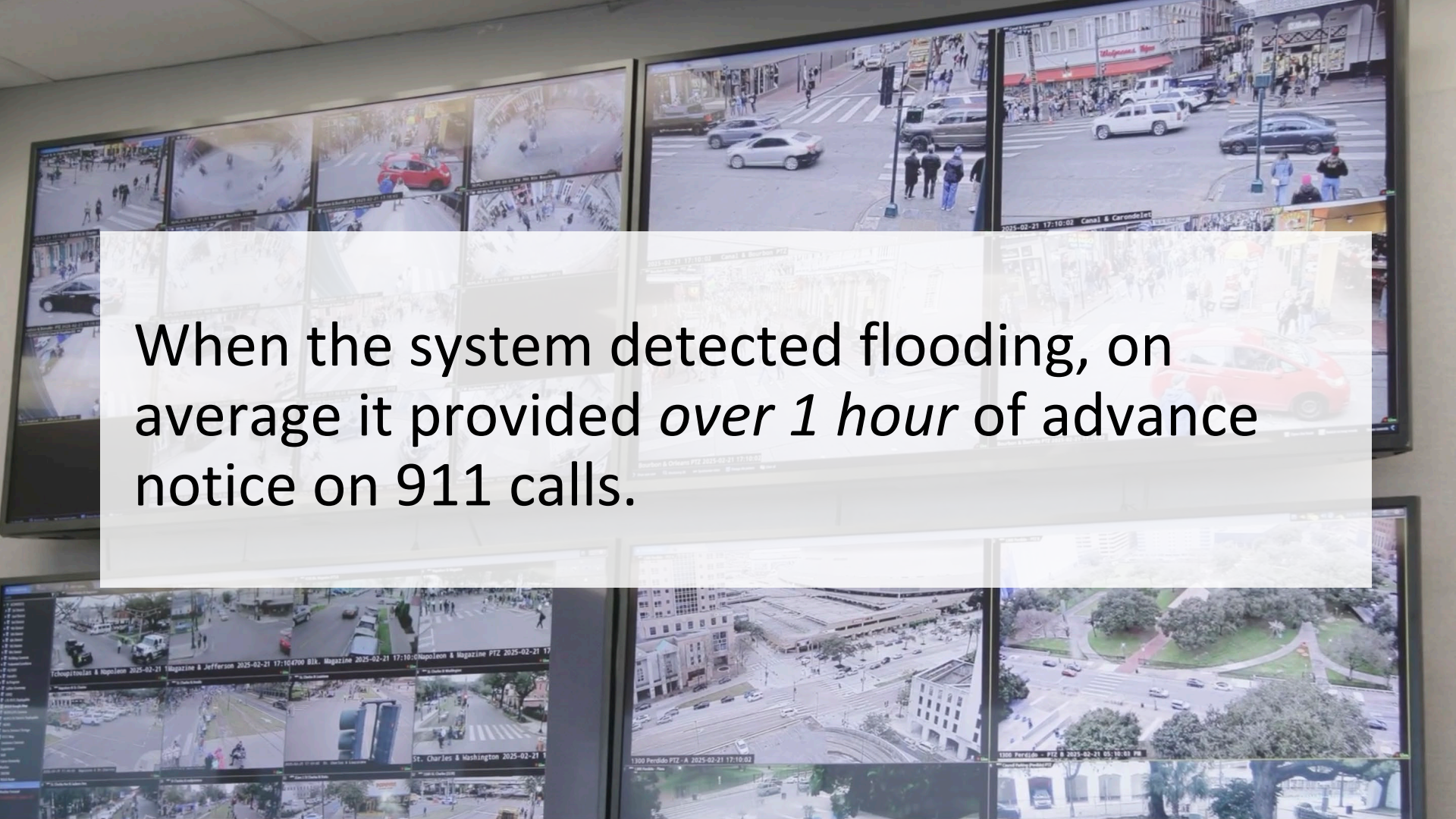




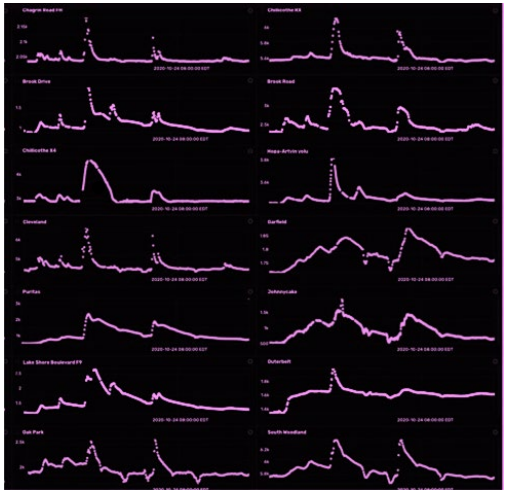

Bartholomew St
Mazant St
France St
N Johnson St
s Marsalis
er for Music
N Prieur St
Japonica St
Poland Ave
Mazant St
France St
Lesseps St
Kentucky St
N Claiborne Ave
N Robertson St
Mazant St
N Villere St
Lesseps St
Kentucky St
Japonica St
Dollar General
Malimo Coffee
ont

