Coming Clean:
What the EPA Knows About the Dangers of Coal Ash

A Summary of the United States Environmental Protection Agency's 2007 Human and Ecological Risk Assessment of Coal Combustion Wastes

A Report by The Environmental Integrity Project and Earthjustice
May 2009

Source: Google Earth Satellite Image (38° 21' 02.44" N, 87° 46' 03.02"W) (May 2009).

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The Environmental Integrity Project (http://www.environmentalintegrity.org) is a nonpartisan and nonprofit organization established in March 2002 to advocate for more effective enforcement of environmental laws. EIP was founded by Eric Schaeffer, who was director of the U.S. Environmental Protection Agency's Office of Regulatory Enforcement. He resigned in 2002 after publicly expressing his frustration with efforts of the Bush Administration to weaken enforcement of the Clean Air Act and other laws.

Earthjustice (http://www.earthjustice.org) is a non-profit public interest law firm dedicated to protecting the magnificent places, natural resources, and wildlife of this earth, and to defending the right of all people to a healthy environment. Earthjustice brings about far-reaching change by enforcing and strengthening environmental laws on behalf of hundreds of organizations, coalitions and communities.

Coming Clean: What the EPA Knows About the Dangers of Coal Ash

Each year, coal-fired power plants dispose of nearly 100 million tons of toxic fly ash, bottom ash, and scrubber sludge in wet ponds and landfills. Can living next to one of these dumpsites increase your risk of getting cancer or other diseases? The U.S. Environmental Protection Agency (EPA) thinks so, especially if you live near one of those wet ash ponds, or surface impoundments, that dot the landscape near large coal plants, the pond has no protective liner, and you get your drinking water from a well. According to a comprehensive but little known risk assessment released by the EPA in 2007, nearby residents have as much as a 1 in 50 chance of getting cancer from drinking water contaminated by arsenic, one of the most common, and most dangerous, pollutants from coal ash.[i]

And that's not all. That same risk assessment says that living near ash ponds increases the risk of damage to the liver, kidney, lungs and other organs as a result of being exposed to toxic metals like cadmium, cobalt, lead, and other pollutants at concentrations far above levels that are considered safe. In addition, the danger to wildlife and ecosystems is simply off the charts, with one contaminant—boron—expected to leach into the environment at levels *two thousand times* thresholds generally considered to be safe.

During the Bush Administration, the EPA made a concerted effort to delay the release of this information. A 2002 screening study, the precursor to the EPA's 2007 risk assessment, identified the same astronomical cancer risks and dangers to aquatic life from coal ash dumps, but it was not made public until *March 4, 2009*—seven years after its publication.[ii] Freedom of Information Act requests to EPA for the risk assessment data during the Bush Administration were denied or resulted in the production of documents with the cancer and noncancer risk estimates blacked out.

What were they hiding? This brief analysis from the Environmental Integrity Project and Earthjustice highlights key findings from the EPA's 2007 risk assessment, which was based on a detailed analysis of landfills and surface impoundments at 181 coal-fired power plants,[iii] primarily identified by a 1995 survey by the Electric Power Research Institute.[iv] Our analysis focuses on the 100 landfills and 110 surface impoundments examined by the EPA that lack effective composite (clay plus synthetic) liners to prevent leaks, since the EPA found unlined and clay-lined waste units present far greater risks to both human health and ecosystems. A complete list of the unlined or clay-lined waste disposal units examined in the EPA's risk assessment can be found in Attachments 1 (surface impoundments) and 2 (landfills).

The EPA's study estimated risks based on a number of factors, including waste characteristics, the type of disposal (e.g., wet pond or "dry" landfill), whether sites were lined, local hydrogeological information, and tests measuring the leaching potential of various pollutants. The assessment was based on predicted exposures of human populations, vegetation, and wildlife to toxic metals that migrate from groundwater contaminated by disposal sites. The human health risks that are discussed below result from exposure to contaminated drinking water. The study estimates risk associated with classes of disposal sites (e.g. ash ponds) rather than specific facilities.

While the EPA's risk assessment model attempts to make the best use of available data, EPA acknowledges that it is based on assumptions that may lead to underestimation or overestimation of risk. For example, at a given site, the actual exposure of nearby residents to contaminated drinking water may be higher or lower than EPA's model assumed. The study does not consider the risk from additional pathways of exposure, e.g., from the direct discharge of pollutants to surface waters through pipes or ditches, contaminated soils, or fugitive dust from uncovered ash sites. For a more complete explanation of the EPA's methodology and limitations, including a discussion of likely underestimation of risks, see Appendix B.

The EPA's study found that the type of disposal (wet or dry) and whether or not disposal sites have protective composite liners[v] to prevent leaking have a dramatic effect on risk. Surface impoundments (wet ponds) consistently show the highest risks, especially if they are unlined. The attached tables identify the size and location of ponds and landfills that are unlined or lined only with clay. Because the data were gathered in the mid-1990s, it is possible that some of the listed dump sites are no longer in use. The EPA study warns, however, that peak pollution from ash ponds can occur long after the waste is placed and is likely to result in peak exposures approximately 78 to 105 years after the ponds first began operation—thus "retired" sites still pose very significant threats.[vi] Lastly, these tables represent only the units that were captured in the EPA's survey in the risk assessment. The number of unlined and clay-lined ash ponds and landfills currently in operation in the United States is likely to be at least *double* the number of units represented in the tables.[vii] In fact, the EPA's latest estimate of the number of coal ash waste ponds has recently increased 40% (from 300 to 427 units), based on information recently submitted by 61 utilities in response to the EPA's March 2009 information request letters.[viii]

Health Risks: Waste Ponds that Mix Coal Combustion Waste and Coal Refuse

A summary of the EPA's assessment of health risks from coal ash ponds can be found in Table A. Seventy of the ash ponds assessed by the EPA's assessment mix both coal ash and other types of coal refuse (e.g., the waste coal produced from coal handling and preparation operations prior to combustion[ix]), and this category of pond was found to be the most hazardous (see Attachment 1 for a list of these sites). For example, the EPA estimated that up to 1 in 50 nearby residents could get cancer from exposure to arsenic leaking into drinking water wells from unlined waste ponds that mix ash with coal refuse. Arsenic has been found to cause multiple forms of cancer, including cancer of the liver, kidney, lung, and bladder, and an increased incidence of skin cancer in populations consuming drinking water high in inorganic arsenic.[x] For context, the Agency typically considers cancer risk to be unacceptable when environmental exposures result in more than one additional cancer per 100,000 people.[xi] Consequently, a lifetime cancer risk of 1 in 50 represents a risk 2000 times the EPA's regulatory goals.

