



RECYCLED WATER

A Tool for Secure Irrigation Water Supply and Stream Flow Restoration in the Sammamish Valley

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PRESENTATION OUTLINE

1. Project Overview
2. Year 1+2: Study Results
 - Contaminants of Emerging Concern
 - Agronomic Parameters
3. 2021 Outreach Results
4. Next Steps
5. Q & A



WASHINGTON WATER TRUST

- Non-profit organization
- Founded 1998
- **Improve and protect stream flows and water quality throughout Washington, benefitting fisheries, wildlife and agriculture.**
- Voluntary, cooperative, market-based strategies
- Work collaboratively with a wide range of partners
- Confidential, non-regulatory organization

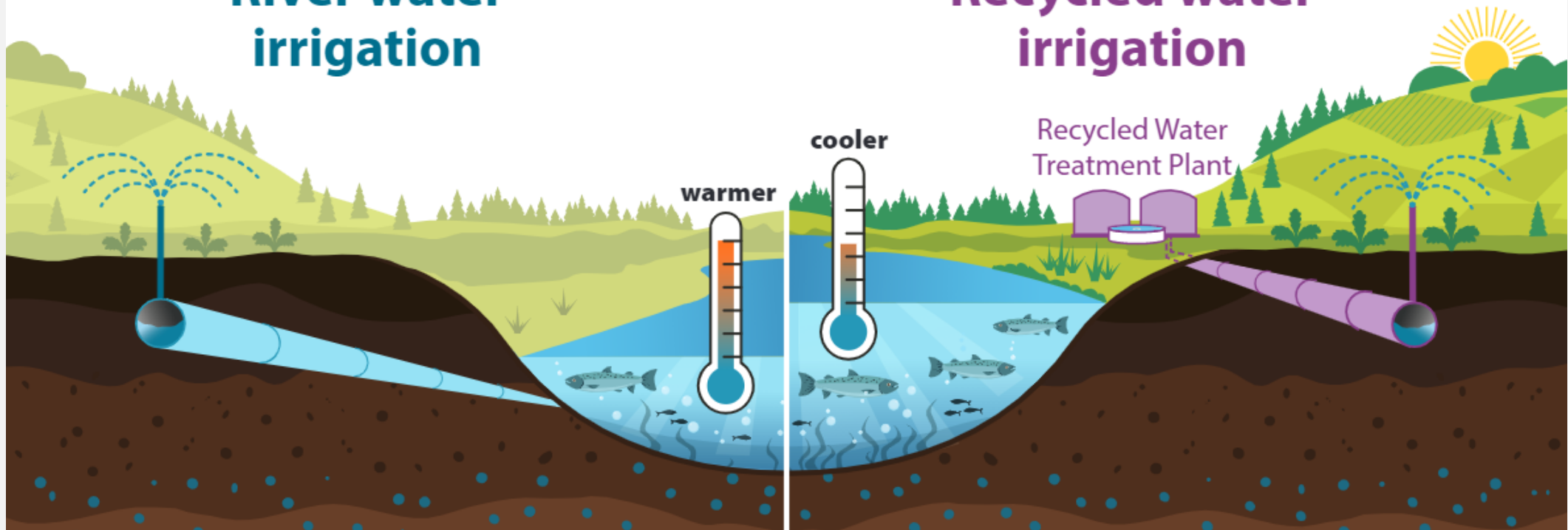


Restoring Sammamish River water to save salmon

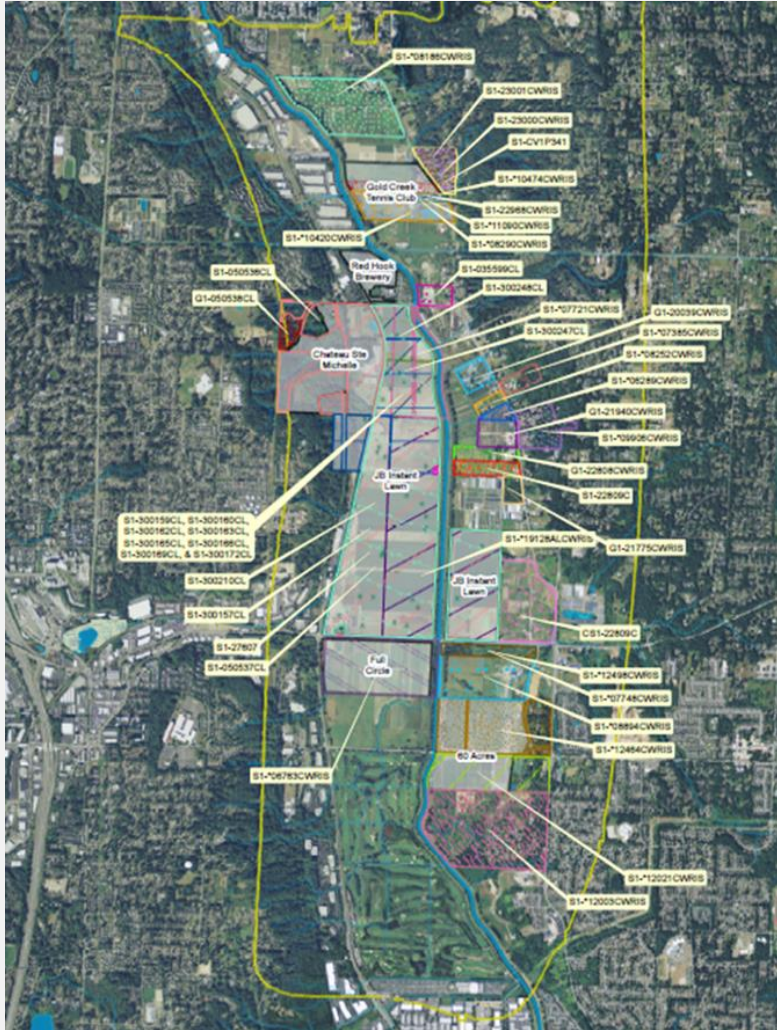
LEAVING WATER IN THE RIVER MEANS BETTER HABITAT FOR FISH

River water irrigation

Recycled water irrigation



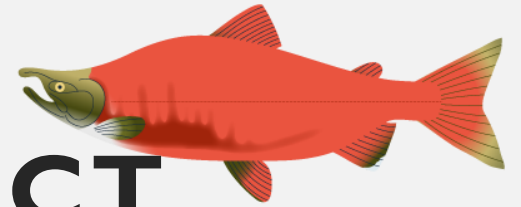
RECYCLED WATER PROJECT



- Fish Critical Basin-WDFW
- Sammamish River Low Flow 25-40 cfs
- **3-5 CFS** Potential Restoration-Irrigation Water Rights
- 2015 Drought
- 2017 Conversation with a Farmer
- 2018-2020: Project Development and Funding



SAMMAMISH VALLEY RECYCLED WATER PROJECT



PROJECT GOALS



Assess the potential impact of irrigating food crops with recycled water.



Identify and address perceptions and concerns of irrigating food crops with recycled water throughout the food supply chain.



Reduce irrigation diversions from the Sammamish river and improve instream habitat for salmon.

