Agency for Toxic Substances & Disease Registry

Public Health Assessments & Health Consultations

PUBLIC HEALTH ASSESSMENT

SANDOVAL ZINC COMPANY
SANDOVAL, MARION COUNTY, ILLINOIS

SUMMARY

The Illinois Department of Public Health (IDPH) completed a public health assessment (PHA) for the Sandoval Zinc site on May 4, 1995. Since the release of the 1995 PHA, several site activities have taken place. IDPH has reviewed and evaluated information from these activities, and offers new conclusions and recommendations for the site.

Overall, the Sandoval Zinc site poses no apparent public health hazard to most of the population in Sandoval. The site may be a public health hazard to preschool children with excessive hand-to-mouth activity exposed to residential surface soils with high levels of lead. However, blood sample results from children in a day care near the site did not show elevated levels of lead.

Based on current conditions, IDPH makes the following recommendations:

1. Continue efforts to prevent trespassing on the site.
2. Continue educational efforts on methods to reduce exposure to metals in the residential environment.
3. Use procedures to minimize dust during on-site remedial operations.

PURPOSE

The Illinois Department of Public Health (IDPH) has reviewed information about several activities at the Sandoval Zinc site that have taken place since the release of the May 4, 1995, public health assessment and offers updated conclusions and recommendations for the site.

BACKGROUND

The Sandoval Zinc site occupies about 13 acres southeast of Sandoval in Marion County, Illinois. It is an abandoned primary and secondary zinc smelter that was next to a coal mining operation. Primary smelting, including processing of zinc ores and associated trace metals, occurred from 1885 to 1915. From 1916 until the facility closed in 1985, the main operation was recycling used metal through secondary smelting. Coal was the primary fuel used to fire the smelting furnaces. Smelting waste may have been transported off the site and used as fill in Sandoval and other nearby communities. Airborne emissions occurred during regular operations and accidental fires. Surface water runoff transported wastes from the site into adjacent ditches, creeks, ponds, and farm properties.

The Illinois Environmental Protection Agency (Illinois EPA) sealed the site by court order in 1991. In spite of fencing and posted signs, trespassing continued. The site is not visible from the main roads or businesses. Most of the Sandoval residential area is west of Highway 51

(Attachment 1). Some small businesses are about one-half mile west of the site along Highway 51. A day care center with about 125 children enrolled is among those commercial properties. The nearest home is north of Route 50, less than 0.5 miles northeast of the site. The population of Sandoval in 1990 was 1,535.

As recorded in the 1995 IDPH PHA, the environmental data available at that time showed that high levels of metals existed on or near the site. IDPH was concerned about the community because of the persistent and cumulative nature of some metals, including lead and zinc, associated with the site. IDPH used on-site concentrations to estimate exposure doses for children, teenagers, and adults trespassing onto the site. Estimated doses for children exceeded several health guidelines, but estimated doses for teenagers and adults did not. The contaminant of greatest concern was lead.

Recommendations of the 1995 PHA included:

Cease/Reduce Exposure Recommendations:

1. The site properties need to be adequately secured and monitored on a regular basis to prevent access to wastes.
2. Education of residents should continue regarding methodologies to minimize exposures to environmental contamination. School parent-teacher organizations, parents, and operators of local day care centers should be contacted to alert them of any potential exposure risks.

Site Characterization Recommendations:

1. Surface soil samples in the nearest residential bare soils, including the day care, should be analyzed for heavy metals to rule out any potential for exposure.
2. Some individual households with older workers and young children should be included in a program of dust analyses. If contaminants are found in significant concentrations in homes, education should be provided to instruct residents how to reduce heavy metal sources in interior environments.
3. Blood lead analyses of area residents should be reviewed to determine if excessive exposures are occurring. Encourage Sandoval parents to comply with state regulations concerning blood lead testing of preschool children. Review existing and future blood lead data to determine if an excessive prevalence of elevations exists.
4. A private well survey and heavy metal sampling should be conducted of the private wells nearest the site. A survey of the existing monitoring wells should be completed to determine if any wells need to be properly abandoned.

Health Activities Recommendations:

1. Restrict public access to site areas.
2. Implement procedures to suppress dust generation and migration if any on-site removal/remedial operations, or demolition activities occur.
3. Where areas of significant off-site contamination are identified, consider strategies for minimizing exposures to site-related contaminated soils on private properties.
4. Implement community health education programs to inform residents how they can reduce their exposure to contaminated soils and dusts.

