Health Consultation

ARSENIC AND LEAD CONTAMINATION IN SOIL, SURFACE WATER, AND SEDIMENT

SPRING MEADOWS LAKE SITE

HELENA, LEWIS AND CLARK COUNTIES, MONTANA

APRIL 11, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared by:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
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Background

The Montana Department of Environmental Quality (DEQ) asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review and evaluate environmental data for public health significance at the Spring Meadow Lake site (the site) in Helena, Montana [1]. The purpose of this health consultation was to determine whether the soil, sediment, and surface water contamination at the site poses a health hazard for:

- recreational users who play, walk, hike, and birdwatch;
- recreational users who swim in the Spring Meadow Lake in the summer; and
- school children who collect environmental samples.

The site is located on the western edge of Helena and consists of 2 main areas of approximately 20 acres: the Spring Meadow State Park and the Montana Wildlife Center. From the early 1900s until the early 1980s, the site was used for mineral processing and sand and gravel mining. The Montana Department of Fish, Wildlife, and Parks (FWP) acquired the land for the Spring Meadow State Park area in 1981 and the Wildlife Center area in 1995 [2]. In 2004, DEQ completed a site inspection and hazardous material inventory and estimated that approximately 10,000 cubic yards of tailing and other mineral processing wastes are located within the site boundary. Contaminated media include surface water, surface and subsurface soil, and sediment. The major contaminants are metals such as arsenic and lead. In 2005, DEQ prepared a Reclamation Investigation (RI) and Expanded Engineering Evaluation and Cost Analysis (EEE/CA) to address environmental impacts associated with the disposal of the mineral processing wastes. The concentrations of arsenic and lead exceeded the Montana DEQ Remediation Division cleanup levels. Human exposure and risk assessments indicated that the site contained arsenic concentrations that pose a potential risk to human health. DEQ is in the process of making site reclamation and cleanup decisions [2].

Discussion

Analytical data were provided by DEQ for the Spring Meadow Lake site. One hundred fifty-three soil samples, 18 sediment samples, and 15 surface water samples were available for this review. Samples were analyzed for metals using inductively coupled plasma-atomic emission spectrometry (ICP-AES). Except for arsenic and lead, the levels of the detected metals were below their applicable comparison values (CVs). CVs are media-specific concentrations considered safe under a default exposure scenario. ATSDR uses them as screening values to identify site-specific contaminants that require further evaluation to determine their potential for adverse health effects. Therefore, only arsenic and lead will be discussed further.

On the basis of the probable site exposure scenarios, ATSDR grouped the environmental data into 4 categories:

- Spring Meadow Lake (Main Body) surface water and sediment sampling data
- Spring Meadow Lake (East Arm) surface water and sediment sampling data
- Montana Wildlife Center area soil sampling data
- Spring Meadow Lake East Arm area soil sampling data

Spring Meadow Lake (Main Body) surface water and sediment sampling data

Nine surface water and 8 sediment samples were taken from the main body of Spring Meadow Lake (Table 1). The highest concentration of arsenic detected was 0.019 milligrams per liter (mg/L) in surface water and 136 milligrams per kilogram (mg/kg) in the sediment. Lead was not detected in surface water samples at the reported method detection limit (MDL) of 0.003 mg/L. The maximum and average lead concentrations in the sediment samples were 319 mg/kg and 79 mg/kg, respectively.

The maximum surface water concentration of arsenic (0.019mg/L) exceeded the ATSDR chronic environmental media evaluation guides **(**EMEGs) for both children (0.003 mg/L) and adults (0.01 mg/L) [3]. ATSDR considers chronic EMEGs to be safe levels for people ingesting 2 liters of water on a daily basis for more than 1 year [3]. However, recreational park users are most likely to be exposed to arsenic in surface water through incidental ingestion of contaminated water (about 20–30 mL for each episode) or through dermal contact while swimming in summer. Arsenic is not easily absorbed through the skin into the human body; thus, infrequent exposure to surface water containing less than 0.5 mg/L of arsenic is not likely to result in any adverse health effects for the general population [4].

ATSDR used the soil chronic EMEG of 200 mg/kg for arsenic as the CV for sediment exposure scenarios. Arsenic levels in the sediments were below the CV; therefore, exposure to sediment is not likely to result in adverse health effects for the general population participating in recreational activities.

