Impact of Nitrogen Removal in Wastewater Treatment on DBP Formation at Downstream Drinking Water Treatment Plants

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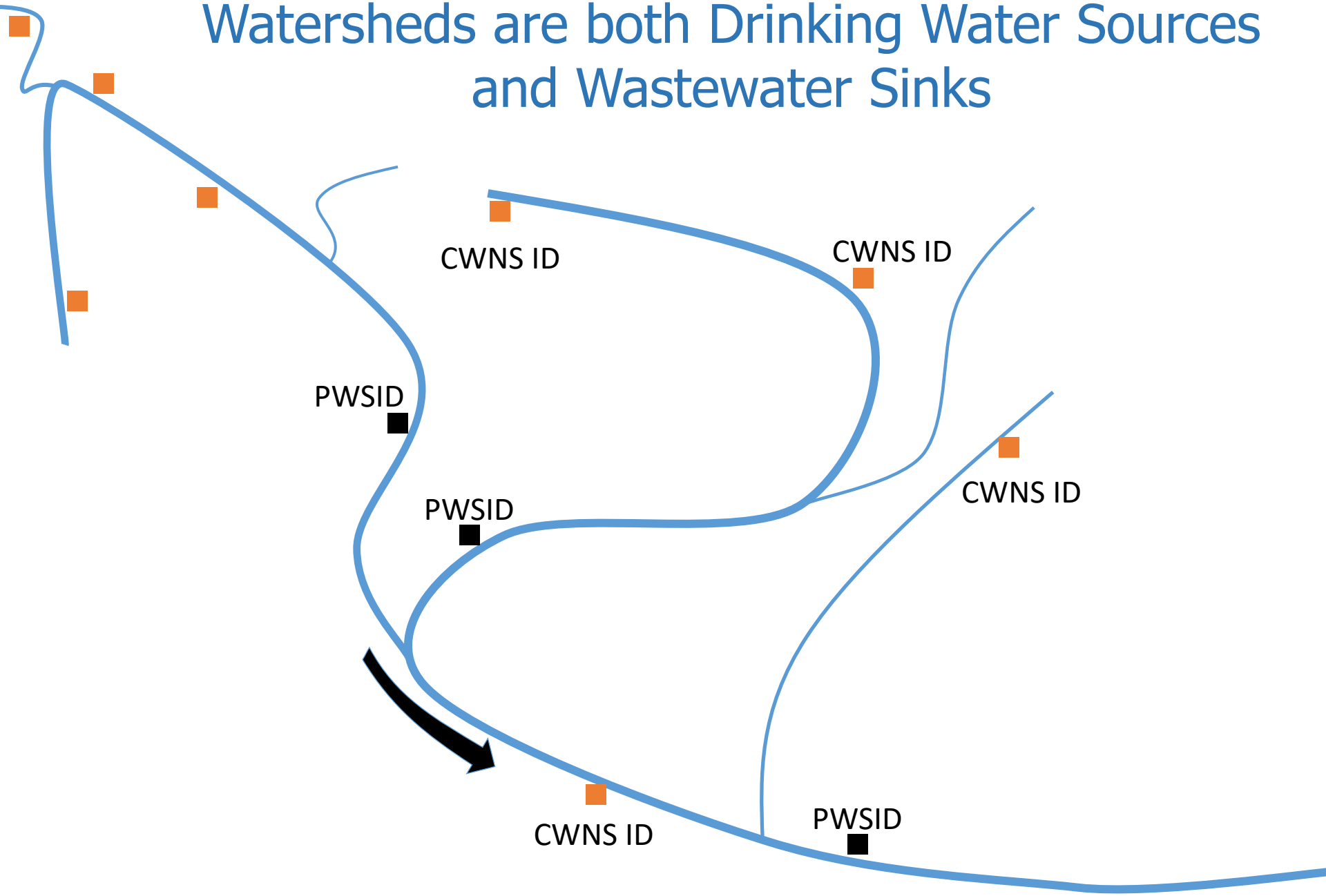
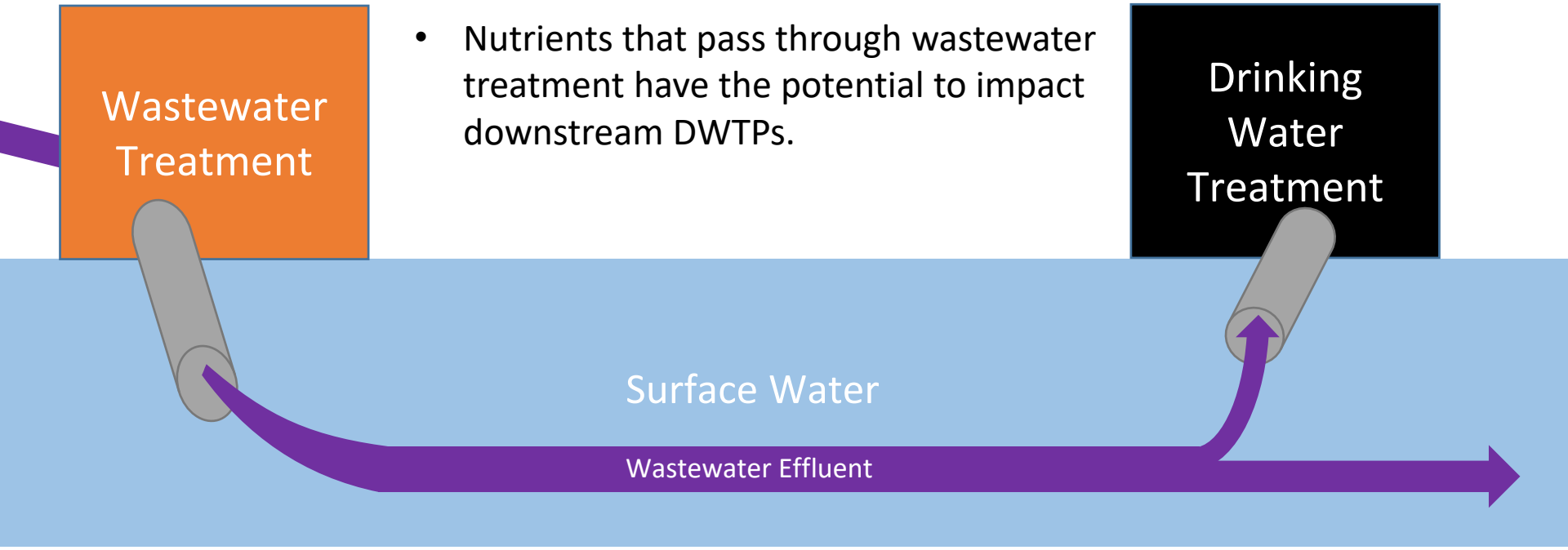
The statements in this presentation do not necessarily reflect the view of the EPA.

