Alex Mofidi, Chris McMeen and Virpi Salo-Zieman
Confluence Engineering Group

Tyler Clary and Patrick Craney
City of Vancouver, Washington

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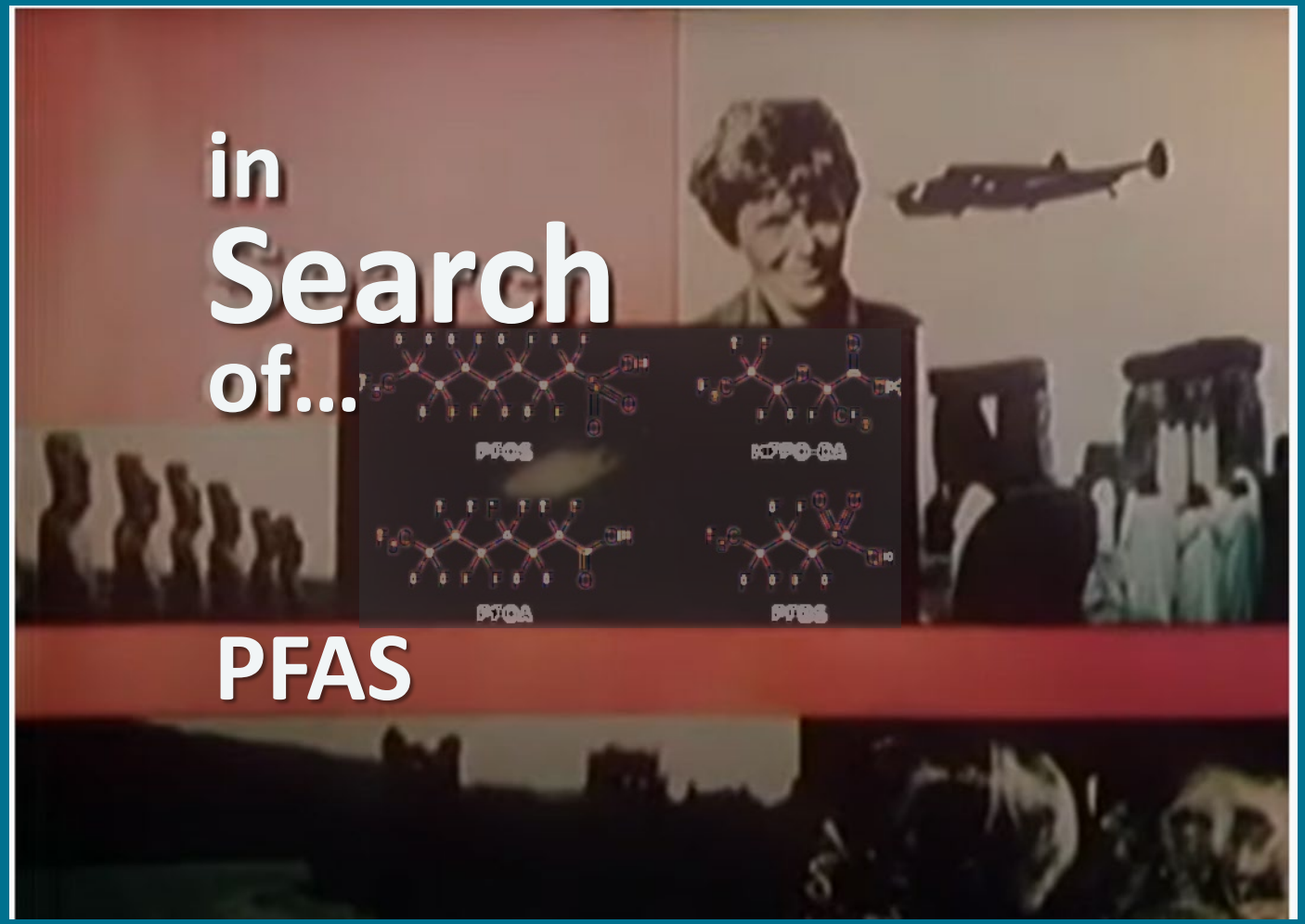
GSI Water Solutions



www.cen.acs.org
American Chemical Society

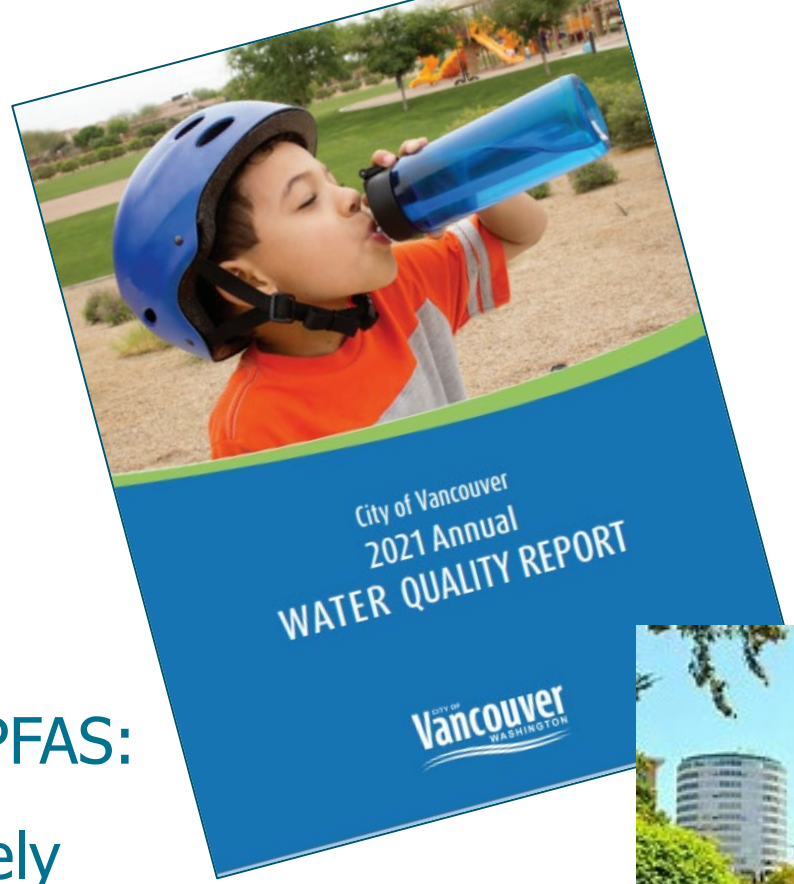
https://www.youtube.com/watch?v=JZ852lCpsTY
YouTube: In Search of (1978)

American Water Works Association
Pacific Northwest Section
2023 Section Conference May 3-5, 2023
Kennewick, WA

confluence ENGINEERING GROUP LLC
CITY OF Vancouver WASHINGTON
GSI Water Solutions, Inc.

Discussion Topics

1. City of Vancouver Background
2. The Influx of PFAS
3. Strategically Finding Environmental PFAS: Modeling and Choosing Sources Wisely
4. Resulting Monitoring Approach



Vancouver's
Water Service Area

Background

Water Supply for City of Vancouver, WA

- 100% Groundwater; Mix of Deep and Shallow Aquifers
- Water Stations (WSs) Comprised of Multiple Wells
- Average 2021 PFOS Data Shown from 1 to 2 samples from each well from each WS

Approximate Values **Vancouver Shallow Aquifer Wells** (Deep Aquifer Sources Not Shown; 2023 Data Not Shown)

WS Number	1	3	4	5	6	7	8	9	14	15
Total Wells, ea.	13	3	6	NA	NA	1	2	5	3	4
Capacity, gpm x 1000	**26**	6	9	--	--	1	1	10	3	2
Aquifer (LO or UO)	LO	LO	LO	--	--	UO	UO	UO	UO	UO
Screen Top Depth, ft	180-220	230-250	85-97	--	--	270	90-165	130-200	150-170	70-115
Year Ops Started	1938	1945	1978	--	--	1970	1958	1974	1979	1981
Avg PFOS (2021)	4.3	7.7	**19.5**	--	--	6.9	**17**	14	**23**	**15**

NA = Wells Not Applicable for this Discussion
LO = Lower Orchard Aquifer UO = Upper Orchard Aquifer

Investigating PFAS Solutions: A Summary

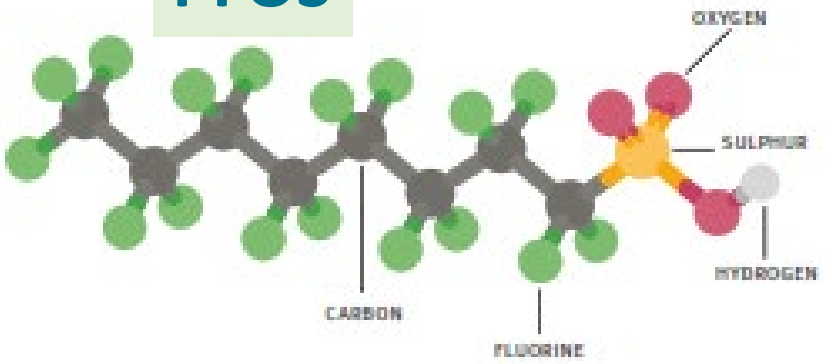
- 2021: PFAS Landscape Unclear
  - No cleanup requirements for Superfund sites <70 ppt (EPA HAL at that time)
  - Expecting WA SALs; levels yet TBD --- and the EPA path is yet unclear
  - Very limited sampling indicates PFAS >detection in shallow wells
  - Vancouver: Develop customer communications & consider environmental sampling
- 2022: PFAS Landscape Changes Rapidly
  - WA SALs expected to be <70 ppt; Vancouver begins investigating treatment
  - Confluence paper investigation into potential PFAS sources (WDOH, Ecology, other)
  - Federal regulatory landscape still uncertain
- Late 2022 / Early 2023: WA SALs set, very low USEPA MCLs proposed
  - No primary point source found in the region – Need to dig deeper

The Influx of PFAS

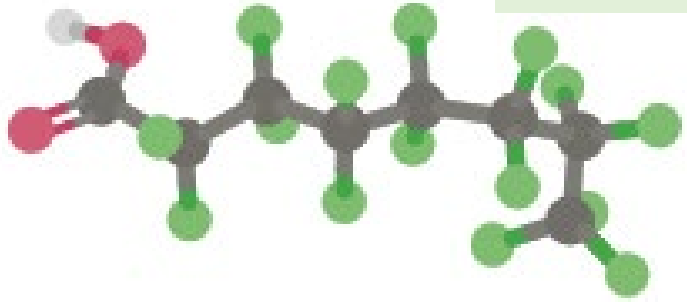
PFAS Have Been Here and Are Here To Stay

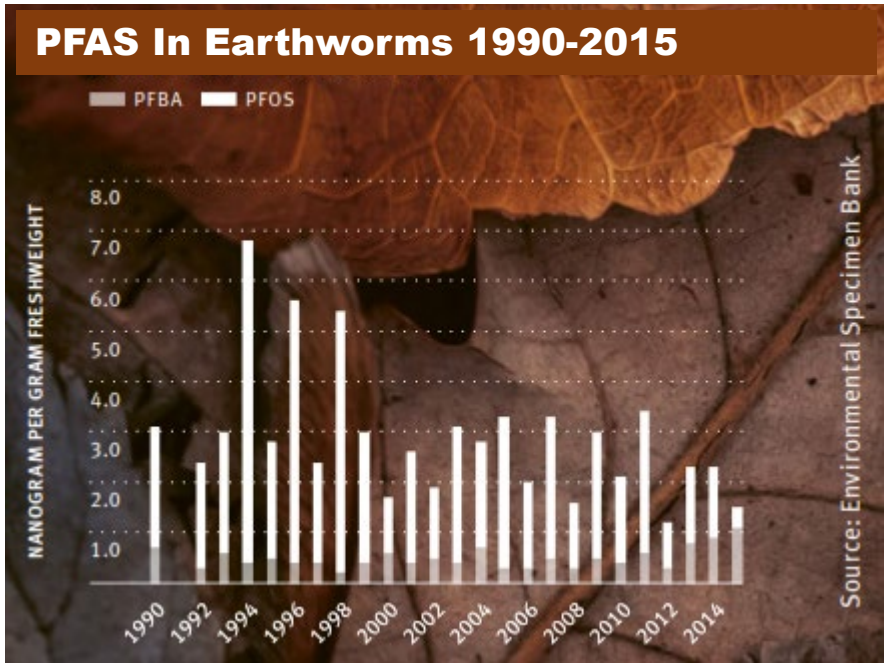
- Perfluorinated compounds used since the 1950s
  - Also polyfluorinated compounds and perfluoroethers (ADONA, GenX)
  - Little information on chemical structures of latest PFAS or environmental behavior
  - Used for frictional resistance, adhesion, waterproof and breathable membranes