The EPA also predicts that these unlined ash ponds can increase the risk of other "noncancer" health effects, such as damage to vital organs like the liver and kidneys and, in the case of lead, damage to the central nervous system. The agency has set maximum contaminant levels ("MCLs") under the Safe Drinking Water Act to limit exposure to hazardous pollutants. But according to the EPA, unlined waste ponds that mix ash and coal refuse will result in exposures up to 9 times the federal standard for lead, a deadly neurotoxin that can damage the central nervous system, especially in young children.

Table A: Surface Impoundments: Highest Health Risks (Groundwater to Drinking Water)			
	90th Percentile HQ or Cancer Risk Value[1 2]		
Chemical	**Unlined Units**	**Clay-Lined Units**	**Potential health Risks**
Conventional CCW			
Arsenic (cancer risk)	1 in 500	1 in 1,111	Nausea; Vomiting; Diarrhea; Cardiovascular Effects; Encephalopathy; Dermal Effects; Peripheral Neuropathy; Skin, Bladder & Lung cancer
Nitrate/nitrite (MCL)	20	10	Methemoglobinemia, infants are particularly vulnerable
Molybdenum	8	5	Fatigue; Headaches; Joint Pains
Boron	7	4	Stomach, Intestines, Kidneys, Liver and Brain Damage; Death; Negative Effects on Male Reproduction
Selenium	2	1	Dizziness; Fatigue; Respiratory Effects; Selenosis (Hair Loss; Nail Brittleness; Neurological Abnormalities)
Lead (MCL)	3	0.7	Learning Disabilities; Kidney, Blood, and Nerve Damage; Children are especially vulnerable to Lead exposure
Codisposed CCW and Coal Refuse			
Arsenic (cancer risk)	1 in 50	1 in 143	Nausea; Vomiting; Diarrhea; Cardiovascular Effects; Encephalopathy; Dermal Effects; Peripheral Neuropathy; Skin, Bladder & Lung cancer
Cadmium	9	3	Diarrhea; Stomach Pains; Severe Vomiting; Bone Fracture; Reproductive Effects; Nerve Damage; Immune System Damage; Psychological Disorders
Cobalt	8	3	Vomiting and Nausea; Vision Problems; Heart Problems; Thyroid Damage
Lead (MCL)	9	1	Learning Disabilities; Kidney, Blood, and Nerve Damage; Children are especially vulnerable to Lead exposure
Molybdenum	3	2	Fatigue; Headaches; Joint Pains

Sources: U.S. Envtl. Prot. Agency (EPA), Human and Ecological Risk Assessment of Coal Combustion Wastes (released as part of a Notice of Data Availability) (Aug. 6, 2007) (draft), Table 4-7, Page 4-14 (does not include data on composite-lined units); and U.S. Department of Health and Human Services, Agency for Toxic Substances & Disease Registry, "Frequently Asked Questions About Contaminants Found at Hazardous Waste Sites" <http://www.atsdr.cdc.gov/toxfaq.html>.

[1] Values are HQs for all chemicals except arsenic; arsenic values are cancer risk.

[2] The Hazard Quotient (HQ) is the ratio of the exposure estimate (dose of contaminants) to a “no adverse effects level” considered to reflect a “safe” environmental concentration or dose.

For other toxic metals, like cadmium and cobalt, a hazard quotient ("HQ") is used to define the concentration of a pollutant that is generally assumed to be "safe." In other words, the HQ is the level at which the pollutant presents no "noncancer" health risks. The EPA estimates that unlined ponds that mix ash and coal refuse will result in exposures up to:

- Nine times the HQ, or "safe" level for cadmium, which can result in kidney disease and fragile bones.[xii] The U.S. Department of Health and Human Services has determined that cadmium is a human carcinogen.[xiii]

- Eight times the HQ for cobalt, which can result in damage to the lung and heart and cause dermatitis. Liver and kidney effects have also been observed in animals exposed to high levels of cobalt.[xiv]

Clay-lined ponds that mix coal ash and refuse appear to pose less risk, although the smaller number of sites evaluated make extrapolation difficult. Clay-lined impoundments were estimated to result in exposures up to 3 times above the HQ, or "safe" threshold, for cadmium and cobalt. The estimated cancer risk from clay-lined impoundments remains very high, however, and was estimated at 1 in 143 for nearby residents exposed to contaminated drinking water.

Attachment 1 lists the location, size, and ownership of the unlined and clay-lined ponds that mix ash and coal refuse that were evaluated in the EPA's risk assessment. North Carolina and Tennessee each have eight of these impoundments, while Illinois has seven and Kentucky has six. Southern Company utilities own or operate twelve sites, while ten each are owned or operated by Tennessee Valley Authority or Duke utilities. Again, these ponds represent only a portion of the universe of unlined and clay-lined ash ponds currently operating throughout the United States.

Health Risks: Ash Ponds Containing Only Coal Combustion Waste

Forty of the coal ash ponds studied by the EPA contained only coal combustion waste. Unlined sites present a lower but still very substantial arsenic cancer risk to nearby residents of about 1 in 500 and about 1 in 1000 for clay-lined sites. These risks are 200 times and 100 times, respectively, greater than the EPA's regulatory goals for limiting cancer risk.