Watersheds are both Drinking Water Sources and Wastewater Sinks



De Facto Reuse (DFR) occurs when the receiving water for wastewater effluent serves as the source water for a downstream drinking water treatment plant

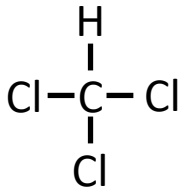
- National survey of DWTPs (Rice and Westerhoff, 2015) indicated ~50% of intakes were influenced by DFR
- About half of the impacted intakes had DFR greater than 1% by volume



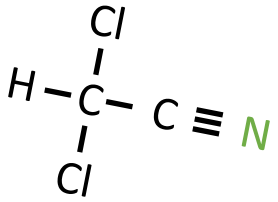
- Nutrients that pass through wastewater treatment have the potential to impact downstream DWTPs.

Rice, J., and Westerhoff, P. (2015). "Spatial and Temporal Variation in De Facto Wastewater Reuse in Drinking Water Systems across the U.S.A." *Environmental Science & Technology*, 49(2), 982-989.

Treatment occurs at the drinking water treatment plant.



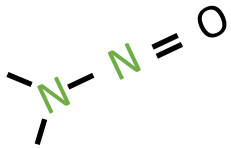
- Coagulation/flocculation and sedimentation
- Filtration
- Disinfection **Critical**

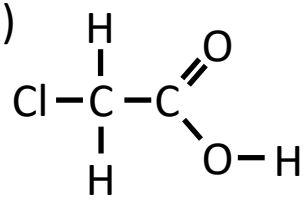


Add chlorine or chloramine to kill pathogens, bacteria, and other living organisms in the water.

