EXA 409 - Case Study: Lead Contamination and Local Exposure Instructor Notes

Course Description: This class participation exercise is positioned at the end of the first day of exposure lectures, after a day or more of health assessment lectures, and is aimed at giving the class a break from the lecture format and applying some of the concepts in a fun, interactive format. A 15-minute lecture sets up the problem. Contamination of soil and drinking water wells has been discovered at a lead manufacturing facility. Follow-up testing confirmed the initial findings, and additional blood monitoring of children in the town has uncovered incidences of elevated blood lead levels. The lecture material includes the set-up, all of the monitoring data, and some background information on lead. Next, the class is broken up into four groups: the manufacturers, the environmental agency with regulatory jurisdiction, the local health department, and citizens/activists. The groups are told that 6 months have passed since the story first broke, and each group has had time to gather more information and prepare a presentation stating their position and proposing next steps at a town hall meeting. Topics that can be explored by the groups in their presentation include: environmental fate (how can the lead get into the wells?), natural background exposures, validity of the monitoring data, severity of the problem (including modeling of blood levels based on water levels), remediation and further data gathering requirements, drinking water restrictions and testing, and other related topics. Each group makes a 3-minute presentation at the town hall meeting, after which the local environmental agency passes a resolution on the issue. This exercise is followed by a discussion of the overall experience and issues encountered in developing and defending stakeholder positions.

Expected Course Duration: Approximately 1.5 hours

Terminal Learning Objective: To apply the concepts from previous EXA courses in the assessment of a hypothetical "real-world" exposure scenario.

Enabling Learning Objectives:

- Interpret exposure data and apply conclusions to risk management decisions.
- Understand how physico-chemical characteristics, release scenarios, fate and transport in the environment, concentrations in environmental media, biokinetics, life stage, and other factors influence exposure.
- Identify and prioritize research needs to inform decisions based on exposure assessment.

Course Materials

- Four stakeholder information packets (one for each stakeholder group)

Course Overview/List of Slides

TITLE SLIDE

What You Can Expect to Learn from this Course (Slide 1)

- In this course, we will depart from the traditional lecture format, and you will have the opportunity to apply the concepts that you have learned in the previous EXA courses to an analysis of a hypothetical "real-world" case study of lead contamination and exposures from a local manufacturing facility.
- First, we will discuss some background to the problem including basic information on lead sources, behavior, and effects, and an overview of the hypothetical case study scenario.
- We will then split into four stakeholder groups representing the manufacturing company, concerned citizens, the local environmental agency, and the local health department, and each stakeholder group will be responsible for using the concepts of exposure assessment to defend a specific position on the issue of lead contamination and local exposure.

PROBLEM OVERVIEW (SLIDE 2)

⇨ To begin this exercise, let's first lay out the problem.

Durite Manufacturing and Surrounding Community (Slide 3)

- (Instructor Note: Point to location of each on the map on the screen.)
- The Durite Manufacturing Company, which employs 1,100 people, is located 5 km to the northwest of the town of Cherryvale, population 2,386.
- At the southern end of Cherryvale (about 2 km further southwest from the Durite Manufacturing site) is a residential area that includes individual dwellings and high-rise apartments.
- Cherryvale Elementary School is 14 km southeast of Durite Manufacturing.
- Residents living between the facility and the school send their kids to Cherryvale Elementary – it is the largest elementary school in the area.
- Just south of the Durite facility is a recreational park with a lake and wooded areas open to the public.
- Public water for Cherryvale is supplied from groundwater, and the municipal wells are about 9 km southeast of the facility.

⇨ The newspaper headlines on the next few slides were published in the Cherryvale City Post about six months ago. Let's look at some of those headlines.

Breaking News (Slide 4)

- Durite Manufacturing Accused of Poisoning Children: Local environmental activist finds levels of lead in soil at factory exceed allowable standards.