PROJECT COMPONENTS

- ✓ Conducted an in-basin research study that evaluated the impact of recycled water vs. Sammamish River water on soil and produce.
- ✓ Conducted producer interviews and consumer outreach to identify concerns and perceptions related to the use of recycled water. Information gathered will be used to create communication material to address these concerns.
- ✓ Identify potential source switch opportunities which could restore up to **5 CFS** with Irrigation Water Rights

Project Team

Washington Water Trust

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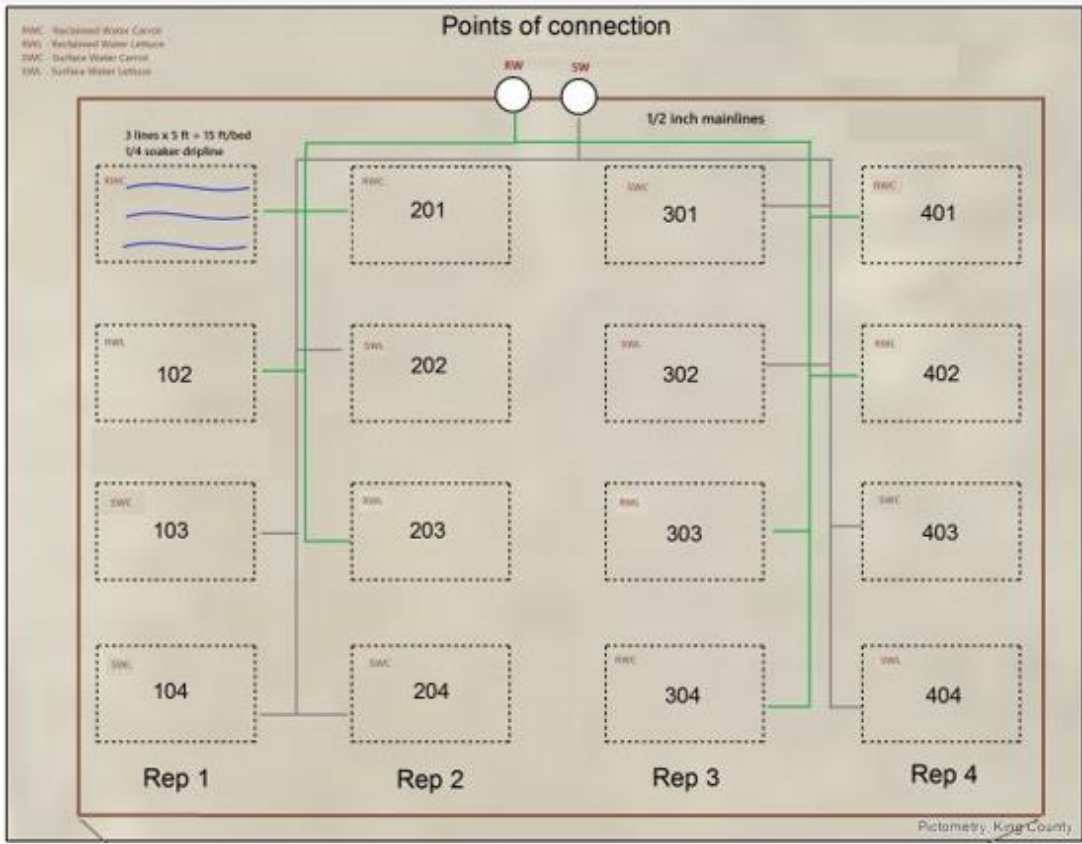
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DEMONSTRATION GARDEN STUDY DESIGN



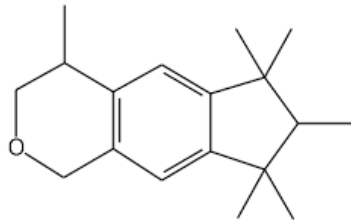
WASTEWATER SOURCES RAISE CONCERNS OVER CHEMICALS IN RECYCLED WATER

“Contaminants of Emerging Concern” or “CECs”...

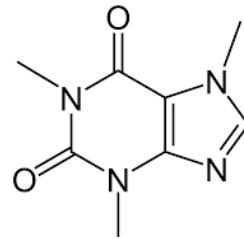


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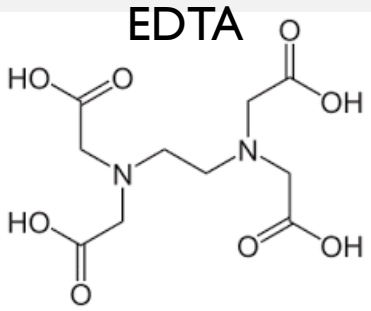
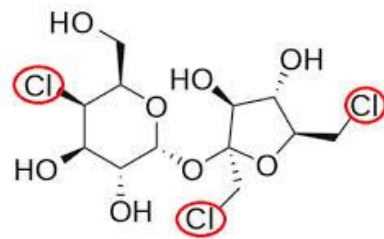
Galaxolide



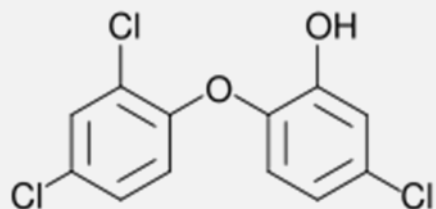
Caffeine



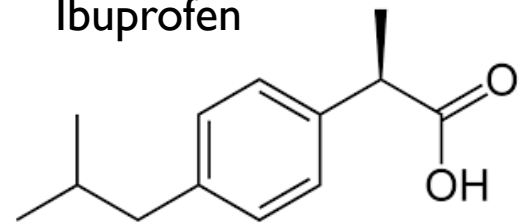
Sucralose



Triclosan



Ibuprofen

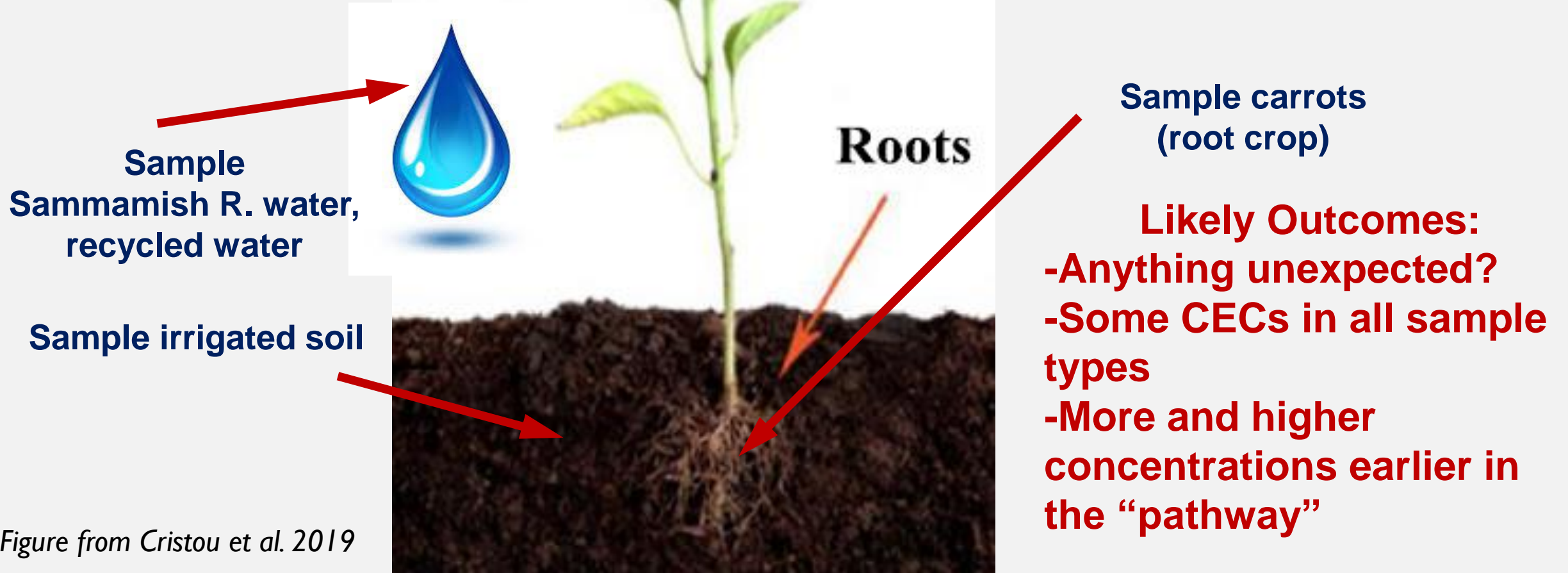


Most people,
most mornings

WHAT HAPPENS TO CECs ON A CROP FIELD??