PFOS



PFOA

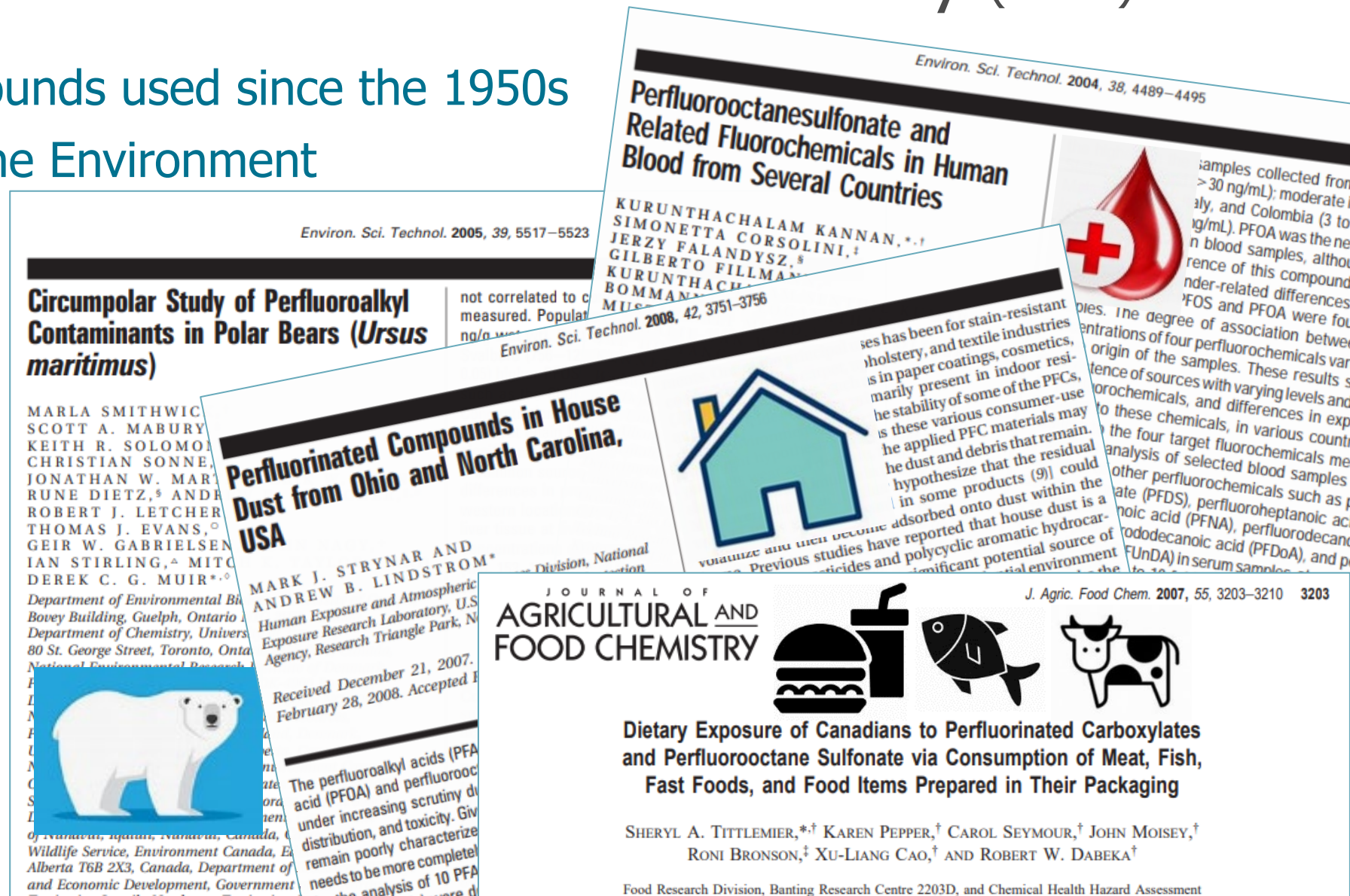




Both figures from 2020, Magazine of the German Environment Agency, What Matters: PFAS Came to Stay. January.

PFAS Have Been Here and Are Here To Stay (Cont.)

- Perfluorinated compounds used since the 1950s
- They Are Prolific in the Environment



PFAS Have Been Here and Are Here To Stay (Cont.)

- Perfluorinated compounds used since the 1950s
- They Are Prolific in the Environment
- They Are Still Being Used
  - Part 139 airports/fire suppress.: MILSPEC F3 (?)
  - Still in your clothing, cookware, etc.
  - Industrial applications
  - Cheap, sold on-line, and a 5-gal bucket can cause >70ppt PFOS in a well*

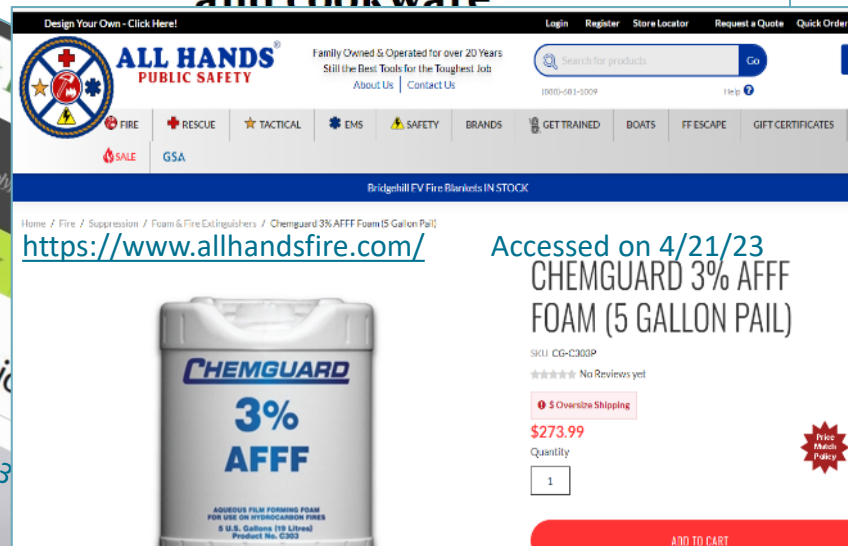
Credit: Tyler Nix/Unsplash

www.ehn.org Site accessed April 6, 2023

REI to ban PFAS in outdoor clothing and cookware

CHEMGUARD MSDS Ingredients Information

CAS NO.	Common Name
7732-18-5	water
57018-52-7	propylene glycol t-butyl ether
7487-88-9	magnesium sulfate
proprietary mixture	proprietary hydrocarbon surfactant
proprietary mixture	proprietary fluorosurfactant

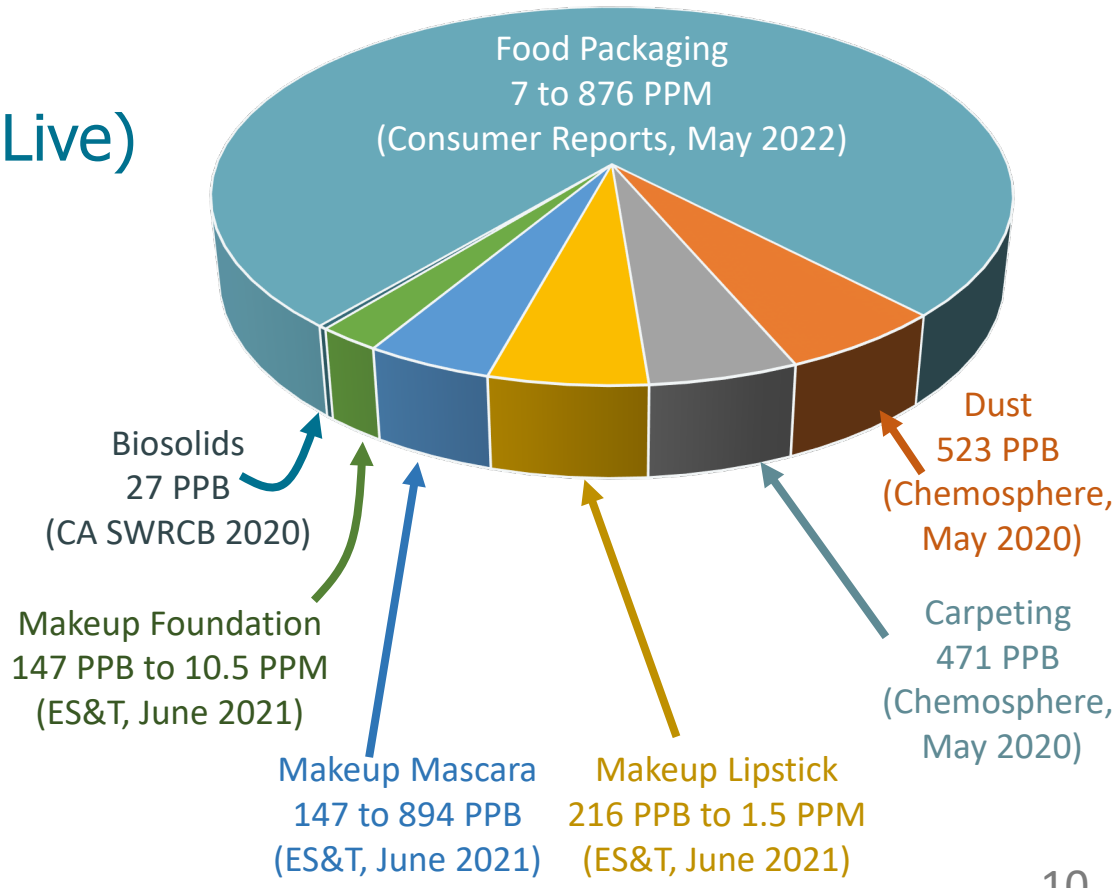


* Based on estimates by Higgins, C., "PFNA in AFFF" Presented to advisory committee of the Delaware River Basin Commission on June 15, 2022.

PFAS Have Been Here and Are Here To Stay (Cont.)

- Perfluorinated compounds used since the 1950s
- They Are Prolific in the Environment
- They Are Still Being Used
- Varying Exposure (Depending On Where We Live)
  - Diet from 16 to >99%
  - Dust and tap water from <1 to 96%
  - Dermal and Inhalation from <1 to 15%
  - Other (carpet, food packaging, and consumer goods) from 2 to 28%

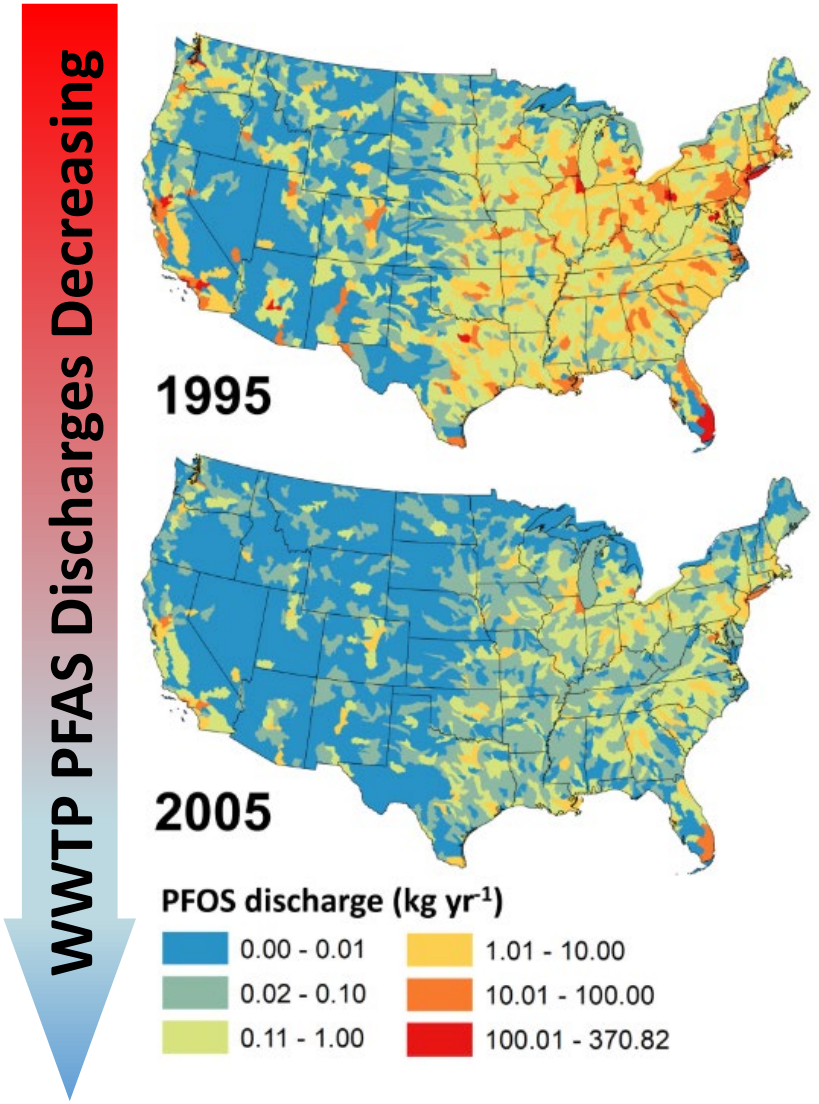
Relative PFAS Levels in Common Items



PFAS Have Been Here and Are Here To Stay (Cont.)

- Perfluorinated compounds used since the 1950s
- They Are Prolific in the Environment
- They Are Still Being Used
- Varying Exposure (Depending On Where We Live)

- Good News: WWTP PFAS Discharges Decreasing



2019, Sunderland et al. "A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects" Journal Expo. Science Environmental Epidemiology.

PFAS Have Been Here and Are Here To Stay (Cont.)

- Perfluorinated compounds used since the 1950s
- They Are Prolific in the Environment
- They Are Still Being Used
- Varying Exposure (Depending On Where We Live)

- Good News: WWTP PFAS Discharges Decreasing

- Bad News:
  - Poor Usage Records for AFFF
  - PFAS can be found everywhere.

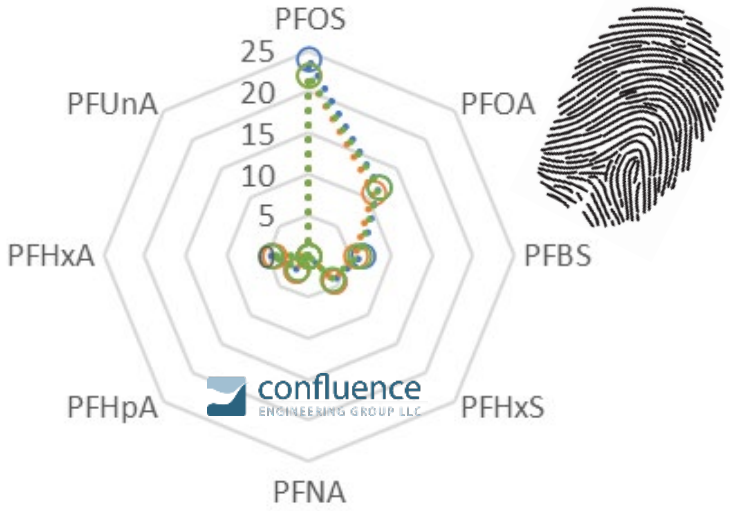
With no primary point source: Where, how, and why do you choose a location to investigate?

