



# Risks to Private Wells

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TEAM 2: PRIVATE WELL RISK ASSESSMENT

JACQUELINE MACDONALD GIBSON, DAVID GENEREUX, JAVAD ROOSTAEI

# High Variation in GenX and PFAS in Private Wells Has Been Observed

>1200 well water samples tested

- 19% > health goal
- 31% non-detect

## Map Key

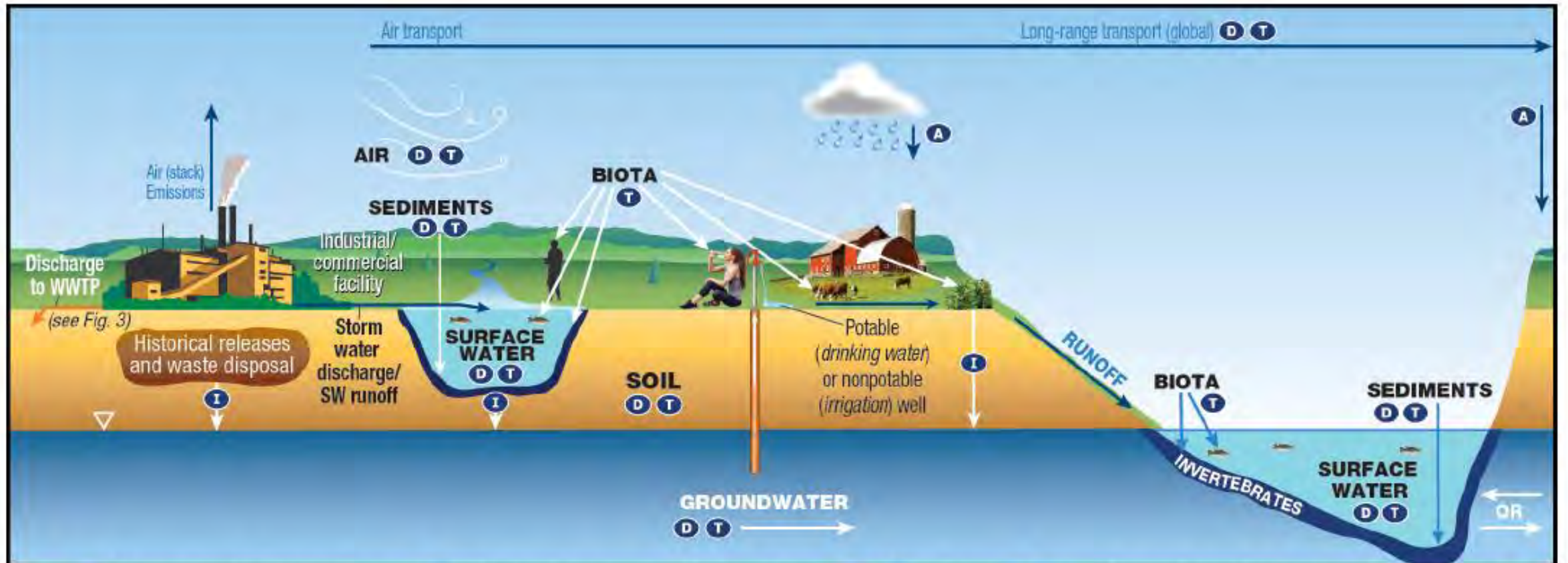
- Red = > 140 ng/L
- Yellow = 0- 140 ng/L
- Green = nondetect

Figure courtesy of DEQ



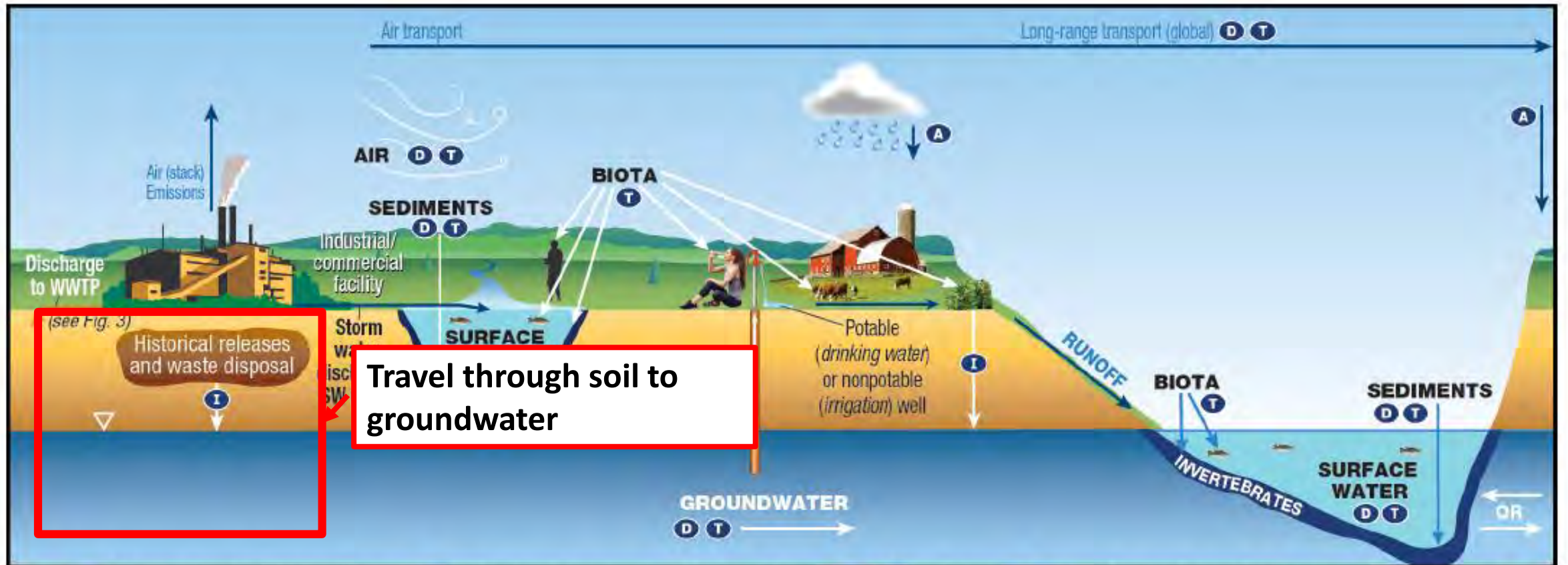


# There Are Many Ways PFAS Could Get Into Well Water



KEY **A** Atmospheric Deposition **D** Diffusion/Dispersion/Advection **I** Infiltration **T** Transformation of precursors (abiotic/biotic)