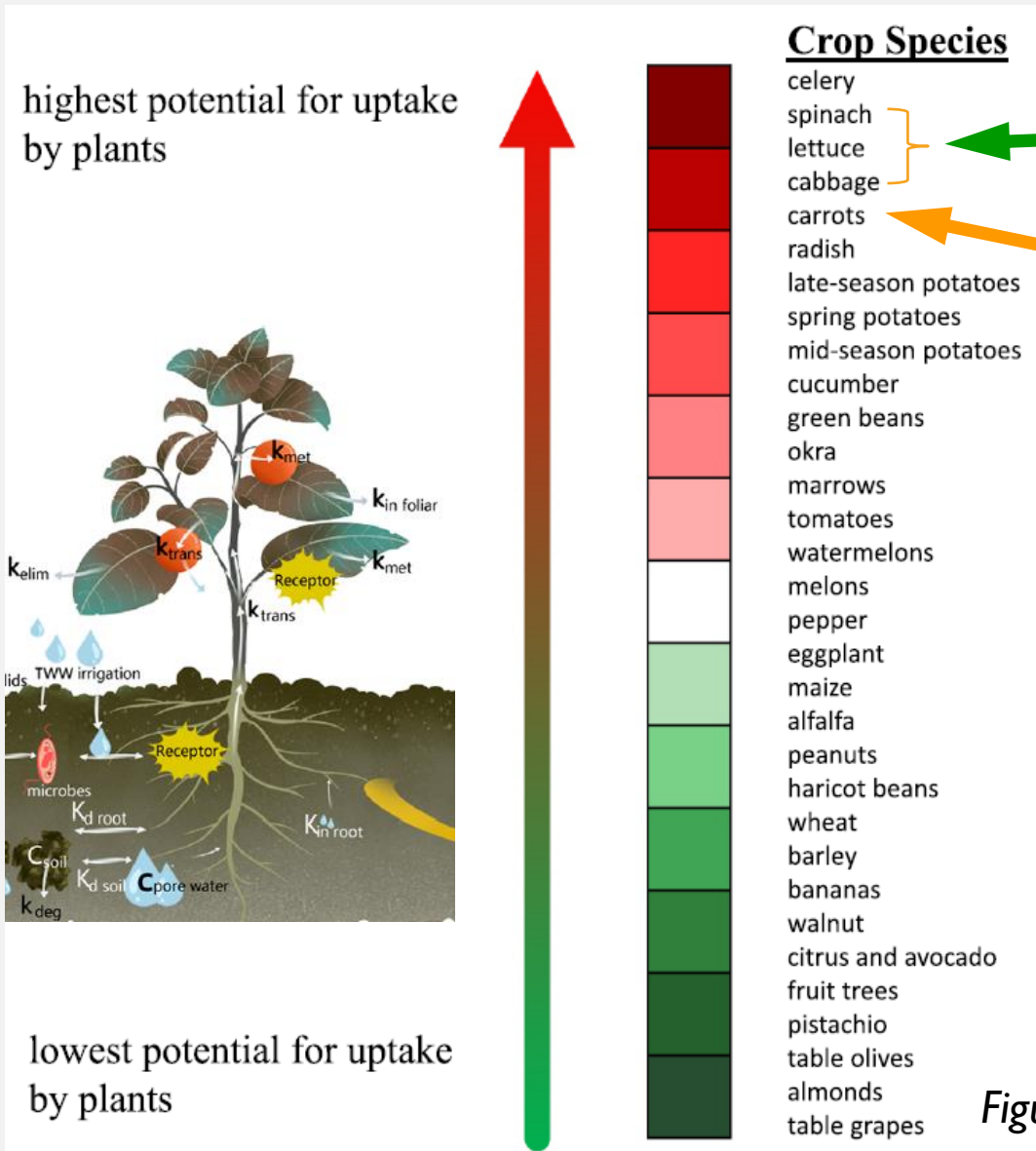
What's present in water, what sticks to soil, what moves into the plant?

Study Design: Measure and compare CECs in irrigation water, soil, and plant tissue



WHY CARROTS AND KALE??

Regional crops, good examples of crops with high rates of CEC uptake...



Leafy Greens: e.g. Kale

Root Crop: e.g. Carrot

Study Design: Not all CECs can move into roots, or move into stems/leaves..

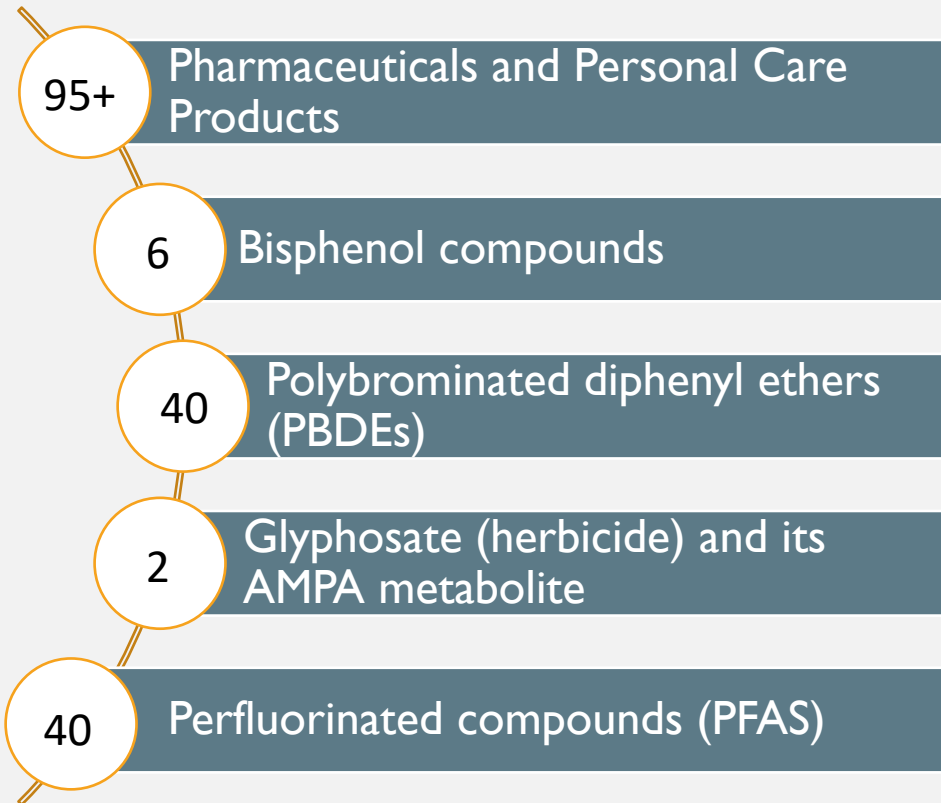
Carrots tell us what CECs can enter roots,

Kale tells us what CECs can move up

Figure from Cristou et al. 2019

SAMPLE ANALYSIS AND PARAMETERS

CEC Sample Matrix (n = 183-204)



CEC samples analyzed by AXYS-SGS commercial lab

Agronomic Parameters (n = 20-30)