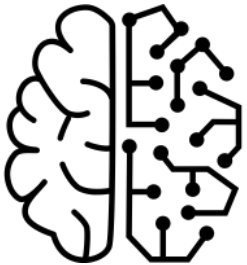

Ringold St
New Basin Canal Trail
Catina St
Milne Blvd
3019
Polk
tation
nter
Catina St
Milne Blvd
Harney St


Bellai
40th St
39th St
Fleur De Lis Park
38th St
37th St
Seattle St
36th St
35th St
Portland St
34th St
34th St
Tacoma St
Bellaire Dr
Fleur de Lis Dr
Ave B
Ave A
33rd St
New Ba
30th St
28th St
26th St
Wed Sep 11 2024 13:00



When the system detected flooding, on average it provided *over 1 hour* of advance notice on 911 calls.





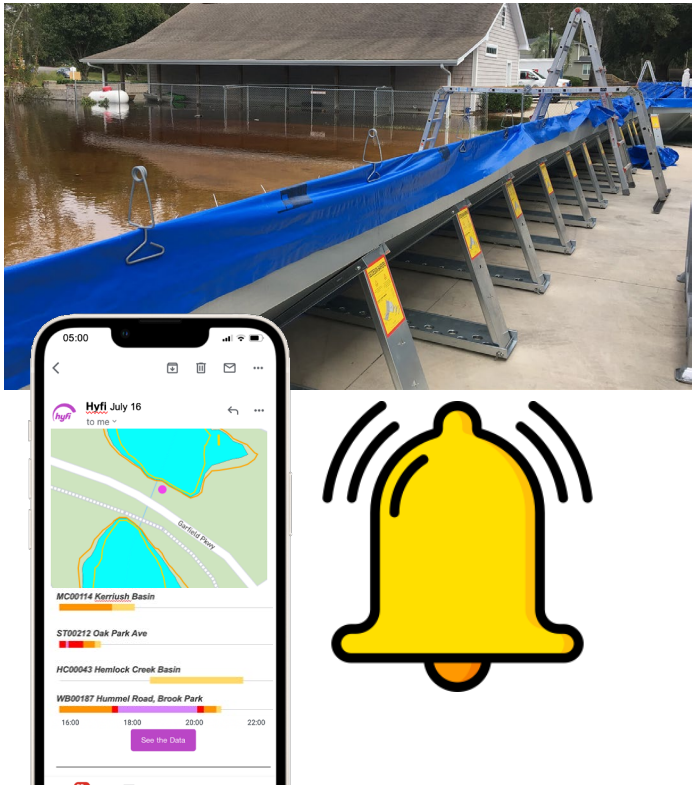
Respond
Real-time