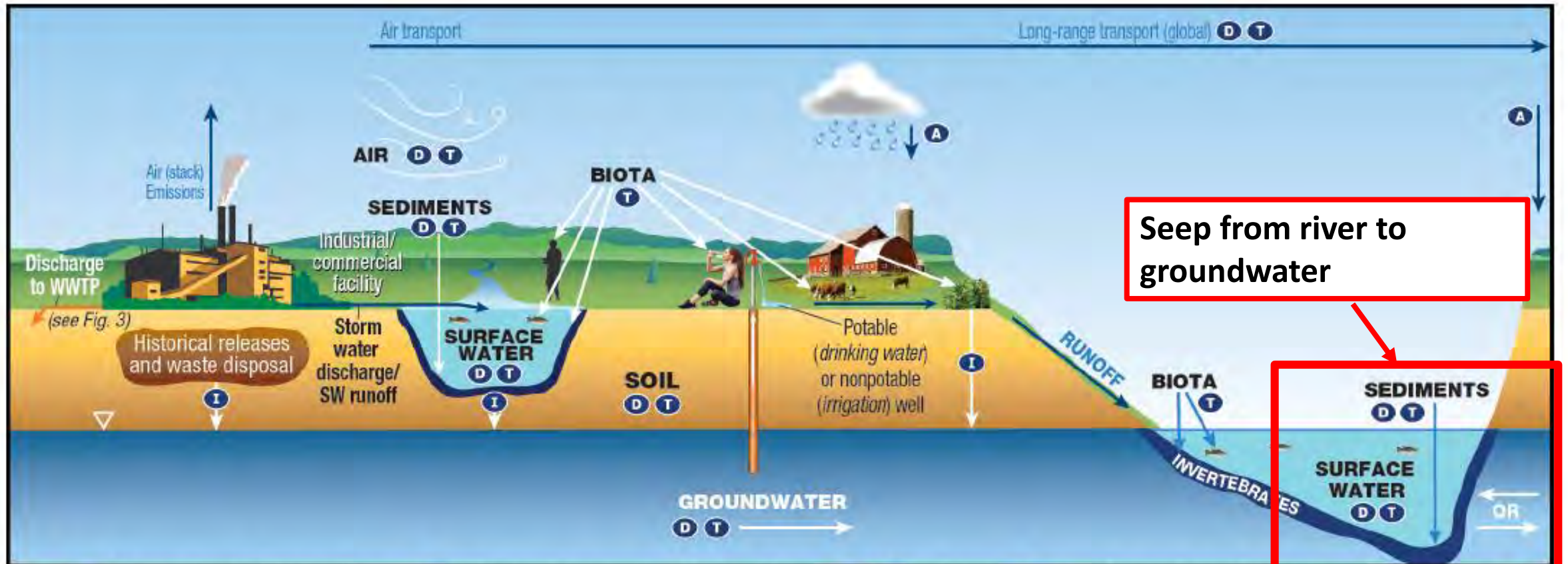
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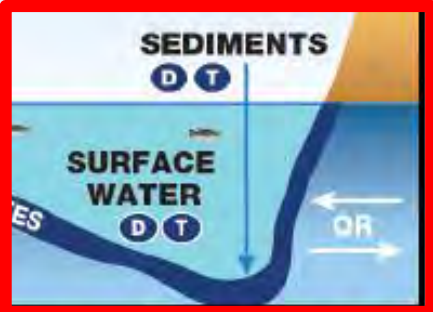
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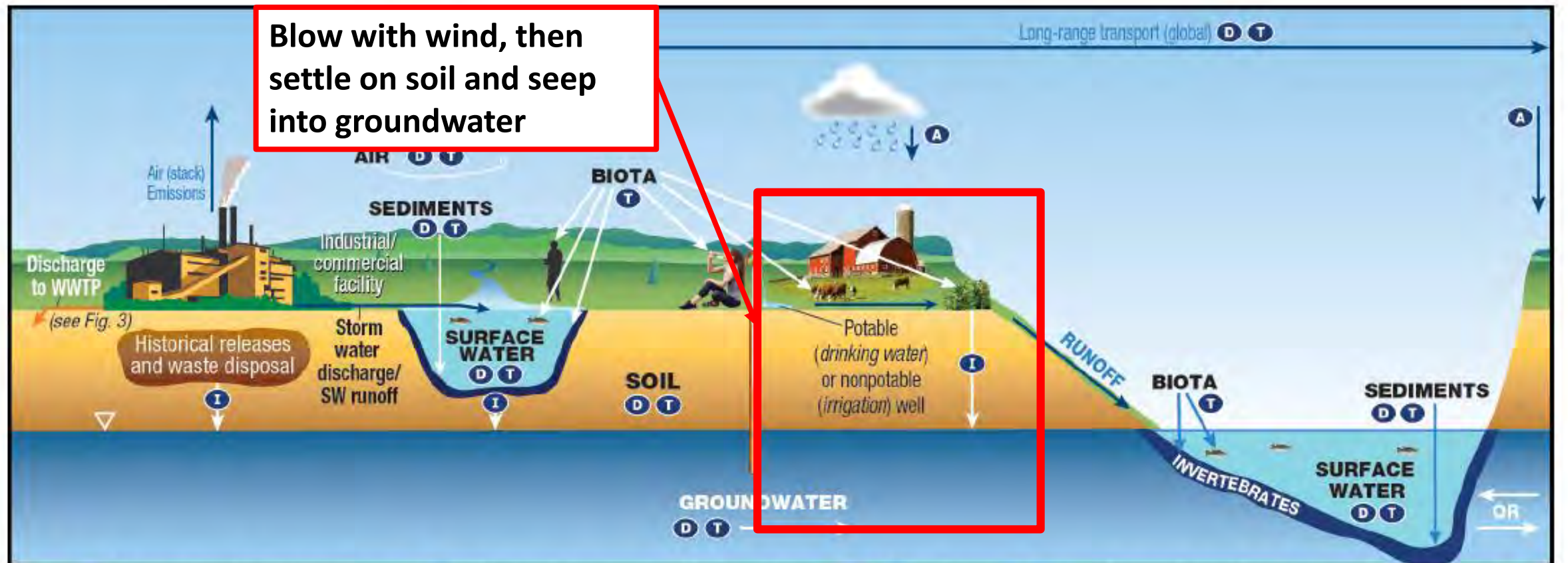


Seep from river to groundwater



KEY A Atmospheric Deposition D Diffusion/Dispersion/Advection I Infiltration T Transformation of precursors (abiotic/biotic)

# There Are Many Ways PFAS Could Get Into Well Water

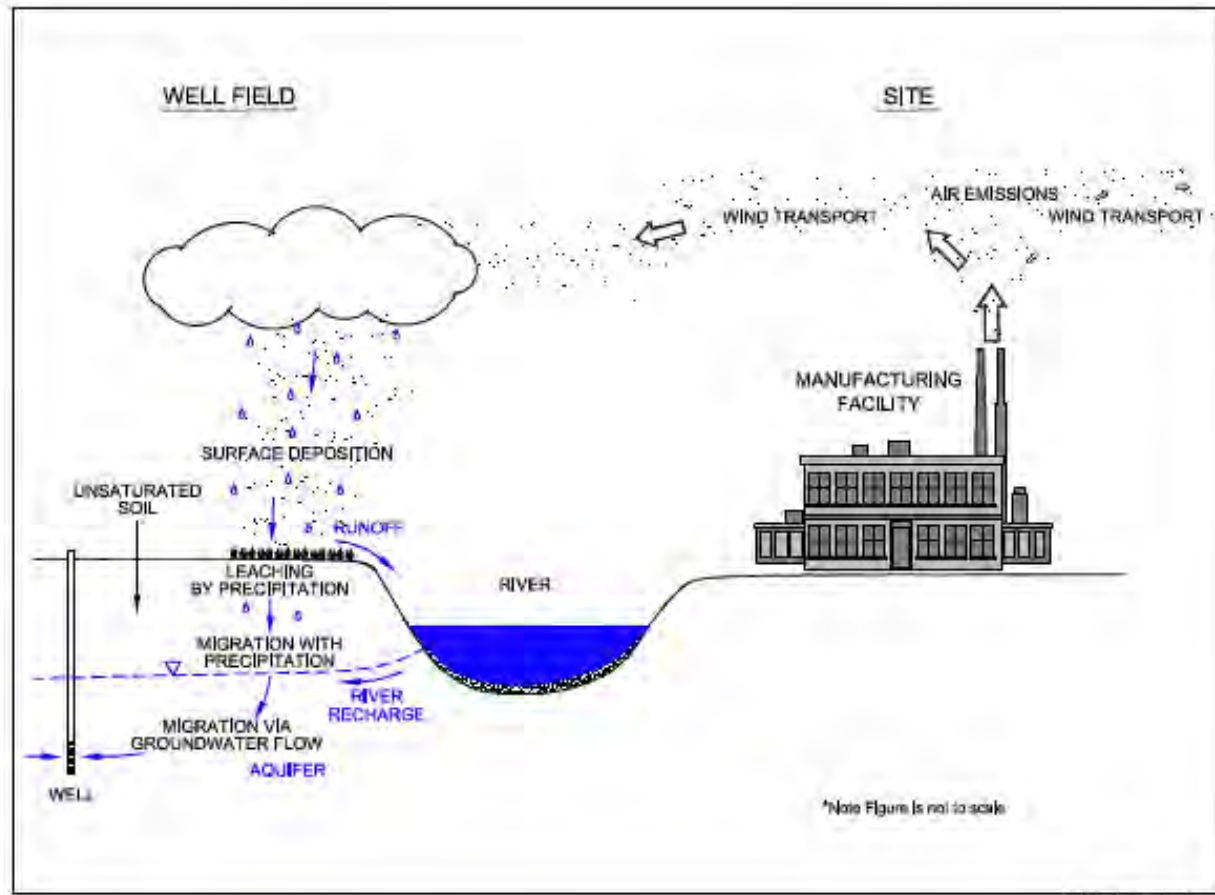


Blow with wind, then settle on soil and seep into groundwater

Potable (drinking water) or nonpotable (irrigation) well

KEY A Atmospheric Deposition D Diffusion/Dispersion/Advection I Infiltration T Transformation of precursors (abiotic/biotic)

# Experience Elsewhere Shows Travel with Wind Can Be the Most Important Source



PFAS spread with wind to water wells near Parkersburg, WV, Chemours facility.

