

In cooperation with the Texarkana Water Utilities

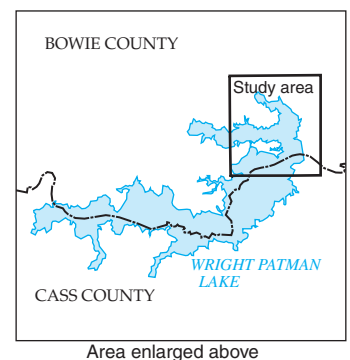
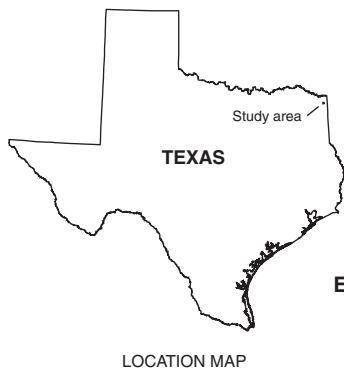
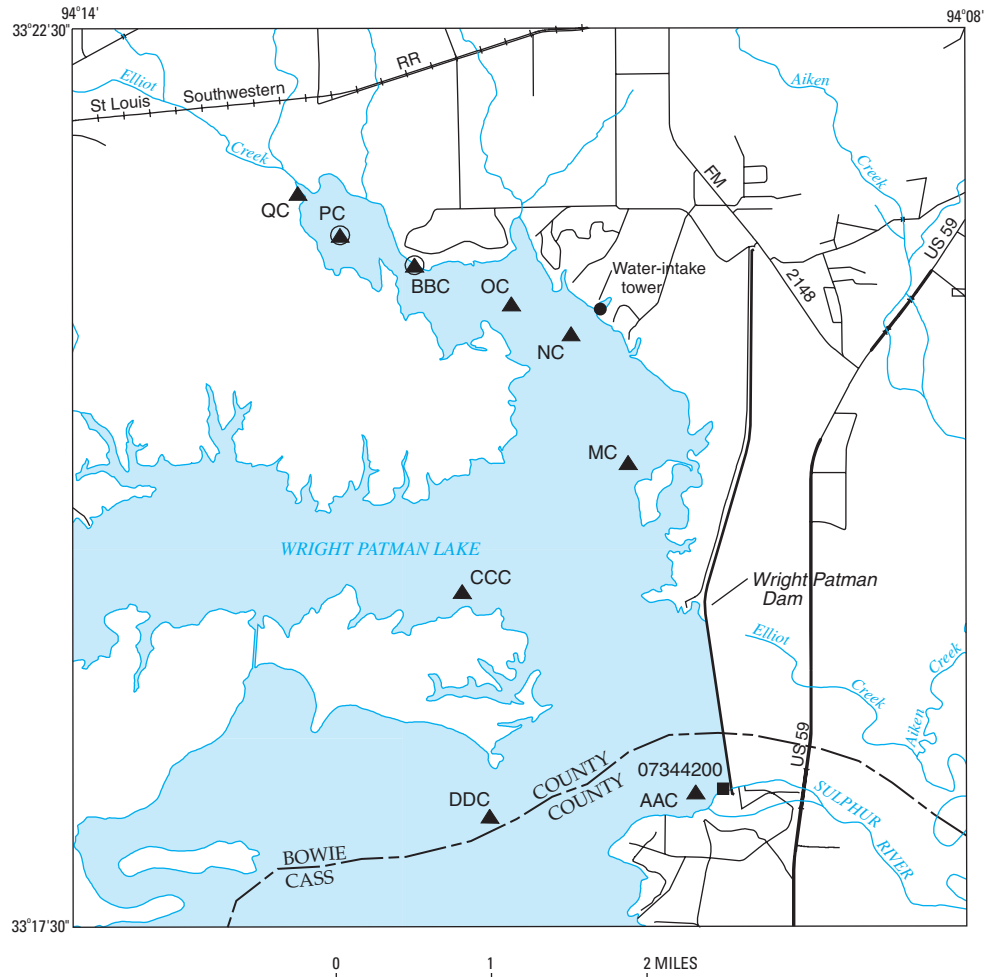
Reconnaissance for Trace Metals in Bed Sediment, Wright Patman Lake, Near Texarkana, Texas