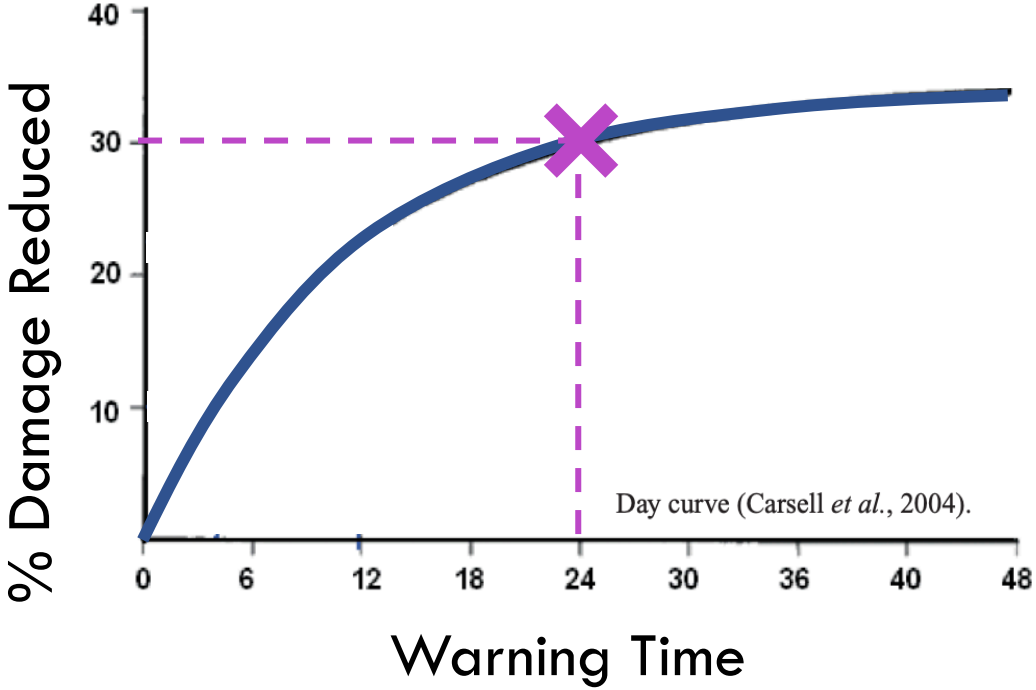
Prepare
Day Ahead

Maintain
Weeks Ahead

Plan
Years ahead

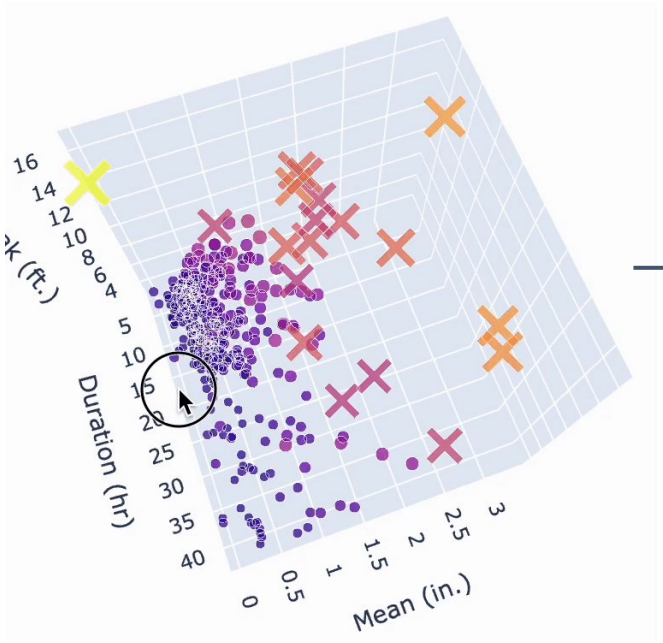
24-hour lead times reduce flood damage by 30% by putting up barriers or moving cars and property to higher ground.

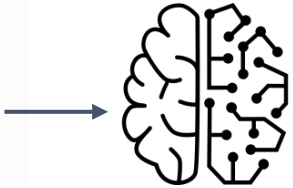


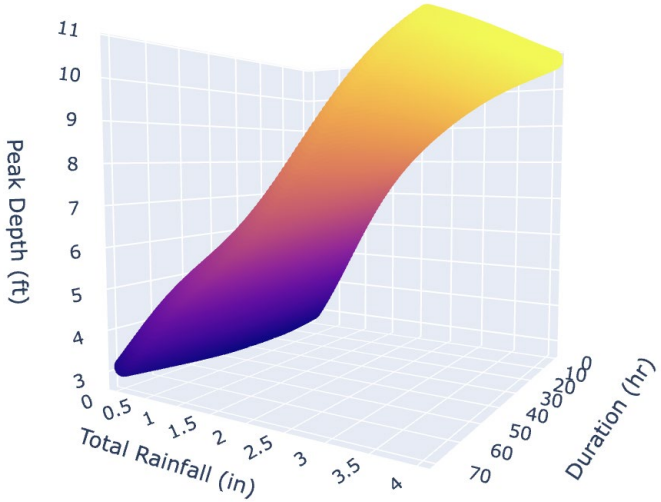


Cleveland, OH

50+ locations along streams, creeks, basins since 2020

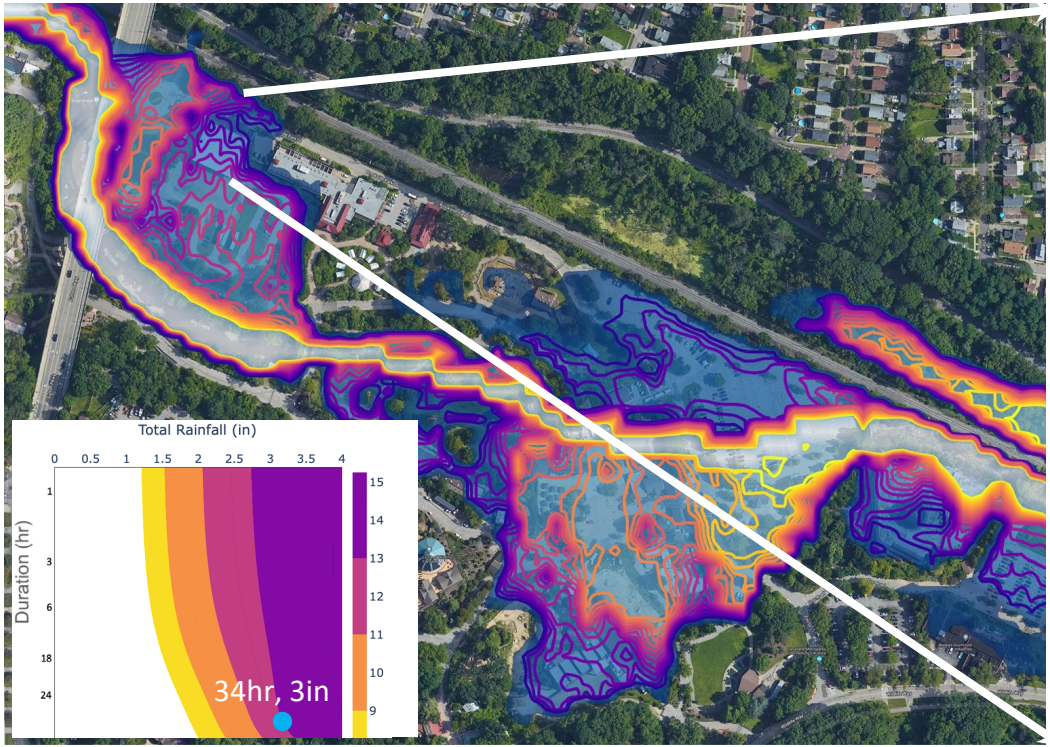

16
14
12
10
8
6
4
k (ft.)
5
10
15
20
25
30
35
40
Duration (hr)
0
0.5
1
1.5
2
2.5
3
Mean (in.)

