STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION & FORESTRY
BOARD OF PESTICIDES CONTROL
28 STATE HOUSE STATION
AUGUSTA, MAINE 04333

JANET T. MILLS
GOVERNOR

AMANDA E. BEAL
COMMISSIONER

November 6th, 2026

To: Alex Peacock, Director of the Maine Board of Pesticide Control
Re: Summary Statement for the Neonicotinoid Risk Assessment

Dear Mr. Peacock-

The attached draft assesses the risk of three most common neonicotinoids used in Maine, *e.g.* imidacloprid, clothianidin, and thiamethoxam. Data were collected from water quality studies performed by the Maine Board of Pesticide Control from 2014-2025. This approach makes the exposure analysis and risk assessment specific to Maine. Data from these monitoring studies were used to determine if exposure presents risk to both humans and aquatic species. This report is still a draft that is seeking comments from the Board of Pesticide Control.

All three neonicotinoids were detected in groundwater, but well below acute toxicity benchmarks established for invertebrates. Imidacloprid was the most frequently detected neonicotinoid in groundwater. However, exposure to imidacloprid from the consumption of groundwater is not anticipated to present a chronic health risk to Maine residents. This conclusion is based on a risk assessment that examined dietary intake of well-water under different scenarios (e.g. age, consumption of well-water, and the concentration of neonicotinoids in well water). Inverse hazard quotients- the ratio of a health-protective benchmark to neonicotinoid exposure- ranged from >2500 to 3.5, and point to low risk of chronic health effects under the worst-case scenarios. Consumption of groundwater contaminated with clothianidin also does not present risk. However, human heath is at risk when consuming groundwater contaminated with thiamethoxam *only* at the maximum concentration detected. This conclusion is based on hazard quotients for all age groups; risk is elevated for infants. In contrast, there is low risk if consuming groundwater contaminated with thiamethoxam at concentrations that are the mean and 90th percentile.

Imidacloprid was the only neonicotinoid detected in surface waters, or streams. Concentrations were well below acute toxicity benchmarks for freshwater animals, but often exceeded chronic toxicity benchmarks. There is negligible risk of imidacloprid causing lethality to any freshwater invertebrate in Maine rivers. However, there is a risk that chronic exposure might impair the physiology of a handful of aquatic insects in Maine; this risk does not extend to aquatic crustaceans, worms, mollusks, amphibians, and fish. This assessment is based a rigorous statistical approach; using Maine-specific data, there is an 8% probability that 20% of aquatic insects could be impacted, and a 15% chance that 15% of aquatic insects could be impacted. Importantly, it is undetermined how- or if- exposure to imidacloprid impacts the physiology of aquatic insects at these concentrations, but it is very unlikely to alter ecological processes in riparian environments.

Please let me know if you have any questions on my risk assessment for neonicotinoids in Maine.

Respectfully,
Doug Van Hoewyk, PhD

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Risk assessment for neonicotinoids in Maine: Human-health and aquatic ecotoxicology

I. Human Health Risk Assessment

The human health risk assessment for the neonicotinoids focused on determining if potential exposure exceeded health-protective levels. To accomplish this, detections of neonicotinoids in Maine groundwaters were analyzed (Table 1). Imidacloprid is the most frequently detected neonicotinoid in groundwater, followed by thiamethoxam. To determine the health risk of neonicotinoids in groundwater, the raw values of detected concentrations were log10-transformed and plotted. This allows one to more easily visualize the distribution of detections in relationship to the EPA human health benchmark in drinking water; Figure 1 shows the distribution of three neonicotinoids detected in Maine groundwater: clothianidin, imidacloprid, and thiamethoxam.

		2014 (n=137)	2020 (n=74)	2021 (n=50)
clothianidin	concentration (ug L-1)	0.022	0.02	0.032
	detection frequency	2.20%	1.40%	2%
	# detections	3	1	1
imidacloprid	concentration (ug L-1)	0.005	0.004	0.004
	detection frequency	11.70%	13.50%	14%
	# detections	16	10	7
thiamethoxam	concentration (ug L-1)	0.033	0.052	0.04
	detection frequency	9%	7%	10%
	# detections	12	5	5

Table 1. Mean concentration, detection frequency, and number of detections for tested neonicotinoids in Maine groundwater. Data were extracted from the Maine Board of Pesticide Control Water Quality monitoring studies. The geometric mean was calculated and reported as mean concentration.