Septic Tanks

Stormwater Infiltration

Small(er) Point-Source Polluters & Industries

Centralized Wastewater Treatment



Fire Dept. AFFF Usage or Training

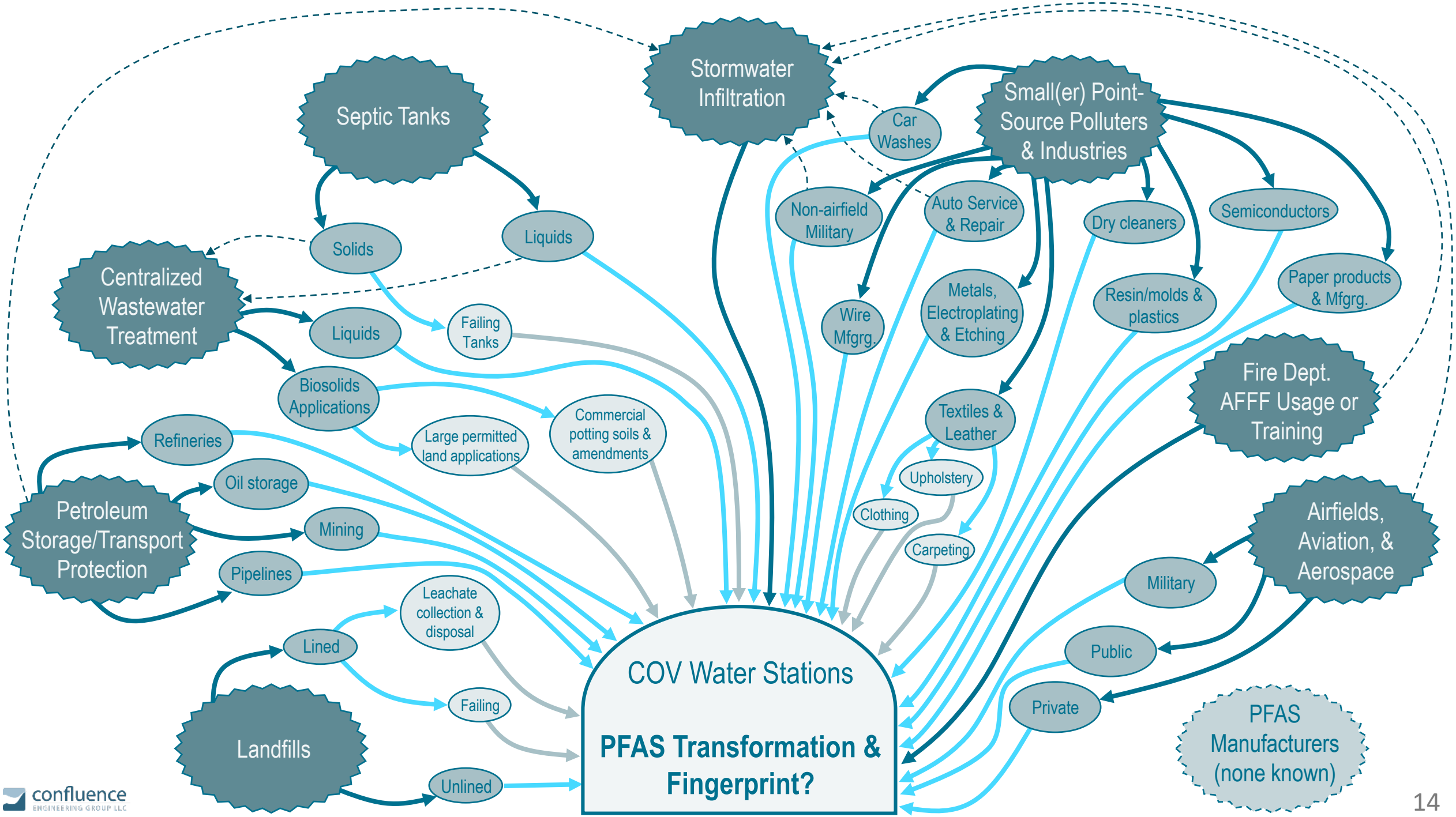
Petroleum Storage/Transport Protection

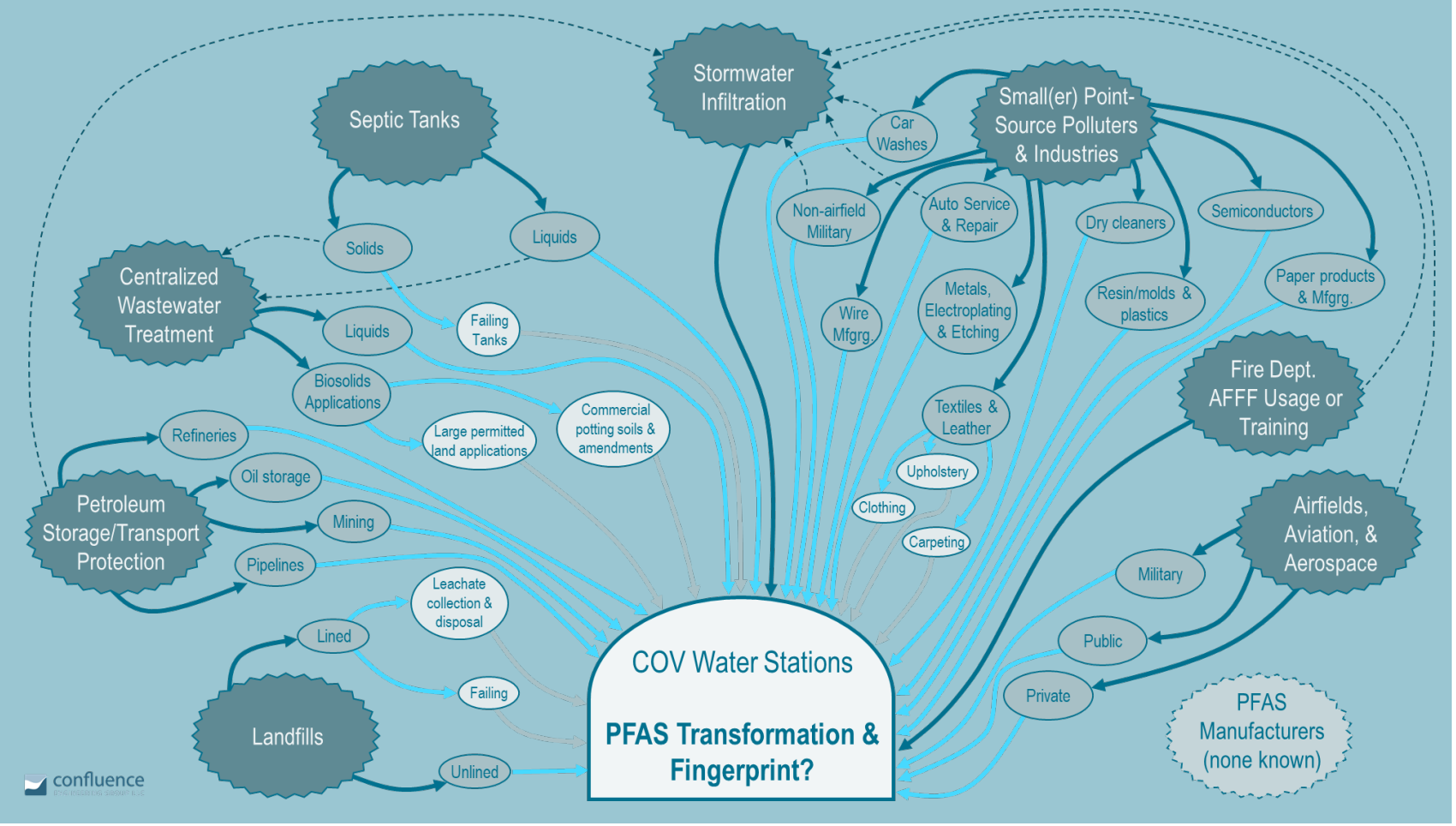
Airfields, Aviation, & Aerospace

COV Water Stations

Landfills

PFAS Manufacturers (none known)


Stormwater Infiltration
Septic Tanks
Small(er) Point-Source Polluters & Industries
Car Washes
Solids
Liquids
Centralized Wastewater Treatment
Non-airfield Military
Auto Service & Repair
Dry cleaners
Semiconductors
Liquids
Failing Tanks
Wire Mfgrg.
Metals, Electroplating & Etching
Resin/molds & plastics
Paper products & Mfgrg.
Biosolids Applications
Fire Dept. AFFF Usage or Training
Refineries
Large permitted land applications
Commercial potting soils & amendments
Textiles & Leather
Upholstery
Oil storage
Petroleum Storage/Transport Protection
Clothing
Carpeting
Airfields, Aviation, & Aerospace
Mining
Pipelines
Military
Leachate collection & disposal
Lined
COV Water Stations
Public
Failing
Private
Landfills
PFAS Transformation & Fingerprint?
Unlined
PFAS Manufacturers (none known)



In Search Of..... PFAS

Goals and Strategy

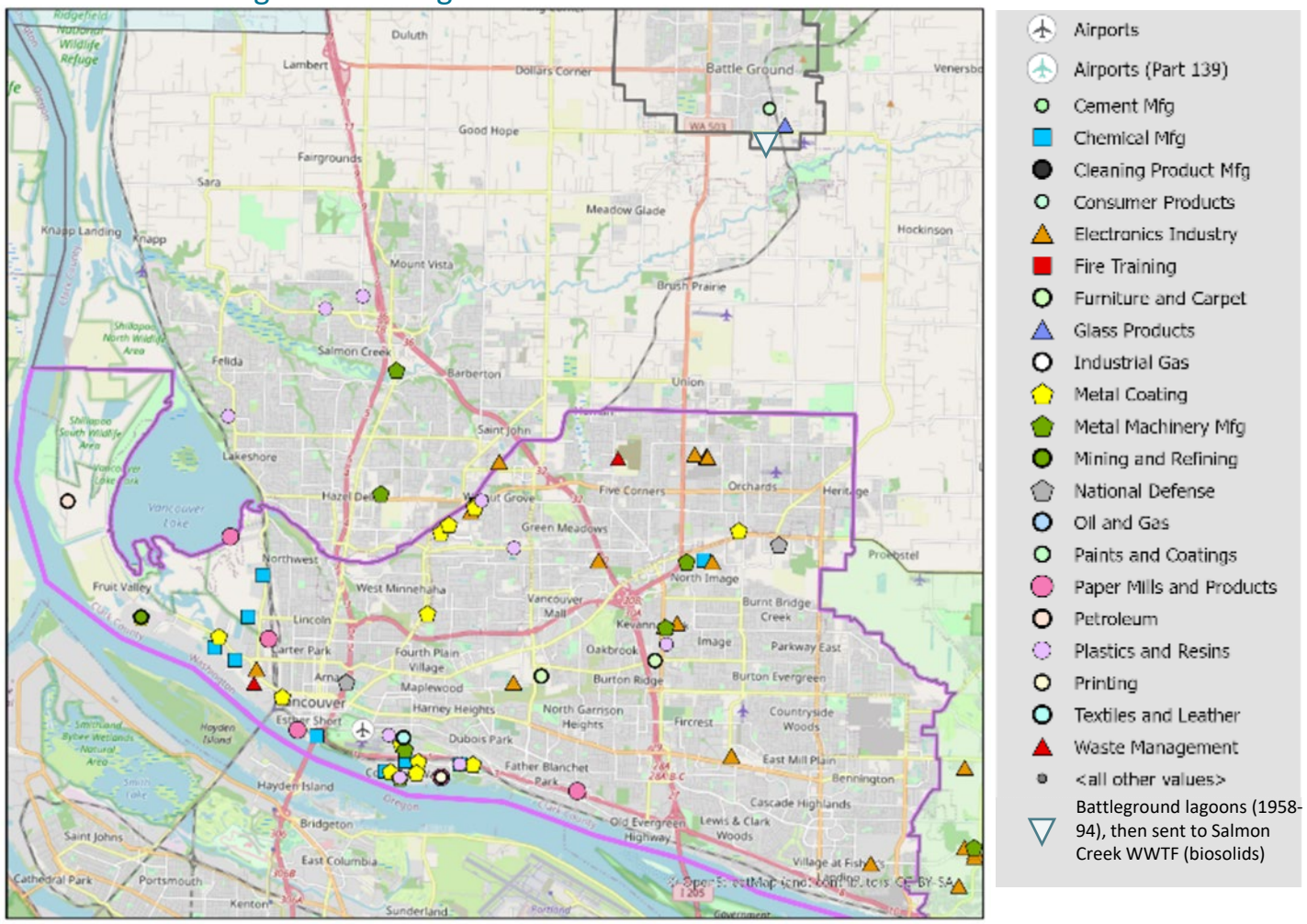
- Identify Opportunities for the City
  - Capital investments that might significantly reduce regional loading
  - O&M or local activities to better identify and reduce higher risk practices

- Identify Point Sources & Define Diffuse PFAS Subsurface Transport
  - Find sources
  - Is the City on the front- or tail-end of subsurface transport
  - Estimate regional/subsurface recycling and "time remaining"
- Inform Wellhead Treatment Planning and/or Communications
- Approach
  - Characterize Highest Potential Sources (and Continue Investigation into Past)
  - Characterize Subsurface Mobility (and fingerprint, although transformation may occur)
  - Implement Adaptive Environmental Monitoring Plan