- This was the headline that broke the news of lead contamination around the site and drew a connection between this contamination and potential harmful exposures to children.
- Understandably, the community was concerned with this news, and four follow-up articles were printed over the next few weeks.

Breaking News (Slide 5)

- The first of these – "Hospital Finds Elevated Blood-Lead Levels in Local Children: Three children show high levels of lead; others show symptoms of exposure" – was published after information was leaked about blood-lead levels measured recently in samples from a few local kids.
  - Shortly after this article was published, the following information came to light.

Breaking News (Slide 6)

- Lead Found in Groundwater: Routine tests show contamination of town drinking water.
  - Other investigative articles followed in the local paper, on the local news, and in community blogs and forums.
  - With so much talk suggesting that Durite Manufacturing was responsible for local lead contamination and dangerous exposures, the community rallied for action.

Breaking News (Slide 7)

- Parents March on Town Hall: Parents and other concerned citizens want answers about lead poisoning of children.
  - And finally, Durite Manufacturing responded with a statement.

Breaking News (Slide 8)

- Durite Manufacturing Claims Facility is Safe: CEO of facility claims factory uses best available control technologies.
- So the CEO claimed that Durite was doing all that was required of them to control emissions of pollutants from the facility.

Problem Overview (Slide 9)

- So here is what we know based on the newspaper articles published in the Cherryvale City Post:
  - First, the soil around the Durite Manufacturing facility is contaminated with lead levels at levels of concern established by CDC.
  - Second, a few children have blood-lead levels of concern and others show symptoms of exposure.
  - Third, the town's drinking water is contaminated with lead.
  - Fourth, the community is concerned and wants answers.

- And finally, the manufacturing facility claims it is in compliance with applicable environmental regulations that require it to use Best Available Control Technologies to control emissions of pollutants.

LEAD BACKGROUND INFORMATION AND DATA (SLIDE 10)

⇨ Now let's take a deeper look into some of the information about lead exposure and health effects that triggered these newspaper headlines.

Lead Characterization and Use (Slide 11)

- First, the stakeholders could easily find background information on lead – the database is abundant.
  - The Agency for Toxic Substances and Disease Registry, or ATSDR, publishes fact sheets and toxicological profiles for chemicals found at many Superfund sites. This information is intended to provide the public with scientific facts.
  - According to the ATSDR Toxicological Profile for Lead:
    - Lead is a heavy metal that occurs naturally in the Earth's crust, but is rarely found as the free metal. Instead, lead forms compounds with other elements.
    - Metallic lead is not very corrosive because lead compound films on the surface protect the metal underneath.
    - Lead can be combined with other metals to form alloys, and lead, lead alloys, and other lead compounds have been used in a number of products over time, including paints and dyes, gasoline, metal pipes, and storage batteries in cars.
    - Using lead in some of these applications – like paints, food cans, and gasoline – has since been banned or otherwise eliminated in the United States, but lead released from these applications might persist in the environment for a long time after use has diminished.
- Source**:** ATSDR Toxicological Profile for Lead (2007)

Lead Environmental Fate and Transport (Slide 12)

- So what does happen to lead once it enters the environment?
- If lead is emitted to the atmosphere, small particles can remain in the air for a long time and can travel far from the emission source.
- Once in the atmosphere, however, lead particles are also subject to wet and dry deposition onto soil and water bodies.
- Lead adsorbs strongly to soil particles. It remains in the upper levels of soil profiles, but can also be transported to surface water via erosion and runoff.
- Re-entrainment of lead-contaminated soil dust, however, is common.
- Lead adsorbed to soil and sediment particles might persist for many years.
- And lead in air, water, and soil from contaminated areas can build up in plants and animals. Most of the lead that is consumed by animals in food, however, will be excreted.

- Source: ATSDR Toxicological Profile for Lead (2007)

Lead Exposure (Slide 13)

? After lead enters the environment, how might people be exposed?

