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MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER BUREAU
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STAFF REPORT

A SEDIMENT CHEMISTRY SURVEY OF TORCH LAKE HOUGHTON COUNTY, MICHIGAN AUGUST 7, 8, and 9, 2007

Staff of the Surface Water Assessment Section, together with staff from the United States Environmental Protection Agency (USEPA) Great Lakes National Program Office, conducted a sediment chemistry survey in Torch Lake, Houghton County, Michigan. The USEPA currently lists Torch Lake, as a Great Lakes Area of Concern, in part, because of elevated levels of polychlorinated biphenyls (PCBs) in fish tissue. The Michigan Department of Community Health currently recommends restricting consumption of northern pike, smallmouth bass, and walleye. In November of 2005, the Water Bureau (WB) of the Michigan Department of Environmental Quality (MDEQ) used semi-permeable membrane devices (SPMD) to evaluate PCB concentrations in Torch Lake (Bohr, 2006). The results of the SPMD study indicate the presence of a potential source of PCBs within the north northern side of Torch Lake. The objective of this study is to evaluate sediments in this area, including several previously identified drum disposal areas, as a potential source of PCBs to the lake.

SUMMARY

1. Seventy-one discrete sediment samples were collected from 36 location in Torch Lake, Houghton County, Michigan, and analyzed for PCBs, silver, arsenic, barium, cadmium, chromium, copper, mercury, lead, selenium, zinc, and percent total solids.

2. The metals analysis demonstrated elevated concentrations of copper and lead consistent with the historical sampling activities.

3. PCBs were detected in 16 of the 71 discrete samples, with quantified concentrations ranging from 130 micrograms/kilogram (ug/kg) to 8,900 ug/kg. PCBs were also detected at 11 of the 36 surficial sampling locations.

4. Surficial sediments in the Hubbell area in Torch Lake appear to have low levels (1,000 ug/kg or less) of PCB concentrations. PCB concentrations in the deeper sediments, except at the very northern end of the sample area (Figure 2), were predominantly below reporting limits.

5. Based on the data collected, the PCB sediment concentrations in the north/northwest basin of Torch Lake are below levels requiring remedial action. However, given that low levels of PCBs are detected in the surficial sediment in the Hubbell sampling area an ongoing upland source of PCBs to Torch Lake can not be ruled out.

METHODS

Sediment samples were collected at selected locations from the USEPA research vessel, "Mudpuppy," using either a ponar dredge sampler or the Vibro-core sampler as described in the Quality Assurance Project Plan (QAPP) (Alexander, 2007). During the sampling event, field staff noticed a one to two inch layer of brown organic material at the top of each ponar sample. The QAPP stated that the entire ponar samples would be homogenized prior to placing in the sample jar. Field staff decided that it would be more beneficial to sample only the thin brown organic material rather than compositing the entire sample. The organic layer was scraped from the top of the sample, place in a separate pan, homogenized, and then placed in the sample jars. All other sampling procedures were consistent with the Torch Lake QAPP. All sediment samples were transported to the MDEQ Environmental Laboratory for chemical analysis.

RESULTS AND DISCUSSION

Sediment sampling locations for Torch Lake are contained in Figures 1, 2, 3, and 4 and Table 1. Results of the sediment chemistry analysis are contained in Table 2. For purposes of evaluation, sediment analysis results were compared to the threshold effect concentration (TEC) and probable effect concentrations (PEC) described in "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems" (MacDonald et. al, 2000). The TEC and PEC values are used as screening tools to assess the potential for aquatic life effects. The TEC is the sediment concentration below which impacts to aquatic life would be less likely to occur. The PEC is the sediment concentration above which impacts to aquatic life would be more likely to occur.

Metals

Sample results throughout the study area showed concentrations of copper and lead above the MacDonald PEC screening levels. These results appear to be consistent with historical sampling events. The 1994 Record of Decision (U.S. EPA 1994) selected No Action as the remedial option to address Torch Lake sediments. The assumption underlying this selection was that implementation of the erosion prevention remedy selected for terrestrial areas of the Site (U.S. EPA 1992) would allow for natural recovery of the sediments. Other metals, such as arsenic, cadmium, chromium, mercury, and zinc where elevated above the PEC, but to a lesser extent.

PCB

Fourteen samples at four core stations (TL07-01, 02, 03, 04) were collected at the north end of Torch Lake in the vicinity of the city of Lake Linden, Michigan (Figure 2). Three of the four core sampling locations showed elevated concentrations of PCBs at deeper depths, while one location showed quantifiable concentrations of PCBs at the surface (0 to 6 inch interval). Station TL07-01 showed the highest concentration quantified in the Torch Lake sediment survey (8,900 ug/kg) in the 43 to 60 inch interval. Station TL07-02 and TL07-03 also showed elevated PCB concentrations at the 28 to 48 inch interval and 21 to 41 inch interval respectively. Field sampling staff stated these three sample intervals showed a yellowish streaking not found in other Torch Lake cores samples.

One ten-foot core (TL07-13) was collected between the north end sampling and the Lake Linden Boat launch (Figure 2). Analytical results at this core station showed PCB concentrations below reporting limits at all sample intervals.

Three ten-foot cores and nine ponar samples were collected at the Lake Linden boat launch area (Figure 3). None of the 16 individual sediment samples collected in this area showed PCB concentrations above reporting limits.