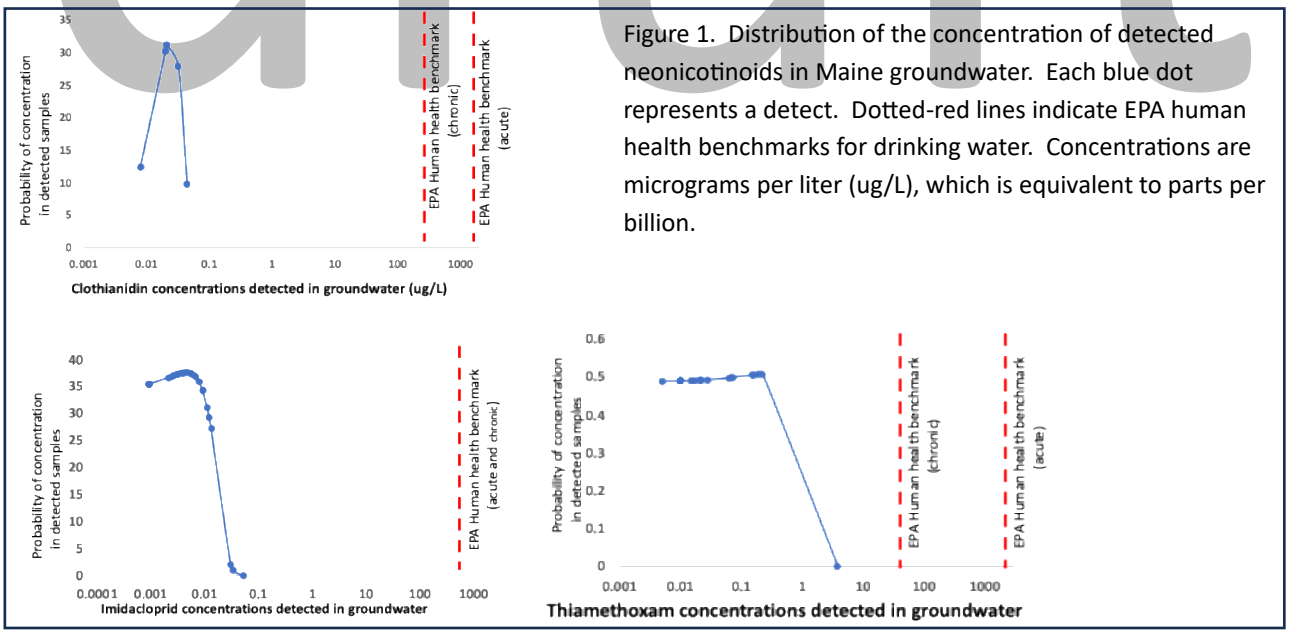


Figure 1. Distribution of the concentration of detected neonicotinoids in Maine groundwater. Each blue dot represents a detect. Dotted-red lines indicate EPA human health benchmarks for drinking water. Concentrations are micrograms per liter (ug/L), which is equivalent to parts per billion.

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Next, we focused on evaluating the health risk of imidacloprid. This was motivated by its high detection rate in Maine groundwater and its relatively high usage. Imidacloprid is also among the most frequently detected neonicotinoid in California and other states (source). To estimate the health risks, inverse hazard quotients were calculated. Values represent the ratio between a protective concentration and estimated exposure in drinking water. Any value above 1 is considered health protective, and greater values indicate greater protection. All hazard quotients were above 1, and ranged from 3.5 to greater than 2,000 (Table 2). The lowest hazard quotient of 3.5 was for infants under the most conservative exposure scenario; this value was generated by using the (*i*) more-conservative California chronic Reference dose (cRfD), (*ii*) the maximum imidacloprid concentration out of all groundwater detections in Maine, and (*iii*) an infant who is the 95% percentile of fluid intake. Even in the most conservative scenario and assuming that the infant is only consuming tap water from the well, the consumption of imidacloprid at the highest concentration is considered 3.5-fold more health-protective than the benchmark. Using the EPA cRfD value, the risk quotient increases to 645 for the infant with the mean fluid intake who is consuming the mean concentration of imidacloprid.

$$\text{Risk Quotient} = \frac{\text{protective concentration (chronic exposure)}}{\text{Estimated concentration consumed in water}} = \frac{\text{Chronic reference dose* body weight * 2.2lbs/kg}}{\text{Fluid intake * imidacloprid concentration}}$$