Many contaminants can be introduced into the environment by urban and industrial activities. The drainage area of Wright Patman Lake is influenced by these activities. Among the contaminants associated with urban and industrial activities are trace metals such as arsenic, lead, mercury, and zinc. These contaminants are relatively insoluble in water and commonly are found in stream, lake, and reservoir bottom sediment, especially the clays and silts within the sediment.

Wright Patman Lake serves as the major potable water supply for the city of Texarkana and surrounding communities. Texarkana, located in the northeastern corner of Texas and the southwestern corner of Arkansas, had a population of about 56,000 in 1998, which reflects an increase of about 3.4 percent from the 1990 census (Ramos, 1999).

Texarkana Water Utilities, which manages the water-treatment facilities for Texarkana, proposes to dredge the lake bed near the water intake in the Elliot Creek arm of Wright Patman Lake. It is possible that arsenic, lead, mercury, and other trace metals might be released into the water if the bed sediment is disturbed. Bed sediment in the Elliot Creek arm of the lake, in particular, could contain trace metals because of its proximity to Red River Army Depot and because industrial land use is prevalent in the headwaters of Elliot Creek.

The U.S. Geological Survey (USGS), in cooperation with



EXPLANATION

- AAC ▲ Bed-sediment sampling site and identifier
- Core sampling site
- 07344200 ■ Reservoir station and number

Figure 1. Location of Wright Patman Lake and bed-sediment and core-sampling sites.

Texarkana Water Utilities, conducted a reconnaissance of Wright Patman Lake to collect bed-sediment samples for analysis of trace metals. This report presents trace metal concentrations in bed-sediment samples collected at six sites along the Elliot Creek arm of the lake, one site each in two adjacent arms, and one site near the dam on June 16, 1999 (fig. 1). One bed-sediment sample was collected at each of the nine sites, and one sediment core was collected at each of two of the sites. Trace metal concentrations are compared to sediment-quality guidelines for the protection of aquatic life and to screening levels based on historical trace metal concentrations in bed sediment of Texas reservoirs.

Setting

Wright Patman Lake, previously known as Lake Texarkana, is located in the lower Sulphur River Basin on the Bowie-Cass County line 10 miles southwest of Texarkana. Average annual rainfall for Bowie County is about 45 inches. The lake was built in the 1950s by the U.S. Army Corps of Engineers (Corps) for flood control, water conservation, and industrial, municipal, and recreational use. The conservation-pool elevation is 220 feet above sea level with a storage capacity of 110,900 acre-feet as surveyed in 1997 (Texas Water Development Board, 2000), which is a 23.7-percent reduction (caused by sedimentation) from 145,300 acre-feet in 1956. The conservation-pool surface area is 20,300 acres; the drainage area is 3,443 square miles. The USGS, in cooperation with the Corps, maintains a continuous water-stage recorder (reservoir station 07344200) (fig. 2) to collect data pertinent to operation of flood-control gates and water-storage inventory.

Red River Army Depot, which opened in 1941, is one of the Nation's largest defense depots. The depot maintains military combat vehicles and serves as an ammunition storage center. The depot is about 18 miles west of Texarkana and consists of 19,081 acres of rolling hills and pine forests in the headwaters of Elliot Creek, which drains into the northeastern part of Wright Patman Lake (Red River Army Depot, 2000).

Sample Collection and Analysis

Six bed-sediment sampling sites (MC, NC, OC, BBC, PC, QC) selected in the Elliot Creek arm bracket the water-intake structure and extend to the upstream end of the arm (fig. 1). The water-intake structure supplies raw water for treatment. Three sampling sites used for comparison of trace metal data were selected in the mouth of each of the two adjacent arms of the lake (CCC, DDC) and near reservoir station 07344200 at the flood-control intake of the dam (AAC) (fig. 1). Site locations were adjusted at the time of sampling to the deepest point of each lake arm, which was assumed to be the pre-reservoir stream channel (thalweg).