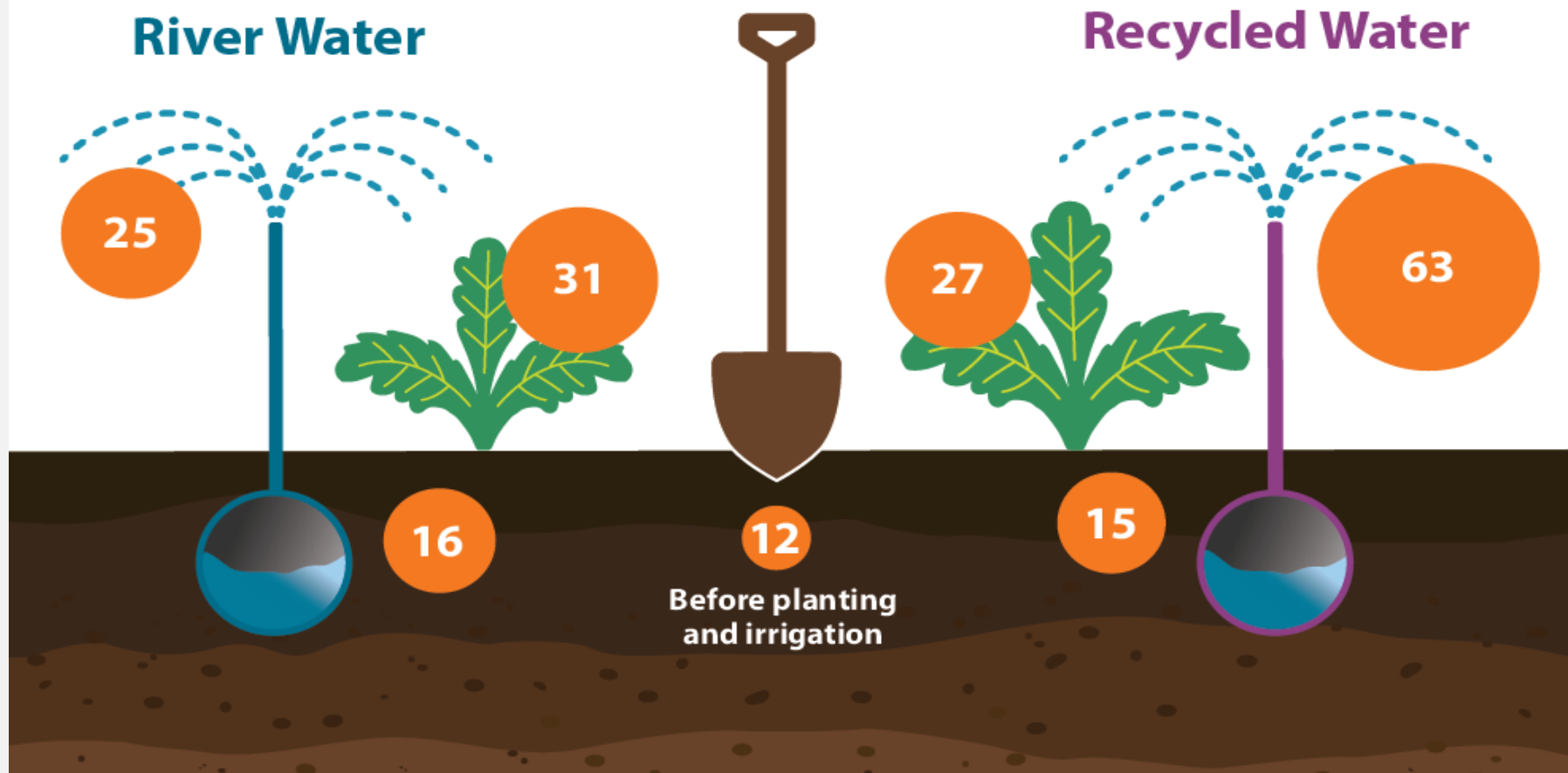
- Nutrients
- Salts
- pH
- Bulk Density

Number of Contaminants of Emerging Concern (CECs) detected locally

CECS
ARE FOUND
EVERYWHERE

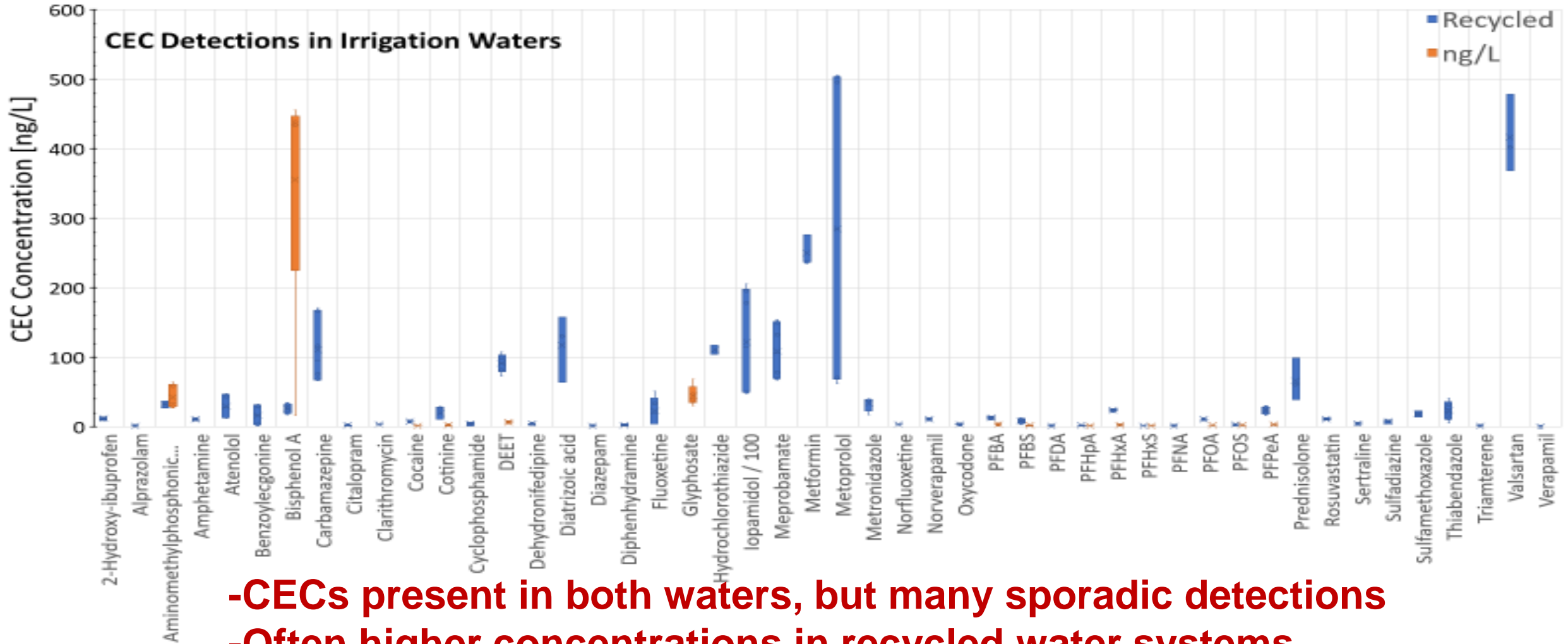
● = Number of CEC Detections
(size relative to number)

Year 1 (2020) Samples



IRRIGATION WATERS: CEC DETECTIONS

Year 1 (2020) Samples



- CECs present in both waters, but many sporadic detections
- Often higher concentrations in recycled water systems
- Brightwater is a relatively high quality recycled water

WATER SAMPLE YEAR 1 RESULTS

Parameter	River Water 25 detections	Brightwater Recycled Water 63 detections
PPCPs (n=118)	11	47
PBDE (n=40)	0	0
Bisphenol (n=6)	2	2
Glyphosate (herbicide) and main metabolite (n=2)	2	2
PFAS/perfluorinated compounds (n=40)	10	12
Compounds with highest concentrations	BPA (>100 ng/L) Glyphosate + metabolite (>10 ng/L)	Iopamidol (>1000 ng/L) Other PPCPs, including caffeine, metformin, carbamazepine (>100 ng/L)



Observations:

- Not all CECs detected in all replicates (year 2 sampling)
- Brightwater pretty high quality among similar recycled waters
- CECs in Sammamish River too