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RfD source	Pesticide Conc.	Infant fluid intake percentile Mean	Infant fluid intake percentile 95th %	Child fluid intake percentile Mean	Child fluid intake percentile 95th %	Adult fluid intake percentile Mean	Adult fluid intake percentile 95th %
Clothianidin							
EPA	mean	795.6	399.3	3348.5	1211.1	5462.8	1180.9
	90%	279.7	140.4	1177.2	425.8	1920.5	415.2
	max	68.9	34.6	289.8	104.8	472.7	102.2
Imidacloprid							
EPA	mean	645.8	325.9	2733.0	988.7	2470.6	964.1
	90%	227.0	114.6	961.0	347.6	868.6	338.9
	max	55.9	28.2	236.6	85.6	213.8	83.4
Cali.	mean	81.2	40.7	341.7	123.6	308.8	120.5
	90%	28.5	14.3	120.1	43.4	108.6	42.4
	max	7.0	3.5	29.6	10.7	26.7	10.4
Thiamethoxam							
EPA	mean	13.03	6.54	54.82	22.59	49.55	19.33
	90%	2.34	1.18	9.87	4.07	8.92	3.48
	max	0.12	0.06	0.49	0.20	0.44	0.17

Table 2. Inverse hazard quotients calculated under different scenarios, e.g. age group, pesticide concentration, and fluid consumption. Values >1 are health-protective; values in red present risk, and indicate exposure is greater than a chronic health-protective level. The EPA chronic reference doses (cRfD) established by the EPA were both used to estimated risk quotients. The more health-protective cRfD established by the State of California was also used to estimate risk for imidacloprid.

Values used to calculate risk quotients. Source: ATSDR, 2023. Exposure Dose Guidance of Water Ingestion. US DHHS

mg/kg body weight/day Chronic reference dose (cRfD)	
US EPA	0.08
Californiia	0.01

Body weight by age (kg)		
infant	child (6-10 yr)	adult
9.2	31.8	80.6

Water intake by age (Liters)			
	infant	child (6-10 yr)	adult
mean	0.554	0.455	1.276
95th percentile	1.104	1.258	3.27

Imidacloprid concentration (microgram/liter or parts per billion)	
mean conc.	0.0045
90% percentile	0.0128
max detection	0.052

Inverse hazard quotients also reveal that there are negligible health risks from the consumption of groundwater contaminated with clothianidin; this is due to the very low concentration that was detected in Maine groundwater.

Inverse hazard quotients indicate risk of consuming groundwater contaminated with thiamethoxam **only** when calculations are performed using the maximum concentration that was detected. Under this assumption, inverse hazard quotients are <1 for all age groups. This hazard is elevated for infants, particularly if an infant's consumption of fluids is in the 95th percentile. The maximum concentration detected for thiamethoxam was 3.8 ug/L, and came from a sampling in 2014; while this value is more than 100-fold higher than the next highest detection, this outlier should not be neglected. When calculating risk using thiamethoxam concentrations that represent the mean and 90% detections, inverse hazard quotients are >1.

II. Environmental Risk Assessment: freshwater animals

Detections of neonicotinoids were assessed for their risk to freshwater animals. These species were selected for priority because of the (*i*) availability of monitoring data that detected neonicotinoids in groundwater and surface water and (*ii*) the likelihood of leaching or running-off into surface water. Risks to other organisms (*e.g.* bees or saltwater organisms) were not considered in this report because we did not have environmental monitoring data in pollen or marine environments that were relevant to Maine.

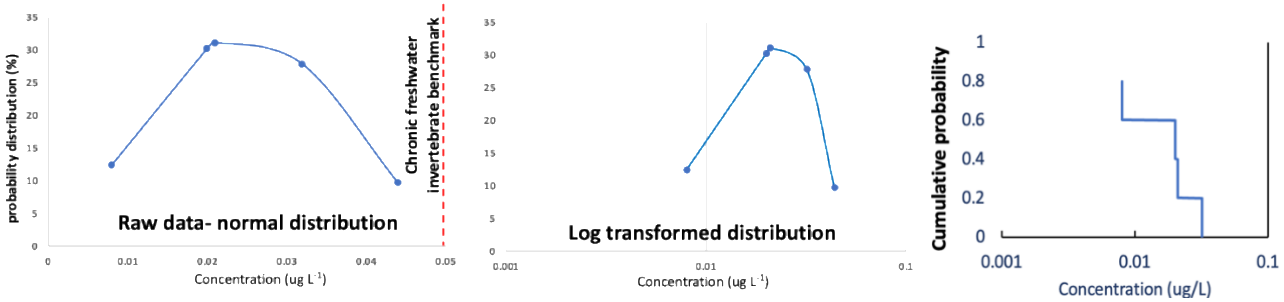
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A. Risks of clothianidin detections in groundwater to aquatic animals