Cl_2 + Organics = Disinfection Byproducts (DBPs)

Cl_2 + Organics + N = N-DBPs



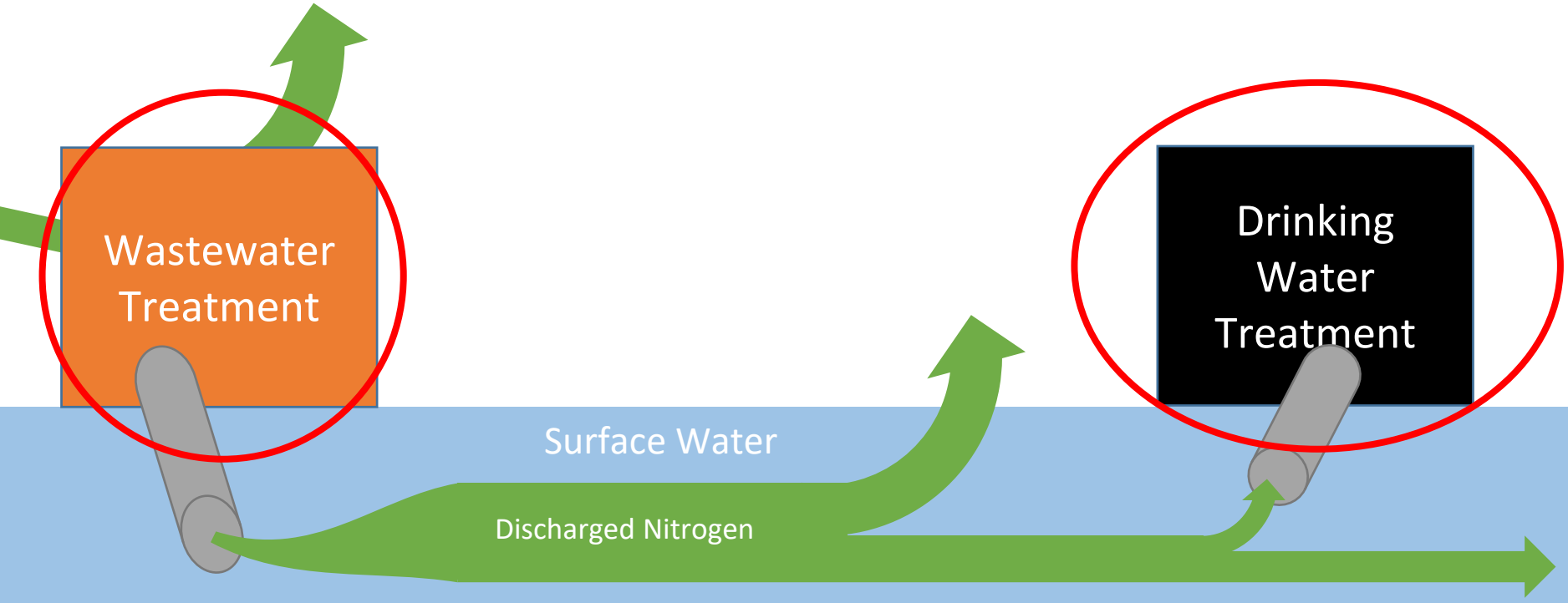


- DBPs Have been linked to adverse reproductive effects and carcinogenicity
- Nitrogenous species are more toxic than their carbonaceous counterparts
- No N-DBP regulations!
  - California notification level for NDMA is 10 ppt (ng/L)

Treatment occurs at the waste water treatment plant.

- Primary Settling
- Secondary BOD removal (activated sludge, trickling filter)
- Tertiary Nutrient Removal
  - Nitrification
  - Denitrification
  - Bio P removal

Understanding the potential effects of wastewater treatment on drinking water systems requires data!

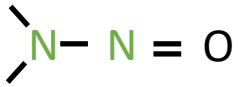


2008 Clean Watersheds Needs Survey (CWNS)

- WW discharge volumes
- Nitrogen treatment

Second Unregulated Contaminant Monitoring Rule (UCMR2)

- Distribution system NDMA



Understanding the potential effects of wastewater treatment on drinking water systems requires data!

