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Risk Management Decision Memorandum Lake Monitoring Operable Unit

Crab Orchard National Wildlife Refuge Superfund Site Marion, Illinois

Prepared for

U.S. Fish & Wildlife Service
Crab Orchard National Wildlife Refuge
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FINAL RISK MANAGEMENT DECISION MEMORANDUM

A Preliminary Screening Analysis Report (PSAR) was completed for the Lake Monitoring Operable Unit (LMOU) at the Crab Orchard National Wildlife Refuge (the Refuge) in April 2001 (URS 2001). The purpose of the investigation was to gather sufficient information to determine if releases to Crab Orchard Lake (Lake) pose a potential threat to human health or the environment and to determine if a Remedial Investigation (RI) is warranted. Surface water and sediment samples were collected at a number of locations throughout the Lake. Analyses consisted of the CERCLA target compound list of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, and the target analyte list of inorganic compounds. Several explosives and other inorganics were also analyzed. Selected analyses were also conducted in biological tissues. By comparing the maximum concentrations of chemicals in surface waters, sediments, and biological tissues to conservative toxicity reference values (TRVs), the PSAR identified a number of chemicals of potential ecological concern (COPECs) and chemicals of potential concern (COPCs - human health).

The US Fish and Wildlife Service (the Service) believes several chemicals warrant further evaluation, including PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs), and cadmium. These will be evaluated as part of other existing operable unit (OU) investigations at the Refuge. Though some chemicals were initially identified as COPECs or COPCs, the Service believes, based on multiple lines of evidence, that further evaluation is not necessary. This document will present the rationale for decision-making supporting no further investigation of these chemicals.

From an ecological risk perspective, this document represents the Scientific Management Decision Point (SMDP) (USEPA 1997). Though the SMDP terminology has not typically been applied to the human health risk evaluation process, the approach and rationale is equally applicable in that the purpose of the screening results discussion is to aid risk managers in the decision-making process.

ECOLOGICAL RISK SCREENING EVALUATION

In the ecological risk evaluation process, a series of assessment and measurement endpoints were selected to aid in evaluation of ecological receptors associated with the LMOU (URS 2001). Each of these endpoints and associated chemicals identified as COPECs are discussed below.

Survival, Growth, and Reproduction of Plankton

Survival, growth, and reproduction of plankton were evaluated by comparing analytical data in surface water to TRVs for surface water (Table 4-2, URS 2001). Bis(2-ethylhexyl)phthalate, aluminum, and iron exceeded their respective screening concentrations for direct exposures in surface water.

Bis(2-ethylhexyl)phthalate: Bis(2-ethylhexyl)phthalate was detected, and the screening concentration was exceeded in 3 of 25 sample locations in Crab Orchard Lake (Figures 3-1 and 4-1, URS 2001). Each of the reported concentrations was J-qualified[1] (Figures 3-1 and 4-1, URS

[1] "J" is a qualifier used to indicate that the reported concentration is only an estimate.

2001) at concentrations ranging from 1.0 (J) to 1.2 (J) micrograms per Liter (ug/L). Bis(2-ethylhexyl)phthalate was also detected in multiple rinsate and method blank samples, indicating field and/or laboratory contamination. In the reference area, bis(2-ethylhexyl)phthalate was detected in 3 of 7 surface water samples ranging from 1.5(J) to 18(J) ug/L (Figure 3-80, URS 2001). Because it was commonly detected in rinsate and method blanks, all detections were J-qualified, and it was detected more frequently and at higher concentrations in the reference area than in Crab Orchard Lake, it is recommended that bis(2-ethylhexyl)phthalate not be investigated further in surface water.

Aluminum. The screening concentration for aluminum is 87 ug/L, which was exceeded in all samples (Figures 3-2 and 4-2, URS 2001). Aluminum was not detected in Little Grassy Lake at a reporting limit of 200 ug/L, but was found throughout Crab Orchard Lake, ranging as high as 2,540 ug/L (Cell D (Sangamo Bay)). Cell locations are shown in Figure 2-3 (URS 2001). There is no Illinois water quality standard for aluminum. The screening concentration is based on the national recommended water quality criterion (USEPA 1999).

Iron. Iron was detected at each of 25 water sample locations, ranging as high as 2,850 ug/L (Figure 3-2, URS 2001). Ten samples exceeded the screening concentration of 1,000 ug/L and were all located in the eastern portion of Crab Orchard Lake (Figures 3-2 and 4-3, URS 2001). These did not appear to be associated with specific source inputs. Iron was not detected in Little Grassy Lake at a reporting limit of 100 ug/L. Thus, it appears that iron concentrations are elevated in Crab Orchard Lake with respect to the reference area. The Illinois water quality standard for iron is 1,000 ug/L (dissolved). Total iron was measured as part of the screening analysis, and the portion in the dissolved phase is unknown.

Sources of iron and aluminum: There is a high correlation between the concentrations of iron and aluminum (r^2 = 0.9) collected in samples throughout the Lake, suggesting iron and aluminum are closely associated and are from a common source. Both iron and aluminum are generally present in conjunction with filterable particulates, except in low pH waters, and are unlikely present in a dissolved form in Crab Orchard Lake. As noted previously, iron and aluminum were not detected in Little Grassy Lake, and the total suspended solids (TSS) in Little Grassy Lake were much lower than measured in Crab Orchard Lake. Also, the watershed of Little Grassy Lake is geologically different from Crab Orchard Lake, which may account for naturally occurring differences in surface water chemistry.

There are a number of possible sources of the elevated iron and aluminum in Crab Orchard Lake. Widespread past coal mining in the Lake watershed may be responsible for the elevated concentrations (Muir *et al.* 1997). Elevated iron concentrations are commonly associated with drainage from surface coal mines (Kleinmann, ed. 2001). The Little Grassy Lake watershed is not a coal mining area, and iron and aluminum were not detected in the surface water.

The highest concentrations of both chemicals were observed in Sangamo Bay (Cell D). These may be associated with clay capping material used in site remediation for the PCB OU, which is adjacent to Sangamo Bay. Clay fines suspended in surface water runoff or from bottom sediments may contribute to the elevated levels in this area.

Groundwater data collected from the Crab Orchard Lake area also indicate highly elevated concentrations of iron and aluminum. More than 30 groundwater samples have been collected from wells at the Metals OU landfill, located just south of Area 7 and Site 15 on the south side of the Lake near its east end (Figure 1-3, URS 2001). None of these wells have shown any indication of contamination, either from before the landfill was installed or afterward. In the samples collected to date, the average aluminum concentration is approximately 65,000 ug/L, with a high concentration of 170,000 ug/L. The average iron concentration is over 100,000 ug/L, with a maximum concentration of 365,000 ug/L. For comparison, the State of Illinois Class I groundwater standard for iron is 5,000 ug/L. There is no standard for aluminum, but for comparison, a recommended maximum concentration for continuous-use irrigation water is 5,000 ug/L (National Academy of Engineering 1972).

Though iron and aluminum exceeded Illinois water quality standards and/or national recommended water quality criteria, they are widespread in Crab Orchard Lake and appear to be naturally occurring, and/or possibly associated with historical mining activities. These constituents may play a role in defining the biological assemblages present in the Lake as a function of natural watershed geological characteristics. However, because they do not appear to be associated with uncontrolled industrial releases, it is recommended that iron and aluminum not be investigated further.

Survival, Growth, and Reproduction of Aquatic Macrophytes

There are insufficient data with which to develop screening concentrations for evaluation of aquatic macrophytes. Therefore, this assessment endpoint was not assessed directly, but is acknowledged as an uncertainty. For decision-making purposes, it is assumed that screening chemicals relative to other assessment endpoints will be sufficiently protective of aquatic macrophytes as well.

Survival, Growth, and Reproduction of Benthic Macroinvertebrates

Survival, growth, and reproduction of benthic macroinvertebrates were evaluated by comparing analytical data in sediment to TRVs for sediment (Table 4-3, URS 2001). Chemicals that exceeded the screening concentrations are discussed below.

Bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate exceeded sediment TRVs at 35 of 46 locations throughout the Lake (Figures 3-3 and 4-4, URS 2001). All but three of the measured bis(2-ethylhexyl)phthalate values were "J" qualified. In general, concentrations were in the range of 100 to 200 micrograms per kilogram (ug/kg) where detected. However, there were a few notably higher concentrations detected. Specifically, concentrations ranged from 1,800 ug/kg to 3,100 ug/kg in three locations: two in the western portion of the Lake, and one in Cell C (Figure 4-4, URS 2001). Cell C is located in the east-central portion of the Lake between the Wolf Creek Road and Highway 148 Causeways (Figure 2-3, URS 2001). In comparison, bis(2-ethylhexyl)phthalate was detected in reference area sediments in each of 10 sediment samples (all J qualified) with a maximum concentration of 1,100 (J) ug/kg (Figure 3-81 (URS 2001).

Mean concentrations[2] were similar in Crab Orchard Lake (359 ug/kg, 95% upper confidence limit (UCL)–520 ug/kg) as compared to the reference area (364 ug/kg, 95% UCL - 566 ug/kg). However, the detection in Cell C is particularly relevant since this is in a drainage area for the Additional and Uncharacterized Sites Operable Unit (AUS OU) Areas 11 and 12, where elevated concentrations in soils were detected (maximum 57,000 ug/kg) in Area 11P and 9,100 ug/kg in Area 12.

Bis(2-ethylhexyl)phthalate was also detected in all 8 rinsate samples taken as part of the sediment sampling program, ranging from 7.8 ug/L to 740 ug/L. Bis(2-ethylhexyl)phthalate was also detected in various method blank samples associated with samples collected as part of the Crab Orchard Lake investigation. As noted previously, bis(2-ethylhexyl)phthalate is a common laboratory contaminant. Even though the detections of bis(2-ethylhexyl)phthalate in three samples were not qualified due to blank contamination, they are likely to be a result of field and/or laboratory contamination.

In summary, the following observations are made with respect to bis(2-ethylhexyl)phthalate:

- It is a commonly observed laboratory contaminant and was detected in all rinsate samples and multiple method blank samples.
- Sediment concentrations are similar in Crab Orchard Lake and the reference area.
- There is a potential source area in AUS OU Areas 11 and 12 that could potentially have contributed to the elevated sediment concentration observed in Cell C.

Given that bis(2-ethylhexyl)phthalate is a common lab artifact and that sediment concentrations are similar in Crab Orchard Lake and the reference area, no further evaluation of bis(2-ethylhexyl)phthalate is recommended in Crab Orchard Lake. This does not preclude bis(2-ethylhexyl)phthalate being evaluated as part of other OUs, such as Areas 11 and 12 of the AUS OU.

Butylbenzylphthalate: Butylbenzylphthalate was detected at only 1 of 46 sediment sample locations (560 ug/kg) in the Lake and was J qualified (Table 4-10 and Figure 4-10, URS 2001). Based on its low frequency of detection, and that it was a J qualified value, it is recommended that butylbenzylphthalate not be investigated further in sediments.

PAHs. Five PAHs exceeded direct exposure screening concentrations (Table 4-3, URS 2001) in a sediment sample collected in northwestern portion of the Lake: 2-methylnaphthalene (72 ug/kg, Figure 4-5), benzo(a)anthracene (110 ug/kg, Figure 4-6), benzo(b)fluoranthene (170 ug/kg, Figure 4-8), benzo(k)fluoranthene (66 ug/kg, Figure 4-9), and pyrene (210 ug/kg, Figure 4-15, URS 2001). Each of these constituents was J-qualified. Potential sources for these chemicals are boating activities at a nearby marina, or runoff from nearby Carterville. It is recommended that further evaluation of PAHs be conducted in the vicinity of the bay near

[2] Calculations presented in Attachment 2

Carterville (Cell A). This investigation will be conducted in conjunction with ongoing evaluations of the AUS OU.

PCBs. Total PCBs based on the sum of congener analyses (maximum 1.28 milligrams per kilogram (mg/kg) – Table 4-3, URS 2001) exceeded the screening concentration (0.06 mg/kg) at three locations in sediments in Cell D (Sangamo Bay) (Figures 3-3 and 4-18, URS 2001). It is recommended that further evaluation of PCBs be conducted. Whether benthic macroinvertebrates are included as part of this additional evaluation should be considered in developing the evaluation program.

Among the inorganics, arsenic, cadmium, manganese, mercury, nickel, and zinc exceeded direct exposure screening concentrations (the threshold effect level [TEL[3]]) in sediments.

Arsenic. Arsenic exceeded its screening concentration in only two of 46 sample locations (Figure 4-20, URS 2001). The screening quotient for the maximum concentration was 1.06 (Table 4-3, URS 2001). Based on the low frequency of exceedance and screening quotient essentially at unity, it is recommended that arsenic not be investigated further.

Cadmium. Cadmium exceeded the TEL in 11 of 46 samples (Figure 4-21, URS 2001). The probable effects level (PEL[4]) for cadmium is 3.2 mg/kg, and the No Effect Concentration (NEC)[5] is 8.0 mg/kg. The PEL was exceeded in 3 samples. The NEC was not exceeded in any samples. Two of the samples that exceeded the PEL were located in the bay near Pigeon Creek (Cell C) (3.6 mg/kg and 4.0 mg/kg). The source of this cadmium is most likely a combination of Sites 22 of the Metals Areas OU and Site 36 of the Miscellaneous Areas OU (MISCA OU). Cadmium was a major COPC at Site 22, the Old Refuge Shop Channel (Figure 1-3, URS 2001), which has been remediated. Cadmium is a primary COPEC at Site 36, the Refuge wastewater treatment plant. Based on cadmium concentrations in sediments, further evaluation of cadmium is warranted in conjunction with Site 36.

The third cadmium sample that exceeded the PEL was located near Site AUS-0069 (6.6 mg/kg). This site is currently being evaluated as part of the AUS OU. Cadmium has been identified as a potential COPEC in the soil and sediment at AUS-0069. Further evaluation of cadmium is also warranted in conjunction with this unit. This will be conducted as part of the ongoing investigation of AUS-0069.

Cadmium is not believed to be a concern in other areas. Though cadmium in Crab Orchard Lake appears to be higher than in Little Grassy Lake, the reported background concentration for cadmium in sediments in Illinois is 5 mg/kg (IEPA 1986). None of the remaining samples

[3] The TEL is the geometric mean of the 15th percentile in the effects data set and the 50th percentile in the no-effects data set, as reported in Ingersoll et al. (1996). The TEL is a level at which effects are rarely observed.
[4] The PEL is the geometric mean of the 50th percentile in the effects data set and the 85th percentile in the no-effects data set as reported in Ingersoll et al. (1996). The PEL is a level above which effects are frequently observed.
[5] The NEC is the maximum concentration in the effects data set above which effects statistically significant effects are always observed, as reported in Ingersoll et al. (1996). The NEC is a level above which effects are likely to be observed.

exceed the PEL. The mean cadmium concentration[6] in the remaining samples was 0.71 mg/kg (95% UCL – 0.94 mg/kg). This is still above the TEL, but well below the PEL and reported background concentrations for sediments in Illinois.

Manganese. Manganese exceeded the sediment screening concentration (TEL – 630 ug/kg) and the reference area upper tolerance limit (UTL) concentration (1,042 mg/kg) (Table 4-1, URS 2001) in 19 of 46 samples (Figure 4-23, URS 2001). The following additional lines of evidence are presented to the Risk Managers for decision-making with respect to manganese:

- The PEL (1,200 ug/kg) was exceeded in 13 samples. The NEC (4,500 ug/kg) was not exceeded in any sediment samples (maximum concentration observed was 2,630 ug/kg).
- The reported Illinois background concentration for manganese is 1,700 ug/kg (IEPA 1996). This was exceeded at four locations.
- The mean manganese concentration in Crab Orchard Lake is 1,056 ug/kg (95% UCL – 1,181 ug/kg), which is below the reported background concentration for Illinois.
- Locations where screening concentrations were exceeded were not indicative of a specific source – locations were widespread and distributed throughout the Lake.
- Manganese is also elevated in groundwater adjacent to the Lake (representative background concentrations as high as 4,580 ug/L in groundwater samples collected from wells near the Metals Area OU Landfill, compared to the State of Illinois Class I Groundwater Standard of 150 ug/L), suggesting that high manganese concentrations are the result of natural geological characteristics in the immediate watershed.
- Manganese is widespread and no specific point source is indicated. However, coal mining in the watershed represents a potential area source contributing manganese to the Lake (Muir *et al.* 1997).

Based on these multiple lines of evidence, particularly on the widespread presence of manganese in surface water, sediment and groundwater, and historical coal mining activities in the watershed, it is recommended that manganese not be evaluated further under the CERCLA process.

Mercury. Mercury exceeded direct exposure screening concentrations for sediments at 6 sample locations (Figure 4-24, URS 2001). At one sample location (SD020), a sediment sample initially resulted in a detectable concentration of 0.35 mg/kg. However, this sample was not collected in accordance with the FSP, and when resampled, mercury was not detected at that location. The maximum concentration of 0.35 mg/kg (used as a conservative measurement of the maximum mercury concentration) exceeds the TEL of 0.174 mg/kg, but is below the PEL of 0.486 mg/kg. The remaining five samples that exceeded the screening concentration in Crab Orchard Lake sediments were approximately the same as the TEL, ranging up to 0.20 mg/kg. The 95% UCL of

[6] Calculations presented in Attachment 2

the mean mercury concentration was 0.16 mg/kg among samples in which mercury was detected,[7] which is below the TEL. The reference area mercury concentration was 0.16 mg/kg in Little Grassy Lake sediments, and was similar to all but one of the concentrations measured in Crab Orchard Lake sediments (i.e., in the 0.35 mg/kg sample), and identical to the 95% UCL. Based on the frequency and magnitude of the exceedance, as well as mean concentration relative to the TEL and the general similarity to reference area sediments, it is recommended that mercury not be investigated further with respect to direct exposures to the benthic macroinvertebrate community in Crab Orchard Lake.

Nickel. Nickel exceeded the screening concentration (TEL - 20 mg/kg) at 4 of 46 sample locations (Figure 4-25, URS 2001). The maximum nickel concentration measured was 22.3 mg/kg, which is below the PEL (33 mg/kg). The screening quotient based on the maximum detected concentration was 1.1 (Table 4-3, URS 2001). Based on a screening quotient near unity, it is recommended that nickel not be investigated further.

Zinc. The screening concentration for zinc (TEL – 98 mg/kg) was exceeded at only 3 of 46 sample locations (maximum concentration is 113 mg/kg, Figure 4-27, URS 2001). The screening hazard quotient for zinc based on the maximum concentration was 1.15 (Table 4-3, URS 2001). All zinc concentrations were well below the PEL for zinc (540 mg/kg). Considering the low frequency of exceedance, and a screening quotient near unity, it is believed that zinc is of little concern, and it is recommended that zinc not be investigated further.

Survival and Growth of Amphibians and Reptiles

There is insufficient information with which to develop screening concentrations for evaluation of amphibians and reptiles. Therefore, this assessment endpoint was not assessed directly, but is acknowledged as an uncertainty. This assessment endpoint is considered indirectly to the extent that larval amphibian data were included in derivation of surface water screening criteria used evaluating plankton as discussed previously. For decision-making purposes, it is assumed that screening chemicals relative to other assessment endpoints will be protective of reptiles and amphibians as well (Appendix A, URS 2001).

Survival, Growth, and Reproduction of Fish

Two lines of evidence were used to assess the effects of contamination on the fish community within the Lake. First, surface water analyses discussed with respect to survival, growth and reproduction of plankton are also applicable to the fish community (Table 4-2, URS 2001). The second line of evidence used was comparing tissue analysis results to tissue residue-based TRVs.

Bis(2-ethylhexyl)phthalate: As discussed previously, the screening concentration for bis(2-ethylhexyl)phthalate was exceeded at 3 of 25 surface water sample locations (Figures 3-1 and 4-1, URS 2001). Each of the reported concentrations was J-qualified (Figures 3-1 and 4-1, URS 2001) at concentrations ranging from 1 to 1.2 ug/L. Because it was commonly detected in

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[7] The value of 0.35 mg/kg was used in this calculation as a conservative approach. Note also that this included only samples in which mercury was detected.

rinsate and method blanks (an indication of common laboratory contamination), all detections were J-qualified, and it was detected more frequently and at higher concentrations in the reference area than in Crab Orchard Lake, it is recommended that bis(2-ethylhexyl)phthalate not be investigated further in surface water.

PCBs: PCBs were commonly detected in fish tissue, and appear to be at levels indicative of a potential risk in Cell D, with a cumulative screening quotient[8] of greater than 5. The cumulative screening quotient also exceeds 1 in Cell C (1.08). It is important to recall here that a no-observed-adverse effect level (NOAEL) was used as the screening concentration, which was subsequently compared to a maximum detected concentration. A screening quotient of about 1 indicates that the maximum concentration measured is at a level at which effects are not indicated. Because the screening quotient in Cell C is near unity, it is unlikely that PCB levels are a concern. However, PCBs pose potential risk to fish in Cell D, and further evaluation is warranted.

Pesticides: For two of the pesticides, endrin and endrin aldehyde, the screening quotients for fish were essentially at unity. A screening quotient of about 1 indicates that the maximum concentration is equal to a no-effect level. This suggests that endrin and endrin aldehyde are not a concern. However, potential additive effects must also be taken into consideration since the endrin compounds are likely similar in toxic effect. This suggests a cumulative screening quotient (i.e., summing the quotients for the individual chemicals) of approximately 2 for the endrin compounds in Cell D.

4,4-DDE exceeded a screening quotient of 1 in Cells C and D (1.9 and 2.4, respectively). Considering the TRVs are based on NOAELs, these tissue concentrations suggest borderline potential for DDE to impact the fish community.

There are also other concerns that arise with respect to the presence of pesticides that potentially relate to fish (as well as other assessment endpoints to be discussed). Specifically, the highest DDE concentrations in fish were measured in the western portion of Cell D. Some pesticides are known to occur near Cell C in conjunction with the wastewater treatment plant at Site 36 of the MISCA OU. However, a potential source is a former pesticide handling area in Area 7 of the AUS OU (Figure 1-3, URS 2001). Area 7 is currently under investigation as part of the AUS OU, and is located near the far eastern portion of Crab Orchard Lake. Pesticides observed in fish in Cells C and D were observed at elevated levels in soils at Area 7 (some of them in the hundreds of parts per million range). This is of particular interest since Cell D, where the highest concentrations in fish were observed, is also the closest fish sampling location to Area 7. However, the closest fish sampling location to Area 7 is more than a mile distant. As a result, concentrations of pesticides in fish in the eastern portion of the Lake represent a potentially significant uncertainty (data gap). Another contributing source of elevated pesticides in fish tissue could be attributable to watershed inputs to Crab Orchard Lake. The watershed of Crab Orchard Creek, the primary tributary of the Lake, has historically been dominated by agricultural activity. Hite and King (1977) indicate the Crab Orchard Lake watershed consists of cropland, 33.7%; pasture 11.0%; forest, 19.5%; and other (urban, mining, state and federal land), 35.8%.

[8] The sum of the quotients for the individual Aroclors.

The most profound effect of watershed inputs such as agricultural run-off (siltation, pesticides, fertilizers) is found in the eastern portion of the Lake where Crab Orchard Creek enters. This impact is further enhanced by an earthen causeway that restricts transport of water and sediments to the western portions of the Lake.

In conclusion, the preliminary ecological risk evaluation suggests that pesticides warrant further evaluation. It is recommended that pesticides be investigated further in conjunction with potential AUS OU source areas (specifically, Area 7).

Aluminum and Iron: As discussed previously in conjunction with the evaluation of plankton, aluminum and iron exceeded screening concentrations for surface water throughout the Lake (Figures 4-2 and 4-3, URS 2001). This is believed to be the result of naturally-occurring geological characteristics of the immediate watershed, and/or associated with historical coal mining activities. It is recommended these constituents not be investigated further.

Mercury: A screening quotient of 1.17 was calculated for mercury in fish tissue in Cell E (Table 4-8). This is essentially at unity and is based on the reporting limit in a sample in which mercury was not detected (reporting limit 3.5 mg/kg). The maximum detection elsewhere in the Lake was 0.54 mg/kg (Table 4-4, URS 2001), in which the screening quotient was about 0.6. Therefore, mercury is not believed to be a concern for fish in Crab Orchard Lake.

Selenium: A screening quotient of 1.13 was calculated for selenium in fish tissue (Table 4-8, URS 2001) in all cells. However, this is based on the reporting limit, as selenium was not detected in fish tissue. Because the screening quotient based on the reporting limit was near unity and selenium was not detected in fish tissue, it is recommended that further investigation not be conducted with respect to selenium in fish tissue.

Survival, Growth, and Reproduction of Herbivorous Birds

Potentially bioaccumulative chemicals (which include mercury and selenium, and all of the organic chemicals detected in sediments and surface water with a log K_{ow} exceeding 3.5) represent preliminary COPECs for evaluation of the survival, growth, and reproduction of herbivorous birds. These include PCBs, several pesticides, PAHs and phthalates. Each of these chemicals is considered more relevant to higher-level consumers (i.e., carnivores, as opposed to herbivores and omnivores) due to the potential bioaccumulating properties of these chemicals. Potential bioaccumulation pathways for these chemicals are more important via ingestion of animal rather than plant tissue. Omnivores will at times have meat as a primary component of the diet when that food is available, but this will not occur at a duration characteristic of carnivores. As a result, carnivores, rather than herbivores or omnivores, represent more relevant receptors. Since carnivores potentially would ingest more of a contaminant that bioaccumulates due to its feeding habits, it is assumed if there is no potential risk to carnivores then there would be no potential risk to exposed herbivores.

A possible exception to this is selenium, which may be important via a plant uptake pathway, and subsequent ingestion of plant materials. As a result, selenium may be an important constituent with respect to herbivores and omnivores. Canton and Van Derveer (1997) and Van

Derveer and Canton (1997) indicated that predicting hazards to birds and fishes (mammals appear relatively resistant to dietary exposures [Eisler 1985; Maier and Knight 1994]) associated with bulk-sediment concentrations is highly dependent upon site-specific conditions, especially the level of total organic carbon (TOC) in sediments. Effects were predicted at bulk-sediment concentrations greater than 2.5 mg/kg, and there are reports of observed effects at 4-6 mg/kg (Lemly 1995). Based on the high concentrations of TOC in sediments of Crab Orchard Lake (averaging 3.5%), this suggests even higher selenium levels would be necessary to elicit effects. The highest selenium concentration measured in Crab Orchard Lake sediments was 2.9 mg/kg in the northwestern portion of the Lake (Figure 4-26, URS 2001). The mean concentration was 1.1 mg/kg and the 95% UCL was 1.2 mg/kg (Attachment 2). Concentrations detected elsewhere in the Lake were all 2.5 mg/kg or less. Based on concentrations of selenium in Crab Orchard Lake sediments, reported effect levels for fish and birds (assumed to include herbivores and omnivores), and high TOC concentrations in sediments, selenium is not considered a concern for herbivorous birds.

In summary, the screening evaluation of higher trophic levels (i.e., insectivorous and piscivorous birds) will provide a reasonable indication of chemicals that may be of potential concern to herbivorous birds. If evaluation of these assessment endpoints suggests that further evaluation of a COPEC is warranted, then evaluation associated with herbivorous birds can be discussed with risk assessors and risk managers as investigations progress.

Survival, Growth, and Reproduction of Herbivorous Mammals

As discussed in conjunction with herbivorous birds, potentially bioaccumulative chemicals represent preliminary COPECs for evaluation of the survival, growth, and reproduction of herbivorous mammals. These include PCBs, several pesticides, PAHs, phthalates, mercury and selenium. Each of these chemicals is considered more relevant to higher-level consumers (i.e., carnivores, as opposed to herbivores and omnivores) based on bioaccumulation potential and increasing concentrations with increasing trophic level. The screening evaluation of higher trophic levels (i.e., insectivorous and piscivorous mammals) will provide a reasonable indication of chemicals that may be of potential concern to herbivorous mammals. If evaluation of these assessment endpoints suggests that further evaluation of a COPEC is warranted, then evaluation associated with herbivorous mammals can be discussed with risk assessors and risk managers as investigations progress.

Survival, Growth, and Reproduction of Omnivorous Birds

As discussed in conjunction with herbivorous birds, potentially bioaccumulative chemicals represent preliminary COPECs for evaluation of the survival, growth, and reproduction of omnivorous birds. These include PCBs, several pesticides, PAHs, phthalates, mercury and selenium. Each of these chemicals is considered more relevant to higher-level consumers (i.e., carnivores, as opposed to herbivores and omnivores) based on bioaccumulation potential and increasing concentrations with increasing trophic level. The screening evaluation of higher trophic levels (i.e., insectivorous and piscivorous birds) will provide a reasonable indication of chemicals that may be of potential concern to omnivorous birds. If evaluation of these assessment endpoints suggests that further evaluation of a COPEC is warranted, then evaluation associated with omnivorous birds can be discussed with risk assessors and risk managers as investigations progress.

Survival, Growth, and Reproduction of Omnivorous Mammals

As discussed in conjunction with herbivorous birds, potentially bioaccumulative chemicals represent preliminary COPECs for evaluation of the survival, growth, and reproduction of omnivorous mammals. These include PCBs, several pesticides, PAHs and phthalates, mercury and selenium. Each of these chemicals is considered more relevant to higher-level consumers (i.e., carnivores, as opposed to herbivores and omnivores) based on bioaccumulation potential and increasing concentrations with increasing trophic level. The screening evaluation of higher trophic levels (i.e., insectivorous and piscivorous mammals) will provide a reasonable indication of chemicals that may be of potential concern to omnivorous mammals. If evaluation of these assessment endpoints suggests that further evaluation of a COPEC is warranted, then evaluation associated with omnivorous mammals can be discussed with risk assessors and risk managers as investigations progress.

Survival, Growth, and Reproduction of Insectivorous Birds

Several lines of evidence were used for evaluating insectivorous birds. Chemical analyses in bird eggs and wholebody tissues were collected from several areas in Crab Orchard Lake (URS 2001). Pesticides and PCBs were analyzed in bird carcasses, PCBs were analyzed in bird eggs, and mercury and selenium were analyzed in bird livers.

PCBs: For PCBs, screening quotients exceeded 1 in bird carcasses and in bird eggs in Cell D (Tables 4-9 and 4-10, URS 2001). This indicates that further evaluation is warranted for PCBs.

Pesticides: To the extent that both analytical data and TRVs are available, none of the screening quotients exceeded 1 for pesticides (Table 4-9, URS 2001). However, there are a number of pesticides detected in which there were no TRVs identified for wholebody tissues (e.g., endrin species, heptachlor epoxide, and chlordane). It has been recommended that pesticides be investigated further with respect to other assessment endpoints. Whether additional evaluation is warranted in conjunction with insectivorous birds should be considered as part of the continued evaluation of pesticides.

Not all potentially bioaccumulative chemicals evaluated in surface water and sediments were analyzed in bird tissues. Specifically, the PAHs and phthalates, which were detected in sediments, were not analyzed in bird tissues. These are discussed below.

PAHs: PAHs were detected in only one location in sediments (near Carterville) at low concentrations and were not detected in surface water. All PAHs detected were J-qualified. It has already been recommended that PAHs be evaluated further with respect to the benthic community. However, despite their relatively high K_{ow}s and lipophilicity, PAHs show little tendency to biomagnify in food chains (Neff 1985; Eisler 1987; Spacie et al. 1995). They are readily absorbed, either directly (to the extent dissolved in water) or via ingestion, but then tend to be rapidly metabolized by most aquatic organisms. Therefore, PAHs are not considered significant concerns to higher trophic level organisms and are not recommended to be investigated further in reference to insectivorous birds.

Bis(2-ethylhexyl)phthalate: Bis(2-ethylhexyl)phthalate was detected in three of 25 water samples at an estimated concentration (J-qualified) of about 1 ug/L (Figure 4-1, URS 2001). It was also detected in a majority of the sediment samples, though most were also J-qualified (Figure 4-4, URS 2001). There are several considerations in interpreting the relevance of bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate is commonly observed as a field and lab contaminant (it was detected in multiple rinsate and method blank samples). Bis(2-ethylhexyl)phthalate was detected in the reference area surface water samples at a higher frequency and higher concentrations than in Crab Orchard Lake, and was also elevated in reference area sediment samples (up to 1.1 mg/kg). This may be a reflection in sampling and analysis methods rather than representative of concentrations in reference area and Crab Orchard Lake media. With respect to potential ingestion pathway exposures, bis(2-ethylhexyl)phthalate has low oral toxicity, generally greater than 100 mg/kgBW/day (BW = body weight), as derived from the summary of oral TRVs in Attachment 1.

Butyl benzyl phthalate and Di-n-octyl phthalate: Two other phthalates were also detected. Butyl benzyl phthalate (0.56 mg/kg) (Figure 4-10, URS 2001) was detected in one of 46 sediment samples, and di-n-octyl phthalate (0.22 to 2.1 mg/kg) (Figure 4-12, URS 2001) was detected in two of 46 sediment samples. All reported sample concentrations were J-qualified, except for one sample of di-n-octyl phthalate. All of the phthalates have a potential to bioaccumulate, but due to the high organic carbon concentrations, will be tightly bound to organic carbon in sediments, and will have limited bioavailability.

The following lines of evidence are presented to support risk management decision-making with respect to phthalates.

For bis(2-ethylhexyl)phthalate:

- Detected in all rinsate samples and various method blank samples
- Detected in higher concentrations and at a greater frequency in surface water in the reference area than in Crab Orchard Lake
- Mean sediment concentrations were comparable between Crab Orchard Lake and the reference area (as discussed previously)
- High organic carbon in sediments will limit bioavailability (e.g., USEPA 1986, USEPA 1993, USEPA 1994, USEPA 1998), though the degree is uncertain.
- Commonly observed field/laboratory contaminant
- Low ingestion pathway toxicity

For butyl benzyl phthalate and di-n-octyl phthalate

- Low frequency of detection – detected in only 1 of 46 sediment samples for butyl benzyl phthalate, and 2 of 46 samples for di-n-octyl phthalate
- All but one detection of di-n-octyl phthalate were J-qualified
- High organic carbon in sediments will limit bioavailability (e.g., USEPA 1986, USEPA 1993, USEPA 1994, USEPA 1998), though the degree is uncertain.

Based on these multiple lines of evidence, it is the recommended that phthalates not be evaluated further with respect to ingestion pathway exposures.

Mercury: Mercury was detected in only 1 of 5 bird liver samples: at 0.1 mg/kg at Site I (the Highway 148 bridge bird colony) (Table 4-11, URS 2001). Though this indicates exposure, it is below concentrations indicative of potential risk (screening quotient 0.1). It is therefore recommended that mercury not be evaluated further with respect to insectivorous birds.

Selenium: Results of the PSAR (URS 2001) suggest selenium is not a concern for insectivorous birds based on concentrations of selenium in the liver (Table 4-11, URS 2001). The only detected selenium concentration in liver (Site H (the Wolf Creek Road bridge bird colony)) had a calculated screening quotient less than one (0.28). It is recommended that selenium not be evaluated further with respect to insectivorous birds.

Survival, Growth, and Reproduction of Insectivorous Mammals

Preliminary COPECs with respect to insectivorous mammals are based solely on the organic chemical log K_{ow}, or in the case of inorganics, detections of mercury or selenium. This relates primarily to bats as the primary insectivorous mammal that will utilize the aquatic portions of Crab Orchard Lake. PCBs, some pesticides, and mercury were detected in fish, and it is therefore reasonable to believe that these chemicals would also be present in emergent aquatic insects that bats may feed upon.

PCBs: For PCBs, available toxicological data for bats indicate they are less sensitive than mink (e.g., Clark 1978; Clark and Stafford 1981– see tabulated oral PCB toxicity data for bats and mink in Attachment 1). It is also likely that the dose obtained by bats would be lower than piscivorous mammals (such as mink) because bats forage over a larger area. In addition, mink are at a higher trophic level than bats. This is important, because based on the biomagnification theory of PCBs (i.e., PCB concentrations increase with increasing trophic level), the diet of mink (fish) would contain greater concentrations of PCBs than the diet of bats (insects). The United States Environmental Protection Agency (USEPA) uses an example in ERAGs (USEPA 1997) relative to focusing efforts in conjunction with PCBs:

> *The primary ecological threat of PCBs in ecosystems is not through direct exposure and acute toxicity. Instead, PCBs bioaccumulate in food chains and can diminish reproductive success in some vertebrate species..... Therefore, reduced*

reproductive success in high-trophic-level species exposed via their diet is a more appropriate assessment endpoint than either toxicity to organisms via direct exposure to PCBs in water, sediments, or soils, or reproductive impairment in lower trophic-level species.

The basis for USEPA's example is that constituents such as PCBs bioaccumulate in food chains. This will be important in future decision-making with respect to PCB evaluation. This rationale is also true for pesticides and mercury. Both pesticides and PCBs have already been identified as warranting further evaluation. Whether further evaluation of pesticides and PCBs with respect to bats is needed should be considered in the planning stages of further monitoring or investigation.

PAHs and Phthalates: Potentially bioaccumulative chemicals not included in the above discussion (they were not analyzed in fish tissue), but detected in Crab Orchard Lake surface water or sediments, include PAHs and phthalates. PAHs and the phthalates were discussed with respect to insectivorous birds. The same rationale and conclusions are applicable to insectivorous mammals. PAHs are not considered significant concerns to higher trophic level organisms and are not recommended to be investigated further with respect to insectivorous mammals. It is also recommended that phthalates not be evaluated further with respect to ingestion pathway exposures.

Mercury: There are no data with which to evaluate the sensitivity of bats (the key aquatic insectivorous mammal) to mercury. This represents an uncertainty in the evaluation. Therefore, the focus for evaluation of mercury will be made in conjunction with piscivorous mammals.

Selenium: Selenium was detected in insectivorous birds, and because of similar diets, it is reasonable to assume that insectivorous mammals are also potentially exposed to selenium. However, mammals appear relatively resistant to dietary exposures of selenium (Eisler 1985; Maier and Knight 1994). Lemly (1997) also points out that fish and aquatic birds are the most sensitive ecological receptors for assessing ecosystem-level impacts associated with selenium. Because selenium does not appear to impact insectivorous birds (as discussed previously for swallows), then it can be concluded based on Lemly (1997) that there will be no risks to insectivorous mammals. Though there is some uncertainty because there are no direct means with which to evaluate selenium in insectivorous mammals, the uncertainty is considered low, and no further evaluation is recommended.

Survival, Growth, and Reproduction of Piscivorous Birds

Two lines of evidence were used for evaluating piscivorous birds. First, analytical data for fish, to the extent available, were input into a simple ingestion model using the kingfisher (Table 4-7, URS 2001). Chemicals in which projected doses exceeded TRVs (i.e., a screening quotient greater than one) were classified as preliminary COPECs. Second, organic chemicals detected in surface water or sediments with a log K_{ow} greater than 3.5 that were not analyzed in fish tissue were selected as preliminary COPECs.

Pesticides: Screening quotients for pesticides (Table 4-7 URS 2001) indicate some pesticides pose potential risks to piscivorous birds in Cell D and Cell C of Crab Orchard Lake. The highest screening quotients were observed in Cell D, where screening quotients exceeded 1 for dieldrin, endrin, endrin aldehyde, and 4,4-DDT. In Cell C, screening quotients exceeded 1 for endrin aldehyde and 4,4-DDT. A hazard quotient of 1.16 was also indicated for 4,4'-DDT in Cell A. Because this is a NOAEL-based quotient of a maximum measured concentration and only slightly exceeds 1, this is probably not significant. As discussed previously, AUS OU Area 7 and agricultural land use in the eastern watershed are potential sources of pesticides. The eastern portion of Crab Orchard Lake represents a potential data gap with respect to evaluation of pesticides. Pesticides have been identified as warranting further investigation in relation to other assessment endpoints. This evaluation will be conducted with the ongoing evaluation of AUS OU Area 7.

PCBs: PCBs pose potential risks to piscivorous birds in Cells C and D (Table 4-7, URS 2001). The predominant PCB concern is in Cell D, of which Sangamo Bay is a part. PCB remediation occurred in Sangamo Bay associated with the PCB OU. Fish PCB concentrations remain elevated in this area at levels of potential ecological concern for piscivorous birds. It is recommended that monitoring be conducted to continue to evaluate the effectiveness of remediation to reduce PCB concentrations in fish, and the associated reduction in potential risks to piscivorous birds.

Mercury: Among the inorganics, mercury was common in fish tissue throughout Crab Orchard Lake (which piscivorous birds ingest), with the exception of Cell E. Though not detected in fish tissue in Cell E, the reporting limits were elevated well above levels detected in other areas of the Lake, and it is reasonable to assume that similar concentrations are present in fish captured from Cell E as in other areas. Screening quotients for all areas within the Lake exceeded 1. Fish concentrations were substantially higher in the reference area (Cell F). Mercury was also measured in fish from Rend Lake. Tissue concentrations and screening quotients in Crab Orchard Lake were similar to those calculated in Rend Lake. Therefore, the mercury observed in fish from Crab Orchard Lake do not appear to be associated with site-specific sources of anthropogenic inputs and there is no incremental increase in risk associated with the presence of mercury as compared to the reference area. It is recommended that mercury not be investigated further with respect to piscivorous birds.

Selenium: Selenium was not detected in fish tissue samples. Reporting limits were higher than the screening concentration, which contributes to uncertainty. However, because selenium was not detected in fish, no further evaluation is recommended.

The second line of evidence for evaluating risks to piscivorous birds is for those chemicals which were not analyzed in tissues, but which have a potential for bioaccumulation based on the chemical log K_{OW}. Chemicals detected in surface water or sediments that fall into this category are bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, di-n-octylphthalate, and several PAHs. PAHs and the phthalates were discussed with respect to insectivorous birds. The same rationale and conclusions are applicable to piscivorous birds. PAHs are not considered significant concerns to higher trophic level organisms and are not recommended to be investigated further. It is also recommended that phthalates not be evaluated further with respect to ingestion pathway exposures.

Survival, Growth, and Reproduction of Piscivorous Mammals

Two lines of evidence were used for evaluating piscivorous mammals. First, analytical data for fish, to the extent available, were input into a simple ingestion model using the mink. Chemicals in which projected doses exceeded TRVs (i.e., a screening quotient greater than 1) were classified as preliminary COPECs (Table 4-6, URS 2001). Second, organic chemicals detected in surface water or sediments with a log K_{ow} greater than 3.5 that were not analyzed in fish tissue were selected as preliminary COPECs.

Pesticides: Screening quotients for pesticides, in general, followed the same trends as for piscivorous birds. Screening quotients (Table 4-6, URS 2001) indicate potential risks to piscivorous mammals, primarily associated with Cell D. In Cell D, concerns were indicated for dieldrin, endrin, endrin aldehyde, and heptachlor epoxide. In Cell C, screening quotients also exceeded 1 for endrin aldehyde and heptachlor epoxide. As discussed previously, AUS OU Area 7 and agricultural runoff are potential sources of pesticides. There is also a data gap with respect to pesticide concentrations in fish in the far eastern portion of Crab Orchard Lake. Based on screening quotients for piscivorous mammals (as well as other assessment endpoints), it is recommended that pesticides be investigated further. This evaluation will be conducted with the ongoing evaluation of AUS OU Area 7.

PCBs: Because of the high sensitivity of mink to PCBs, screening quotients for PCBs exceeded 1 throughout Crab Orchard Lake. Cell D was of greatest concern with a screening quotient of 95 for Aroclor 1254 and greater than 100 when total PCBs are considered. As with piscivorous birds, monitoring of PCBs in conjunction with Cell D (in particular) is warranted. However, it may be prudent to expand the area evaluated for piscivorous mammals to include other areas of the Lake, and to include fish more representative of the dietary preferences of piscivorous mammals.

2,3,7,8-TCDD equivalents: The screening quotient for dioxins/furans slightly exceeded unity for the mink in Cell D (1.16). The 95% UCL concentration for carp, which contained the highest concentrations, was about 3.2 nanograms per kilogram (ng/kg) (Figure 3-50, URS 2001). This is about 0.76 of the maximum concentration of 4.2 ng/kg (Table 4-4, URS 2001). The screening quotient based on the 95% UCL would be about 0.9. Because the screening concentration is based on a NOAEL, the maximum concentration is near unity, and the 95% UCL-based quotient is less than 1, dioxins and furans are not considered a significant concern.

Mercury: Mercury was common in fish tissue throughout Crab Orchard Lake. The only location in which a piscivorous mammal screening quotient exceeded 1 was in Cell E. This quotient was based on a reporting limit in the absence of measured detected concentrations of mercury in fish in Cell E. It is reasonable to assume that similar concentrations in relation to the rest of the Lake are present in fish captured from Cell E and that the screening quotients would be similar as well (*i.e.*, less than 1). Mercury is not considered a concern for piscivorous mammals in Crab Orchard Lake. As discussed previously, piscivorous mammals are also a reasonable indicator of the presence of potential risks associated with insectivorous mammals. Results of the piscivorous mammal evaluation suggest that mercury is also not a concern for insectivorous mammals.

Selenium: With respect to selenium, the same general rationale presented for piscivorous birds is applicable to piscivorous mammals. Also, Lemly (1997) states that fish and aquatic birds are the most sensitive ecological receptors for assessing ecosystem-level impacts associated with selenium. Though there is uncertainty associated with the selenium results, the uncertainty is considered low, and it is recommended selenium not be investigated further in relation to piscivorous mammals.

The second line of evidence for evaluating risks to piscivorous mammals is for those chemicals which were not analyzed in tissues, but which have a potential for bioaccumulation based on the chemical log K_{ow}. Chemicals detected in surface water or sediments that fall into this category bis(2-ethylhexyl)phthalate, benzyl butyl phthalate, di-n-octylphthalate, and are several PAHs. PAHs and the phthalates were discussed with respect to insectivorous birds and the same rationale and conclusions are applicable to piscivorous mammals. PAHs are not considered significant concerns to higher trophic level organisms and are not recommended to be investigated further. It is also recommended that phthalates not be evaluated further with respect to ingestion pathway exposures.

Ecological Screening Analysis Summary

The following key issues were identified in the Crab Orchard Lake ecological screening analysis:

1) PAHs were detected in sediments of the Crab Orchard Lake bay near Carterville. Potential risks were a concern with respect to the benthic macroinvertebrate community. It is recommended that PAHs be investigated further in conjunction with the AUS OU.

2) PCB levels in eggs and wholebody tissues suggest potential risks to insectivorous birds in Crab Orchard Lake Cell D. Because of similar diets, PCB exposures may also be elevated for insectivorous mammals (bats). In addition, PCB levels in fish may be sufficiently high to pose risks to fish and piscivorous birds in Cell D. Fish PCB concentrations may also be sufficiently elevated to pose risks to piscivorous mammals throughout the Lake. Potential risks appear highest in Cell D, but may also extend to other areas of the Lake for carnivorous mammals. PCB remediation has already taken place in Sangamo Bay (Cell D) at the PCB OU. It is recommended that monitoring of PCBs be conducted to evaluate the effectiveness of the remediation in mitigating risks associated with PCBs at the PCB OU. Specific target objectives should be established for the monitoring program, with decision criteria that would institute re-evaluation of remedial effectiveness if the target objectives are not met.

3) Pesticide levels in fish may be sufficiently high to pose risks to fish and piscivorous birds and mammals in Cell D, and to a lesser extent, in Cell C (bay near Pigeon Creek). There is a data gap with respect to pesticides in the far eastern portion of Crab Orchard Lake (part of Cell D). AUS OU Area 7 and non-point source watershed runoff are potential sources for pesticides in this region. The closest fish sampling location in the Lake Monitoring OU screening assessment (Sangamo Bay – Cell D) was more than a mile distant from a known pesticide source in AUS OU Area 7. Results of the screening evaluation suggest that additional investigation to support evaluation of the fish, and piscivorous birds and mammals may be warranted. Whether insectivorous mammals and birds should be included in

decision-making should also be considered. Additional evaluation is recommended in this area of the Lake in conjunction with the evaluation of AUS OU Area 7.

4) Concentrations of cadmium may pose risks to benthic macroinvertebrates in two areas of the Lake. One area is located near AUS-0069, which is a potential source of cadmium. Cadmium has been detected above background and screening levels in soil and sediment at AUS-0069. The second area is in Cell C (bay near Pigeon Creek), where known cadmium sources include the Refuge wastewater treatment plant (MISCA OU, Site 36) and the Metals Area OU. It is recommended that additional evaluation of cadmium be conducted in conjunction with the evaluation of AUS-0069 and MISCA OU, Site 36.

HUMAN HEALTH RISK SCREENING EVALUATION

In the human health risk evaluation, exposures to surface water and sediments were examined in the PSAR (URS 2001). Risk from consumption of fish is addressed by the State of Illinois in their fish sampling program and fish advisory. Therefore, human health risk through fish consumption was not addressed in the PSAR.

Surface Water

There were no exceedances of human health screening criteria for surface water.

Sediment

Except for arsenic discussed below, the only other human health screening criteria for sediment that were exceeded were the Region 9 and State of Illinois Tiered Approach to Corrective Action Objectives (TACO) migration to groundwater values. The migration to groundwater screening criteria address the potential for contaminants to leach from the soil (sediment in this case) and impact groundwater. The Region 9 screening criteria selected were for the case where the dilution/attenuation factor (DAF) is equal to unity. A DAF of unity assumes that there is no dilution or attenuation of the contaminant after it is leached from the soil (sediment) and moves to the groundwater. For the State of Illinois TACO criteria, the screening values for Class I groundwater were used. In both cases, the criteria were established to protect groundwater from contamination that would cause maximum contaminant levels (MCLs) or State of Illinois Class I standards to be exceeded.

Either one or both of the migration to groundwater screening values were exceeded for one organic constituent and several inorganics, as discussed below.

Benzo(a)anthracene. The Region 9 migration to groundwater screening criterion of 80 ug/kg for benzo(a)anthracene was exceeded at one location, at a J-qualified detection of 110 ug/kg (Figure 3-3, URS 2001). The State of Illinois TACO migration to groundwater screening value for benzo(a)anthracene is 2,000 ug/kg. There is no MCL or State of Illinois Class I standard for benzo(a)anthracene. Based on the frequency and magnitude of the exceedance, it is recommended that benzo(a)anthracene not be retained as a COPC for further evaluation. Note that PAHs at the locations of the benzo(a)anthracene exceedance are recommended for evaluation for ecological risk, as discussed above.

Arsenic. The background sediment value of 10 mg/kg for arsenic was exceeded at two mid-Lake locations, at concentrations of 10.3 and 11.7 mg/kg (Figures 3-4 and 4-20 URS 2001). The Region 9 DAF 1 value for arsenic is 1 mg/kg and the State of Illinois TACO migration to groundwater value for arsenic is 28 mg/kg. The MCL/State of Illinois Class I standard for arsenic is 50 ug/L. Arsenic was not detected in the surface water in the Lake, at a reporting limit of 10 ug/L, suggesting that arsenic is not leaching to any significant extent. The arsenic detections also exceeded both the Region 9 cancer-based preliminary remediation goal (PRG) and the State of Illinois TACO screening criteria for industrial soil exposure. Considering that the samples were taken at mid-Lake (Figure 4-20), potential for significant human exposure is small. In addition, the calculated cancer risk based on the Region 9 PRG, 4.3 x 10^{-6} is well with EPA's acceptable range of 10^{-4} to 10^{-6} (Table 4-13). Based on the frequency and magnitude of the exceedance, it is recommended that arsenic not be retained as a COPC for further evaluation.

Cadmium. Cadmium was detected in Lake sediments above background and above both the Region 9 DAF 1 value of 0.4 mg/kg and the State of Illinois TACO value of 3.7 mg/kg (Figures 3-4 and 4-21, URS 2001). Cadmium detections exceeded background and the Region 9 DAF 1 criterion at 11 locations, and the State of Illinois TACO criterion at two locations. The MCL for cadmium is 5 ug/L. The maximum detection in surface water was 0.53J ug/L. If the water in the Lake is hydraulically connected to a State of Illinois Class I aquifer below the Lake, it would not be expected to increase the cadmium concentration in the groundwater above the MCL or State of Illinois Class I standard, based on these data. Therefore, it is recommended that cadmium not be retained for further evaluation on the criterion of possible impacts to groundwater. There are ecological issues related to cadmium, as discussed elsewhere in this section.

Mercury. Mercury exceeded both the background sediment value (0.15 mg/kg) and the State of Illinois Class I migration to groundwater screening value of 0.15 mg/kg at six locations in the Lake (Figures 3-4 and 4-24, URS 2001). The maximum detected concentration was 0.20 mg/kg. Mercury was detected in the surface water at one location at a concentration of 0.2J ug/L, essentially at the same concentration as the maximum concentration in the background site, 0.16 ug/kg, where mercury was detected in three samples. The MCL/State of Illinois Class I standard for mercury is 2 ug/kg. If the water in the Lake is hydraulically connected to a State of Illinois Class I aquifer below the Lake, it would not be expected to increase the mercury concentration in the groundwater above the MCL or Class I standard, based on these data. Therefore, it is recommended that mercury not be retained for further evaluation on the criterion of possible impacts to groundwater.

Nickel. Nickel exceeded both the background sediment value of 16.9 mg/kg and the Region 9 migration to groundwater screening value of 7 mg/kg at eleven locations scattered throughout the Lake (Figures 3-4 and 4-25, URS 2001). The maximum detection was 20.8 mg/kg, in roughly the center of the Lake. The State of Illinois TACO screening value of 76 mg/kg for nickel was not exceeded. The maximum detection in surface water was 103 ug/L, essentially at the MCL/Class I standard of 100 ug/L for nickel. If the water in the Lake is hydraulically connected to a Class I aquifer below the Lake, it would not be expected to increase the nickel concentration in the groundwater above the MCL or Class I standard, based on these data. Therefore, it is recommended that nickel not be retained for further evaluation on the criterion of possible impacts to groundwater.

Selenium. Selenium exceeded both the background sediment value of 0.64 mg/kg and the Region 9 DAF 1 value (0.3 mg/kg) at 33 locations, mostly in the western part of the Lake (Figure 3-4, URS 2001). The State of Illinois TACO migration to groundwater screening value was exceeded at a few locations. The maximum detection was 2.9 mg/kg, in the northwestern corner of the Lake. In the surface water at the Lake, selenium was detected at a maximum concentration equal to the reporting limit (2.6J ug/L). The MCL/State of Illinois Class I standard for selenium is 50 ug/L. If the water in the Lake is hydraulically connected to a Class I aquifer below the Lake, it would not be expected to increase the selenium concentration in the groundwater above the MCL or State of Illinois Class I standard, based on these data. Therefore, it is recommended that selenium not be retained for further evaluation on the criterion of possible impacts to groundwater.

UNCERTAINTY

There is uncertainty inherent in the preliminary risk screening process. By definition, limited data are collected during the preliminary site assessment. It is because of this that conservative approaches for evaluating the potential for risk are applied during the screening stage to minimize the potential for eliminating chemicals early in the process that may indeed warrant further evaluation (for example, use of NOAELs in comparison to the maximum observed concentration). For many of the preliminary assessment endpoints however, toxicity information is simply unavailable, which contributes to uncertainty for these endpoints. In other instances, the ability to detect chemicals in a medium is insufficient with which to interpret whether there is a potential for effects to be present (i.e., elevated reporting limits in comparison to the screening concentration). All of these contribute to uncertainty to the risk evaluation, and subsequently in risk management decision-making.

A number of specific chemicals were characterized as "uncertainties" in the PSAR (URS 2001) because they were 1) detected, but there was no screening concentration, or 2) they were not detected but the analytical reporting limit was above the screening concentration. These are discussed below.

Ecological

With respect to the ecological evaluation, chemicals characterized as uncertainties are summarized in Table 4-14 of the PSAR (URS 2001). A large number of volatile and semivolatile organic compounds were characterized as uncertainties in surface water and/or sediments. With the exception of the PAHs, none of these chemicals were detected in either surface water (25 samples) or sediment (46 samples) from Crab Orchard Lake. Therefore, the potential uncertainties associated with these chemicals is considered low. PAHs were identified as uncertainties in surface water, but were classified as a COPEC in sediments and recommendations were made for further evaluation. Whether both surface water and sediment are included in further evaluation should be considered when designing additional studies.

Similarly, some PCBs were characterized as uncertainties in surface water or sediments. Further investigation of PCBs has been recommended.

Several pesticides were identified as uncertainties in sediments and/or bird tissue (wholebody). These include aldrin, alpha-chlordane, alpha-endosulfan, beta-BHC, beta-endosulfan, delta-BHC, endosulfan sulfate, and gamma BHC and gamma-chlordane. However, none of these exceeded screening concentrations, or suggested potential risks associated with fish, or ingestion exposures to piscivorous birds or mammals. Therefore, the uncertainties associated with these constituents in sediments or bird tissue are considered low. Methoxychlor and toxaphene were characterized as uncertainties in surface water and sediment, but were not a concern in any of the biological tissues tests, and therefore uncertainty is considered low. Dieldrin and heptachlor epoxide were uncertainties in surface water, but further evaluation was recommended since potential risks were indicated when considering biological matrices. Heptachlor was an uncertainty in surface water and bird tissue (wholebody), but did not exceed screening concentrations for fish or piscivorous birds and mammals. Thus, the uncertainty associated with heptachlor, by itself, is considered low. However, even though risks were not apparent for some individual pesticides, further investigation of pesticides was recommended based on the screening results associated with a few chemicals in this group. Considerations of potential additive effects associated with pesticides of similar modes of toxic action should be considered in designing additional studies, including those with screening quotients less than 1 in the preliminary screening evaluation.

Among the inorganics, barium and beryllium were characterized as uncertainties in sediments. Both were detected, but no screening concentrations were identified. For both barium and beryllium, however, the maximum concentrations measured in Crab Orchard Lake were below the background 95% UTL concentration. Selenium was also detected in sediments, but no screening concentration for direct exposures to benthic macroinvertebrates was identified. However, Lemly (1997) points out that fish and aquatic birds are the most sensitive ecological receptors for assessing ecosystem-level impacts associated with selenium. Lemly (1995) indicates no effects are anticipated in birds or mammals until sediment concentrations are in the 4-6 mg/kg range. The maximum measured selenium concentration in sediments in Crab Orchard Lake was 2.9 mg/kg, thus selenium does not appear to be a concern for birds or mammals. Since these are the most sensitive ecological receptors, then it is concluded that selenium is not a concern for benthic macroinvertebrates as well. Cobalt was identified as an uncertainty in surface water: it was not detected but the reporting limit exceeded the screening concentration. Cobalt was not considered a potential concern in sediments, so the uncertainty associated with cobalt is considered low.

In summary, the uncertainty associated with chemicals that could not be effectively evaluated due to the absence of screening concentrations or analytical limitations (reporting limits) is generally considered low. Further evaluation of chemicals identified as uncertainties is not recommended, except for PAHs, PCBs and certain pesticides, which were identified as potential concerns in other media where they could be effectively evaluated.

Human Health

With respect to the human health evaluation, chemicals characterized as uncertainties are summarized in Table 4-15 of the PSAR (URS 2001). Media evaluated with respect to human health included surface water and sediments. With only one exception, all chemicals classified as uncertainties in one medium were found not to pose risks in the other medium. The lone exception to this is indeno(1,2,3-cd)pyrene, which was characterized as an uncertainty in both surface water and sediment. However, it was not detected in either medium and was classified as an uncertainty based on the reporting limit. In all cases, uncertainty associated with these chemicals is considered low. Unless elevated concentrations of these chemicals are subsequently identified as part of ongoing investigations at other OUs (e.g., AUS OU), further investigation is not recommended for chemicals classified as uncertainties in the human health screening evaluation.

CONCLUSIONS

This section of the report summarizes decisions and actions based on results of the PSAR (URS 2001). With respect to the human health evaluation, no further investigation will be conducted in Crab Orchard Lake. With respect to the ecological screening analysis, monitoring or further evaluation will be conducted for PCBs, PAHs, pesticides and cadmium, in specific areas in conjunction with other existing OUs at the Crab Orchard National Wildlife Refuge.

No new sources specific to the Lake were identified in this investigation. All areas recommended for additional evaluation can be investigated with other OUs established for the Refuge. These OUs have either been remediated or are scheduled for investigation.

For chemicals other than PCBs, PAHs, pesticides, and cadmium, it is believed that the weight of evidence suggests that these constituents do not pose a potential threat to human health or the environment sufficient to warrant further action.

Specific decisions and actions associated with PCBs, PAHs, pesticides, and cadmium are summarized in Table 1, and are discussed below. For these specific compounds, the screening risk assessment did indicate the potential for risk to ecological receptors and further investigation can be conducted in conjunction with other existing OUs.

PCBs

PCBs will not be investigated further under the Lake Monitoring OU. However, potential risks to fish, piscivorous birds, piscivorous mammals, insectivorous birds, and insectivorous mammals were noted. The highest concentrations of PCBs in Crab Orchard Lake were observed in Cell D (Sangamo Bay). The potential risk from PCBs will be evaluated as part of the PCB OU.

Because the PCB OU has been remediated, it is assumed that the PCB levels in fish and birds will decline with time. To further evaluate PCBs, a monitoring program will be implemented under the PCB OU. One purpose of the monitoring program will be to assess whether the PCBs in the fish and bird tissue are affecting ecological health of these receptors, and whether the

PCBs in fish tissue pose a threat to piscivores at the site. A second purpose is to monitor PCB body burdens in ecological receptors and to verify the assumption of downward trends following the PCB OU remediation.

PAHs

PAHs will not be investigated further as part of the Lake Monitoring OU. However, potential risks to the benthic macroinvertebrate community were noted. PAHs were detected in sediments in a bay of Crab Orchard Lake near Carterville. The source and extent of PAH contamination within this tributary of Crab Orchard Lake is not known. The potential risk from PAHs will be evaluated as part of the ongoing AUS OU investigation.

Pesticides

Pesticides will not be investigated further under the Lake Monitoring OU. However, potential risks to fish, piscivorous birds, and piscivorous mammals were noted. The highest concentrations of pesticides in the Crab Orchard Lake investigation were observed in fish tissues in Cell D (Sangamo Bay). There are no known pesticide sources in the small drainage area of Sangamo Bay, though agricultural use of pesticides throughout the watershed may contribute pesticides to the Lake. The only known existing significant pesticide source in the vicinity is in Area 7 of the AUS OU, east of Sangamo Bay. The potential risk from pesticides will be evaluated as part of the ongoing AUS OU investigation.

Cadmium

Cadmium will not be investigated further under the Lake Monitoring OU. However, potential risks to benthic macroinvertebrates were noted for cadmium at two locations in Crab Orchard Lake. One location was in close proximity to Site AUS-0069 while the other was in close proximity to MISCA OU Site 36. The potential risk from cadmium near Site AUS-0069 will be evaluated as part of the ongoing AUS OU investigation. The potential risk from cadmium in Pigeon Creek Bay will be evaluated as part of the pre-design investigation for Site 36.

Summary

This report presents risk management decisions regarding COPECs that warrant further evaluation in Crab Orchard Lake. Specifically, PCBs, PAHs, pesticides, and cadmium will be addressed as part of other existing Crab Orchard National Wildlife Refuge Superfund Site OUs. Since the areas and chemicals of concern will be evaluated along with other existing OUs, there is no need to retain a Lake Monitoring OU. Therefore, once the issues warranting further evaluation are incorporated into other existing OUs, then the Lake Monitoring OU will be closed.

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TABLE 1

SUMMARY OF RISK MANAGEMENT DECISIONS

Assessment Endpoint	COPEC	Medium[1]	Receptor of Interest	Further Work Recommended?
Survival, Growth and Reproduction of Plankton	Bis(2-ethylhexyl)phthalate Iron Aluminum	Surface Water	Plankton	No
Survival, Growth and Reproduction of Aquatic Macrophytes		Sediment	Plants	No (Uncertainty)
Survival, Growth and Reproduction of Benthic Macro-invertebrates	Bis(2-ethylhexyl)phthalate Butylbenzylphthalate PAHs PCBs Arsenic Cadmium Manganese Mercury Nickel Zinc	Sediment	Benthic Macro-invertebrates	PAHs – As part of AUS OU – primary area of interest is in bay near Carterville. Cadmium – As part of AUS OU 069, MISCA Site 36. PCBs - To be considered in monitoring of Cell D under PCB OU. No further evaluation of other COPECs.
Survival and Growth of Amphibians and Reptiles		Surface Water	Amphibians and Reptiles	No (Uncertainty)

TABLE 1
SUMMARY OF RISK MANAGEMENT DECISIONS

Assessment Endpoint	COPEC	Medium[1]	Receptor of Interest	Further Work Recommended?
Survival, Growth and Reproduction of Fish	Bis(2-ethylhexyl)phthalate PCBs Pesticides Aluminum Iron Mercury Selenium	Surface Water and Biota	Fish	PCBs - To be considered in monitoring of Cell D under PCB OU. Pesticides - primary area of interest is eastern portion of lake (e.g., Cells C and D). To be evaluated as part of AUS OU Area 7. No further evaluation of other COPECs.
Survival, Growth, and Reproduction of Herbivorous Birds	PCBs Pesticides PAHs Phthalates Mercury Selenium	Surface Water and Sediment	Herbivorous birds	No: However, assessment endpoint should be considered in future problem formulation where specific COPECs are being further evaluated for other assessment endpoints.
Survival, Growth, and Reproduction of Herbivorous Mammals	PCBs Pesticides PAHs Phthalates Mercury Selenium	Surface Water and Sediment	Herbivorous mammals	No: However, assessment endpoint should be considered in future problem formulation where specific COPECs are being further evaluated for other assessment endpoints.

TABLE 1

SUMMARY OF RISK MANAGEMENT DECISIONS

Assessment Endpoint	COPEC	Medium[1]	Receptor of Interest	Further Work Recommended?
Survival, Growth, and Reproduction of Omnivorous Birds	PCBs Pesticides PAHs Phthalates Mercury Selenium	Surface Water and Sediment	Omnivorous birds	No: However, assessment endpoint should be considered in future problem formulation where specific COPECs are being further evaluated for other assessment endpoints.
Survival, Growth, and Reproduction of Omnivorous Mammals	PCBs Pesticides PAHs Phthalates Mercury Selenium	Surface Water and Sediment	Omnivorous mammals	No: However, assessment endpoint should be considered in future problem formulation where specific COPECs are being further evaluated for other assessment endpoints.
Survival, Growth, and Reproduction of Insectivorous Birds	PCBs Pesticides PAHs Phthalates Mercury Selenium	Sediment and Biota	Insectivorous birds	PCBs - To be considered in monitoring of Cell D under PCB OU. Pesticides - primary area of interest is eastern portion of lake (e.g., Cells C and D). To be evaluated as part of AUS OU Area 7. No further evaluation of other COPECs.

TABLE 1
SUMMARY OF RISK MANAGEMENT DECISIONS

Assessment Endpoint	COPEC	Medium[1]	Receptor of Interest	Further Work Recommended?
Survival, Growth, and Reproduction of Insectivorous Mammals	PCBs Pesticides PAHs Phthalates Mercury Selenium	Sediment and Biota	Insectivorous mammals	PCBs - To be considered in monitoring of Cell D under PCB OU. Pesticides - primary area of interest is eastern portion of lake (e.g., Cells C and D). To be evaluated as part of AUS OU Area 7. No further evaluation of other COPECs.
Survival, Growth, and Reproduction of Piscivorous Birds	PCBs Pesticides PAHs Phthalates Mercury Selenium	Sediment and Biota	Piscivorous birds	PCBs - To be considered in monitoring of Cells C and D, under PCB OU. Pesticides - primary area of interest is eastern portion of lake (e.g., Cells C and D). To be evaluated as part of AUS OU Area 7. No further evaluation of other COPECs.
Survival, Growth, and Reproduction of Piscivorous Mammals	PCBs Pesticides PAHs Phthalates Mercury Selenium TCDD	Sediment and Biota	Piscivorous mammals	PCBs - To be considered in monitoring of Cells C and D, and perhaps extended to other areas of the lake, all evaluated under PCB OU. Pesticides - primary area of interest is eastern portion of lake (e.g., Cells C and D). To be evaluated as part of AUS OU Area 7. No further evaluation of other COPECs.

[1] Indicates the primary medium in which risk was identified. This does not preclude examining other media as part of further evaluation (e.g., for evaluation of transport pathways)

Note: Based on results of the risk screening analysis, no further evaluation of human health risks will be conducted in Crab Orchard Lake. However, risk from consumption of fish is addressed by the State of Illinois in their ongoing fish sampling program and fish advisory.

ATTACHMENT 1 – ORAL TOXICITY SUMMARIES

Oral Toxicity of Bis(2-ethylhexyl)phthalate – Birds and Mammals

Oral Toxicity of Polychlorinated Biphenyls (PCBs) – Mammals

Oral Toxicity of Bis(2-ethylhexyl)phthalate - Birds and Mammals

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		30000	OHM/TADS
Rat	LD_{50}	Single Dose	Mortality		30600	RTECS, Environ. Health Perspec. 3:131, 1973
Rat	LD_{50}	Single Dose	Mortality		26000	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		14200	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		30000	RTECS, Internat. J. Abnormal Develop. 14:259, 1976
Rabbit	LD_{50}	Single Dose	Mortality		34000	OHM/TADS
Guinea Pig	LD_{50}	Single Dose	Mortality		26000	RTECS, IARC, 29:269, 1982
Rabbit	LD_{50}	15-day	Mortality	(gavage)	2000	Parmar et al 1988 as cited in ATSDR 1992
Guinea Pig	LD_{50}	15-day	Mortality	(gavage)	2000	Parmar et al 1988 as cited in ATSDR 1992
Dog	LOAEL	1-year	Cloudy & Enlarged Liver	0.09ml/kg-BW/day	88.7	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Rat	LOAEL	21-day	Fetotoxicity	7.14 g/kg-total dose	340	RTECS, Toxicol. Appl. Pharmacol. 26:253, 1973
Rat	LOAEL	10-day (gestation)	Fetotoxicity	10 g/kg-total dose	1000	RTECS, Indian J. Exper. Biol. 27:885, 1989
Rat	LOAEL	12-day (gestation)	Developmentary Abnormalities	9766 mg/kg-total dose	465	RTECS, Inter. J. Abnormal Develop. 35:41, 1987
Rat	LOAEL	20-day (gestation)	Fetal resorptions	(diet)	1055	Tyl et al. 1988 as cited in ATSDR 1992
Rat	LOAEL	90-day	Growth	1.5 g/kg-diet	130.5	HSDB, IARC, V29, 280, 1982
Rat	LOAEL	3-week	Liver & Kidney Weight	0.1%-diet	8694	HSDB, EPA Document 40-8226118
Rat	LOAEL	7-day	Survival	17.5 g/kg-total dose	2500	RTECS,Toxicol. Appl. Pharm. 61:205, 1981
Rat	LOAEL	6-week	Survival	59388 mg/kg-total dose	1414	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	17-week	Decreased Weight Gain	168 g/kg-total dose	1412	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	21-day	Liver Weight	19796 mg/kg-total dose	943	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	21-day	Liver Weight	25.2 g/kg-total dose	1200	RTECS, Toxicol. Appl. Pharm. 77:116, 1985
Rat	LOAEL	14-day	Liver Weight	14 g/kg-total dose	1000	RTECS, Toxicol. Letters 66:317, 1993
Rat	LOAEL	365-day	Decrease in body weight gain	(diet)	600	Marsmar et al 1988 as cited in ATSDR 1992
Rat	LOAEL	365-day	Decrease in body weight gain	(diet)	200	Carpenter et al as cited in ATSDR 1992

Oral Toxicity of Bis(2-ethylhexyl)phthalate - Birds and Mammals

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LOAEL	79-week	Decrease in body weight gain, increased liver weight	(diet)	1000	Tamura et al 1990 as cited in ATSDR 1992
Rat	LOAEL	102-week	Decrease in body weight gain	(diet)	100	Ganning et al 1991 as cited in ATSDR 1992
Rat	LOAEL	108-week	Decrease in body weight gain, increased liver weight	(diet)	1000	Roa et al 1990 as cited in ATSDR 1992
Rat	LOAEL	2-year	Testicular damage	(diet)	2000	Price et al. 1987 as cited in ATSDR 1993
Rat	LOAEL	2-year	Decreased body weight gain, increased liver, kidney weights	(diet)	200	Carpenter et al as cited in ATSDR 1992
Mouse	LOAEL	14-day	Survival	84 g/kg-total dose	6000	RTECS, Toxicol. Letters 66:317, 1993
Mouse	LOAEL	13-week	Survival	33852 mg/kg-total dose	372	RTECS, NTP-TR-217, 82
Mouse	LOAEL	103-week	Kidney & Pituitary Histopathology	6000 mg/kg-diet	1033	HSDB, Kluwe *et al*., 1982
Mouse	LOAEL	Gestation	Birth Defects, Maternal Weight Gain	0.2%-diet	34857	HSDB, Shiota & Nishimura, 1982
Mouse	LOAEL	8-day (gestation)	Decreased Litter Size	78.88 g/kg-total dose	9860	RTECS, Terat. Carcin. Mutagen. 7:29, 1987
Mouse	LOAEL	7-day (gestation)	Fetotoxicity	1 g/kg-total dose	143	RTECS, Environ. Health Prespect. 45:71, 1982
Mouse	LOAEL	17-day (gestation)	Fetal malformations	(diet)	91	Tyl et al. 1988 as cited in ATSDR 1992
Mouse	LOAEL	105-day	Reproduction	1000 mg/kg-diet	183.3	Lamb et al. 1987 as cited in Sample et al., 1996
Guinea pig	LOAEL	1-year	Liver weight	(diet)	52	Carpenter et al as cited in ATSDR 1992
Dog	NOAEL	1-year	Organ Weight & Liver Function	0.06ml/kg-BW/day	59.2	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Dog	NOAEL	1-year	Renal, hepatic function, growth	(capsule)	59	Carpenter et al as cited in ATSDR 1992
Rat	NOAEL	7-day	Histopathology	2%-diet	17405	HSDB, EPA Document #878210916, ihc# OTS026292, 1982
Rat	NOAEL	20-day (gestation)	Fetal Development	(diet)	357	Tyl et al. 1988 as cited in ATSDR 1992
Rat	NOAEL	90-day	Body Weight & Histopathology	7.5 g/kg-diet	579	HSDB, IARC, V29, 280, 1982
Rat	NOAEL	103-week	Survival	12000 mg/kg-diet	1044	HSDB, IARC, V29, 279, 1982
Rat	NOAEL	108-week	Weight gain, liver weights	(diet)	10	Roa et al 1990 as cited in ATSDR 1992

Oral Toxicity of Bis(2-ethylhexyl)phthalate - Birds and Mammals

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	NOAEL	1-year	Reproduction	(diet)	200	Carpenter et al. As cite in ATSDR 1992
Rat	NOAEL	2-year	Weight gain, liver and kidney weights	(diet)	65	Carpenter et al as cited in ATSDR 1992
Mouse	NOAEL	Gestation	Fetal Development	0.1%-diet	17429	HSDB, Shiota & Nishimura, 1982
Mouse	NOAEL	17-day (gestation)	Fetal malformations	(diet)	44	Tyl et al. 1989 as cited in ATSDR 1992
Mouse	NOAEL	105-day	Reproduction	100 mg/kg-diet	18.3	Lamb et al. 1987 as cited in Sample et al., 1996
Guinea pig	NOAEL	1-year	Liver weight	(diet)	16	Carpenter et al as cited in ATSDR 1992
Marmoset	NOAEL	14-day	Liver & Testes Effects	5mM/kg-BW/day	1953	HSDB, Rhodes, et al., Environ. Health Prespect. 65:299, 1986
Ringed Dove	NOAEL	4-weeks	Reproduction	10 mg/kg-diet	1.11	Peakall 1974 as cited in Sample et al., 1996

DEHP Density = 0.9864 g/ml, Reference is HSDB
DEHP Molecular Weight = 390.6, Reference is ASTER
Rat Average Body Weight (Chronic Exposure) = 0.3045 kg, Reference is USEPA, 1988, EPA 600/6-87/008
Rat Average Food Consumption (Chronic Exposure) = 0.0.0265 kg/day, Reference is USEPA, 1988, EPA 600/6-87/008
Mouse Average Body Weight (Chronic Exposure) = 0.0363 kg, Reference is USEPA, 1988, EPA 600/6-87/008
Mouse Average Food Consumption (Chronic Exposure) = 0.00625 kg/day, Reference is USEPA, 1988, EPA 600/6-87/008
Female Mouse Average Body Weight (Mature) = 0.035 kg, Reference is USEPA, 1988, EPA 600/6-87/008
Female Mouse Average Food Consumption (Mature) = 0.0061 kg/day, Reference is USEPA, 1988, EPA 600/6-87/008

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference
Rat	LD_{50}	Not Reported	1016	Mortality		2300	RTECS, National Technical Information Service PB85-143766
Rat (NS)	LD_{50}	Not Reported	1242	Mortality		794-1269	HSDB, USEPA, AWQCD: PCBs, p. C-35 (1980) EPA 440/5-80-068
Rat (NS)	LD_{50}	Single dose	1242	Mortality		800-8700	EPA 1980, NAS 1979 as cited in Eisler 1986
Mink	LD_{50}	Not Reported	1242	Mortality		3	Aulerich & Ringer 1977 as cited in Eisler 1986
Mink	LD_{50}	9 months	1242	Mortality	8.6 mg/kg diet	1.18	Ringer 1983 as cited in Eisler 1986
Rat (NS)	LD_{50}	Single dose	1248	Mortality		800-11,000	EPA 1980, NAS 1979 as cited in Eisler 1986
Rat	LD_{50}	Not Reported	1248	Mortality		11,000	RTECS, Annual Review of Pharmacology 14:139, 1974
Albino Mice (male)	LD_{100}	6.2 days	1254	100% Mortality	4000 ppm-diet	780	Sanders et. al. 1974 Bull. Environ. Contam. And Toxicol. 12:394-399
Rat	LD_{50}	Single dose	1254	Mortality		500 - 1400	Hudson et al. 1984 as cited in Eisler 1986
Rat	LD_{LO}	8-month	1254	Mortality	500 mg/kg-diet	40.8	EPA 440/5-80-068, 1980
Mouse (Male - ICR)	LD_{50}	2-week	1254	Mortality	in diet but conc. not provided	130	Sanders et al. 1974 as cited in ATSDR 1996
White-footed mouse	LD_{50}	3-week	1254	Mortality	>100 mg/kg-diet	>19.5	Sanders & Kirkpatrick 1977 as cited in Eisler 1986
Raccoon	LD_{50}	8-day	1254	Mortality	>50 mg/kg-diet	>2.5	Montz et al. 1982 as cited in Eisler 1986
Cottontail Rabbit	LD_{50}	12-week	1254	Mortality	>10 mg/kg-diet	>0.6	Zepp & Kirkpatrick 1976 as cited in Eisler 1986
Mink	LD_{50}	9-month	1254	Mortality	6.7 mg/kg-diet	0.92	Ringer et al. 1984 as cited in Eisler 1986
Rat	LD_{50}	Single dose	1260	Mortality		1300 - 10000	NAS 1979 as cited by Eisler 1986
Rat	LD_{50}	Single dose	1262	Mortality		1300 - 3200	EPA 1980, NAS 1979 as cited in Eisler 1986
Rat	LD_{50}	Single dose	1262	Mortality		11300	RTECS, Ann. Rev. Pharmacol., 1974
Mink	LOAEL	1 year	Total PCB	Reproduction and kit survival	1.5 ppm in fish diet (carp)	0.21	Hornshaw & Aulerich 1983 J. Toxicol. Environ. Health 11:933-946

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference
Mink	LOAEL	1 year	Total PCB	Reproduction and kit survival	0.66 ppm in fish diet (Perch scraps & sucker)	0.09	Hornshaw & Aulerich 1983 J. Toxicol. Environ. Health 11:933-946
Rat	LOAEL	21-day	1016	Fertility		2	RTECS, Toxicologist 12:320, 1992
Mink	LOAEL	18-month	1016	Kit Growth	25 mg/kg-diet	3.43	Aulerich & Ringer 1980 as cited in Sample et al. 1996
Mink	LOAEL	247-day	1016	Reproductive Succes and Postnatal Mortality	20 mg/kg-diet	2.75	Bleavins et al. 1980 as cited in IRIS 1996
Rat (S/D)	LOAEL	36 weeks	1242	Reproduction	150 ppm in diet	10.7	Jonsson et.al. 1976 Arch. Environ. Contam. Toxicol. 3:479-490
Pig	LOAEL	91-day	1242	Reduced Growth	20 mg/kg-diet	9.2	Hansen et al. 1976 as cited in ATSDR 1996
Pig	LOAEL	16 weeks	1242	Birth Weights		5.8	RTECS, Amer. J. of Veterinary Research 36:23, 1975
Ferret	LOAEL	9-month	1242	Reproductive failure	20 mg/kg-diet	1.4	Bleavins et al. 1980 as cited in Fuller & Hobson 1986
Mink	LOAEL	7-months	1242	Reproductive failure	5 ppm of diet	0.69	Bleavins et al. 1980 as cited in Sample et al. 1996
Rat	LOAEL	6-weeks	1248	Growth	1000 mg/kg-diet	81.5	Allen & Abrahamson 1973 as cited in NIOSH 1977
New Zealand Rabbit (Females)	LOAEL	4-weeks	1248	Growth of Offspring	250 mg/kg-diet	7.63	Thomas & Hinsdill 1980 as cited in IRIS 1996
Albino Mice (male)1	LOAEL	15 days	1254	60% mortality, weight loss, reduction of food consumption	1000 ppm-diet	131	Sanders et. al. 1974 Bull. Environ. Contam. And Toxicol. 12:394-399[a]
Rat (S/D)	LOAEL	10 days-gestation	1254	Fetal body weght and survival	100 ppm	7.94	Spencer 1982 Bull. Environ. Contam. Toxicol. 28:290-297[b]
Rat (Female W)	LOAEL	2-week	1254	Growth	in diet but conc. not provided	50	Kling et al. 1978 as cited in ATSDR 1996
Rat (W)	LOAEL	Gestation - Lactation	1254	Birth Weight, Growth, and Pup Survival	269 mg/kg-diet	13.5	Overman et al. 1987 as cited in IRIS 1996
Rat (S)	LOAEL	186-day	1254	Growth and Pup Survival	100 mg/kg-diet	7.2	Linder et al. 1974 as cited in IRIS 1996
Rat (S)	LOAEL	2-generation	1254	Reduced Litter Size	20 mg/kg-diet	1.5	Linder et al. 1974 as cited in IRIS 1996
Rat (W)	LOAEL	1-month	1254	Fertility, Litter Size, and Pup Survival	in diet but conc. not provided	30	Brezner et al. 1984 as cited in ATSDR 1996

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference
Rat (S/D)	LOAEL	10-day - gestation	1254	Fetal Body Weight and Survival	in diet but conc. not provided	5	Spencer 1982 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	104-week	1254	Decreased Survival	in diet but conc. not provided	2.5	NCI 1978 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	104-week	1254	Growth	in diet but conc. not provided	1.25	NCI 1978 as cited in ATSDR 1996
Rat (S)	LOAEL	8-month	1254	Growth	in diet but conc. not provided	36.4	Kimbrough et al. 1972 as cited in ATSDR 1996
Rat (W)	LOAEL	30-day	1254	Growth	in diet but conc. not provided	50.0	Kling et al. 1978 as cited in ATSDR 1996
Rat (W)	LOAEL	52-week	1254	Growth	in diet but conc. not provided	10	Phillips et al. 1972 as cited in ATSDR 1996
Rat (S/D)	LOAEL	10- gestation	1254	Decreased Fetal Weight	900 mg/kg-diet	21.5	HSDB, Spencer, Bull. Environ. Contam. Toxicol. 28:270, 1982
Rat (W)	LOAEL	9-week	1254	Fetal Reabsorption	70 mg/L in drinking water	9.7	Baker et al 1977 as cited in Fuller & Hobson 1986
Mouse (Female ICR)	LOAEL	108-days	1254	Decreased Conception	in diet but conc. not provided	2.5	Welsh 1985 as cited in ATSDR 1996
Pig	LOAEL	182-days	1254	Fewer Pigs	in diet but conc. not provided	1.0	Earl et al. 1974 as cited in Fuller&Hobson 1986
Dog (Beagle)	LOAEL	60-day	1254	Fetal Reabsorbtion	in diet but conc. not provided	5.0	Earl et al. 1974 as cited in Fuller&Hobson 1986
Dog (Beagle - male)	LOAEL	2-year	1254	Effects on Spermogenesis and Testes Size	100 mg/kg-diet	3.1	Kimbrough et al. 1973 as cited in Fuller & Hobson 1986
Mink	LOAEL	8-month	1254	Reproductive Failure	2 mg/kg-diet	0.27	Aulerich & Ringer 1977 as cited in IRIS 1996
Mink	LOAEL	6-month	1254	Offspring Mortality	1 mg/kg-diet	0.14	Wren et al. 1987 as cited in IRIS 1996
Mink	LOAEL	4-month	1254	Reproductive Failure	5 mg/kg-diet	0.69	Aulerich & Ringer 1977 as cited in Sample et al. 1996
Mink	LOAEL	28-day	1254	Growth	in diet but conc. not provided	1.8	Hornshaw et al. 1986 as cited in ATSDR 1996
Mink	LOAEL	90-day	1254	100% Stillbirths	in diet but conc. not provided	1.3	Kihlstrom et al. as cited in ATSDR 1996
White-Footed Mouse	LOAEL	2-3-weeks	1254	Frank Effect Level on Reproduction	400 mg/kg-diet	62	Sanders & Kirkpatrick 1975 as cited in Sample et al. 1996
White-Footed Mouse	LOAEL	60-day	1254	Reproductive Effects	200 mg/kg-diet	31	Merson & Kirkpatrick 1976 as cited in Sample et al. 1996

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference
White-Footed Mouse	LOAEL	18-month	1254	Reduced Litter Size	10 mg/kg-diet	1.35	Linzey 1987 as cited in Sample et al. 1996
Oldfield Mouse	LOAEL	12-month	1254	Reduced Litter Size and Pup Survival	5 mg/kg-diet	0.68	McCoy et al. 1995 as cited in Sample et al. 1996
Rat (Female S)	LOAEL	8-month	1260	Growth	in diet but conc. not provided	38.2	Kimbrough et al. 1972 as cited in ATSDR 1996
Rat (S)	LOAEL	67-day	1260	Litter Size	in diet but conc. not provided	35.4	Linder et al. 1974 as cited in ATDSR 1996
Female Brown Bat	LOAEL	40 days	1260	Mortality, body weight	1000 ppm in mealworm diet	139.10	Clark & Stafford 1981 J. Toxicol. Environ. Health 7:925-934
Rat	LOAEL	186-day	1260	Litter Size/Pup Survival	500 mg/kg-diet	40.8	Fuller&Hobson, Capt. 7 Vol 2 In PCBs and the Environ. CRC Press (1986)
Mink	NOAEL	90 days	236 HCB	Reproduction	5 ppm in diet	0.69	Aulerich et.al. 1985 J.Environ. Environ.Health 15:63-79
Mink	NOAEL	90 days	245 HCB	Reproduction	5 ppm in diet	0.69	Aulerich et.al. 1985 J.Environ. Environ.Health 15:63-79
Mice	NOAEL	18 days	2,4',5-TCB	Reproductive capacity	0.05mg/day (penut oil vehicle)	1.54	Orberg 1977 Ambio 6:278-280
Mice	NOAEL	18 days	2,2',4,4',5,5'-HCB	Reproductive capacity	0.05mg/day (penut oil vehicle)	1.54	Orberg 1977 Ambio 6:278-280
Mink	NOAEL	18-month	1016	Reproduction/Kit Growth	10 mg/kg-diet	1.37	Aulerich & Ringer 1980 as cited in Sample et al. 1996
Mink	NOAEL	39-week	1016	Reproduction/Kit Growth	2 mg/kg-diet	0.27	Aulerich & Ringer 1977 as cited in IRIS 1996
Ferret	NOAEL	9-month	1016	Reproduction	20 mg/kg-diet	1.4	Beavins et al. 1980 as cited in Fuller & Hobson 1986
Rat (S/D)	NOAEL	36 weeks	1242	Reproduction	75 ppm in diet	5.37	Jonsson et.al. 1976 Arch. Environ. Contam. Toxicol. 3:479-490
Rat (S/D)	NOAEL	2-month	1242	Growth	in diet but conc. not provided	1.5	Bruckner et al. 1974 as cited in ATSDR 1996
Rat (S/D)	NOAEL	10-day gestation	1242	Fertility of F1 generation	not specified	30	Gellart & Wilson 1979 as cited in Fuller & Hobson 1986
Mink	NOAEL	247-day	1242	Growth and Gastric Ulceration	2 mg/kg-diet	0.27	Bleavins et al. 1980 as cited in ATSDR 1996
Rat	NOAEL	8-week	1248	Growth	300 mg/kg-diet	24.5	HSDB, Quazi, et al., Agri. Biol. Chem. 48:1581-1586, 1984

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference
New Zealand Rabbit (Females)	NOAEL	4-week	1248	Reproduction/Growth of Offspring	100 mg/kg-diet	3.05	Thomas & Hinsdill 1980 as cited in IRIS 1996
Rat (Male F-344)	NOAEL	4-day	1254	Growth	in diet but conc. not provided	3.9	Carter 1984 as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	4-day	1254	Growth	in diet but conc. not provided	1.9	Carter 1985 as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	2-week	1254	Growth	in diet but conc. not provided	1.9	Carter & Koo 1984 as cited in ATSDR 1996
Rat (S/D)	NOAEL	10-day - gestation	1254	Fetal Body Weight and Survival	in diet but conc. not provided	2.5	Spencer 1982 as cited in ATSDR 1996
Rat (Female S/D)	NOAEL	5-month	1254	Growth	in diet but conc. not provided	4.3	Byrne et al. 1987 as cited in ATSDR 1996
Rat (Female S)	NOAEL	2-month	1254	Growth	in diet but conc. not provided	5.0	Goldstein et al. 1974 as cited in ATSDR 1996
Rat (W)	NOAEL	52-week	1254	Growth	in diet but conc. not provided	1	Phillips et al. 1972 as cited in ATSDR 1996
Rat (S)	NOAEL	8-month	1254	Growth	in diet but conc. not provided	7.5	Kimbrough et al. 1972 as cited in ATSDR 1996
Mouse (BALB/C)	NOAEL	11-month	1254	Growth	in diet but conc. not provided	49.8	Kimbrough & Linder 1974 as cited in ATSDR 1996
Mouse (ICR)	NOAEL	108-days through gestation	1254	Fertility, Litter Size, Devolpment, Growth	100 mg/kg-diet	12.5	Welsh 1985 as cited in IRIS 1996
Rabbit (NZ)	NOAEL	8-week	1254	Body Weight	in diet but conc. not provided	6.5	Street & Sharma 1975 as cited in ATSDR 1996
Cottontail rabbit	NOAEL	12 weeks	1254	Reproduction	10 ppm-diet	0.56	Zepp and Kirkpatrick 1976 J. Wildl. Manage. 40:491-495[c]
Cow	NOAEL	180-day	1254	Reproduction	1000 mg/day	3	HSDB, Willett, et al., Fundam. Appl. Toxicol. 9:60, 1987
Dog (Beagle)	NOAEL	60-day (Including gestation)	1254	No effects on reproduction		1.0	Earl et al. 1974 as cited in Fuller & Hobson 1986
Mink	NOAEL	90 days	1254	Survival	2.5 ppm in diet	0.34	Aulerich et.al. 1985 J.Environ. Environ.Health 15:63-79
Mink	NOAEL	4.5-month	1254	Reproduction	1 mg/kg-diet	0.14	Aulerich & Ringer 1977 as cited in Sample et al. 1996

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference
Mink	NOAEL	28-day	1254	Growth	in diet but conc. not provided	1.1	Hornshaw et al. 1986 as cited in ATSDR 1996
Rat	NOAEL	8-month	1254	Survival	200 mg/kg-diet	16.3	EPA 440/5-80-068, 1980
Rat (S)	NOAEL	2-generation	1254	Reproduction & Litter Size	5 mg/kg-diet	0.32	Linder et al. 1974 as cited in IRIS 1996
White-footed Mouse	NOAEL	21-day gestation	1254	Reproductive Effects	100 mg/kg-diet	15.45	Sanders & Kirkpatrick 1977 as cited in Fuller & Hobson 1986
Rabbit	NOAEL	15 weeks	1260	fertilzation rate	4 mg/kg BW (3 times/wk)	1.71	Seiler et.al. 1994 Human Reproduction 9:1920-1926[d]
Rat (Female S)	NOAEL	8-month	1260	Growth	in diet but conc. not provided	7.2	Kimbrough et al. 1972 as cited in ATSDR 1996
Rat (Male S)	NOAEL	8-month	1260	Growth	in diet but conc. not provided	38.2	Kimbrough et al. 1972 as cited in ATSDR 1996
Rat (S)	NOAEL	67-day	1260	Reproduction	in diet but conc. not provided	6.9	Linder, et al. 1974 as cited in ATSDR 1996
Rat (S)	NOAEL	367-day	1260	Growth	in diet but conc. not provided	5	Kimbrough et al. 1975 as cited in ATSDR 1996
Brown bat	NOAEL	28 days	1260	Litter weight and number of alive litter	6.36 ppm in diet (15mealworms/day)	0.88	Clark 1978 Bull. Environ. Contam. Toxicol. 19:707-724
Mink	NOAEL	198 days	1260	Reproduction	1.36 ppm wet wt in diet	0.19	Halbrook et.al. 1999 Environ.Toxicol.and Chem. 18:649-654[d]
Female Brown Bat	NOAEL	40 days	1260	Body weight	15 ppm in mealworm diet	2.09	Clark & Stafford 1981 J. Toxicol. Environ. Health 7:925-934
Big Brown Bat	NOAEL	22-day	1260	Survival & Growth	6.36 mg/kg-diet	0.885	TERRETOX, Clark Bull. Environ. Contam. Toxicol. 19:707-714, 1978

a= total dose (mg/kg BW) information obtained from manuscript. Dose per day was calculated just by dividing number of days.
b= PCB concentration, total amount of food intake per day, and body weight obtained from the manuscript
c= dose per day obtained from the manuscript. Average body weight (0.325 kg) from USEPA 1988, 1993
d= dose (mg/kg-BW/day) obtained from the manuscript
e=average body weight (1.246) as cited in Silvia and Downing 1995
f= Body weight information obtained from the manuscript
Average Cattle Body Weight = 329 kg Reference is USEPA, 1988 EPA/60/6-87/008
Adult Raccoon Body Weight = (average of male & female) = 5.616 kg; Reference is USEPA, 1993; EPA/600/R-93/187a
Adult Raccoon Food Consumption = (based on all mammals) = $0.0687 \times BW(kg)^{0.822}$, Reference is USEPA, 1993; EPA/600/R-93/187a
Mature Mink Body Weight = (average male & female) = 1.0195 kg; Reference is USEPA, 1993, EPA/600/R-93/187a
Mature Mink Food Consumption = (average male & female) = 0.14 kg/day, Reference is USEPA, 1993, EPA/600/R-93/187a

Oral Toxicity of Polychlorinated Biphenyls (PCBs) - Mammals

Test Species	Endpoint	Duration	Aroclor	Effect	Concentration	Dose (mg/kgBW-day)	Reference

Mature White Footed Mouse Body Weight = (average male & female) = 0.021 kg; Reference is USEPA, 1993, EPA/600/R-93/187a

Mature White-footed Mouse Food Consumption = (average male & female) = 0.195 g/g-BW/day, Reference is USEPA, 1993, EPA/600/R-93/187a

Adult Cottontail Rabbit Body Weight = (average of male & female) = 1.189 kg; Reference is USEPA, 1993; EPA/600/R-93/187a

Adult Cottontail Rabbit Food Consumption = (based on rodents) = 0.0621 x $BW(kg)^{0.564}$, Reference is USEPA, 1993; EPA/600/R-93/187a

Mature Rat Body Weight = (average male & female) = 0.325 kg, Reference is USEPA, 1987, EPA/600/6-87/008

Mature Rat Food Consumption = (average male & female) = 0.0265 kg/day, Reference is USEPA, 1987, EPA/600/6-87/008

Mature Sprague-Dawley Rat Body Weight = (average male & female) = 0.475 kg, Reference is USEPA, 1987, EPA/600/6-87/008

Mature Winstar Rat female body weight = 0.297 kg; Reference is USEPA, 1987, EPA/600/6-87/008

Mature Winstar Rat female water ingestion = 0.041 L/day; Reference is USEPA, 1987, EPA/600/6-87/008

Mature Sprague-Dawley Rat Food Consumption = (average male & female) = 0.034 kg/day, Reference is USEPA, 1987, EPA/600/6-87/008

White-Footed Mouse body weight = 0.022 kg; Reference is Green & Miller 1987 as cited in Sample et al. 1996

White-Footed Mouse food ingestion = 0.0034 kg/day; Reference is Green & Miller 1987 as cited in Sample et al. 1996

Average Pig Body Weight = 225 kg, Food Ingestion = 4.5 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008

New Zealand Rabbit female body = 3.93 kg; Reference is USEPA, 1988 EPA/60/6-87/008.

New Zealand Rabbit female food ingestion = 0.12 kg/day; Reference is USEPA, 1988 EPA/60/6-87/008.

Beagle Dog body weight = 14 kg; Reference is USEPA, 1988 EPA/60/6-87/008.

Beagle Dog body food ingestion = 0.435 kg/day; Reference is USEPA, 1988 EPA/60/6-87/008.

ATTACHMENT 2 – STATISTICAL ANALYSES

The attached tables contain statistical analyses of specific COPECs in Crab Orchard Lake and Little Grassy Lake (reference area) sediments. To select an appropriate 95 upper confidence limit (UCL) of the mean, data were first evaluated to determine if they were normally or lognormally distributed. This was done using the Shapiro-Wilks W-test for datasets smaller than 50 or the D'Agostino D-Test for datasets larger than 50 (Gilbert 1987). Based on the results of the data distribution, the following approach was used to calculate the 95% UCL of the mean (USEPA 1997):

- If the data were normally distributed, then the Student's *t* approach was used to develop the 95% UCL for the arithmetic mean of the dataset (USEPA 1997).

- If the data were lognormally distributed, lognormal-theory-based formulas were used to compute the mean variance unbiased estimator (MVUE) of the population mean and standard deviation, and the 95% UCL of the mean was calculated with the jackknife method (USEPA 1997b, Sokal and Rohlf 1981).

- If the data were neither normally nor lognormally distributed, then the nonparametric jackknife method was used to calculate the 95% UCL (USEPA 1997, Sokal and Rohlf 1981).

References:

Gilbert, R. O. 1987. *Statistical Methods for Environmental Pollution Monitoring.* Van Nostrand Reinhold Co., New York. 320 p.

Sokal, R.R., and F.J. Rolhf. 1981. *Biometry: The Principles and Practice of Statistics in Biological Research.* 2nd. Ed., W.H. Freeman and Co., San Francisco, CA. 859p.

USEPA 1997. *The Lognormal Distribution in Environmental Applications.* United States Environmental Protection Agency, Office of Research and Development and the Office of Solid Waste and Emergency Response. EPA/600/R-97/006.

Bis(2-ethylhexyl)phthalate

Little Grassy Lake Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPB

Sample#	Value	Qualifier
1	200	j
2	110	j
3	180	j
4	470	j
5	77	j
6	130	j
7	970	j
8	250	j
9	150	j
10	1100	j

Number of Values	10
Percent Detection	100.00%
Percent of Detections J-coded	100.00%

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis.

Raw Data Results	
Normal Mean	**3.64E+02**
Standard Deviation	3.71E+02
Coefficient of Variance (%)	102.11%
Maximum Detection	1.10E+03
Minimum Detection	7.70E+01
Maximum Non-detection[1]	All Detects
Minimum Non-detection[1]	All Detects
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.781
Calculated Value for dataset	0.736
90% UCL using CLT	5.14E+02
95% UCL using CLT	5.57E+02
Natural Log-Transformed Results	
MVUE of the log-mean	3.48E+02
Standard error of the log-mean[2]	1.23E+02
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Pass
Critical Value	0.842
Calculated Value for dataset	0.911
90% UCL of the MVUE[2]	5.11E+02
95% UCL of the MVUE[2]	**5.66E+02**
NonParametric Results	
Jackknifed Mean	3.64E+02
Jackknifed Standard Error	1.17E+02
90% UCL of the mean	5.26E+02
95% UCL of the mean	5.79E+02

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method

Bis(2-ethylhexyl)phthalate

Crab Orchard Lake Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier
1	130	J
2	160	J
3	180	J
4	110	J
5	110	J
6	3100	
7	190	J
8	230	J
9	170	J
10	110	J
11	560	J
12	120	J
13	100	J
14	110	J
15	170	J
16	260	J
17	110	J
18	63	J
19	81	J
20	90	J
21	150	J
22	67	J
23	320	U
24	250	U
25	100	J
26	110	J
27	275	U
28	325	U
29	220	J
30	210	J
31	340	U
32	1800	
33	160	J
34	310	J
35	94	J
36	305	U
37	2500	J
38	230	J
39	150	J
40	470	J
41	100	J
42	450	J

Number of Values	42
Percent Detection	85.71%
Percent of Detections J-coded	94.44%

The data are neither normally or log-normally distributed. There were a sufficient number of detected values to perform statistical analysis.

Raw Data Results	
Normal Mean	3.59E+02
Standard Deviation	6.19E+02
Coefficient of Variance (%)	172.35%
Maximum Detection	3.10E+03
Minimum Detection	6.30E+01
Maximum Non-detection[1]	3.40E+02
Minimum Non-detection[1]	2.50E+02
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.922
Calculated Value for dataset	0.453
90% UCL using CLT	4.82E+02
95% UCL using CLT	5.16E+02
Natural Log-Transformed Results	
MVUE of the log-mean	2.96E+02
Standard error of the log-mean[2]	6.72E+01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.942
Calculated Value for dataset	0.855
90% UCL of the MVUE[2]	3.79E+02
95% UCL of the MVUE[2]	4.05E+02
NonParametric Results	
Jackknifed Mean	3.59E+02
Jackknifed Standard Error	9.55E+01
90% UCL of the mean	4.84E+02
95% UCL of the mean	5.20E+02

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method

Manganese in Litte Grassy Lake

Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier
1	506	J
2	705	J
3	367	J
4	591	J
5	316	J
6	570	J
7	1190	J
8	431	J
9	516	J
10	749	J

Number of Values	10
Percent Detection	100.00%
Percent of Detections J-coded	100.00%

The data are best described as normally distributed and there were a sufficient number of detected values to perform a statistical analysis.

Raw Data Results	
Normal Mean	**5.94E+02**
Standard Deviation	2.50E+02
Coefficient of Variance (%)	42.04%
Maximum Detection	1.19E+03
Minimum Detection	3.16E+02
Maximum Non-detection[1]	All Detects
Minimum Non-detection[1]	All Detects
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Pass
Critical Value	0.781
Calculated Value for dataset	0.869
95% UCL using T-test	7.39E+02
Natural Log-Transformed Results	
MVUE of the log-mean	5.92E+02
Standard error of the log-mean[2]	7.75E+01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Pass
Critical Value	0.842
Calculated Value for dataset	0.972
90% UCL of the MVUE[2]	6.98E+02
95% UCL of the MVUE[2]	7.33E+02
NonParametric Results	
Jackknifed Mean	**5.94E+02**
Jackknifed Standard Error	7.90E+01
90% UCL of the mean	7.03E+02
95% UCL of the mean	7.39E+02

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method

Manganese in Crab Orchard Lake

Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier
1	629	
2	598	
3	370	
4	677	
5	728	
6	1470	E
7	1440	E
8	1070	E
9	464	
10	1290	E
11	660	
12	409	J
13	1050	
14	1340	
15	1180	
16	1310	
17	1040	
18	1030	
19	857	J
20	1380	
21	2010	
22	1190	
23	491	
24	638	
25	1010	
26	1850	
27	2310	
28	906	
29	713	
30	1170	
31	1590	
32	266	
33	692	
34	1640	
35	979	
36	1290	
37	967	
38	976	
39	907	
40	1030	
41	833	
42	1100	
43	538	
44	853	
45	1070	
46	996	
47	2630	

Number of Values	47
Percent Detection	100.00%
Percent of Detections J-coded	4.26%

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis.

Raw Data Results	
Normal Mean	1.056E+03
Standard Deviation	4.85E+02
Coefficient of Variance (%)	45.93%
Maximum Detection	2.63E+03
Minimum Detection	2.66E+02
Maximum Non-detection[1]	All Detects
Minimum Non-detection[1]	All Detects
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.927
Calculated Value for dataset	0.930
90% UCL using CLT	1.15E+03
95% UCL using CLT	1.17E+03
Natural Log-Transformed Results	
MVUE of the log-mean	1.06E+03
Standard error of the log-mean[2]	7.07E+01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Pass
Critical Value	0.946
Calculated Value for dataset	0.983
90% UCL of the MVUE[2]	1.15E+03
95% UCL of the MVUE[2]	1.181E+03
NonParametric Results	
Jackknifed Mean	1.06E+03
Jackknifed Standard Error	7.08E+01
90% UCL of the mean	1.15E+03
95% UCL of the mean	1.17E+03

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method

Cadmium

Crab Orchard Lake Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier
1	0.25	U
2	0.18	J
3	0.16	J
4	0.09	J
5	0.17	U
6	0.375	U
7	0.08	J
8	0.35	U
9	0.2075	U
10	0.4	U
11	0.18	U
12	0.12	J
13	2.9	
14	0.12	J
15	0.275	U
16	0.2275	U
17	0.35	U
18	0.275	U
19	0.275	U
20	2.2	
21	3.6	
22	4	
23	2.7	
24	0.1975	U
25	0.2225	U
26	0.25	U
27	0.425	U
28	2.1	
29	6.6	
30	1.1	
31	2.4	
32	0.375	U
33	0.2075	U
34	0.2475	U
35	0.275	U
36	2.7	
37	0.25	U
38	0.25	U
39	1.4	
40	0.275	U
41	0.275	U
42	0.225	U
43	2.8	
44	0.25	U
45	0.3	U
46	2.6	
47	0.275	U

Number of Values	47
Percent Detection	40.43%
Percent of Detections J-coded	31.58%

There are a sufficient number of values for statistical analysis, however, there is also less than 50% detection within the dataset.

Raw Data Results	
Normal Mean	9.68E-01
Standard Deviation	1.37E+00
Coefficient of Variance (%)	141.75%
Maximum Detection	6.60E+00
Minimum Detection	8.00E-02
Maximum Non-detection[1]	4.25E-01
Minimum Non-detection[1]	1.70E-01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.927
Calculated Value for dataset	0.650
90% UCL using CLT	1.22E+00
95% UCL using CLT	1.30E+00
Natural Log-Transformed Results	
MVUE of the log-mean	8.70E-01
Standard error of the log-mean[2]	2.23E-01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.946
Calculated Value for dataset	0.840
90% UCL of the MVUE[2]	1.15E+00
95% UCL of the MVUE[2]	1.24E+00
NonParametric Results	
Jackknifed Mean	9.68E-01
Jackknifed Standard Error	2.00E-01
90% UCL of the mean	1.23E+00
95% UCL of the mean	1.30E+00

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method

Cadmium in all samples (<3.2 mg/kg)

Crab Orchard Lake Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier
1	0.08	J
2	0.09	J
3	0.12	J
4	0.12	J
5	0.16	J
6	0.18	J
7	0.17	U
8	0.18	U
9	0.1975	U
10	0.2075	U
11	0.2075	U
12	0.2225	U
13	0.225	U
14	0.2275	U
15	0.2475	U
16	0.25	U
17	0.25	U
18	0.25	U
19	0.25	U
20	0.25	U
21	0.275	U
22	0.275	U
23	0.275	U
24	0.275	U
25	0.275	U
26	0.275	U
27	0.275	U
28	0.3	U
29	0.35	U
30	0.35	U
31	0.375	U
32	0.375	U
33	0.4	U
34	0.425	U
35	1.1	
36	1.4	
37	2.1	
38	2.2	
39	2.4	
40	2.6	
41	2.7	
42	2.7	
43	2.8	
44	2.9	

Number of Values	44
Percent Detection	36.36%
Percent of Detections J-coded	37.50%

There are a sufficient number of values for statistical analysis, however, there is also less than 50% detection within the dataset.

Raw Data Results	
Normal Mean	**7.11E-01**
Standard Deviation	9.13E-01
Coefficient of Variance (%)	128.37%
Maximum Detection	2.90E+00
Minimum Detection	8.00E-02
Maximum Non-detection[1]	4.25E-01
Minimum Non-detection[1]	1.70E-01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.924
Calculated Value for dataset	0.617
90% UCL using CLT	8.87E-01
95% UCL using CLT	9.37E-01
Natural Log-Transformed Results	
MVUE of the log-mean	6.41E-01
Standard error of the log-mean[2]	1.49E-01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.944
Calculated Value for dataset	0.819
90% UCL of the MVUE[2]	8.28E-01
95% UCL of the MVUE[2]	8.84E-01
NonParametric Results	
Jackknifed Mean	7.11E-01
Jackknifed Standard Error	1.38E-01
90% UCL of the mean	8.90E-01
95% UCL of the mean	**9.42E-01**

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method

Selenium

Crab Orchard Lake Sediment

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier
1	0.57	J
2	0.57	J
3	0.92	J
4	0.78	
5	1.2	J
6	2.5	
7	0.88	J
8	0.27	J
9	0.83	J
10	0.92	
11	0.68	J
12	0.75	J
13	2.3	
14	2.2	
15	0.78	J
16	0.5	J
17	1.3	
18	0.81	J
19	0.72	J
20	0.58	J
21	0.71	J
22	1.8	
23	2	
24	1.5	
25	0.73	J
26	0.99	
27	0.33	J
28	0.44	J
29	1	
30	1.5	
31	0.85	
32	2.4	
33	1.5	J
34	0.7	J
35	1.6	
36	0.55	U
37	2.4	
38	0.5	U
39	0.3	J
40	1.4	
41	0.53	J
42	0.32	J
43	0.55	U
44	0.43	J
45	2.9	
46	1.2	
47	0.96	J

Number of Values	47
Percent Detection	93.62%
Percent of Detections J-coded	56.82%

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis.

Raw Data Results	
Normal Mean	**1.07E+00**
Standard Deviation	6.71E-01
Coefficient of Variance (%)	62.91%
Maximum Detection	2.90E+00
Minimum Detection	2.70E-01
Maximum Non-detection[1]	5.50E-01
Minimum Non-detection[1]	5.00E-01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Fail
Critical Value	0.927
Calculated Value for dataset	0.866
90% UCL using CLT	1.19E+00
95% UCL using CLT	1.23E+00
Natural Log-Transformed Results	
MVUE of the log-mean	1.07E+00
Standard error of the log-mean[2]	1.02E-01
Tested for Normality using the	W-Test
Normality Test Result (alpha = 0.05)	Pass
Critical Value	0.946
Calculated Value for dataset	0.965
90% UCL of the MVUE[2]	1.20E+00
95% UCL of the MVUE[2]	**1.24E+00**
NonParametric Results	
Jackknifed Mean	1.07E+00
Jackknifed Standard Error	9.79E-02
90% UCL of the mean	1.19E+00
95% UCL of the mean	1.23E+00

UCL - Upper confidence limit of the mean
CLT - Central Limit Theorum
MVUE - Minimum Variance Unbiased Estimate
[1] = 1/2 the reporting limit
[2] = using the jackknife method