Is wind also important in NC?

# Research Objectives

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1. Determine why some wells are contaminated and others are not.
  - What features of the wells, landscape, geology, weather, and geographic location influence risks to wells?
2. Develop user-friendly web site to help private well owners assess risks.
3. Estimate how long it will take to “flush out” the PFAS that are already in the groundwater.



# Methods

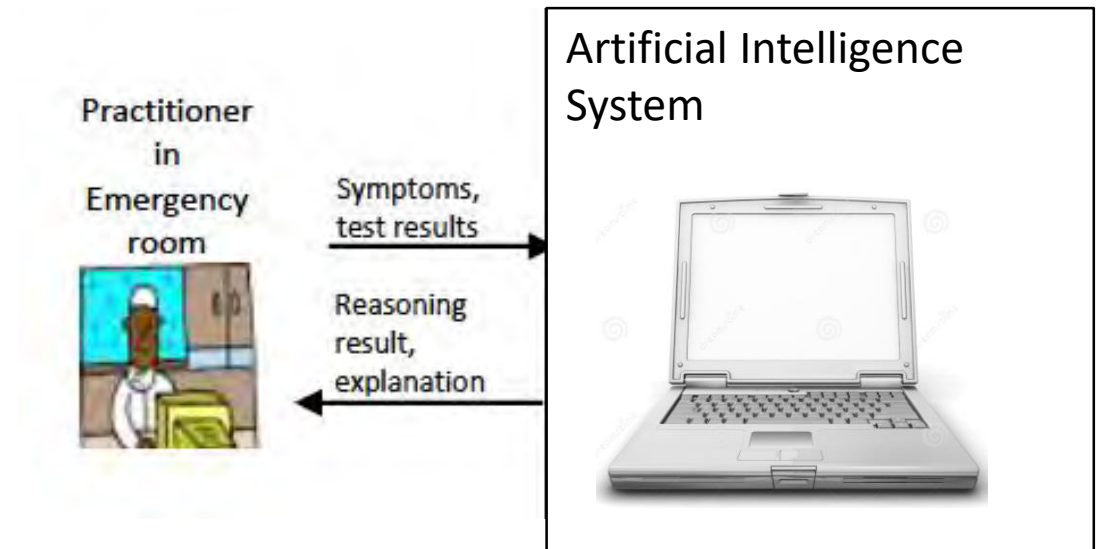
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# Use “Artificial Intelligence” to Predict Wells at Risk

U.S. NATIONAL ACADEMIES OF SCIENCES,  
ENGINEERING, AND MEDICINE

DOCTORS USE IT TO DIAGNOSE DISEASES

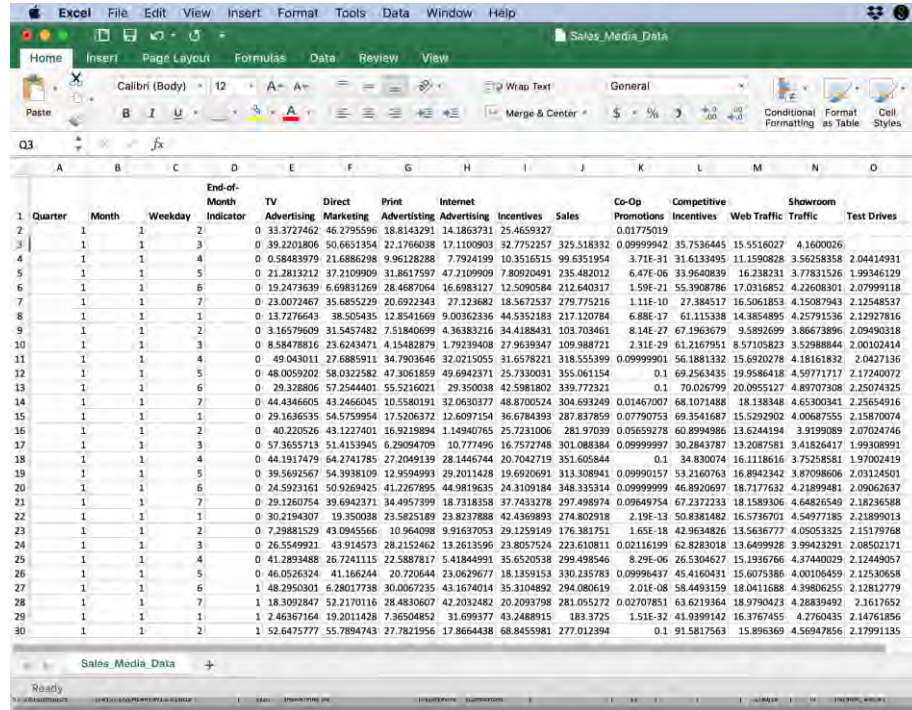
“Artificial intelligence is being called the “new electricity.”



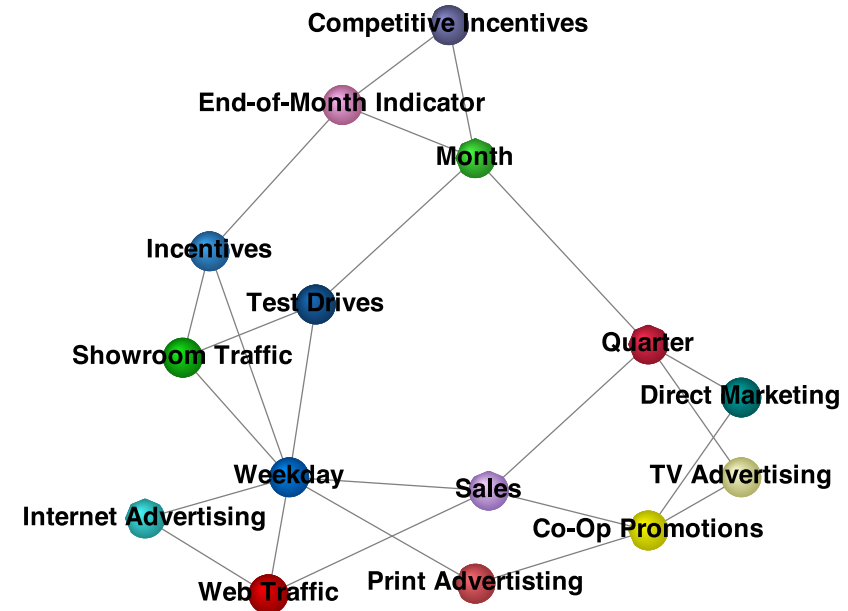
# Our Artificial Intelligence Algorithms Search for Patterns in Data

BIG DATABASES TAKE UP A LOT OF SPACE

IF WE CAN IDENTIFY PATTERNS, NEED LESS SPACE TO STORE DATA

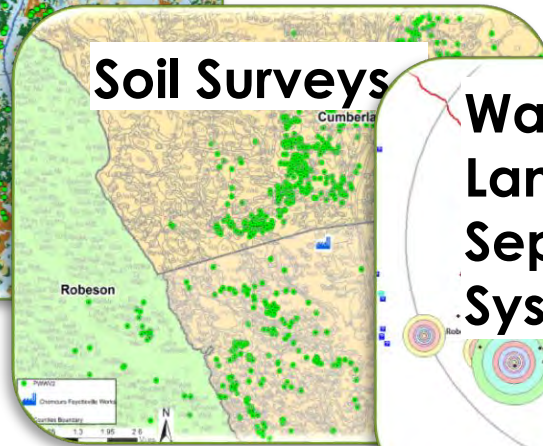
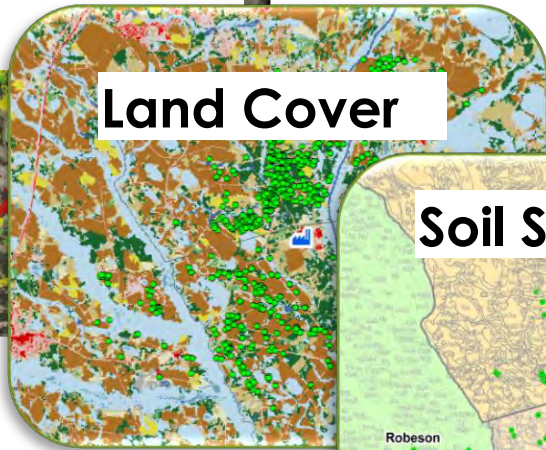
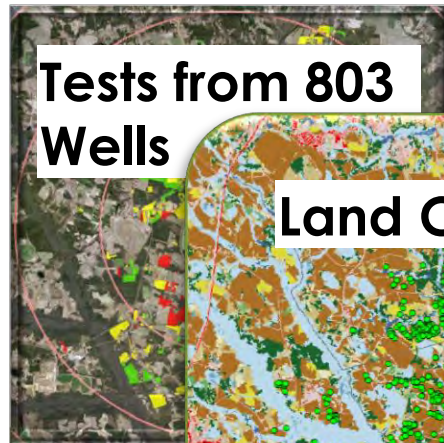