Characterize Sources

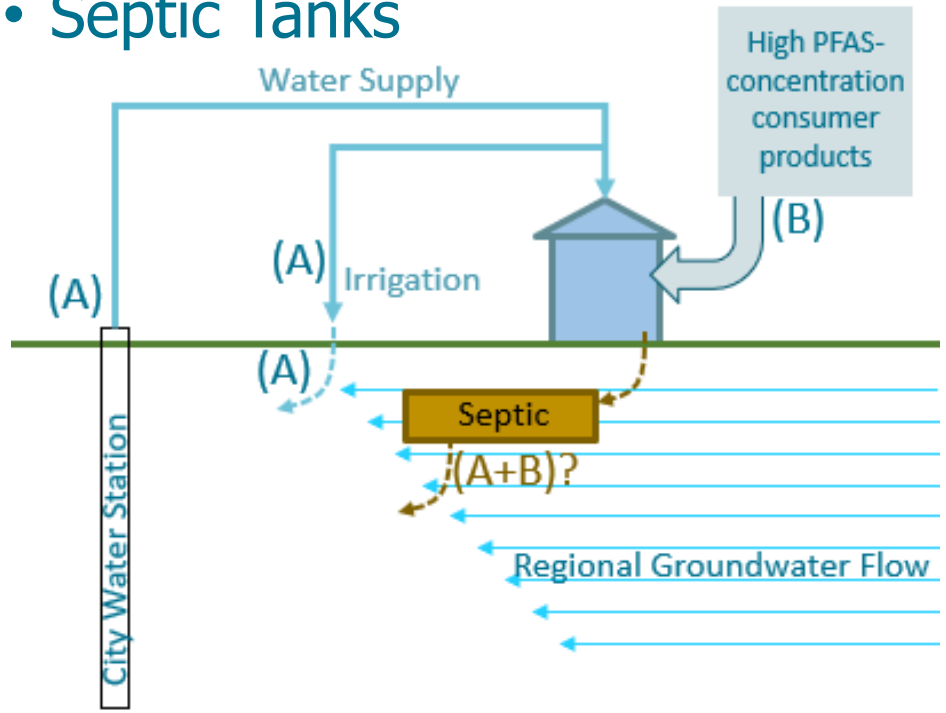
- USEPA PFAS Tool, Superfund Sites <70 ppt PFAS (or no data), WA Ecology & WDOH Info., & "find" past AFFF use

GIS Info Gathering and Tracking

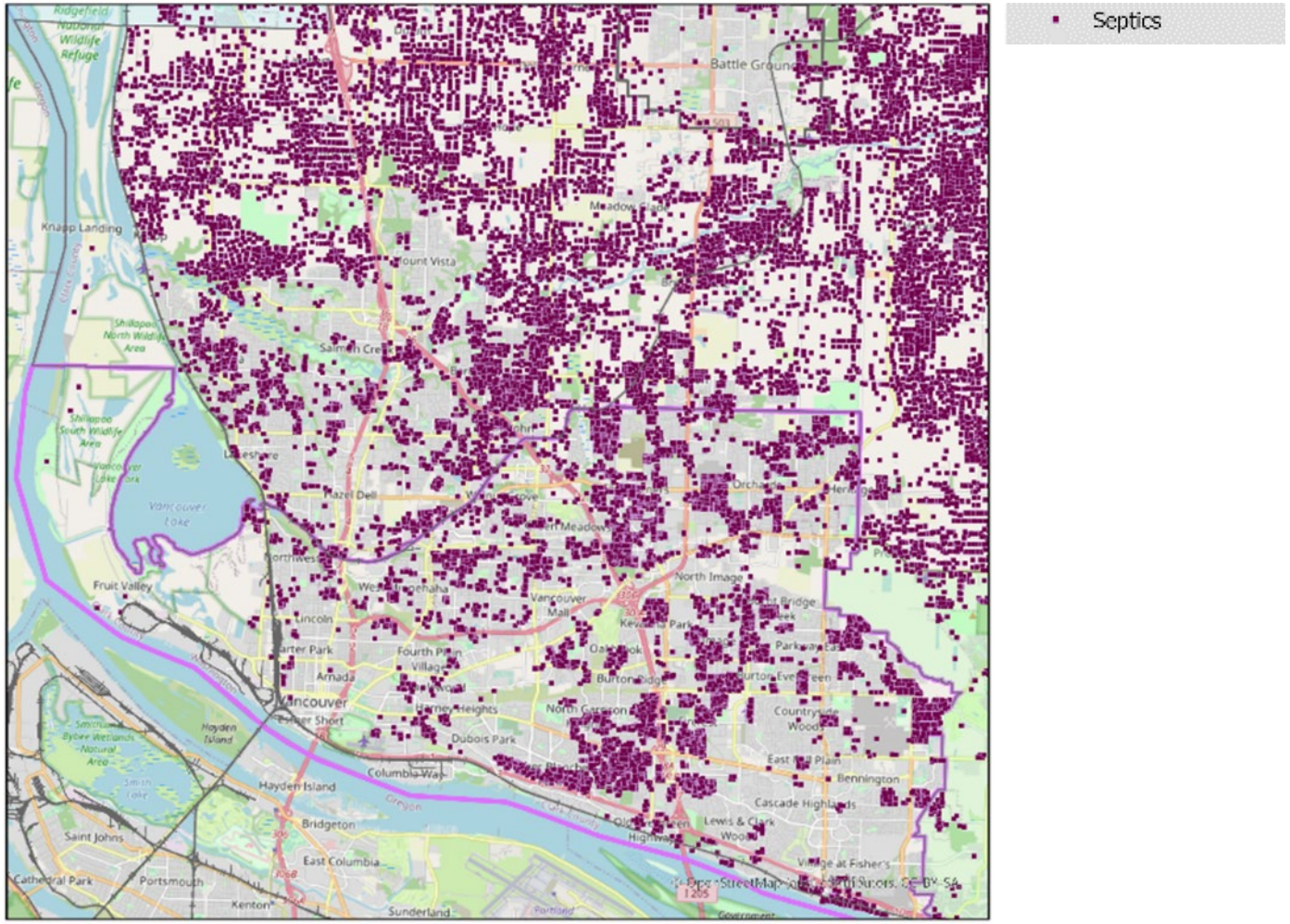


Characterize Sources (Cont.)

- USEPA PFAS Tool, Superfund Sites <70 ppt PFAS (or no data), WA Ecology & WDOH Info., & "find" past AFFF use
- Septic Tanks

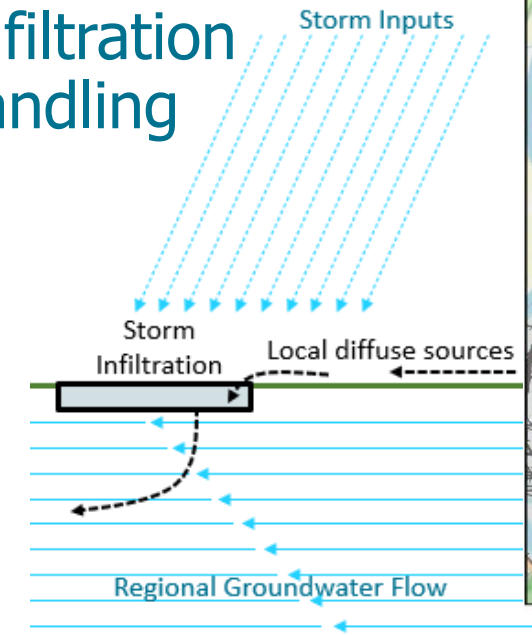


GIS Info Gathering and Tracking

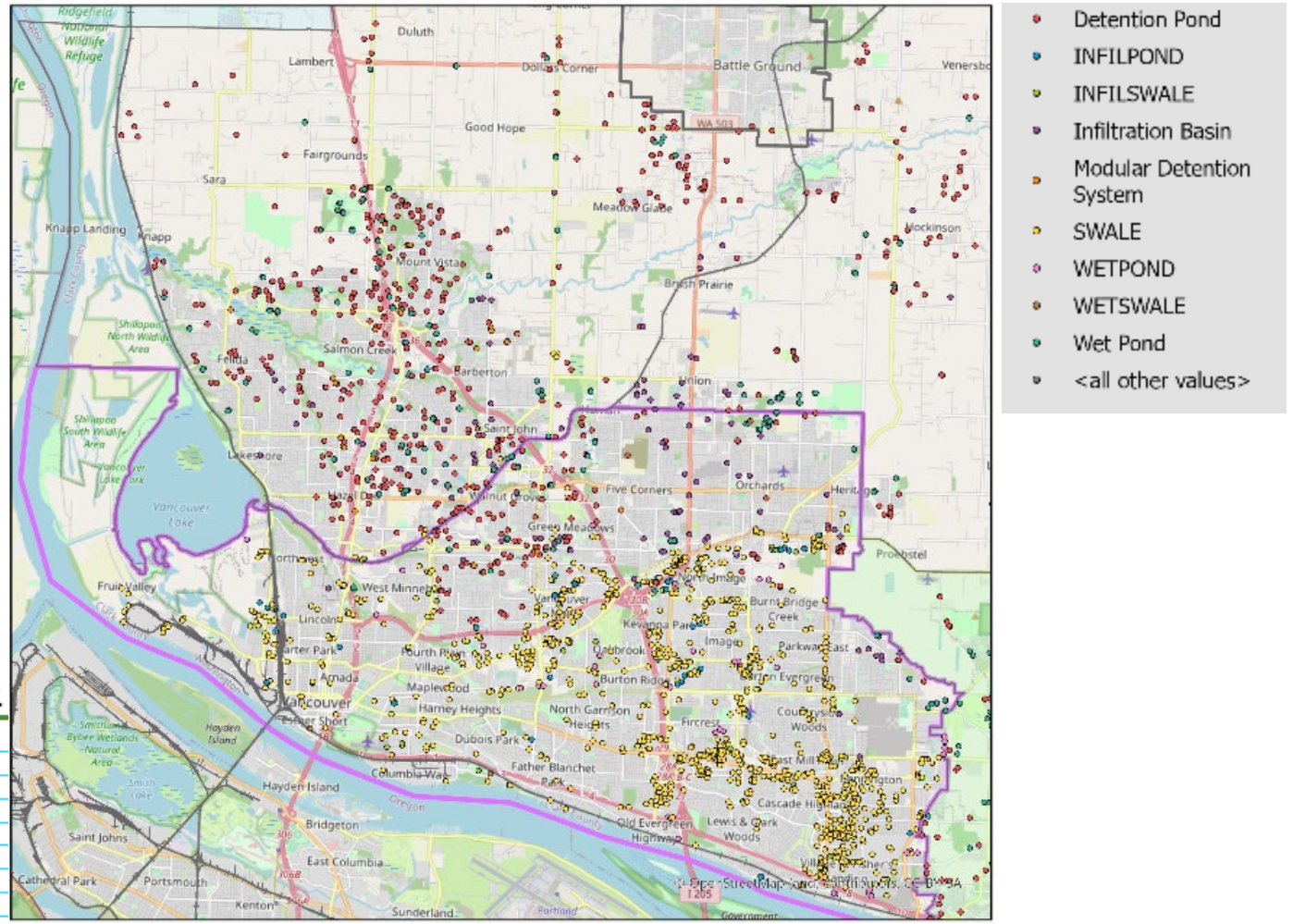


Characterize Sources (Cont.)

- USEPA PFAS Tool, Superfund Sites <70 ppt PFAS (or no data), WA Ecology & WDOH Info., & "find" past AFFF use
- Septic Tanks
- Drywells & Infiltration Structures Handling 60% of City Stormwater: More than any other Western WA municipality)

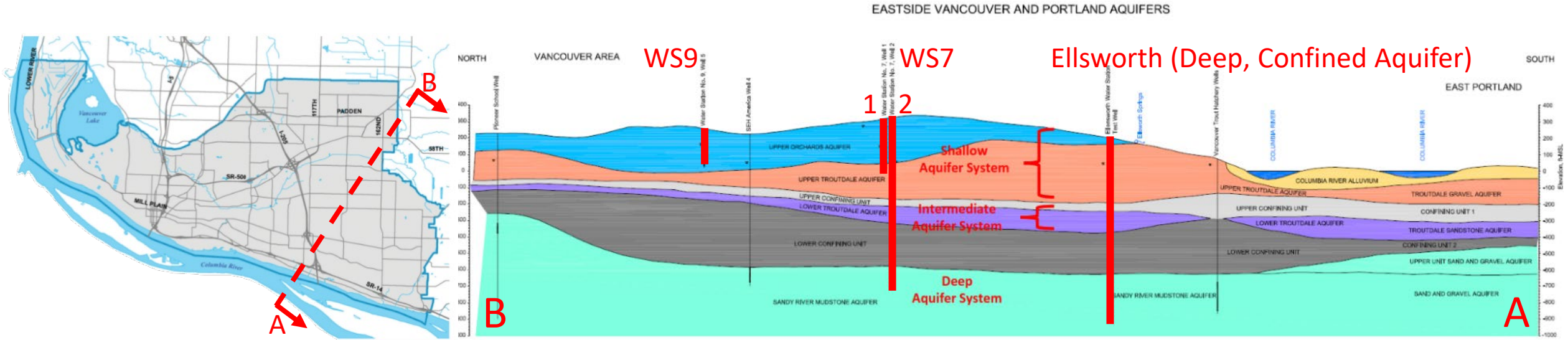


GIS Info Gathering and Tracking



Update the Portland Basin Groundwater Model

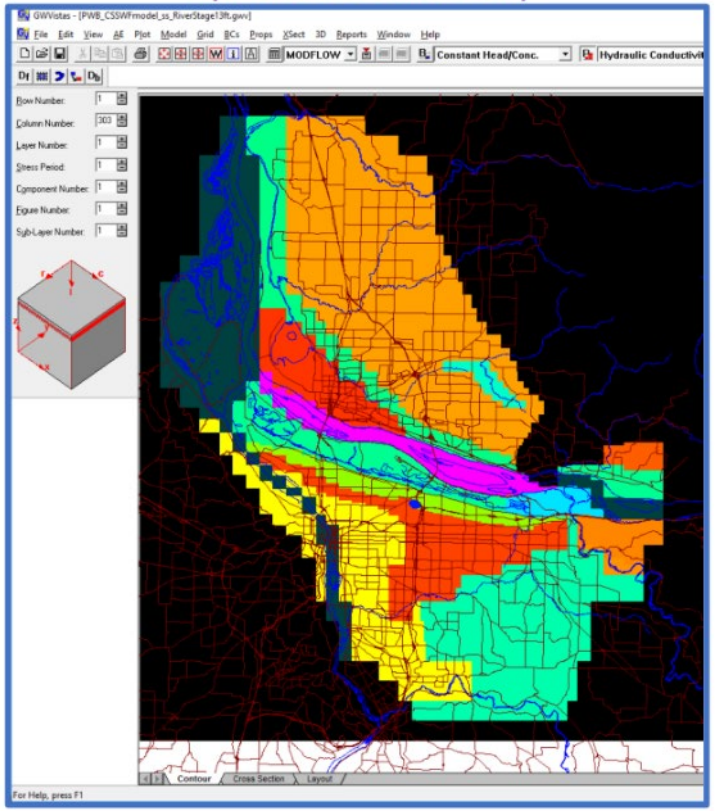
- Initially developed by USGS in mid 1990's



