

## Monitoring Program for Mercury in Precipitation in Indiana: Data Summary for 2001--2007



in cooperation with



Mercury Deposition Network of



# U.S. Geological Survey / Indiana Department of Environmental Management Monitoring Program for Mercury in Precipitation in Indiana Data Summary for January 2001 through December 2007

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## Monitoring Program Data

The Indiana mercury-monitoring program is part of the National Atmospheric Deposition Program (NADP) Mercury Deposition Network (MDN) in North America. In the NADP-MDN, weekly precipitation samples are collected and analyzed for mercury. The weekly data are finalized and posted in the NADP-MDN on-line archive at <http://nadp.sws.uiuc.edu/mdn/>. The data for Indiana presented in this summary are based on the MDN weekly data.

## Monitoring Stations in the Data Summary

Five monitoring stations for mercury in precipitation are operated in Indiana. They are listed by name, NADP- MDN identification number, and location:

- Roush Lake (IN20) near Huntington in Huntington County, northeastern Indiana;
- Clifty Falls (IN21) near Madison in Jefferson County, southeastern Indiana;
- Fort Harrison (IN26) near Indianapolis in Marion County, central Indiana;
- Bloomington (IN28) near Bloomington in Monroe County in southwestern Indiana;
- Indiana Dunes (IN34) near Porter in Porter County in northwestern Indiana.

Four of the monitoring stations were operated January 2001 through December 2007—Roush Lake, Clifty Falls, Bloomington, and Indiana Dunes. The Fort Harrison station was operated April 2003 through December 2007. These five stations are planned to operate during 2009.

## Contents of the Data Summary

This data summary quantifies precipitation, mercury concentrations, and mercury wet deposition in Indiana. The data are presented in illustrations and tables.

Five illustrations show the following:

- Annual volume-weighted mercury concentration, annual mercury wet deposition, and annual normalized mercury wet deposition at each station, 2001 through 2007, on a state map (figure 1);
- Annual volume-weighted mercury concentration, annual mercury wet deposition, and annual normalized mercury wet deposition at each station, grouped by year, 2001 through 2007, on bar graphs (figure 2);
- Annual mercury wet deposition and annual precipitation at each station, grouped by station, 2001 through 2007, on bar graphs (figure 3); and
- Distributions of mercury concentrations in weekly precipitation samples (figure 4) and distributions of weekly mercury wet deposition (figure 5) at each station, 2001 through 2007, on box plots.

Three tables summarize information from five monitoring stations in Indiana, 2001 through 2007:

- Number and types of precipitation samples (table 1);
- Total mercury concentrations (table 2); and
- Total mercury wet deposition (table 3).

## Terms in the Data Summary

Following are definitions of the terms used in the summary, the units of measure, and methods of calculation.

### Precipitation Terms

**Weekly precipitation** is the amount of rain, snow, and mixed (liquid and frozen) precipitation recorded by the rain gage at the monitoring station. Units are inches because inches are used most frequently in weather reports in the United States. (The NADP-MDN website lists weekly precipitation in millimeters; one inch is equal to 25.4 millimeters; one millimeter is equal to 0.0393701 inch.)

**Annual precipitation** is the sum of the weekly precipitation amounts for a year (typically 52 weeks).

**Precipitation sampling attempted** means the weekly installation of a clean sampling bottle and funnel in the automated precipitation collector.

**Weekly precipitation sample** is accumulated in the sampling bottle as the automated collector uncovers the funnel each time precipitation occurs. A sample is defined as 0.01 inch or more of precipitation recorded by the rain gage or accumulated in the sampling bottle during one week.

**Dry sample** means that less than 0.01 inch of precipitation is recorded by the rain gage or accumulated in the sampling bottle during one week.

### Concentration Terms

**Mercury concentrations** in precipitation samples and mercury wet deposition in this summary are for total mercury. Total mercury includes inorganic mercury and methylmercury.

**Mercury concentration** is determined by laboratory analysis of the weekly precipitation sample accumulated in the automated collector. Concentration is mercury mass per volume of precipitation. Units are nanograms per liter (equivalent to 0.001 microgram per liter and approximately one part per trillion).

**Median mercury concentration** is a descriptive statistic for a group of mercury concentrations. When concentrations are ranked from smallest to largest, the median separates the ranked concentrations into two parts—half of the concentrations are greater than the median and half of the concentrations are less than the median. Units are nanograms per liter.