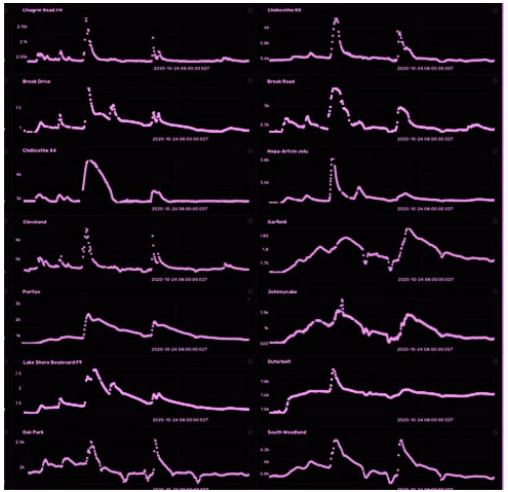


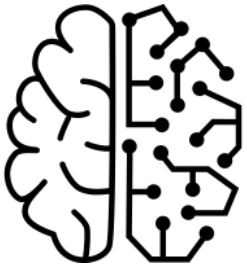

11
10
9
8
7
6
5
4
3
Peak Depth (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
Total Rainfall (in)
10
20
30
40
50
60
70
Duration (hr)

Big Creek @ Cleveland (Zoo)

Preliminary results. USGS reported 13.26 ft (Operating limit 14.5 ft)