SOIL SAMPLES

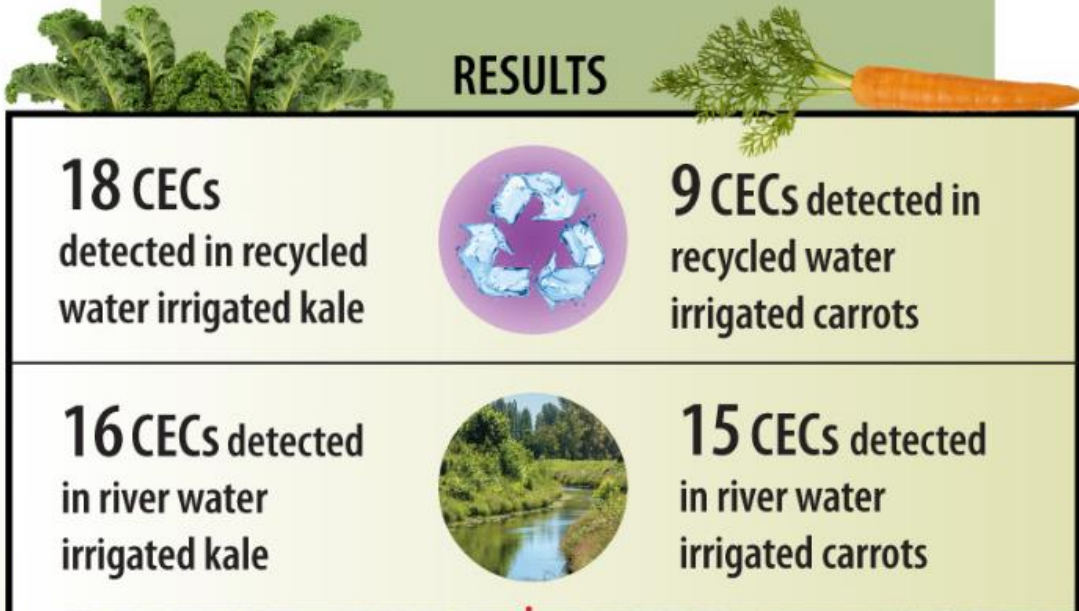
Pre-irrigation sampling: 12 CECs, including BPA, caffeine, PPCPs and PFAS compounds. Trace concentrations.

River plots: 16 CECs in both 2020 and 2021, concentrations still low. CECs: AMPA, PFAS, and PPCPs. Some PFAS and common CECs were found in all samples. Sporadic detections of other CECs.

Recycled water plots: 15 CECs (2020) or 29 CECs (2021), including BPA, caffeine, other PPCPs and PFAS. Concentrations low. PFAS and common PPCPs (e.g., metformin) were detected in all samples. Sporadic detections of other CECs.

No clear evidence of CEC accumulation in soils with recycled water irrigation. Only metformin, was detected at concentrations consistently higher in recycled water irrigated soil relative to the Sammamish River irrigated soils. Nothing obvious from this study (might need longer time periods and more water).

Crops: Year 1 CEC Results



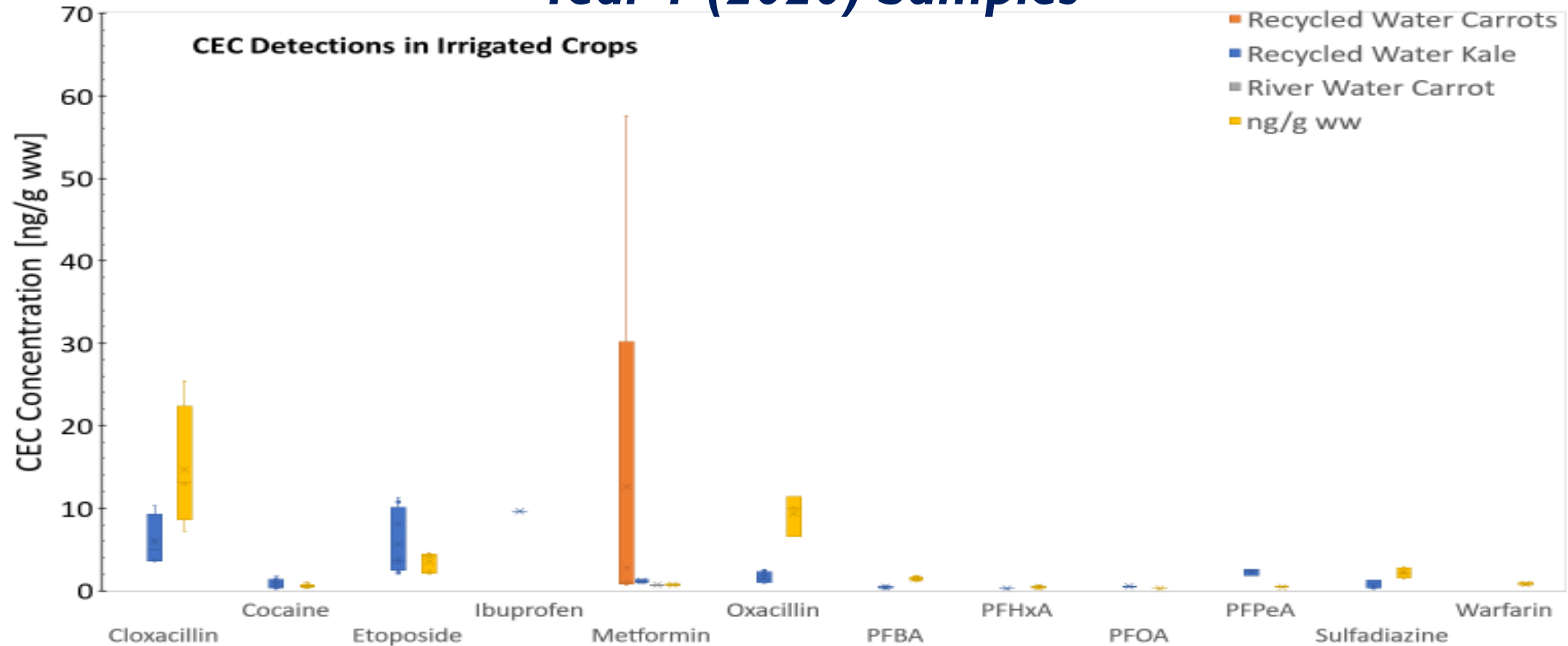
CEC detection #s were similar for both river water and recycled water irrigation.

Only 9 CECs were present at concentrations well above method LOD and were present in ≥ 2 replicates:

- PFAS (2) and 6 PPCPs
- In both river and recycled water irrigated plants
- Concentrations in recycled water tended to be higher
- Trace amount of cocaine also detected in waters and crop plants

IRRIGATED CROPS: CEC DETECTIONS

Year 1 (2020) Samples

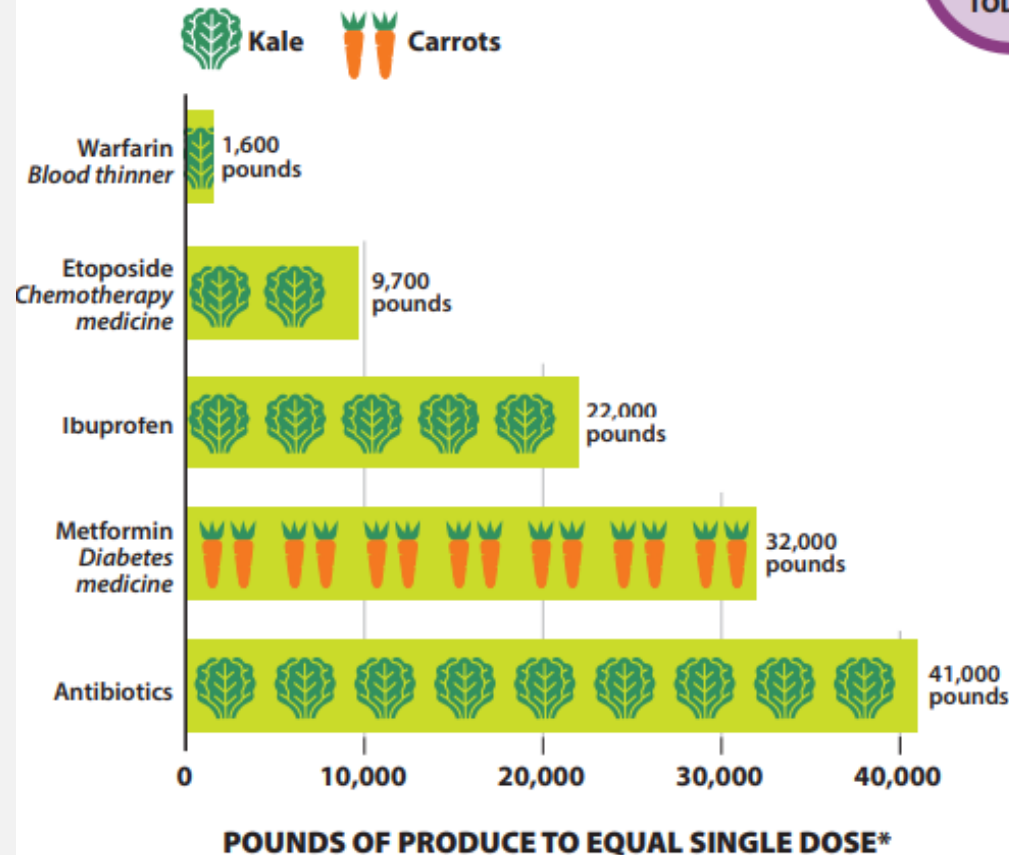


- CECs present in both crops, more/higher in kale
- Risks mostly driven by PFAS (etoposide in year 1?)