**Volume-weighted mercury concentration** is a computed value of a group of mercury concentrations weighted by the ratios of the sample volumes of the weekly samples to the total sample volume for the group. The volume-weighted concentration is a better representation of mercury concentrations in a group of precipitation samples than a simple mean (known as an “average”). Large concentrations in small volume samples will bias a simple mean but not a volume-weighted concentration. Units are nanograms per liter.

### Deposition Terms

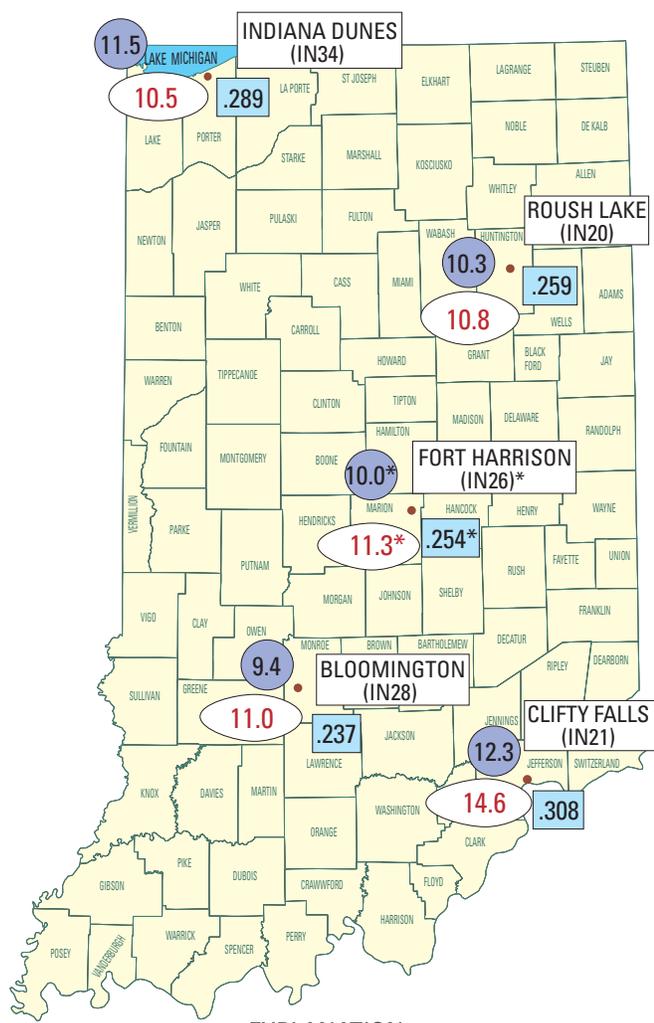
**Mercury wet deposition** is the rate of mercury mass deposited in precipitation, per unit area, per unit time. Units for the mass per unit area are micrograms per square meter (1 microgram equals 1,000 nanograms).

**Weekly mercury wet deposition** is the product of the mercury concentration in the weekly precipitation sample and the weekly precipitation amount, divided by the unit area. Units are micrograms per square meter per week.

**Estimated weekly mercury wet deposition** provides a wet deposition value when a sampler malfunction or other error causes a mercury concentration to not be reported. Mercury wet deposition is estimated with the valid weekly precipitation amount and the seasonal volume-weighted mercury concentration. Units are micrograms per square meter per week.

**Annual mercury wet deposition** is the sum of the weekly mercury wet deposition for a year (typically 52 weeks). Units are micrograms per square meter per year.

**Annual normalized mercury wet deposition** is the annual mercury wet deposition divided by the annual precipitation. Differences in annual wet deposition among monitoring stations that are caused by differences in annual precipitation are removed when comparisons are made with normalized wet deposition. Units are micrograms per square meter per year per inch of precipitation.