Nine ten-foot cores and ten ponar samples were collected in the Hubbell area (Figure 4). Six (TL07-05, 06, 07, 08, 12, 17) of the nine core sampling stations had quantifiable concentrations

of PCBs in the 0 to 6 inch interval, with concentrations ranging from ranging from 130 ug/kg (TL07-06) to 510 ug/kg (TL07-12). The remaining core samples showed PCB concentrations below reporting limits. Four (TL07-17, 21, 22, 23) of the 10 ponar samples had quantifiable concentrations of PCB, with concentrations ranging from 340 ug/kg (TL07-21) to 1,100 ug/kg (TL07-17). All remaining ponar samples showed PCB concentrations below the reporting limits. Station TL07-17 had both a core sample and a ponar sample collected, with quantified PCB concentrations of 160 ug/kg in the 0 to 6 inch interval of the core and 1,100 ug/kg in the ponar. The results for this station demonstrate the PCB in the surficial samples is likely found in the one to two inch thick brown organic layer described above.

It should be noted, that the several of the surficial samples in the Hubbell area had elevated reporting limits compared to the reporting limits from other samples. In many cases the reporting limits were elevated above other quantified concentrations. Based on personal communications with the MDEQ Environmental Laboratory, the elevated reporting limits were due to low solids content, and do introduce some uncertainty to the concentrations of PCB in these samples. However it should be noted that these reporting limits are below typical action levels for PCB.

The PCB results from this study appear to compare well with the results from the 2005 SPMD study (Bohr, 2006). The highest concentrations of PCB in the SPMD study were found in the Hubbell area, which is the area were 10 of the 11 surficial sediment samples with quantified PCB were found. Based on comparison of these studies, it is possible that the PCB found in the top few inches of sediment in the Hubbell area is the source of the PCB found in the 2005 SPMD study and that the surficial PCB are the result of historical activities in the area. It is also possible that there is a low level upland source of PCB to Torch Lake in this area. A detailed upland source identification study could be conducted to make that determination.

While these sample results do show elevated concentrations of PCB in the deeper sediment intervals of Torch Lake in the north end sample area (Figure 2) and low concentrations of PCB in surficial sediment of Torch Lake in the Hubbell area (Figure 3), the WB would not recommend remedial actions to address these sediments at this time. An evaluation of the relative risk of these low levels of PCB in sediment and water column would need to be completed before additional remedial work could be recommended. In 2007, the Michigan Department of Natural Resources, in coordination with the WB Fish Consumption Monitoring Program staff, collected several fish species for PCB analysis. Once this analysis has been completed, the WB should be able to evaluate the need for additional studies.

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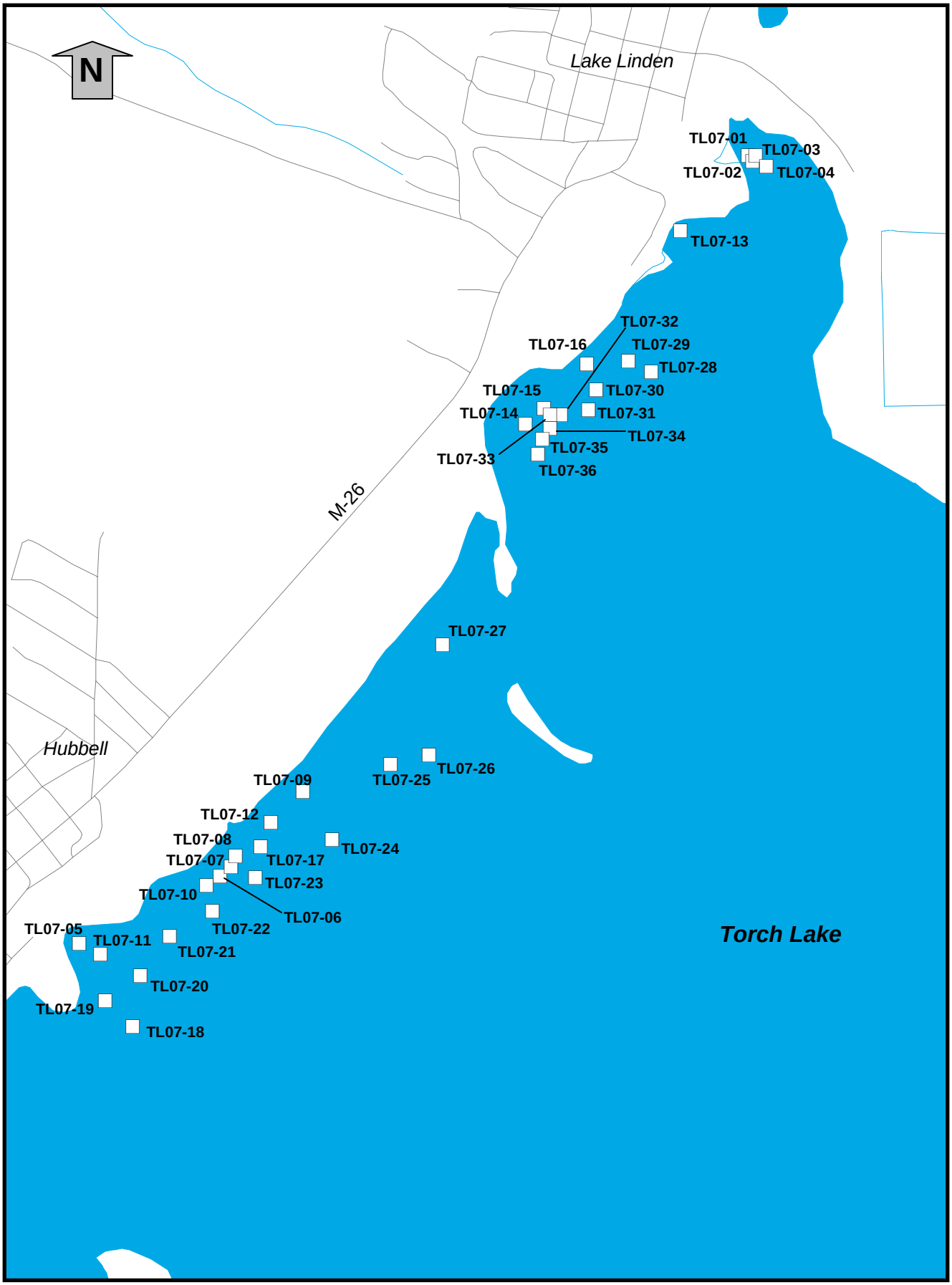