HUMAN EXPOSURES: THOUSANDS OF POUNDS OF PRODUCE EQUALS A SINGLE DOSE OF PHARMACEUTICAL CECS

Pharmaceuticals in recycled water

You would need to eat this much produce every day to be exposed to a single dose of a drug

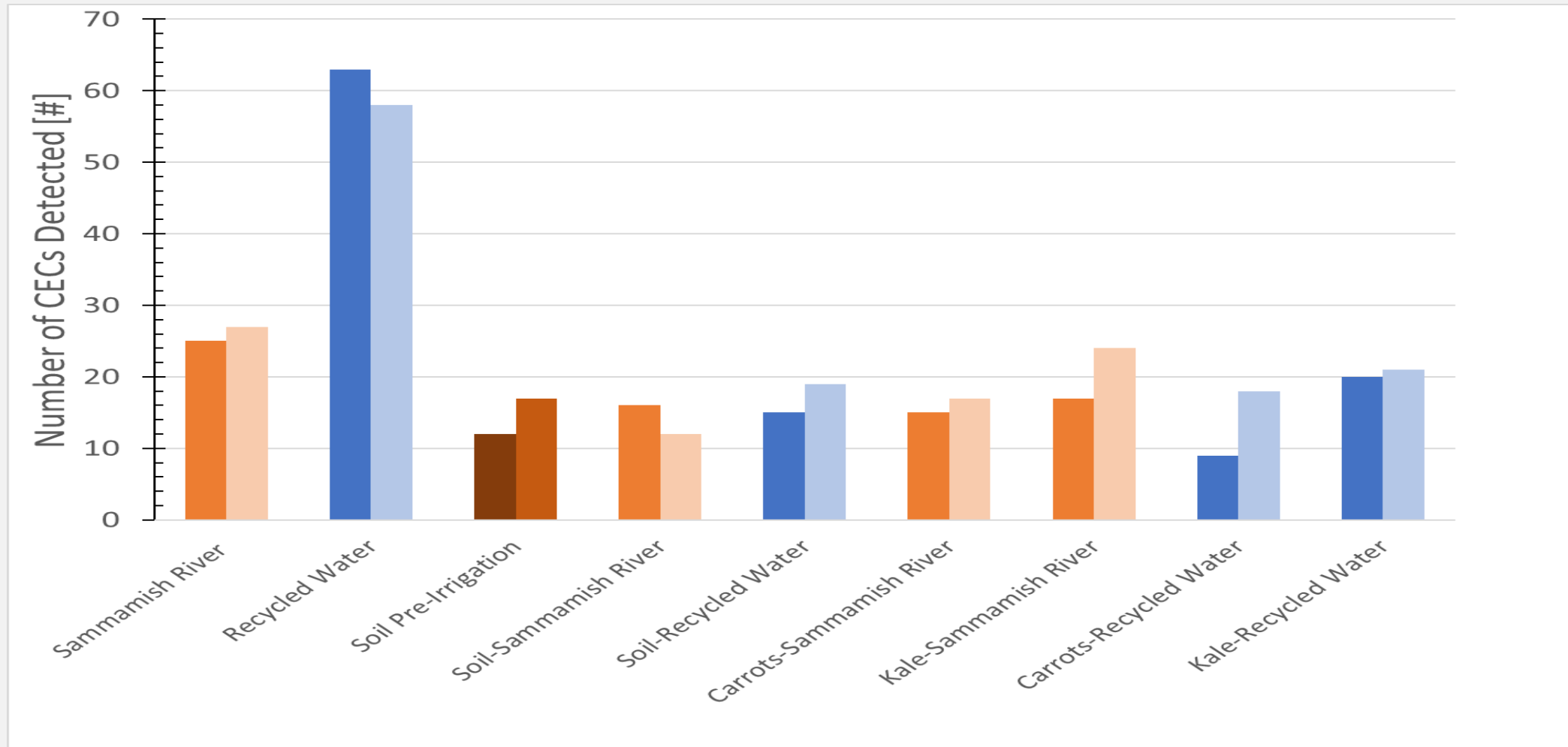


Compound	Max. Detected Concentration in Water [ng/L]	Max. Detected Concentration in Edible Crops [ng/g]	Typical Pharmaceutical Dose [mg/d]	Quantity of water or produce representing one pharmaceutical dose (per day)
Antibiotics	40	13.1	250-2000	>1,600,000 gallons >41,000 lbs
Metformin	276	57.6 (once) 2.8 (all others)	850-2000+	>810,000 gallons >32,000 lbs
Warfarin	Not detected	1.3	1-10	>1,600 lbs
Etoposide	Not detected	11.3	50-300	>9,700 lbs
Cocaine	8.1	1.7	10-100	>320,000 gallons >12,000 lbs
Ibuprofen	4	9.6	100-1000	>6,600,000 gallons >22,000 lbs

* Dosage from drugs.com

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ALL SAMPLE TYPES: YEAR 1 VS. YEAR 2