  (provide 2 minutes for class t answer and discuss)

- The general population is primarily exposed to lead by swallowing lead-contaminated dusts generated from flaking of lead paint, atmospheric fallout of emitted particles, and contact with contaminated soil.
- To a lesser degree, the general population is exposed to lead via consumption of lead-contaminated water and foods.
- Lead in drinking water generally comes from deteriorated lead plumbing and erosion of natural lead-containing deposits in drinking water sources.
- Lead may be introduced to food products through plant uptake from soil or by atmospheric deposition. Food products may also be exposed to lead during transport, processing, packaging, or preparation. However, lead levels in food are generally low and have decreased drastically since 1989 when lead-soldered food cans were phased out.
- Children are particularly vulnerable to exposure to lead-contaminated dusts and leaded paint chips.
- By and large, deteriorated leaded paint causes most of the severe lead poisoning in children in the United States.
- Children are more vulnerable to high lead exposures because they don't behave like adults; babies and young children often put their hands and other objects in their mouths, and these objects can have lead dust on them.
- Many exposure studies have focused on the correlation between lead in soil and dust, and lead concentrations in the blood of children.
- Sources**:** ATSDR Toxicological Profile for Lead (2007), EPA Basic Information on Lead in Paint, Dust, and Soil (http://www.epa.gov/lead/pubs/leadinfo.htm#health), and EPA Drinking Water Contaminants (http://water.epa.gov/drink/contaminants/)

Lead Health Effects (Slide 14)

- Lead can cause toxicity through multiple modes of action operating in multiple systems. As a result, effects from lead exposure are varied and numerous. A few of the known, important effects are listed here.
- In the general population, exposure to lead can result in elevated blood-lead and bone-lead levels associated with problems in the cardiovascular, nervous, and renal systems.
- Some of these effects include high blood pressure and hypertension, cognitive function decrements such as depression and anxiety, and reduced kidney fuction.
- Children, however, are not only more vulnerable to lead exposure, but also more sensitive.
  - Their growing bodies absorb more lead and their brains and nervous systems are more sensitive to the damaging effects of lead.

- Lead toxicity in children may occur at 5 µg/dL blood or possibly less.
- Recent studies have demonstrated an association between loss of 1 to 5 IQ points with a 10 µg/dL increase in blood-lead levels in children, and importantly, these studies have identified no threshold for effects on IQ. In other words, lead exposure at any level potentially decreases the cognitive ability of children, thus leading to learning and behavioral problems.
- Other effects on children include impaired impaired motor skills (which may persist even after blood-lead levels have returned to normal), and atopic and inflammatory conditions such as asthma and allergy.
- Sources**:** ATSDR Toxicological Profile for Lead (2007) and EPA Basic Information on Lead in Paint, Dust, and Soil (http://www.epa.gov/lead/pubs/leadinfo.htm#health)

Correlation between Lead Levels in Soil and in Blood (Slide 15)

- This slide illustrates the correlation between soil-lead and blood-lead concentrations.
- The figure shows the results of two different biokinetic model runs for which different model parameters were adjusted to determine the relative contribution of lead-contaminated soil to blood-lead levels.
- In the first model run, the only source of lead modeled in the scenario was from soil.
- The relationship between the amount of lead in the soil and amount of lead in blood is illustrated in Series one, which is the bottom line on the graph. As lead levels in the soil increase, lead levels in blood also increase at intervals, resulting in a linear relationship between lead in soil and lead in blood.
- In the second model run, other pathways for lead exposure are introduced, such as from air, diet, drinking water, house dust, and maternal contributions.
- In this scenario, series two, which is the top line on the graph, shows that the levels of lead in blood increase as compared to the scenario in which soil was the sole contributor, but only marginally.
- Soil still appears to be the primary driver of lead levels in blood.
- Lead in paint, however, was not included in this scenario, and this is known to be a major contributor to blood-lead levels in people residing in lead-contaminated buildings.

