Probabilistic Risk Assessment for the Derivation of Human Health Ambient Water Quality Criteria

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

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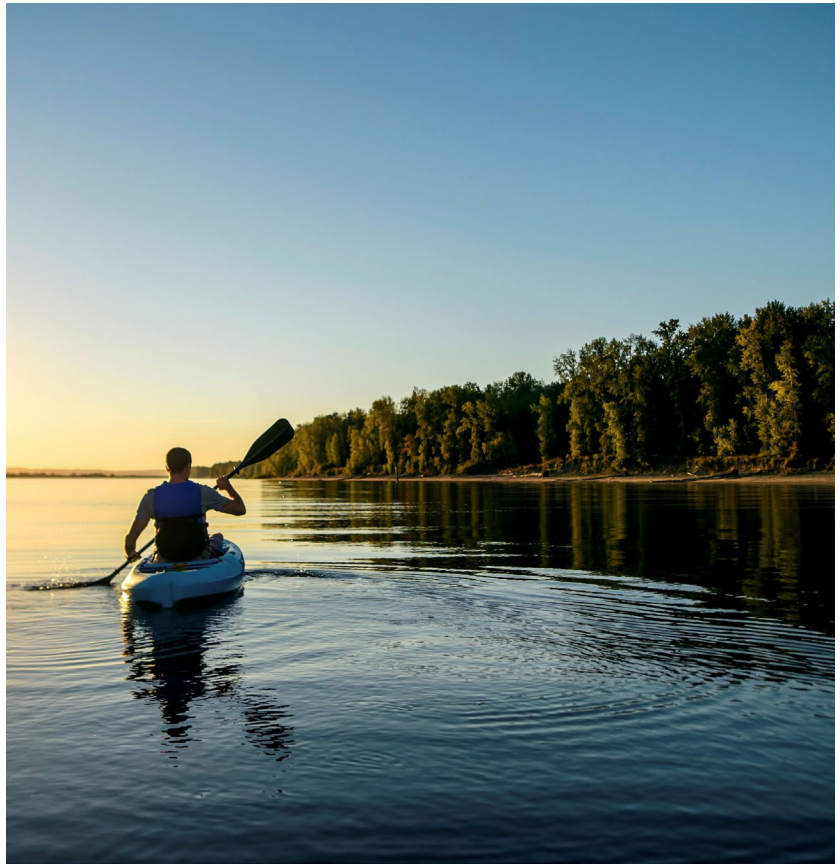
2022 Triennial Review Items being considered

- EPA's 2005 Aquatic Life Criteria for Diazinon and Nonylphenol
- EPA's 2015 Human Health Criteria
- EPA's 2016 Aquatic Life Criteria for Selenium
- EPA's 2018 Aquatic Life Criteria for Aluminum
- EPA's 2019 recommended HABs Recreational Criteria and/or Swim Advisories
- Site-specific Cu and Zn criteria based on a WER Study done for the City of Atlanta
- Updated designated uses of waterbodies based on public recommendations
- Site-specific chlorophyll *a* and pH criteria for Lakes Burton, Rabun and Tugalo

Human Health Criteria Background

- A HHC is the highest concentration of a pollutant in water that is not expected to pose a significant risk to human health over a lifetime.
  - Humans can be exposed to these pollutants through ingestion of treated drinking water or consumption of contaminated fish and shellfish.



EPA's recommendations:

- 2000 EPA Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health
- 2002 National Recommended Human Health Criteria
- 2015 EPA Updated Ambient Water Quality Criteria for the Protection of Human Health

Human Health Criteria

- EPA finalized updates to the ambient water quality criteria for the protection of human health in 2015.
- Reflected the latest scientific information and implementation of existing EPA policies found in Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000).
- Revised criteria for 94 chemicals.

$$AWQC = RfD \cdot RSC \cdot \left(\frac{BW}{DI + \sum_{i=2}^{4} (FI_i \cdot BAF_i)} \right)$$

Exposure

RSC = Relative Source Contribution (%, to account for other sources of exposure).

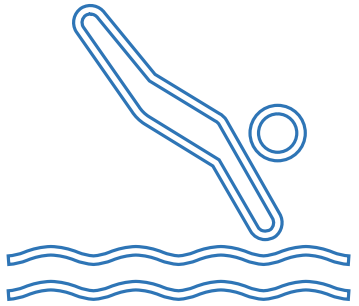
BW = Human Body Weight (70 kg for average adult).

DI = Drinking Water Intake (2 L/day for average adult).

FI = Fish Intake (kg/day).

Bioaccumulation

BAF = Bioaccumulation Factor (L/kg).



Derivation of Human Health Criteria

$$= \frac{\text{Toxicity Endpoints} \times \text{Body Weight}}{\text{Drinking Water Intake} + \left(\text{Fish Consumption} \times \text{Bioaccumulation Factors}\right)}$$

Toxicity Endpoints

- The Hazard Quotient (HQ) is the toxicity endpoint for non carcinogens and is determined based on the parameter-specific reference dose (RfD) and relative source contribution (RSC), which accounts for non water sources of exposure.
- Incremental life-time increased cancer risk is the toxicity endpoint for carcinogens. It is determined based on the parameter-specific cancer slope factor (CSF).
  - Represents one's risk of developing cancer (in addition to background cancer risk) if exposed to the criterion level over a lifetime.
  - Ex: 10^{-6} = 1 in 1 million, 10^{-5} = 1 in 100,000, 10^{-4} = 1 in 10,000

Updated Exposure Inputs

- **Body weight: 80 kg** (176 lb)
  - Previous criteria based on 70 kg
- **Drinking Water: 2.4 L/day** (10 cups)
  - Previous criteria based on 2 L/day
- **Fish Consumption: 22 g/day** (0.78 oz)
  - Previous criteria based on 17.5 g/day

Updated Exposure Inputs

- Bioaccumulation factors (BAFs)
  - Accounts for chemical accumulation in fish from all exposure routes (water, diet, sediment, etc.)
- Updated health toxicity values
- Relative source contributions (RSCs)
  - Accounts for additional routes of exposure other than water and fish consumption