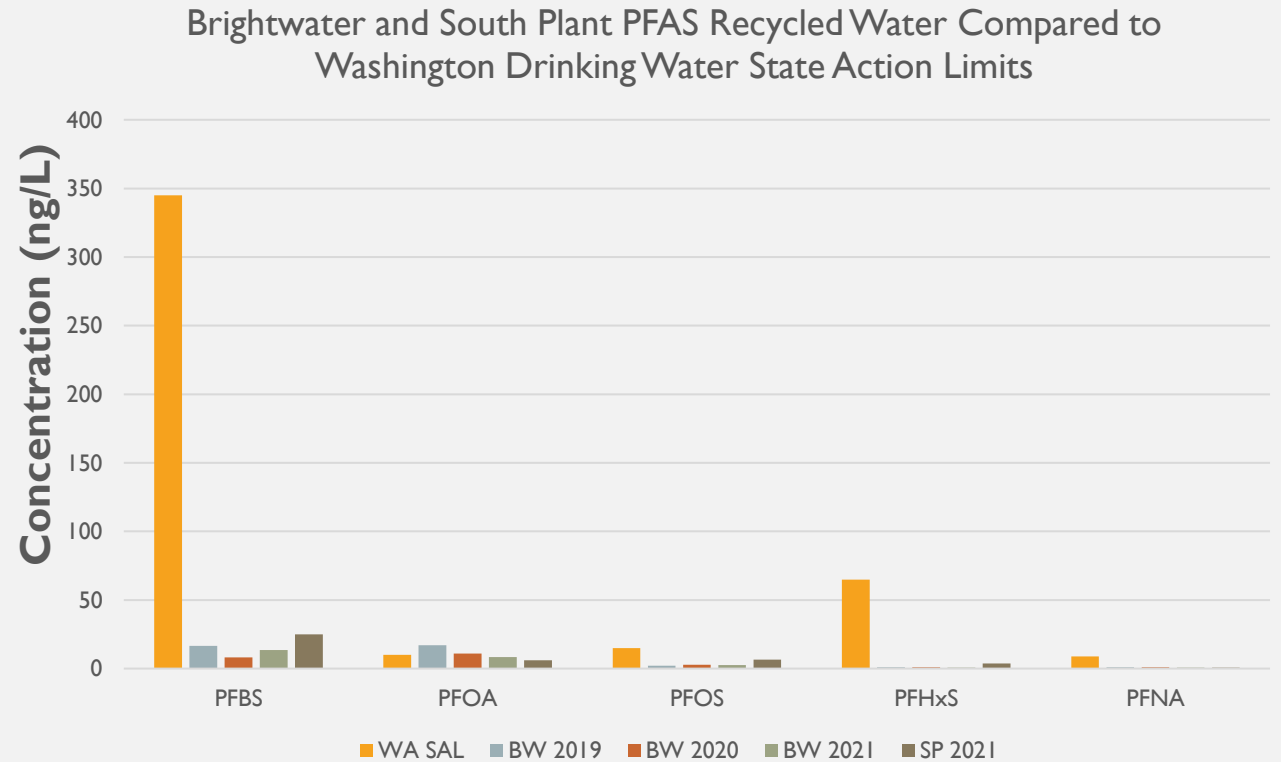


- Pretty similar numbers and general compositions across both years
- Some individual chemicals very different in occurrence and concentration
- Similar CEC numbers, but higher concentrations in recycled water systems

PFAS Compound	Brightwater RW Average (ng/L) 2019 - 2020 - 2021	South Plant RW Average (ng/L) 2021	Sammamish River Average (ng/L) 2020-2021
PFPeA	24.2 - 23.8 - 36.2	12.5	2.3 - 1.8
PFHxA	17.0 - 24.2 - 22.6	40.2	1.5 - 2.5 - 2.7
PFBS	16.5 - 8.3 - 13.7	25.1	1.3 - 1.9 - 2.2
PFBA	7.4 - 13.0 - 10.9	19.1	3.5 - 2.2
PFOA	17.0 - 11.1 - 8.5	6.1	1.5 - 2.1 - 1.6
PFOS	2.1 - 2.9 - 2.6	6.6	2.0 - 2.4 - 1.8
PFHpA	3.2 - 2.2 - 1.8	4.9	1.1 - 0.9
PFDA	1.6 - 1.3 - 1.5	0.8	n/d
PFOSA	0.9 - 0.6	n/d	0.7 - 1.6
PFHxS	0.9 - 0.9 - 0.8	3.7	1.2 - 1.2 - 1.2
PFNA	1.0 - 1.0 - 0.7	0.8	0.5 - 0.4

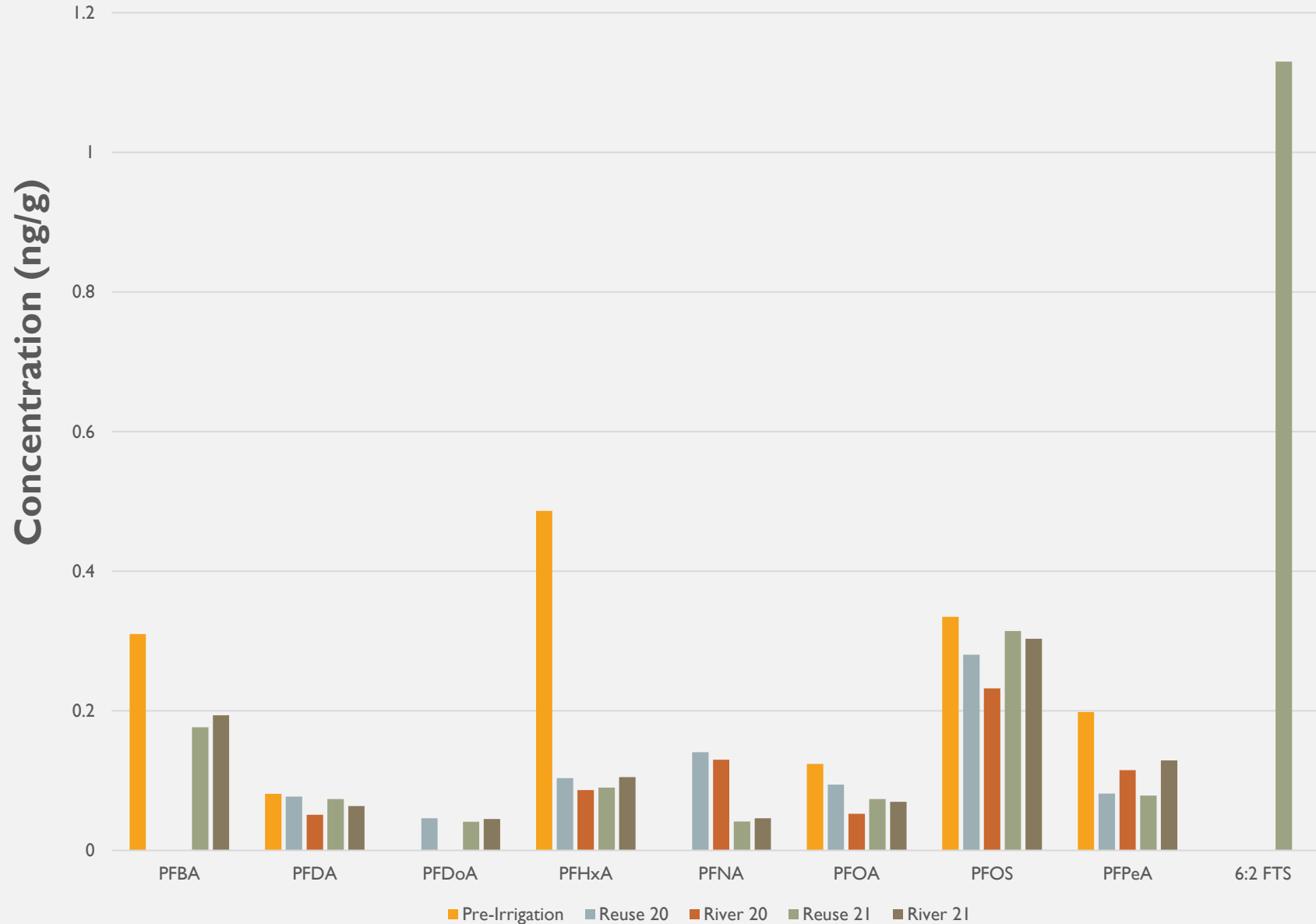
PFAS IN WATER

-No action limits or guidelines for irrigation water, but recycled water PFAS data are at or well below Washington drinking state water action limits (SAL)



PFAS IN SOIL

PFAS Measurements in Soil by Water Type

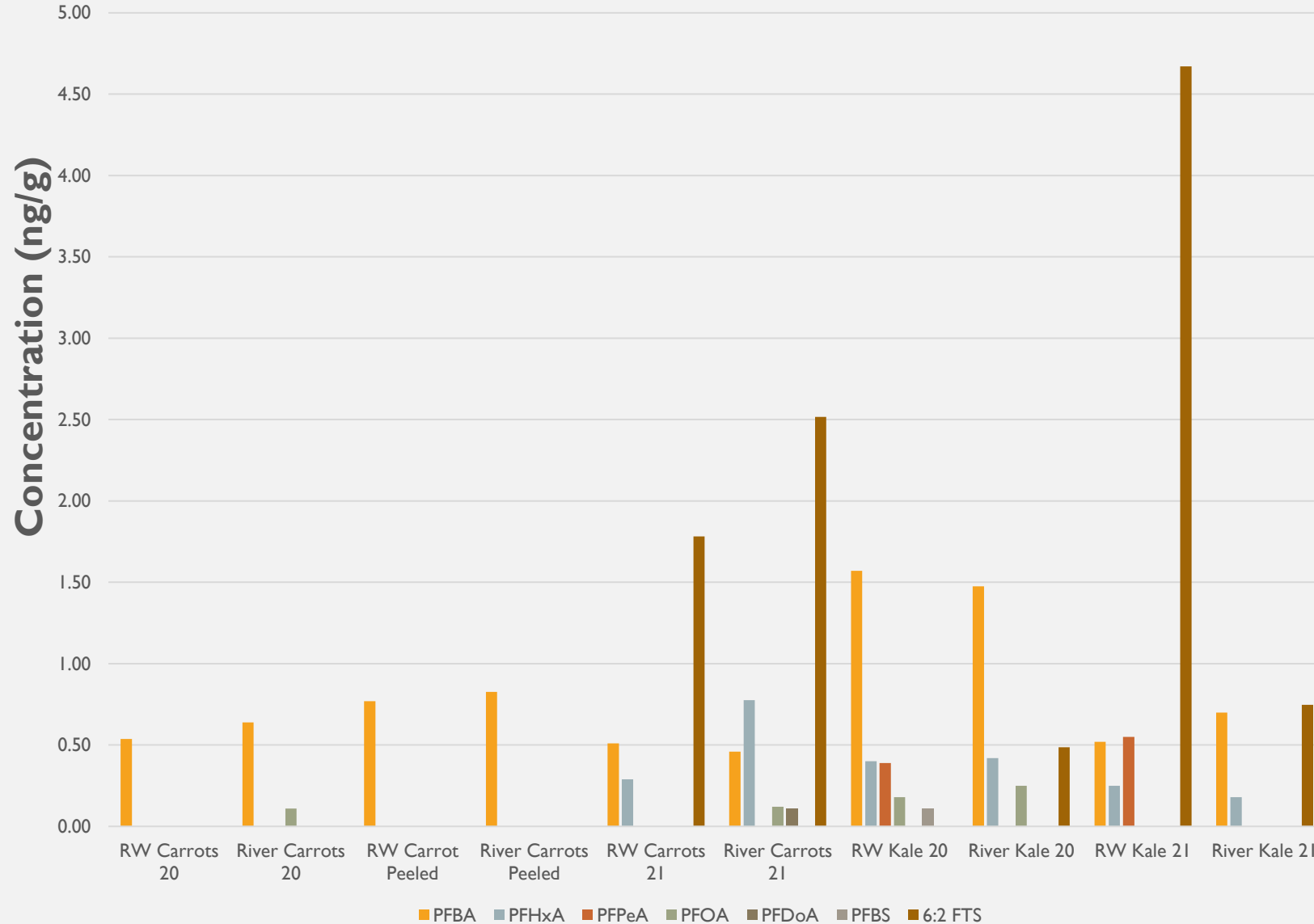


-Highest concentrations measured prior to irrigation

-Concentrations trended by year more closely than water type

PFAS IN PLANT TISSUES

PFAS Crop Measurement by Crop and Water Type



-Detections/concentrations were similar between river and recycled water irrigation

-Concentrations: kale > carrots, (greater water uptake)

SOUTH PLANT CEC SAMPLING

South Plant Rank	Relative concentration (ng/L)	CEC	Role	Bright-water Rank	Relative concentration (ng/L)
1	30-34,000	Iopamidol	Xray contrast agent	1	1,400-8,600
2	800-5,600	Bisphenol A	Plasticizer	21	7-24
3	2,000-4,400	Metformin	Diabetes medication	31	1-15
4	1,800-2,300	Lamotrigine	Antiseizure anticonvulsant	6	15-150
5	1,400-1,500	Hydrochlorothiazide	Diuretic	16	11-23
6	1,000-1,300	Diphenhydramine	Antihistamine	42	1-4
7	570-1,400	Azithromycin	Antibiotic	35	3
8	700-1,000	Diatrizoic acid	Xray contrast agent	2	75-1,840
9	700-800	Topiramate	Antiseizure, anticonvulsant	3	485-745
10	600-700	Gemfibrozil	Cholesterol control	44	1.75-2.25

CEC concentrations were considerably higher for most compounds than samples from Brightwater

Pharmaceuticals were the most detected and at the highest concentrations

Notably, PFAS concentrations, were not that different between South Plant and Brightwater

SAMMAMISH RESEARCH CEC INITIAL CONCLUSIONS



CECs are everywhere, come from multiple sources



CEC detections align with other recycled water research; Brightwater recycled water tends to have low concentrations (relatively)



CEC compositions in natural waters correlate with land use



Irrigating with recycled water provides many benefits and is a low risk exposure pathway for CECs. "Generally accepted as safe"

AGRONOMIC RESULTS: YIELD



Recycled water test garden: Year 1 crop yield and soil health results

Kale

POUNDS PER
GARDEN BED

10

147%
more

5



River
Water

Recycled
Water

Carrots

POUNDS PER
GARDEN BED

3

25%
more



River
Water

Recycled
Water

NUTRIENTS
IN RECYCLED
WATER MEANS
MORE CROP
YIELD

Recycled water
supports healthy
soil and plants

- ✓ Soil pH
- ✓ Salts
- ✓ Conductivity



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2021 OUTREACH





2021 CONSUMER OUTREACH

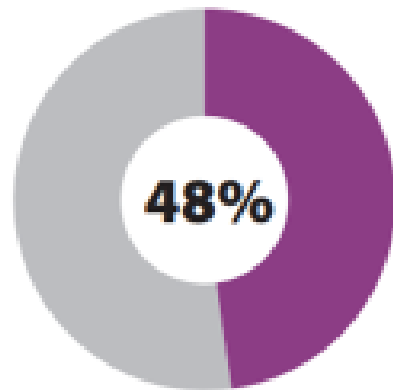
- Outreach at farmers markets
 - Four markets in 2021
 - Engaged 500 individuals
- Baseline Survey
- Two focus groups led by OSU Grad student

Consumer outreach indicates strong support for using recycled water for food crop irrigation.

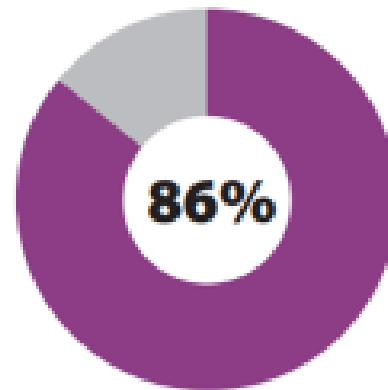
A survey was developed to understand public sentiment towards recycled water.

Participants were provided the following definition: *"Recycled water is highly treated wastewater that has been filtered and disinfected to remove solids and other impurities. Simply put, recycled water is treated water that is used more than once."*

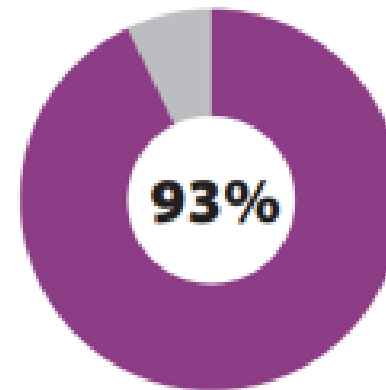
Participants reported:



had "some to a strong" understanding of the term recycled water



would eat crops grown with recycled water



would eat crops grown with recycled water if it helped salmon



PRODUCER OUTREACH

- 15 Structured Interviews
 - 2 Farmer Field Days (2020-2021)
- Farmers are supportive of recycled water but are concerned about consumer's opinions on using recycled water for irrigation.



2022 OUTREACH





2022 CONSUMER OUTREACH

- Outreach at farmers markets
 - Seven markets in 2022
 - Engaged >300 individuals
- Informed Consumer Survey
- Host additional focus groups

NEXT STEPS

- Year 2 data analysis of the Research Study (CECs and agronomic data)-
Finalize Technical Report
- Continue Outreach along the Food Supply Chain
 - 2022 Consumer Outreach
 - Finalize Social Science Report
- Establish On-Farm Demonstration Projects
- Continue to assess potential source switch opportunities in the Sammamish



QUESTIONS?



Thank You To Our
Project Funders:

BULLITT
FOUNDATION



King County

KCD
King Conservation District