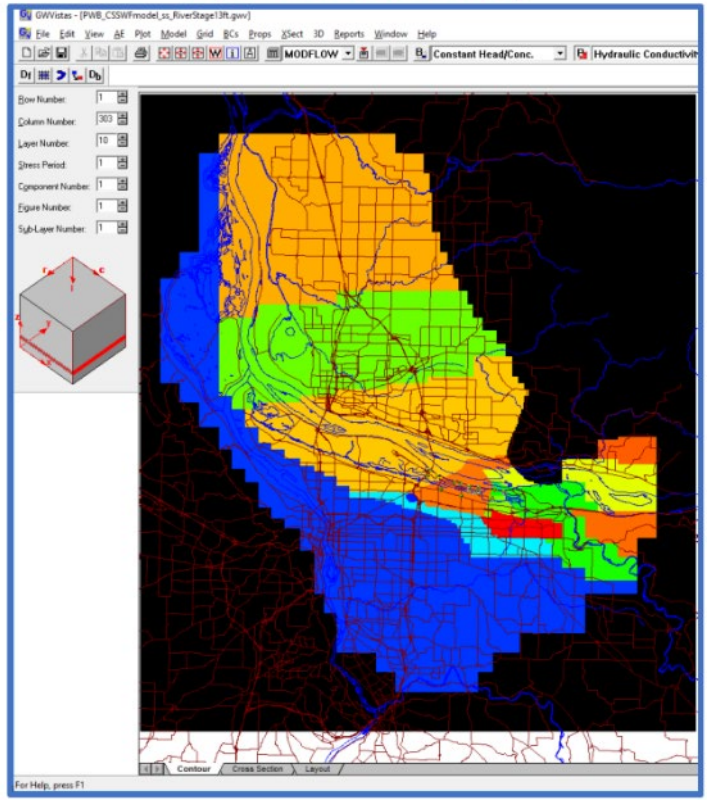
Update the Portland Basin Groundwater Model (Cont.)

- Initially developed by USGS in mid 1990's
- Refinements made by GSI
  - Grid resolution for capture zone analysis
  - Surface hydrostratigraphy contact elevations
  - Calibration simulations with City Water Stations
  - Covers entire City & portions of County south of the East Fork Lewis River

Shallow Aquifer
Hydraulic Conductivity

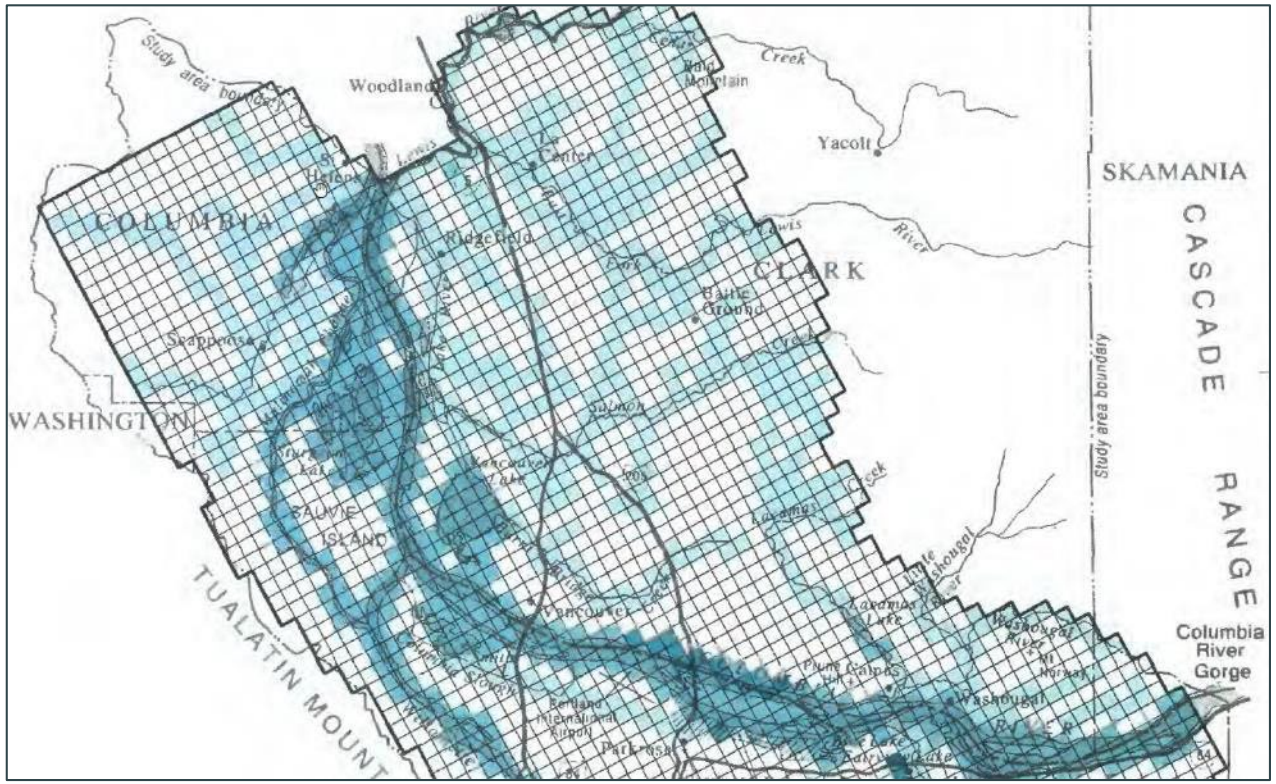


Deep Aquifer
Hydraulic Conductivity

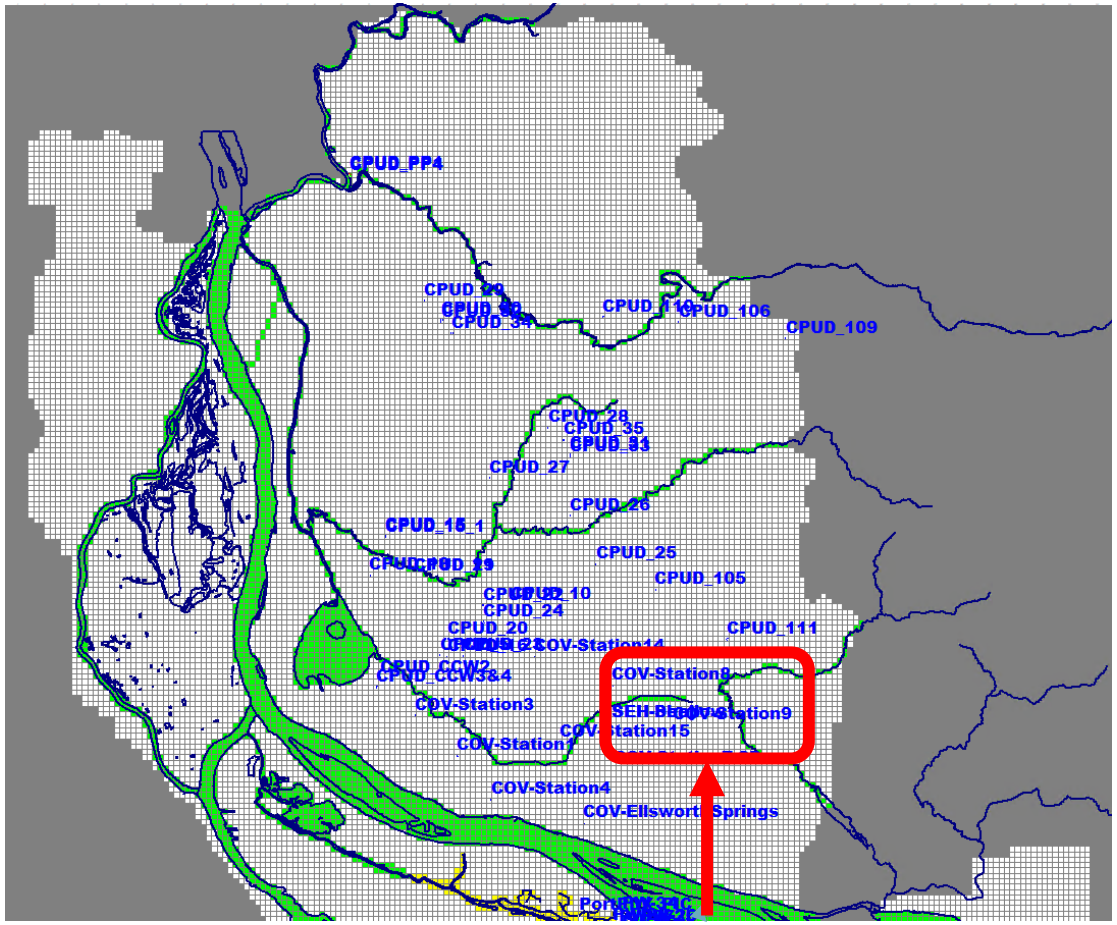


Update the Portland Basin Groundwater Model (Cont.)