In addition, the risk of other diseases is high:

- Unlined ponds are predicted to result in drinking water exposures of nitrate/nitrites at up to 20 times the "maximum contaminant levels" established under the Safe Drinking Water Act; even clay-lined sites are expected to exceed those limits by a factor of ten. Nitrates/nitrites are associated with methemoglobinemia ("blue baby syndrome"), which decreases the ability of the blood to transport oxygen, a condition that can cause death in infants.[xv] Lead levels in drinking water are predicted to reach up to 3 times the federal limit.

- Exposure to boron leached from unlined ponds is expected to exceed the HQ, or "safe" level, by up to a factor of eight, and by up to a factor of four for clay-lined ponds. High levels of boron have been linked to serious ailments of multiple organs, including the stomach, kidney, liver and brain.[xvi] The study also showed high levels of molybdenum, which can lead to mineral imbalances, anemia and developmental problems.[xvii]

- Five of the unlined ash ponds evaluated in the EPA study containing only coal combustion waste are in North Carolina; three each are in Michigan, Ohio, and West Virginia.

Health Risks: Landfills

The EPA's risk assessment predicted that coal ash landfills posed less risk to human health than coal ash ponds. Still, the EPA determined that the cancer risk from exposure to arsenic is as high as 50 times the agency's regulatory goals. The EPA found the risk to be 1 in 2000 from exposure to arsenic in drinking water for residents living near unlined landfills containing coal ash and coal refuse. The study also found that unlined landfills would result in thallium exposures at 3 times the "no risk" threshold. Exposure to high levels of thallium over a short time can lead to vomiting, diarrhea, temporary hair loss, and effects on the nervous system, lungs, heart, liver, and kidneys, and even death.[xviii] Animal data suggest that the male reproductive system may be susceptible to damage by low levels of thallium.[xix] In addition, the EPA found clay-lined and unlined landfills pose elevated risks from exposure to antimony and molybdenum. A list of unlined landfills can be found in Attachment 2.

The study's conclusions concerning coal ash landfills may have significantly underestimated risk. In fact, the EPA's list of actual damage cases includes numerous examples of landfills that have poisoned drinking water and surface water.[xx] For example, drinking water wells surrounding a "dry landfill" in Anne Arundel County, Maryland were found to exceed federal drinking water standards for several toxic metals, including arsenic, cadmium, thallium, beryllium, aluminum and manganese. The contaminants were traced to leachate from the landfill, and Constellation Energy paid $54 million to settle a lawsuit brought by nearby residents.[xxi] In addition, a northern Indiana town has become a Superfund site due to the leaching of chemicals from a partially unlined coal ash landfill.[xxii]

Table B: Landfills: Highest Health Risks (Groundwater to Drinking Water)			
	90th Percentile HQ or Cancer Risk Value[1 2]		
Chemical	**Unlined Units**	**Clay-Lined Units**	**Potential Health Risks**
Conventional CCW			
Arsenic (cancer risk)	1 in 2,500	1 in 5,000	Nausea; Vomiting; Diarrhea; Cardiovascular Effects; Encephalopathy; Dermal Effects; Peripheral Neuropathy; Skin, Bladder & Lung Cancer
Thallium	3	2	Stomach Pains; Nerve Damage; Joint Pains; Vision Damage; Fatigue; Headaches
Antimony	2	0.8	Eye Irritation; Hair Loss; Lung Damage; Heart and Fertility Problems. Liver and Blood Damage; Skin Irritation
Codisposed CCW and Coal Refuse			
Arsenic (cancer risk)	1 in 2,000	1 in 5,000	Nausea; Vomiting; Diarrhea; Cardiovascular Effects; Encephalopathy; Dermal Effects; Peripheral Neuropathy; Skin, Bladder & Lung cancer
Thallium	2	1	Stomach Pains; Nerve Damage; Joint Pains; Vision Damage; Fatigue; Headaches
Molybdenum	2	0.6	Fatigue; Headaches; Joint Pains

Sources: U.S. Envtl. Prot. Agency (EPA), Human and Ecological Risk Assessment of Coal Combustion Wastes (released as part of a Notice of Data Availability) (Aug. 6, 2007) (draft). Table 4-5, Page 4-12 (does not include data on composite-lined units); and U.S. Department of Health and Human Services, Agency for Toxic Substances & Disease Registry, "Frequently Asked Questions About Contaminants Found at Hazardous Waste Sites" <http://www.atsdr.cdc.gov/toxfaq.html>.

[1] Values are HQs for all chemicals except arsenic; arsenic values are cancer risk.

[2] The Hazard Quotient (HQ) is the ratio of the exposure estimate (dose of contaminants) to a “no adverse effects level” considered to reflect a “safe” environmental concentration or dose.

Ecological Risks:

The EPA's study also found very substantial risk from coal ash disposal to aquatic ecosystems and the wildlife they support. The EPA evaluated these ecological risks for both landfills and ponds, but the report does not distinguish risks based on whether liners are in use, or whether ash is commingled with coal refuse. Predicted exposures are compared to ecological hazard quotients for specific pollutants, e.g., concentrations that are thought to be safe for aquatic life.

The results are eye-opening:

- Ash ponds are predicted to leak boron into surface waters at concentrations up to *2000* times higher than levels estimated to be safe for aquatic life (2000 times the HQ). Even landfills will release boron at levels 200 times above the HQ, or safe level, according to the EPA.

- Based on predicted exposures to river otters, lead from ash ponds will reach surface waters at concentrations 20 times higher than the HQ, or safe level, while arsenic and selenium concentrations will be 10 times higher. Selenium is particularly dangerous in aquatic environments because even a very small amount can rapidly attain levels that are toxic to fish and wildlife because of rapid bioaccumulation in food chains and resultant dietary exposure.[xxiii]

- Toxic metals can also be embedded in the sediment at the bottom of rivers or lakes, where they can be very difficult to remove, and poison plants and bottom feeding fish. The EPA's study predicts lead leached from surface impoundments will reach levels that are 200 times higher than levels considered harmless, while arsenic will exceed the safe threshold by 100 times. Arsenic and lead from landfills are also expected to contaminate sediments at levels several times above "no risk" thresholds.