Quarter	Month	Weekday	End-of-Month Indicator	TV Advertising	Direct Marketing	Print Advertising	Internet Advertising	Incentives	Sales	Co-Op Promotions	Competitive Incentives	Web Traffic	Showroom Traffic	Test Drives	
1	1	1	2	0	33.3727452	46.2795596	18.8143291	14.1863731	25.4659327	0.01175019					
2	1	1	3	0	39.2201806	50.6631354	22.1766038	17.1100903	32.7752257	0.09999942	35.7536445	15.5516027	4.16000026		
3	1	1	4	0	0.58483979	21.6886298	9.96128288	7.7924199	10.3516515	99.6351954	3.71E-31	31.6133495	11.1590828	3.56258358	2.04414931
4	1	1	5	0	21.2813212	37.2109900	31.8617597	47.2109900	7.80920491	235.482012	6.47E-06	33.9640839	16.238231	3.77831526	1.99346129
5	1	1	6	0	15.2473639	6.69831269	28.4687064	16.6983127	12.5090584	212.640317	1.59E-21	55.3908786	17.0316852	4.22608301	2.07999118
6	1	1	7	0	23.0072467	35.6855229	20.6922343	27.123682	18.5672537	279.775216	1.11E-10	27.384517	16.5061853	4.15087943	2.12548537
7	1	1	1	0	13.7276643	38.505435	12.8541669	9.00362336	44.5352183	217.120784	6.88E-17	61.115338	14.3854895	4.25791536	2.12927816
8	1	1	2	0	3.16579609	31.5457482	7.51840699	4.36383216	34.4188431	103.703461	8.14E-27	67.1963679	9.5892699	3.86673896	2.09490318
9	1	1	3	0	8.58478816	23.6243471	4.15482879	1.79239408	27.9639347	109.988721	2.31E-29	61.2167951	8.57105823	3.52988844	2.00102414
10	1	1	4	0	49.043011	27.6885911	34.7903646	32.0215055	31.6578221	318.555399	0.09999901	56.1881332	15.6920278	4.18161832	2.0427136
11	1	1	5	0	48.0059302	38.0323582	47.3051859	49.6942371	25.7330031	355.061154	0.1	69.2563435	19.9586418	4.59771717	2.12740072
12	1	1	6	0	29.328806	57.2544001	55.5216021	29.350038	42.5981802	339.772321	0.1	70.026799	20.0955127	4.89707308	2.25074325
13	1	1	7	0	44.4346605	43.2466045	10.5580191	32.0630377	48.8700524	304.693240	0.01467007	68.1071488	18.138348	4.65300341	2.25645916
14	1	1	1	0	29.1636535	54.5759954	17.5206372	12.6097154	36.6784393	287.837859	0.07790573	69.3541687	15.5292902	4.00687555	2.15870074
15	1	1	2	0	40.220526	43.1227401	16.9219894	1.14940765	25.7231006	281.97039	0.05659278	60.8994986	13.6244194	3.9199089	2.07024746
16	1	1	3	0	57.3655713	51.4153945	6.29094709	10.777496	16.7527248	301.088384	0.09999997	30.2843787	13.2087581	3.41826417	1.99308991
17	1	1	4	0	44.1917479	64.2741785	27.2049139	28.1446744	20.7042719	351.605844	0.1	34.830074	16.1118616	3.75258581	1.97002419
18	1	1	5	0	39.5692567	54.3938109	12.9594993	29.2011428	19.6920691	313.308941	0.09990157	53.2160763	16.8942342	3.87098606	2.03124501
19	1	1	6	0	24.5923161	50.9269425	41.2267895	44.9819635	24.3109184	348.335314	0.09999999	46.8920697	18.717632	4.2189481	2.09062637
20	1	1	7	0	29.1260754	39.6942371	34.4957399	18.7318358	37.7433278	297.498974	0.09649754	67.2727233	18.1589306	6.64826540	2.18236358
21	1	1	1	0	30.2194307	19.350038	23.5825189	23.8237888	42.4369893	274.802918	2.19E-13	50.8281482	16.5726701	4.54977385	2.18890113
22	1	1	2	0	7.28881529	43.0945565	10.964098	9.91657053	29.1259149	176.381751	1.65E-18	42.9634826	13.5636777	4.0052325	2.15179768
23	1	1	3	0	26.5549921	43.914573	28.2152462	13.2613596	23.8057524	223.610811	0.02116199	62.8283018	13.6499928	3.99423291	2.08502171
24	1	1	4	0	41.2893488	26.7241115	22.5887817	5.41844991	35.620538	299.498546	8.29E-06	26.5304627	15.1936766	4.37440029	2.12440057
25	1	1	5	0	46.0526324	41.166244	20.720644	23.0629677	18.1359153	330.235783	0.09996437	45.4160431	16.075386	4.00106459	2.12530658
26	1	1	6	1	48.2950301	6.28017738	30.0067235	43.1674014	35.3104892	294.080619	2.01E-08	58.4493159	18.0411688	3.9806255	2.12812779
27	1	1	7	1	18.3092847	52.2170116	28.4830607	42.2032482	20.2093798	281.055272	0.02707851	63.6219364	18.9790423	3.88069492	2.1617652
28	1	1	1	1	2.46367164	19.2011428	7.36504852	31.6993777	43.2488915	183.3725	1.51E-32	41.9399142	16.3767455	4.2760435	2.14761896
29	1	1	2	1	52.6475777	55.7894743	27.7821956	17.8664438	68.8455981	277.012394	0.1	91.5817563	15.896369	4.56947856	2.17991135





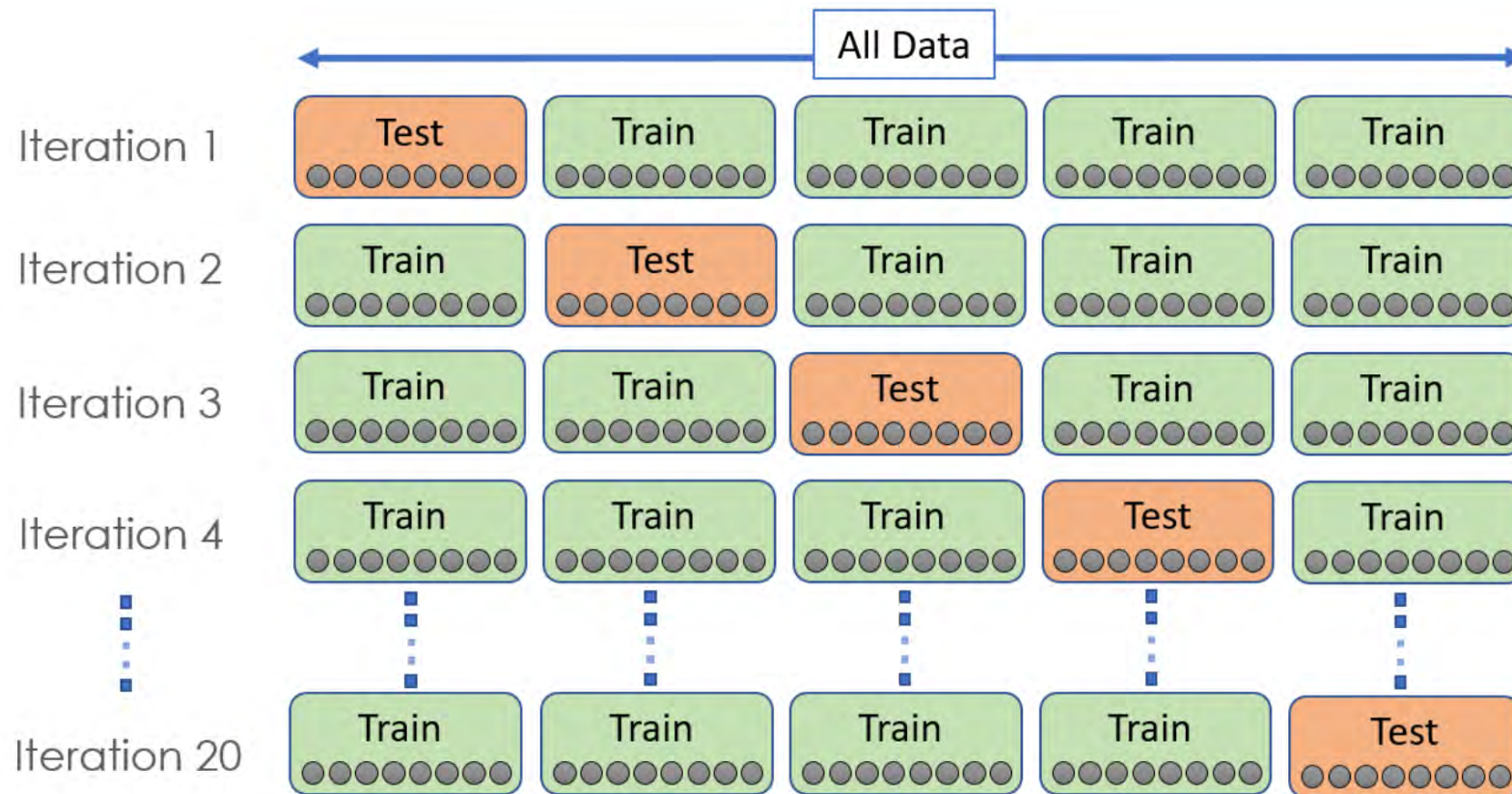
# We Built a Database of Multiple Factors That Might Influence GenX in Well Water