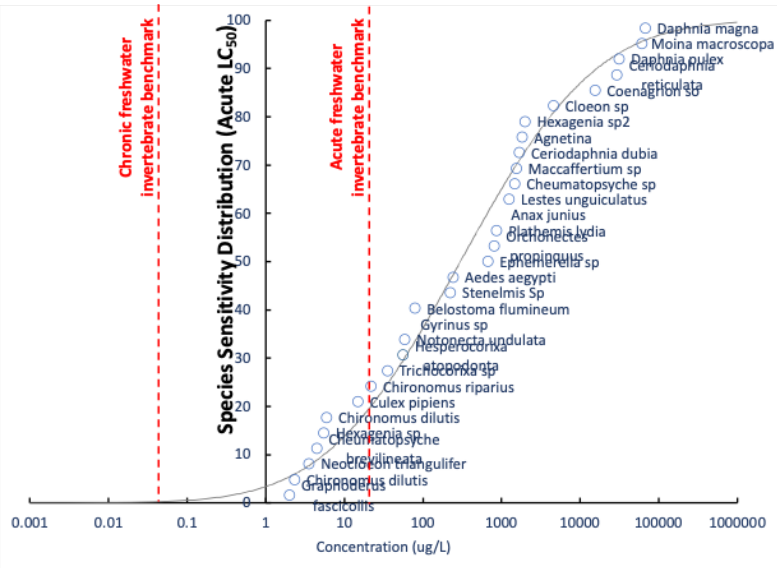
Clothianidin has not been detected in Maine surface water in any monitoring study conducted by the Maine Board of Pesticide Control. Thus, the only the risks of clothianidin in groundwater were considered. To evaluate the risks of neonicotinoids to aquatic animals, a joint distribution curve was generated to visualize both the (*i*) probability of concentrations detected in the environment and (*ii*) the probability of the number of species affected. This allowed the calculation of a risk curve which estimates the probability of adverse effects at each concentration. A description of the methodology is described below.

Methodology

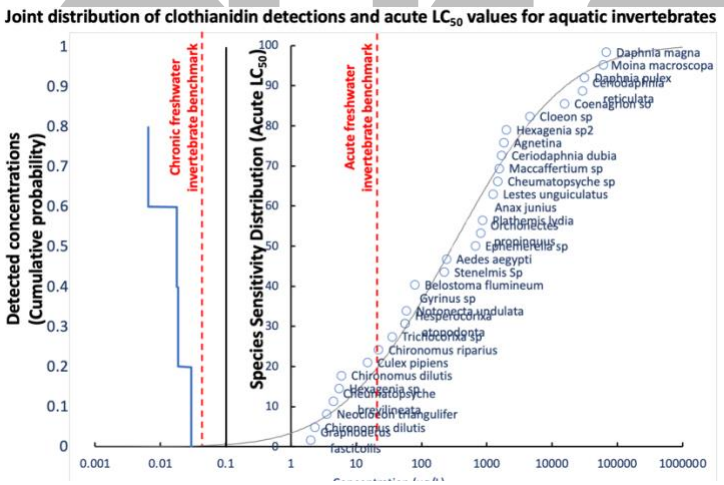
Step 1: The probability for clothianidin detects were log transformed; this allows the distribution of the detections to be visualized. Next, the cumulative probability was calculated.



Step 2: Generate a species sensitivity distribution (SSD). This curve shows the distribution of acute LC_{50} values for aquatic animals, which is the concentration of a clothianidin that is lethal to half of the population. The dotted lines were added to indicate EPA benchmarks for aquatic freshwater invertebrates. Values used to generate the SSD were based on EPA data (get source).

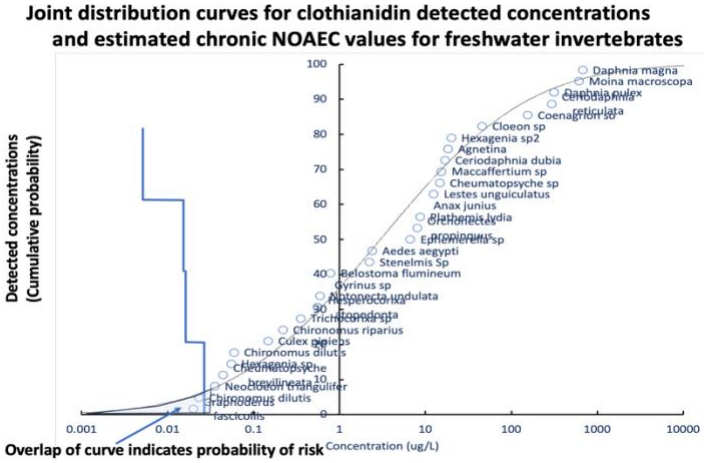


Step 3. Joint Distribution showing potential overlay of clothianidin detections and LC_{50} values.