- Started with a list of previously ground-truthed DWTPs where high de facto reuse (DFR) was present (identified by Rice et al. 2015)
  - DFR estimate based on average streamflow and upstream WWTP discharge volumes
- Further refined the list
  - Single surface water intake plants
  - No potential international contributions
  - Chlorine (16) or chloramine (16) disinfectants

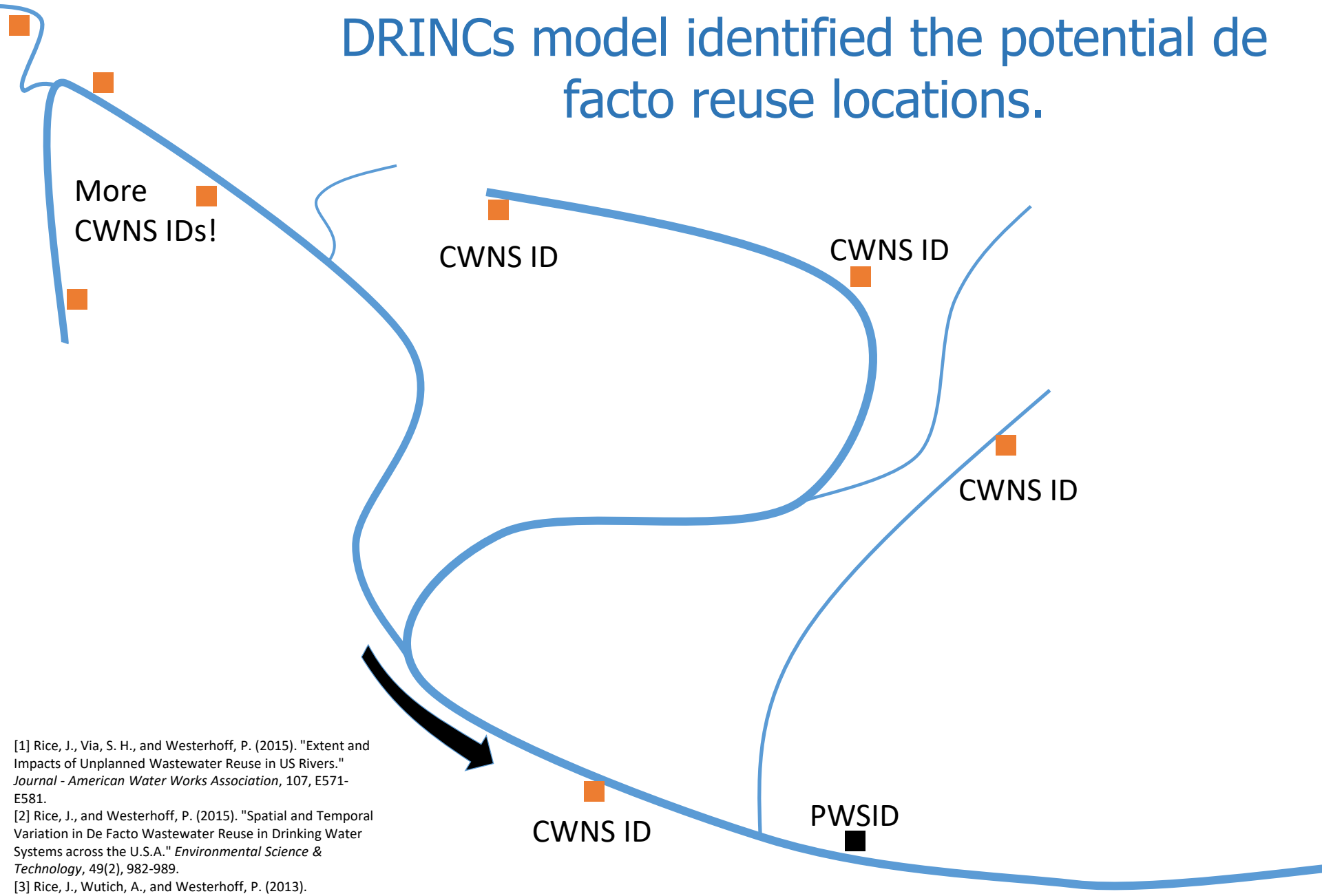
"High DFR set" 31 systems

- Compared with full set of UCMR2 plants that:
  - Served >10,000 people
  - Used chlorine/chloramine
  - Surface water as source

"UCMR2 set" 318 systems

Rice, J., Via, S. H., and Westerhoff, P. (2015). "Extent and Impacts of Unplanned Wastewater Reuse in US Rivers." *Journal - American Water Works Association*, 107, E571-E581.

DRINCs model identified the potential de facto reuse locations.