803 wells

76 types of data

# We “Train” the Model on Part of the Data and Test Its Accuracy on the Rest

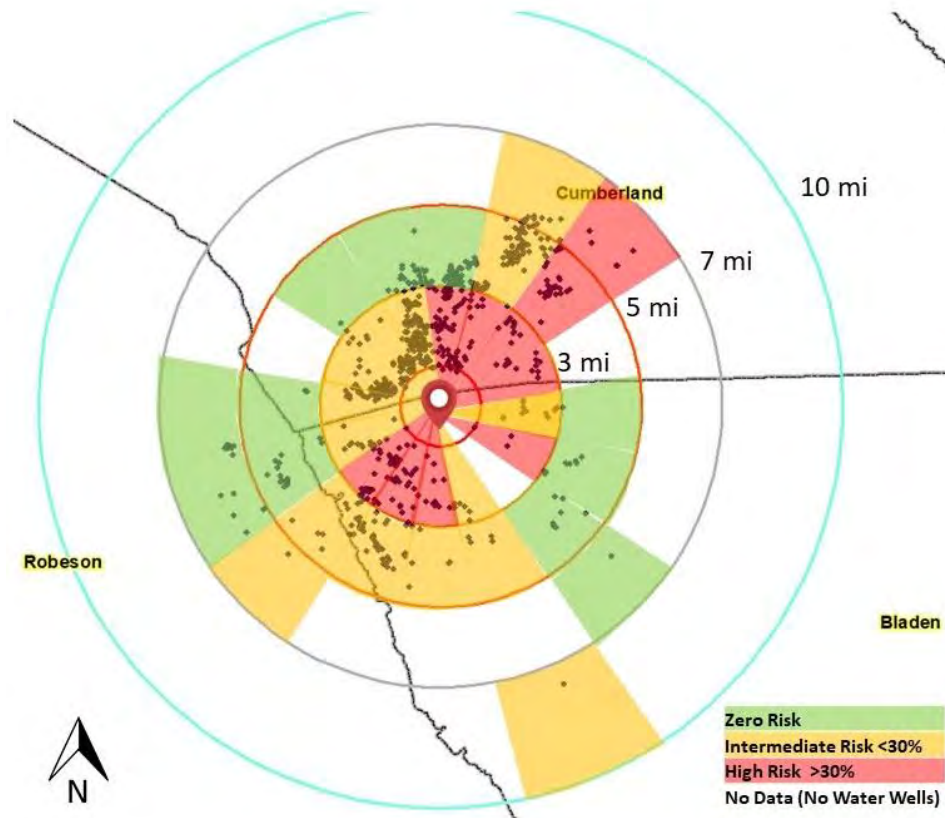


# Preliminary Results

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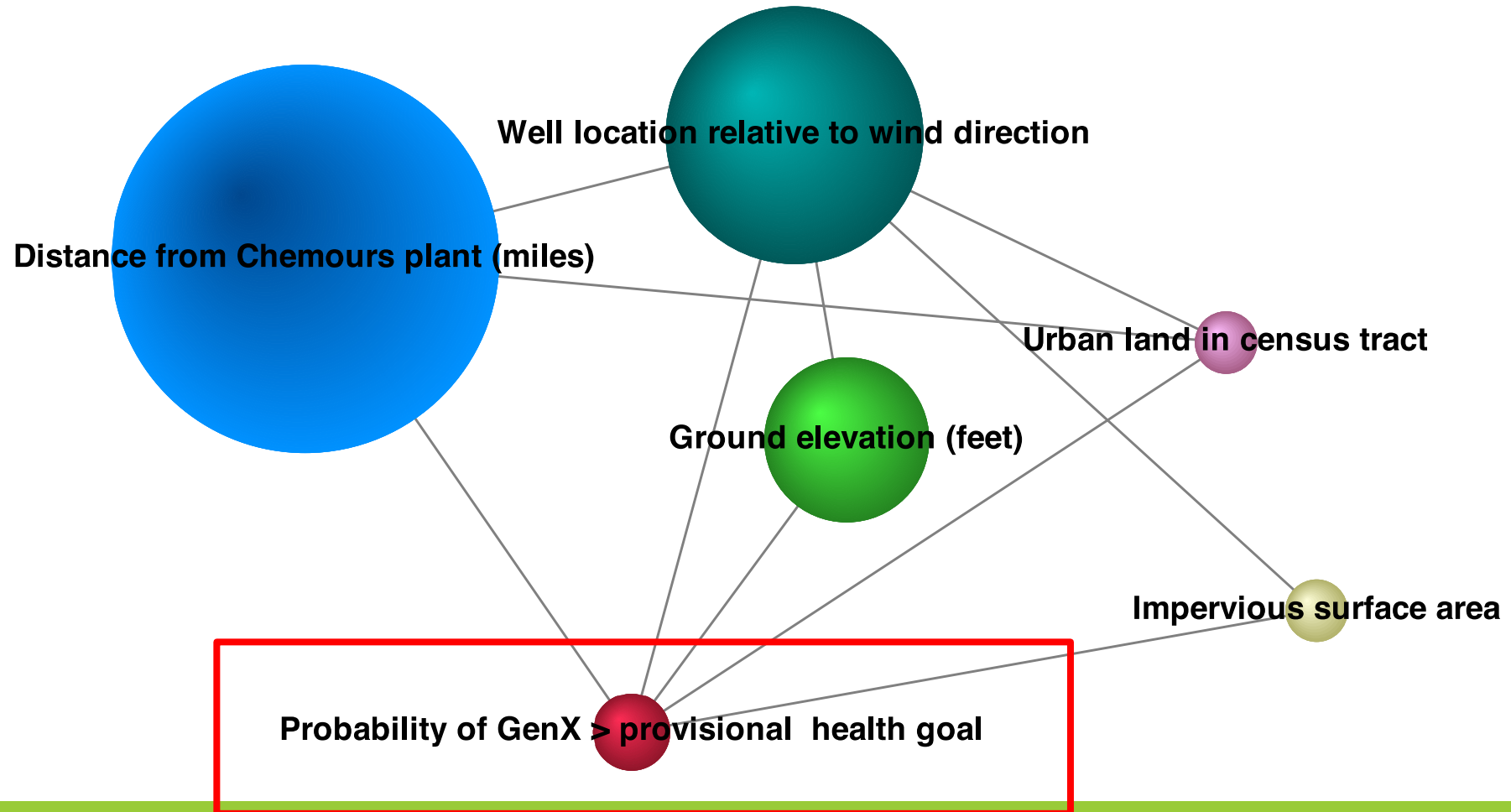
# Artificial Intelligence System Predicts Where GenX Is Likely to Exceed Health Goal