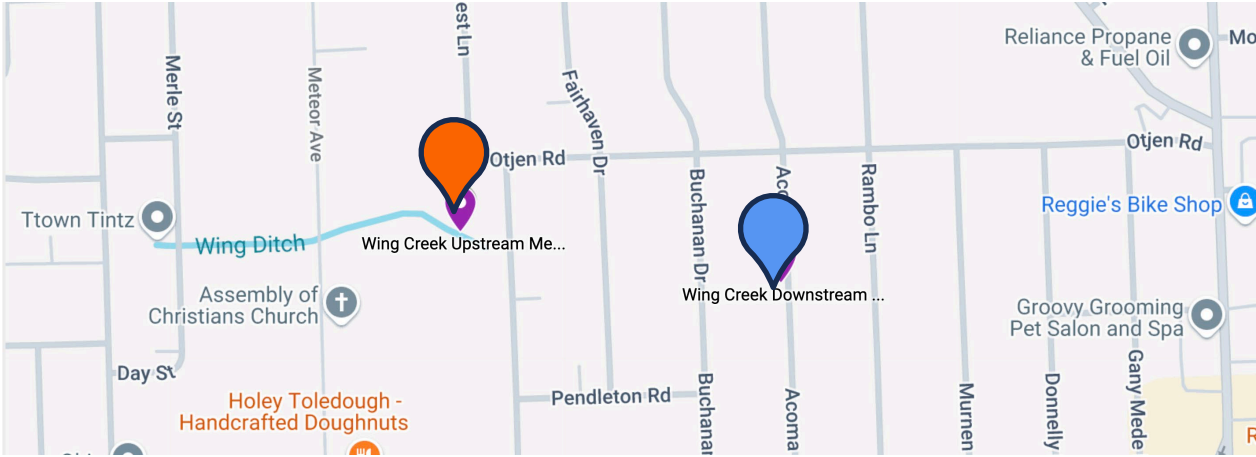
Respond
Real-time

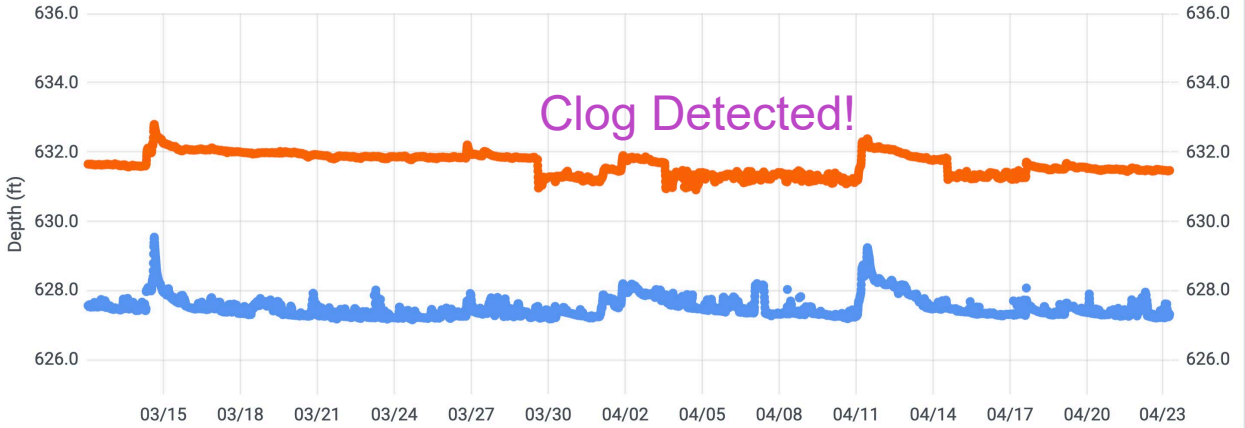
Prepare
Day Ahead

Maintain
Weeks Ahead

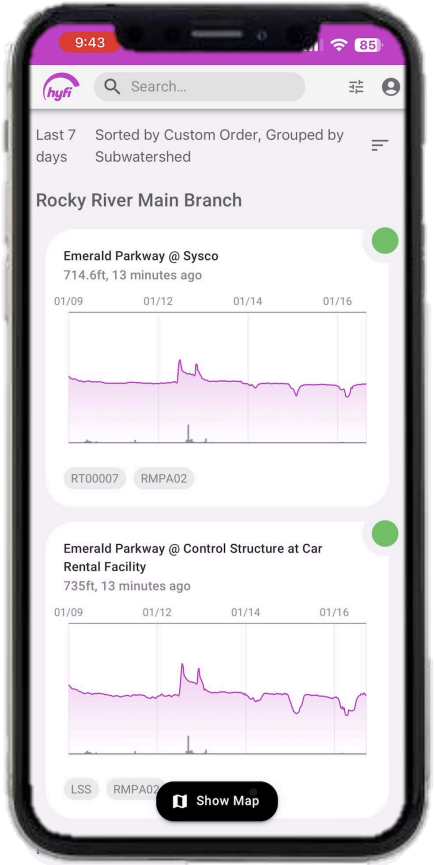
Plan
Years ahead

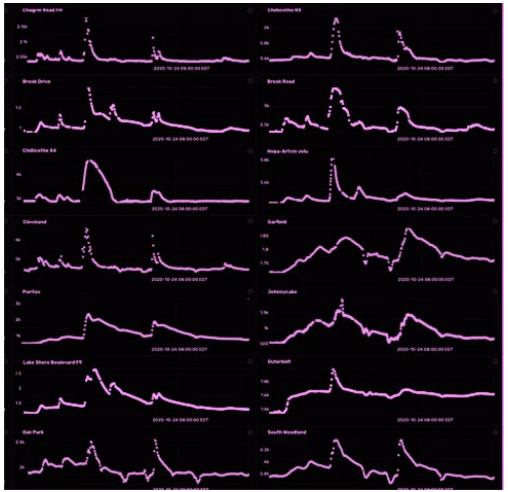
Debris & Jam Detection

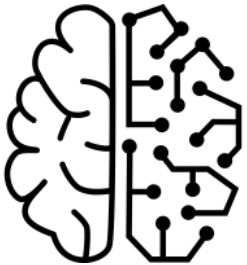





1042


9:43
85
hyfi
Search...
Last 7 days
Sorted by Custom Order, Grouped by Subwatershed
Rocky River Main Branch
Emerald Parkway @ Sysco
714.6ft, 13 minutes ago
01/09
01/12
01/14
01/16
RT00007
RMPA02
Emerald Parkway @ Control Structure at Car Rental Facility
735ft, 13 minutes ago
01/09
01/12
01/14
01/16
LSS
RMPA02
Show Map