[1] Rice, J., Via, S. H., and Westerhoff, P. (2015). "Extent and Impacts of Unplanned Wastewater Reuse in US Rivers." *Journal - American Water Works Association*, 107, E571-E581.
[2] Rice, J., and Westerhoff, P. (2015). "Spatial and Temporal Variation in De Facto Wastewater Reuse in Drinking Water Systems across the U.S.A." *Environmental Science & Technology*, 49(2), 982-989.
[3] Rice, J., Wutich, A., and Westerhoff, P. (2013). "Assessment of De Facto Wastewater Reuse across the U.S.: Trends between 1980 and 2008." *Environmental Science & Technology*, 47(19), 11099-11105.

Each wastewater plant was classified by its treatment type: Conventional, Nitrifying, BNR.

Each waste stream entering a DW plant was classified by the fraction of the indirect reuse associated with different nitrogen conversion.

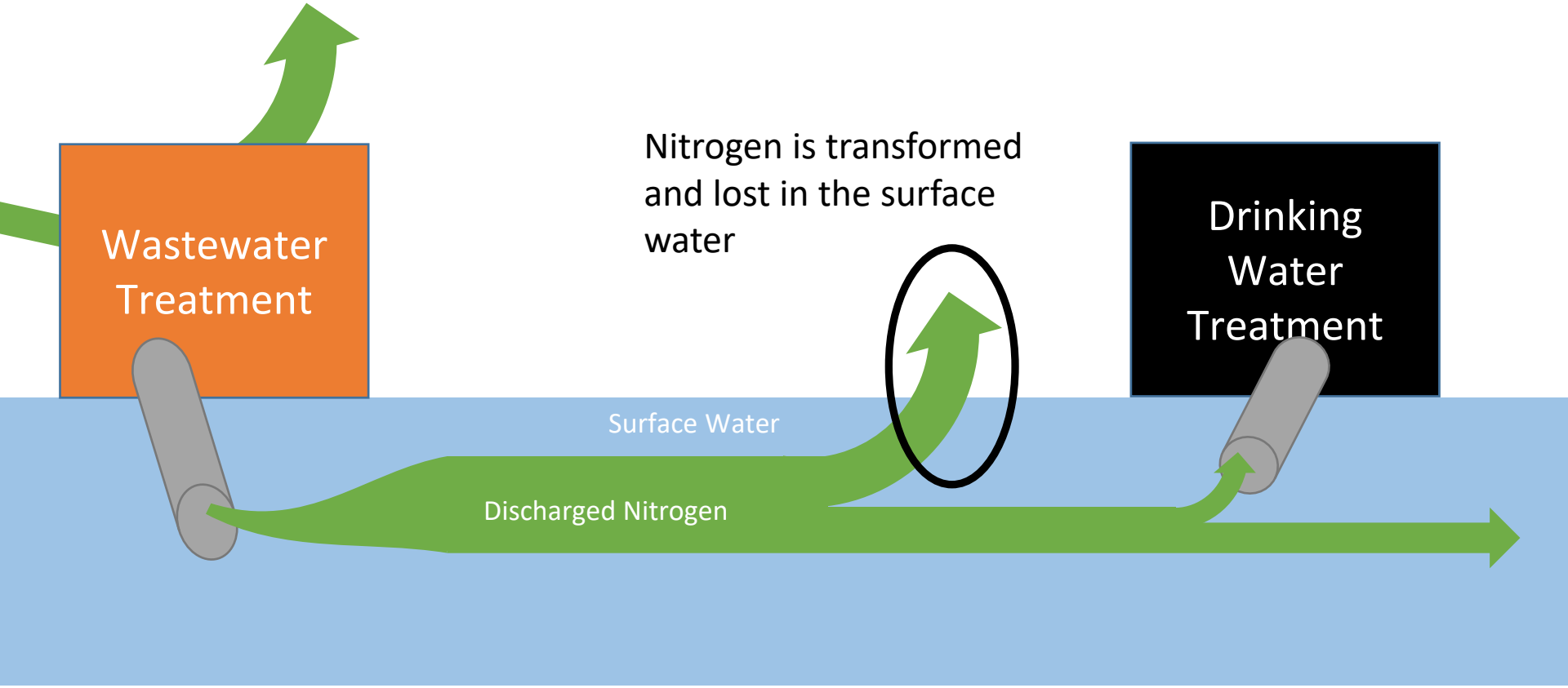
$$Fraction\ Nitrified = \frac{WW\ flow\ from\ plants\ with\ ammonia\ removal}{Total\ contributing\ WW\ flow}$$

$$Fraction\ Denitrified = \frac{WW\ flow\ from\ plants\ with\ nitrogen\ removal}{Total\ contributing\ WW\ flow}$$

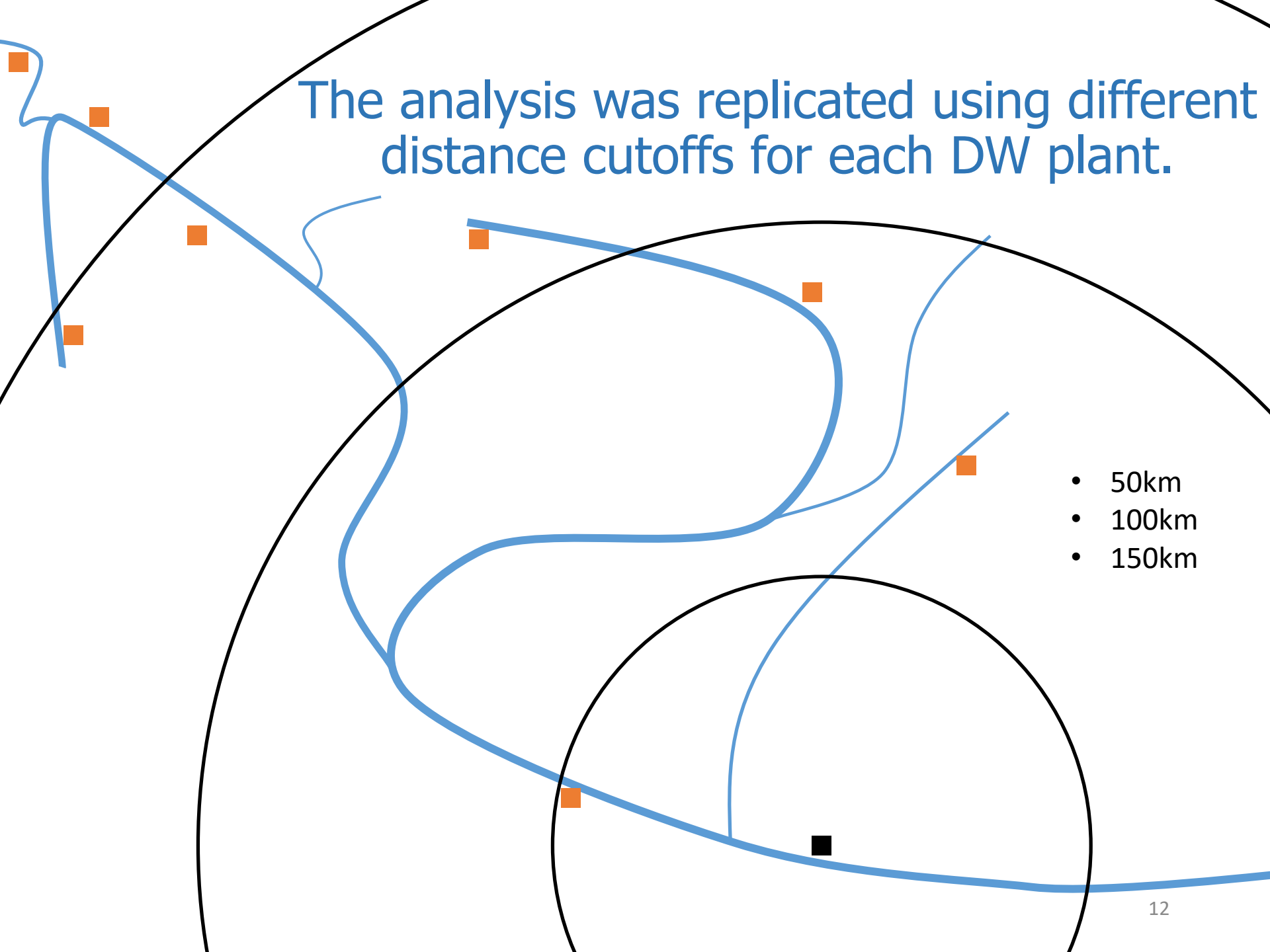
$$Fraction\ N\ Treatment = \frac{WW\ flow\ from\ plants\ with\ nitrogen\ or\ ammonia\ removal}{Total\ contributing\ WW\ flow}$$

NDMA at high DFR plants had higher detection rates and threshold exceedance than the UCMR2 baseline

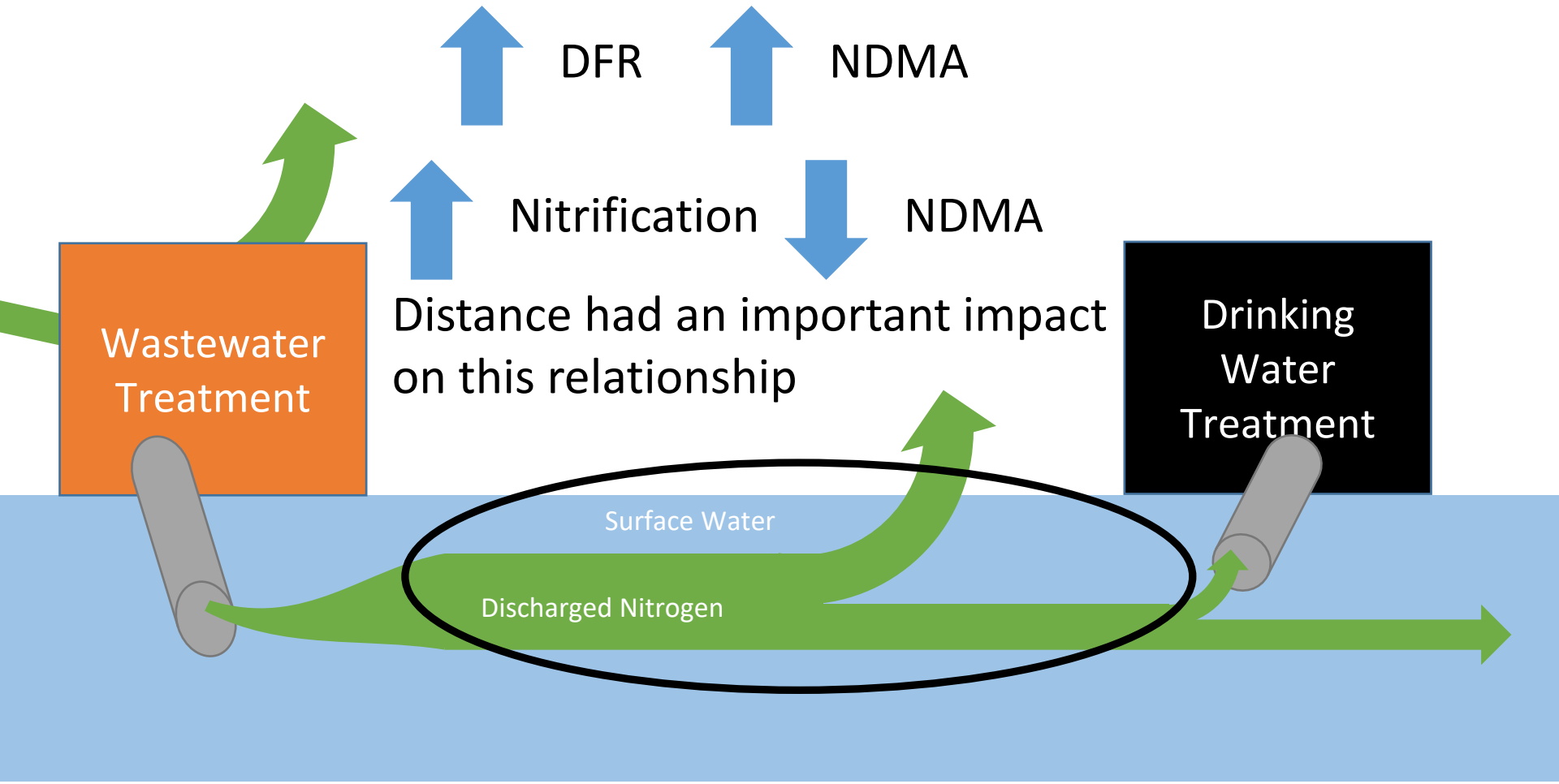
Proximity matters as nitrogen is transformed in surface waters through natural processes.



The analysis was replicated using different distance cutoffs for each DW plant.



De Facto reuse and upstream treatment affect NDMA formation potential downstream.



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