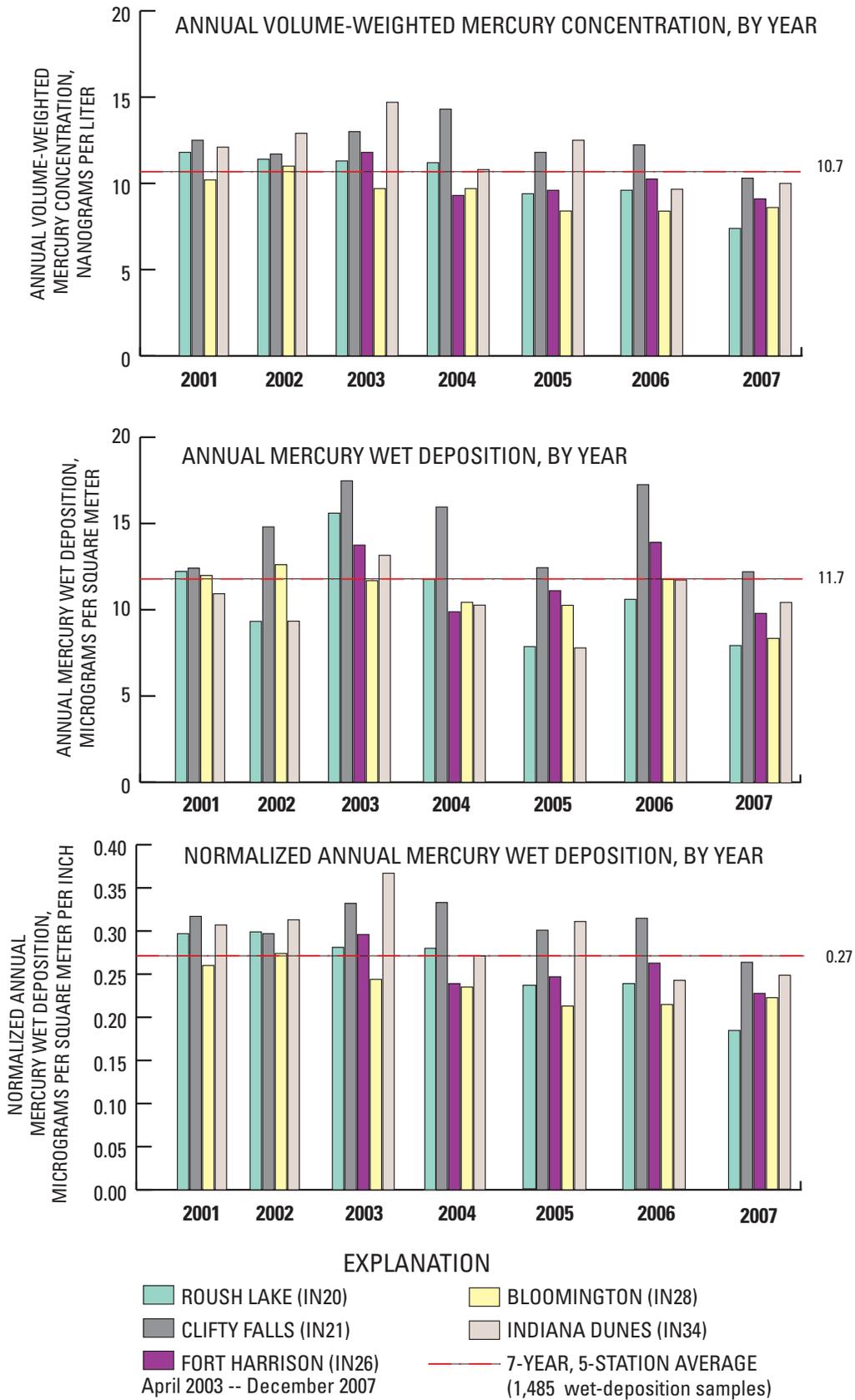


**EXPLANATION**

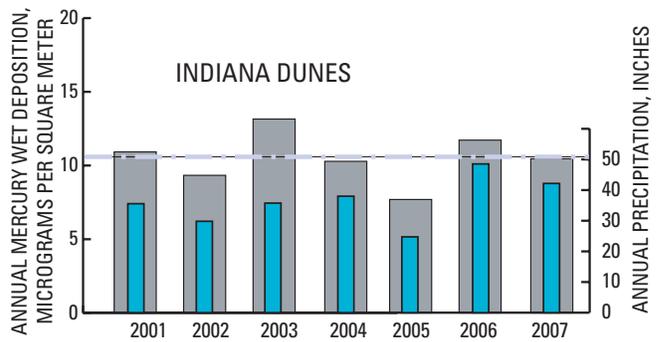
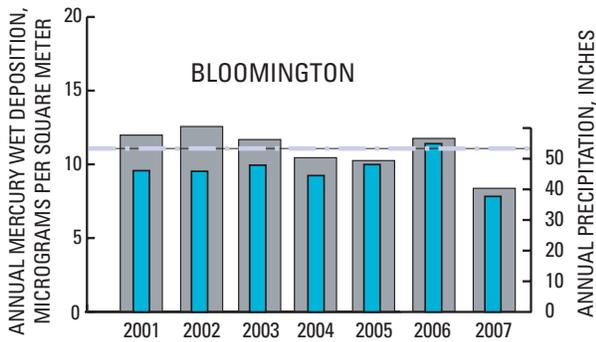
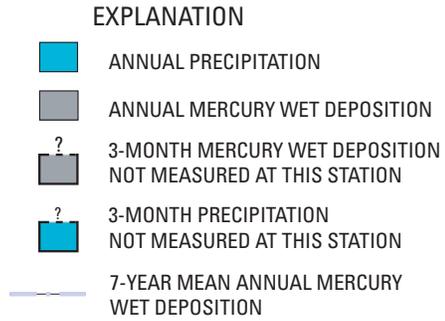
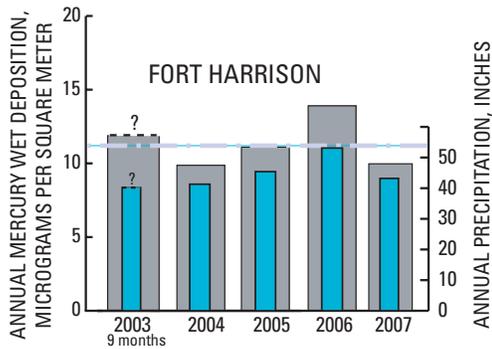
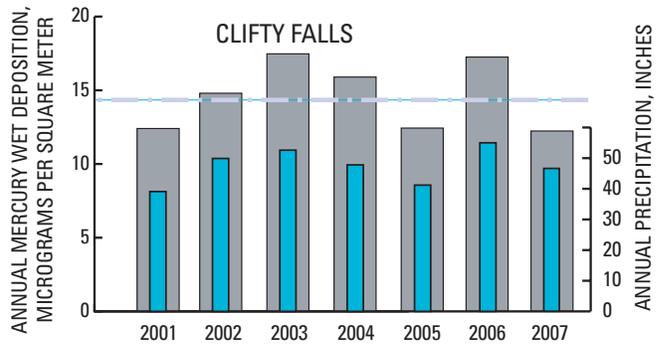
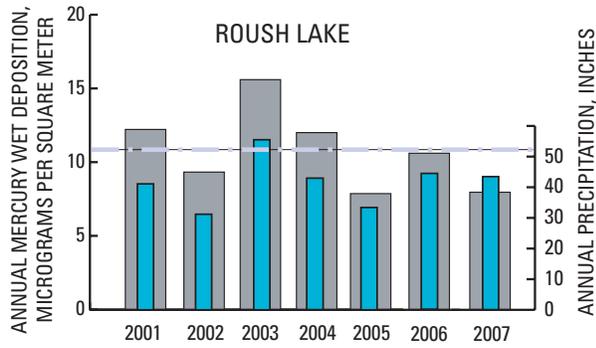
- Mercury monitoring station
- INDIANA DUNES (IN34) Monitoring station name and Mercury Deposition Network identification number
- 11.5 Annual average volume-weighted mercury concentration in nanograms per liter
- 10.5 Annual average mercury wet deposition in micrograms per square meter per year (1 microgram = 1,000 nanograms)
- .289 Annual average normalized mercury wet deposition in micrograms per square meter per inch of precipitation per year