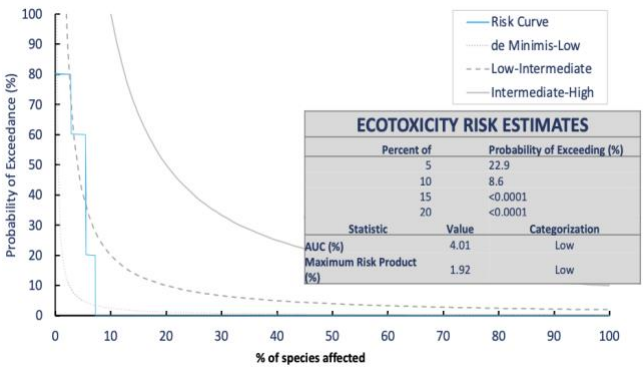
Detections of clothianidin (dark blue line) were at concentrations that do not exceed LC_{50} values for any species. The interpretation is that risk of exceeding LC_{50} values is negligible at the concentrations detected in Maine groundwater.

Step 4: assess probability of detections exceeding chronic NOAEC levels. Create another joint distribution curve showing potential overlay of clothianidin detections and the estimated No Observed Adverse Effect Level (NOAEL). The NOEALs were estimated by decreasing the LC_{50} value by 100-fold, which is a semi-conservative approach.



This curve does show an overlap between the distribution of clothianidin in the groundwater and estimated NOAEC values. This overlap represents risk that can be calculated in a risk curve.

Step 5. Generate a risk curve based on the above joint distribution curve.



The risk curve is depicted in blue. Curves representing different levels of risk are plotted and depicted in the key.

Interpretation: there is a 23% chance that the No Observed Adverse Effect Level (NOAEL) will be exceed for 5% of aquatic animals. This is categorized as low risk based on the area under the curve (AUC). Exceeding the NOAEL may or may not affect the species' physiology and development in the environment, but still signals that risk is present.

B. Risks of thiamethoxam in groundwater to aquatic organisms

B1. Risk of exceeding LC_{50} values. The methodology discussed above for clothianidin was repeated for thiamethoxam. Data used to generate the Species Sensitivity Distribution curve were based on EPA LC_{50} values. Similar to clothianidin, there is negligible risk (<0.001 %) that concentrations of thiamethoxam detected in Maine groundwater will exceed 5% of species' LC_{50} values.

B2. Risk of exceeding NOAEC values. NOAEC values were estimated by decreasing the LC_{50} values 100-fold. A joint distribution curve was generated that depicts the (*i*) distribution of thiamethoxam concentrations in groundwater and (*ii*) the distribution of thiamethoxam predicted NOAEC values (Figure 2). A risk curve was generated to calculate the probability of the risk of thiamethoxam exceeding NOAEC levels for freshwater invertebrates (Figure 3).

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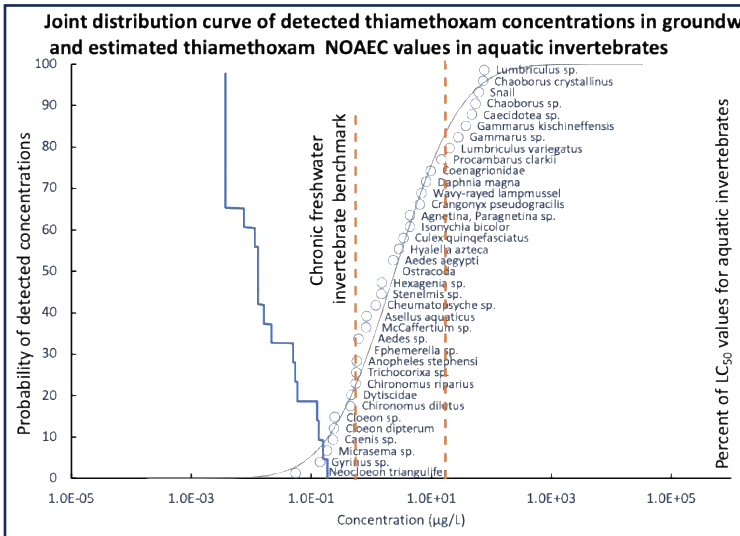


Figure 2. Joint distribution curve that depicts the cumulative probability of thiamethoxam concentrations that were detected in Maine groundwater (dark blue line) and the distribution of estimated NOAEC values for aquatic invertebrates (light blue line). Overlap denotes risk and warrants a risk curve.