USGS Portland Basin Model
Cell size 3,000 x 3,000 feet

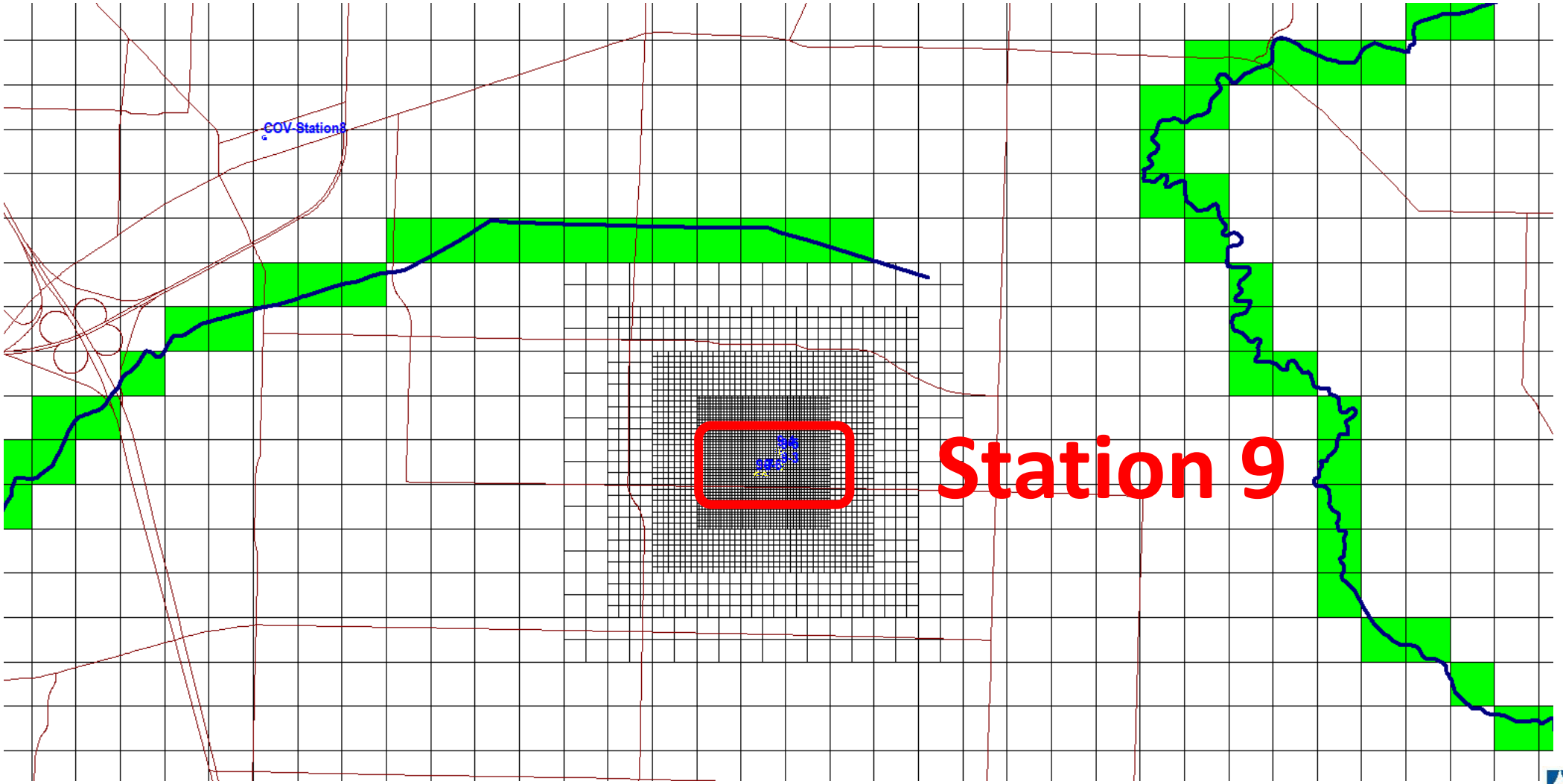


City of Vancouver Model
Cell size 800 x 800 feet



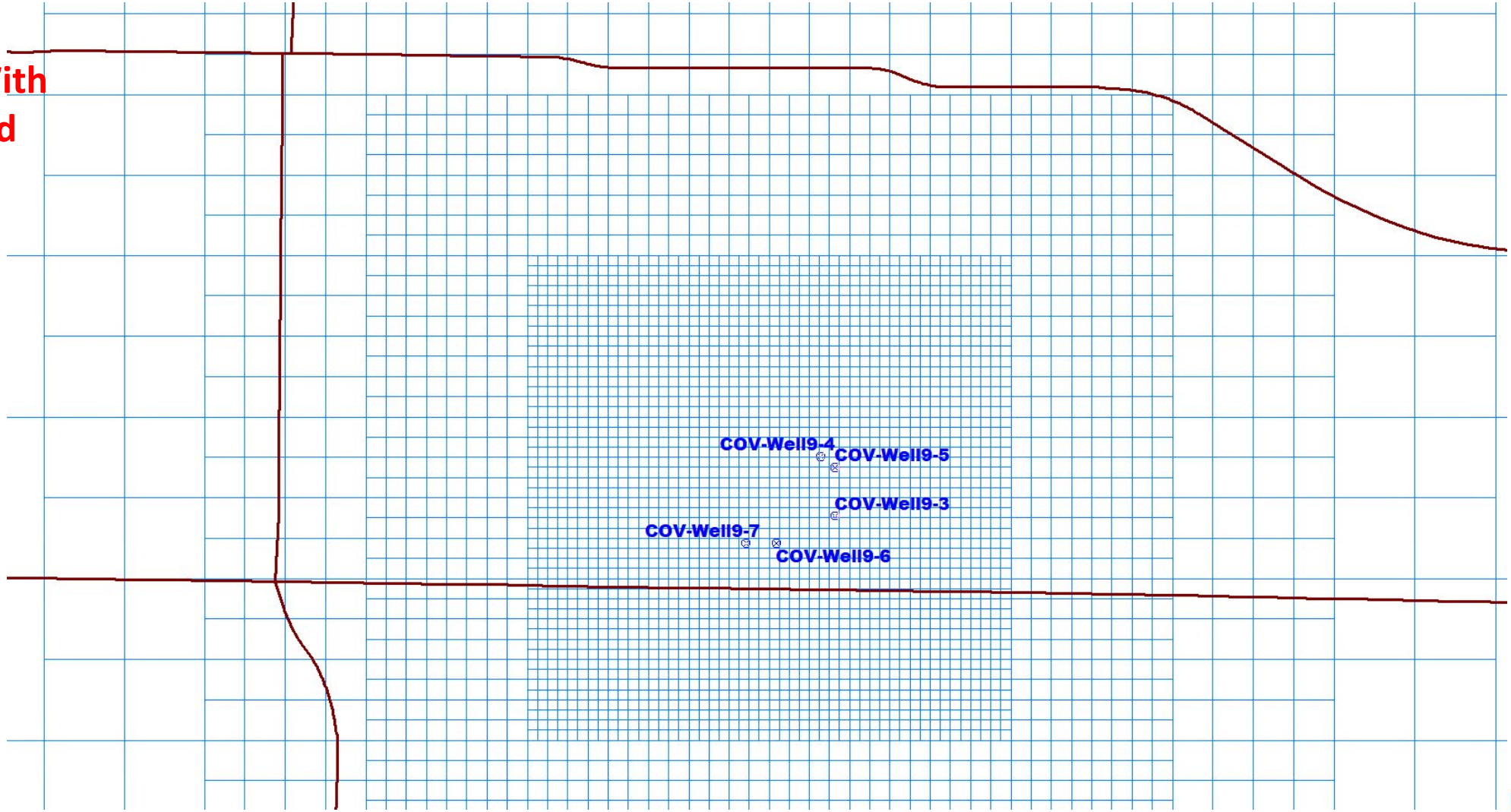
Imbedded Grid
(Next Slide)

Update the Portland Basin Groundwater Model (Cont.)



Update the Portland Basin Groundwater Model (Cont.)

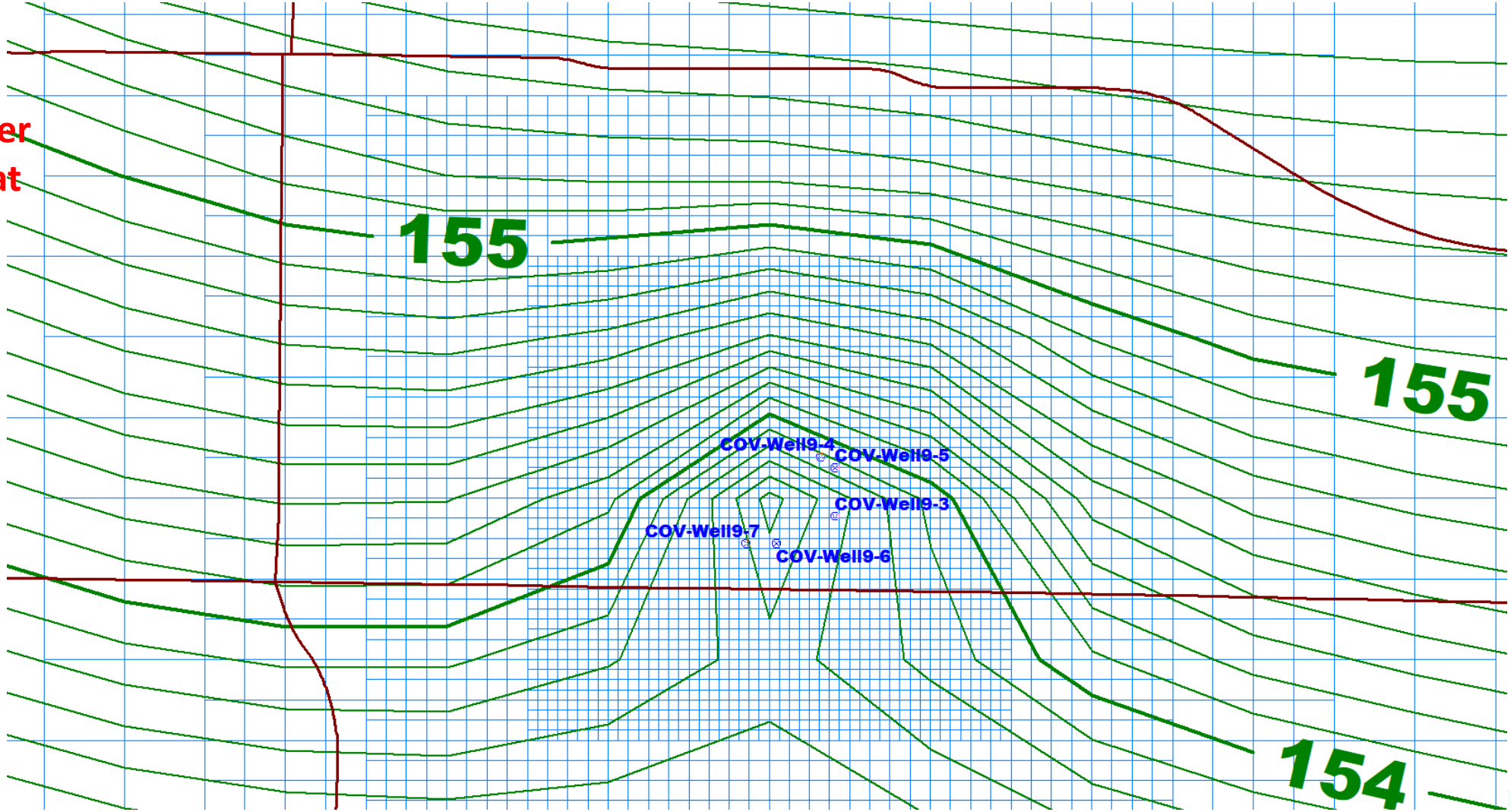
Station 9 With 50-Foot Grid Cells Inside 800-Foot Regional Grid



Update the Portland Basin Groundwater Model (Cont.)

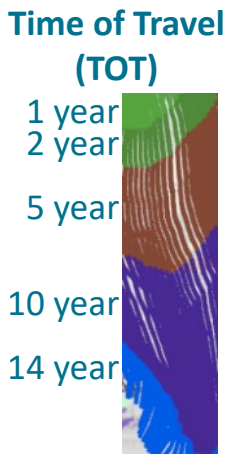
Computed Groundwater Elevations at Station 9 During Pumping Operations

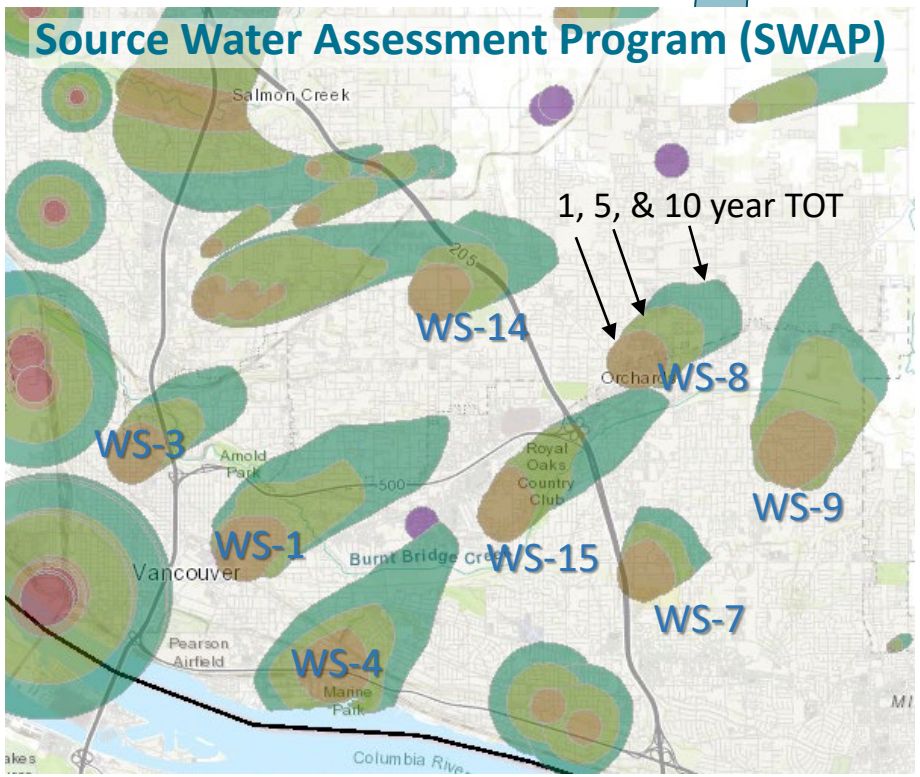
0.1-foot contour interval

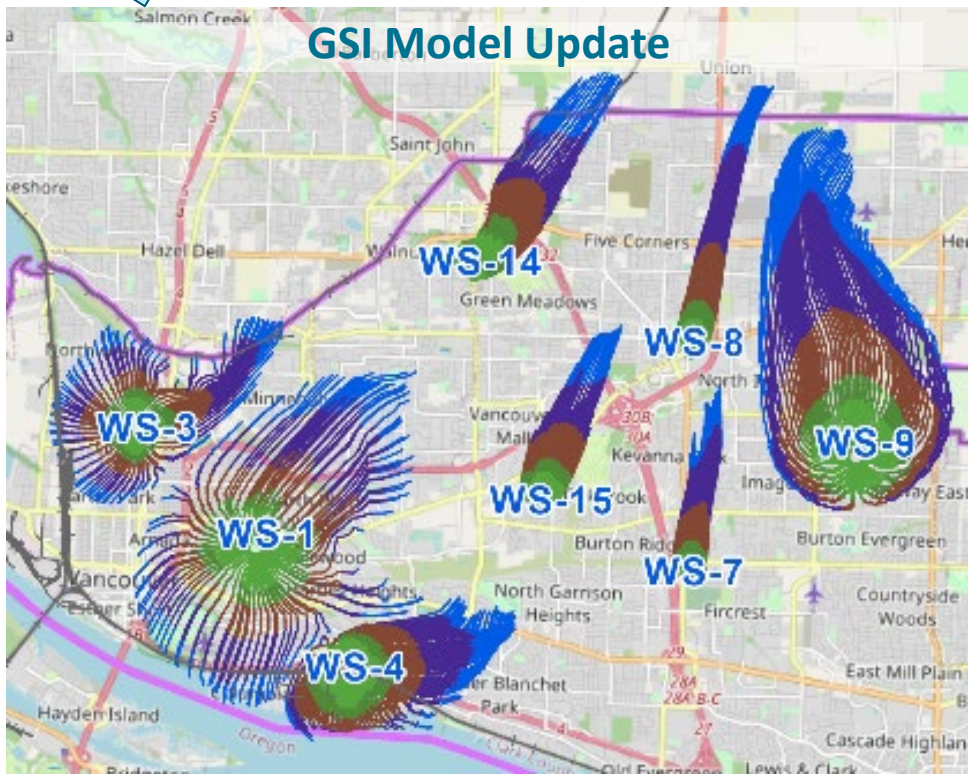


Groundwater Model Results

- Significant Differences from Previous Well Capture Zones
  - Area shapes
  - Direction





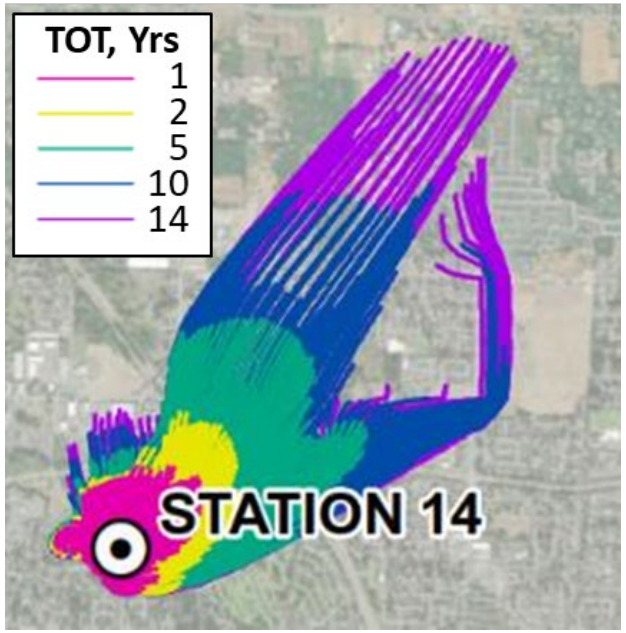


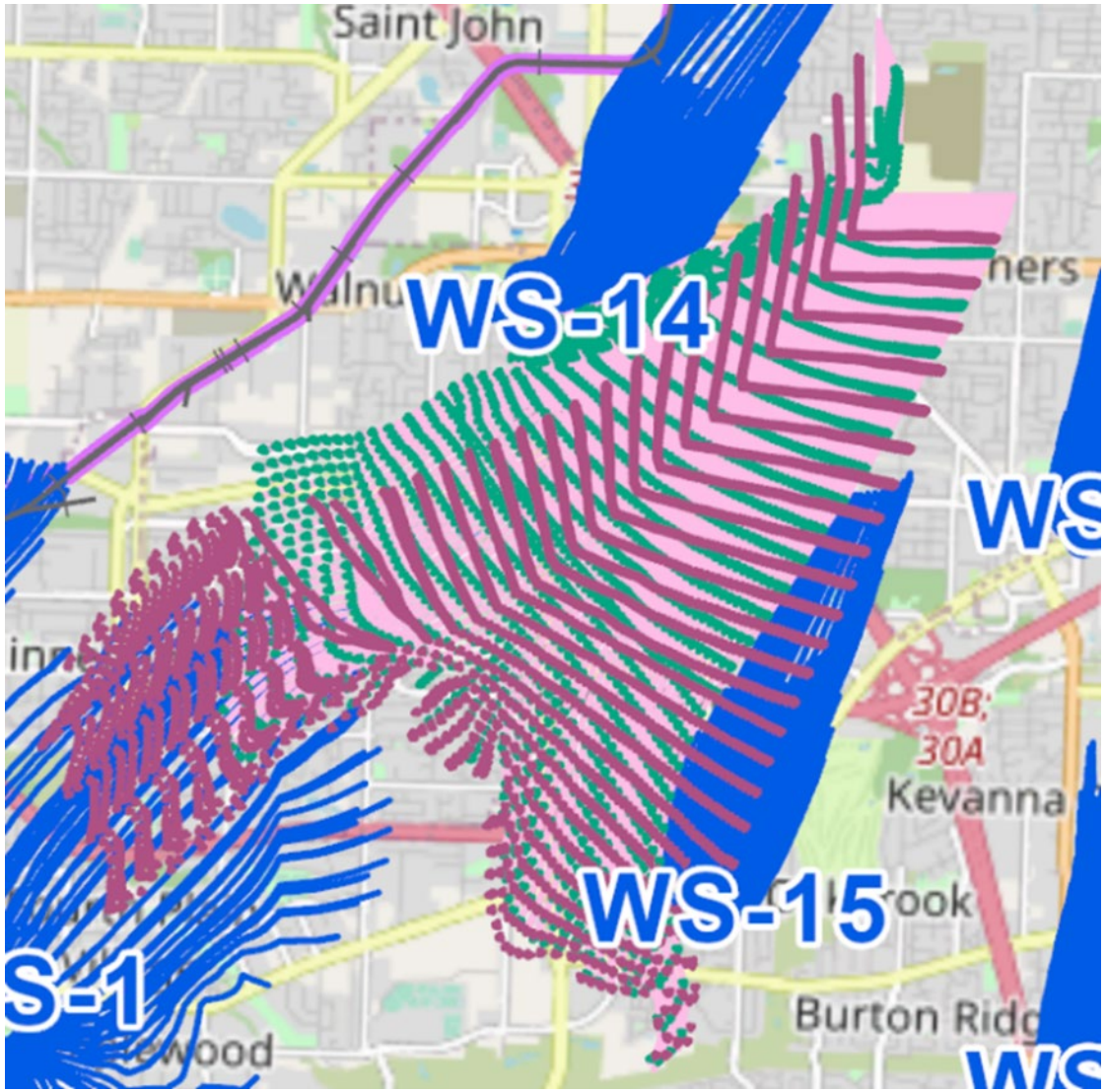
https://fortress.wa.gov/doh/swap/index.html

Groundwater Model Results (Cont.)

- Significant Differences from Previous Well Capture Zones

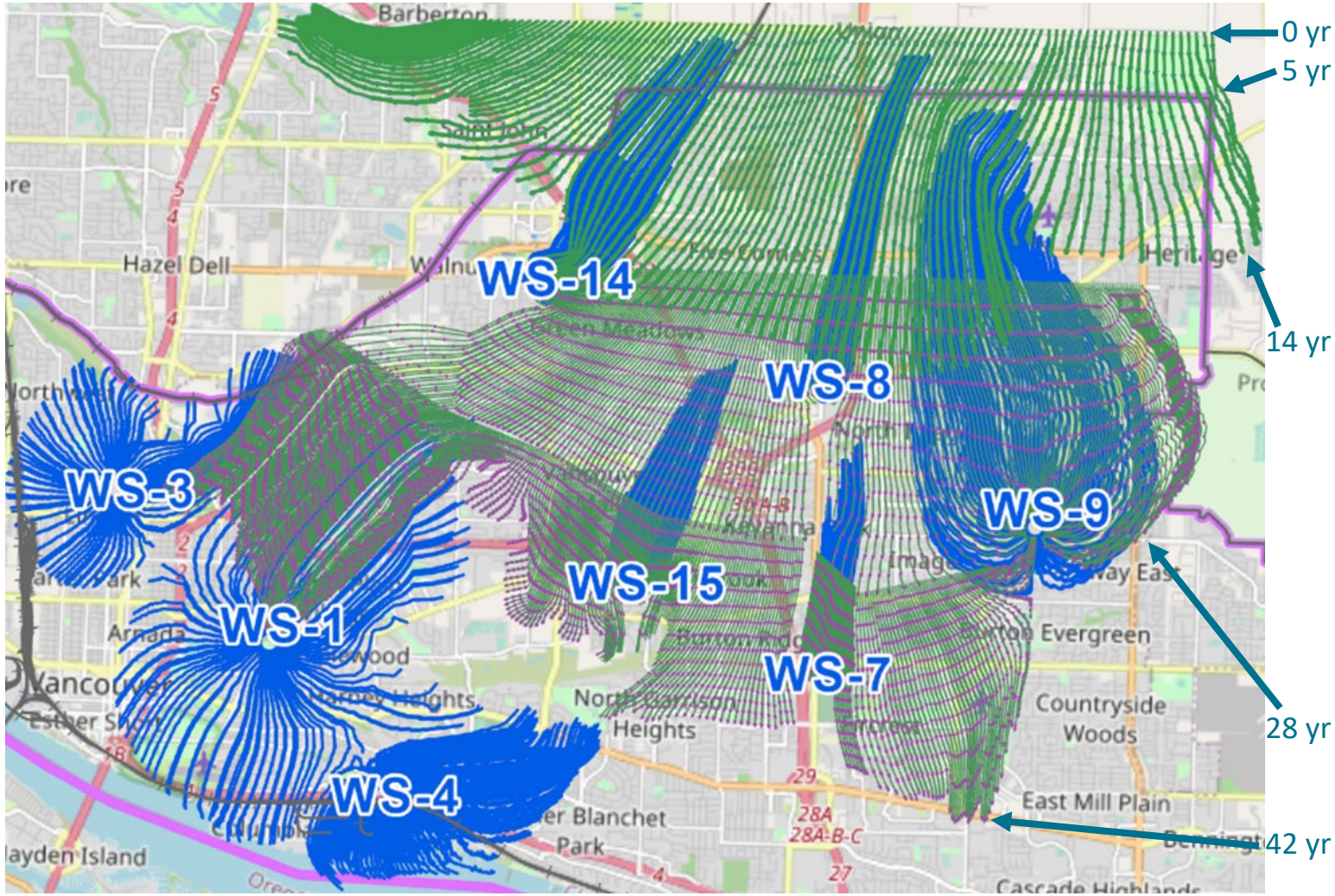
- Sensitivity Analysis Insights (hydraulic conductivity unknowns)

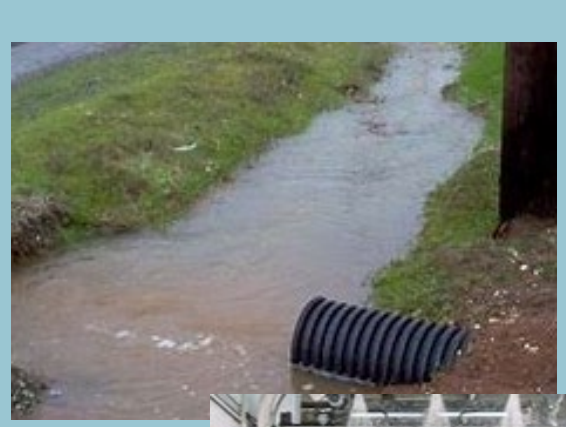


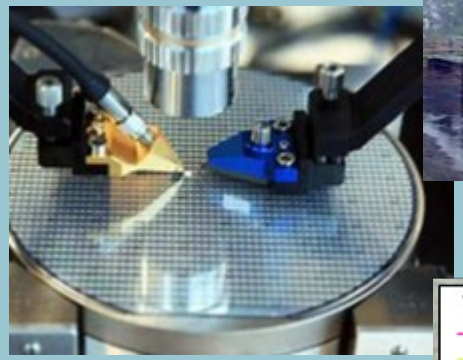


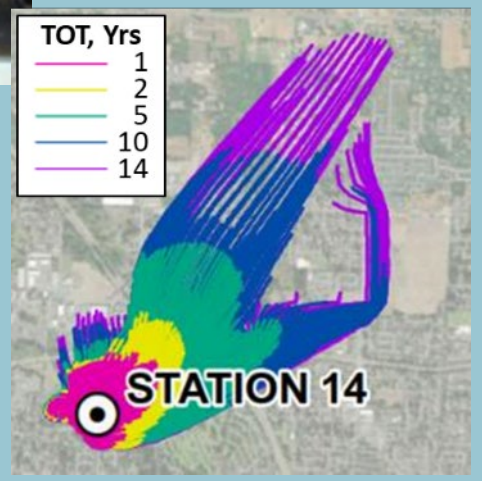
Groundwater Model Results (Cont.)

- Significant Differences from Previous Well Capture Zones
- Sensitivity Analysis Insights (hydraulic conductivity unknowns)
- Overall Increased Granularity and View of City-Wide GW Flow
  - Unconfined aquifer leakage
  - Approx 50-yr TOT
  - Interestingly: 1x turnover for PFAS's peak time of use



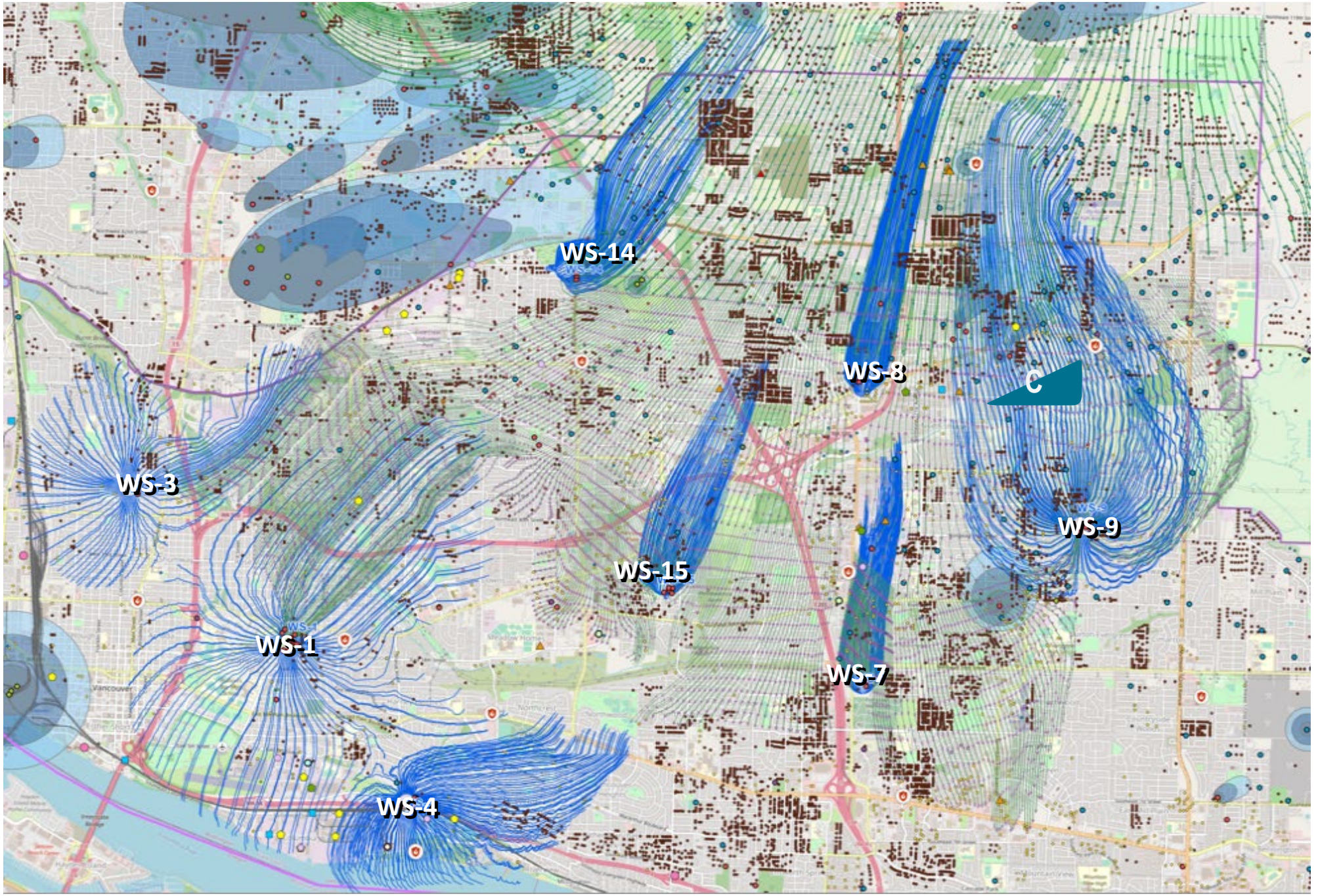






Monitoring Approach

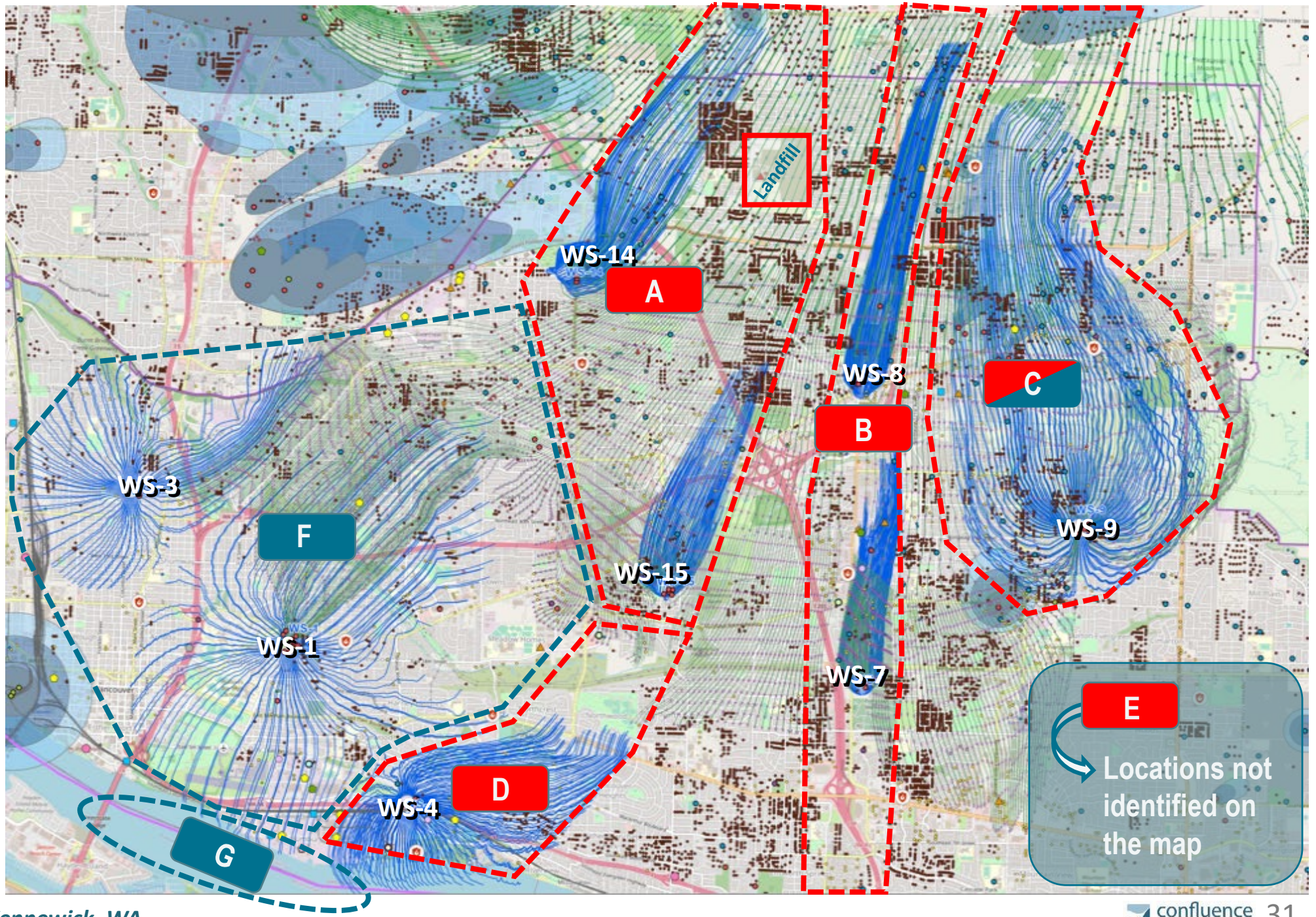
Proposed Monitoring Areas



Proposed Monitoring Areas (Cont.)

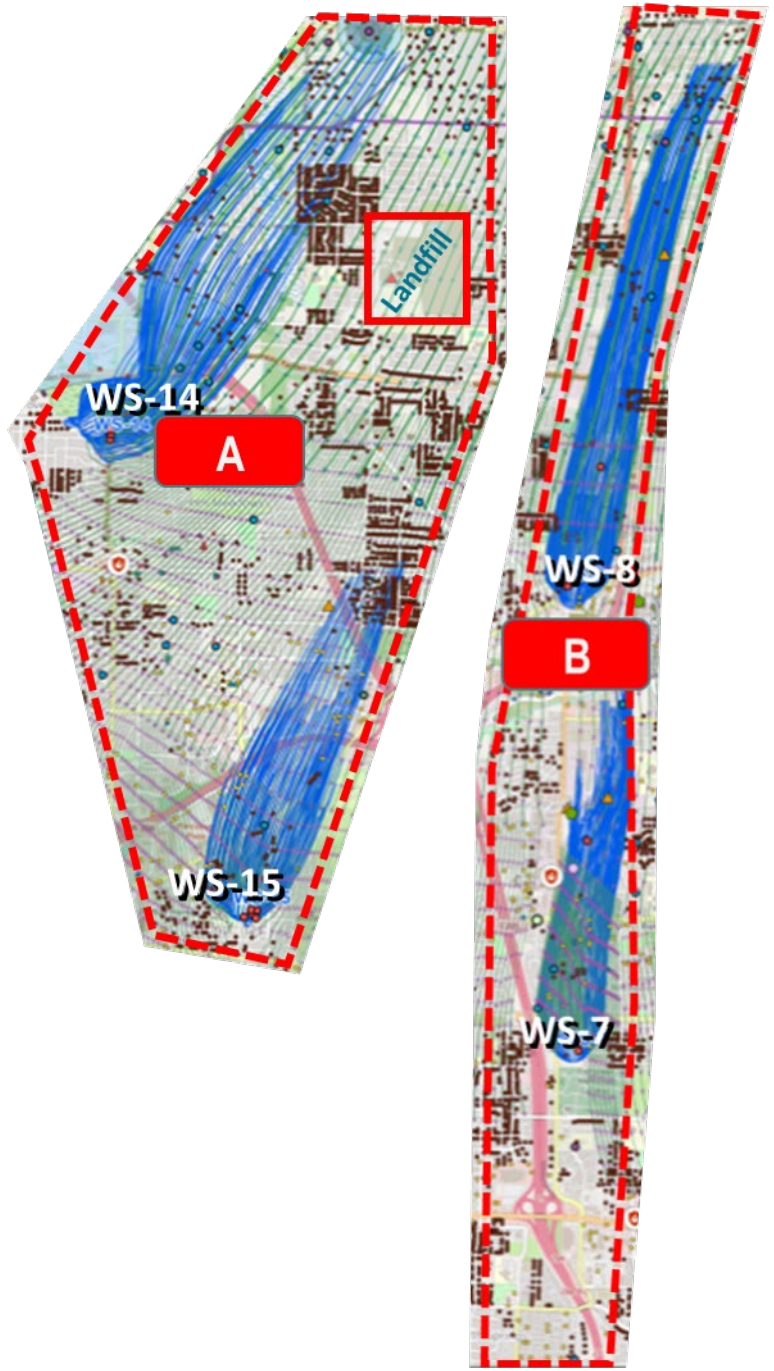
X Primary

X Secondary



Proposed Monitoring Areas (Cont.)

Monitoring Zone ID	Zone Description	Likely Characterizations Made
A	WS 14+15 and Landfill (L)	Diffuse and L sources, transport tracking (L⇨15)
B	TOT through WS 8 and 7	Diffuse sources, transport tracking (8⇨7-1)
C	WS 9	Diffuse sources
D	WS 4 with TOT after WS 15	Diffuse sources, transport tracking (L⇨15⇨4)
E	WW characteristics	Diffuse sources (and correlation with sucralose to use as a surrogate for future septic/WW sampling)
F	WS 1+3, TOT after WS 14	Diffuse sources, transport (L⇨14⇨3; L⇨15⇨1)
G	Columbia river	River source contribution for WS 1+4, defining if stormwater is a significant impact to the river levels



X Primary sampling recommendation

X Secondary sampling recommendation

Proposed Monitoring Areas (Cont.)

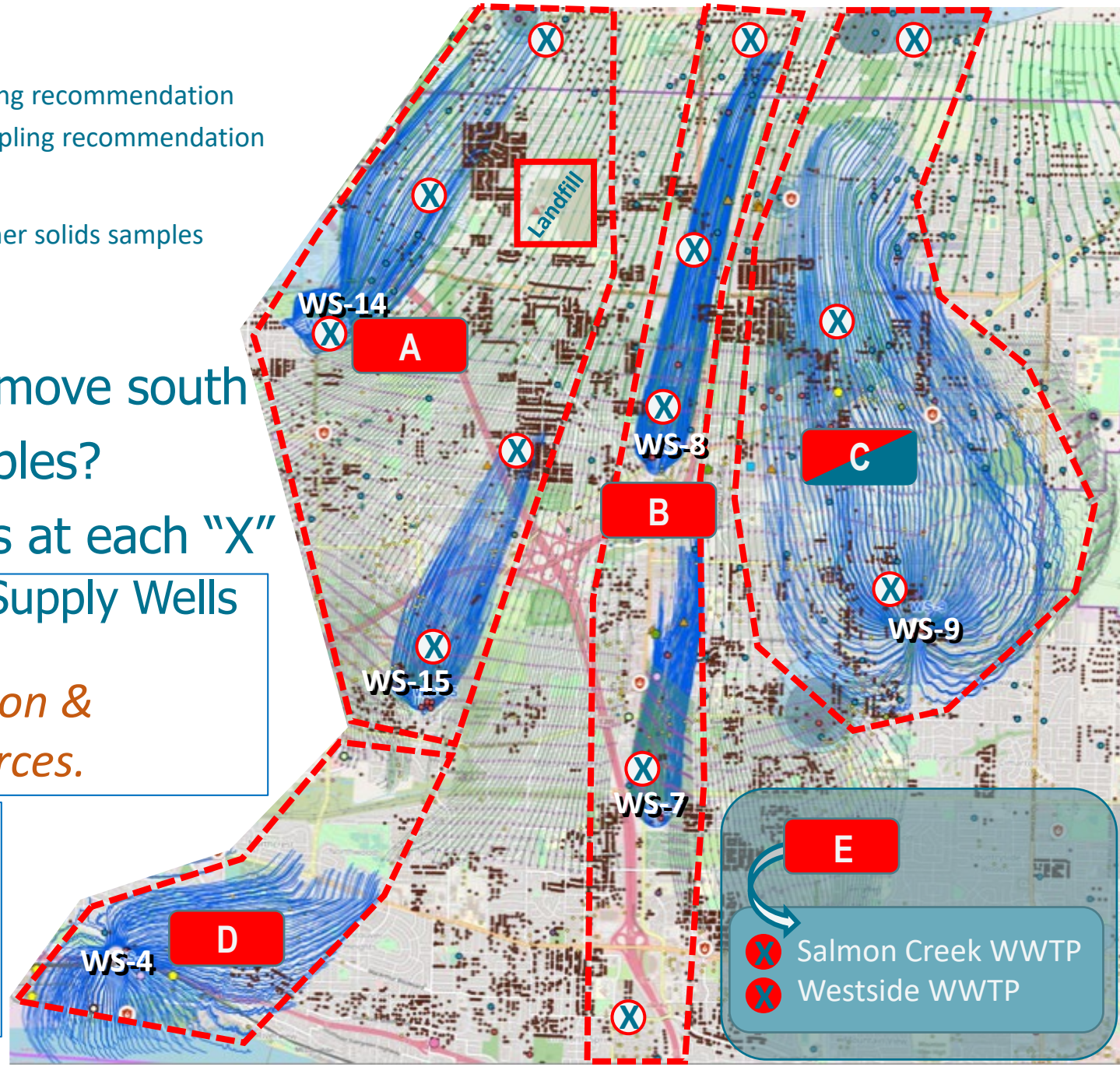
X Primary sampling recommendation

X Secondary sampling recommendation

X Liquid samples

X Biosolids or other solids samples

- Start in the North for A, B, C then move south
- Is there data or do we collect samples?
- Geospatial selection of nearby sites at each "X"
  - Class A and Class B Public Water Supply Wells and City monitoring wells
    - ⇨ *Subsurface characterization & helping to finding point sources.*
  - Septic systems (with surrogates) & stormwater capture structures
    - ⇨ *Significance of diffuse pollution & helping find point sources.*



Next Steps

- Moving Forward With Environmental Monitoring
- Results will consider PFAS magnitude and fingerprint identification
- Digest Results and Adapt Monitoring
  - New sites/locations?
  - Identifying point sources?
  - Drop a sample type off the list?
- Reach goal of PFAS ‘found’ and provide City with information that supports opportunities to further protect public health

In Search of….
PFAS

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Thank You!

American Water Works Association
Pacific Northwest Section
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Kennewick, WA

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