In May and June 1996, Illinois EPA collected additional environmental samples, interviewed area citizens, coordinated blood lead screening of children attending the nearby daycare facility, and collected residential soil samples. In September 1997, Illinois EPA completed an Expanded Site Inspection Report (Illinois EPA, 1997).

Illinois EPA contractors began some clean up activities in June 1998. The perimeter fence

was replaced in sections and repaired. Four warning signs were posted on steel poles inside the fence on all four sides of the property. All site buildings were dismantled and sent off the site as scrap. Approximately 350 cubic yards of diesel fuel-contaminated zinc waste was removed from the site, and 19 groundwater monitoring wells were sealed. Work was completed by January 1999.This document updates assessment of the site since those recent activities.

Site Visits

IDPH and Illinois EPA staff visited the site on May 19, 1998. Vandals had stolen or damaged much of the fence around the site. Tire tracks were seen throughout the property, winding through the unsecured buildings. Generally, the site was the same as described in the previous health assessment (IDPH, 1995). Open fields surround the site on all sides except to the north where the CSX Railroad tracks are found.

An area between operation buildings on the eastern portion of the site may have been used for processing water for smelting operations or a reservoir for waste water. A large farm pond east of the site outside the fence line contains metals in its sediment, supports aquatic life, and may be used for fishing and swimming. Tracks made by three-wheeled recreational vehicles and bicycles were found circling the pond. Part of the farm field next to the southern site boundary may be affected by the site because it is grey in color and supports little vegetation.

Smelting waste and cinders cover the site. This metal-rich fill has resulted in some contamination of the underlying aquifer. Exposure to metal-contaminated groundwater may have occurred in one home with a private well. Only one home responding to the 1990 census reported having a private, dug well, and the remaining Sandoval households reported using municipal water from Centralia, Illinois.

Surface runoff from the site empties into drainage ditches outside the eastern and western fence lines. The ditches receive runoff from the fields north of the site via culverts built under the railroad tracks. The ditches divert water to the marshy areas to the south, eventually emptying into a local creek.

Some waste had been stored inside the buildings, and many of the buildings were in disrepair in 1998. The roof of one large building had collapsed to ground level. Another physical hazard that may only be problematic during rainy seasons is an in-ground reservoir that collects water beneath one building. Two large above-ground storage tanks were located on the south side of the building complex. One tank appeared to contain some fuel oil.

Construction debris such as lumber, bricks, and concrete chunks was scattered throughout the site. Other debris, such as rusted metal goods and broken glass, also was present. Because of its isolated location, the site has been used as a dumping ground.

IDPH staff revisited the site on April 1, 1999. A 6-foot-tall chain link fence surrounded the site, although there were some gaps in the fence along the north and east sides that would allow access by a determined trespasser. All buildings on the site had been torn down and removed, leaving only the deteriorated concrete foundations and supports. An open, aboveground tank that was full of water was outside the fence on the east perimeter of the site.

DISCUSSION

IDPH did not identify elevated blood lead levels in children in the Sandoval zip code; however, IDPH wanted to be sure that the most sensitive of the target population had been

tested. Plans were made in the summer of 1996 to screen volunteers from the 125 preschool children enrolled at a daycare less than 0.5 miles west of the site. IDPH provided information to the daycare operator and parents regarding methods to avoid and reduce potential lead exposures. An air-conditioned, mobile clinic was made available for one day in August 1996. Thirty-three children were tested for lead concentrations in whole blood, and no child had an elevated blood lead level (Marion County Health Department, 1996). The current standard for blood lead levels in young children and pregnant women is 10 micrograms per deciliter (g/dL) of whole blood (U.S. DHHS, 1991).

Staff from Illinois EPA interviewed Sandoval residents in 1996. Former workers and long-time residents who provided information said they regularly observed smoke from the plant at the high school 1.25 miles from the site and at the drive-in theater north of the site. Some Sandoval employees went home ill with symptoms of headaches, chills, and vomiting. They estimated that the recovery time from these symptoms was about 8 hours. Crops grown next to the site were reported to have low yields. Individuals also reported that smelting waste was transported to private and public properties in Sandoval and surrounding communities to be used for fill, walkways, and roads. A pond east of the site was used for fishing and for swimming until a community swimming pool was constructed about 50 years ago.