Exposure to lead in the surface water and sediment at the main body of the Spring Meadow Lake is not a concern. Lead was not detected in the surface water and lead concentrations in the sediment were below 400 mg/kg. ATSDR considers that soil levels above 400 mg/kg would require further evaluation (see the section on Child Health Considerations) [5].

Table 1. Spring Meadow Lake (main body) surface water and sediment sampling data

Sample ID	Sample Date	Sample Media	Unit	Arsenic	Lead
SW 103	7/2004	surface water	mg/L	0.017	< 0.003
SW104	7/2004	surface water	mg/L	0.017	< 0.003
SW105	7/2004	surface water	mg/L	0.017	< 0.003
SW106	7/2004	surface water	mg/L	0.016	< 0.003
SW107	7/2004	surface water	mg/L	0.017	< 0.003
SW108	7/2004	surface water	mg/L	0.017	< 0.003
SW109	7/2004	surface water	mg/L	0.019	< 0.003
SW111	7/2004	surface water	mg/L	0.017	< 0.003
SW202-TM	8/2005	surface water	mg/L	0.012	< 0.003
SW202-DM	8/2005	surface water	mg/L	0.011	< 0.003
SD103	7/2004	sediment	mg/kg	<10	31
SD106	7/2004	sediment	mg/kg	<10	16
SD107	7/2004	sediment	mg/kg	10	14
SD108	7/2004	sediment	mg/kg	<10	39
SD109	7/2004	sediment	mg/kg	136	105
SD111	7/2004	sediment	mg/kg	12	38
SD207	4/2005	sediment	mg/kg	105	70
SD208	4/2005	sediment	mg/kg	110	319

mg/L = milligrams per liter (parts per million)
mg/kg = milligrams per kilogram (parts per million)
TM = total recoverable metal analysis
DM = dissolved metal analysis
< = less than the reported method detection limit (MDL) of 0.003mg/L

Spring Meadow Lake (East Arm) surface water and sediment sampling data

Five surface water and 5 sediment samples were collected from the East Arm area of Spring Meadow Lake (Table 2). The highest concentration of arsenic in the surface water was 0.032 mg/L. The maximum and average concentrations of arsenic detected in sediment were 2,130 and 599 mg/kg, respectively. Lead was not found in surface water samples at the method detection limit (MDL) of 0.003 mg/L. The maximum and average lead concentrations in the sediment samples were 1,478 mg/kg and 555 mg/kg, respectively. As previously noted, exposure to surface water and sediment containing arsenic and lead at these levels is not likely to result in any adverse health effects for the general population participating in recreational activities.

However, because the East Arm area is relatively shallow and arsenic and lead concentrations were high in the sediment, incidental ingestion of contaminated sediment might result in harmful doses for sensitive populations such as preschool children and children with pica behavior (see discussion in the next section).

Table 2. Spring Meadow Lake (East Arm) surface water and sediment sampling data (mg/L)

Sample ID	Sample Date	Sample Media	Unit	Arsenic	Lead
SW102	7/2004	surface water	mg/L	0.017	< 0.003
SW110	7/2004	surface water	mg/L	0.240	<0.003
SW112	7/2004	surface water	mg/L	0.020	< 0.003
SW201-TM	4/2005	surface water	mg/L	0.012	<0.003
SW201-DM	4/2005	surface water	mg/L	0.012	< 0.003
SW203-TM	4/2005	surface water	mg/L	0.032	< 0.003
SW203-DM	4/2005	surface water	mg/L	0.030	0.005
SD102	7/2004	sediment	mg/kg	10	79
SD110	7/2004	sediment	mg/kg	2130	1478
SD112	7/2004	sediment	mg/kg	726	1030
SD201	7/2004	sediment	mg/kg	95	135
SD202	4/2005	sediment	mg/kg	34	53
SD203	4/2005	sediment	mg/kg	19	64
SD204	4/2005	sediment	mg/kg	32	163
SD205	4/2005	sediment	mg/kg	31	130
SD206	4/2005	sediment	mg/kg	20	70
SD301	6/2005	sediment	mg/kg	15	27
SD302	6/2005	sediment	mg/kg	50	53
SD303	6/2005	sediment	mg/kg	17	28

mg/L = milligram per liter (parts per million)
mg/kg = milligram per kilogram (parts per million)
TM = total recoverable metal analysis
DM = dissolved metal analysis
< = less than the reported MDL of 0.003mg/L