Table C: Surface Impoundments: Highest Ecological Risk (Groundwater to Surface Water)

Chemical	90th Percentile HQ[1]	Pathway	Receptor
Boron	2000	direct contact	aquatic biota
Lead	20	ingestion	river otter
Arsenic	10	direct contact	aquatic biota
Selenium	10	direct contact	aquatic biota
Cobalt	5	direct contact	aquatic biota
Barium	2	direct contact	aquatic biota
Cadmium	1	direct contact	aquatic biota

Source: U.S. Envtl. Prot. Agency (EPA), Human and Ecological Risk Assessment of Coal Combustion Wastes (released as part of a Notice of Data Availability) (Aug. 6, 2007) (draft), Table 4-14, Page 4-22.

[1]The Hazard Quotient (HQ) is the ratio of the exposure estimate to an effects concentration considered to represent a "safe" environmental concentration or dose. Values greater then 1 are indicative of risk to human health.

Table D: Surface Impoundments: Highest Ecological Risk (Groundwater to Sediment)			
Chemical	**90th Percentile HQ[1]**	**Pathway**	**Receptor**
Lead	200	ingestion	spotted sandpiper
Arsenic	100	ingestion	spotted sandpiper
Cadmium	20	direct contact	sediment biota

Source: U.S. Envtl. Prot. Agency (EPA), Human and Ecological Risk Assessment of Coal Combustion Wastes (released as part of a Notice of Data Availability) (Aug. 6, 2007) (draft), Table 4-15, Page 4-23.

[1]The Hazard Quotient (HQ) is the ratio of the exposure estimate to an effects concentration considered to represent a "safe" environmental concentration or dose. Values greater then 1 are indicative of risk to human health.

Table E: Landfills: Highest Ecological Risk (Groundwater to Surface Water)			
Chemical	**90th Percentile HQ[1]**	**Pathway**	**Receptor**
Boron	200	direct contact	aquatic biota
Lead	4	ingestion	river otter
Selenium	1	direct contact	aquatic biota

Source: U.S. Envtl. Prot. Agency (EPA), Human and Ecological Risk Assessment of Coal Combustion Wastes (released as part of a Notice of Data Availability) (Aug. 6, 2007) (draft), Table 4-14, Page 4-22.

[1]The Hazard Quotient (HQ) is the ratio of the exposure estimate to an effects concentration considered to represent a "safe" environmental concentration or dose. Values greater then 1 are indicative of risk to human health.

Conclusion

The EPA's 2007 risk assessment shows that the disposal of coal ash, especially in unlined ponds, results in alarmingly high risks of cancer and diseases of the heart, lung, liver, stomach and other organs and can seriously harm aquatic ecosystems and wildlife near disposal sites. These risks are driven by exposure to toxic metals that leach from groundwater into drinking water, surface waters and sediment. Some of the sites evaluated by the EPA may no longer be "active," but the Agency has warned that contamination from coal ash ponds will not peak until about 78 to 105 years *after* waste is dumped, while peak exposure from landfills may occur after even longer periods of time.

For too long, the federal government and power industry have left he public in the dark as to the risks presented by the voluminous toxic waste they produce. Even as recently as December 2008, after the 1 billion gallon spill from its Kingston Power Plant, the Tennessee Valley Authority claimed that coal ash posed little risk to human health or the environment. The EPA's 2007 risk assessment, nevertheless, brings the real threats to light.

Given what the Agency already knows, ash ponds must be phased out—and cleaned out—within five years, to keep their toxic cargo from building up and jeopardizing the health of nearby residents, poisoning wildlife, and contaminating rivers and streams. So called “dry landfills”—especially those that are unlined—also pose unacceptable risks, and ought to be regulated as hazardous waste disposal sites.

There is some good news. The EPA’s evaluation shows that the use of composite liners (double liners composed of clay and synthetic barriers) significantly reduces risk by decreasing the amount of toxins that leak out of ash and into groundwater. These composite liners ought to be required at dry landfills, along with leak detection and monitoring systems to identify and capture any leachate that does escape. On March 2, 2009, 109 public interest organizations recommended that the EPA require these measures, as well as other safeguards, in a letter to EPA Administrator Lisa Jackson.[xxiv]

The EPA’s risk assessment clearly establishes that unlined coal ash disposal sites—wet and dry—are hazardous to human health and the environment, posing unacceptably high cancer and noncancer risks to those living nearby and poisoning aquatic life of adjacent water bodies with bioaccumulative poisons. We hope the new leadership at the EPA will act on that knowledge before it is too late.

Appendix A. Coal Combustion Waste Constituents: Health and Environmental Effects

Some of the most hazardous constituents in coal combustion waste include:

Arsenic:
Ingesting arsenic, even in low doses, through drinking water or by eating fish in which arsenic has bioaccumulated, "can cause nausea, vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of 'pins and needles' in hands and feet."[xxv] Freshwater plants and bivalves have been shown to accumulate arsenic,[xxvi] whereby it enters the food supply for fish, other wildlife, and humans. The toxicity of arsenic in the environment is impacted by a number of factors, including temperature, pH, phosphate concentration, and other parameters.[xxvii] Arsenic is ranked #1 on the Agency for Toxic Substances and Disease Registry's (ATSDR) 2007 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Priority List of Hazardous Substances, which determines contaminant rankings based on a combination of their frequency, toxicity, and potential for exposure at National Priorities List (NPL) sites.[xxviii]

Boron:
"Exposure to large amounts of boron (about 30 grams of boric acid) over short periods of time can affect the stomach, intestines, liver, kidney and brain and can eventually lead to death."[xxix] Boron can also bioaccumulate in plants, and is therefore ingested in fruits and vegetables as well as in drinking water.[xxx] Boron is also known to be highly toxic to plants and algae, inhibiting growth, protein content, chlorophyll content and photosynthesis.[xxxi] Chronic exposure to low levels of contamination can impair development in fish, notably the rainbow trout.[xxxii]