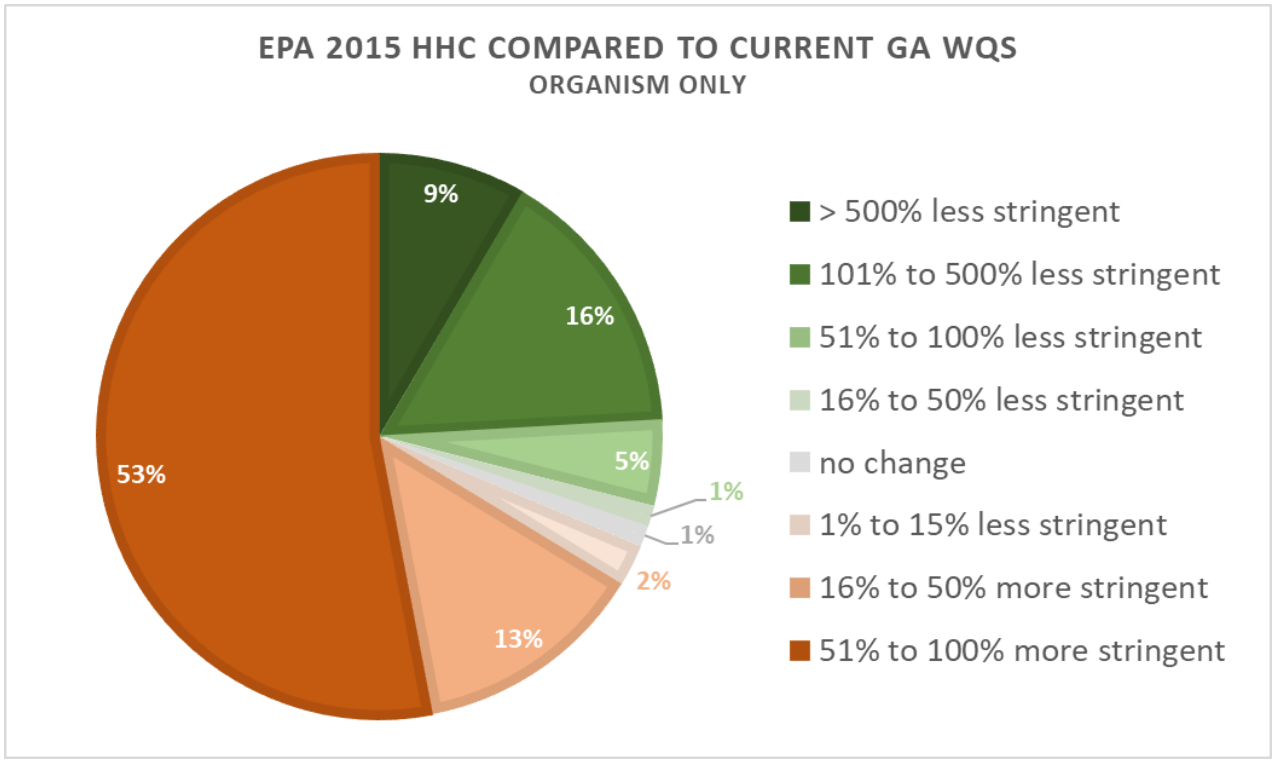
Deterministic Risk Assessment

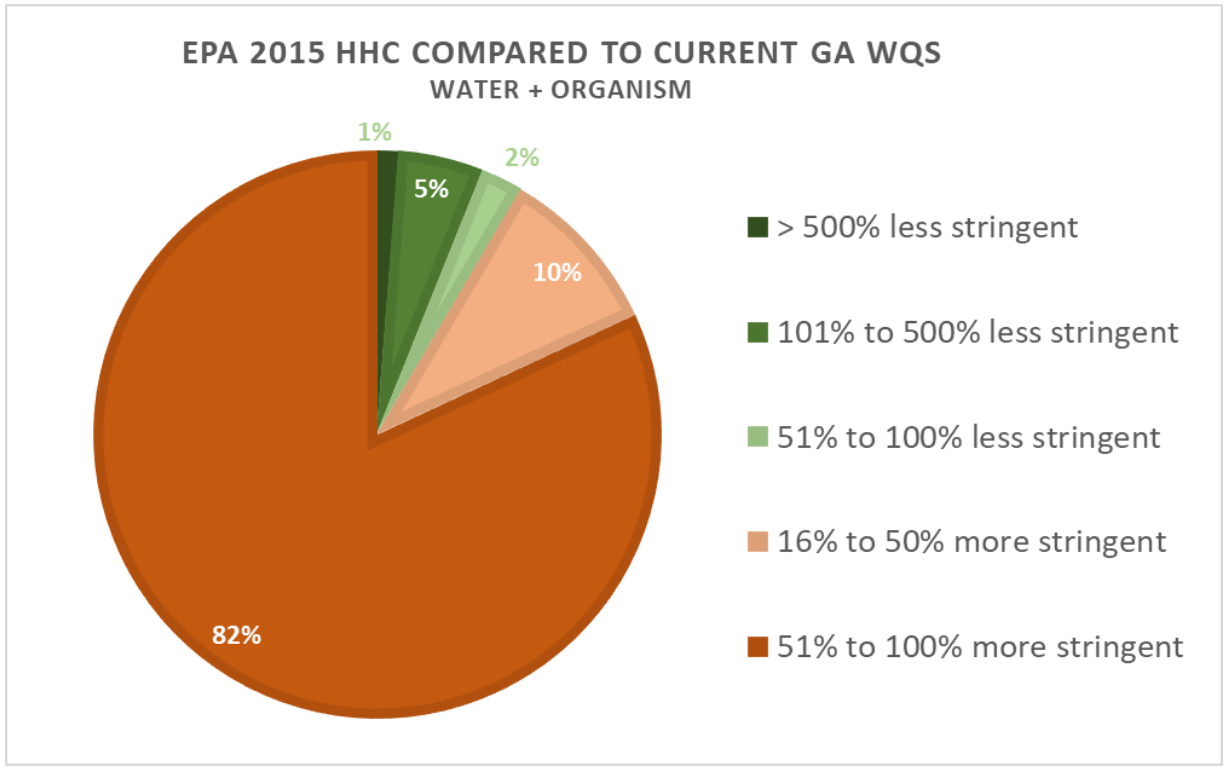
$$= \frac{\text{Toxicity Endpoints} \times \text{80 kg}}{\text{2.4 L/day} + \left(\text{22 g/day} \times \text{Bioaccumulation Factors}\right)}$$

Georgia's current HHC compared to EPA 2015 HHC

Chemical Name	Current Georgia WQS (µg/L)	EPA 2015 AWQC (µg/L)		% difference current vs EPA 2015	
		Water + Organism	Organism Only	Water + Organism	Organism Only
1,1,2,2-Tetrachloroethane	4	0.2	3	-95%	-25%
1,1,2-Trichloroethane	16	0.55	8.9	-97%	-44%
1,1-Dichloroethylene	7100	300	20000	-96%	182%
1,2,4-Trichlorobenzene	70	0.071	0.076	-100%	-100%
1,2-Dichlorobenzene	1300	1000	3000	-23%	131%
1,2-Dichloroethane	37	9.9	650	-73%	1657%
1,2-Dichloropropane	15	0.9	31	-94%	107%
1,2-Diphenylhydrazine	0.2	0.03	0.2	-85%	0%
1,3-Dichlorobenzene	960	7	10	-99%	-99%
1,3-Dichloropropene	21	0.27	12	-99%	-43%
1,4-Dichlorobenzene	190	300	900	58%	374%
2,4,6-Trichlorophenol	2.4	1.5	2.8	-38%	17%
2,4-Dichlorophenol	290	10	60	-97%	-79%
2,4-Dimethylphenol	850	100	3000	-88%	253%
2,4-Dinitrophenol	5300	10	300	-100%	-94%
2,4-Dinitrotoluene	3.4	0.049	1.7	-99%	-50%

How do EPA's criteria recommendations compare to GA's current WQS?