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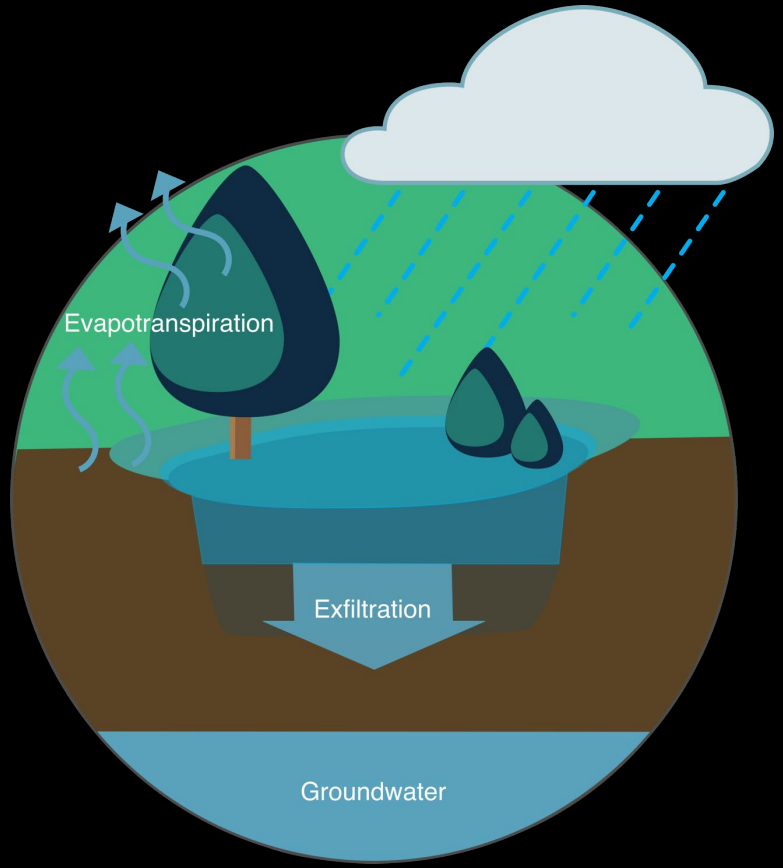
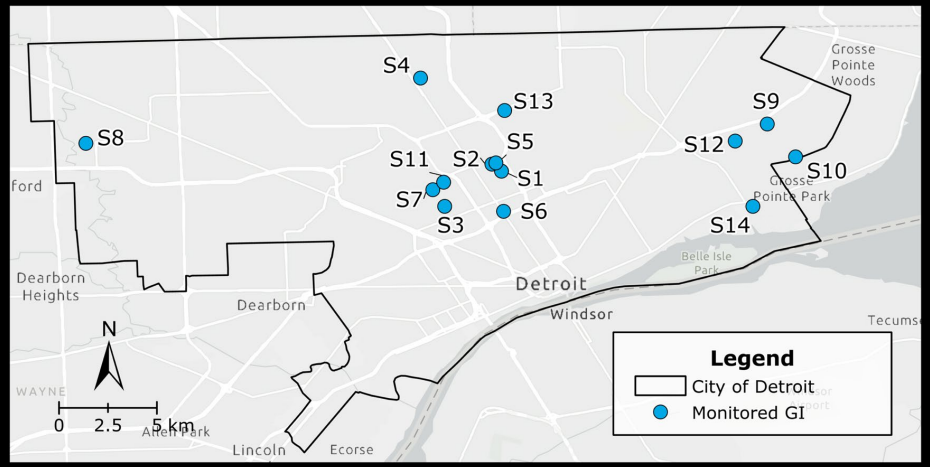
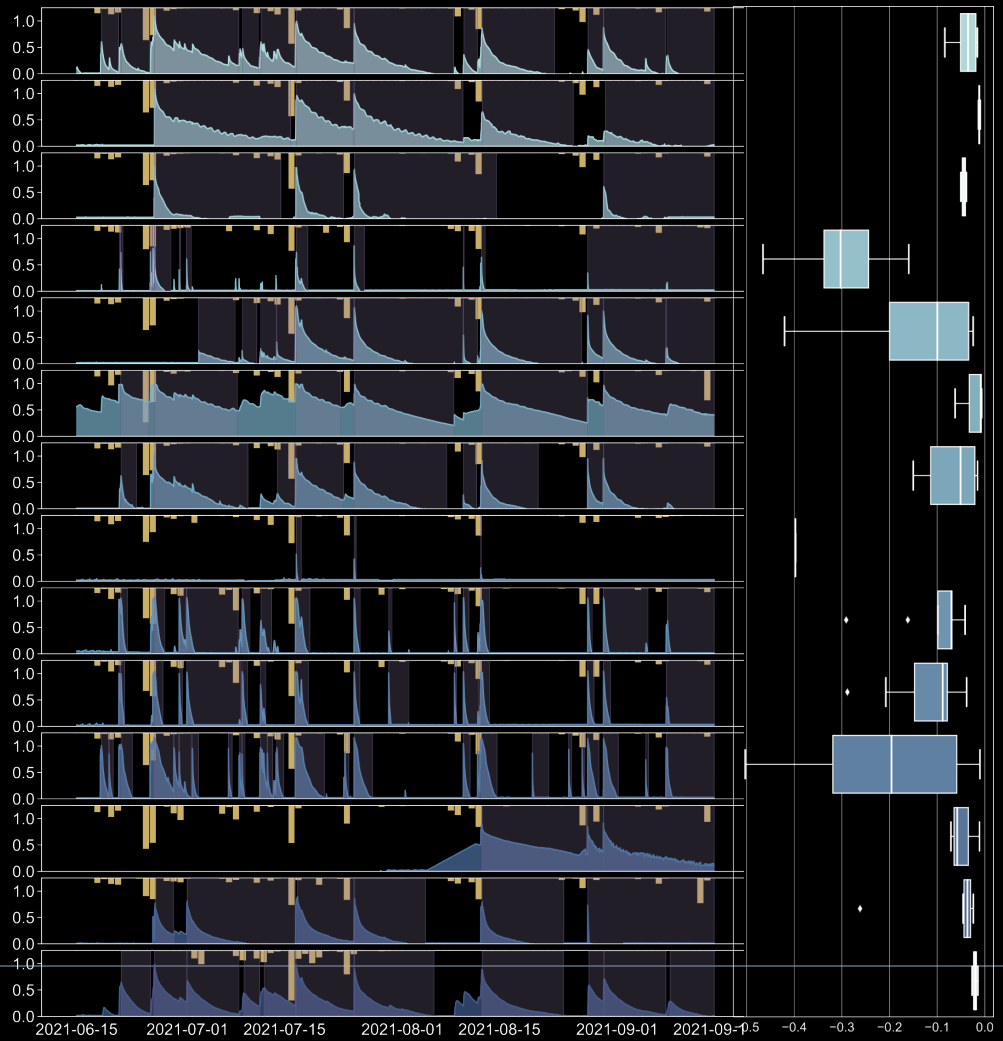
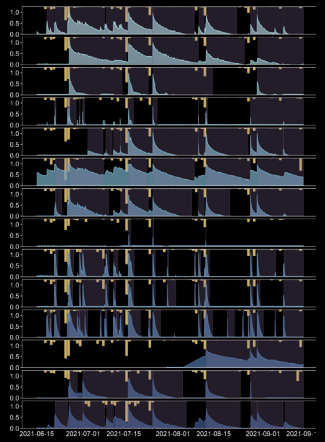
MICHIGAN
ENGINEERING