Cadmium:
The Centers for Disease Control's (CDC) Third National Report Spotlight on Cadmium states that, "exposure to low levels of cadmium in air, food [and]… water over time may build up cadmium in the kidneys and may cause kidney disease," and that long-term effects of cadmium exposure also include fragile bones.[xxxiii] Moreover, the U.S. Department of Health and Human Services and the International Agency for Research on Cancer have determined that cadmium and cadmium compounds are known human carcinogens and EPA has determined that cadmium is a probable human carcinogen.[xxxiv] Cadmium exposure can occur through ingestion of contaminated drinking water or by eating aquatic organisms in which cadmium has accumulated.[xxxv] Exposure to cadmium is moderately to highly toxic to aquatic plants, invertebrates, and fish.[xxxvi] Environmental toxicity of cadmium is highly variable depending on hardness, pH, temperature, and other parameters. [xxxvii] Cadmium is listed 7th on the 2007 CERCLA Priority List of Hazardous Substances.

Cobalt:
Exposure to high levels of cobalt can result in lung and heart effects and dermatitis.[xxxviii] Liver and kidney damage are also possible.[xxxix] Moreover, cobalt from CCW is

especially dangerous to human health in the environment when co-disposed with coal refuse because its mobility increases under more acidic conditions.[xl] Cobalt has been found to inhibit the growth of photosynthetic microorganisms and can be toxic to fish, notably the rainbow trout.[xli] Cobalt ranks 49th on the 2007 CERCLA Priority List of Hazardous Substances.

Lead:

The detrimental health effects of lead are well known. "No safe blood level has been identified" for lead,[xlii] making it one of the most toxic constituents of coal waste. Because children absorb lead more easily than adults, "lead levels of 10 micrograms or more in a deciliter of blood can damage ability to learn."[xliii] At blood levels greater than or equal to 25 micrograms per deciliter, lead exposure can cause damage to the kidneys, blood and nervous system.[xliv] "At very high levels, lead poisoning can cause mental retardation, coma, convulsions or death."[xlv] Lead ranks second after arsenic on the 2007 CERCLA Priority List of Hazardous Substances.

Molybdenum:

The American Cancer Society warns that "symptoms of too much molybdenum include tiredness, dizziness, rashes, low white blood cell counts, and anemia. High molybdenum levels are also linked to gout."[xlvi] The Environmental Working Group also links molybdenum ingestion to reproductive and fertility complications.[xlvii]

Nitrates/Nitrites:

Studies show that "short term exposure to nitrate levels above the MCL can cause serious illness and even death, especially in infants," because nitrate converts to nitrite in the body, which oxidizes the iron in blood hemoglobin to the point that it cannot carry oxygen.[xlviii] Symptoms of "blue baby syndrome," as the condition is commonly known, include shortness of breath and bluish skin. Moreover, long term exposure to contaminant levels above the MCL may cause "dieresis, increased starchy deposits, and hemorrhaging of the spleen."[xlix] The environmental effects of nitrate are well known; adding large quantities of limiting nutrients to rivers and streams contributes to algal blooms and decreased oxygen concentrations that choke out wildlife and ultimately contribute to downstream water impairment, the most devastating of which is the gulf coast "dead zone."

Selenium:

Short term oral exposure to high concentrations of selenium causes nausea, vomiting, and diarrhea, while chronic exposure to "mildly excessive" concentrations can lead to selenosis, a condition resulting in brittle hair, deformed nails and numbness in the limbs.[l] Selenium causes respiratory and liver damage in animals and may affect reproduction in farm animals.[li] Moreover, because selenium bioaccumulates in plants, farm animals are particularly susceptible to toxic effects from selenium ingestion.[lii] Selenium ranks 147th out of 275 toxic constituents on the 2007 CERCLA Priority List of Hazardous Substances.

Appendix B. Methodology and Limitations

EPA's Methodology

In order to evaluate the risks posed by coal combustion waste (CCW) to individuals who live near landfills and surface impoundments used for CCW disposal, the EPA compiled a database of 41 "constituents of concern in CCW" in 2002 and 2003.[liii] The database includes waste concentration data from three types of waste samples: landfill leachate analyses; porewater analyses from surface impoundments and landfills, and analyses of whole waste samples.[liv] In order to determine which constituents were potentially hazardous enough to warrant a full-scale analysis, the EPA first engaged in Hazard Identification to select only those constituents with human health or ecological benchmarks and then conducted Constituent Screening to compare health-based benchmarks with conservative estimates of exposure concentrations to screen out constituents and exposure pathways that posed no significant concern.[lv] The remaining 21 CCW constituents and 3 exposure pathways not screened out were then evaluated in a Full-Scale Monte Carlo Risk Analysis.[lvi]

The full-scale analysis modeled risks based on surveyed characteristics from 181 CCW disposal sites[lvii] using a site-based probabilistic approach that provided a distribution of risks for each receptor by allowing for variability of some factors. The EPA modeled two waste management options, surface impoundments and landfills, as well as three liner conditions, unlined, clay-lined, and composite-lined.[lviii] It also modeled three waste types, conventional CCW, FBC wastes, and codisposed CCWs and coal refuse.[lix] The site-based approach allowed for modeling of different factors such as waste management practices, environmental settings (e.g. hydrogeology, climate, and hydrology), and groundwater ingestion scenarios. Notably, to estimate the release of constituents from waste management units (WMUs), the EPA used a survey conducted by the Electric Power Research Institute (EPRI) in 1995 to determine size, design (including liner characteristics), and locations of onsite CCW landfills,[lx] which does not take into account disposal that has continued at these sites or the reality that there are often long lead times before peak pollution events.