Figure 1. Torch Lake sediment sampling locations, Houghton County, Michigan, August 7, 8, and 9 2007.

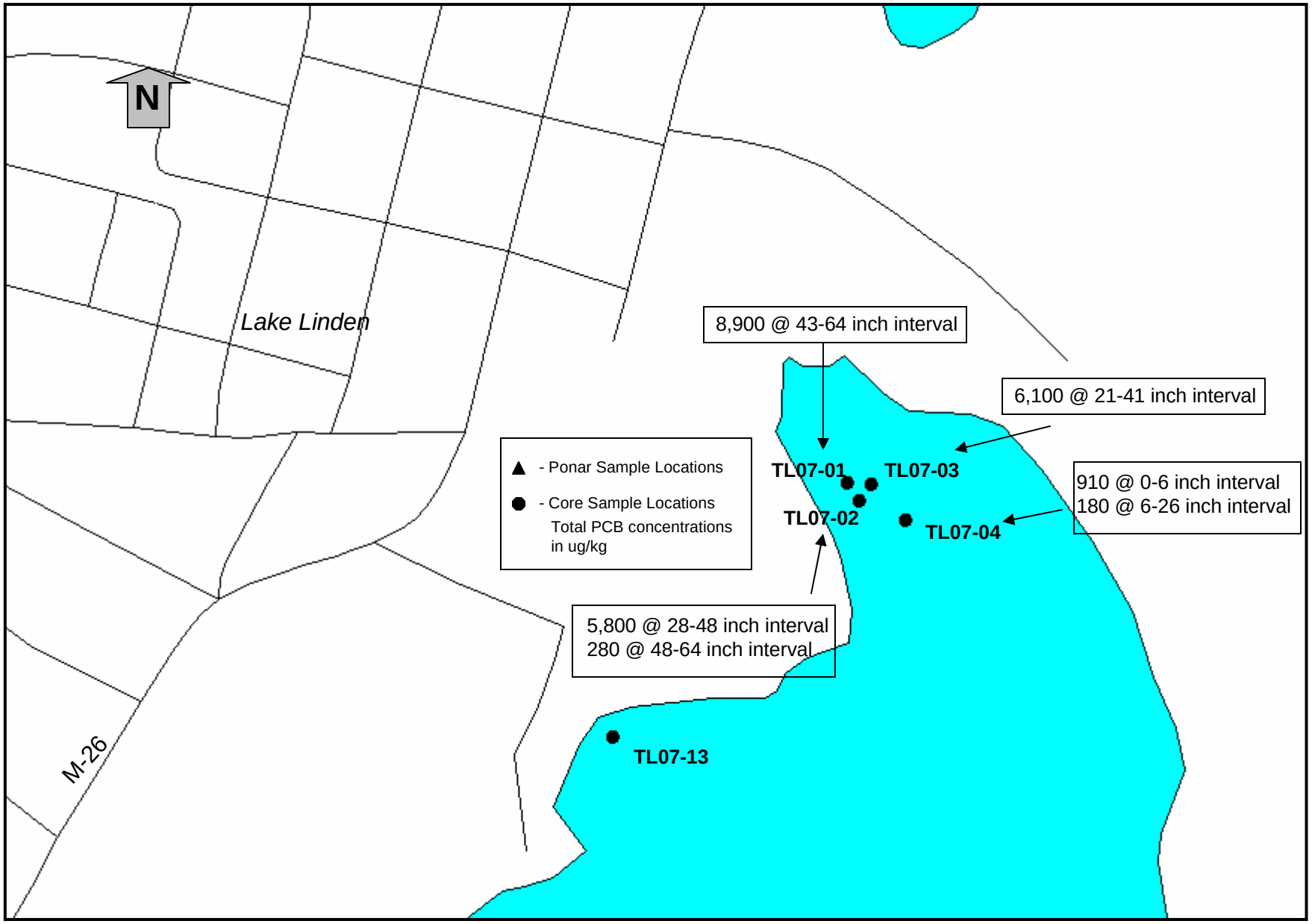

Figure 2. North end Torch Lake sampling locations and PCB concentrations August 7, 8, and 9, 2007