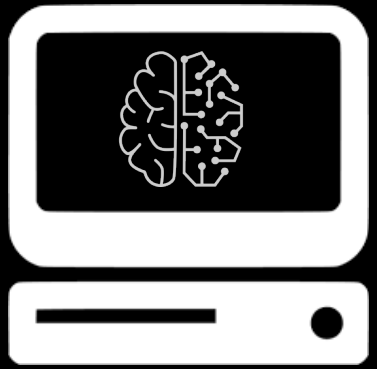

Evapotranspiration
Exfiltration
Groundwater

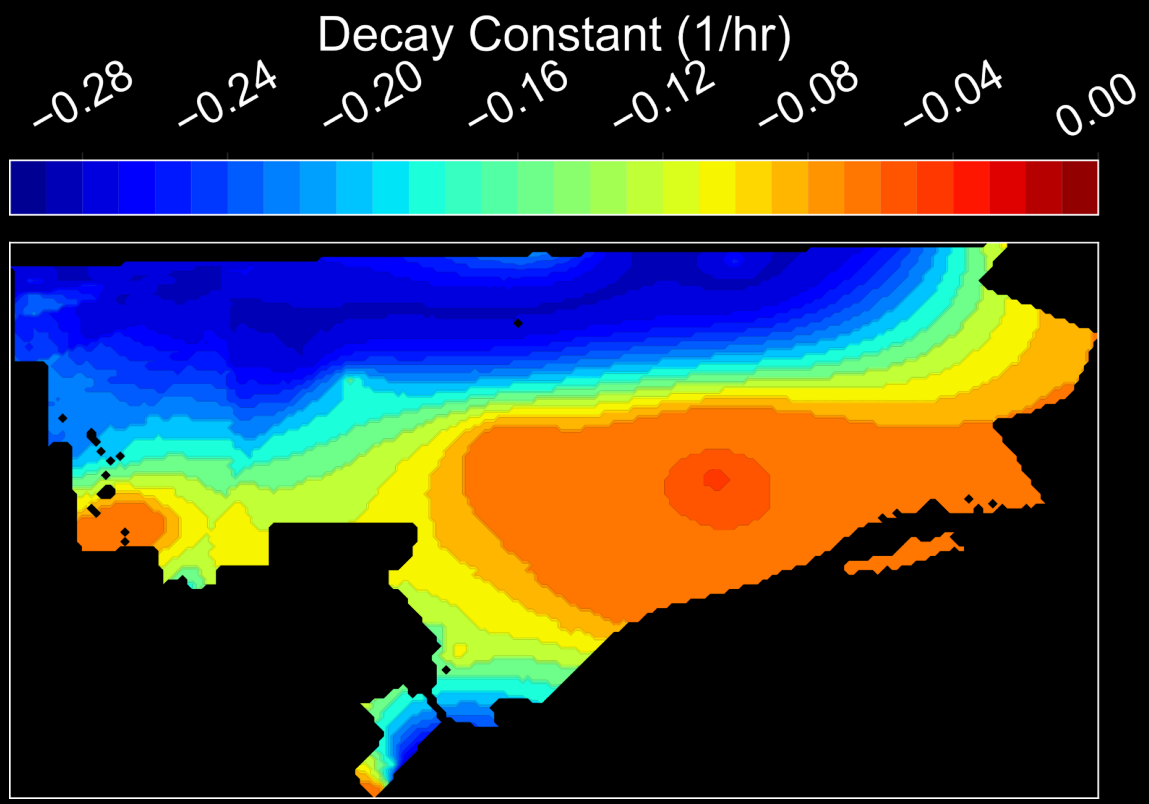

S4
S13
S9
S8
S5
S12
S11
S2
S1
S10
S7
S6
S3
S14
Grosse Pointe Woods
Grosse Pointe Park
Belle Isle Park
Ford
Dearborn Heights
Dearborn
Detroit
Windsor
Tecumse
N
WAYNE
0 2.5 5 km
Allen Park
Lincoln
Ecorse
Legend
City of Detroit
Monitored GI

hyfi.io


1.0
0.5
0.0
2021-06-15
2021-07-01
2021-07-15
2021-08-01
2021-08-15
2021-09-01
2021-09-15
−0.5
−0.4
−0.3
−0.2
−0.1
0.0