In order to determine probabilistic risks, the EPA used a Monte Carlo simulation, by which many model input parameter values were varied over 10,000 iterations of the model per waste management scenario to yield a statistical distribution of exposures and risks.[lxi] Probabilistic risks were then evaluated at the 50^{th} and 90^{th} percentiles. A risk or hazard estimate at the 90^{th} percentile, which the EPA used as the high end of the risk distribution, represents the scenario in the statistical distribution at which 90% of probabilistic exposure scenarios pose lower risks and 10% pose equal or higher risks than that value.

The Risk Assessment analyzed exposures and risks to determine which CCW disposal scenarios and environmental conditions were above applicable risk criteria.[lxii] The EPA adopted a risk criteria factor of 10^{-5} for excess cancer risks and a hazard quotient (HQ) of greater than 1 for noncancer effects to human and ecological receptors.

HQ is the ratio of the likely exposure concentration to the highest concentration at which there are no observable adverse effects.[lxiii] To determine the "HQ" for non-cancer health effects, the EPA compares the exposure concentration (mg/kg/day) to the ATSDR's Minimal Risk Level (MRL) or the EPA's Reference Dose (RfD), which quantifies the level of an exposure to a chemical at which no adverse health effects will occur. Thus: HQ = Exposure concentration (mg/kg/day)/ MRL or RfD. Accordingly, an HQ of 1 represents the highest concentration of likely exposure at which there are no observable adverse effects. Likewise, an HQ of 3 means that the maximum concentration of likely exposure is three times the concentration at which there are no observable adverse effects. However, although there is a positive correlation between HQ and harm, it is not necessarily a 1:1 ratio. For example, at an HQ of 3, the concentration of likely exposure is three times higher than the no observable adverse effects limit, but the increased risk of harm cannot be definitively said to be greater than or less than 300%.

Limitations of EPA's Risk Assessment

EPA conducted a peer review of its 2007 risk assessment in 2008, calling on five scientists from a variety of disciplines.[lxiv] Some scientists alleged that the assessment overestimated risk, and others claimed that it was an underestimation. For example, one scientist stated that the ecological database and benchmarks used to calculate the ecological HQs were overly conservative and that the model used to calculate the transport of contaminants overestimated the movement of some pollutants.[lxv] Another scientist indicated that the assessment would be improved by the inclusion of more data revealing the actual location of drinking water wells near ash ponds and landfills.[lxvi]

On the other hand, significant criticisms alleging underestimation of risk by the scientists chosen by the EPA to review the assessment included: (1) the failure of the EPA to assess how coal ash pollutants interact with each other to increase risk to human health and aquatic organisms;[lxvii] (2) the EPA's failure to consider critical exposure pathways including direct exposure to the slurried wastes in impoundments and direct exposure to the effluent from impoundments discharged offsite;[lxviii] (3) the EPA's failure to consider the inhalation pathway for human health risks;[lxix] (4) the EPA's failure to assess the true time of exposure to contaminants in landfills and surface impoundments from the date of deposition until removal of wastes;[lxx] (5) the EPA's failure to assess multiple exposure pathways for humans and ecological receptors;[lxxi] (6) the EPA's failure to employ data that reflects the actual concentration of pollutants in waste pond water and landfill leachate;[lxxii] (7) the EPA's failure to consider the likelihood of liner failure at landfills and impoundments;[lxxiii] (8) the EPA's failure to consider the disposal of coal ash in landfills below the water table and to consider the limits of the clay and composite liners currently in use at most waste units;[lxxiv] (9) the EPA's failure to consider the impact of exposure of infants and children to coal ash contaminants;[lxxv] and (10) the EPA's failure to consider additional coal ash contaminants that commonly leach from coal ash.[lxxvi]

In addition, in public comments, additional scientists criticized the model the EPA used as the basis for groundwater modeling in its risk assessment, EPACMTP, for its propensity to significantly *underestimate* risks from a variety of factors.[lxxvii] Among the many shortcomings of EPACMTP is that it "cannot simulate scenarios where the waste is disposed within the underlying aquifer," despite the frequent disposal of CCW in landfills within the saturated zone and despite the fact that such disposal below the water table expedites leaching of contaminants from the waste.[lxxviii] In addition, EPACMTP cannot account for multiple or changing leachate compositions, nor can it simulate instances where leachate alters the properties of the receiving aquifer, such as how pH and Eh can impact the mobility of many CCW contaminants.[lxxix]

In fact, EPA acknowledged that there were uncertainties it could not explicitly address, resulting in an *underestimation* of many risks. For example, because porewater data was unavailable to determine leachate from CCW landfills, EPA relied on Toxicity Characteristic Leaching Procedure (TCLP) analyses, which underestimated risks from selenium, which EPA recognizes is a frequent cause of CCW damage cases.[lxxx] Also, the high number of nondetect values for mercury in CCW leachate from landfills and surface impoundments and for antimony and thallium in surface impoundments likely means the EPA *significantly* underestimated risks to human health and ecological receptors.[lxxxi]In addition, the EPA admits that it failed to estimate risk for terrestrial amphibians despite damage cases indicating risk to these amphibians from exposure to selenium, failed to address impacts on endangered species, critical habitats, or managed lands, and failed to analyze synergistic or additive risks of being exposed to multiple constituents or by multiple pathways, all of which will result in an understatement of risk.

Perhaps the most critical limitation in the EPA's 2007 Risk Assessment was that it failed to "address direct releases to surface water, which are permitted under the National Pollutant Discharge Elimination System (NPDES) of the Clean Water Act."[lxxxii] One of the EPA's peer reviewers commented that the risk assessment "grossly underestimates risks from surface impoundments to humans and the environment" because of this deficiency.[lxxxiii] By not addressing "direct releases to surface water," the EPA has also failed to address unpermitted discharges to surface water, the precise scenario that occurred at TVA's Kingston plant in December of 2008. By not addressing the effects of major discharges like those that occurred at TVA's Kingston plant or any less dramatic discharges of that nature, EPA clearly, and significantly, underestimated the risks CCW can pose.

Endnotes

[i] U.S. Envtl. Prot. Agency (EPA), Human and Ecological Risk Assessment of Coal Combustion Wastes (released as part of a Notice of Data Availability) (Aug. 6, 2007) (draft) (hereinafter EPA Risk Assessment).