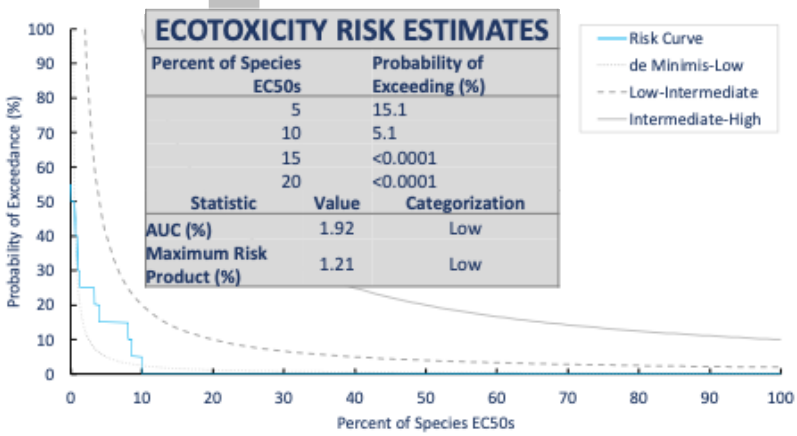


Figure 3. Risk curve in blue indicates that there is a 15% chance that thiamethoxam detections in Maine groundwater will exceed the predicted NOAEC values for 5% of all aquatic species. This risk is categorized as low.

C. Risks of imidacloprid to aquatic organisms

C1. Risk of exceeding acute LC_{50} values for freshwater invertebrates.

Imidacloprid was the only neonicotinoid to be detected in both groundwater and surface water (Table 3; Figure 4). Similar to clothianidin and thiamethoxam, the probability of groundwater or surface water detections exceeding a concentration above any species' LC_{50} value is negligible (<0.001% chance of exceeding LC_{50} for 5% of all species).

	groundwater				surface water				
	2014	2020	2021		2018-19	2019	2021	2023	2025
	(n=137)	(n=74)	(n=50)		(n=18)	(n=51)	(n=12)	(n=54)	(n=38)
detection frequency	11.70%	13.50%	14%	detection frequency	17%	26%	0	3.70%	13%
# detections	16	10	7	# detections	3	14	0	2	5
concentration (ug L-1)	0.005	0.004	0.004	concentration (ug L-1)	0.015	0.002	--	0.005	0.002

Table 3. Detections of imidacloprid in groundwater and surface water in Maine.

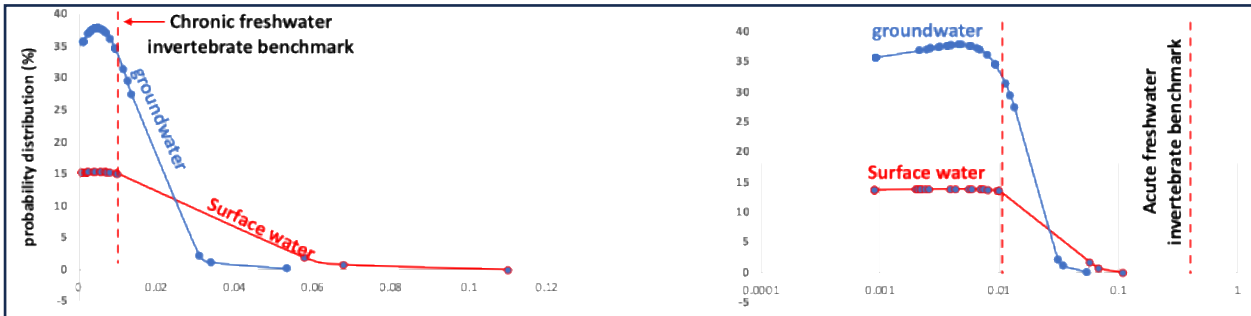


Figure 4. Distributions of imidacloprid detections in Maine groundwater (blue) and surface water (red). Raw data (left) were log-transformed (right) to visualize the relationship between detections and the acute freshwater invertebrate benchmark established by the EPA.