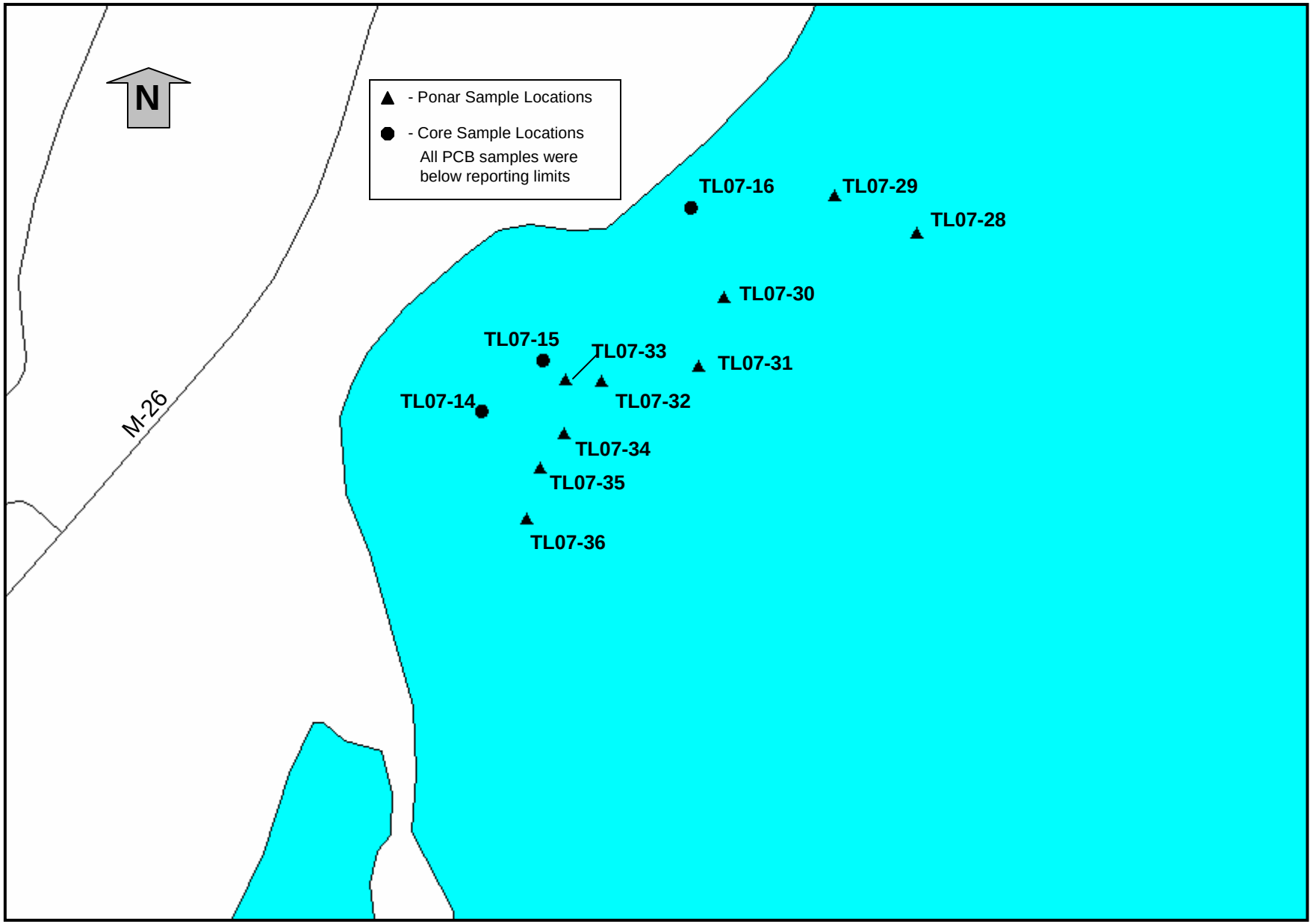

Figure 3. Lake Linden boat launch area Torch Lake sampling locations and PCB concentrations August 7, 8, and 9, 2007

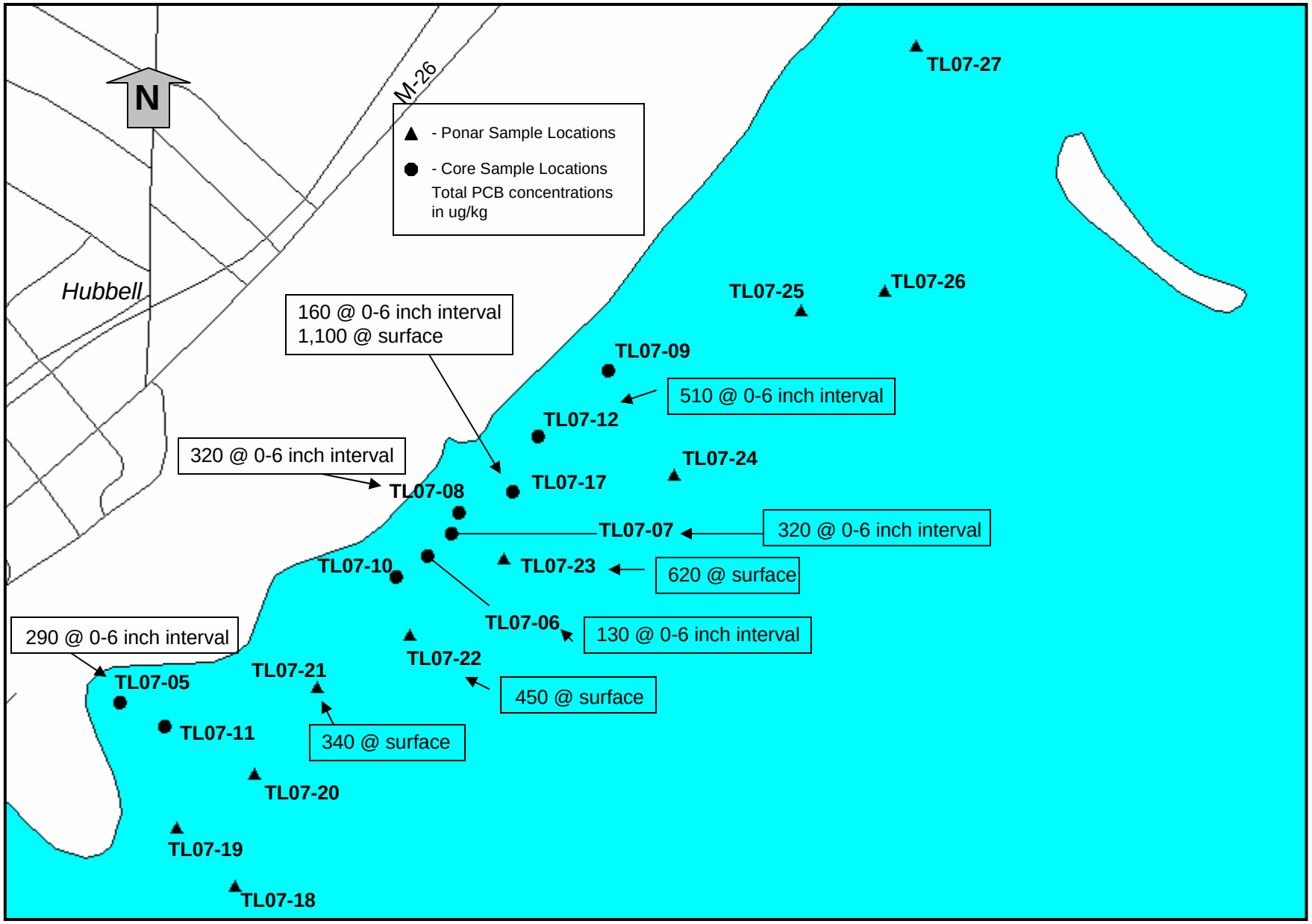

Figure 4. Hubbell area Torch Lake sampling locations and PCB concentrations August 7, 8, and 9, 2007

Table 1. Torch Lake sediment chemistry sampling locations latitude/longitude and sample type, August 7, 8, and 9, 2007.

Station ID	Location	Latatude	Longitude	Sample Type
TL07-01	Torch Lake	47 11.332	088 24.412	Vibro-core
TL07-02	Torch Lake	47 11.330	088.24.406	Vibro-core
TL07-03	Torch Lake	47 11.334	088 24.399	Vibro-core
TL07-04	Torch Lake	47 11.323	088 24.383	Vibro-core
TL07-05	Torch Lake	47 10.378	088 25.528	Vibro-core
TL07-06	Torch Lake	47 10.462	088 25.288	Vibro-core
TL07-07	Torch Lake	47 10.477	088 25.272	Vibro-core
TL07-08	Torch Lake	47 10.489	088 25.267	Vibro-core
TL07-09	Torch Lake	47 10.566	088 25.153	Vibro-core
TL07-10	Torch Lake	47 10.449	088 25.315	Vibro-core
TL07-11	Torch Lake	47 10.369	088 25.495	Vibro-core
TL07-12	Torch Lake	47 10.532	088 25.203	Vibro-core
TL07-13	Torch Lake	47 11.241	088 24.530	Vibro-core
TL07-14	Torch Lake	47 11.008	088 24.784	Vibro-core
TL07-15	Torch Lake	47 11.030	088 24.757	Vibro-core
TL07-16	Torch Lake	47 11.082	088 24.681	Vibro-core
TL07-17	Torch Lake	47 10.502	088 25.226	Vibro-core & Ponar Dredge
TL07-18	Torch Lake	47 10.282	088 25.434	Ponar Dredge
TL07-19	Torch Lake	47 10.314	088 25.481	Ponar Dredge
TL07-20	Torch Lake	47 10.346	088 25.422	Ponar Dredge
TL07-21	Torch Lake	47 10.390	088 25.374	Ponar Dredge
TL07-22	Torch Lake	47 10.424	088 25.301	Ponar Dredge
TL07-23	Torch Lake	47 10.463	088 25.229	Ponar Dredge
TL07-24	Torch Lake	47 10.510	088 25.100	Ponar Dredge
TL07-25	Torch Lake	47 10.603	088 25.001	Ponar Dredge
TL07-26	Torch Lake	47 10.619	088 24.938	Ponar Dredge
TL07-27	Torch Lake	47 10.744	088 24.917	Ponar Dredge
TL07-28	Torch Lake	47 11.076	088 24.571	Ponar Dredge
TL07-29	Torch Lake	47 11.086	088 24.611	Ponar Dredge
TL07-30	Torch Lake	47 11.050	088 24.665	Ponar Dredge
TL07-31	Torch Lake	47 11.026	088 24.675	Ponar Dredge
TL07-32	Torch Lake	47 11.022	088 24.725	Ponar Dredge
TL07-33	Torch Lake	47 11.019	088 24.741	Ponar Dredge
TL07-34	Torch Lake	47 11.002	088 24.744	Ponar Dredge
TL07-35	Torch Lake	47 10.992	088 24.753	Ponar Dredge
TL07-36	Torch Lake	47 10.976	088 24.764	Ponar Dredge

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-01 (0-6)	TL07-01 (6-24)	TL07-01 (24-43)	TL07-01 (43-64)	TL07-02 (0-28)	TL07-02 (28-48)	TL07-02 (48-64)	TL07-03 (0-21)
Aroclor 1016	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	ND RL = 140	ND RL = 140
Aroclor 1221	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	ND RL = 140	ND RL = 140
Aroclor 1232	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	ND RL = 140	ND RL = 140
Aroclor 1242	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	5100	ND RL = 180	3000	ND RL = 140	ND RL = 140
Aroclor 1248	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	130	ND RL = 140
Aroclor 1254	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	3800	ND RL = 180	2800	150	ND RL = 140
Aroclor 1260	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	ND RL = 140	ND RL = 140
Aroclor 1262	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	ND RL = 140	ND RL = 140
Aroclor 1268	ug/Kg dry			ND RL = 130	ND RL = 120	ND RL = 170	ND RL = 5200	ND RL = 180	ND RL = 3100	ND RL = 140	ND RL = 140
Total PCB	ug/Kg dry	59.8	676	ND	ND	ND	8900	ND	5800	280	ND
Silver	mg/Kg dry	NA	NA	0.22	1.3	1.2	450	0.87	290	39	0.31
Arsenic	mg/Kg dry	9.79	33	1.0	1.3	2.7	49	2.3	38	8.2	1.6
Barium	mg/Kg dry	NA	NA	22	52	220	130000	310	84000	4100	150
Cadmium	mg/Kg dry	0.99	4.98	ND	ND	0.33	85	0.27	38	3.6	ND
Chromium	mg/Kg dry	43.4	111	9.5	11	15	200	13	130	38	8.7
Copper	mg/Kg dry	31.6	149	140	430	670	120000	370	78000	8600	160
Mercury	mg/Kg dry	0.18	1.06	ND	ND	.09	1.5	ND	1.7	.30	ND
Lead	mg/Kg dry	35.8	128	9.2	110	150	75000	100	44000	2500	19
Selenium	mg/Kg dry	NA	NA	ND	ND	0.27	20	0.27	18	2.6	ND
Zinc	mg/Kg dry	121	459	23	40	80	6800	54	3500	430	38
% Total Solids	%			78.8	80.2	58.3	50.1	55.6	51.8	69.3	69.8

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-03 (21-41)	TL07-03 (41-70)	TL07-04 (0-6)	TL07-04 (6-26)	TL07-04 (36-60)	TL07-04 (60-95)	TL07-05 (0-6)	TL07-05 (6-22)
Aroclor 1016	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Aroclor 1221	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Aroclor 1232	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Aroclor 1242	ug/Kg dry			3200	ND RL = 130	460	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Aroclor 1248	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Aroclor 1254	ug/Kg dry			2900	ND RL = 130	450	180	ND RL = 140	ND RL = 140	290	ND RL = 170
Aroclor 1260	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Aroclor 1262	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	50	ND RL = 240	ND RL = 170
Aroclor 1268	ug/Kg dry			ND RL = 3200	ND RL = 130	ND RL = 470	ND RL = 140	ND RL = 140	ND RL = 140	ND RL = 240	ND RL = 170
Total PCB	ug/Kg dry	59.8	676	6100	ND	910	180	ND	50	290	ND
Silver	mg/Kg dry	NA	NA	380	9.3	80	11	6.1	5.4	3.4	5.6
Arsenic	mg/Kg dry	9.79	33	55	5.6	26	5.7	5.8	4.7	22	18
Barium	mg/Kg dry	NA	NA	99000	620	12000	410	88	71	190	340
Cadmium	mg/Kg dry	0.99	4.98	37	0.59	ND	0.60	ND	ND	1.1	ND
Chromium	mg/Kg dry	43.4	111	120	44	51	45	44	44	200	500
Copper	mg/Kg dry	31.6	149	120000	3500	28000	3900	3400	3000	3300	3400
Mercury	mg/Kg dry	0.18	1.06	2.6	.12	.60	.13	.07	.07	1.2	.11
Lead	mg/Kg dry	35.8	128	42000	300	7800	400	39	23	180	33
Selenium	mg/Kg dry	NA	NA	23	0.31	5.0	0.40	ND	ND	0.42	ND
Zinc	mg/Kg dry	121	459	4100	140	1000	180	110	110	330	260
% Total Solids	%			49.4	74.3	47.2	69.9	72.1	73.7	41.4	58.6

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-06 (0-6)	TL07-06 (6-36)	TL07-06 (36-72)	TL07-07 (0-6)	TL07-07 (6-36)	TL07-07 (36-72)	TL07-08 (0-6)
Aroclor 1016	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Aroclor 1221	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Aroclor 1232	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Aroclor 1242	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Aroclor 1248	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Aroclor 1254	ug/Kg dry			130	ND RL = 190	ND RL = 170	320	ND RL = 200	ND RL = 150	210
Aroclor 1260	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Aroclor 1262	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	110
Aroclor 1268	ug/Kg dry			ND RL = 200	ND RL = 190	ND RL = 170	ND RL = 230	ND RL = 200	ND RL = 150	ND RL = 220
Total PCB	ug/Kg dry	59.8	676	130	ND	ND	320	ND	ND	320
Silver	mg/Kg dry	NA	NA	10	3.9	2.4	6.4	4.3	2.0	5.6
Arsenic	mg/Kg dry	9.79	33	32	15	3.1	40	13	2.7	47
Barium	mg/Kg dry	NA	NA	96	50	87	94	58	71	110
Cadmium	mg/Kg dry	0.99	4.98	2.4	0.25	ND	1.3	0.23	ND	0.93
Chromium	mg/Kg dry	43.4	111	98	64	74	96	92	42	97
Copper	mg/Kg dry	31.6	149	4000	2700	3000	4300	2900	1900	4800
Mercury	mg/Kg dry	0.18	1.06	.39	.46	.33	.21	.43	.13	.19
Lead	mg/Kg dry	35.8	128	160	19	8.7	320	34	7.9	350
Selenium	mg/Kg dry	NA	NA	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/Kg dry	121	459	430	190	220	670	240	120	930
% Total Solids	%			50.2	52.9	58.5	44.2	50.9	67.9	45.9

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-08 (6-36)	TL07-08 (36-72)	TL07-09 (0-6)	TL07-09 (6-36)	TL07-09 (36-72)	TL07-10 (0-6)	TL07-10 (6-36)	TL07-10 (36-72)
Aroclor 1016	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1221	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1232	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1242	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1248	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1254	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1260	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1262	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Aroclor 1268	ug/Kg dry			ND RL = 180	ND RL = 150	ND RL = 240	ND RL = 170	ND RL = 170	ND RL = 180	ND RL = 170	ND RL = 240
Total PCB	ug/Kg dry	59.8	676	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/Kg dry	NA	NA	4.2	2.9	6.6	3.2	2.5	4.7	2.7	2.2
Arsenic	mg/Kg dry	9.79	33	18	4.0	38	12	3.3	23	7.7	4.9
Barium	mg/Kg dry	NA	NA	70	86	83	47	85	80	74	140
Cadmium	mg/Kg dry	0.99	4.98	ND	ND	0.52	ND	ND	0.66	0.34	0.37
Chromium	mg/Kg dry	43.4	111	77	48	79	90	77	85	84	57
Copper	mg/Kg dry	31.6	149	3500	2600	6300	3800	3400	3400	2600	2100
Mercury	mg/Kg dry	0.18	1.06	.35	.20	.29	.39	.31	.44	.32	.28
Lead	mg/Kg dry	35.8	128	55	9.7	160	21	10	100	39	14
Selenium	mg/Kg dry	NA	NA	ND	ND	ND	ND	ND	ND	ND	0.46
Zinc	mg/Kg dry	121	459	270	150	570	200	210	260	220	180
% Total Solids	%			55.9	65.3	41.9	57.9	59.5	55.7	59.0	42.5

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-11 (0-6)	TL07-11 (6-36)	TL07-11 (36-72)	TL07-12 (0-6)	TL07-12 (6-36)	TL07-12 (36-71)	TL07-13 (0-6)	TL07-13 (6-26)
Aroclor 1016	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1221	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1232	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1242	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1248	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1254	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1260	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	510	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1262	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Aroclor 1268	ug/Kg dry			ND RL = 220	ND RL = 200	ND RL = 170	ND RL = 240	ND RL = 170	ND RL = 130	ND RL = 130	ND RL = 130
Total PCB	ug/Kg dry	59.8	676	ND	ND	ND	510	ND	ND	ND	ND
Silver	mg/Kg dry	NA	NA	2.2	6.1	2.4	6.3	3.4	0.17	3.3	4.0
Arsenic	mg/Kg dry	9.79	33	20	16	3.6	93	11	1.3	7.5	8.7
Barium	mg/Kg dry	NA	NA	110	83	180	73	66	26	15	19
Cadmium	mg/Kg dry	0.99	4.98	0.34	0.21	ND	3.6	ND	ND	ND	0.22
Chromium	mg/Kg dry	43.4	111	180	130	180	73	59	8.3	28	27
Copper	mg/Kg dry	31.6	149	2800	1800	2400	7600	4200	90	800	1300
Mercury	mg/Kg dry	0.18	1.06	.14	.22	.30	.19	.29	ND	ND	.09
Lead	mg/Kg dry	35.8	128	85	31	12	280	24	2.2	34	70
Selenium	mg/Kg dry	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/Kg dry	121	459	400	260	180	860	220	17	98	120
% Total Solids	%			46.3	49.9	59.3	41.8	59.6	78.0	76.9	78.3

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-13 (26-40)	TL07-13 (40-66)	TL07-14 (0-6)	TL07-14 (6-35)	TL07-14 (35-49)	TL07-15 (0-6)	TL07-15 (6-36)	TL07-16 (0-6)	TL07-16 (6-25)
Aroclor 1016	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1221	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1232	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1242	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1248	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1254	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1260	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1262	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Aroclor 1268	ug/Kg dry			ND RL = 130	ND RL = 130	ND RL = 220	ND RL = 130	ND RL = 140	ND RL = 290	ND RL = 250	ND RL = 200	ND RL = 150
Total PCB	ug/Kg dry	59.8	676	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/Kg dry	NA	NA	8.1	8.0	2.0	7.3	7.9	0.52	0.58	3.4	9.3
Arsenic	mg/Kg dry	9.79	33	18	3.8	12	3.5	2.7	13	13	16	9.1
Barium	mg/Kg dry	NA	NA	21	17	100	48	38	120	96	65	61
Cadmium	mg/Kg dry	0.99	4.98	0.27	ND	0.46	ND	ND	ND	ND	0.31	ND
Chromium	mg/Kg dry	43.4	111	32	20	25	21	19	15	14	37	27
Copper	mg/Kg dry	31.6	149	2400	7100	3800	8000	9800	810	1000	2100	7100
Mercury	mg/Kg dry	0.18	1.06	.12	.07	ND	ND	ND	ND	ND	.22	.16
Lead	mg/Kg dry	35.8	128	72	10	47	9.9	7.1	23	19	47	26
Selenium	mg/Kg dry	NA	NA	ND	ND	0.45	ND	ND	0.64	0.54	0.37	0.25
Zinc	mg/Kg dry	121	459	120	78	140	100	97	52	62	120	100
% Total Solids	%			74.4	76.6	46.5	78.8	72.0	34.5	40.4	49.4	68.0