\* Fort Harrison data are from April 2003 -- December 2007

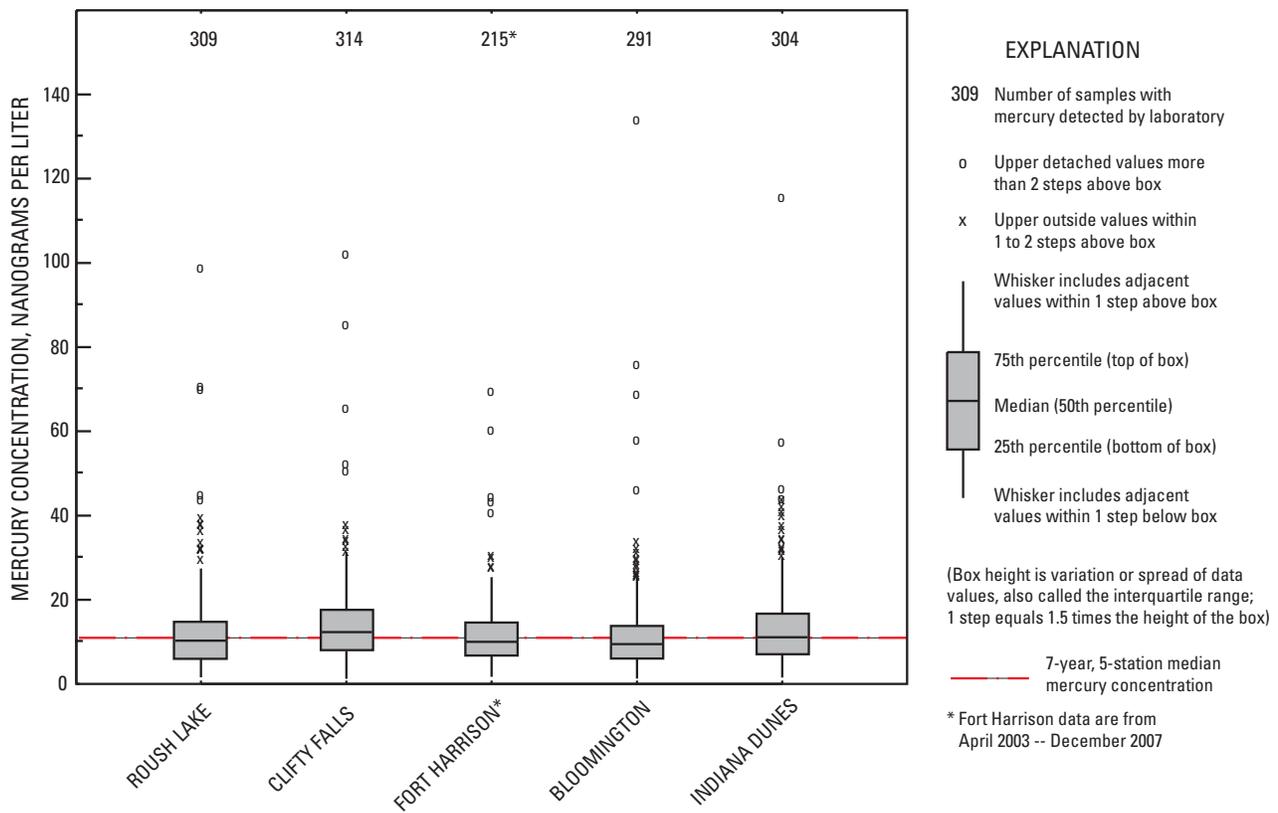
**Figure 1.** Annual mercury concentrations in precipitation and annual mercury wet deposition at five monitoring stations in Indiana, January 2001 through December 2007.



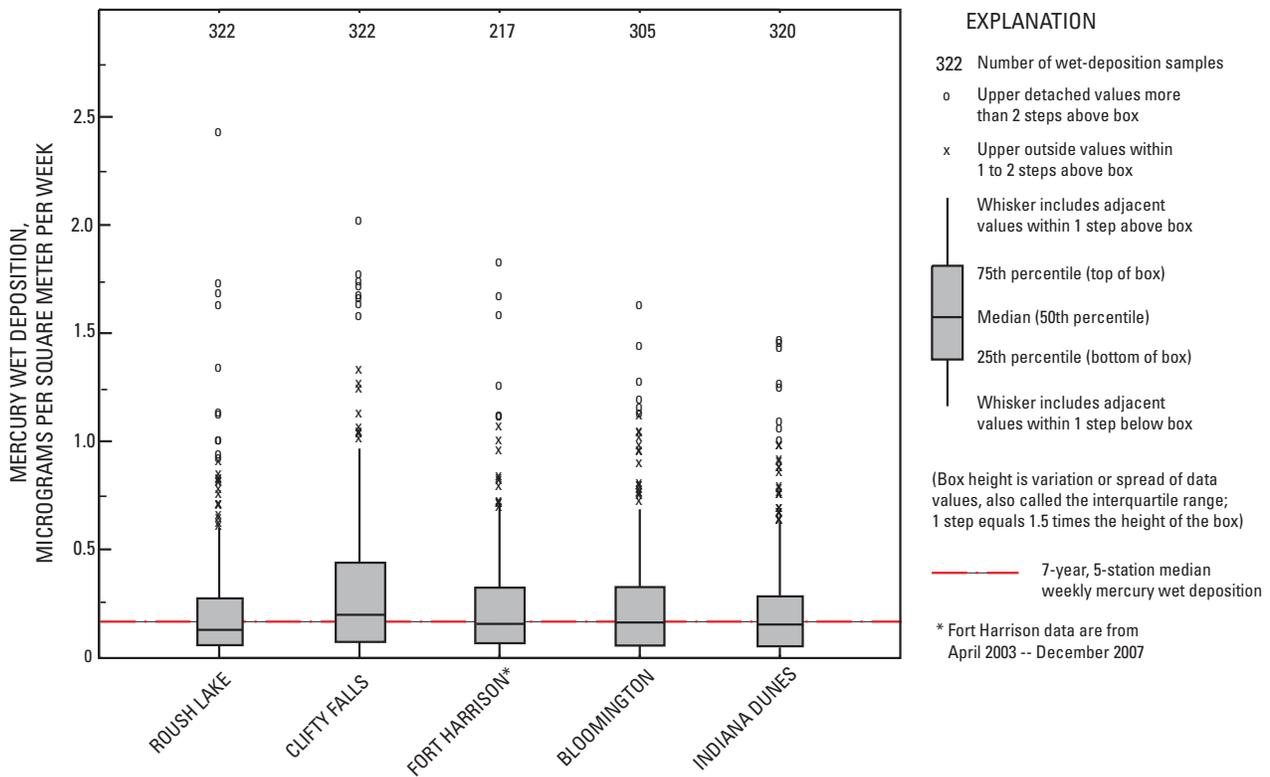
**Figure 2.** Annual volume-weighted mercury concentrations in precipitation, annual mercury wet deposition, and annual normalized mercury wet deposition at five monitoring stations in Indiana, January 2001 through December 2007.