Montana Wildlife Center area soil sampling data

The Montana Wildlife Center opened in March 2004 and certain areas are open to the public for recreational uses and to school children for outdoor environmental class activities. Twenty-nine soil samples were available for the Montana Wildlife Center area. Arsenic concentrations ranged from less than 10 to 57,500 mg/kg, with an average surface soil[1] concentration of 5,554 mg/kg. The range of lead concentrations ranged from 18–39,000 mg/kg, with a surface soil average of 3,222 mg/kg (Table 3).

[1] Samples taken at depths from zero to three quarters of a foot (0–23 cm) below the ground surface

Table 3. Montana Wildlife Center area soil sampling data (mg/kg)

Sample ID	Sample Date	Depth (ft)	Arsenic	Lead
TP104-1	7/2004	1	2,910	2,410
TP104-1.2	7/2004	1.2	2,640	2,320
TP106	7/2004	1	20,700	5,220
TP107-4	7/2004	4	27,000	39,000
TP107-5	7/2004	5	1,250	2,730
TP109	7/2004	12	57,500	28,600
TP111	7/2004	2	34,200	23,100
TP113	7/2004	1	451	819
TP115	7/2004	2	5,890	4,260
TP116	7/2004	4.5	951	915
TP120-1	7/2004	1	2,920	2,480
TP120-3	7/2004	3	222	1,970
TP170A	4/2005	0.3–0.5	<10	18
TP170B	4/2005	1.67–2.33	50	567
TP170C	4/2005	2.67–3.17	61	60
TP171A	4/2005	0.17–1	33,700	16,300
TP171B	4/2005	1–1.67	59	60
TP171C	4/2005	2.5–3	43	31
TP172A	4/2005	1.5–1.67	30	52
TP173A	4/2005	0–0.75	158	1,209
TP173B	4/2005	0.83–1.67	1240	3,010
TP173C	4/2005	1.83–2	54	27
TP174A	4/2005	0–0.67	76	298
TP174B	4/2005	1.17–1.33	65	55
TP174C	4/2005	1.5–1.67	11	84
TP174D	4/2005	2.5–2.67	39	33
SS204	7/2004	0.5	302	468
SS206	7/2004	0.1	2,430	2,160
SS207	7/2004	0.1	2,200	2,120

mg/kg = milligram per kilogram
< = less than the reported MDL of 10 mg/kg

To determine whether harmful effects might occur from acute and chronic exposures to arsenic, ATSDR reviewed numerous studies documenting the effects of arsenic in humans. Several factors should be considered when evaluating the potential for harm associated with arsenic in soil, including its bioavailability, pica-like behavior in children, and carcinogenic effects.

Small children and children with soil-pica behavior are a special concern for acute exposures because ingesting large amounts of soil/sediment could lead to significant arsenic exposure. Children who eat large amounts of soil exhibit soil-pica behavior. Soil-pica behavior is most likely in preschool children as part of their normal exploratory activities. General pica behavior is greatest in children aged 1–2 years and decreases with age [6–8]. This behavior occurs in as little as 4% or as much as 21% of children [9–12]. For this health consultation, ATSDR used a range of soil intake of 600–5000 milligrams (about $^{1}/_{8}$–1 teaspoon) of soil to estimate exposure for soil-pica children [13–15]. ATSDR used the average surface soil arsenic concentration (5,554 mg/kg) to calculate and compare the doses to acute and chronic minimum risk levels (MRLs). The estimated doses are listed in Table 4.

