How Climate Change Affects PFAS Transport in the Environment

Water Pollution Working Group of the Climate Change Task Force

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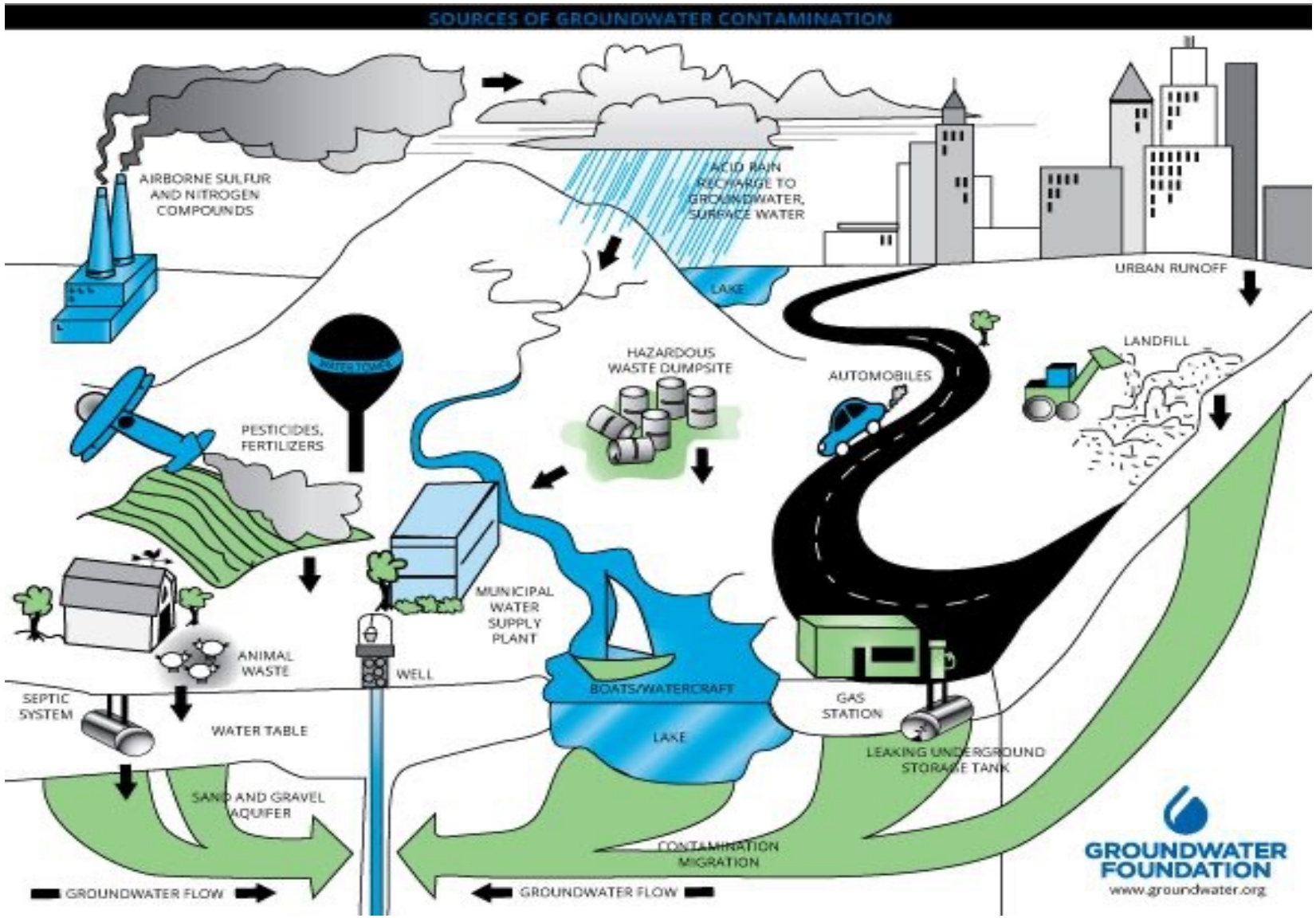
PFAS is Generally Transported Like Other Suites of Contaminants

- Various suites of common anthropogenic (man-made) pollutants such as fuels (e.g., gasoline), solvents (trichloroethylene or perchloroethylene), metals (e.g., road runoff), pesticides or nitrates (fertilizers) often are transported in surface water and groundwater in ways similar to the transport of PFAS.
- Basic transport mechanisms of PFAS are reviewed
- Unique aspects of PFAS compounds are reviewed


SOURCES OF GROUNDWATER CONTAMINATION
AIRBORNE SULFUR AND NITROGEN COMPOUNDS
ACID RAIN RECHARGE TO GROUNDWATER, SURFACE WATER
URBAN RUNOFF
LAKE
LANDFILL
HAZARDOUS WASTE DUMPSITE
AUTOMOBILES
PESTICIDES, FERTILIZERS
MUNICIPAL WATER SUPPLY PLANT
ANIMAL WASTE
WELL
SEPTIC SYSTEM
WATER TABLE
BOATS/WATERCRAFT
GAS STATION
LAKE
LEAKING UNDERGROUND STORAGE TANK
SAND AND GRAVEL AQUIFER
CONTAMINATION MIGRATION
GROUNDWATER FLOW
GROUNDWATER FLOW
GROUNDWATER FOUNDATION
www.groundwater.org

Airborne Deposition of PFAS is Widespread

- Known sources of PFAS in the air:
  - Teflon manufacturing facilities
  - PFAS-containing coating facilities
  - Chrome plating facilities
  - Landfills
  - Plastics manufacturers
  - Wastewater Treatment Plants (WWTPs)

Flooding Concentrates PFAS in Surface Soils

- Increased flooding from more intense storms due to CC **increases the deposition of pollutants in floodplains** and low-lying urban areas. This redistribution and concentration of pollutants (including PFAS) in surface soils will increasingly leach into groundwater.