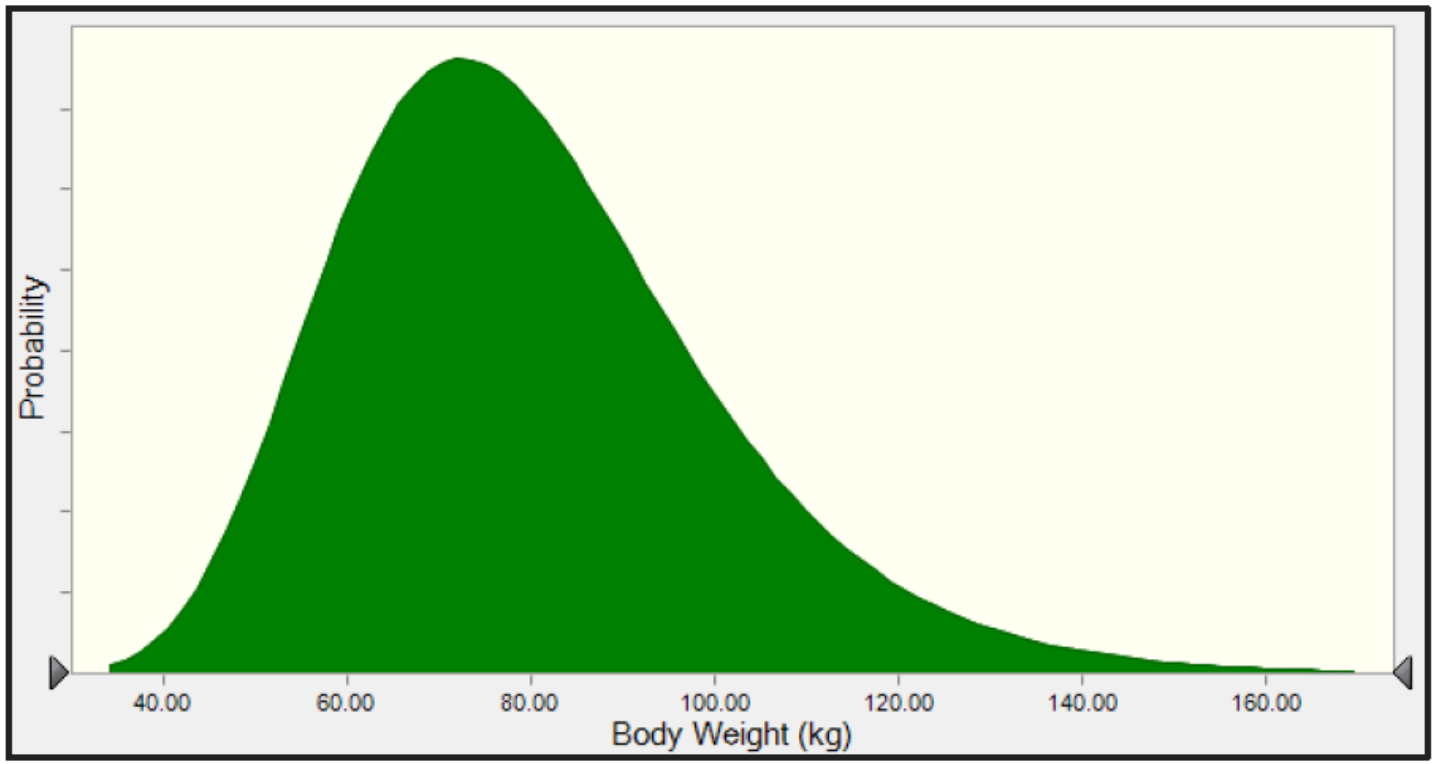
Georgia's concerns with the deterministic method

- Compounded conservatism
- Does not account for variability among the population
- Impossible to determine the percentage of the population being protected
- National rather than regional fish consumption rates

Deterministic vs. Probabilistic

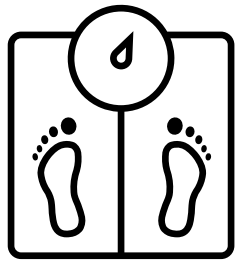
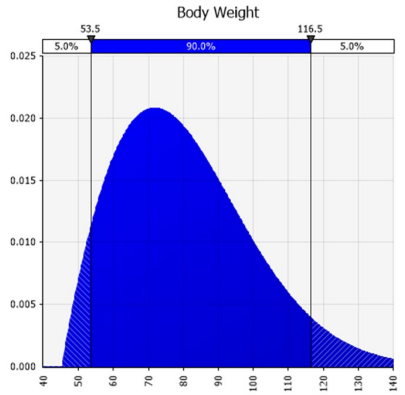
- Deterministic risk assessment – single value for each parameter
  - Often results in compounded conservatism
  - Can’t identify target population
- Probabilistic risk assessment – distribution for one or more parameters
  - Allows for transparent risk management decisions
  - Identifies target population and level of protection

What is a distribution?



- Shows the possible values for a variable and how often they occur
- More accurately accounts for the variability in the population than selecting a single-value input

Probabilistic Risk Assessment

Toxicity Endpoints x  

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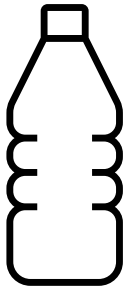
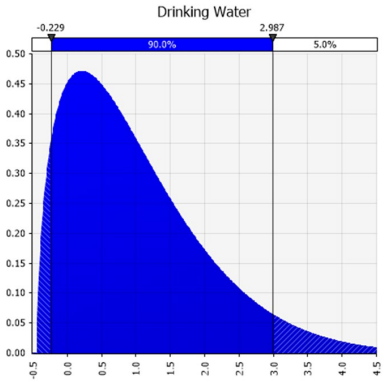
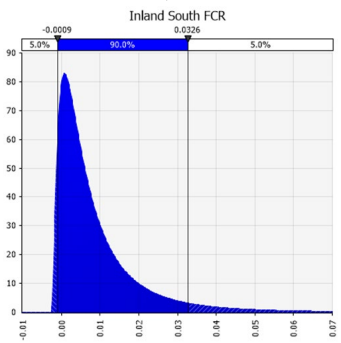
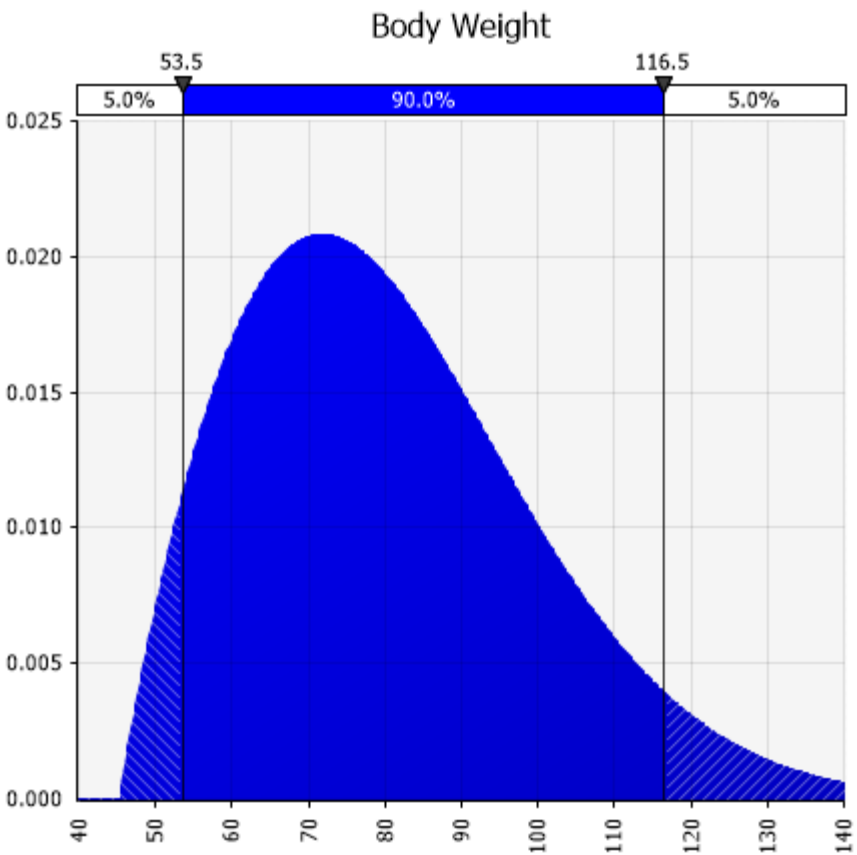
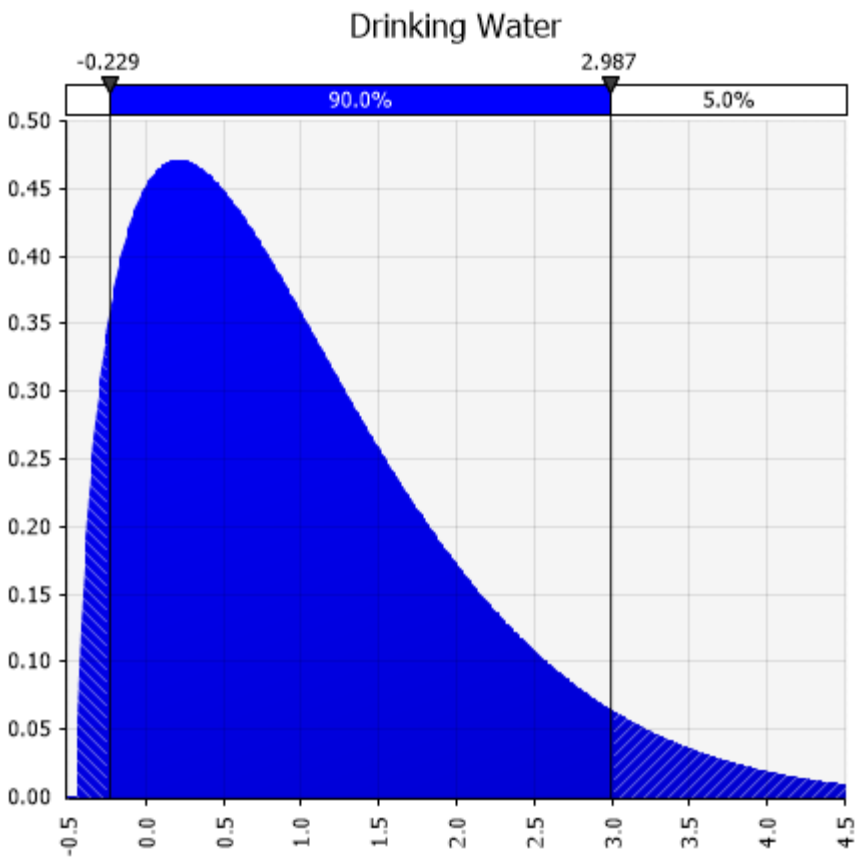
 

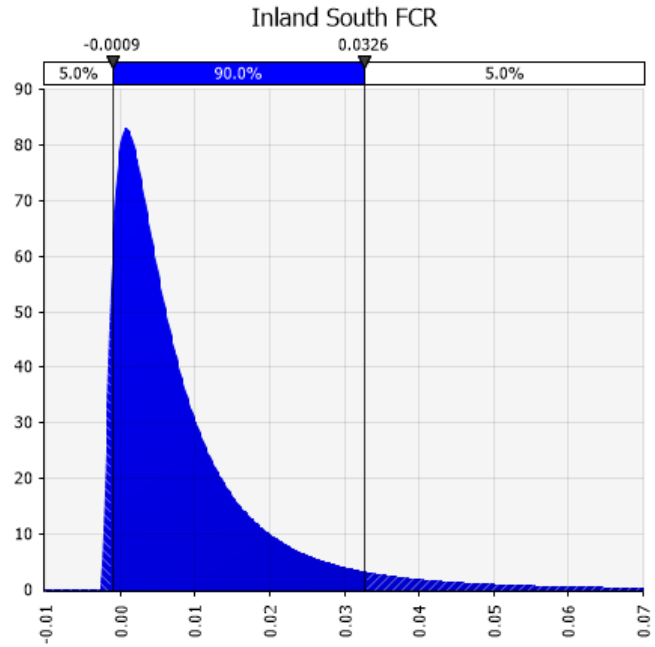
+ ( 

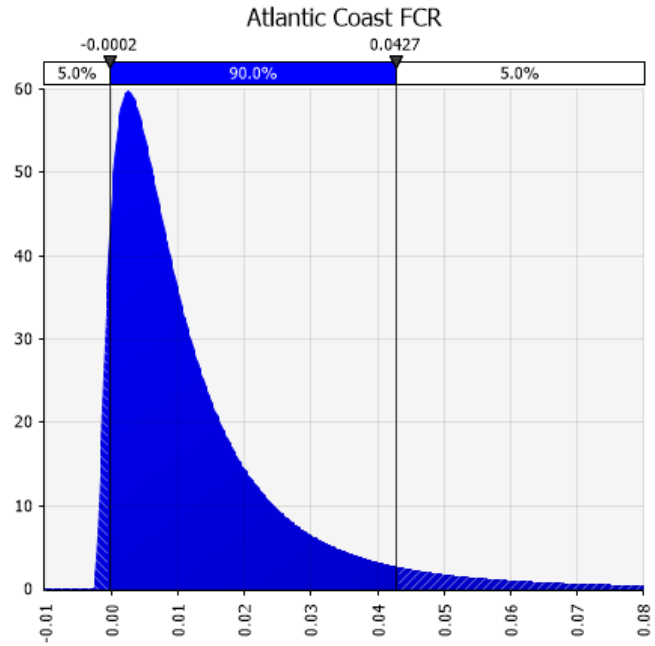
x Bioaccumulation Factors)

Distributions as inputs

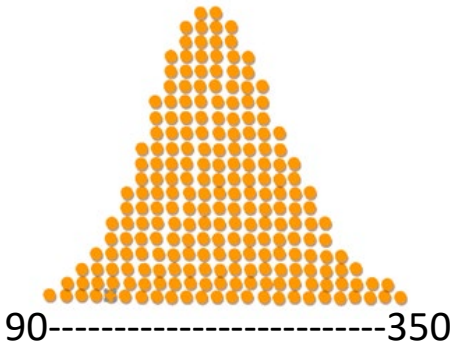


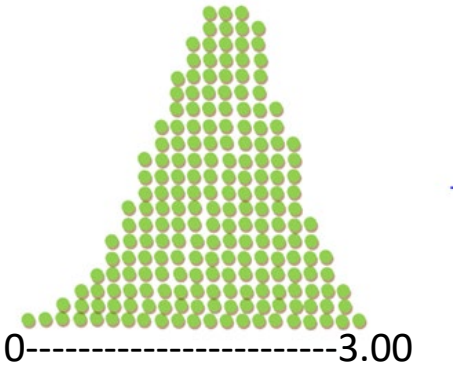


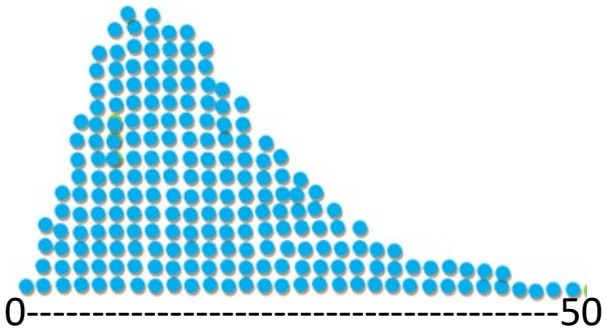


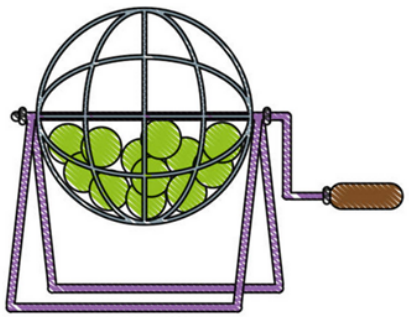


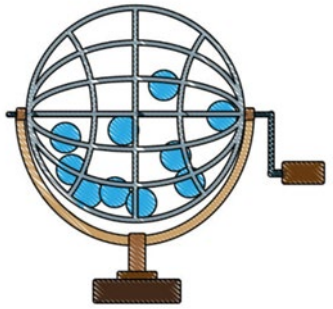
What is Monte Carlo?



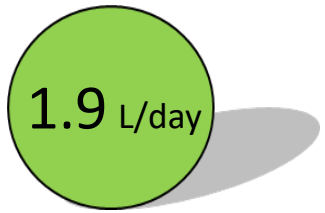








Body Weight



Water Intake

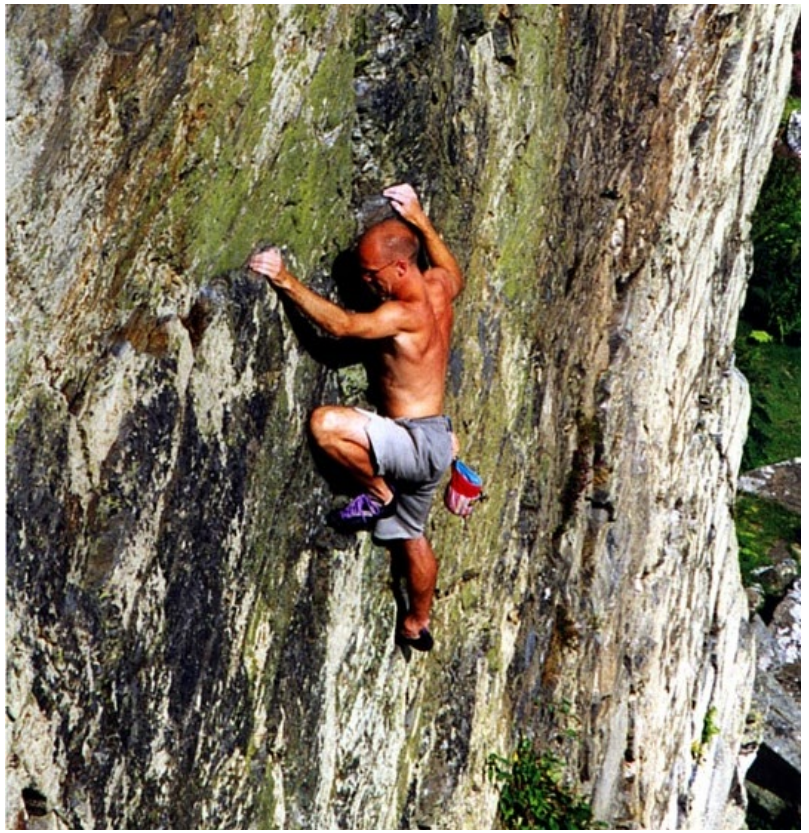
Fish Consumption

Scenario 1:

Target Risk = 0.000001, 50th percentile

Scenario 2:

Target Risk = 0.00001, 90th percentile



Scenario 3:

Target Risk = 0.0001, 99th percentile

Levels of Risk

Example criteria selection

Summary of Final Probabilistic AWQC	Scenario 1				Scenario 2				Scenario 3				Final Probabalistic AWQC (mg/L)	
	Target Risk = 0.000001, Hzd = 1, %ile = 0.5				Target Risk = 0.00001, Hzd = 1, %ile = 0.9				Target Risk = 0.0001, %ile = 0.99					
	Probabalistic AWQC (mg/L)				Probabalistic AWQC (mg/L)				Probabalistic AWQC (mg/L)					
	Water + Organism		Organism Only		Water + Organism		Organism Only		Water + Organism		Organism Only		Water + Organism	Organism Only
Chemical Name	Cancer Risk	Non-cancer HQ	Cancer Risk	Non-cancer HQ	Cancer Risk	Non-cancer HQ	Cancer Risk	Non-cancer HQ	Cancer Risk	Non-cancer HQ	Cancer Risk	Non-cancer HQ	Minimum of all scenarios	Minimum of all scenarios
1,1,1-Trichloroethane	NA	3.61E+01	NA	5.35E+02	NA	1.18E+01	NA	1.76E+02	NA	1.18E+01	NA	1.76E+02	1.18E+01	1.76E+02
1,1,2,2-Tetrachloroethane	4.59E-04	3.67E-01	8.08E-03	6.46E+00	1.49E-03	1.19E-01	2.66E-02	2.13E+00	8.16E-03	1.19E-01	9.48E-02	2.12E+00	4.59E-04	8.08E-03
1,1,2-Trichloroethane	1.60E-03	7.31E-02	2.69E-02	1.22E+00	5.21E-03	2.38E-02	8.85E-02	4.04E-01	2.86E-02	2.37E-02	3.15E-01	4.02E-01	1.60E-03	2.69E-02
1,1-Dichloroethylene	NA	9.72E-01	NA	4.91E+01	NA	3.05E-01	NA	1.62E+01	NA	3.04E-01	NA	1.62E+01	3.05E-01	1.62E+01
1,2,4,5-Tetrachlorobenzene	NA	1.03E-04	NA	1.06E-04	NA	2.94E-05	NA	2.96E-05	NA	2.95E-05	NA	2.97E-05	2.94E-05	2.96E-05
1,2,4-Trichlorobenzene	2.18E-04	1.26E-02	2.39E-04	1.38E-02	7.53E-04	4.37E-03	7.78E-04	4.51E-03	2.99E-03	4.35E-03	3.01E-03	4.50E-03	2.18E-04	2.39E-04
1,2-Dichlorobenzene	NA	3.32E+00	NA	1.02E+01	NA	1.34E+00	NA	3.36E+00	NA	1.34E+00	NA	3.35E+00	1.34E+00	3.36E+00
1,2-Dichloroethane	2.96E-02	1.53E+00	1.95E+00	1.00E+02	9.26E-02	4.77E-01	6.49E+00	3.34E+01	5.03E-01	4.75E-01	2.38E+01	3.33E+01	2.96E-02	1.95E+00
1,2-Dichloropropane	2.66E-03	1.71E+00	9.30E-02	5.98E+01	8.42E-03	5.42E-01	3.07E-01	1.98E+01	4.59E-02	5.40E-01	1.11E+00	1.97E+01	2.66E-03	9.30E-02
1,2-Diphenylhydrazine	9.70E-05	NA	6.29E-04	NA	3.45E-04	NA	2.07E-03	NA	1.92E-03	NA	7.39E-03	NA	9.70E-05	6.29E-04
1,3-Dichlorobenzene	NA	1.84E-02	NA	4.66E-02	NA	7.42E-03	NA	1.38E-02	NA	7.42E-03	NA	1.37E-02	7.42E-03	1.38E-02
1,3-Dichloropropene	7.94E-04	4.84E-01	3.53E-02	2.15E+01	2.49E-03	1.52E-01	1.17E-01	7.12E+00	1.36E-02	1.52E-01	4.22E-01	7.10E+00	7.94E-04	3.53E-02

Criteria adoption

- Georgia's current WQS have human health criteria for 83 of the pollutants in EPA's 2015 update.
- These 83 pollutants each have a single criterion value based on the "organism only" criteria from EPA's 2002 recommendation
- There are 11 pollutants in EPA's 2015 update for which Georgia has no current human health criteria and will be adopting criteria based on our PRA results
- Our PRA analysis resulted in 2 criteria values for each pollutant; one to protect human health from exposure through fish consumption ("organism only") and one to protect human health from exposure through fish consumption and water ingestion ("water + organism").
- EPD is planning to adopt the "organism only" criteria values for all waterbodies except those designated as a Drinking Water source, which will get the "water + organism" criteria values.

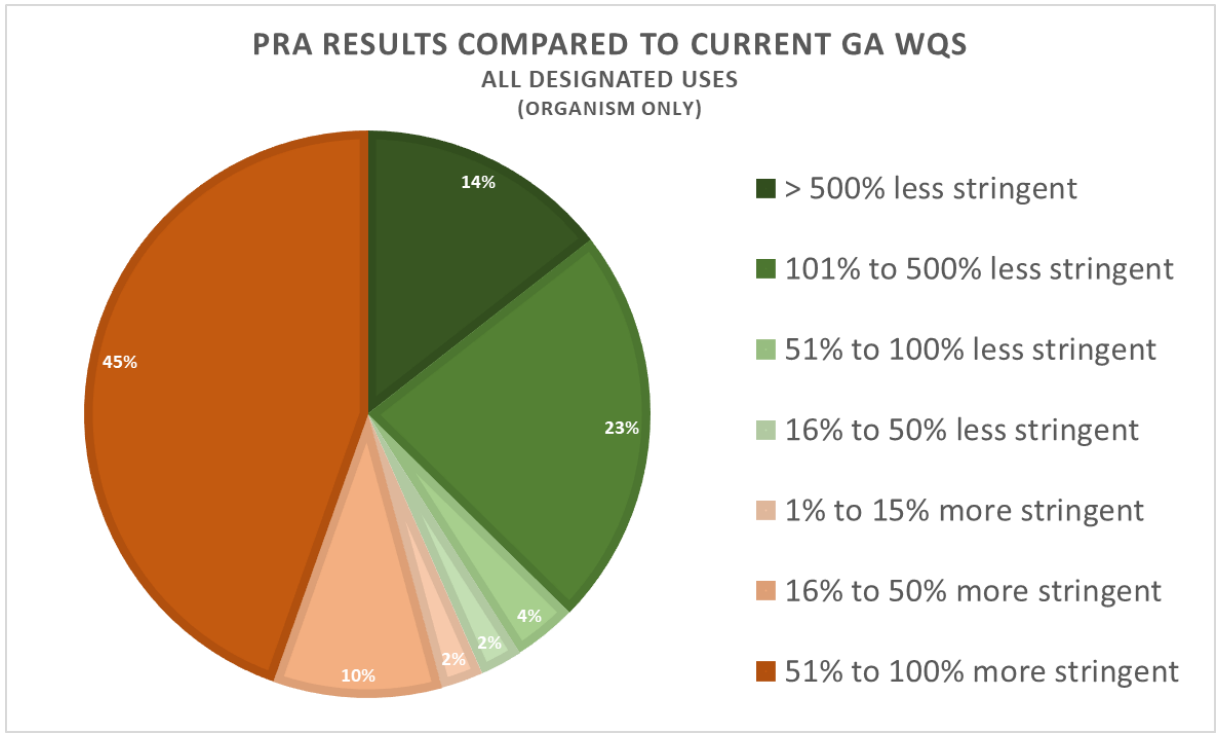
Criteria values (PRA results)

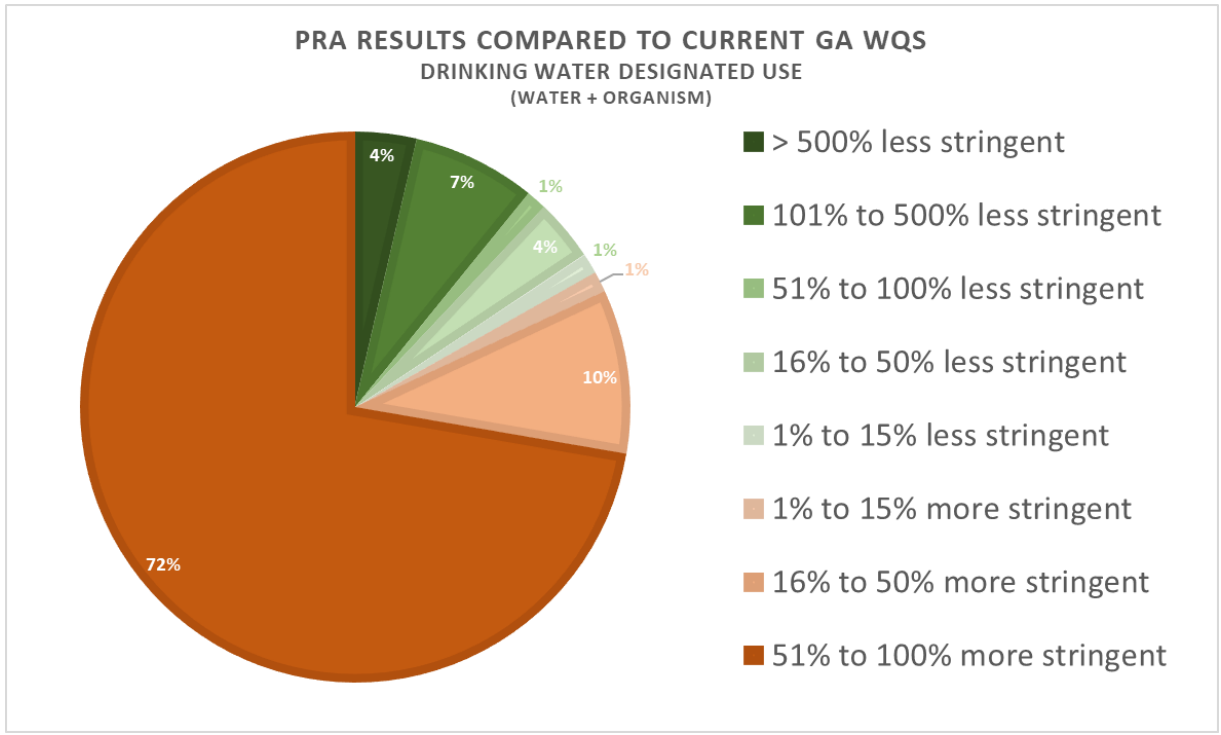
Proposed Criteria updates for 391-3-6-.03(5)(e)(iv)

# in WQS	Pollutant and CAS #	Current criteria for all designated uses (µg/L)	New criteria for drinking water designated use (µg/L)	New criteria for all other designated uses (µg/L)
1	Acenaphthene (CAS RN[1] 83329)	990	69	76
3	Acrolein (CAS RN[1] 107028)	9.3	3.1	320
4	Acrylonitrile (CAS RN[1] 107131)	0.25	0.18	27
5	Aldrin (CAS RN[1] 309002)	0.00005	0.0000027	0.0000027
6	Anthracene (CAS RN[1] 120127)	40000	290	320
9	Benzidine (CAS RN[1] 92875)	0.0002	0.00043	0.032
10	Benzo(a)Anthracene (CAS RN[1] 56553)	0.018	0.0048	0.0051
11	Benzo(a)Pyrene (CAS RN[1] 50328)	0.018	0.00048	0.00051
12	3,4-Benzofluoranthene (CAS RN[1] 205992)	0.018	0.0048	0.0051
13	Benzene (CAS RN[1] 71432)	51	1.7 - 3.0	48 - 87
15	Benzo(k)Fluoranthene (CAS RN[1] 207089)	0.018	0.048	0.051

Table of proposed values for 83 existing criteria and 11 new criteria

How do the updated criteria values compare to our current criteria?

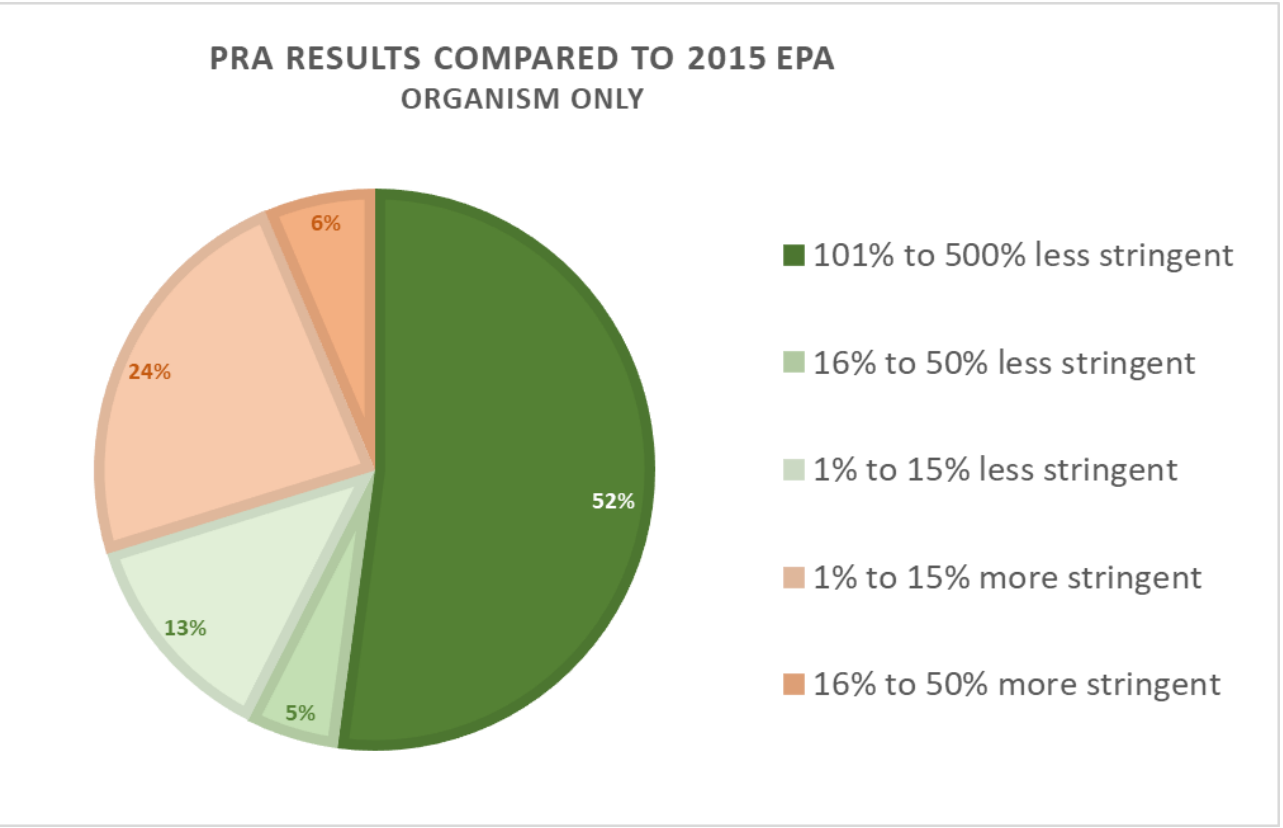


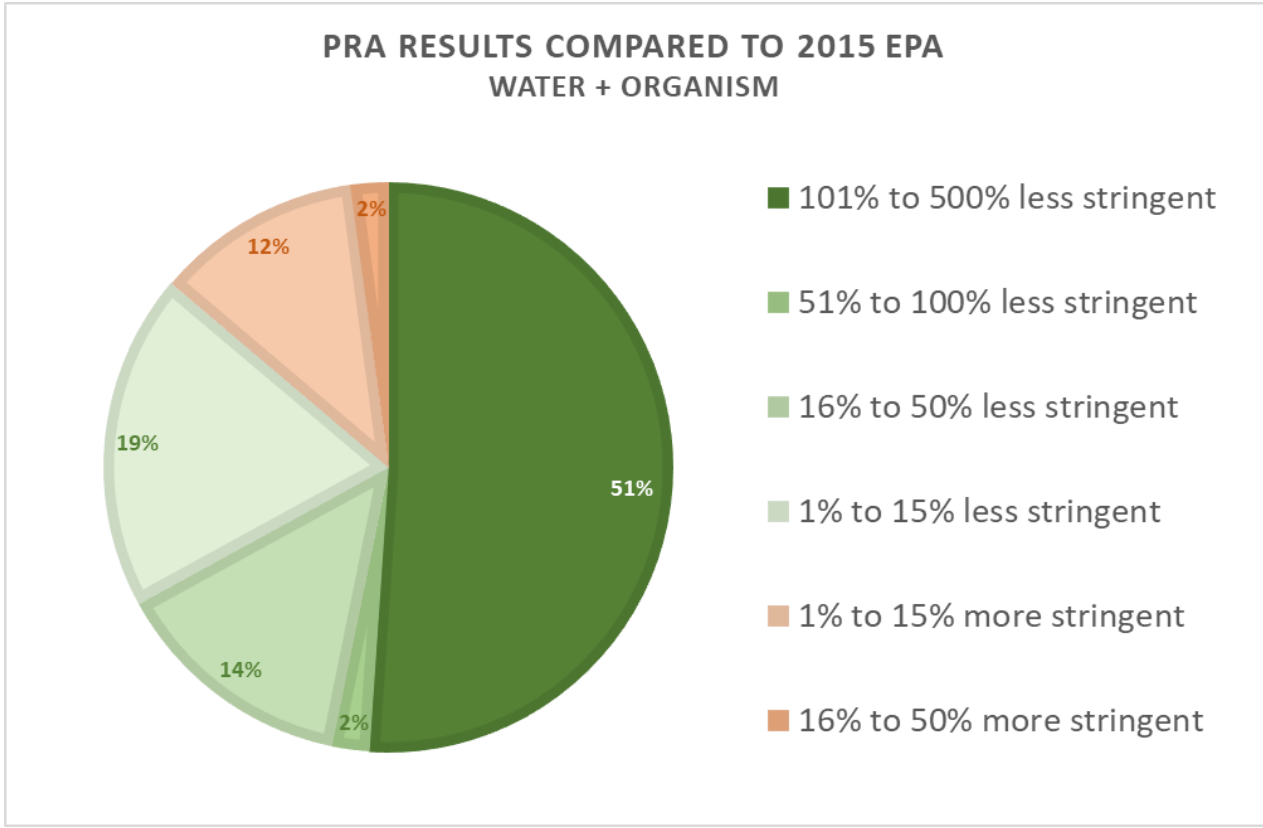


GA's proposed HHC compared to 2015 EPA HHC

	Final Probabalistic AWQC (ug/L)		EPA 2015 AWQC (ug/L)		% difference final HHC vs 2015	
Chemical Name	**Water + Organism**	**Organism Only**	**Water + Organism**	**Organism Only**	**Water + Organism**	**Organism Only**
1,1,1-Trichloroethane	**1.18E+04**	**1.76E+05**	1.00E+04	2.00E+05	**18%**	**-12%**
1,1,2,2-Tetrachloroethane	**4.59E-01**	**8.08E+00**	2.00E-01	3.00E+00	**129%**	**169%**
1,1,2-Trichloroethane	**1.60E+00**	**2.69E+01**	5.50E-01	8.90E+00	**191%**	**202%**
1,1-Dichloroethylene	**3.05E+02**	**1.62E+04**	3.00E+02	2.00E+04	**2%**	**-19%**
1,2,4,5-Tetrachlorobenzene	**2.94E-02**	**2.96E-02**	3.00E-02	3.00E-02	**-2%**	**-1%**
1,2,4-Trichlorobenzene	**2.18E-01**	**2.39E-01**	7.10E-02	7.60E-02	**206%**	**214%**
1,2-Dichlorobenzene	**1.34E+03**	**3.36E+03**	1.00E+03	3.00E+03	**34%**	**12%**
1,2-Dichloroethane	**2.96E+01**	**1.95E+03**	9.90E+00	6.50E+02	**199%**	**200%**
1,2-Dichloropropane	**2.66E+00**	**9.30E+01**	9.00E-01	3.10E+01	**196%**	**200%**
1,2-Diphenylhydrazine	**9.70E-02**	**6.29E-01**	3.00E-02	2.00E-01	**223%**	**214%**
1,3-Dichlorobenzene	**7.42E+00**	**1.38E+01**	7.00E+00	1.00E+01	**6%**	**38%**
1,3-Dichloropropene	**7.94E-01**	**3.53E+01**	2.70E-01	1.20E+01	**194%**	**194%**
1,4-Dichlorobenzene	**3.25E+02**	**9.08E+02**	3.00E+02	9.00E+02	**8%**	**1%**
2,4,5-Trichlorophenol	**3.41E+02**	**5.73E+02**	3.00E+02	6.00E+02	**14%**	**-5%**
2,4,6-Trichlorophenol	**3.53E+00**	**6.14E+00**	1.50E+00	2.80E+00	**135%**	**119%**

How do our PRA results compare to EPA's 2015 HHC recommendations?






Questions?
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