**Figure 3.** Annual mercury wet deposition and annual precipitation at five monitoring stations in Indiana, January 2001 through December 2007.



**Figure 4.** Standard boxplots showing the distribution of mercury concentrations in weekly precipitation samples from five monitoring stations in Indiana, January 2001 through December 2007.



**Figure 5.** Standard boxplots showing the distribution of weekly mercury wet deposition at five monitoring stations in Indiana, January 2001 through December 2007.

**Table 1.** Number and types of weekly precipitation samples from mercury monitoring at five stations in Indiana, January 2001 through December 2007

[first five shaded rows contain totals for each station; last shaded row contains totals for all five stations]

Station name and Mercury Deposition Network identification number	Year	Number of samples attempted	Number of mercury wet-deposition samples <sup>a</sup>	Number of dry samples <sup>b</sup>	Types of wet-deposition samples		
					Number of rain samples	Number of snow samples	Number of mixed samples <sup>c</sup>
Roush Lake (IN20)	2001	52	46	6	38	2	6
	2002	52	48	4	33	5	10
	2003	53	49	4	33	8	8
	2004	52	42	10	28	1	13
	2005	52	48	4	33	5	10
	2006	52	46	6	37	1	8
	2007	52	43	9	30	4	9
<b>7 years</b>		<b>365</b>	<b>322</b>	<b>43</b>	<b>232</b>	<b>26</b>	<b>64</b>
Clifty Falls (IN21)	2001 <sup>d</sup>	50	44	6	39	0	5
	2002	52	45	7	39	3	3
	2003	53	51	2	41	4	6
	2004	52	43	9	36	1	6
	2005	52	49	3	38	2	9
	2006	52	44	8	37	0	7
	2007	52	46	6	39	2	5
<b>7 years</b>		<b>363</b>	<b>322</b>	<b>41</b>	<b>269</b>	<b>12</b>	<b>41</b>
Fort Harrison (IN26)	2003 <sup>e</sup>	39	35	4	32	0	3
	2004	52	43	9	34	1	8
	2005	52	46	6	34	3	9
	2006	52	48	4	41	1	6
	2007	52	45	7	32	3	10
<b>5 years</b>		<b>247</b>	<b>217</b>	<b>30</b>	<b>173</b>	<b>8</b>	<b>36</b>
Bloomington (IN28)	2001	52	44	8	37	3	4
	2002	52	43	9	37	3	3
	2003	53	44	9	33	5	6
	2004	52	41	11	33	1	7
	2005	52	45	7	33	3	9
	2006	52	47	5	41	0	6
	2007	52	41	11	32	1	8
<b>7 years</b>		<b>365</b>	<b>305</b>	<b>60</b>	<b>246</b>	<b>16</b>	<b>43</b>
Indiana Dunes (IN34)	2001	52	46	6	38	1	7
	2002	52	43	9	31	6	6
	2003	53	48	5	32	13	3
	2004	52	47	5	35	4	8
	2005	52	44	8	31	6	7
	2006	52	46	6	37	0	9
	2007	52	45	7	29	4	12
<b>7 years</b>		<b>365</b>	<b>319</b>	<b>46</b>	<b>233</b>	<b>34</b>	<b>52</b>
<b>Five stations</b>	<b>7 years</b>	<b>1,705</b>	<b>1,485</b>	<b>220</b>	<b>1,153</b>	<b>96</b>	<b>236</b>

<sup>a</sup>Includes samples with estimated mercury wet deposition.