[ii] Constituent Screening for Coal Combustion Wastes, prepared for EPA, Office of Solid Waste, by RTI, Contract No. 68-W-98-085 (Oct. 2002), Docket No. EP-HQ-RCRA-2006-0796-0470 (posted at www.regulations.gov on Mar. 4, 2009).

[iii] EPA Risk Assessment, supra note i, at appendix B-10. For a table detailing CCW plants with onsite landfills and surface impoundments modeled in EPA's full-scale analysis, see id. at 2-8, tbl. 2-4.

[iv] Id. at 3-1 (citing Electric Power Research Institute (EPRI), Coal Combustion By-Products and Low Volume Wastes Comanagement Survey (June 1997). For a complete list of CCW Disposal Sites (Plants) modeled, see id. at Appendix B-1-1.

[v] EPA defines "composite" liners as a system that combines a plastic (e.g., high-density polyethylene (HDPE) membrane) over either geosynthetic or natural clays. Id. at B-3.

[vi] Id. at 4-7 to 4-8.

[vii] Final Regulatory Determination on Wastes from the Combustion of Fossil Fuels, 65 Fed. Reg. 32,214 (Envtl. Prot. Agency, May 22, 2000) at 32,216.

[viii] Statement of Barry Breen, Assistant Administrator, Office of Resource Conservation, US EPA before the Subcommittee on Environment and Water Resources, House Committee on Transportation and Infrastructure, April 30, 2009.

[ix] Coal refuse is the waste coal produced from coal handling, crushing, and sizing operations, and tends to have a high sulfur content and low pH from high amounts of sulfide minerals (like pyrite). Coal refuse includes "combined ash and coal gob," "combined ash and coal refuse," and "combined bottom ash and pyrites." EPA Risk Assessment, supra note i, at 1-5, fn. 4.

[x] EPA, Integrated Risk Information System (IRIS), Arsenic (CASRN 7440-38-2). http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=0278.

[xi] EPA Risk Assessment, supra note 1, at 4-1.

[xii] Agency for Toxic Substances and Disease Registry (ATSDR), ToxFaqs for Cadmium, http://www.atsdr.cdc.gov/tfacts5.html#bookmark05.

[xiii] Id.

[xiv] ATSDR, ToxFaqs for Cobalt. http://www.atsdr.cdc.gov/tfacts33.html.

[xv] Consumer Fact Sheet on Nitrates/Nitrites, EPA Office of Groundwater and Drinking Water, available at http://www.epa.gov/OGWDW/dwh/c-ioc/nitrates.html. See also EPA, Integrated Risk Information System, http://www.epa.gov/iris/subst/0076.htm (nitrate) and http://www.epa.gov/iris/subst/0078.htm (nitrite).

[xvi] ATSDR, ToxFaqs for Boron, http://www.atsdr.cdc.gov/tfacts26.html#bookmark05.

[xvii] EPA, Integrated Risk Information System, Molybdenum (CASRN 7439-98-7), http://www.epa.gov/iris/subst/0425.htm.

[xviii] ATSDR, ToxFaqs for Thallium, http://www.atsdr.cdc.gov/tfacts54.html.

[xix] Id.

[xx] EPA, Coal Combustion Waste Damage Case Assessments, available at www.regulations.gov, Document ID EPA-HQ-RCRA-2006-0796-0015 (July 9, 2007).

[xxi] Brendan Kearney, Judge Approves $54M Fly-Ash Suit Settlement, Maryland Daily Record, Dec. 30, 2008, http://www.envirovaluation.org/index.php/2009/01/12/judge-approves-54m-fly-ash-suit-settleme.

[xxii] EPA, Pines Ground Water Plume Site, http://www.epa.gov/region5/sites/pines/ (last visited May 5, 2009). See also "Not in My Lifetime: The Fight for Clean Water in Town of Pines, Indiana," Clean Air Task Force, 2004, http://www.catf.us/publications/view/23.

[xxiii] Dennis A. Lemly, Aquatic Selenium Pollution is a Global Environmental Safety Issue, 59 Ecotoxicology and Environmental Safety 44, at 44 (2004), available at http://www.treesearch.fs.fed.us/pubs/7293.

[xxiv] Letter from Environmental Integrity Project, Earthjustice, and others to Lisa Jackson, U.S. EPA Administrator (Mar. 2, 2009), available at http://www.environmentalintegrity.org/pub607.cfm.

[xxv] ATSDR, ToxFAQs, available at www.atsdr.cdc.gov/tfacts2.html.