Table 4. Estimated arsenic doses from ingestion of arsenic–contaminated soil in the Montana Wildlife Center area

Population	Soil intake (mg/day)	Exposure Factor	Body weight (kg)	Estimated dose (mg/kg/day)	Acute MRL (mg/kg/day)
Adult	100	0.28	70	0.0009	0.005
Preschool child	200	0.28	16	0.0082	0.005
Elementary school child	200	0.28	36	0.0036	0.005
Pica-child	600	1	11	0.1272	0.005
Pica-child	1,000	1	11	0.2121	0.005
Pica-child	3,000	1	11	0.2726	0.005
Pica-child	5,000	1	11	1.0630	0.005

Formula used to estimate the daily intake (ID): ID = concentration × soil intake × bioavailability factor × exposure factor/body weight
Bioavailability factor assumed to be 42% based on an EPA study [16]
Exposure factor assumed to be 0.28 based on an exposure frequency of 2 days/week for the general population
MRL = minimum risk level

ATSDR developed a provisional acute and chronic oral MRL for arsenic of 0.005 mg/kg per day and 0.0003 mg/kg per day, respectively. The MRL is an exposure level below which noncancerous harmful effects are unlikely. The acute MRL is based on several transient effects, including nausea, vomiting, and diarrhea. It should be noted that

- the acute MRL is 10 times below the levels known to cause harmful effects in humans
- the acute MRL is based on people exposed to arsenic dissolved in water, and not arsenic in soil—a fact that might influence how much arsenic can be absorbed
- the chronic MRL of 0.0003 mg/kg per day is about 46 times below the lowest observed adverse effect level (LOAEL) of 0.014 mg/kg per day [3].

It is unlikely that adults and children undertaking general activities (walking, hiking, birdwatching, and collecting environmental samples) at the Montana Wildlife Center will experience harmful effects from arsenic in soil. However, children who eat excessive amounts of soil (more than 600 mg/day), and who play in and ingest soil from the area with the highest arsenic levels might receive a dose exceeding the acute MRL and the dose that caused temporary harmful effects in a human study [17].

ATSDR concurs with the RI and EEE/CA human risk assessment that a low increased cancer risk (1 to 2 extra cases per 10,000 people exposed) exists for people who use the area for long-term recreational activities. No significant increase in cancer risk would be expected for a short-term (i.e., 2 years) recreational exposure prior to remedial cleanup).

ATSDR considers that soil lead levels above 400 mg/kg need further evaluation because of the unique susceptibility of children [5]. The range of soil lead concentrations was 18–39,000 mg/kg, with a surface soil average of 3,222 mg/kg at the Montana Wildlife Center. If they are in areas where contact with soil is frequent, such as play areas with bare surface soil, these sample hot spots might present a health hazard for children.

Spring Meadow Lake East Arm area soil sampling data

Thirty-four soil samples were available for the Spring Meadow Lake East Arm area. The range of arsenic concentrations was 21–10,400 mg/kg, with a surface soil average of 811mg/kg (Table 5). Lead concentrations ranged from 20–6,180 mg/kg, with a surface soil average of 665 mg/kg.

Table 5. Spring Meadow Lake East Arm Area Soil sampling data (mg/kg)

Sample ID	Sample Date	Depth (ft)	Arsenic	Lead
TP119	7/2004	1	8,980	5,840
TP126	7/2004	2	3,280	1,920
TP127-2	7/2004	2	1,240	690
TP127-4	7/2004	4	163	95
SS216	7/2004	0.5	1,520	1,340
TP151	4/2005	0–0.5	219	154
TP152	4/2005	0–0.67	54	140
TP153A	4/2005	0–0.5	329	247
TP153B	4/2005	1.5–2	< 50	89
TP154A	4/2005	0.67–1.5	879	998
TP154B	4/2005	5–5.5	44	72
TP155A	4/2005	0–0.33	434	677
TP155B	4/2005	1.5– 2	37	75
TP156A	4/2005	0.83–1	101	83
TP156B	4/2005	3–3.5	624	572
TP157A	4/2005	0.33–0.5	180	146
TP157B	4/2005	2–3	45	37
TP158A	4/2005	0.5–0.75	1,460	1,310
TP158B	4/2005	2.33–2.67	62	76
TP159A	4/2005	0.33–0.5	1,290	926

TP160A	4/2005	0.33–0.5	5,400	3,330
TP161A	4/2005	0–0.5	804	614
TP162A	4/2005	0–0.17	126	269
TP162B	4/2005	3–3.5	100	115
TP163A	4/2005	0–0.5	172	189
TP164A	4/2005	0–0.33	754	1,220
TP164B	4/2005	1.33–2	461	373
TP165A	4/2005	0.33–0.5	502	389
TP166A	4/2005	0–0.33	570	537
TP166B	4/2005	1–1.5	26	20
TP167A	4/2005	1.17–1.67	10,400	6,180
TP167B	4/2005	1.83–2	101	82
TP168A	4/2005	0.17–0.5	37	37
TP168B	4/2005	1.5–2	21	30
TP168C	4/2005	2.17–5	110	108
TP169A	4/2005	0–0.5	781	590
TP169B	4/2005	0.5–1.5	609	496