Illinois EPA collected on-site waste and off-site residential soil samples in 1996 (Attachment 2). Surface soil samples from 0 to 6 inches deep were collected from five areas on the site. The samples appeared to consist of smelting wastes and cinders. These five samples were analyzed for organic and inorganic compounds.

Illinois EPA invited IDPH to participate in a workshop for middle school students at Sandoval on May 19, 1998. Before the workshop, IDPH staff accompanied Illinois EPA to the site to meet with contractors. Later that morning a workshop for approximately 70 students and their teachers was held. IDPH provided information regarding the health effects of lead to the audience and gave a "Get the Lead Out" videotape to the teacher who organized the workshop. Illinois EPA staff discussed funding and regulatory activities associated with placing the site on the National Priorities List. The purpose of this community health education program was to inform residents how they can avoid or reduce their exposures to metal-rich soil and dust.

Contaminants of Interest

IDPH compared the results of each soil sample with the appropriate screening comparison value used to select contaminants for further evaluation for carcinogenic and non-carcinogenic health effects. Chemicals found at levels greater than comparison values or those for which no comparison value exists were selected for further evaluation. A discussion of each health screening value used is found in Attachment 3.

IDPH evaluated the results of on-site surface soil (waste) samples and sediment samples provided by Illinois EPA (Illinois EPA, 1997). The organic chemicals tested included volatile organic compounds, semivolatile organic compounds (SVOCs), and pesticides. One sample collected from an area associated with an oil storage tank contained some SVOCs, but not at a level of health concern. This material has been removed. The remaining organic chemical results were estimated values or found in laboratory blanks and are not at levels of health concern.

The inorganic chemicals selected for further evaluation from on-site soil and sediment sampling data are listed in Table 1. The on-site metals that are most consistently elevated above background levels are arsenic, cadmium, chromium, copper, lead, nickel, and zinc. Not surprisingly, zinc is the most abundant metal and is found in elevated concentrations in every sample analyzed.

Table 2 contains the inorganic chemicals of interest for the residential properties sampled. Most of these samples were collected from 0 to 6 inches below ground level. These data are the basis for further discussion. Some chemicals were not selected for further review in this assessment because of low toxicity or low concentrations found in the residential soil samples. Inorganic chemicals that were not selected were aluminum, antimony, beryllium, calcium, iron, mercury, potassium, selenium, silver, sodium, thallium, vanadium, and cyanide.

Public Health Implications

This section includes discussions of potential health effects for possible exposure scenarios to contaminants found off the site. The concentration range, the mean value, and median value of the residential soil samples in units of milligrams of metal per kilogram of soil (mg/kg) are shown in Table 3.

Several completed exposure pathways exist at the site (Table 4). Because the peak operation of this facility pre-dates most environmental and worker protection regulations, IDPH suspects that former employees were chronically exposed to products, waste, and emissions via inhalation and ingestion. In addition, past operational air emissions distributed metals to surrounding properties, and past residents were likely exposed through inhalation and ingestion. Today, the site is abandoned.

Trespassing has historically been a problem at this isolated site even though fencing has been repaired and replaced regularly. Illinois EPA contractors recently repaired and replaced fencing.

IDPH calculated estimated exposure doses for adults and children to see if doses exceed minimal risk levels (MRLs). The MRL is a health screening guideline used to determine whether the exposure should be further evaluated. If MRLs were exceeded, IDPH reviewed studies to determine if estimated doses approached the lowest observed adverse effect level for humans.

Residents may be exposed to metals in the soil in their yards. For one exposure scenario, IDPH assumed children inadvertently ingested the soil while playing twice a week over a 5-year period in a contaminated area of the yard where vegetation was not very thick. A "pica" child exhibits excessive hand-to-mouth activity and is considered to ingest 25 times more soil than a typical child. Estimated exposure doses were also calculated for adult residents who would be exposed to contaminated soil twice a week over a 5-year period, with a body weight of 70 kg and a soil ingestion rate of 100 milligrams per day. Estimated dose calculations do not show a public health hazard for most of the population for the metals measured in residential soils.