LOCAL MONITORING DATA (SLIDE 16)

⇨ So that summarizes what is in the general lead database.

⇨ Next, let's go back to Cherryvale and consider what is known about the local situation.

⇨ Limited monitoring data were gathered on the lead levels in the local media and blood samples from children living near the Durite Manufacturing site.

⇨ What did these data show?

Lead in Soil (Slide 17)

- Of the eight measured soil concentrations at the Durite Manufacturing site, three were above the EPA standard of 400 mg/kg for lead in bare soils used as children's play areas, as shown in yellow on the site map on this slide.
- Two of these concentrations were above the EPA standard pf 1,200 mg/kg set for bare soil in residential areas not used as children's play areas.
- As shown in green, three soil concentrations were below the EPA standard for lead in children's play areas.
- Lead is found naturally in soil at concentrations up to about 50 mg/kg – as you can see, two of the three concentrations below the EPA standard for children's play areas are still higher than what is expected to result from natural sources.
- Finally, the two sampling areas shown in blue represent areas where lead was not detected in the soil.
- Sources: TSCA Section 403 (http://epa.gov/lead/pubs/leadhaz.htm)

Lead in Ground Water (Slide 18)

- The wells used to supply drinking water were also tested. As shown in yellow on the map on this slide, of the six measured concentrations in the Cherryvale municipal drinking water wells, two exceeded the EPA treatment technique standard of 15 µg/L for lead in drinking water.
- A treatment technique is defined in the 1974 Safe Drinking Water Act as "an enforceable procedure or level of technological performance that water systems must follow to ensure control of a contaminant"
- Only one of the concentrations on this slide exceeded 100 µg/L, which is the upper bound of range of concentrations found in natural waters.
- All but one of the measurements, however, exceed the average national level of about 3 100 µg/L.
- Sources**:** EPA Basic information about Lead in Drinkingwater (http://water.epa.gov/drink/contaminants/basicinformation/lead.cfm); Safe Drinking Water Act of 1974 (http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm)

Lead Levels in Children's Blood (Slide 19)

- Of the six children tested for lead exposure, half had blood-lead levels that exceeded the first CDC level of concern of 5 µg/dL.
- Above this level, CDC advises community-wide lead poisoning prevention activities.
- The highest measured blood-lead level was 25 µg/dL, which was taken from a 2-year old whose parents worked at the Durite Manufacturing site, and who is rumored to have spent the last year at the Durite Day Care Center on site.
- This child's blood-lead level was above 20 µg/dL, a level above which medical evaluation and environmental investigation and remediation is advised by CDC.

- None of the children tested for lead, however, had blood-lead levels at or above 45 µg/dL, for which CDC recommends immediate medical treatment.
- Source: ATSDR Toxicological Profile for Lead (2007)

STAKEHOLDER PARTICIPATION (SLIDE 20)

- Now that we have some preliminary information on lead and some preliminary data on the level of lead contamination in the area that triggered the original newspaper articles, it's time to get input from the stakeholders.
- You, as stakeholders, will have 6 months to look into the problem, conduct follow-up studies, and develop a standpoint on the issues raised by the local news.
- This is your opportunity to get creative.

Activity Instructions (Slide 19)