< = less than the reported MDL of 50 mg/kg

As discussed previously, children, especially those with soil-pica behavior, are a special concern for acute exposures at this area. ATSDR used the average surface soil arsenic concentration of 811 mg/kg to calculate the estimated arsenic doses from ingestion of arsenic-contaminated soil in the East Arm area (Table 6).

Table 6. Estimated arsenic doses from ingestion of contaminated soil in the East Arm area

Population	**Soil Intake (mg/day)**	**Exposure Factor**	**Body weight (kg)**	**Estimated Dose (mg/kg/day)**	**Acute MRL (mg/kg/day)**
Adults	100	0.28	70	0.0001	0.005
Preschool children	200	0.28	16	0.0012	0.005
Elementary school children	200	0.28	36	0.0005	0.005
Pica-children	600	1	11	0.0186	0.005
Pica-children	1,000	1	11	0.0310	0.005
Pica-children	3,000	1	11	0.0929	0.005
Pica-children	5,000	1	11	0.2548	0.005

Formula used to estimate the daily intake (ID): ID = concentration × soil intake x bioavailability factor × exposure factor/body weight
Bioavailability factor assumed to be 42% based on an EPA study [16]
Exposure factor assumed to be 0.28 based on an exposure frequency of 2 days/week for the general population
MRL = minimum risk level

The dose calculations indicate that adults and children who engage in general activities at the East Arm area are unlikely to experience harmful effects from exposure to arsenic in the soil. Children who eat excessive amounts of soil (more than 600 mg/day), play in, and ingest soil from parts of the area with the highest arsenic levels might exceed the acute MRL and the dose that caused temporary harmful effects in a human study [17]. No significant increase in cancer risk would be expected from a short-term exposure at this area.

In the East Arm area, the range of lead concentrations was 20–6,180 mg/kg, with a surface soil average of 665 mg/kg. If these sample hot spots are in areas where contact with soil is frequent, such as play areas with bare surface soil, these sample hot spots might present a health hazard for children.

Child Health Considerations

ATSDR recognizes the unique vulnerabilities of children from exposure to contaminants in their environment. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than adults and therefore breathe dust, soil, and vapors closer to the ground. A child's smaller size and higher intake rate result in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children could sustain permanent damage. ATSDR has considered these factors in its conclusions and recommendations for this site. The CVs used in this health consultation represent exposures that could be continued for a lifetime without appreciable health risks for the general population—including potentially susceptible subgroups such as children.

Conclusions

On the basis of the available environmental data, ATSDR concludes the following:

- General activities will not produce exposures that pose an acute or intermediate public health hazard. Arsenic and lead exposures from swimming in Spring Meadow Lake and hiking and playing in the Spring Meadow Park and the Montana Wildlife Center within the next 2 years are not expected to result in harmful health effects for most park users.

- School children who collect environmental samples at the site are unlikely to experience harmful effects from arsenic and lead in soil, sediment, or surface water.

- Specific activities for sensitive populations pose a potential public health hazard. Pica children could get acute arsenic toxicity from a one-time exposure to soil and sediment in the areas to be remediated and at a few of the soil or sediment hot spots. Lead concentrations in surface soil at the site also present a health concern to children who frequently play in the high concentration areas.

There is a small increased risk (1 to 2 extra cases per 10,000 people exposed) of developing cancer for the people recreating for long periods in the contaminated areas. No significant increase in cancer risk would be expected for a short-term exposures (i.e., 2 years of recreational exposure before remedial cleanup).

ATSDR classifies this site as a public health hazard, as sensitive populations (pica children) could get acute arsenic toxicity from a one-time exposure to soils at the site.

Recommendations

- Post signs that restrict children from using the highly contaminated areas and advise people to wash their hands before eating and drinking.

- Remediation or removal of contaminated soil at the site is needed to minimize exposures to arsenic and lead.

- Develop a comprehensive site safety and health plan for remedial activities that addresses all potential health and physical hazards associated with the actions selected.

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