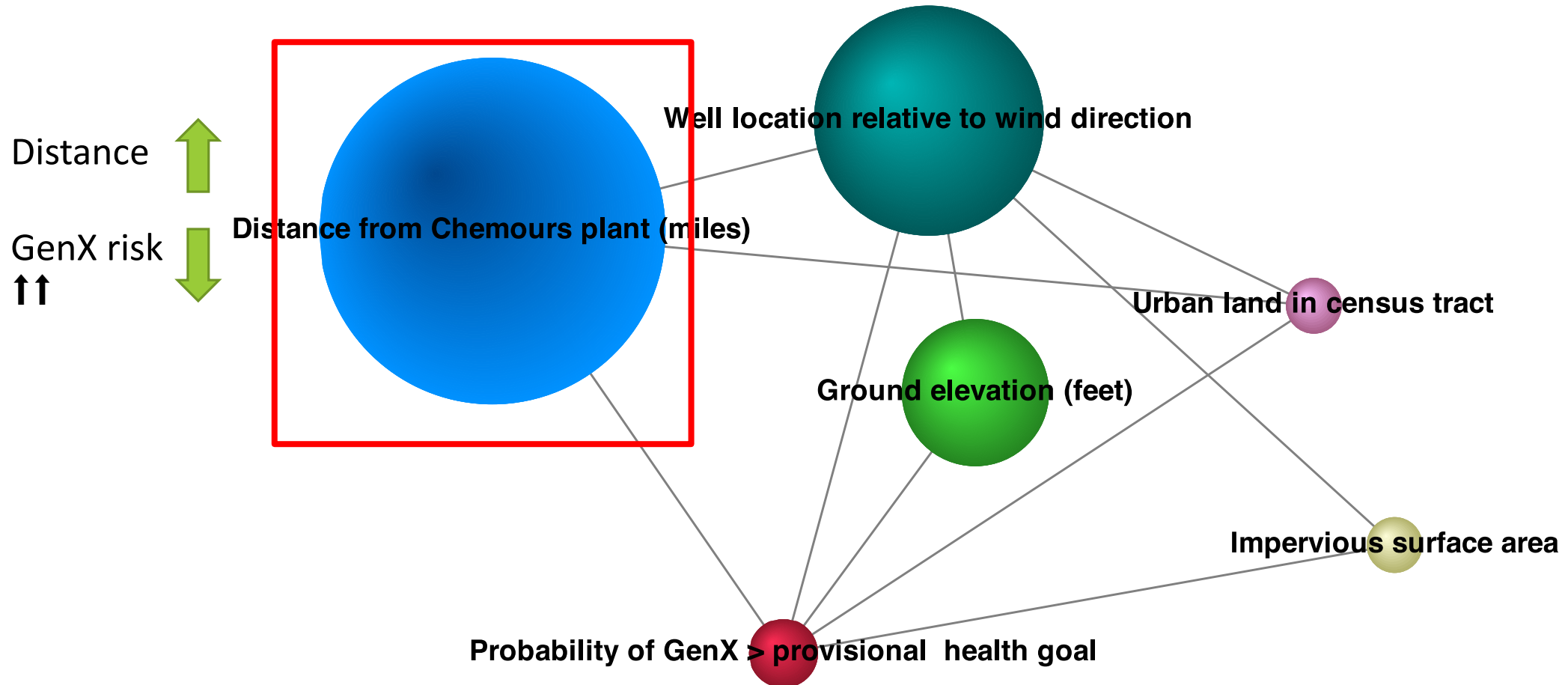
Predicted chance of GenX occurrence above provisional health goal (140 ng/L)

# Distance, Wind Direction Are the Major Factors Influencing GenX in Wells (So Far)

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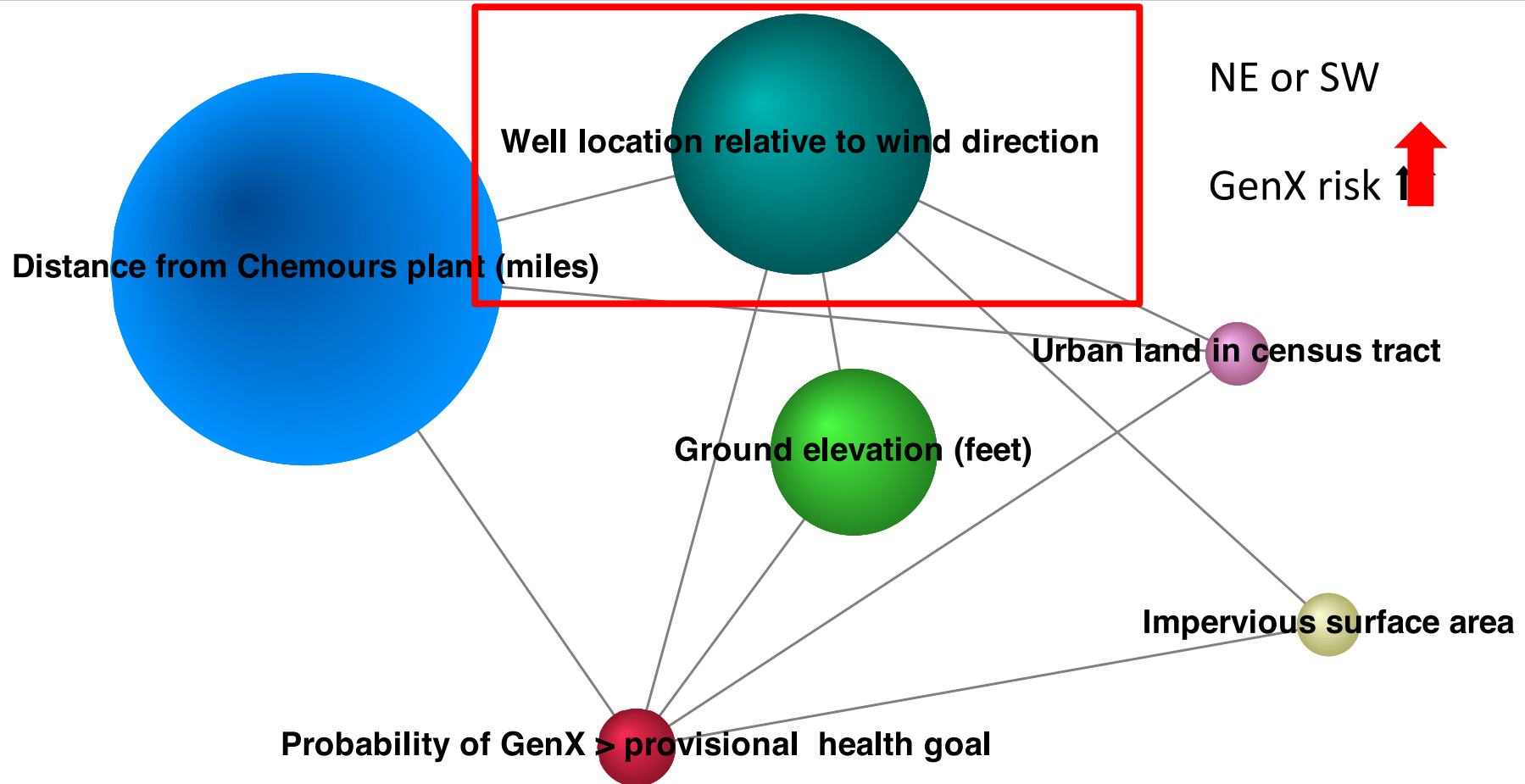


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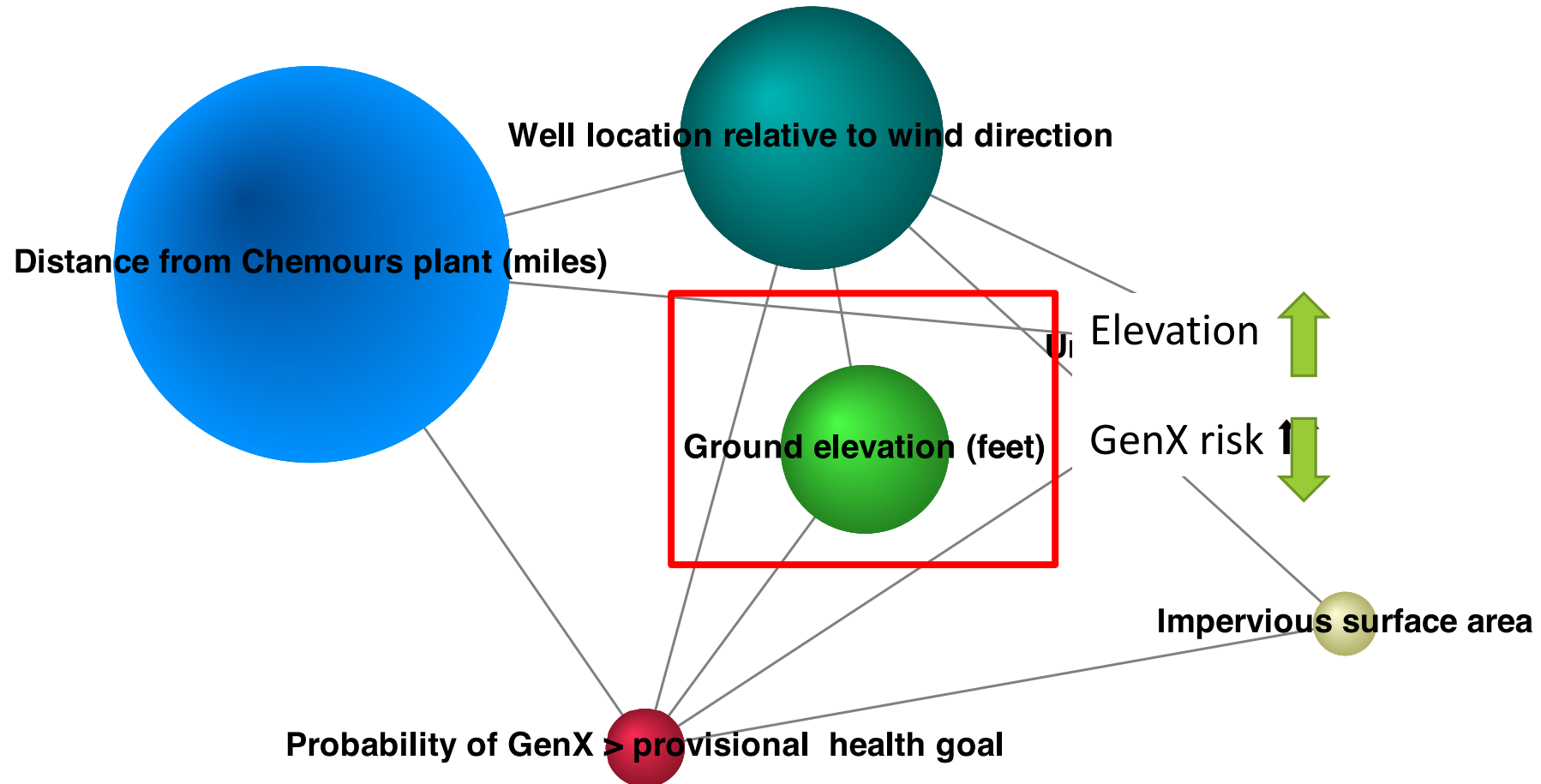




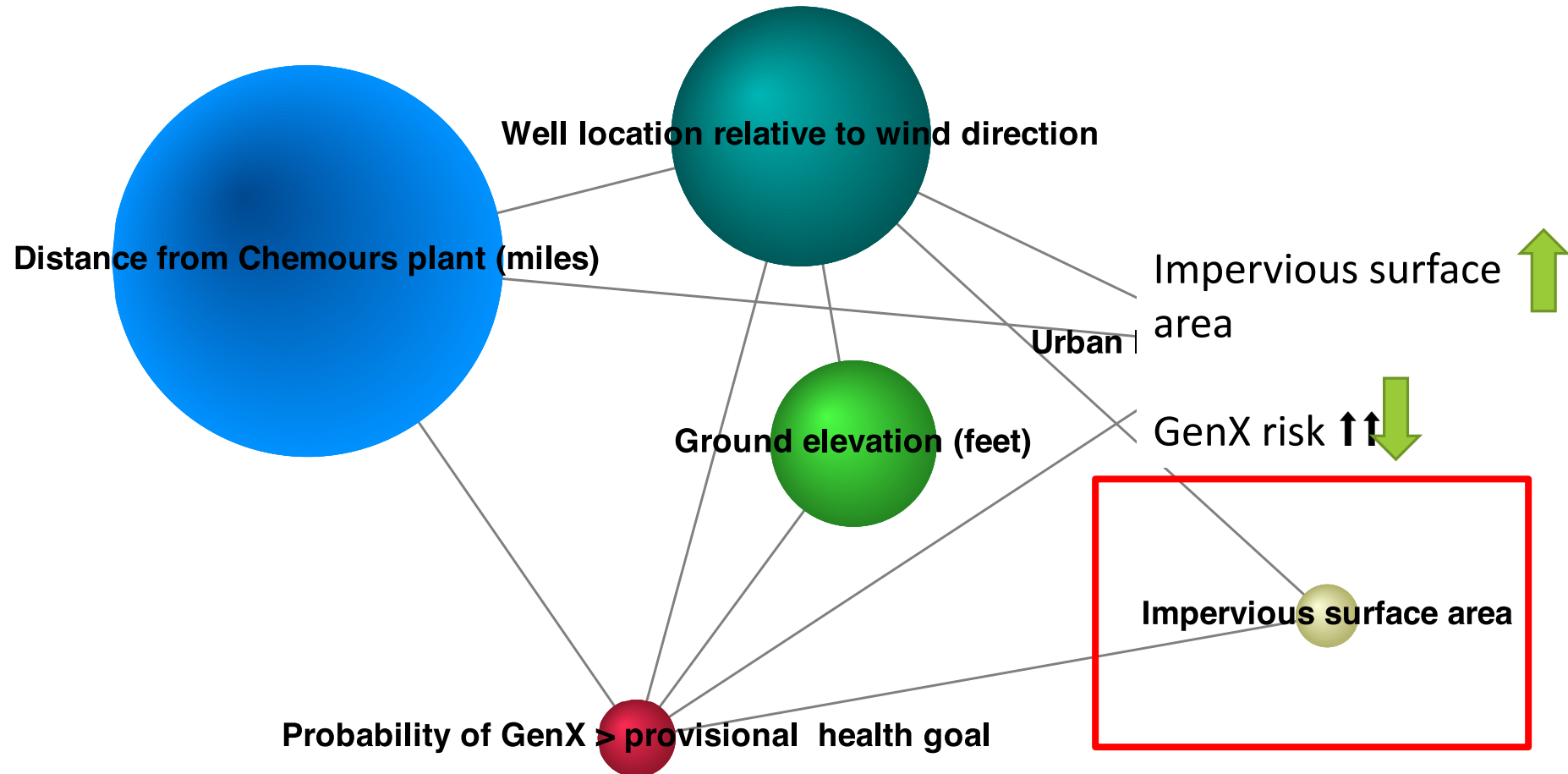
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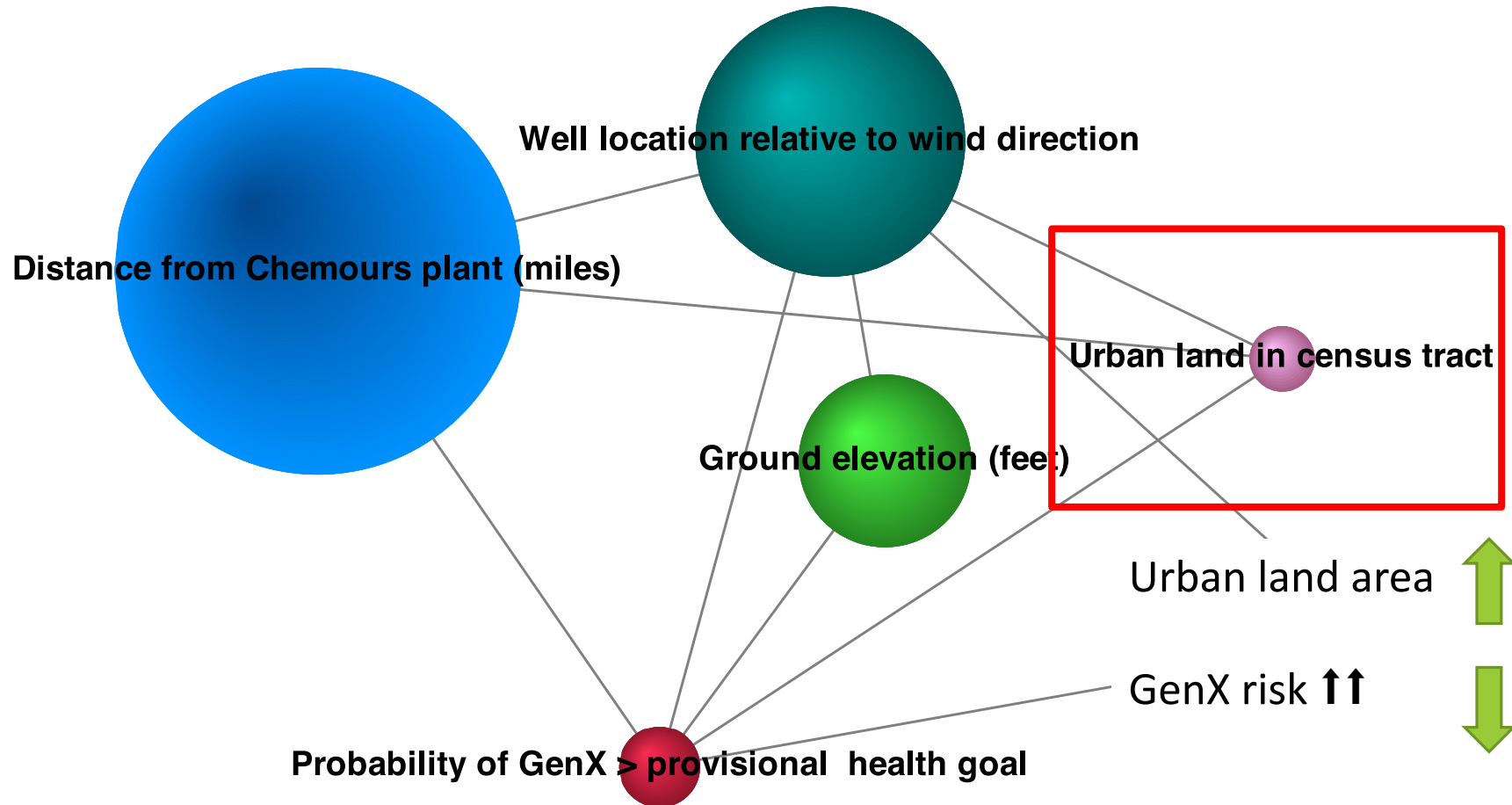
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# Model Can Achieve High Accuracy In Finding At-Risk Wells (But with “False Positives”)

Chance of Finding Wells with High GenX	Chance of a False Positive
91%	57%

# Model Can Achieve High Accuracy In Finding At-Risk Wells (But with “False Positives”)

Chance of Finding Wells with High GenX	Chance of a False Positive
91%	57%
87%	43%

# Model Can Achieve High Accuracy In Finding At-Risk Wells (But with “False Positives”)

Chance of Finding Wells with High GenX	Chance of a False Positive
91%	43%
87%	43%
85%	39%

# Model Can Achieve High Accuracy In Finding At-Risk Wells (But with “False Positives”)

Chance of Finding Wells with High GenX	Chance of a False Positive
91%	43%
87%	57%
85%	39%
61%	19%



# Prototype Web Version Allows Users to Predict Risks at Untested Wells

The screenshot shows a web browser window with the URL <https://simulator.bayesialab.com/#!simulator/372551481288>. The page title is "Risk of GenX in Private Wells Near the Chemours Facility, NC". The interface includes a header with the "NORTH CAROLINA PFAS Testing Network" logo and a "Bayesia Simulator" section with a dropdown menu set to "JMG Model 8cJMG for Web".

The main content area is divided into two columns. The left column contains several input fields: "Distance from Chemours plant (miles)" with a slider set to "Mean" and a small image of a facility; "Observed" (unchecked); "Well location relative to wind direction"; "Ground elevation (feet)"; "Impervious surface area"; and "Urban land in township". The right column displays a "Probability of GenX > provisional health goal" section with two rows of data:

Distance Category	Probability
<=140	0.81
>140	0.19

# To Improve Accuracy, We Need Data on Well Characteristics

- Depth
- Year constructed
- Construction type

**Cumberland County Public Health Department**  
227 Fountainside Lane  
Fayetteville NC 28301-  
(910) 433-3660

Application Date: 1/5/05 **Application Number: 2005-15**

**Reason(s) for Application: NEW WELL**

Pin Number: 0339-99-2771  
Site Address: 3388 COUNTY LINE RD Fayetteville NC 28306  
Subdivision: \_\_\_\_\_ Lot: \_\_\_\_\_ Phase: \_\_\_\_\_ Section: \_\_\_\_\_  
 vacant  Occupied

**APPLICANT INFORMATION:**  
Name: BILLS WELL DRILLING COMPANY Applicant Status: Contractor / Builder  
Phone: 910-483-7400 Alt. Phone: \_\_\_\_\_  
Address: 800 MCARTHUR RD Fayetteville NC 28311

Type of Well: Drilled Type of Establishment: Mobile Home  
# Bedroom: 3 Square Footage: \_\_\_\_\_  
Year House Built: \_\_\_\_\_ Date Property Originally Deeded Recorded: \_\_\_\_\_

Plat / Property Approved Conditionally by Planning Department  
 Basement Finishes Proposed  
 Property Zoned \_\_\_\_\_ Zoning Permit No.: 0

**\*\* CLEARLY STAKE ALL CORNERS AND LINES OF THE PROPERTY. STAKE ALL CORNERS OF ALL PROPOSED STRUCTURES. SURVEY PLAT OR SITE PLAN MUST BE ATTACHED TO THIS APPLICATION \*\***

House Bill 50: (1) If a local health department, health care or other governmental agency for commercial, public, bank, business, or other (100) class of existing completed applications for the permit, then the Department of Environmental, Health and Natural Resources may withhold public health funding from that local health department. This act health, for addresses, has approved by the local planning authority and recorded with the County Register of Deeds, a copy of the recorded subdivision plat that is drawn to scale.

I hereby make application to the Cumberland County Health Department for a site evaluation for the on-site sewage disposal system for the above-described property. I agree that the contents of this application are true and represent the maximum facilities to be placed on the property. I understand if the site is altered, or the intended use changes, the permit shall become invalid. I understand that as applicant, I am responsible for identifying and marking property lines and make the site accessible for the personnel of the Cumberland County Health Department to conduct their evaluation. I additionally understand that I am responsible for notifying the health department if my property contains any wetlands as designated by the Army Corps of Engineers, and if the site is subject to approval by other public agencies.

Applicant Signature: Jean Bill Kominick Date: 1-5-2005 Fees: \$100.00  
Received By: T. Valery (initials) TJ Date: 1-5-2005

**FIELD WORK RESULTS BASED ON ATTACHED PLAT/SITE PLAN:** AREA: \_\_\_\_\_ LTAR: \_\_\_\_\_  
Site Classification: \_\_\_\_\_ Design Flow: \_\_\_\_\_ gpd Soil Type: \_\_\_\_\_  
Paper: \_\_\_\_\_

**Wastewater System:** Septic Tank: \_\_\_\_\_ gallons Pump Tank: \_\_\_\_\_ gallons  
Type: \_\_\_\_\_ Specify: \_\_\_\_\_

Number of Lines: \_\_\_\_\_ Length of Each Line: \_\_\_\_\_ Width of Each Line: \_\_\_\_\_ Trench Depth: \_\_\_\_\_  
Conditions: \_\_\_\_\_  
Soil/Site Evaluation By: \_\_\_\_\_ Date: \_\_\_\_\_

R-7

# Summary

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Our goals are to

1. Predict which wells are at risk of PFAS contamination, and identify factors influencing those risks.
2. Develop a user-friendly web tool for well owners to use to predict risks.
3. Understand how long it will take for PFAS to “flush out” of the groundwater.

Results so far suggest that

- GenX in private wells may originate from GenX in air.
- Risk can be predicted, even with limited data on well characteristics.

# Next Steps

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- Collect data on well depth, construction type, age for as many of the 803 wells as possible.
- Refine the predictive model with these new data.
- Make the model available on the Web.
- Answer questions about how long it will take for GenX and other PFAS to flush from the groundwater.



# Acknowledgments



## ❑ Funding Source

- North Carolina Policy Collaboratory

## ❑ Collaborators

- Dr. Detlef Knappe, NCSU
- Dr. David Genereux, NCSU
- Zenora Anne Saelua, UNC
- Riley Mulhern, UNC



## ❑ Organizations

- Local Health Departments at Cumberland, Robeson and Bladen Counties