[xxvi] World Health Organization International Programme on Chemical Safety INCHEM: Environmental Health Criteria for Arsenic (IPCS INCHEM EHC), available at http://www.inchem.org/documents/ehc/ehc/ehc224.htm#5.1.8.
[xxvii] Id.
[xxviii] ATSDR, 2007 CERCLA Priority List of Hazardous Substances, available at www.atsdr.cdc.gov/cercla/07list.html.
[xxix] ATSDR Public Health Statement, available at www.atsdr.cdc.gov/toxprofiles/phs26.html
[xxx] United Nations Environment Program, International Program on Chemical Safety and Environmental Health Criteria, available at www.inchem.org/documents/ehc/ech/ehc204.htm#SectionNumber:5.2.
[xxxi] IPCS INCHEM EHC for Boron, available at http://www.inchem.org/documents/ehc/ehc/ehc204.htm#PartNumber:9.
[xxxii] Id.
[xxxiii] Centers for Disease Control and Prevention (CDC), Third National Report Spotlight on Cadmium, available at www.cdc.gov/exposurereport/pdf/factsheet_cadmium.pdf.
[xxxiv] ATSDR Public Health Statement, available at www.atsdr.cdc.gov/toxprofiles/phs5.html.
[xxxv] Id.
[xxxvi] IPCS INCHEM EHC for Cadmium, available at http://www.inchem.org/documents/ehc/ehc/ehc135.htm#PartNumber:6.
[xxxvii] Id.
[xxxviii] ATSDR, ToxFAQs for Cobalt, available at www.atsdr.cdc.gov/tfacts33.html.
[xxxix] Id.
[xl] ATSDR Public Health Statement, available at http://www.atsdr.cdc.gov/toxprofiles/phs33.html.
[xli] IPCS INCHEM, Concise International Chemical Assessment Document 69, Cobalt, at chpt. 10, available at http://www.inchem.org/documents/cicads/cicads/cicad69.htm#10.0.
[xlii] CDC, Third National Report on Human Exposure to Environmental Chemicals: Spotlight on Lead, available at www.cdc.gov/exposurereport/pdf/factsheet_lead.pdf.
[xliii] Id.
[xliv] Id.
[xlv] Id.
[xlvi] American Cancer Society, Making Treatment Decisions, Molybdenum, www.cancer.org/docroot/ETO/content/ETO_5_3x_Molybdenum.asp.
[xlvii] Environmental Working Group, Chemical Index, Molybdenum, www.ewg.org/chemindex/chemicals/23518.
[xlviii] Eugene R. Weiner, Applications of Environmental Chemistry 228 (2000).
[xlix] Id.
[l] ATSDR Public Health Statement, available at www.atsdr.cdc.gov/toxprofiles/phs92.html; ATSDR ToxFAQs, available at www.atsdr.cdc.gov/tfacts92.html.
[li] IPCS INCHEM EHC for Selenium, available at http://www.inchem.org/documents/ehc/ehc/ehc58.htm#SubSectionNumber:1.1.5.
[lii] Id. at http://www.inchem.org/documents/ehc/ehc/ehc58.htm#SubSectionNumber:7.1.1.
[liii] EPA Risk Assessment, supra note 1, at A-2.
[liv] Id. The data used to create the database included waste characterization data from its 1999 Report to Congress ("RTC"), public comments from the RTC and the May 22, 2000 Final Regulatory Determination, data available to EPA after the comment period for the Final Regulatory Determination, and data identified in literature searches. See id. at A-1-1 for the complete list of data sources used in the 2003 CCW constituent database.
[lv] EPA Risk Assessment, supra note 1, at A-6.
[lvi] Id. at ES-3.
[lvii] Id. at B-10.
[lviii] Id. at 1-5.
[lix] Id. Coal refuse is defined as "waste coal produced from coal handling, crushing, and sizing operations, and tends to have a high sulfur content and low pH from high amounts of sulfide minerals (like pyrite)," and includes "combined ash and coal gob," "combined ash and coal refuse," and "combined bottom ash and pyrites.'" See id. at 1-5 &n.4.
[lx] Id. at 1-2.

[lxi] Id. at 4-1.
[lxii] Id. at 6-1.
[lxiii] See EPA Superfund Glossary, available at www.epa.gov/region5superfund/ecology/html/glossary.html#hazard.
[lxiv] Peer Review of "Draft Hunan and Ecological Risk Assessment of Coal Combustion Wastes," EPA-HQ-RCRA-2006-0796-0467 (Sept. 25, 2008), available at www.regulations.gov.
[lxv] Id. See comments of Nicolas Basta, Ph.D., Ohio State University, at 4 and 8.
[lxvi] Id. See comments of Charles Harvey, Ph.D., Massachusetts Institute of Technology, at 1.
[lxvii] Id. See comments of Charles Harvey, Ph.D., Massachusetts Institute of Technology, at 4, William Hopkins, Ph.D. Virginia Polytechnic Institute and State University, at 6 (hereinafter Peer Review comments).
[lxviii] Id. See Comments of William Hopkins at 2–3.
[lxix] Id. See Comments of William Hopkins at 6.
[lxx] Id. See Comments of William Hopkins at 7.
[lxxi] Id. See Comments of William Hopkins at 8.
[lxxii] Id. See Comments of William Hopkins at 9, R. Kerry Rowe, Ph.D., at 4, and Donna J. Vorhees, Sc.D., at 6.
[lxxiii] Id. See Comments of R. Kerry Rowe at 6.
[lxxiv] Id. See Comments of R. Kerry Rowe at 9.
[lxxv] Id. See Comments of Donna J. Vorhees, Sc.D., The Science Collaborative, at 2.
[lxxvi] Id. See Comments of Donna J. Vorhees, Sc.D., The Science Collaborative, at 3, and R. Kerry Rowe at 6.
[lxxvii] See, e.g., Letter from Charles H. Norris, P.G. and Mark A. Hutson, P.G, to Stephen Johnson, EPA Administrator, Re: Docket ID No. EPA-HQ-RCRA-2006-0796, Feb. 11, 2008, at Document ID EPA-HQ-RCRA-2006-0796-0446.2, at 2.
[lxxviii] Id. at 2, 4.
[lxxix] Id. at 2, 3.
[lxxx] See, e.g., EPA Risk Assessment, supra note 1, at ES-11 (stating that "available data for landfills were mainly Toxicity Characteristic Leaching Procedure (TCLP) analyses, which may not be representative of actual CCW leachate. . . . This suggests that selenium risks may be *underestimated*, which is consistent with selenium as a cause for CCW damage cases") (emphasis added).
[lxxxi] See EPA Risk Assessment, supra note 1, at ES-11. For example, exposure to antimony, even at very low levels, causes significant health effects, and one type of antimony, antimony trioxide, is a possible carcinogen. See Appendix A. In addition, EPA has classified mercury as a possible carcinogen, and mercury has also been linked to nervous system, brain, and lung damage and been deemed extremely harmful to children and fetuses. See Appendix A. Thallium bioaccumulates in plants and animals and has been linked to numerous human health effects including hair loss, damage to lungs, heart, liver, and kidneys, and death. See Appendix A.
[lxxxii] EPA Risk Assessment, supra note 1, at 1-3.
[lxxxiii] Peer Review comments, supra note lxvii. Comments of William Hopkins at 2 (emphasis added).