Residential soil sample X117 contained the highest levels of copper, lead, nickel, and zinc. This sample is unusual in that the levels found are more concentrated than those found at the other 22 properties. Sample X117 was collected from a yard about 0.5 miles northwest of the site (Attachment 2).

Cadmium

Estimated exposure to cadmium exceeded the ATSDR MRL for pica children at about half of the sample locations; however, the estimated oral dose is less than the no observed adverse effect level for humans exposed to cadmium. Health guidelines for other children and adults would not be exceeded at any of the sample locations.

Lead

Exposure to lead can cause adverse health effects, especially for young children and pregnant

women, since lead is a neurotoxin that permanently interrupts normal brain development. Lead has no beneficial biological function and is known to accumulate in the body. ATSDR has not developed a health guideline for lead because no safe threshold has been identified. The U.S. Food and Drug Administration (USFDA) published a provisional tolerable daily lead intake value of 6 micrograms for a 10-kg child based on a blood lead level of 10 micrograms per deciliter. A survey of a variety of foods determined the average adult lead intake to be 54 micrograms per day (g/day) (ATSDR, 1997).

The Sandoval Zinc smelter did not specifically process lead. Although some lead was likely present in the air emissions from the smelter, large amounts of lead were probably not distributed to off-site residential properties. The range of lead concentrations in the 23 residential samples is 27 to 2,840 ppm. The next highest lead concentrations were 1,150 and 1,060 ppm. A total of 3 of the 23 yards contained more than 1,000 ppm lead, which is the level of lead IDPH established as permissible for residential areas (IDPH, 1994). The Sandoval median soil lead value is 189 ppm, which is greater than the median level found in Illinois, but within the range of lead concentrations found in the state (Illinois EPA, 1994). Blood samples collected from 33 preschool children in August 1996 did not show elevated levels of lead.

Zinc

Zinc would be expected to be much higher than background samples throughout the community since 100 years of zinc smelting took place east of the residential area. The highest zinc concentration in an on-site sample was about 10 times greater than the highest residential sample. The range of zinc levels in residential soils was from 108 ppm to 21,400 ppm. Pica children may ingest excess zinc to the point that they experience nausea, but other persons of any age are unlikely to be exposed to enough zinc to cause adverse health effects.

Other Metals

Magnesium and manganese were found at levels similar to those found in background samples from uncontaminated areas throughout Illinois. Although greater than background concentrations, IDPH does not believe exposure to levels of arsenic, barium, chromium, and nickel in residential soils would cause adverse health effects.

Copper levels were elevated, but no health guideline has been developed for copper. Estimates for exposure to copper in food range from 1-5 mg/day (ATSDR, 1990). Daily contact with copper in soil would result in exposures much less than those from copper commonly found in food, so adverse health effects are unlikely.

Past Worker Exposures

Although current estimated ingestion doses of these metals do not appear to consistently exceed health guidelines for most of the population, former workers were likely to have had past inhalation exposures that may have been problematic since lung tissues tend to absorb metals more completely than tissues in the gastrointestinal tract. During interviews with Illinois EPA staff in 1996, residents described the symptoms of workers during past smelter operations, which are similar to "metal fume fever" and heat-related illnesses. Reportedly, the presence of thick, white smoke was a common occurrence in the past. No historical exposure data (blood lead levels) are known to exist from any biomonitoring of workers at the smelter. No air sampling data are currently available.

On-site Hazards

Older children and adults who trespass on the site may regularly be exposed to material high in lead and other metals that are more concentrated near the old smelting operations. Since

the frequency of trespass is unknown, estimating potential exposure is very difficult. Still, a trespasser may be exposed to metals at levels that would exceed health guidelines. In addition, some on-site physical hazards remain.

COMMUNITY HEALTH CONCERNS

No public meeting has been held for this site, but IDPH has participated in community involvement activities with area residents who have asked questions and expressed concerns about issues at the site. The following information is a summary of the health concerns expressed, and IDPH's responses to these questions.

1. What health effects can be caused by exposure to lead in soil?

IDPH has not found any evidence that Sandoval residents are being exposed to high levels of lead in soil. Exposure to lead can cause adverse health effects, especially for young children and pregnant women, since lead is a neurotoxin that permanently interrupts normal brain development. Lead has no beneficial biological function and is known to accumulate in the body. The Sandoval Zinc smelter did not specifically process lead. Although some lead was likely in the air emissions from the smelter, large amounts of lead were probably not distributed to off-site residential properties.

