# DE FACTO REUSE IMPACTS ON DRINKING WATER QUALITY AT SMALL PUBLIC WATER SYSTEMS IN THE UNITED STATES

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## I. Background

- Nearly 15,000 WWTPs serve about 76% percent of the U.S. population with approximately 238.2 million people in 2012
- De facto reuse (DFR) occurs when treated wastewater is discharged into the upstream of a public water system (PWS)
- Many of contaminants of emerging concerns (CECs) and pathogens (such as *Cryptosporidium parvum* or *Giardia lamblia)* in treated effluents can resist removal through conventional water treatment processes and enter potable water
- Our prior study concluded that >50% of large PWSs serving > 10,000 people (N = 2,160) have at least one wastewater treatment plant (WWTP) discharge upstream[1]
- However, about three times more PWS surface water intakes serving communities <10,000 people

*Research Need*

- To perform a complete national wide analysis of extent de facto potable reuse and predict population expose to CECs in tap water

## II. Modeling Approach

- A geospatial model of the De Facto Reuse Incidence in our Nations Consumable Supply (DRINCS)
- Expand the DRINCS model with the EPA database for small PWSs (Surface water intakes = 5,184)
- Outfalls of treated wastewater to surface water in the US (N = 14,651) obtained from Clean Watershed Needs Survey 2008
- National Hydrography Dataset (1:100,000 scale) (USGS NHD)
- Validation of the DRINCS with field observation of the CECs occurrence at PWSs[3]
- Equation: $DFR = \frac{\sum Q_{ww,i}}{Q_{SW}} \times 100\%$
  - $Q_{ww,i}$ :cumulative upstream WWTP design discharges (cfs)
  - $Q_{sw}$ :streamflow at the surface water intake (cfs)

## III. Modeling Results

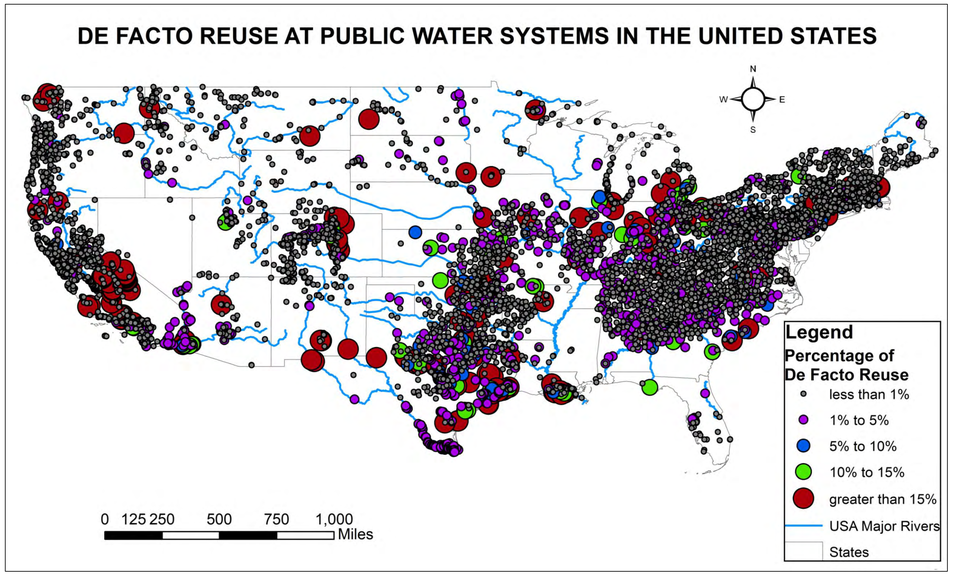


Fig 1. Nationwide de facto reuse at PWSs under mean annual streamflow condition (all surface water intakes were completely groundtruthed for precise locations (N = 8, 969)

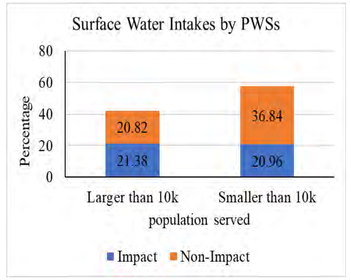


Fig 2. Number of surface water intakes non- or impacted by treated wastewater upstream categorized based upon population served by a public water system

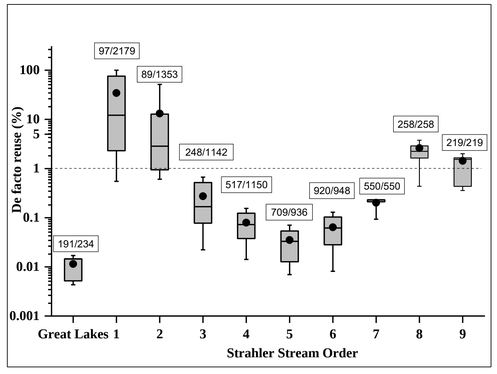


Fig 3. De facto reuse at PWSs as a function of Strahler stream order. Top and bottom of box = 75th and 25th percentiles respectively; top and bottom of whisker = 90th and 10th percentiles respectively; line across inside of box = median (50th percentile). 191/234 = 191 is the number of surface water intakes with DFR>0 upstream WWTPs and 234 is the total PWS surface water intakes)

## IV. Conclusions

- More than 40% of surface water intakes by all PWSs in the U.S were impacted by treated wastewater upstream under mean annual streamflow condition (N = 3,798)
- High occurrence of DFR at smaller PWSs under mean annual streamflow with about 50% surface water intakes impacted by treated wastewater (N = 1,880)
- Smallest streams (1st order and 2nd order) or largest streams had higher DFR
- PWS intakes on the 3rd through 7th order stream had DFR below 1% due to natural runoff diluting wastewater

## V. Future Work

- Further statistical analysis on DFR levels at large PWSs and smaller system (serving more or less than 10,000 people)
- Modernize the DRINCS 2.0 model with year 2012 WWTP information
- Groundtruth work for all outfalls of treated wastewater to surface water (N ~ 15,000)

*Application of the DRINCS*

- The DRINCS model is capable of estimating travel times which are important to understand the natural attenuation capacity of surface water systems for wastewater-derived CECs
- Identify hotspots (with higher risk of) de facto potable reuse where monitoring programs could be performed and where infrastructure upgrades could most effectively reduce human exposures to CECs.

## References and Acknowledgement

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