<sup>b</sup>Dry sample defined as less than 0.01 inch of precipitation; includes field blank and system blank samples.

<sup>c</sup>Mixed sample contains liquid and frozen precipitation.

<sup>d</sup>Does not include 2 weeks prior to start of monitoring in January 2001.

<sup>e</sup>Does not include 13 weeks prior to start of monitoring in April 2003.

**Table 2.** Mercury concentrations in weekly precipitation samples at five monitoring stations in Indiana, January 2001 through December 2007.

[ng/L, nanogram per liter; first five shaded rows contain median or volume-weighted mercury concentrations or total number of samples for each station; last shaded row contains median or volume-weighted mercury concentrations or total number of samples for all five stations]

Station name and Mercury Deposition Network identification number	Year	Median mercury concentration (ng/L) <sup>a</sup>	Volume-weighted mercury concentration (ng/L) <sup>a</sup>	Number of samples with mercury detected by laboratory	Number of samples with mercury wet deposition estimated	Number of mercury wet-deposition samples
Roush Lake (IN20)	2001	11.4	11.8	44	2	46
	2002	10.1	11.4	42	6	48
	2003	11.0	11.3	47	2	49
	2004	8.9	11.2	42	0	42
	2005	9.7	9.4	48	0	48
	2006	10.0	9.6	45	1	46
	2007	10.2	7.4	41	2	43
	<b>7 years</b>	<b>10.2</b>	<b>10.3</b>	<b>309</b>	<b>13</b>	<b>322</b>
Clifty Falls (IN21)	2001	11.2	12.5	43	1	44
	2002	13.4	11.7	44	1	45
	2003	12.6	13.0	51	0	51
	2004	14.3	14.3	42	1	43
	2005	11.3	11.8	46	3	49
	2006	12.1	12.2	43	1	44
	2007	11.0	10.3	45	1	46
	<b>7 years</b>	<b>12.2</b>	<b>12.3</b>	<b>314</b>	<b>8</b>	<b>322</b>
Fort Harrison (IN26)	2003 <sup>b</sup>	10.9	11.8	34	1	35
	2004	8.6	9.3	43	0	43
	2005	10.0	9.6	45	1	46
	2006	9.0	10.2	48	0	48
	2007	8.4	9.1	45	0	45
	<b>5 years</b>	<b>9.8</b>	<b>10.0</b>	<b>215</b>	<b>2</b>	<b>217</b>
Bloomington (IN28)	2001	10.9	10.2	44	0	44
	2002	9.8	11.0	35	8	43
	2003	10.3	9.7	42	2	44
	2004	9.5	8.9	41	1	42
	2005	9.3	8.4	45	0	45
	2006	9.4	8.4	46	1	47
	2007	9.2	8.6	39	2	41
	<b>7 years</b>	<b>9.6</b>	<b>9.4</b>	<b>291</b>	<b>14</b>	<b>305</b>
Indiana Dunes (IN34)	2001	12.7	12.1	43	3	46
	2002	11.3	12.9	38	5	43
	2003	14.1	14.7	44	4	48
	2004	10.1	10.8	47	0	47
	2005	11.2	12.5	43	1	44
	2006	9.1	9.6	45	1	46
	2007	10.9	10.0	44	1	45
	<b>7 years</b>	<b>11.1</b>	<b>11.5</b>	<b>304</b>	<b>15</b>	<b>319</b>
<b>Five stations</b>	<b>7 years</b>	<b>11.0</b>	<b>10.7</b>	<b>1,433</b>	<b>52</b>	<b>1,485</b>

<sup>a</sup>Median and volume-weighted mercury concentrations computed for samples with mercury detected by laboratory. 7-year median and volume-weighted mercury concentrations are computed from weekly concentrations, not from single-year median or volume-weighted mercury concentrations in this table.