PFAS Spreads as Groundwater Levels Rise

- Warmer temperatures from CC increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to "hold" water. Increased evaporation is causing drought in some areas and dropping water levels, but also causing increased precipitation in other areas and raising groundwater (gw) levels.
- Recent studies confirm that PFAS compounds in shallow soils normally above the water table will be mobilized (i.e., caught up in the rising gw) & spread to downgradient areas.

PFAS in Wastewater Treatment Plants (WWTPs)/Biosolids

- Background: WWTPs are enormous collection points for PFAS. Biosolids (sludge) from WWTPs are applied to ag lands as they do have some favorable nutrients, but they also routinely have PFAS.
- PFAS in WWTPs effluent and in their biosolids must be controlled.
- Without targeted removal of PFAS at WWTPs, PFAS can move through the treatment process into both the recycled water and biosolids.

PFAS is Currently Not Collected in WWTPs

- WWTPs do not collect the PFAS that is flowing into their systems because PFAS is a relatively new type of contaminant & it requires very expensive installation of carbon filtration or ion exchange
- During monsoonal rains, increased amounts of PFAS flow into WWTPs & the PFAS-rich effluent is typically uncontrolled & flows into waterbodies or into surficial soils where it eventually leaches into underlying groundwater

Typical PFAS Concentrations Flowing Into/Out of WWTP: Bainbridge Island

July 2021: PFOA influent @ 4.2 ppt and effluent at 22 ppt

Conclusion: WWTP is a collection point for PFAS

		Mar-20		July-20		Average Removal
CECs	Unit	Influent	Effluent	Influent	Effluent	Efficiency (%)
PBDE - 33	pg/L	642	180	890	190	75
PBDE - 49	pg/L	757	77.2	958	86.9	90
PBDE - 47	pg/L	32100	869	41800	1060	97
PBDE - 66	pg/L	487	42.4	664	49	92
PBDE - 100	pg/L	5240	144	6950	184	97
PBDE - 99	pg/L	26700	592	35500	779	98
PBDE - 85	pg/L	1080	21	966	17.8	98
PBDE - 154	pg/L	1810	45.7	2160	53	98
PBDE - 153	pg/L	1810	37.7	2670	42	98
PBDE - 183	pg/L	355	< 9.1	514	16	> 97
PFAS Compounds						
N-Methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	ng/L	0.48	< 1.4	NA	NA	0
Perfluorobutane sulfonic acid (PFBS)	ng/L	1.4	0.98	*0.72*	*2.1*	30
Perfluorobutanoic acid (PFBA)	ng/L	< 0.4	< 0.4	3.2	7.4	0
Perfluorodecane sulfonic acid (PFDS)	ng/L	< 13	1.3	< 0.3	< 0.3	0
Perfluorodecanoic acid (PFDA)	ng/L	< 1.2	1.3	1.8	3.1	0
Perfluorododecanoic acid (PFDoDA)	ng/L	< 1.3	< 1.3	1.5	< 1.3	> 13
Perfluoroheptanoic acid (PFHpA)	ng/L	1.1	1.9	1.6	4.1	0
Perfluorohexanoic acid (PFHxA)	ng/L	< 8.8	< 8.8	< 8.8	71	0
Perfluorononanoic acid (PFNA)	ng/L	< 1.1	< 1.1	2.2	2.5	0
Perfluorooctane sulfonic acid (PFOS)	ng/L	3.3	1.8	*2.6*	*2*	34
Perfluorooctanoic acid (PFOA)	ng/L	3.1	11	4.2	22	0
Perfluoropentanoic acid (PFPeA)	ng/L	31	13	34	9.8	65
Perfluorotetradecanoic acid (PFTeDA)	ng/L	< 2	< 2	4.5	2.9	36
Perfluorotridecanoic acid (PFTrDA)	ng/L	< 1.3	< 1.3	2.7	2.7	0
Perfluoroundecanoic acid (PFUnDA)	ng/L	< 1.5	< 1.5	1.7	< 1.5	> 12
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/L	< 0.55	< 0.55	*0.61*	< 0.55	> 10
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	ng/L	*0.58*	*0.19*	*0.5*	*0.32*	52
N-Methyl perfluorooctane sulfonamidoethanol	ng/L	NA	NA	*3.2*	< 1.4	> 56
N-Ethy perfluorooctane sulfonamidoethanol	ng/L	NA	NA	*2.3*	< 0.5	> 78
Phenolic Compounds						0
Nonylphenol Monoethoxylate	µg/L	NA	NA	12	< 4	> 67
Nonylphenols, Total	µg/L	NA	NA	5.3	< 2	> 62
Phthalates						
Bis(2-ethylhexyl) Phthalate	µg/L	< 2.8	< 0.28	4.7	*4.7*	> 0
Diethyl Phthalate	µg/L	*5.7*	< 0.3	*3.8*	*0.43*	> 92
Di-n-butyl Phthalate	µg/L	< 2.4	< 0.24	*2.4*	*0.3*	88

NA = Not tested

* The removal efficiency is defined as 0 when effluent concentration is greater than influent