Bed-sediment samples were collected using a 25-pound stainless steel Ponar sampler (6- by 6-inch mouth, 6-inch penetration) (fig. 3). The sampler was deployed with a rope and allowed to free-fall from the boat to the lake bottom. Upon impact, the sampler automatically closed to capture the bottom sediment. The retrieved sample was removed from the sampler, mixed, and submitted for laboratory analysis.



Figure 2. USGS reservoir station 07344200 at intake structure of Wright Patman Dam (photograph by author).

Sediment cores were collected at sites BBC and PC in water less than 10 feet deep using modified PVC schedule 40 pipe (10 feet long, 1.5-inch diameter). The pipe was driven through the bottom sediment to depths of about 24 and 18 inches at sites BBC and PC, respectively. These depths were assumed to penetrate pre-reservoir soils, but no positive identification of pre-reservoir soils was made at time of coring. The cores were extracted, mixed, and submitted for laboratory analysis.

A four-parameter water-quality monitor measured field properties (pH, temperature, specific conductance, and dissolved oxygen) at each site at 10-foot intervals (depth permitting) from water surface to lake bottom. The lake pool elevation on June 16, 1999, was 7.0 feet above the conservation-pool elevation.

Laboratory analyses were done by the USGS National Water Quality Laboratory in Lakewood, Colo. Inductively coupled plasma-mass spectrometry (ICP-MS) was used to analyze all trace metals except mercury, which was analyzed using continuous-flow cold vapor-atomic absorption spectrometry (CV-AAS) (Briggs and Meier, 1999; O'Leary and others, 1996). Trace metal analyses for the nine bed-sediment samples and the



Figure 3. Ponar sampler used to collect sediment from Wright Patman Lake (photograph by J.D. Benton, U.S. Geological Survey).

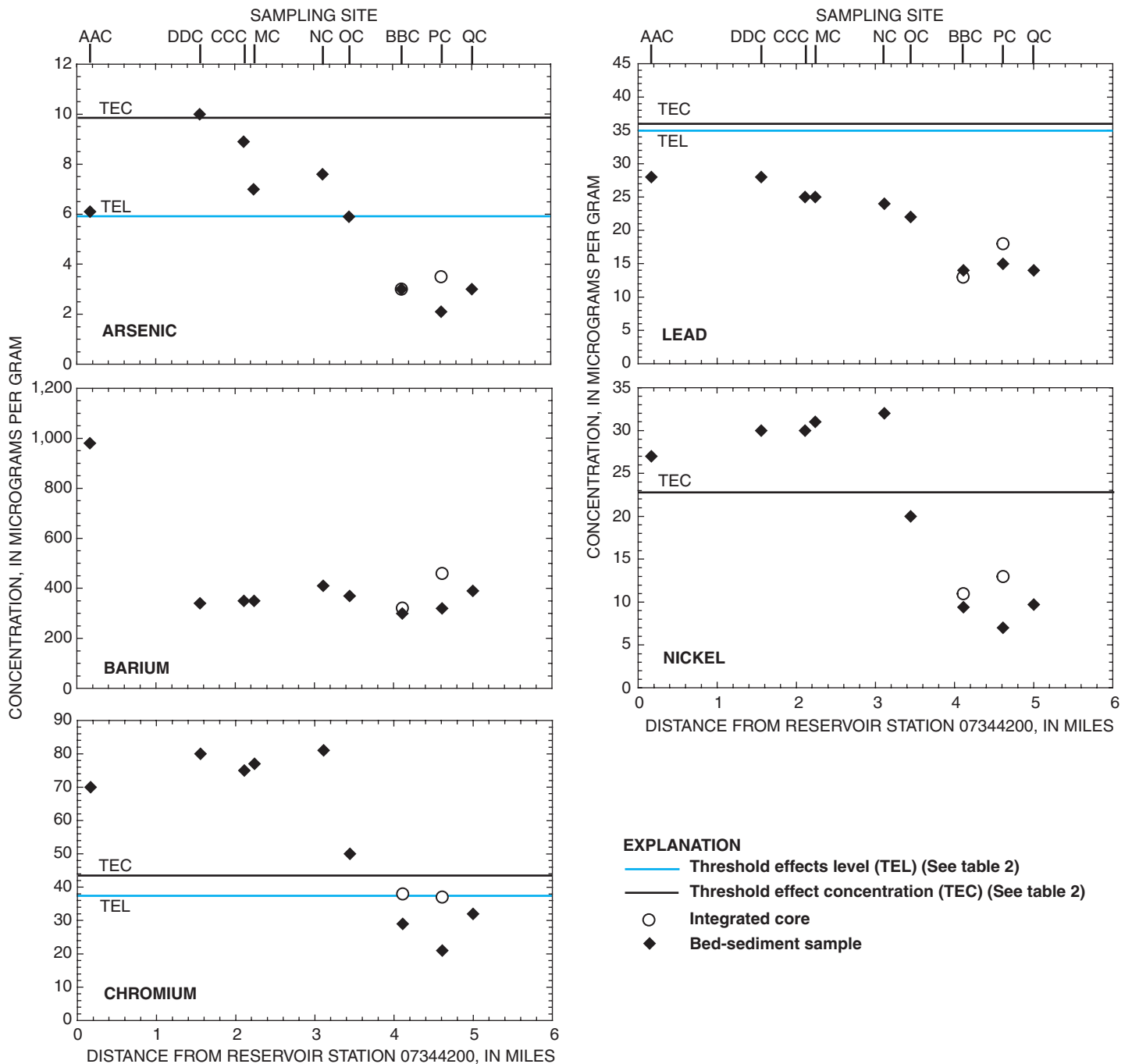


Figure 4. Concentrations of selected trace metals in bed-sediment and composite-core samples relative to distance from station 07344200 near the dam.

two composite sediment cores and the laboratory minimum reporting level for each trace metal are listed in table 1.

Trace Metal Concentrations

Concentrations of arsenic, barium, chromium, lead, and nickel at the nine sampling sites relative to distance from station 07344200 near the dam are shown in figure 4; concentrations of core samples shown represent the entire length of core. Concentrations of arsenic, chromium, lead, and nickel from the sediment samples generally increase with increasing distance

down the Elliot Creek arm of the lake. The apparent increase in concentration of those trace elements down the Elliot Creek arm of the lake probably is caused by a trend toward fine-grained material (silt and clay). High correlations (about 0.90) between metals concentrations and percent fine-grained material in lake bottom sediment is common (P.C. Van Metre, U.S. Geological Survey, written commun., 2000).

Comparison to Sediment-Quality Guidelines

Sediment-quality guidelines (table 2) are not enforceable standards but do provide a basis for deciding whether additional

Table 1. Trace metal concentrations in bed-sediment and composite-core samples from Wright Patman Lake near Texarkana

[All capitals indicates sediment-quality guidelines available (table 2); asterisk indicates screening level available (table 2); single underline indicates concentration greater than Environment Canada threshold effects level (TEL) only; double underline indicates concentration greater than consensus-based threshold effect concentration (TEC) only; bold italic indicates concentration greater than both TEL and TEC; overline indicates concentration greater than screening level; MRL, minimum reporting level; mg/kg, milligrams per kilogram; <, less than]

Trace metal	Units	MRL	AAC	BBC	BBC (core)	CCC	DDC	MC	NC	OC	PC	PC (core)	QC
Aluminum	percent	0.005	6.4	2.7	3.1	7.8	8.6	7.2	7.6	5.1	2.2	3.4	2.4
Antimony	mg/kg	.1	.85	.41	.45	.78	.76	.86	.76	.74	.37	.6	.52
ARSENIC*	mg/kg	.1	<u>6.1</u>	3	3	<u>8.9</u>	<i>10</i>	<u>7</u>	<u>7.6</u>	5.9	2.1	3.5	3
Barium*	mg/kg	1	<u>980</u>	<u>300</u>	<u>320</u>	<u>350</u>	<u>340</u>	<u>350</u>	<u>410</u>	<u>370</u>	<u>320</u>	<u>460</u>	<u>390</u>
Beryllium	mg/kg	.1	2.2	.97	1.8	2.5	2.9	2.1	2	1.9	.72	1.6	.92
Bismuth	mg/kg	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
CADMIUM*	mg/kg	.1	.43	.38	.1	.17	.25	.28	.11	.46	.48	.17	.32
Calcium	percent	.005	.46	.13	.12	.58	.66	.62	.71	.36	.12	.16	.092
Celuminum	mg/kg	1	84	51	63	74	77	77	81	60	40	80	51
CHROMIUM*	mg/kg	1	<u>70</u>	29	<u>38</u>	<u>75</u>	<u>80</u>	<u>77</u>	<u>81</u>	<u>50</u>	21	37	32
Cobalt	mg/kg	1	13	8.4	10	13	13	13	12	12	6.1	11	7.6
COPPER*	mg/kg	1	<u>37</u>	16	8.8	<u>29</u>	24	<u>34</u>	<u>27</u>	<u>28</u>	14	11	18
Europium	mg/kg	1	1.2	<1	<1	1.2	1.3	1.2	1.3	<1	1	1.1	1
Gallium	mg/kg	1	16	5.9	7.2	19	20	18	20	11	4.3	7.5	5.9
Gold	mg/kg	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Holmium	mg/kg	1	<1	<1	<1	1.1	<1	<1	1.1	<1	<1	<1	<1
Iron	percent	.005	3.6	.9	1.1	4.8	4.9	4.2	4.7	2	.72	1.2	.95
Lanthanum	mg/kg	1	44	25	30	39	41	41	44	31	20	40	27
LEAD*	mg/kg	1	28	14	13	25	28	25	24	22	15	18	14
Lithium	mg/kg	1	43	22	25	51	60	46	51	34	13	23	17
Magnesium	percent	.005	.3	.093	.12	.43	.59	.4	.5	.22	.075	.13	.087
Manganese*	mg/kg	4	720	320	860	1,300	<u>1,600</u>	700	1,200	430	210	960	280
MERCURY*	mg/kg	.02	<u>.2</u>	.13	.06	.1	.09	.13	.09	.16	.05	.12	.07
Molybdenum	mg/kg	.5	.87	<.5	<.5	.89	.88	1.1	.93	.63	<.5	<.5	<.5
Neodymium	mg/kg	1	34	24	28	33	34	36	41	24	16	32	21
NICKEL ¹ *	mg/kg	2	<u>27</u>	9.4	11	<u>30</u>	<u>30</u>	<u>31</u>	<u>32</u>	20	7	13	9.7
Niobium	mg/kg	4	22	8.7	10	23	26	26	26	15	7.7	12	11
Phosphorus	percent	.005	.062	.023	.024	.15	.15	.078	.11	.043	.025	.026	.029
Potassium	percent	.005	.88	.66	.83	.89	.97	.87	.97	.94	.75	.99	.67
Scandium	mg/kg	2	8.7	3.4	4.2	10	11	10	11	6.6	2.9	4.5	2.7
Silver*	mg/kg	.1	1.2	.45	.65	1.1	1.3	1.4	1.2	.99	.68	.47	.58
Sodium	percent	.005	.13	.16	.21	.11	.1	.11	.1	.2	.18	.32	.18
Strontium	mg/kg	2	88	41	47	110	130	110	130	78	41	69	48
Tantalum	mg/kg	1	1.7	<1	<1	1.9	2.2	2	2.3	1.4	<1	<1	<1
Thallium	mg/kg	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Thorium	mg/kg	1	12	5.9	6.3	13	14	13	16	9.6	4.7	9.3	6.5
Tin	mg/kg	1	2.6	<1	1.1	3.4	3.5	3	3.1	2.1	<1	1.4	1.1
Titanium	percent	.005	.38	.25	.29	.38	.42	.42	.41	.34	.22	.3	.22
Uranium	mg/kg	.1	3.6	1.6	1.7	3.5	3.3	3.7	3.7	2.6	1.4	2.5	1.9
Vanadium	mg/kg	2	110	47	56	130	140	130	130	75	35	59	50
Ytterbium	mg/kg	1	2.5	1.5	1.8	2.8	2.8	2.7	2.8	1.9	<1	2	1.4
Yttrium	mg/kg	1	24	11	17	26	25	27	27	18	9.6	19	12
ZINC*	mg/kg	2	110	44	36	100	110	110	110	77	35	43	50

¹No Environment Canada guidelines available.

Table 2. Sediment-quality guidelines and screening levels for lakes and reservoirs

[All concentrations are in milligrams per liter, dry weight; TEL, threshold effects level; PEL, probable effects level; TEC, threshold effect concentration; PEC, probable effect concentration; TNRCC, Texas Natural Resource Conservation Commission; NG, no guideline]

Trace metal	Environment Canada sediment-quality guidelines ¹		Consensus-based sediment-quality guidelines ²		TNRCC 85th-percentile screening level ³
	TEL	PEL	TEC	PEC	
Arsenic	5.9	17.0	9.79	33.0	37.3
Barium	NG	NG	NG	NG	297
Cadmium	.6	3.5	.99	4.98	2.00
Chromium	37.3	90.0	43.4	111	40.0
Copper	35.7	197	31.6	149	24.4
Lead	35.0	91.3	35.8	128	58.7
Manganese	NG	NG	NG	NG	1,400
Mercury	.17	.486	.18	1.06	.198
Nickel	NG	NG	22.7	48.6	29.9
Silver	NG	NG	NG	NG	1.6
Zinc	123	315	121	459	156

¹ Canadian Council of Ministers of the Environment, 1999.

² MacDonald and others, 2000.

³ Texas Natural Resource Conservation Commission, 2000, table 4–15.

monitoring might be desirable. The Environment Canada (EC) sediment-quality guidelines are based on numerous studies relating concentrations to measured biological effects on aquatic organisms. The EC threshold effects level (TEL) represents the concentration below which adverse effects are “rarely” expected to occur, and the EC probable effects level (PEL) represents the concentration above which adverse effects are probable or “frequently” expected to occur (Canadian Council of Ministers of the Environment, 1999).

The consensus-based guidelines (MacDonald and others, 2000) were developed from published sediment-quality guidelines that have been derived from a variety of approaches. These synthesized guidelines consist of a threshold effect concentration (TEC) below which adverse effects are not expected to occur and a probable effect concentration (PEC) above which adverse effects are expected to occur more often than not. An apparent advantage of the consensus-based guidelines is that MacDonald and others (2000) evaluated the reliability of the TECs and PECs for assessing sediment-quality conditions by determining their predictive ability—that is, the ability of the guidelines to correctly classify field-collected sediments as nontoxic or toxic to one or more aquatic organisms.

Comparison of trace metal concentrations in bed-sediment samples (table 1) with EC TELs (table 2) shows that, of the seven trace metals with TELs, four exceeded the respective TELs at at

least one of the nine sampled sites. Concentrations of chromium exceeded the TEL at seven sites (AAC, BBC [core], CCC, DDC, MC, NC, OC); concentrations of arsenic exceeded the TEL at five sites (AAC, CCC, DDC, MC, NC); and concentrations of copper and mercury exceeded the respective TELs at one site (AAC).

Comparison of trace metal concentrations in bed-sediment samples with consensus-based TECs (table 2) shows similar results, because TELs and TECs (except for arsenic) do not differ appreciably. Of the eight trace metals with TECs (same as those with TELs, plus nickel), concentrations of the same trace metals that exceeded the TELs—arsenic, chromium, copper, and mercury—plus nickel exceeded the respective TECs at at least one of the nine sampled sites. Concentrations of chromium exceeded the TEC at six of the seven sites at which the TELs were exceeded; concentrations of nickel exceeded the TEC at five of the same sites as chromium; concentrations of copper exceeded the TEC at two sites (AAC, MC); and concentrations of arsenic and mercury exceeded the respective TECs at one site each (DDC and AAC).

Sediment samples at the three sites farthest up the Elliot Creek arm of the lake (BBC, PC, QC) had no trace metals with concentrations that exceeded the TELs or the TECs. At site NC, the site nearest the proposed dredging area adjacent to the water-intake structure, chromium concentrations were greater than both the TEL and the TEC; arsenic concentrations were greater than the TEL; and nickel concentrations were greater than the TEC.

Exceedance of EC TELs for metals in urban lake sediment is common (P.C. Van Metre, U.S. Geological Survey, written commun., 2000). Trace metal concentrations in Wright Patman Lake sediment generally are comparable to those in sediment of some other lakes influenced by urban land use sampled by the USGS (for example, Van Metre and Callender, 1996; 1997). No concentration of the seven trace metals that have PELs and eight trace metals that have PECs exceeded the respective PEL or PEC at any site.

Comparison to Screening Levels

Unlike sediment-quality guidelines, Texas Natural Resource Conservation Commission (TNRCC) screening levels (table 2) are not effects-based; they represent the 85th-percentile concentrations of contaminants in historical reservoir samples collected in Texas during the 10-year period September 1988–August 1998 (Texas Natural Resource Conservation Commission, 2000). Barium concentrations at all sampled sites exceeded the screening level. Chromium exceeded the respective screening levels at six sites (AAC, CCC, DDC, MC, NC, OC); copper exceeded the screening level at five sites (AAC, CCC, MC, NC, OC); nickel exceeded the screening level at four sites (CCC, DDC, MC, NC); and manganese and mercury at one site each (DDC and AAC).

References

Briggs, P.H., and Meier, A.L., 1999, The determination of 42 elements in geological materials by inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 99–166, 15 p.

- Canadian Council of Ministers of the Environment, 1999, Canadian sediment quality guidelines for the protection of aquatic life—Summary tables, *in* Canadian environmental quality guidelines: Winnipeg, Environment Canada, 5 p.
- MacDonald, D.D., Ingersoll, C.G., and Berger, T.A., 2000, Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems: Archives of Environmental Contamination and Toxicology, v. 39, p. 20–31.
- O’Leary, R.M., Hageman, P.L., and Crock, J.G., 1996, Mercury in water, geologic, and plant materials by continuous flow-cold vapor-atomic absorption spectrometry, *in* Arboagst, B.F., ed., Analytical methods manual for the Mineral Resources Program: U.S. Geological Survey Open-File Report 96–525, p. 42–50.
- Ramos, M.G., ed., 1999, 2000–2001 Texas almanac: Dallas, The Dallas Morning News, Inc., 672 p.
- Red River Army Depot, 2000, Red River today: Accessed March 15, 2000, at URL <http://www.redriver.army.mil/pg2.htm>
- Texas Natural Resource Conservation Commission, 2000, Guidance for screening and assessing Texas surface and finished drinking water quality data, 2000: Accessed August 31, 2000 at URL <http://www.tnrcc.state.tx.us/water/quality/data/wqm/index.html>
- Texas Water Development Board, 2000, Reservoir surveys: Accessed March 15, 2000, at URL http://www.twdb.state.tx.us/hydro_survey/
- Van Metre, P.C., and Callender, Edward, 1996, Identifying water-quality trends in the Trinity River, Texas, USA, 1969–1992, using sediment cores from Lake Livingston: Environmental Geology, v. 28, no. 4, p. 190–200.
- _____, 1997, Water-quality trends in White Rock Creek Basin from 1912–1994 identified using sediment cores from White Rock Lake reservoir, Dallas, Texas: Journal of Paleolimnology, v. 17, p. 239–249.
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