2021-06-15
2021-07-01
2021-07-15
2021-08-01
2021-08-15
2021-09-01





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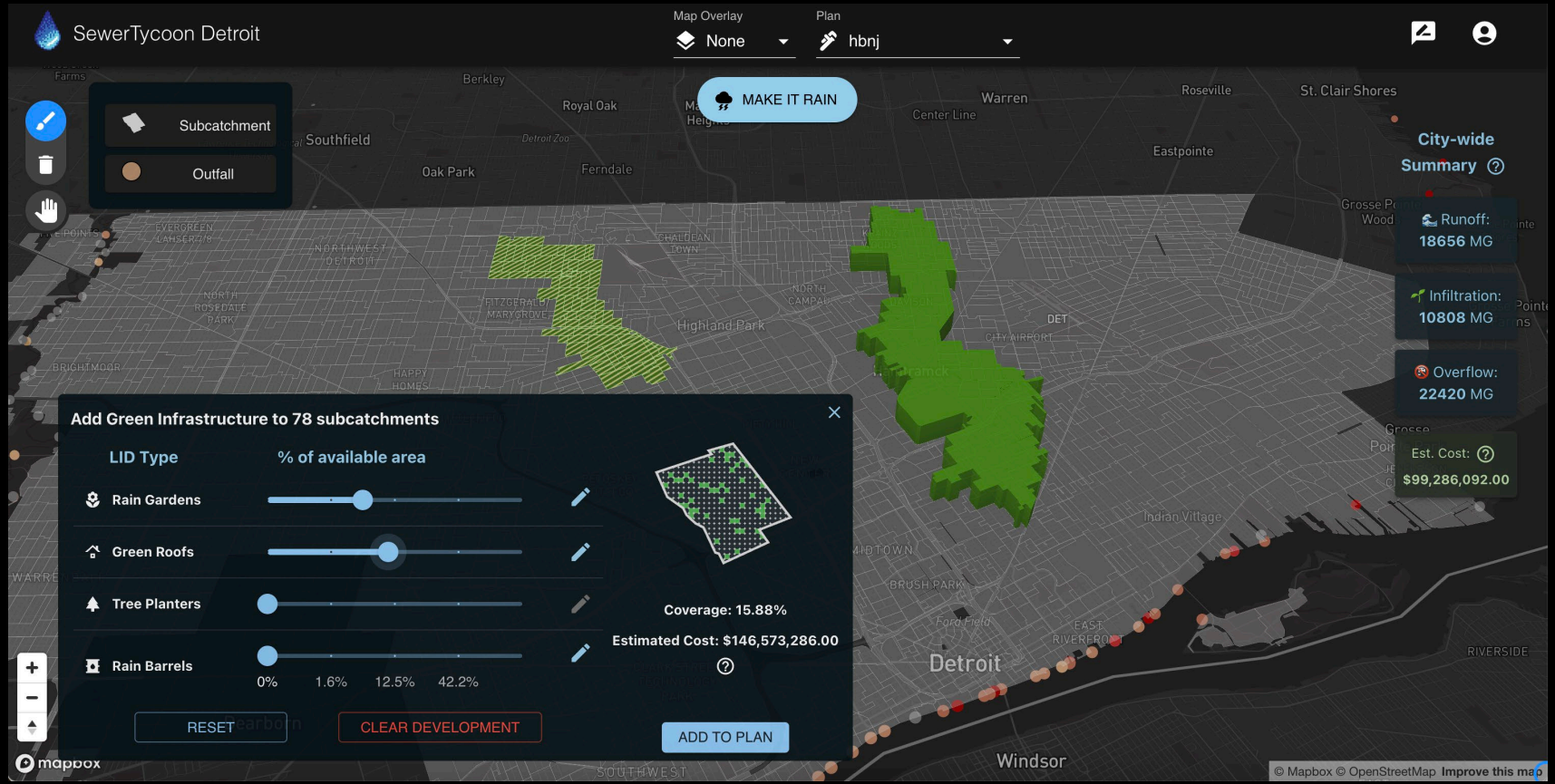

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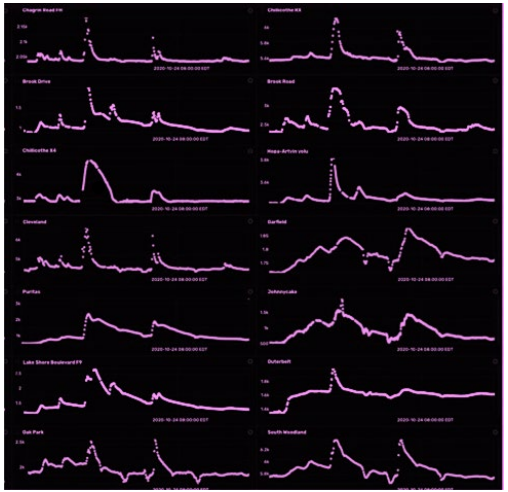

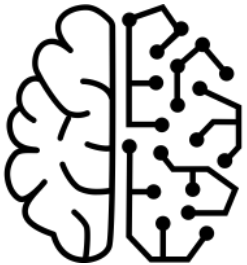

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AI tricks for pipes…and people

www.digitalwaterlab.org **www.hyfi.io**