<sup>b</sup>Does not include 13 weeks prior to start of monitoring in April 2003.

**Table 3.** Mercury wet deposition at five monitoring stations in Indiana, January 2001 through December 2007.[ $\mu\text{g}/\text{m}^2$ , microgram per square meter;  $\mu\text{g}/\text{m}^2/\text{inch}$ , microgram per square meter per inch]

Station name and Mercury Deposition Network identification number	Year	Annual precipitation (inch)	Annual mercury wet deposition <sup>a</sup> ( $\mu\text{g}/\text{m}^2$ )	Annual normalized mercury wet deposition <sup>b</sup> ( $\mu\text{g}/\text{m}^2/\text{inch}$ )	Average weekly mercury wet deposition <sup>c</sup> ( $\mu\text{g}/\text{m}^2$ )	Average mercury wet deposition per sample <sup>d</sup> ( $\mu\text{g}/\text{m}^2$ )
Roush Lake (IN20)	2001	41.1	12.22	0.297	0.235	0.278
	2002	31.2	9.33	0.299	0.179	0.222
	2003	55.5	15.60	0.281	0.294	0.332
	2004	42.9	12.00	0.280	0.231	0.286
	2005	33.4	7.86	0.236	0.151	0.164
	2006	44.3	10.60	0.239	0.200	0.236
	2007	43.4	7.96	0.184	0.153	0.194
	<b>Average</b>	<b>41.7</b>	<b>10.80</b>	<b>0.259</b>	<b>0.206</b>	<b>0.244</b>
Clifty Falls (IN21)	2001	39.1	12.41	0.317	0.248	0.289
	2002	49.9	14.80	0.297	0.285	0.336
	2003	52.6	17.47	0.332	0.330	0.343
	2004	47.8	15.90	0.333	0.312	0.379
	2005	41.2	12.43	0.301	0.235	0.270
	2006	54.9	17.25	0.314	0.332	0.401
	2007	46.6	12.24	0.263	0.235	0.272
	<b>Average</b>	<b>47.5</b>	<b>14.64</b>	<b>0.308</b>	<b>0.282</b>	<b>0.327</b>
Fort Harrison (IN26)	2003 <sup>e</sup>	40.2	11.89	0.296	0.029	0.350
	2004	41.3	9.87	0.239	0.193	0.229
	2005	45.4	11.23	0.247	0.212	0.250
	2006	53.1	13.90	0.262	0.267	0.290
	2007	43.2	9.83	0.227	0.189	0.218
	<b>Average</b>	<b>44.7</b>	<b>11.34</b>	<b>0.254</b>	<b>0.178</b>	<b>0.267</b>
Bloomington (IN28)	2001	46.1	11.98	0.260	0.240	0.272
	2002	45.9	12.57	0.274	0.242	0.359
	2003	47.9	11.68	0.244	0.220	0.278
	2004	44.5	10.45	0.235	0.205	0.261
	2005	48.1	10.26	0.213	0.194	0.228
	2006	54.9	11.76	0.214	0.226	0.256
	2007	37.7	8.38	0.222	0.161	0.215
	<b>Average</b>	<b>46.4</b>	<b>11.01</b>	<b>0.237</b>	<b>0.213</b>	<b>0.267</b>
Indiana Dunes (IN34)	2001	35.6	10.93	0.307	0.219	0.254
	2002	29.8	9.34	0.313	0.180	0.246
	2003	35.8	13.16	0.368	0.248	0.299
	2004	38.0	10.29	0.271	0.202	0.219
	2005	24.7	7.70	0.311	0.145	0.179
	2006	48.5	11.72	0.242	0.225	0.261
	2007	42.2	10.46	0.248	0.201	0.238
	<b>Average</b>	<b>36.4</b>	<b>10.51</b>	<b>0.294</b>	<b>0.203</b>	<b>0.242</b>
<b>5 stations (33 values)</b>	<b>Average</b>	<b>43.2</b>	<b>11.68</b>	<b>0.272</b>	<b>0.219</b>	<b>0.270</b>

<sup>a</sup>Includes samples with estimated mercury wet deposition.<sup>b</sup>Computed as annual mercury wet deposition divided by annual precipitation.<sup>c</sup>Computed as annual mercury wet deposition divided by number of samples attempted (table 1).<sup>d</sup>Computed as annual mercury wet deposition divided by number of wet-deposition samples (table 1).<sup>e</sup>Does not include 13 weeks prior to start of monitoring in April 2003