2. Is trespassing onto the site dangerous?

On-site soils contain elevated levels of chemicals, so it is possible that a frequent trespasser may be exposed to contaminants. Some physical hazards remain at the site that may result in injury. Since the demolition of the on-site buildings, it is expected that the site will not attract as many trespassers.

CHILD HEALTH INITIATIVE

IDPH and ATSDR recognize that children are especially sensitive to some contaminants. For that reason, IDPH includes children when evaluating exposures to contaminants.

CONCLUSIONS

Overall, the site currently poses no apparent public health hazard to most of the population in Sandoval. The site may be a public health hazard to preschool children with excessive hand-to-mouth activity exposed to residential surface soils with high levels of lead. However, the blood sample results from children in a day care near the site did not show elevated levels of lead. Older children and adults who formerly trespassed onto the site may have been exposed to contaminants and received a dose that exceeded health guidelines for lead and other metals found near the old smelting operations. Clean up activities that began in June 1998, and completed in January 1999, have likely reduced the number of trespassers visiting the site.

Since primary smelting occurred only during the first 30 years of operation, the trace metals found in ores did not consistently accumulate to high concentrations in residential soils. Secondary smelting of zinc products continued for another 80 years, and subsequently, zinc concentrations are consistently elevated throughout the community. Because lead is present in some residential yards, educational efforts remain important for families with small children.

RECOMMENDATIONS

Many of the recommendations listed in the 1995 IDPH Public Health Assessment have been addressed in some manner. The following are recommended based on current conditions:

1. Continue efforts to prevent trespassing on the site.
2. Continue educational efforts on methods to reduce exposure to metals in the residential environment.
3. Use procedures to minimize dust if additional remedial activities are conducted.

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CERTIFICATION

This Sandoval Zinc public health assessment was prepared by the Illinois Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with its findings.

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Illinois Environmental Protection Agency (1994). A Summary of Selected Background Conditions for Inorganics in Soil. August 1994.

Marion County Health Department (1996) Summary of August 23, 1996 blood lead screening at Sandoval . Memo. Salem, Illinois. September 10, 1996.

U.S. Department of Health and Human Services (1991) Preventing Lead Poisoning in Young Children, Atlanta, Centers for Disease Control.

TABLES

Table 1. Sandoval On-site Soil and Sediment Samples - Selected Metals (sampling depth 0-6") in parts per million (ppm) from May 1996 Illinois EPA Sampling Event.

METAL	X101	X102	X103	X104	X105	X201	X203	X204	X20
Arsenic	44	19	58	32	8	37	20	4B	15
Barium	155	55B	225	157	160	186	158	113	231
Cadmium	61	49	19	4	4	6	11	2B	3
Chromium	22	40	52	24	12	13	15	7.8	12
Copper	1820	1170	4050	1270	764	725	537	28	57
Lead	22300	2460	3220	2700	603	3300	833	50	156
Magnesium	840B	4760	709B	496B	1120B	1170B	950B	942B	1300
Manganese	293	273	326	683	637	860	1010	502	1820
Nickel	292	608	3750	530	84	83	242	10B	23
Zinc	339000	214000	97400	15300	3360	6520	6300	261	205c
Location	Near	Near	Near	Near	Pond	Culvert	SE	E PPE	N of

	entry	aboveground tank	SW corner of furnace	SE fence line corner	western bank	N of RR and E pond	ditch	(Back-ground)	RR and W ditch

B = metal found in laboratory blank

Table 2. Sandoval Residential Property Surface Soil - Selected Metals (0-6" in depth) in parts per million (ppm) from May 1996 Illinois EPA Sampling Event.

SAMPLE	X106	X107	X108	X109	X110	X111	X112	X113	X114	X115
Arsenic	9	11	8	22	12	6	45	5	11	11
Barium	106	135	133	131	304	123	283	85	237	127
Cadmium	0.5B	3	0. 3B	0.5B	19	0.8B	7	0.4B	1B	0.5B
Chromium	10	10	11	11	52	9	26	7	14	12
Copper	21	503	14	155	133	42	408	36	96	33
Lead	69	1060	27	174	220	131	1150	85	248	47
Magnesium	1010B	3070	787B	958B	2420	1340B	4020	436B	515B	2620
Manganese	591	384	248	192	299	494	479	371	245	417
Nickel	10	67	7B	24	55	25	258	14	10B	13
Zinc	349	5200	112	791	1290	554	12500	442	464	272
LOCATION	Park	School grounds	19 Orchard (Back-ground)	High School	Orange behind daycare	RT 50 E of site	Gore home	N	4162 RT 51	Spa

Table 2 (continued). Sandoval Residential Property Surface Soil - Selected Metals (0-6" in depth) in parts per million (ppm) from May 1996 Illinois EPA Sampling Event.

SAMPLE	X118	X119	X120	X121	X122	X123	X124	X125	X126	X127
Arsenic	12	12	8	16	1B	10	6	9	6	9
Barium	370	362	202	478	51	86	198	213	127	132
Cadmium	2	1	2	5	0.6B	0.3B	0.7B	4	0.3B	0.7B

Chromium	25	15	8	24	7	12	16	17	10	13
Copper	107	51	197	204	13	20	45	84	17	152
Lead	266	385	418	747	33	49	135	170	39	274
Magnesium	1050B	793B	1140B	2090	9090	939B	2170	1090B	1130B	1460
Manganese	363	946	631	1020	179	508	562	584	512	615
Nickel	18	17	24	28	12	6B	19	17	9B	61
Zinc	897	591	2090	1650	226	108	431	1420	150	1200
LOCATION	N Main	School-yard	Clay	114 S. Main	Pearl	Maple	Wyoming	Maple	Main	Nevada

Table 3. Comparison of Sandoval Residential Soil Samples to Illinois Background Levels (in milligrams per kilogram).

METALS	Off-site Soil			Illinois Soils(a)		
	Range	Mean	Median	Ranges	Mean	Median
Arsenic	1-45	12	9	0.35-24	6.7	5.9
Barium	51-478	192	135	<5-1720	130	119
Cadmium	0.3-19	2.4	0.8	<2.5-8.2	0.97	0.5
Chromium	7-52	15	12	<2-151	17.3	14.0
Copper	13-1630	177	68	1-156	19.7	14.0
Lead	27-2840	390	189	4.7-647	49.2	25
Magnesium	436-9090	1853	1130	476-74500	7231	3410
Manganese	179-1020	491	479	61.5-5590	767	631
Nickel	7-495	53	18	<3-135	16.8	14.1
Zinc	23-21400	2356	773	<5.5-798	102.9	67.4

a) "A Summary of Selected Background Conditions for Inorganic in Soil" Illinois EPA/ENV/94-161, August 1994.

Table 4. Completed Exposure Pathways

Pathway Name:	Source	Medium	Exposure Point	Exposure Route	Receptor Population	Time of Exposure	Expos Activit

Off-site Surface Soil	Smelter	Residential Soil	Yards	Ingestion Inhalation	Residents	Past Present Future	Contact contam soil.
On-site Surface Soil	Smelter	Surface Soil	Surface material	Ingestion Inhalation	Trespassers	Past Present Future	Contact contam materia
Contam-inated Air	Smelter	Air	Site and surrounding area	Inhalation	On-site Smelter Workers; Area Residents	Past	Primar Second. Smeltir

ATTACHMENTS

Attachment 1. Location of Sandoval Zinc

Attachment 2. Approximate Location of Off-Site Soil Samples

ATTACHMENT 3: COMPARISON VALUES USED IN SCREENING CONTAMINANTS FOR FURTHER EVALUATION

Environmental Media Evaluation Guides (EMEGs) are developed for chemicals based on their toxicity, frequency of occurrence at National Priority List (NPL) sites, and potential for human exposure. They are derived to protect the most sensitive populations and are not action levels, but rather comparison values. They do not consider carcinogenic effects, chemical interactions, multiple route exposure, or other media-specific routes of exposure, and are very conservative concentration values designed to protect sensitive members of the population.

Reference Dose Media Evaluation Guides (RMEGs) are another type of comparison value derived to protect the most sensitive populations. They do not consider carcinogenic effects, chemical interactions, multiple route exposure, or other media-specific routes of exposure, and are very conservative concentration values designed to protect sensitive members of the population.

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations based on a probability of one excess cancer in a million persons exposed to a chemical over a lifetime. These are also very conservative values designed to protect sensitive members of the population.

Table of Contents

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