- The activity that you are about to begin is in preparation for a town hall meeting in which you as stakeholders will get to share your perspectives on the lead contamination issue.
- First, I will ask you to separate into the four stakeholder groups.
- Please decide if you would like to represent the manufacturers, the local environmental agency, the local health department, or the concerned citizens and activists.
- You are encouraged to go against what your instincts tell you and to join the group you would normally be least likely to represent. For example, if you are a staunch environmentalist, you should choose to represent the manufacturers in this exercise. If you have been involved in environmental policy for a long time, choose to represent the concerned citizens and activists.
- (Instructor Note: allow two minutes to select and assign groups. Have sticky notes or name tags evenly divided among stakeholder groups. Start at one end of the room, and ask participants to pick the group they would like to represent. Hand each participant a sticky note or nametag with their stakeholder group until the groups are filled and evenly distributed. The last few participants may not get a choice of which group to represent. If this method does not seem to be working, randomly assign the participants into the different groups.)
- You will have 30 minutes to review the information in your packet, select a team spokesperson, establish where your stakeholder group stands on the issue of lead contamination from the Durite Facility, and create a 3-slide presentation defending that position and proposing next steps for addressing the issue.
- Each group will have 3 minutes to present at the town hall meeting and 2 minutes for taking questions.
- At the end of the exercise, the local environmental agency will pass a resolution on what the next steps will be to address the issue based on stakeholder input.

Activity Instructions, continued (Slide 20)

- From this point on, assume that you have a an unlimited budget and can conduct new studies. The purpose of these new studies is to collect new information to support your point of view.
- In developing your presentations to support your stakeholder position, also consider the aspects of exposure assessment that you've studied in the previous EXA courses.

DEVELOPING STAKEHOLDER PERSPECTIVES (WHAT DID YOU LEARN IN THE LAST SIX MONTHS?) (SLIDE 21)

- Now it is time to start thinking about what your stakeholder group has done in the last six months, and what new information has come to light.
- Before you begin, each stakeholder group will receive a packet that contains the the following:
  - Activity Instructions
  - A copy of the slides from this presentation
  - An EPA fact sheet on lead in paint, dust, and soil
  - An EPA fact sheet on lead air pollution
  - And a set of discussion starters, or questions that you should use to begin discussing the important issues that should be considered in developing your stakeholder perspective,
- You don't need to read through every detail in this packet, but you should skim the information to see if there is anything in it that might help you to shape an argument or illustrate a point.

⇨ Okay, you may now start developing your stakeholder perspectives and putting together your presentations.

⇨ I'll let you know when you are down to the last 5 minutes and need to start wrapping up your presentations.

⇨ Do you have any questions before we break out into the group discussions?

- (Instructor Note: A short, informal discussion with the participants will help to clarify the goals of this exercise. The gist of the assignment is that anything goes – participants are encouraged to come up with information they claim to have generated in the last six months and present this information as support for their argument. There will invariably be conflicting data, which will need to be taken into consideration during the resolution. As long as the participants understand that there are no constraints to the "new data" they can present, the activity should progress smoothly. Hints to this effect should be given sparingly and only if agroup seems to be getting bogged down. If a group is stuck, try asking them to think about how their stakeholder perspective might be shaped by any of the following – and if they can conduct new studies in these areas to support their standpoint:
  - The environmental fate and transport of lead
  - Background exposures to lead from sources other than the Durite Manufacturing facility
  - How much you can rely on the monitoring data

- How severe the problem currently is based on the correlations between lead levels in environmental media and blood-lead levels of children
- What remediation and data gathering strategies are available and how feasible they might be
- And whether immediate action like drinking water restrictions should be implemented)

Breaking News (Slide 22)

- (Instructor Note: Put this slide up on the screen when the participants have about 5 minutes left to prepare their presentations.)
- The town of Cherryvale is going to have a town hall meeting and is inviting all of you to attend and offer your perspectives as members of the four different stakeholder groups.
- After the town hall meeting, the local environmental agency is going to make a resolution about next steps to address this problem.
- You have about 5 minutes to wrap up your presentations.
- (Instructor Note: Allow the participants 5 minutes to wrap up.)

Town Hall Meeting (Slide 23)

- The Cherryvale Town Hall meeting will now begin. Each spokesperson will have 3 minutes to present new information and defend their stakeholder group's stand on the issue. The floor will then be opened up for a 2-minute question and answer session before moving onto the next presentation.
- We will start with a presentation from the local environmental agency. If you are a member of this stakeholder group, please carefully consider the information brought up by the other stakeholder groups that present after you. You will have a couple of minutes to deliberate at the end of the presentations, after which you will be asked to pass a resolution on how to address the issue.
- (Instructor Note: Guide the participants through the presentations and Q&A sessions, then ask the local environmental agency to take two minutes to decide on a resolution. Their spokesperson will present this resolution to the participants.)