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C2. Risk of imidacloprid exceeding chronic NOAEC values for freshwater invertebrates.

A total of 10 detections of imidacloprid exceeded the chronic freshwater invertebrate benchmark (n= 4 surface water, and n= 6 for groundwater). Therefore, the risks to species in these aquatic environments were evaluated separately. The species sensitivity distribution curve was created using estimated NOAEC values for 64 freshwater species (*e.g.* insects, crustaceans, mollusks, worms, amphibians, and fish); these data are from EPA and academic groups, and the methodology is discussed in Appendix I. A joint distribution curve (Figure 5) was created to show the overlay of the species sensitivity distribution and probability of detected concentrations of imidacloprid. This overlay reveals two important trends. First, insects are the class of species most at risk of imidacloprid detections. Secondly, imidacloprid in surface water (*i.e.* streams) is a greater risk to insects compared to groundwater.

These data motivated us to focus on assessing the risks of insects exposed to imidacloprid in streams. To accomplish this objective, species sensitivity curves were generated for each category on species. This approach allowed us to isolate the impact of imidacloprid on insects and compare this risk to other categories of species (Figure 6). Risk curves were generated to estimate the probability that exposure to imidacloprid will exceed NOAEC values; this analysis reveals that the risks of imidacloprid is specific to insects (*i.e.* NOAEC exceedances could occur for more than 5% of insects). Other species are anticipated to be less impacted, as exposure to imidacloprid will not exceed NOAEC levels (Table 4)

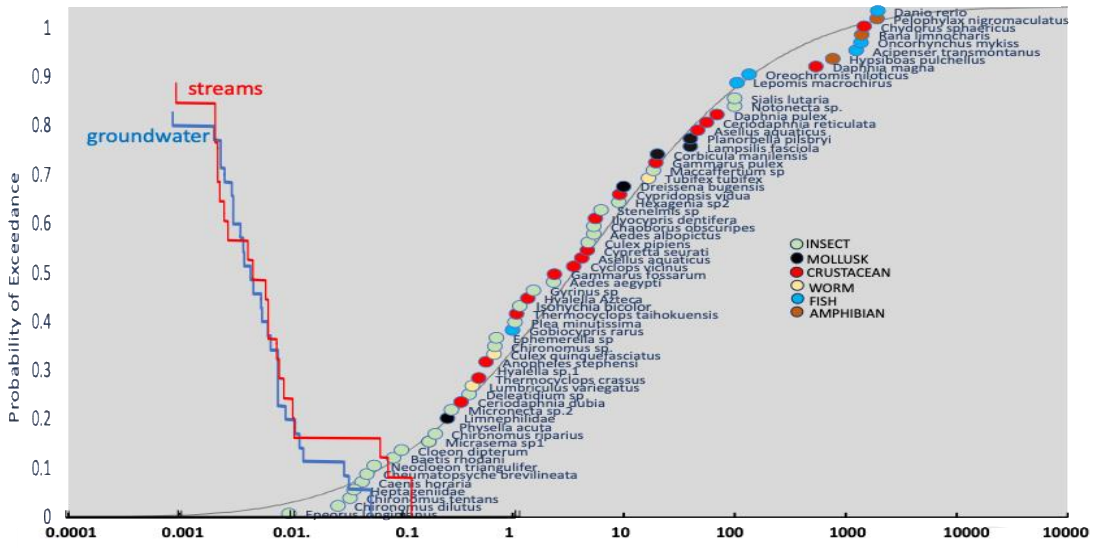


Figure 5. Joint Distribution curve shows the (*i*) probability of environmental exposure of imidacloprid in groundwater and surface water and (*ii*) imidacloprid NOAEC values for aquatic species.

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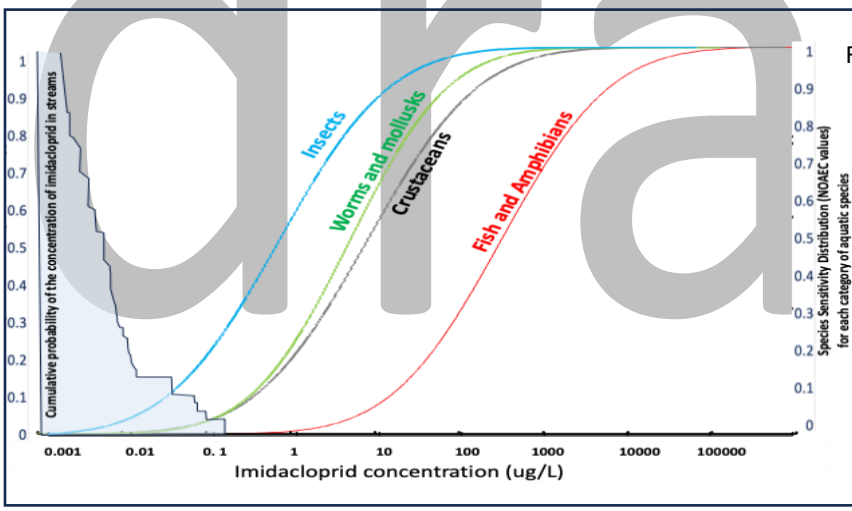


Figure 6. Aquatic species were grouped into categories and separately analyzed by creating species sensitivity curves. This approach reveals that insects are particularly at risk of imidacloprid exposures that exceed NOAEC values.

Probability of imidacloprid exceedance (%)

% species exceeding NOAEC

	all aquatic species		insects		crustaceans		mollusks and worms		fish and amphibeans	
	ground	stream	ground	stream	ground	stream	ground	stream	ground	stream
5%	6.10	8.4	11.5	15.4	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
10%	<0.0001	4.2	5.8	15.4	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
15%	<0.0001	<0.0001	<0.0001	15.4	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
20%	<0.0001	<0.0001	<0.0001	7.7	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
25%	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

	all aquatic species		insects		crustaceans		mollusks and worms		fish and amphibeans	
	ground	stream	ground	stream	ground	stream	ground	stream	ground	stream
AUC	1.77	2	3.44	4.8	0.15	0.52	0.12	0.47	<0.01	<0.01
maximum risk	0.77	0.8	1.24	2.6	0.05	0.29	0.04	0.27	<0.01	<0.01

Table 4. Probabilities of exceedances generated from risk curves for all aquatic species and different categories of species. Values in red represent the probability that exposure to imidacloprid will exceed NOAEC levels

C3. Comparison of imidacloprid stream exposure data to another New England state

There were a total of 24 imidacloprid detections in Maine streams from three water quality monitoring studies. We deemed it worthwhile to compare these data to another New England state that had a more robust dataset, which included 657 detections in streams. Compared to Maine, the other state had a distribution curve that was shifted to the right, which indicates a higher concentration of imidacloprid in streams and increased risk of exposure to aquatic organisms. Nearly half of the imidacloprid detections in the New England state exceeded the chronic freshwater aquatic benchmark (Figure 7).

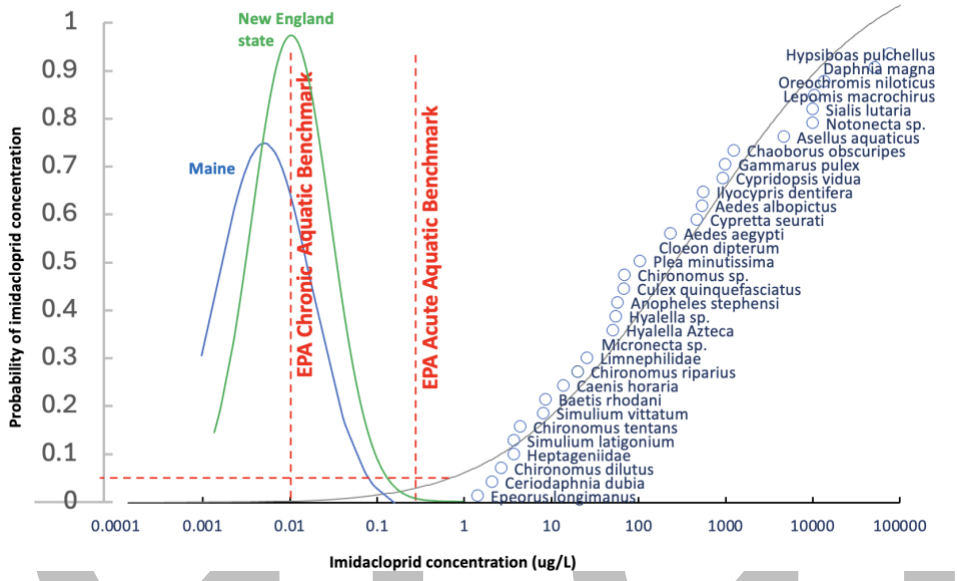


Figure 7. Comparison of imidacloprid concentrations detected in Maine and another New England state streams.