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-17 (0-6")	TL07-17 (6-36")	TL07-17 (36-72")	TL07-17 (ponar)	TL07-18	TL07-19	TL07-20	TL07-21	TL07-22
Aroclor 1016	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1221	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1232	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1242	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1248	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1254	ug/Kg dry			160	ND RL = 190	ND RL = 170	1100	ND RL = 290	ND RL = 500	ND RL = 510	340	450
Aroclor 1260	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1262	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Aroclor 1268	ug/Kg dry			ND RL = 250	ND RL = 190	ND RL = 170	ND RL = 450	ND RL = 290	ND RL = 500	ND RL = 510	ND 530	ND RL = 680
Total PCB	ug/Kg dry	59.8	676	160	ND	ND	1100	ND	ND	ND	340	450
Silver	mg/Kg dry	NA	NA	4.3	4.7	1.9	6.8	2.5	4.0	4.7	5.1	6.4
Arsenic	mg/Kg dry	9.79	33	37	18	3.4	150	32	40	39	59	310
Barium	mg/Kg dry	NA	NA	61	53	58	110	82	160	170	150	210
Cadmium	mg/Kg dry	0.99	4.98	0.72	ND	ND	1.9	11	1.0	1.1	1.8	1.8
Chromium	mg/Kg dry	43.4	111	73	69	48	64	77	60	110	89	*57*
Copper	mg/Kg dry	31.6	149	3200	3100	3000	4400	2500	2400	2300	3200	2500
Mercury	mg/Kg dry	0.18	1.06	.17	.38	.23	.57	.23	.45	.50	.48	.60
Lead	mg/Kg dry	35.8	128	170	21	6.8	430	520	190	160	250	550
Selenium	mg/Kg dry	NA	NA	ND	ND	ND	0.78	ND	0.89	0.81	0.76	0.93
Zinc	mg/Kg dry	121	459	460	230	170	340	430	290	260	270	270
% Total Solids	%			40.3	53.5	60.5	22.1	34.7	19.9	19.8	18.7	14.6

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-23	TL07-24	TL07-25	TL07-26	TL07-27	TL07-28	TL07-29	TL07-30	TL07-31	TL07-32
Aroclor 1016	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1221	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 500 K	ND RL = 480 K
Aroclor 1232	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1242	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1248	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1254	ug/Kg dry			620	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1260	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1262	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Aroclor 1268	ug/Kg dry			ND RL 720	ND RL = 650	ND RL = 760	ND RL = 690	ND RL = 760	ND RL = 580	ND RL = 480	ND RL = 460	ND RL = 420	ND RL = 280
Total PCB	ug/Kg dry	59.8	676	620	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/Kg dry	NA	NA	5.2	5.0	4.3	4.5	3.2	4.5	5.7	4.0	3.0	1.1
Arsenic	mg/Kg dry	9.79	33	70	47	42	40	30	31	34	28	17	8.9
Barium	mg/Kg dry	NA	NA	160	140	220	170	95	190	160	150	150	93
Cadmium	mg/Kg dry	0.99	4.98	1.1	1.3	1.0	1.2	0.77	0.89	1.1	0.78	0.62	0.27
Chromium	mg/Kg dry	43.4	111	*52*	*56*	*45*	*46*	41	42	48	37	32	18
Copper	mg/Kg dry	31.6	149	3800	2200	1800	1700	1600	1700	2000	1900	1500	650
Mercury	mg/Kg dry	0.18	1.06	.54	.48	.55	.49	.39	.47	.20	.40	.32	ND
Lead	mg/Kg dry	35.8	128	240	180	120	120	120	90	140	94	66	31
Selenium	mg/Kg dry	NA	NA	0.89	0.96	0.98	0.85	0.94	0.85	0.75	0.30	0.30	0.30
Zinc	mg/Kg dry	121	459	210	240	200	200	150	170	200	160	130	75
% Total Solids	%			13.9	15.4	13.1	14.5	13.1	17.3	21.0	21.8	23.9	35.7

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)

Table 2. Sediment chemistry results for the Torch Lake sampling event, Houghton County, Michigan, August 7, 8, and 9 2007. Concentrations shaded light gray are greater than the TEC and concentrations shaded in dark gray are greater then the PEC.

Parameters	Units	TEC	PEC	TL07-33	TL07-34	TL07-35	TL07-36
Aroclor 1016	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1221	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1232	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1242	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1248	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1254	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1260	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1262	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Aroclor 1268	ug/Kg dry			ND RL = 190	ND RL = 210	ND RL = 340	ND RL = 400
Total PCB	ug/Kg dry	59.8	676	ND	ND	ND	ND
Silver	mg/Kg dry	NA	NA	0.41	1.2	1.7	2.4
Arsenic	mg/Kg dry	9.79	33	4.0	13	14	19
Barium	mg/Kg dry	NA	NA	68	78	100	130
Cadmium	mg/Kg dry	0.99	4.98	ND	0.25	0.39	0.47
Chromium	mg/Kg dry	43.4	111	11	17	23	27
Copper	mg/Kg dry	31.6	149	270	1200	1200	2200
Mercury	mg/Kg dry	0.18	1.06	ND	.11	.20	.31
Lead	mg/Kg dry	35.8	128	16	38	47	71
Selenium	mg/Kg dry	NA	NA	ND	0.23	0.43	0.35
Zinc	mg/Kg dry	121	459	43	68	96	120
% Total Solids	%			51.5	47.6	29.3	25.2

ND = not detected - RL = reporting limit - K = RL raised due to matrix interference - NA = not available
TEC = threshold effect concentration = PEC = probable effect concentration (MacDonald et.al, 2000)