Activity Wrap-Up (Slide 24)

- Thank you to the stakeholder groups for offering their perspectives on this issue. You can now go back to your original seats and shed your stakeholder personas.
- To wrap up this activity, let's discuss some of the challenges to addressing this issue.
- First of all, did you find the original data to be problematic or confusing in any way? If so, in what way?
  - Instructor note: The following questions should be addressed in this discussion (ask these questions, as needed, during the discussion if the participants do not bring up these issues):

- Were enough samples taken to provide a complete and accurate picture of the local contamination? (Answer: No. Wild variation in the concentrations of the few sampled taken do not create a meaningful picture of the contamination. More samples should be taken to understand the pattern of contamination and determine if a soil concentration gradient exists as distance from the facility increases.)
- What does it mean that some detection limits were near regulatory standards? (Answer: A detection limit is both the lowest concentration that can reliably be deistinguished from zero and is the level below the concentration that can be established with any precision. As a result, if a limit of detection is near a regulatory limit and a nondetect is reported, it is possible that concentrations in the sample were above the regulatory limit, but those concentrations could not be established with any accuracy.)
- Were the different notations for non-detects an issue for any of the groups?

- Second, how did the municipal wells become contaminated?
  - Instructor note: The following questions should be addressed in this discussion (ask these questions, as needed, during the discussion if the participants do not bring up these issues):
    - Is overland flow a probable source? (Answer: No. The lake would intercept overland flow.)
    - Is groundwater flow a probable source? (Answer: No. the lake would also intercept groundwater flow. As a result, water transport of lead is not likely.)
    - Is air transport followed by deposition to surface soils off-site a feasible mode of contamination? (Answer: Possibly, depending largely on particle size. If lead is emitted from the facility to the air, it might deposit on local media.)
- How could the condition of the wells contribute to contamination? (Answer: if wells are old and cracked, direct inflow from surface is possible. Also, presence of corroding plumbing within the well could contribute.)
- Third, what is the responsibility of industry in an arena of uncertainty?
  - Instructor note: The following questions should be addressed in this discussion (ask these questions, as needed, during the discussion if the participants do not bring up these issues):
    - Did the environmental agency say that further study is necessary in the light of new data presented by the groups? If yes, then great! If no, then they should have.
    - Did the health department or anyone else bring up the possibility of other sources of lead, such as old homes with lead paint? (Same answers as above)
    - Are we quick to point the finger of blame at industry?
- And finally, how did the way the problem was formulated affect the risk management decisions for this issue?
  - Instructor Note: This will be an open-ended discussion, but can include the following components:
    - No management goals were articulated up front (i.e., Was the goal to determine whether a specific population or life-stage within a specific area was “safe” given current levels of lead in media? Was the goal to isolate the source of contamination and employ remediation and mitigation strategies?)

- No boundaries were applied to the analysis (i.e., no specific assessment endpoints were selected as most important to examine
- The nature of the problem was not defined adequately characterized (i.e., Could the lead contamination from the local manufacturing plant really be contributing to high levels of exposures given the history of the town? Was the contamination more realistically from aging infrastructure like lead-based paint in houses and aging wells?
- A conceptual model was not used to diagram the potential relationships between the lead contaminants, exposures, and assessment endpoints. As a result, more attention was given to exposure pathways that were not relevant to the issue at hand (e.g., lead in drinking water was likely not related to lead releases from the manufacturing plant).
- A plan was not provided for how to characterize risk.

REFERENCES

ATSDR. (2007) Toxicological Profile for Lead. U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA. Available online at: http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf.