Making Sense of the Data

Communities affected by environmental contamination often see long reports full of data. Take time to understand these reports, it can save you time and money. Industry officials, decision-makers, and the community will take you more seriously if you show you understand the numbers and terms.

> *People were surprised – as soon as the stuff was on the wall, we could puzzle out the bigger story together.*
>
> *Slowing down lets the group figure some things out themselves. It also helps them decide what they want to ask an expert about.*

Start with a first look...

A First Look at Technical Documents

Look carefully at a document like

- a report of environmental test results
- an environmental impact statement
- a permit document.

See what you can figure out as a group. Then, list and prioritize the questions you still have.

...then practice giving the data meaning.

Converting Between Units: Practice converting ppm or ppb to mg/kg and µg/kg or mg/L and µg/L.

Mapping Data: Put data onto a map to see hot spots.

Compare to Standards: Compare test results to health-based standards to find the worst contamination.

If you get stuck on a definition, review a fact sheet.

Common Units: Fact sheets (with optional activities) for common units in environmental testing.

- Order of magnitude
- Metric prefixes (kilo-, milli-, micro-)
- Cubic meters (m^3)
- Liters, milliliters, deciliters (L, mL, dL)
- Kilograms, grams, milligrams, and micrograms (kg, g, mg, µg)
- Acres and Hectares
- Tons and Tonnes
- Watts (W) and more
- Parts per million and billion (ppb, ppb)

Limits and Levels: Fact sheets about common limits and levels in environmental testing:

- Detection Limits and Reporting Limits
- Background Levels
- Reference Dose (RfD)
- Cancer Slope Factor and Unit Risk Factor
- Reference Concentration (RfC) for Inhalation
- Water quality standards
- Soil quality standards
- Air quality standards
- Occupational Safety and Health Administration Permissible Exposure Limits (OSHA PELs)

Overview

Participants examine selections from a technical document and become familiar with typical sections. They record their observations and questions on sticky notes, and group those notes by category. Then they discuss next steps needed to identify information in the document that will help their campaign.

When to Use It

When a community has a technical document that seems impenetrable; they don't know where to begin.

If you are leading this workshop at a conference where there is no particular technical document, you can find sample data sets in the *Data Sources* section at sfa.terc.edu.

Depending on the group's questions, follow this workshop with other activities from Making Sense of the Data, Drawing Your Own Conclusions, and Pieces of the Risk Puzzle.

Skills

- Problem-solving through collaboration
- Identifying key information needed, and strategizing about how to find it

Notes for Facilitator

This workshop does not offer strategic advice about how to proceed with a campaign after reading a technical document, or about whether and how to challenge the findings in the document. Understanding your document is an important first step, but your strategy will depend on many things – politics, state regulations, economics, and more.

Smart Moves

- Slow down
- Talk it out
- Seek verification

Time: 60 Minutes

Preparation

Choose which kind of technical document you have. Review the appropriate page of *Strategies for Reading...*

- *Environmental Testing Results Reports*
- *Environmental Impact Statements*
- *Permit Documents*

Using *Strategies for Reading ...* select 1-2 pages from each "typical section" of your document. If possible, enlarge each of the selected pages on a photocopier.

Post one large blank sheet labeled "Other Questions or Observations."

Cut apart *Participant Instructions* slips (p. 3). Tape them on each posted page.

Using *Strategies for Reading...* prepare blank poster-paper sheets with the Categories of Questions & Observations that match your technical document:

- Definitions and Properties
- The Process
- Results (or Predictions)
- Health Risks
- Action Needed

Materials

Enlarged selected pages from the technical document (posted on the wall or tables of the meeting room, leave plenty of space between them)

Participant instructions slips from p. 3 (one per posted document page, taped to that page)

Blank sheets with Categories of Questions and Observations (posted on the wall or tables)

Sticky notes (medium-sized)

Markers and pens

Step 1: Set the Stage (5 minutes)

Tell participants that technical documents* can be confusing, and while we might not be able to understand everything about them, together we can make sense of a few selected excerpts. If we figure out what questions we still have, that will help us determine next steps. Then explain the activity.

** or "Environmental Test Results," "Environmental Impact Reports," or "Permit Documents" as appropriate.*

Step 2: In pairs or small groups of 3-4 (20 minutes)

Give each person sticky notes and a pen or marker. Divide into pairs or small groups. Tell each group to start with one of the technical document pages posted.

After reading each page, they should share their observations and questions with each other, then write them on sticky notes and post them on the pages (one question or observation per note).

Encourage them to write specific questions – ones that will make sense if they are moved around and read by another participant. You may want to 'seed' a few pages with some notes of your own. Groups move from page to page, until they have visited most pages.

Step 3: Organize (10 minutes)

Turn the group's attention to the blank Questions & Observations sheets. Ask participants to take a few sticky notes off the the technical documents and move them to the sheets that best fit each question. If participants are not sure where to move some notes, they can discuss with each other or you. Keep going until all the sticky notes are categorized.

When this is done, take a few minutes to look at the categorized questions together. Participants then write their names next to any questions they think they can answer.

Step 4: Debrief (15 minutes)

- Lead the group in discussion. As needed, share your own observations.
- How was that experience? What patterns did you see? What insights did you have?
- Which questions and observations stand out as most important?
- Which questions need to be answered *first* to help the group's goals?

Tell the group that questions can be answered in different ways: using resources, looking online, asking experts, doing activities at future meetings. Some questions have no specific answer, but can guide the work.

Step 5: Next Steps (10 minutes)

[If the group is very large, do this after the meeting with a smaller group of people who are interested.] Discuss and identify steps needed to answer the questions identified as most important or that need to be answered first. Possible next steps include:

- Divide up questions about definitions or technical processes among members of the group. Ask a few people to research the answers before the next meeting. They can develop expertise on on the topic, and then teach the rest of the group.
- Do a related *Statistics for Action* activity at the next meeting to help with a key concept.
- Consult an EPA or engineering expert between meetings, or bring them to the next meeting.

(Cut into strips and attach one to each posted document page)

Instructions

Look at this page carefully. What do you notice? What seems clear? What does not make sense? What questions do you have? Write down your observations and questions, one per sticky note.

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Strategies for Reading Environmental Testing Results Reports

These reports show the results of tests in which samples of soil, air, water, or sediment were taken from specific locations, brought to a laboratory, and examined to see if the samples show evidence of certain chemicals. They show where the samples were taken, how much contamination was found in each sample, and how the levels of contamination found compare to any applicable legal standards.

A report may be written by multiple organizations. A common scenario: The EPA or DEP commissions the tests and decides where to sample, but contracts with an environmental engineering company to do the actual work. The engineers then take the samples, but contract with a chemical laboratory to analyze the samples. Then the lab returns the raw results, the engineering company summarizes the most important findings, and the agency determines if any action is needed.

Remember, the reports will *not* show contamination in locations that were not tested, or of contaminants for which the lab didn't or couldn't test. For more details about soil or water testing, review the *Soil Quality Guide: Digging into the Dirt* and *Water Quality Guide: Read Before You Drink* on the SfA web site.

Typical Sections

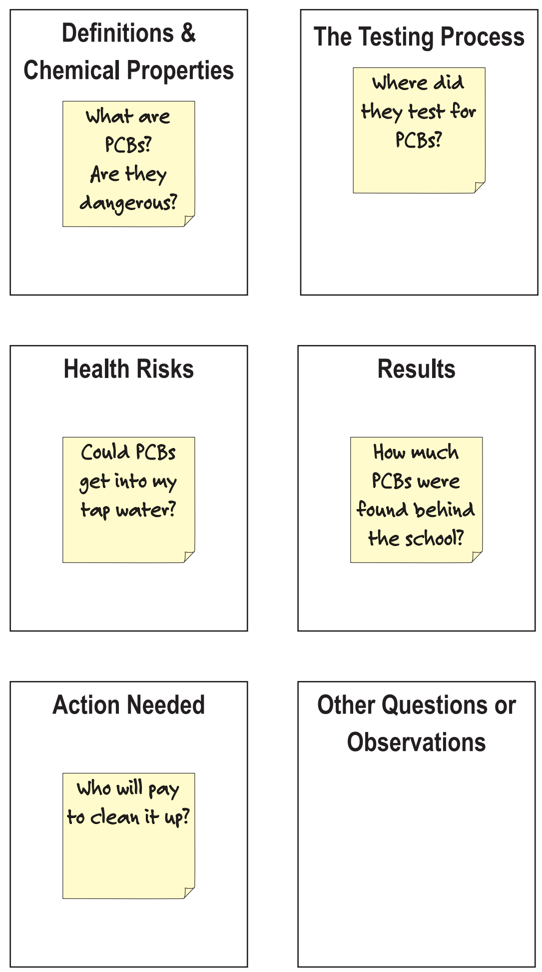
Select a typical page or two from each of the following sections, if available:

1. Narrative summary of report
2. Tables with a summary of the most important data
3. Maps of the site with testing locations marked
4. Tables of full lab results, including results both over and under the detectable limits
5. Descriptions of samples from the field (temperature, pH)
6. "Chain of custody" reports

Categories of Questions & Observations

On the right are typical categories into which questions and observations can be grouped.

An example is given for each, but you don't need to write the example on the posted paper. Just the category will do.



Strategies for Reading Environmental Impact Statements

An Environmental Impact Statement (EIS) or Report (EIR) is a written summary of an environmental impact assessment. An assessment is required when a new project (factory, development, construction) might have an impact on environmental or human health. In some cases, an EIS is made before cleaning up a polluted site, to see if the cleanup itself would put anyone at risk.

An EIS answers the question, "If this proposed project goes forward, how could it affect the environment and/or public health?" It will *not* answer the political question, "Should this project be allowed to proceed?"

Typical Sections

Select a typical page or two from each of the following sections, if available:

1. Introduction explaining why the project is being proposed
2. Description of the places that might be affected
3. Variety of alternatives for implementing the project. One should be a "No Action" alternative, predicting impacts if things were left as-is. This is used as a baseline for comparing the other alternatives.
4. Analysis of the environmental impacts of each of the alternatives, including things like:
- impacts to threatened or endangered species
- impacts on air and water quality
- impacts to historic and cultural sites
- social and economic impacts on local communities
- cost analysis for each alternative, including costs to mitigate expected impacts
5. Optional or Additional Sections:
- Evidence of funding for the complete project
- Proposed environmental mitigation plans, if the preferred alternative will cause significant impact

Categories of Questions & Observations

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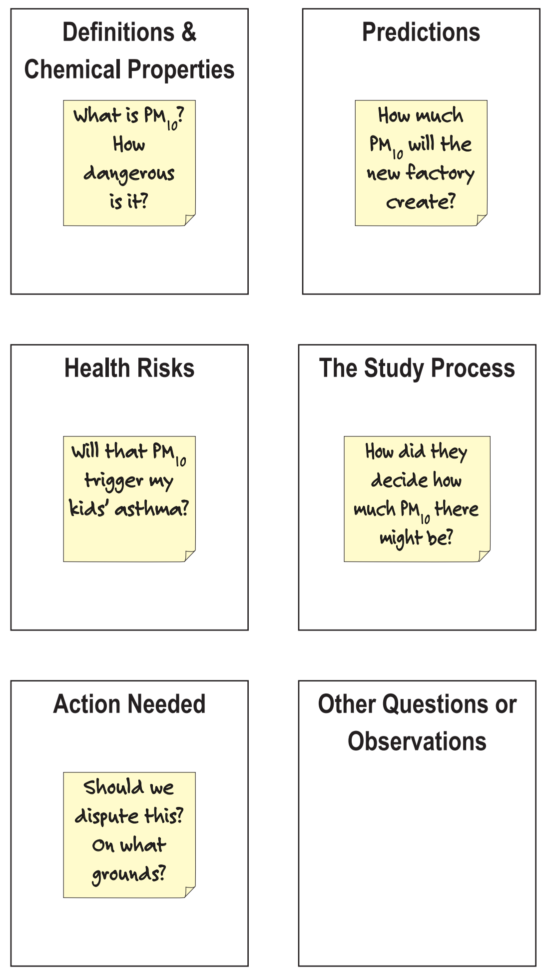
An example is given for each, but you don't need to write the example on the posted paper. Just the category will do.



Strategies for Reading Permit Documents

Permits are granted by government agencies. Many documents are generated in a permitting process. Permit granting is political – a balance of socio-economic benefits vs. environmental degradation. Granting or renewing a permit requires public involvement, where people can comment on both sides of that balance.

A *permit application* is a document proposing a new project. The proposing company fills out the application. A government agency then decides whether or not to grant the permit, and what restrictions the permit should specify. Most permits eventually expire and must be renewed.

A *release permit* lets a company put a certain amount of pollution into the water, air, or soil in a period of time. This can be called a release, discharge, runoff, or effluent.

A *site permit* allows a company to construct a building and parking lots, checking to see if the company has a plan (both during construction and long-term) for dealing with water, sewage, trash, construction pollution, electricity, traffic, stormwater runoff, etc.

Other permits limit the amount or type of fuel a company can burn, or how much water or power they can use. Special permits are required for companies whose business is storing or treating hazardous waste.

Typical Sections

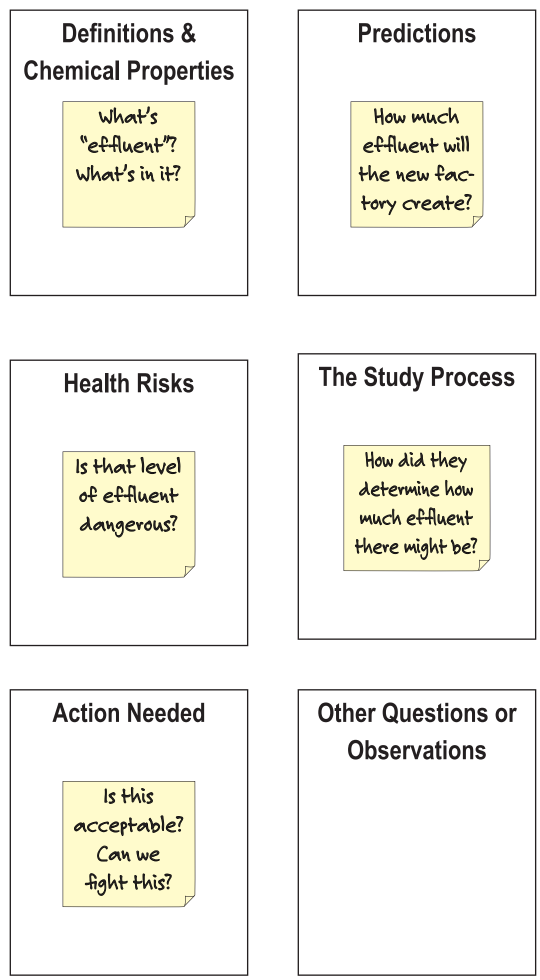
Select a typical page or two from each section. Section names vary greatly, depending on the type of permit and the granting agency. Focus on the issue you care about most. If you think the company isn't being truthful, use sections that depend on numbers provided by the company. Most permit documents specify exact numbers for each building, tank, boiler, furnace, machine, etc. regulating:

- what it does, and how long and how often it can operate
- what chemicals are used and how, where and how they are stored, and any possible contact with people
- how much fuel, water, or power it can consume
- how much contamination it can release in a period of time
- how often it should be monitored and inspected, and how that information should be kept and reported

Categories of Questions & Observations

On the right are typical categories into which questions and observations can be grouped.

An example is given for each, but you don't need to write the example on the posted paper, just the category.



Activities Overview

Participants discuss, read, and practice using one or more units of measurement found in environmental science. Includes a fact sheet, and facilitator guide for each of the following units:

- Order of magnitude
- Metric prefixes (like kilo-, mega-, milli-, micro-) [fact sheet only]
- Cubic meters (m^3)
- Liters (L), milliliters (mL), and deciliters (dL)
- Kilograms (kg), grams (g), milligrams (mg), and micrograms (μg)
- Acres and Hectares
- Tons and Tonnes
- Watts (W), kilowatts (kW), megawatt (MW), kilowatt-hours (kWh), megawatt-hours (mWh), and million-megawatt-hours (MMWh) [fact sheet only]
- Parts per million (ppm) and parts per billion (ppb)

When to Use Them

Before (or along with) a reading of technical documents or reports that refer to any of these units. Choose only the unit or units related to your community; don't use all the fact sheets.

You can use the fact sheets by themselves as handouts to supplement a meeting or other activity. For a better understanding and practice using the units, you can also frame each fact sheet with the questions and/or activities on the corresponding facilitator supplement.

Steps

Each activity follows the same format. See the facilitator supplement for each unit for details.

1. **Launch the discussion:** Ask if anyone has heard of a [unit] before or can give an example. Offer a list of familiar things and ask which one is closest to a [unit].
2. **In pairs or in the whole group:** Read and discuss the fact sheet.
3. **Optional activity:** Engage the group in an activity to give them a more physical sense of the unit, or to practice using the unit.

Worth Noting

The fact sheets use many analogies to help participants understand the units. These analogies can be unscientific and imprecise. They shouldn't be used in a scientific way. However, they can be useful in making memorable messages or images for the media or the wider community.

Smart Moves

- Compare to what you know
- Use your senses

Skill: Estimating and verifying the size of commonly-used units, and developing personal or familiar analogies to describe those units.

Time: 10 minutes (without activity)
20-30 minutes (with activity)

Preparation

Choose which units will be covered.

Review the *Fact Sheet* and *Facilitator Supplement* for each unit chosen.

If doing an activity, note any extra materials needed.

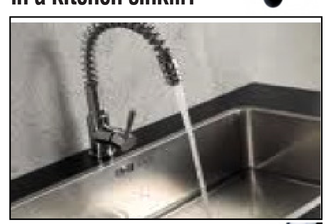
Materials Needed

Fact Sheets (1 per participant per unit)

Facilitator Supplement (1 per facilitator per unit)

Any additional materials needed for the activity

Is a part per million more like a drop of ink in a kitchen sink...?



...or in a tanker truck?

Metric Prefixes

Definitions

The metric system uses standard prefixes with its units, to show changes in the order of magnitude.

Prefix	Short	Word	Number	Scientific
Giga-	G-	billion	1,000,000,000	$x10^{9}$
Mega-	M-	million	1,000,000	$x10^{6}$
kilo-	k-	thousand	1,000	$x10^{3}$
deci-	d-	tenth	1/10 or 0.1	$x10^{-1}$
centi-	c-	hundredth	1/100 or 0.01	$x10^{-2}$
milli-	m-	thousandth	1/1,000 or 0.001	$x10^{-3}$
micro-	μ-	millionth	1/1,000,000 or 0.000001	$x10^{-6}$

Examples

Grams, kilograms, and milligrams are different units. But they all measure mass; just on different orders of magnitude:

- A kilogram (kg) is 1,000 grams (g), 1,000,000 milligrams, and 1,000,000,000 micrograms.
- A milliliter (mL) is 1/1000 of a liter, or 0.001 L.

Uses

Technically, you can use any of these prefixes with any metric unit. In practice, some are common and others are rare. For example, it's common to measure liquid in liters and milliliters, but deciliters are only used when talking about measuring toxins in human blood. Nobody uses kiloliters, but people working for public water systems might use megaliters or gigaliters. There is no special pattern; each profession has its own culture.

Order of Magnitude

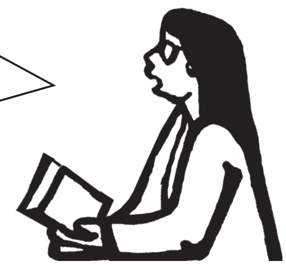
"Order of magnitude" is a term often used in environmental work. It is a quick, general way to communicate the size or quantity of something. There are a few ways the term is used:

Estimating or Generalizing

When guessing the size of a number, people may not be able to be very specific, but they can guess whether it's closer to 1, 10, 100, or 1,000, etc. (or 0.1, 0.01, 0.001, etc.) This "ballpark" estimate helps start a conversation, even without precise numbers.

Example: The regulator knows background levels are generally between 6-14 ppm. They're rarely as low as 1 ppm or as high as 100 ppm.

In this part of the state, background levels of arsenic in the soil are on the order of magnitude of 10 ppm.



Comparing

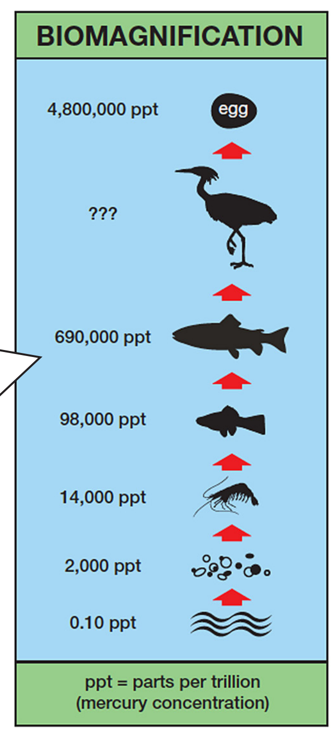
When comparing two numbers quickly, the exact comparison might not be as important as the order of magnitude comparison. Health effects from contamination don't change much with a small increase in contamination. Usually it takes an order of magnitude increase or decrease in contamination to cause a significant change in health effects.

Example: The screening level for a contaminant is 2 mg/kg. Some test results show 3 mg/kg. The risk assessor knows screening levels are generally set by order of magnitude.

Contamination is a little over the screening level, but not by much; they're on the same order of magnitude. We'll do more testing, but there's no reason to panic.

Example: Mercury contamination becomes more concentrated as it goes up the food chain.

Mercury levels may be less than a part per trillion in the river, but it's 7 orders of magnitude higher in a crane's egg.



Source: Source: U.S. Department of the Interior, U.S. Geological Survey, Center for Coastal Geology

Order Of Magnitude

Launch the Discussion

Remind or tell the group why you're covering this topic (it came up at a previous meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

Has anyone heard the phrase "order of magnitude" before? What do you think it is?

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

Activity 1: Ask the group to compare familiar things by order of magnitude. Make sure people say what aspect is being compared: Length? Area? Volume? Weight? Expense? Prompt with the comparisons below (don't give an answer until participants have had a chance to guess.)

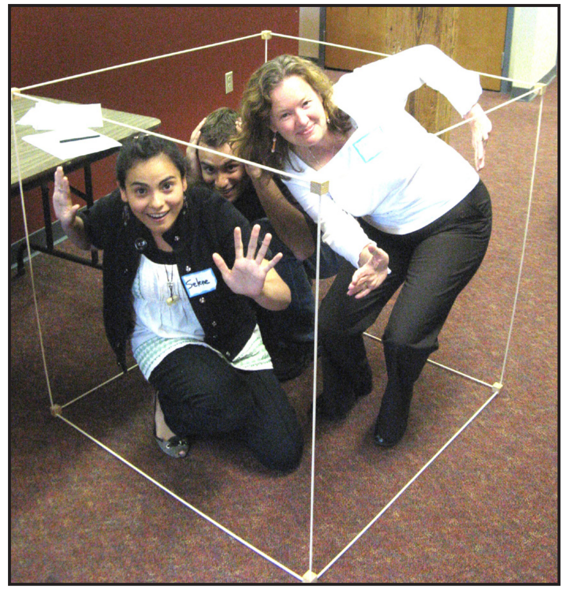
- Height of an adult, and height of a toddler? (same order of magnitude)
- Amount of water in a tablespoon, and amount of water in a gallon? (two)
- Time in an hour, and time in a year? (four)
- Weight of a bicycle, and weight of a car? (two)
- Weight of a person, and weight of an elephant? (two)

Then, ask participants to come up with their own order of magnitude comparisons.

Activity 2: Find a common small object, like a post-it note or a dollar bill. Have the group figure out big it would be if it were one or two orders of magnitude larger. Mark how big it would be on the floor.

Cubic Meters (m³)

Definition



A cubic meter (m³) is the space contained by a cube one meter on each side. It's a measure of volume, equal to 1,000 liters, or 264 gallons.

(A meter is 100 centimeters, the same as 39.4 inches, or a little longer than a yard.)

Uses

Cubic meters are used to measure a volume of air. Air contamination is usually measured in milligrams or micrograms of contamination per cubic meter (mg/m³ or µg/m³).

Examples

- Five 55-gallon barrels are about the same as a cubic meter.
- The space underneath a 6' x 2½' table that is 2½' high is about a cubic meter.
- A 12-foot storage pod holds about 21 cubic meters.
- A typical refrigerator takes up about 1.5 cubic meters of space in a room (but holds less than that).
- A typical adult male breathes a cubic meter of air every 2 hours.

Cubic Meters (m^3)

Launch the Discussion

Remind or tell the group why you're talking about cubic meters (it came up at a meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

Has anyone heard of a cubic meter before?

It might be best to compare it to a standard 55-gallon steel drum or barrel - the kind used for oil or waste. (Confirm participants are familiar with these before continuing.) How many 55-gallon drums do you think are in a cubic meter? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.)

- Half of a 55-gallon drum?
- A full one?
- Two?
- Five? (Answer: A cubic meter is a little less than five 55-gallon drums.)
- Ten?

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

- Build a cubic meter using 12 meter sticks. Alternatively or use 3 meter sticks and the corner of a room to define the outlines of a cubic meter.
- Find something in the room that takes up about a cubic meter of space (or something like half or twice that size). Measure it out to confirm. Estimate: how many of those would fit in the room? Then measure the dimensions of the room to confirm.
- How much lead (or any other contaminant) would it take to contaminate the air in the room above the air quality standard of 0.15 $\mu g/m^3$ (or any other air quality standard?) Calculate the volume of the air in room in cubic meters. Use this Fact Sheet together with the Fact Sheet for kilograms and grams if needed.

Liters (L), milliliters (mL), and deciliters (dL)

Definition

A liter (L) is a measure of (usually liquid) volume. A cube 10 centimeters (cm) on each side is equal to a liter, though a liter can be any shape.

A milliliter (mL or ml) is 1/1000 of a liter. It's equal in volume to a cubic centimeter (cm^3 or cc).

A deciliter (dL) is 1/10 of a liter.

A "drop" is not an official measurement because actual drops of liquid come in many sizes. However, a general rule is that there are 20 "drops" in one mL.

Uses

Liters are the standard way to measure large amounts of liquid, especially water, in scientific laboratories. Water contamination is usually measured in miligrams or micrograms of the contaminant per liter of water (mg/L or µg/L).

One liter of water (but not other liquids) has a mass of one kilogram (kg). This means that you can convert mg/L to "parts per million" and µg/L to "parts per billion" when describing water contamination. Can you find the million-to-one relationship in mg/L?

Milliliters are used for smaller measures of liquid, like liquid medicine. One mL of water has a mass of one gram (g).

Deciliters (dL) are used in giving blood test results, but aren't common to see elsewhere.

Examples

- A liter is a little bigger than a quart. There are about 3.8 liters in a gallon.
- The most common size for a large bottle of soda/pop is two liters, which holds a little less than a six-pack of 12-ounce cans.
- A typical bottle of wine is 750 mL, or 3/4 of a liter.
- A 12-cup coffee carafe is about 1.5 L.
- There are 5 mL in one teaspoon.
- One dL is a little less than half of a measuring cup.

Liters (L), milliliters (mL), and deciliters (dL)

Launch the Discussion

Remind or tell the group why you're covering this topic (it came up at a previous meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

Has anyone heard of a liter before?

What's an example of a liter?

Which do you think is closer to a liter? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.)

- A measuring cup? (about 1/4 of a liter)
- A quart? (a quart is a little less than a liter)
- A gallon? (3.8 liters)

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

Display several empty bottles or containers of different shapes and sizes, labeled A, B, C, etc. At least one should be a liter. If possible, include a 10 cm x 10 cm x 10 cm cube. Write down the capacity of each bottle, for your own notes. Remove or cover any labels on the bottles that say how much they hold.

Have participants guess which one is a liter. Have a jug or pitcher of water handy so people can check their guesses and compare by pouring water from a smaller container into a larger one.

Kilograms (kg), grams (g), milligrams (mg), and micrograms (µg)

Definition

A gram (g) is a metric unit for a small amount of mass or weight. It's equal to the weight of one cubic centimeter (or one milliliter) of water.

A kilogram (kg) is 1,000 grams. A kg has the same weight as one liter of water.

A milligram (mg) is one thousandth of a gram. There are one thousand mg in a g, and one million mg in a kg.

A microgram (µg, ug, or Ug) is one millionth of a gram. There are one million µg in a g, and one billion µg in a kg.

Uses

In environmental science, these units are frequently used in relation to each other, because even a tiny amount of contamination in a large amount of soil, water, or air can be harmful.

Soil contamination is often measured in mg or µg of contaminant per kg of soil sampled. Water contamination is measured in mg or µg of contaminant per liter of water. Air contamination is measured in mg or µg of contaminant per cubic meter of air.

Because there are one million mg in a kg, the ratio mg/kg is sometimes expressed as "parts per million (ppm)." Similarly, µg/kg sometimes appears as "parts per billion (ppb)."

Examples

- A kg weighs about 2.2 pounds.
- There are about 28 g in 1 ounce.
- A 2-L bottle of soda/pop weighs 2 kg. A major league baseball bat weighs about 1 kg.
- A dollar bill, a small paper clip, and a packet of artificial sweetener each weigh about 1 g.
- Medical pills are often described in mg, but you shouldn't use that as a way of understanding how big a mg is: A "200-mg" tablet of ibuprofen contains 200 mg of the drug, but it also contains fillers and coatings to help the drug release slowly. A whole 200-mg pill weighs much more than 200 mg.
- One mg is almost too small to see. One grain of fine table sugar or salt might be about one mg. One µg is definitely too small to see without a microscope.



Kilograms (kg), grams (g), milligrams (mg), and micrograms (µg)

Note: The discussion and activities below focus on grams and kilograms. If your group is more interested in milligrams and micrograms, first do the activity below. Then, use the 1,000-to-1 relationship between kg and g to imagine the *same* relationship between g and mg, or mg and µg.

Launch the Discussion

Remind or tell the group why you're talking about these units (it came up at a meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

Kilograms: What's an example of a kilogram? Which of these do you think is closer to a kilogram? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.)

- A deck of cards? (about 1/10 of a kilogram)
- A baseball bat? (about 1kg)
- A gallon of water? (3.8 kg)
- A cinder block? (12 -14 kg)

Grams: What's an example of a gram? Which do you think is closest to a gram? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.)

- A drop of water? (0.05 g)
- A piece of copier paper? (about 4.5 g)
- A packet of artificial sweetener? (about 1 g)
- A tablespoon of sugar? (about 12 g)

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work. If the group is focused on mg and µg, have participants make statements like, "There are as many milligrams in a packet of sweetener as there are packets of sweetener in a baseball bat."

Activities

Bring in a digital bathroom scale (for kg) and/or a sensitive digital kitchen scale (for grams). Bring in objects of various weights and invite participants to guess the weight in kilograms/grams, and then weigh the objects to verify. Invite people to guess and check with objects in the room or in their pockets: Books, keys, wallets, water bottles, etc. For a special challenge, have participants guess which one is closest to 1 g or 1 kg.

Acres and Hectares

What is It?

An acre measures surface area. It's equivalent to 43,560 square feet. There are 640 acres in one square mile. The acre was originally 22 yards by 220 yards, the amount of land that one person could plow in one day with one ox. But there is no standard shape for an acre; it is any shape with that area.

In the metric system, the thing most similar to an acre is a hectare, which is 10,000 square meters, or a square measuring 100 meters x 100 meters. A hectare is about two and a half acres.

Uses

In the U.S., it's common to measure large areas of land in acres. Plots of land for building houses are frequently described as fractions of acres (1/4 acres, 1/10 acre, etc.)

Hectares are rarely used in the U.S., except when comparing to international measures.

A quick internet search will tell you the area of most cities and states in acres or square miles.

Examples

A football field without the end zones is about 48,000 square feet. So an acre is a little less than that – about the same as the area between the two 5-yard lines.

A typical Home Depot store is 130,000 square feet, or about 3 acres.

The area of Rhode Island is 776,957 acres.

Acres

Launch the Discussion

Remind or tell the group why you're covering this topic (it came up at a previous meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

What's an example of an acre?

Which do you think is closest to an acre? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.)

- A football field? (a little more than an acre)
- An average Home Depot? (about 3 acres)
- The area of Rhode Island? (776,957 acres)

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

Use a tape measure to measure the floor of the room. Calculate the floor's area in square feet. Alternatively, you can come with information about the area of a place everyone knows (like the local high school gym). Then calculate how many 'floors' of that room would make an acre.

Tons and Tonnes

Definition

One ton, also known as a "short ton," is 2,000 pounds.

One tonne, also known as a "metric tonne" or "metric ton" is 1,000 kg, or 2,204 pounds.

One "long ton" is 2,240 pounds. This term is rarely used in the U.S. except in shipbuilding.

Uses

Tons and tonnes are usually used for very large weights of solid material, like waste going to a landfill, or coal going to a power plant. In the U.S., the word "ton" by itself usually means short tons. People who mean metric tonnes will usually specify that.

Examples

- Ten 200-lb men weigh a ton.
- Three Harley-Davidson V-Rods weigh a ton.
- A cubic yard of concrete weighs about two tons.
- A typical Ford F-150 truck with a driver and a full tank of gas weighs a little less than three tons.

Tons

Launch the Discussion

Remind or tell the group why you're covering this topic (it came up at a previous meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

Has anyone heard of a ton before?

What's an example of something that weighs a ton?

Which do you think is closest to a ton? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.)

- A Harley-Davidson? (A Harley V-Rod is about 1/3 ton.)
- A VW Bug? (1967 model was a little less than a ton. The 2012 model is 1.5 tons)
- A Hummer 2? (Over 3 tons)

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

Using a bathroom scale, weigh a few heavy objects in the room. Then calculate how many of each object would be needed to make a ton.

Parts per Million (ppm) and Parts per Billion (ppb)

Definition

Parts per million (ppm) and parts per billion (ppb) show a relationship between two quantities that use the same units. A part per million could be one drop per one million drops, one gram per one million grams, etc. By definition, one ppm = 1,000 ppb.

Ppm/ppb can be measured by *weight* (ppmw/ppbw) or by *volume* (ppmv/ppbv), depending on what's being measured. Some documents will tell you if it's weight or volume, other times you will need to figure it out yourself.

Uses

Ppm and ppb are often used like a percent, but for very small amounts. The word percent literally means "part per hundred". So, 1% = 10,000 ppm = 10,000,000 ppb.

For soil, mg/kg = ppm and µg/kg = ppb. This is always by weight.

For water, mg/L = ppm and µg/L = ppb, if comparing by weight. These equations are *not* true in the rare cases where measuring ppm/ppb by liquid volume.

For air, ppm and ppb are always by volume. There is no direct conversion between ppm/ppb and mg/m^3 or $µg/m^3$; it will depend on the density of the contaminant in the air, and on air temperature and pressure.

Examples

Part per Million

Other ways of thinking about parts per million:

- 1 drop of ink in a large kitchen sink (about 13 gallons).
- One drop in the fuel tank of a mid-sized car
- One inch in 16 miles
- One minute in two years
- One car in a line of traffic from Cleveland to San Fransisco
- One penny in $10,000

Part per Billion

Other ways of thinking about parts per billion:

- one drop of ink in a large tanker truck (about 13,000 gallons)
- 1 car in a line of cars that goes around the Earth 100 times
- Three seconds out of a century
- One penny in $10,000,000
- One grain of sand in a sand box

Parts per million (ppm) and parts per billion (ppb)

Launch the Discussion

Remind or tell the group why you're covering this topic (it came up at a previous meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

ppm**: Has anyone heard of a part per million before? What's an example of a part per million?** Which do you think is closest to a part per million? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.) Is it like one drop of ink in:

- A cup of water? (1 part in 4,730, or 211 ppm)
- A gallon of water? (1 part in 75,700, or 13 ppm)
- A large kitchen sink? (about 1 ppm)
- An olympic-sized swimming pool? (1 part in 5,000,000,000, or 0.005 ppm, or 5 ppb)

ppb**: Has anyone heard of a part per billion before? What's an example of a part per billion?**

Which do you think is closest to a part per billion? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.) Is it like one drop of ink in:

- A large kitchen sink? (about 1 ppm, or 1,000 ppb)
- A bathtub? (1 part in 3,180,000, or 315 ppb)
- An olympic-sized swimming pool? (about 5 ppb. This is the closest answer, but the most accurate would be one drop spread across five olympic swimming pools)
- Lake Erie? (1 part in 1×10^{18}, or one billionth of a part per billion)

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

In the *SfA* activity *Converting Between Units*, participants practice converting parts per million or parts per billion to either mg/kg and μg/kg (for soil) or mg/L and μg/L (for water).

Watts (W), kilowatts (kW), Megawatts (MW), kilowatt-hours (kWh), Megawatt-hours (mWh), and Million-Megawatt-hours (MMWh)

Definition

One watt (W) is a measure of electrical power, which is the amount of energy an electric device uses (or produces) per second. A kilowatt (kW) is 1,000 W, and a megawatt is 1,000,000 W.

A kilowatt-hour (kWh) is the amount of energy used by using one kilowatt of power for one hour. A megawatt-hour (MWh) is the amount of energy used by using one megawatt of power for one hour. One million-megawatt-hour (MMWh) is one million megawatt hours.

Uses

Household appliances are rated in watts or kilowatts, to show how much power they consume when in use.

A electricity bill shows how many kilowatt-hours of energy were used.

Power plants are rated in megawatts, to describe how much power they can produce.

Megawatt-hours and million-megawatt hours might be used to describe how much energy a power plant produced in a year, or how much energy a whole city or state used in a year.

Sometimes an amount of power plant fuel (coal, oil, natural gas, biomass, nuclear) will be described in MWh. This is an estimate of the amount of heat energy it can create if burned. Not all of that energy can be converted into electrical energy.

Examples

- Old-style incandescent light bulbs use 60W or 100W of power.
- A hot-air hair dryer or a toaster oven might use about 2 kW of power.
- One kW is about 1.34 horsepower.
- A major FM radio station transmitter broadcasts 50 kW of radio signal.
- A small power plant might produce less than 100 MW for about 50,000 homes. Large power plants might produce 500-1,000 MW.

Fact Sheets

Environmental advocates see many kinds of limits and levels. What are these limits? If a test result exceeds one of them, are there implications for health or legal liability?

This resource has fact sheets for limits and levels you might read or hear about. Each tells you what the limit is, how it's used, how it's determined, and how it relates to health. Most of the fact sheets also list a web site with more information.

Many states have health-based standards that are more restrictive than the federal standards. The states may call those standards by different names. If you want to use the conservative standards, check both federal and state regulations, and choose the limit you prefer.

Many fact sheets refer to units like mg/kg, ppm, and µg/m3. For help understanding these units, see the fact sheets in the resource Common Units.

Fact Sheets Included	Soil	Water	Air	Health-Based Standard?	Legal?
Detection Limits	Y	Y	Y		
Reporting Limits	Y	Y	Y		Y
Background Levels	Y	Y	Y		~
Reference Dose (RfD)	Y	Y		Y	
Cancer Slope Factor and Unit Risk Factor	Y	Y	Y	Y	
Maximum Contaminant Levels (MCLs) & MCL Goals (MCLGs)		Y		Y	Y
Groundwater Objectives (GWOs) and Preventive Action Limits (PALs)		Y		Y	Y
Screening Quick Reference Tables (SQuiRTs)	~	Y		~	
Residential and Industrial Soil Screening Levels (RSSLs and ISSLs)	Y			Y	
National Ambient Air Quality Standards (NAAQS) for Criteria Air Pollutants (CAPs) and Air Quality Index (AQI)			Y	Y	Y
Reference Concentration (RfC) for Inhalation			Y	Y	
Occupational Safety and Health Administration Permissible Exposure Limits (OSHA PELs)	~		Y	~	Y

"**Y**" means "Yes"

"**~**" means "more complicated than yes or no." See the fact sheet for the full story.

Detection Limits and Quantitation Limits

What are they?

Every measuring device has limits. If you put one penny on a digital bathroom scale, the scale still reads zero. If you keep adding pennies, you eventually see a number at 0.1 lb (one tenth of a pound). That means 0.1 lb is the detection limit for that scale. Anything less is not detected. Tests for air, water, and soil contamination methods also have detection limits, below which a contaminant can't be detected. They also have quantitation limits, below which they can detect a contaminant, but the amount can't be accurately measured ("quantified").

How are they used?

Detection and quantitation limits are called by different names on test results:

- instrument detection limit (IDL)
- method detection limit (MDL)
- practical quantitatation limit (PQL)
- limit of quantification (LOQ)
- minimum quantitation limit (MQL)

When test results are below detection limits, you may see ND, meaning "Not Detected" or U ("Under the detection limit") or an * or < symbol. In each case, there should be a note somewhere on the page showing the detection limit. Sometimes the number will appear in the results themselves, like "<5," meaning "less than five."

How are they determined?

Detection limits are determined by the equipment and methods used for testing. A lab should choose equipment and methods that will detect contamination well below health-based standards. If 50 μg/L might be hazardous, but the the detection limit is 100 μg/L, then a "not detected" won't tell you whether or not you're at risk. It's better to set detection limits at 5 μg/L, one-tenth the level of concern. However, very sensitive tests are expensive, and not always necessary. If the screening level is 5,000 μg/kg, you don't need a test that can find as little as 1 μg/kg. Also, a very sensitive instrument might not work for high levels of contamination – your bathroom scale wouldn't work to weigh an elephant or a truck!

How are they related to human health?

Detection limits aren't directly related to health or safety. If you have test results, it's more important to compare levels to a health-based standard, like a screening level or legal limit. Detection limits are only a problem if they're set too high, and risky results are undetectable.

Monitoring Well -16' BGS	Units	Baseline 1/2/2008		04/01/2008		07/07/2008		10/01/2008	
		Result	Limit	Result	Limit	Result	Limit	Result	Limit
		VOLATILE ORGANICS							
Vinyl Chloride	ug/L 2	**530**	25	**100** ug/L	1.0	**100**	5.0	**16**	10
1,1-Dichloroethene	ug/L	<	25	**1.1**	1.0	<	5.0	<	10
trans-1,2-Dichloroethene	ug/L	**70**	25	**20**	1.0	<	5.0	**19**	10
cis-1,2-Dichloroethene	ug/L	**6,800**	25	**2,100**	1.0	**160**	5.0	**2,300**	100
Trichloroethene	ug/L 5	**1,200**	25	**2,500** ug/L	1.0	**82**	5.0	**2,300**	100
Tetrachloroethene	ug/L	**1,800**	25	**4,100**	1.0	**330**	5.0	**2,900**	100

Here, for each testing date the results appear next to a "Limit." But this isn't a legal limit, it's the detection limit. Notice how the detection limit changes each month as the lab tries to find a limit that will detect the contamination, but won't be far more sensitive than is needed.

Reporting Limits

What are they?

In cases where testing has been mandated by a government agency, the agency may require contamination above a certain level to be reported, even if it is below the level of concern.

How are they used?

Laboratories must use equipment and procedures that are capable of detecting contamination as low as the reporting limit. Sometimes tests show contamination above a reporting limit, but below a health-based standard. In those cases, a community might want to test nearby, to see if there is a contamination 'hot spot' they might have missed.

How are they determined?

The reporting limits may be set at a particular fraction of the level of concern. For example, if the legal limit for a contaminant is 20 µg/L, the agency might set the reporting limit at 2 µg/L, which is one-tenth the level of the limit. That way, they will know if contamination is anywhere close to the legal limit.

How are they related to human health?

Contamination levels over the reporting limit aren't a health concern, unless the levels *also* go over a health-based standard.

Background Levels

What are they?

Background levels (usually measured in soil) are the levels of contaminants that you might normally expect to find in a place, but that can't be attributed to a single polluting source. Some toxins may be in the soil because they are naturally occurring, like arsenic or uranium. Others may be due to widespread human use – for example, lead from car exhaust in the mid-20th century spread widely in soil and water. Background levels vary from place to place.

For air and water, different terms may be used for the same idea. Scientists may say "ambient air quality" to mean a background level of outdoor air quality when comparing with contaminated indoor air. But this can be confusing, because there are also ambient air quality standards (see NAAQS) that have nothing to do with background levels.

How are they used?

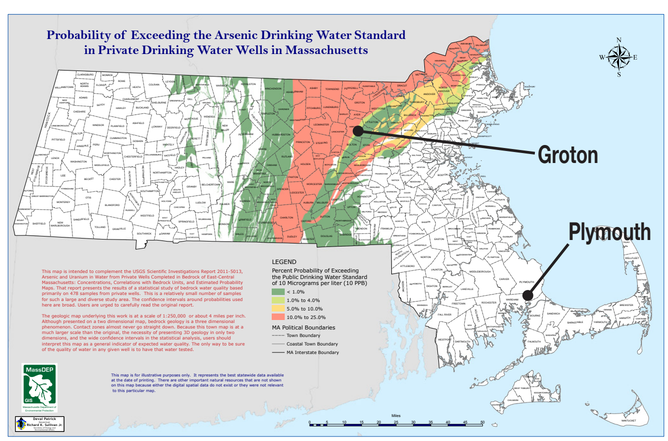
Comparing a test result to background levels helps show how unusual a test result is. If a test result is significantly above background levels, there might be a specific human cause for the contamination. Showing unusually high test results can help determine legal liability for cleanup costs or shutdowns.

How are they determined?

Background levels are determined by testing over a very large area, like a whole county or state. The background level is often set at a value like the 90th percentile (meaning 90% of the samples were below that level, so it would be unusual to find a sample above that level). Sometimes the background level is simply the average of all the samples.

How are they related to human health?

Background levels and ambient air quality are determined by measurements, not by safety. A test result for a toxin that is close to the 'normal' background level might still be a health concern, if the background level is very high. On the other hand, if the background level is very low, a test result might be above background levels but might not be a health concern. For health risk insights, compare test results to health-based standards, not to background levels.



This map reflects background levels of arsenic in Massachusetts well water. A high arsenic level in a private well in Groton might not be unusual, because it could be from the high background level. But the same level in Plymouth ***would*** be unusual, so it might be easier to prove it came from a specific business. In either place, you should avoid drinking contaminated water.

Reference Dose (RfD)

What are they?

RfD is the amount of a substance, per unit of body weight, that a person could consume every day for their rest of their life with no increased likelihood of negative health effects. RfDs are measured in mg/kg/day – milligram of toxin per kilogram of body weight per day. (*Note:* RfDs do not address cancer risks; there is no 'safe' level for a cancer-causing toxin. See *Cancer Slope Factor* for more.)

How are they used?

RfDs are not legally binding by themselves, but they are the "building blocks" of almost all risk assessment. Health-based standards should be set so that a person with typical daily exposure won't get more than the RfD of the contaminant. For example, a toxicologist knows a typical (154-lb) person drinks 2 - 4 liters of water per day. They might set the MCL for a toxin in drinking water so someone drinking that water would not exceed the reference dose.

Another example: A risk assessor focused on risks from contaminated soil might see if anyone's exposure to that soil might lead to them absorbing more than the RfD of a toxin. Risk assessors also look at multiple paths of exposure: If someone is exposed to a toxin through the soil, water, and air, do all of those exposures add up to exceed the RfD?

A risk assessor might find that the level of contamination in a particular case is unlikely to be harmful even if it exceeds a particular standard. If exposure is less than typical (people rarely drink this water or come into contact with this soil) then there is less risk of exceeding the RfD.

How are they determined?

RfDs are based on tests of laboratory animals. Sometimes they are based on human health studies from accidental exposure. Scientists start with a level of the toxin that has shown no observable negative effects (NOEL/NOAEL), or the lowest level of the toxin that *has* shown negative effects (LOEL/LOAEL) in lab animals. They then make that number smaller by safety factors:

NOAEL

↓

÷ 1 to 10 for effects that may be apparent in humans that are not apparent in lab animals

↓

÷ 1 to 10 for effects in sensitive populations like children or elderly people

↓

÷ 1 to 10 for unknown effects

↓

RfD

In this way, an RfD may end up being 1,000 times smaller than a NOAEL.

How are they related to human health?

RfDs are set based on health risks, and are intended to be very conservative. They assume a lifetime of daily exposure at the RfD, so exposure slightly above the RfD for a short time is unlikely to increase health risks. Again, RfDs are for *non-cancer* effects. See *Cancer Slope Factor*.

For More

epa.gov/iris/subst - or check your state's environmental agency's website.

Cancer Slope Factor and Unit Risk Factor

What are they?

A *cancer slope factor* gives the percent increase in the risk of getting cancer associated with a dose of a toxin (in mg of toxin per kg of body weight) every day for a lifetime.

A *unit risk factor* is based on the slope factor, but is specific to air (and sometimes water). The inhalation unit risk factor answers, "How many more cancer cases per million people would I expect to see for every microgram of this toxin per cubic meter of air?" For water, it's for every microgram of toxin per liter of drinking water.

How are they used?

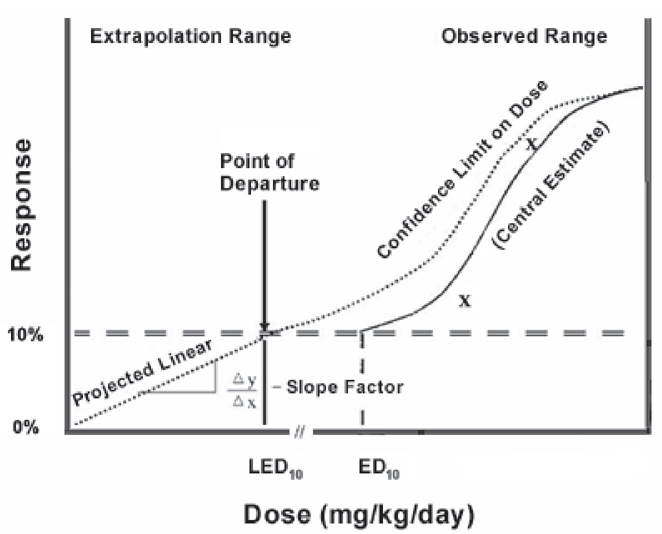
A risk assessor will apply cancer slope factors and unit risks to test results to calculate how many more cancer cases a population might be likely to see if that population had a lifetime of exposure to that amount of a toxin. Slope factor is general, while unit risk is specific to air or water.

How are they determined?

Cancer slope factors and unit risks are usually based on tests on laboratory animals. Sometimes (but rarely) they are based on human health studies from accidental exposure. Calcuations for people assume a 70-kg adult, exposed to the toxin for 70 years by breathing 20 m^3 of air (or drinking 2 L of water) per day.

How are they related to human health?

There are no 'safe' levels for carcinogens, because damage to a single cell can cause cancer. However, lower levels of a carcinogen will cause fewer additional cancer cases. If studies show that a certain level of a carcinogen isn't likely to cause one new cancer case out of one million people, officials may decide that it is 'acceptable', even if it is not technically risk-free.



Scientists look at data from experiments and find the relationship between the dose (how much toxin is consumed) and the response (health effects). If they know what dose affects one in ten lab animals, and what dose affects one in a hundred lab animals, they can calculate the dose that would affect one in a million.

For More

epa.gov/iris/subst ...or check your state's environmental agency.

Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)

What are they?

The EPA publishes maximum contaminant levels (MCLs) for different toxins in drinking water. MCLs are measured in milligram (mg) or microgram (µg) of contaminant per liter (L) of water.

How are they used?

MCLs have legal weight. Public water systems are required to keep contamination below MCLs. If a business has contaminated private drinking water wells above the MCLs, the company may be liable for damages, health care costs, and cleanup costs.

How are they determined?

MCL Goals (MCLGs) reflect 'safe' levels as closely as toxicologists can determine: if you drink this water every day for your entire life, you will not be any more likely to experience ill effects than if you didn't drink that water. See *Reference Dose* for more on the science of how MCLs are set. For carcinogenic (cancer-causing) contaminants, there is no safe level, and so the MCLG is zero.

Unfortunately, achieving a zero (or extremely low) level is not always physically or politically possible. So MCLGs are ideal, but not legally binding. Regulators then set the MCL, which *is* legally binding, "as close to the MCLG as feasible, using the best available treatment technology and taking cost into consideration."

How are they related to human health?

MCLs are are a legal guideline, but they aren't a dividing line between 'safe' and 'unsafe'. The MCLGs offer the best protection of health. Some states, tribal groups, and European countries have more protective standards.

Remember that both MCLs and MCLGs are set assuming a lifetime of exposure. If contamination is only slightly over the MCLG, drinking one glass of it is unlikely to harm you. MCLs are most protective of human health in that they allow government agencies to take action to reduce contamination.

Inorganic Chemicals

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term)
Antimony	0.006	0.006	Increase in blood cholesterol; decrease in blood sugar
Arsenic	0[7]	0.010 as of 01/23/06	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer

For more

water.epa.gov/drink/contaminants or check your state's environmental agency website.

Groundwater Objectives (GWOs) and Preventive Action Limits (PALs)

What are they?

GWOs are legal standards set by states for underground water. PALs are based on GWOs, and trigger action to prevent contamination from exceeding the GWO. GWOs and PALs may have different names in different states.

How are they used?

Groundwater objectives are legally binding. A business found to be contaminating groundwater beyond a GWO can be shut down. If contamination exceeds a PAL, a business must take action to prevent further contamination, like reducing emissions or slowing production. PALs don't trigger a shutdown, but they can serve as a serious warning that something needs to change.

GP-26 Monitoring Well -16' BGS	RIDEM GA Groundwater Objectives	RIDEM Groundwater Quality PALs
Vinyl Chloride	2	1
1,1-Dichloroethene	7	3.5
trans-1,2-Dichloroethene	100	50
cis-1,2-Dichloroethene	70	35
Trichloroethene	5	2.5
Tetrachloroethene	5	2.5

How are they determined?

GWOs are set to be protective of people and ecologies for a variety of uses. For example, in Massachusetts there are 3 GWO categories, each with its own objectives:

GW-1: Strongest standards, for groundwater that could be used for drinking water.

GW-2: Meant to limit contamination from evaporating out of shallow groundwater and going into the air in a nearby building.

GW-3: Minimum standards that apply to all groundwater in the state.

Preventive Action Limits are based on the groundwater objectives – often set at one half or one tenth of the GWOs.

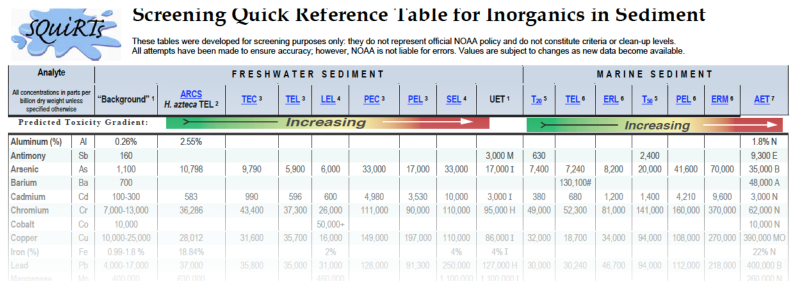
How are they related to human health?

GWOs are set to be protective of human and ecological health. The set levels are based on assumptions about typical behavior. People with much more (or much less) contact with groundwater should keep exposure in mind when assessing a particular situation.

Screening Quick Reference Tables (SQuiRTs)

What are they?

These tables contain a range of levels, all relating to potential damage to aquatic life (tiny animals living in water) from different levels of contamination in surface water (rivers, ponds, bays, etc.) and sediment.



SQuiRTs

Screening Quick Reference Table for Inorganics in Sediment

These tables were developed for screening purposes only: they do not represent official NOAA policy and do not constitute criteria or clean-up levels.
All attempts have been made to ensure accuracy; however, NOAA is not liable for errors. Values are subject to changes as new data become available.

Analyte		FRESHWATER SEDIMENT									MARINE SEDIMENT						
All concentrations in parts per billion dry weight unless specified otherwise		"Background" [1]	ARCS H. azteca TEL [2]	TEC [3]	TEL [3]	LEL [4]	PEC [3]	PEL [3]	SEL [4]	UET [1]	T_{20} [5]	TEL [6]	ERL [6]	T_{50} [5]	PEL [6]	ERM [6]	AET [7]
Predicted Toxicity Gradient:			Increasing								Increasing						
Aluminum (%)	Al	0.26%	2.55%														1.8% N
Antimony	Sb	160								3,000 M	630			2,400			9,300 E
Arsenic	As	1,100	10,798	9,790	5,900	6,000	33,000	17,000	33,000	17,000 I	7,400	7,240	8,200	20,000	41,600	70,000	35,000 B
Barium	Ba	700										130,100#					48,000 A
Cadmium	Cd	100-300	583	990	596	600	4,980	3,530	10,000	3,000 I	380	680	1,200	1,400	4,210	9,600	3,000 N
Chromium	Cr	7,000-13,000	36,286	43,400	37,300	26,000	111,000	90,000	110,000	95,000 H	49,000	52,300	81,000	141,000	160,000	370,000	62,000 N
Cobalt	Co	10,000				50,000+											10,000 N
Copper	Cu	10,000-25,000	28,012	31,600	35,700	16,000	149,000	197,000	110,000	86,000 I	32,000	18,700	34,000	94,000	108,000	270,000	390,000 MO
Iron (%)	Fe	0.99-1.8 %	18.84%			2%			4%	4% I							22% N
Lead	Pb	4,000-17,000	37,000	35,800	35,000	31,000	128,000	91,300	250,000	127,000 H	30,000	30,240	46,700	94,000	112,000	218,000	400,000 B
Manganese	Mn	400,000	630,000			460,000			1,100,000	1,100,000 I							260,000 N

How are they used?

Like other screening levels, they are not legally binding. They are used as a quick comparison to measure the severity of contamination, and potential ecosystem effects.

How are they determined?

The levels are set by the National Oceanic and Atmospheric Administration (NOAA). There are levels for "No Observable Adverse Effects Level (NOAEL)" all the way to "Severe Effects Level (SEL)". These levels are set based on lab experiments and tests of actual contaminated bodies of water. One of the most common levels used is the "Threshold Effects Level (TEL)" which is the lowest level of contamination thought to harm aquatic life.

How are they related to human health?

SQuiRT levels are set based on ecological health, not human health. However, if a test result shows very high levels compared to a severe SQuiRT level, be careful around that body of water. You will want to see results from additional tests before swimming, drinking nearby well water, or eating fish from the contaminated water.

For more:

response.restoration.noaa.gov/environmental-restoration/environmental-assessment-tools

Residential Soil Screening Levels (RSSLs)
Industrial Soil Screening Levels (ISSLs)

What are they?

Screening is a first pass at soil testing. Investigators try to locate contamination at a site, and to see how much there is. In EPA language, this is "Phase II" or "site characterization." Investigators compare test results to EPA Region III Soil Screening Levels to determine how concerned they should be about the contamination. SSLs are measured in milligram of the toxin per kilogram of soil (mg/kg) which is the same as parts per million (ppm). Smaller amounts are measured in micrograms per kilogram (µg/kg), the same as parts per billion (ppb).

How are they used?

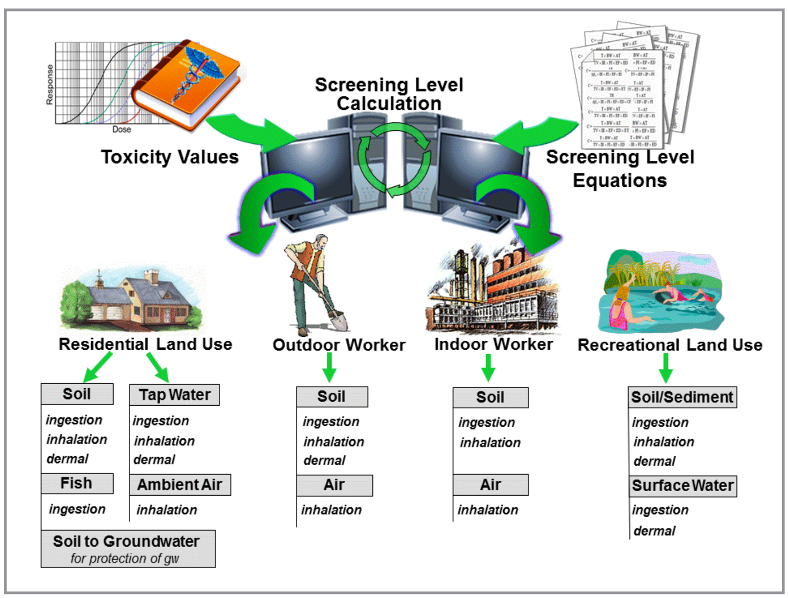
Screening levels are widely used as a point of reference for various contaminants. There are different screening levels for residential and industrial use. If contamination in a sample exceeds a screening level, it is cause for concern, but it does not automatically mean that people are in danger or that a cleanup is legally required. It usually means there should be more testing in that area, to get details about the contamination, and about current and planned uses for the site.

How are they determined?

SSLs are based on two factors: the relative toxicity of the contaminant, and on "typical" human exposure to soil. Residential levels (RSSIs) are set lower than Industrial levels (ISSLs), because people spend more time at home than at work, and because the most vulnerable populations (children and the elderly) are not often exposed to industrial settings. Workers in industrial settings can also be required to wear protective clothing if there is contamination.

How are they related to human health?

Screening levels are based on "typical" exposures, but in reality, people have a wide range of contact with soil. If test results are above screening levels, a risk assessor should study how people might come into contact with that soil, and assess risk of exposure.



For more:

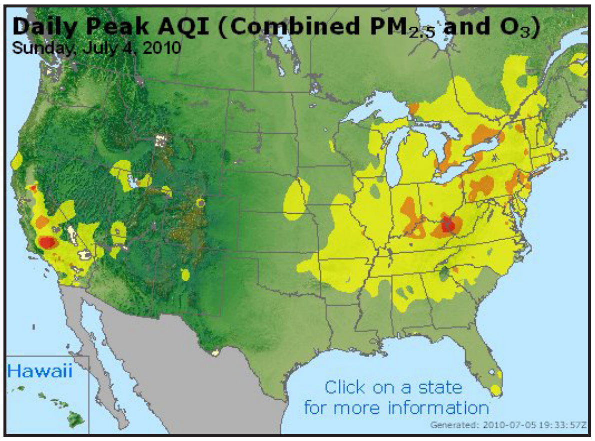
epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables
Or check your state's environmental agency website.

National Ambient Air Quality Standards (NAAQS) for Criteria Air Pollutants (CAPs) and Air Quality Index (AQI)

What are they?

NAAQS regulate six CAPs considered harmful to public health and the environment:

- ground-level ozone (O_3)
- particulate matter (PM)
- carbon monoxide (CO)
- sulfur dioxide (SO_2)
- nitrogen dioxide (NO_2)
- lead (Pb)



There are two types of standards for each CAP. Primary standards provide public health protection. Secondary standards protect community assets beyond public health. AQI is scale that gives a quick sense of a day's air quality based on five CAPs (all except lead).

How are they used?

States measure air quality, particularly in urban areas, and compare to NAAQS. Places where air contamination exceeds one or more standards are called "non-attainment" areas. In those areas, states must have a plan describing how they will try to improve air quality.

AQI is a scale ranging from 0-500; a lower AQI is safer. An AQI of 100 corresponds to the primary standard for each CAP. As air quality changes on a daily or even hourly basis, the AQI can tell you how clean or polluted your air is and associated health effects. If you hear a warning on the radio about a hazardous air quality forecast, it's based on the AQI.

How are they determined?

Primary NAAQS are intended to protect public health, including protecting the health of sensitive populations like asthmatics, children, and the elderly.

Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The AQI at a particular moment is based on air sampling. It's based on how close each of five CAPs is to its standard, with 100 representing the standard. It's weighted more heavily toward the most hazardous pollutants.

How are they related to human health?

Primary NAAQS and AQI are meant to protect human health. Small or temporary exceedences might affect sensitive people. High or long-term exceedances may harm many people.

For more

epa.gov/air/criteria.html

Reference Concentration (RfC) for Inhalation

What are they?

RfC is a concentration of a toxin in the air that is unlikely to cause non-cancer health problems, even if a person breathes air with that concentration for an entire lifetime. It is usually measured in mg/m^3 or $\mu g/m^3$.

How are they used?

RfCs are not legally binding, but they can be used as a guide for assessing risk. RfCs are also not as widely monitored and enforced as the NAAQS.

How are they determined?

RfCs are usually based on tests on laboratory animals. Sometimes they are based on human health studies from accidental exposure.

How are they related to human health?

Air contamination below RfCs is unlikely to cause health problems, even in the most sensitive people. As contamination goes higher above the RfC, the more likely it is to cause problems.

RfCs are only set for *non-cancer* effects. If an air toxin is a carcinogen, there is no 'safe' level. See *Cancer Slope Factor*.

For More

epa.gov/iris/subst

Except for NAAQS, states regulate air quality more directly than the EPA. California lists their RfCs (calling them Reference Exposure Levels, or RELs) at:

oehha.ca.gov/air/allrels.html

Use these, or your own state's standards if the EPA lists no RfC.

Occupational Safety and Health Administration Permissible Exposure Limits (OSHA PELs)

What are they?

PELs are regulatory limits on the amount or concentration of a substance in the air in a workplace. There are also some PELs for skin exposure to workplace contaminants. Most PELs apply to industry in general, though some are specific to shipyard employment and the construction industry.

How are they used?

Most OSHA PELs apply to the average level of air contamination over an 8-hour period in a workplace. This is called an "8-hour time weighted average (TWA)." There are also *short-term exposure limits* based on 15-minute periods, and *ceiling limits* that should never be exceeded. If a business exceeds a PEL, they can be fined. If they exceed PELs regularly, they can be shut down.

How were they determined?

The American Conference of Governmental Industrial Hygienists (ACGIH) regularly publishes a set of guidelines called Threshold Limit Values (TLVs®). In 1972, OSHA adopted the TLVs as official PELs.
Even though the TLVs have continued to be updated since then, only a few PELs have been changed in that time. Most PELs have not. Changes have been proposed in the past, but have been blocked in the regulatory process.

How are they related to human health?

The TLV guidelines were theoretically related to human health, but were not originally intended to be hard limits determining safety. PELs are widely criticized by environmental scientists and regulators for being based on outdated science. Many PELs would fail a modern EPA risk assessment. PELs should *not* be considered protective of human health.

For more

osha.gov/law-regs.html

or check your state's labor law enforcement agency website.

Activity Overview

Participants fill in a table converting parts per million or parts per billion to either mg/kg and µg/kg (for soil) or mg/L and µg/L (for water).

When to Use It

When you need to compare test results with standards, but they're not in the same units. They need to be in the same units before comparing.

Suggested companion activities

- May be needed after Making Sense of the Data.
- Accompany with the appropriate handouts from Common Units.
- This skill may be needed before doing The Summary vs. The Lab, Compare to Standards, or As Toxic As...?

Steps

1. **Launch the activity:** We have our [soil/water] data, but they don't always use the same units. This will help us practice converting between those different units. (Pass out the ppm/ppb handout. Review the relationship between ppm/ppb and units in [soil/water.])
2. **In pairs:** Here's a chance to practice converting between units. (Pass out the [soil/water] worksheet. Optional: Use a calculator if people need help getting started.)
3. **Debrief:**
   - How did this go? Was it hard or easy?
   - (If applicable) Do you feel ready to try this with our own data?

Worth Noting

Some people quickly and easily catch on to equivalent units. Others will need a lot of coaching. They may multiply by 1,000 when they should divide instead. If participants struggle, they can start by using a calculator. You can also suggest they break 1,000 down into three tens (e.g., 1.5➔15➔150➔1,500).

With help, once they have a chance to convert a few results from one unit to another, they may start to see patterns, and begin to feel more certain about the relationships between units. This will help them be able to respond more quickly and flexibly in situations where numbers get thrown around.

Smart Moves

- Play with different ways to say it
- Seek verification

Skill: Build fluency converting between units

Time: 20 minutes

Preparation

Choose which workeet you will use: *Soil Contamination* or *Water Contamination*

Review the ppm/ppb handout in *Common Units* and the participant instructions.

If you are unfamiliar with the units themselves, review the handout *Common Units* about kg/mg/µg (and Liters, if needed).

Materials

Answer sheet (1 per facilitator)

Worksheet (1 per participant)

Ppm/ppb handout from *Common Units* (1 per participant)

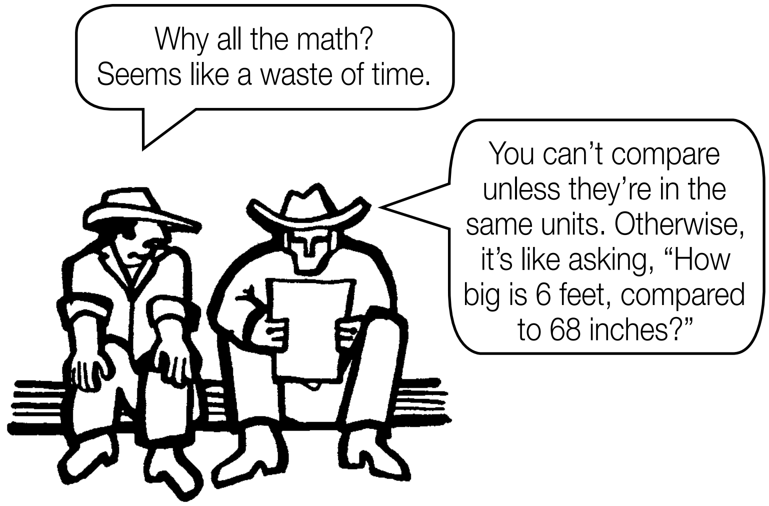
Pens or pencils (1 per participant)

Calculators (a few for the group to share, optional)

Contaminant	Sample Results (in ppb)	Sample Results in mg/kg	Soil Screening Levels Residential Standards* in mg/kg	In ppb
Benzo(a)anthracene	6,780	6.78	1.1	1,100
Benzo(a)pyrene	6,380	6.38	1.3	1,300
Benzo(b)fluoranthene	1,030	1.03	1.5	1,500
Dibenzo(a,h)anthracene	280	0.28	0.2	200
Fluoranthene	2,540	2.54	3,100	3,100,000
Fluorene	33	0.033	3,100	3,100,000
Indeno(1,2,3,-cd)pyrene	920	0.92	0.86	860

Soil Contamination

One ppm is the same as 1,000 ppb, and one mg/kg is the same as 1,000 µg/kg. In soil, mg/kg is the same as ppm, and µg/kg is the same as ppb.



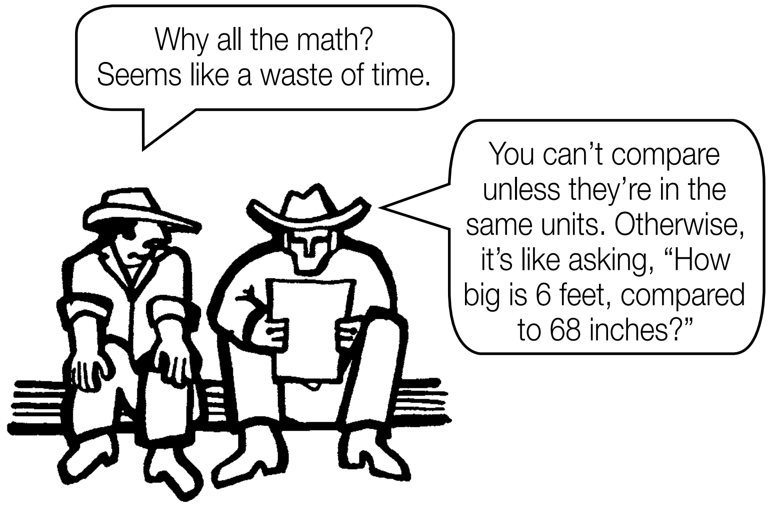
Directions

1. The sample results use different units from the state screening levels. Convert the sample results to the same units as the screening levels, and write them in the table below.
2. Then, just to be sure, convert the screening levels to the same units as the sample results.
3. Compare the sample results in mg/kg with the screening levels in mg/kg. Which sample results are higher than the screening levels? Circle them.
4. Now check your work: Compare the sample results in ppb with the screening levels in ppb. Which sample results are higher than the screening levels? Do they match with the ones you already circled?

Contaminant	Sample Results (in ppb)	Sample Results in mg/kg	Soil Screening Levels Residential Standards*	
			in mg/kg	In ppb
Benzo(a)anthracene	6,780		1.1	
Benzo(a)pyrene	6,380		1.3	
Benzo(b)fluoranthene	1,030		1.5	
Dibenzo(a,h)anthracene	180		0.2	
Fluoranthene	2,540		3,100	
Fluorene	33		3,100	
Indeno(1,2,3,-cd)pyrene	920		0.86	

Answers: Soil Contamination

One ppm is the same as 1,000 ppb, and one mg/kg is the same as 1,000 µg/kg. In soil, mg/kg is the same as ppm, and µg/kg is the same as ppb.



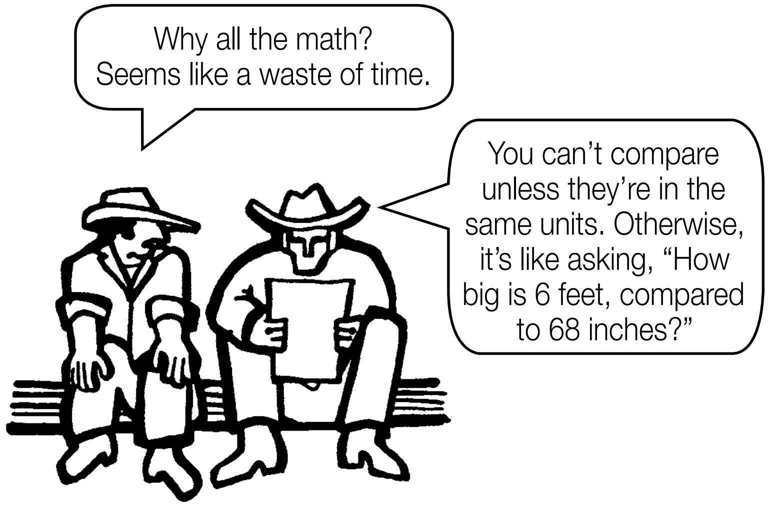
Directions

1. The sample results use different units from the state screening levels. Convert the sample results to the same units as the screening levels, and write them in the table below.
2. Then, just to be sure, convert the screening levels to the same units as the sample results.
3. Compare the sample results in mg/kg with the screening levels in mg/kg. Which sample results are higher than the screening levels? Circle them.
4. Now check your work: Compare the sample results in ppb with the screening levels in ppb. Which sample results are higher than the screening levels? Do they match with the ones you already circled?

Contaminant	Sample Results (in ppb)	Sample Results in mg/kg	Soil Screening Levels Residential Standards*	
			in mg/kg	In ppb
Benzo(a)anthracene	6,780	6.78	1.1	1,100
Benzo(a)pyrene	6,380	6.38	1.3	1,300
Benzo(b)fluoranthene	1,030	1.03	1.5	1,500
Dibenzo(a,h)anthracene	280	0.28	0.2	200
Fluoranthene	2,540	2.54	3,100	3,100,000
Fluorene	33	0.033	3,100	3,100,000
Indeno(1,2,3,-cd)pyrene	920	0.92	0.86	860

Water Contamination

One ppm is the same as 1,000 ppb, and one mg/L is the same as 1,000 µg/L. In water, mg/L is the same as ppm, and µg/L is the same as ppb.



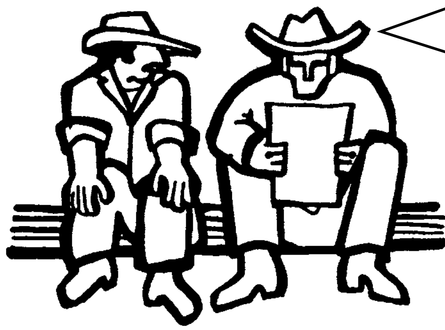
Directions

1. The sample results use different units from the state water standards. Convert the sample results to the same units as the standards, and write them in the table below.
2. Then, just to be sure, convert the water standards to the same units as the sample results.
3. Compare the sample results in mg/L with the water standards in mg/L. Which sample results are higher than the standards? Circle them.
4. Now check your work: Compare the sample results in ppb with the water standards in ppb. Which sample results are higher than the standards? Do they match with the ones you already circled?

Contaminant	Sample Results (in µg/L)	Sample Results in ppm	State water standards	
			in ppm	In µg/L
Benzo(a)anthracene	6,780		1.1	
Benzo(a)pyrene	6,380		1.3	
Benzo(b)fluoranthene	1,030		1.5	
Dibenzo(a,h)anthracene	180		0.2	
Fluoranthene	2,540		3,100	
Fluorene	33		3,100	
Indeno(1,2,3,-cd)pyrene	920		0.86	

Answers: Water Contamination

One ppm is the same as 1,000 ppb, and one mg/L is the same as 1,000 µg/L. In water, mg/L is the same as ppm, and µg/L is the same as ppb.



Directions

1. The sample results use different units from the state water standards. Convert the sample results to the same units as the standards, and write them in the table below.
2. Then, just to be sure, convert the water standards to the same units as the sample results.
3. Compare the sample results in mg/L with the water standards in mg/L. Which sample results are higher than the standards? Circle them.
4. Now check your work: Compare the sample results in ppb with the water standards in ppb. Which sample results are higher than the standards? Do they match with the ones you already circled?

Contaminant	Sample Results (in µg/L)	Sample Results in ppm	State water standards	
			in ppm	In µg/L
Benzo(a)anthracene	6,780	6.78	1.1	1,100
Benzo(a)pyrene	6,380	6.38	1.3	1,300
Benzo(b)fluoranthene	1,030	1.03	1.5	1,500
Dibenzo(a,h)anthracene	180	0.28	0.2	200
Fluoranthene	2,540	2.54	3,100	3,100,000
Fluorene	33	0.033	3,100	3,100,000
Indeno(1,2,3,-cd)pyrene	920	0.92	0.86	860

Activity Overview

Participants compare environmental test results to health-based standards for contamination in soil, water, and air (for details, see fact sheets for health-based standards in the Limits and Levels resource.) They post the results on the wall and determine which results are highest compared to the standard.

When to Use It

When a group receives test results, and wants to know where contamination is the highest. The activity is based on soil, air, or water tests, but the basic idea can be adapted for any data: blood tests, public health data, vehicle traffic. If there is no "standard," compare to typical/background levels or past data

Suggested companion activities:

- Use after A First Look at Technical Documents.
- Use with appropriate fact sheets from Common Units and Limits & Levels.
- Follow up with Mapping Data, Finding Newsworthy Data

Steps

1. **Launch the activity:** We have our test results. It's tempting to just look for the biggest numbers. But some contaminants are more toxic than others. So first, we need to compare each result with a health-based standard for that contaminant. In our case, the standard is the [name the standard, like the MCL or RSSL]. Hand out test results, participant instructions, pens, calculators, and sticky notes. Divide up the data among the group. If needed, do one contaminant together as a group.
2. **In pairs:** Compare each result to its standard, as shown on the participant instructions. As groups finish, ask, "Who has the result that is *highest* compared to its standard?" Guide the group in posting the results on the wall, as shown in the *Facilitator Supplement*.
3. **Debrief:**
   - What strikes you about the results?
   - What contaminants or locations should we worry about most?
   - Are there any we probably *don't* need to worry about?

For the facilitator: Variations

- If you only have a few sample locations, but many contaminants, make a column for each sample instead of for each contaminant. Or, group results by sample location, like "by the pond."
- If using this activity at a workshop, you can find a full sample data set in the "data sources" section of sfa.terc.edu

Smart Moves

- Use your senses.
- Play with different ways to show it and say it.

Skill: Comparing test results to health standards.

Time: 30 minutes

Materials

Facilitator Supplement (one per facilitator)

Participant Instructions (one per person or pair)

Pads of sticky notes, different colors if possible

Pens or markers (enough for everyone)

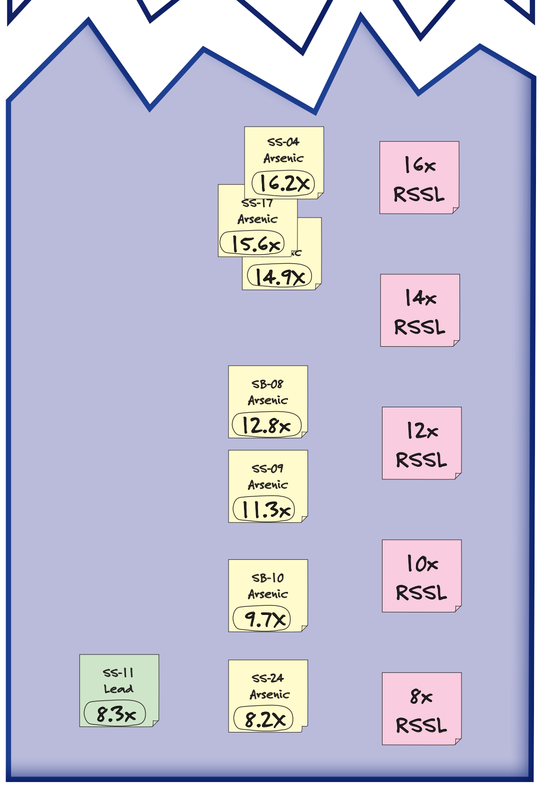
Calculators (one per pair, you can skip if participants have calculators on their phones)

Preparation

If there are many samples or contaminants, choose the ones that seem most troubling for the group to focus on. Think of how you will divide up that data among your group.

Identify the health-based standards for each contaminant. If they are not listed in the results, look them up and bring them to the meeting.

Confirm the units for the samples match the units for the levels of concern.



Placing the Notes

1. Take the highest level compared to standard. Stick it on the wall as high as you can. If no result is higher than the standard, use the standard as the highest point.

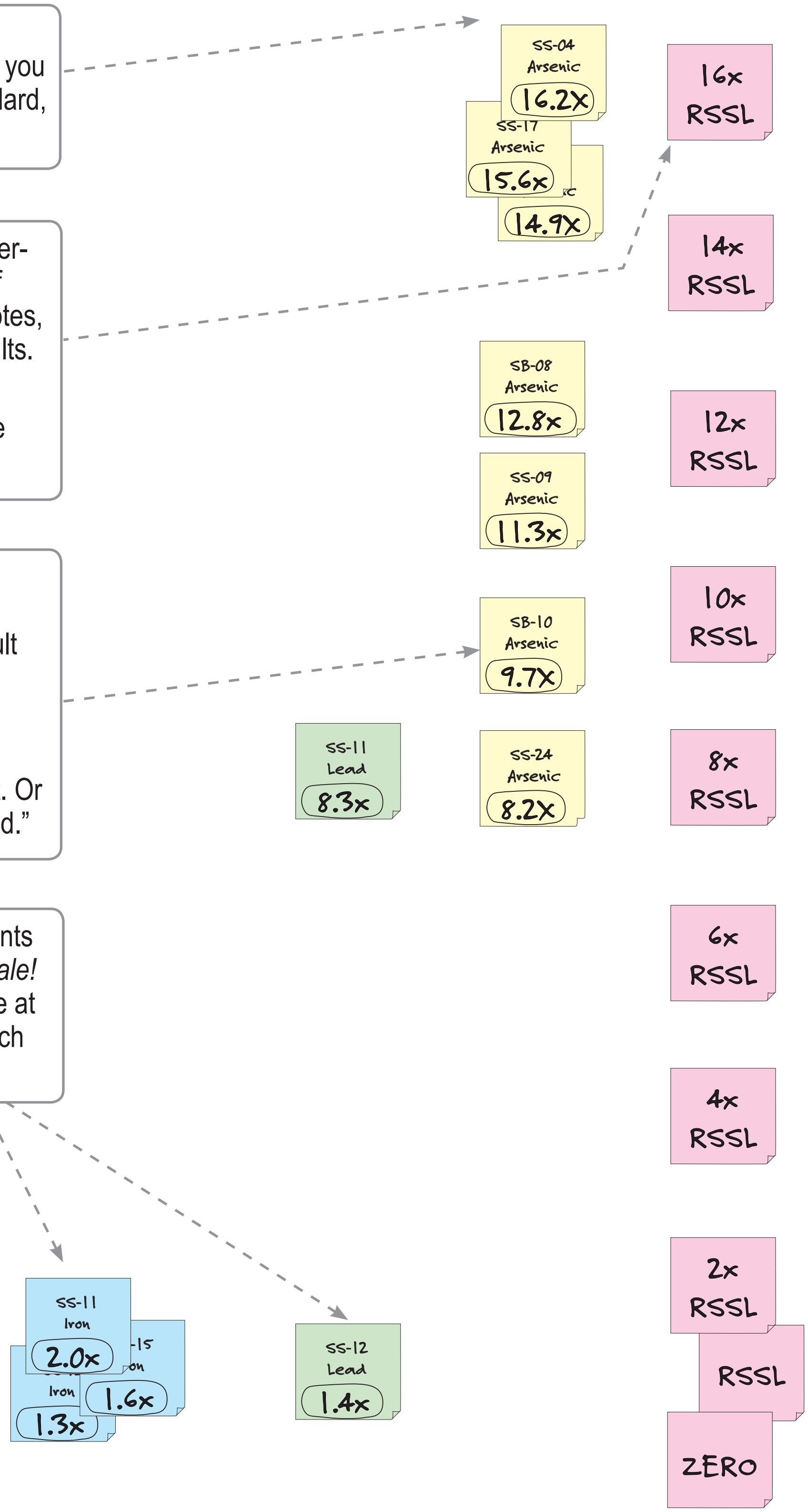
2. Using the floor as zero, make a number-scale that divides the space between. If possible, use different-colored sticky notes, so people don't confuse scale with results.

   Note: if you can identify the highest level *before* the activity, you can make up the scale in advance.

3. Place the other test results for that contaminant in a column. Use the scale to help guide how high or low each result should go.

   If there are few samples but many contaminants, make a column for each sample instead of for each contaminant. Or group them by location, like "by the pond."

4. Place results from different contaminants in different columns, *using the same scale!* Don't put the highest result for each one at the top, or you won't be able to see which contaminant is *most* over the standard.



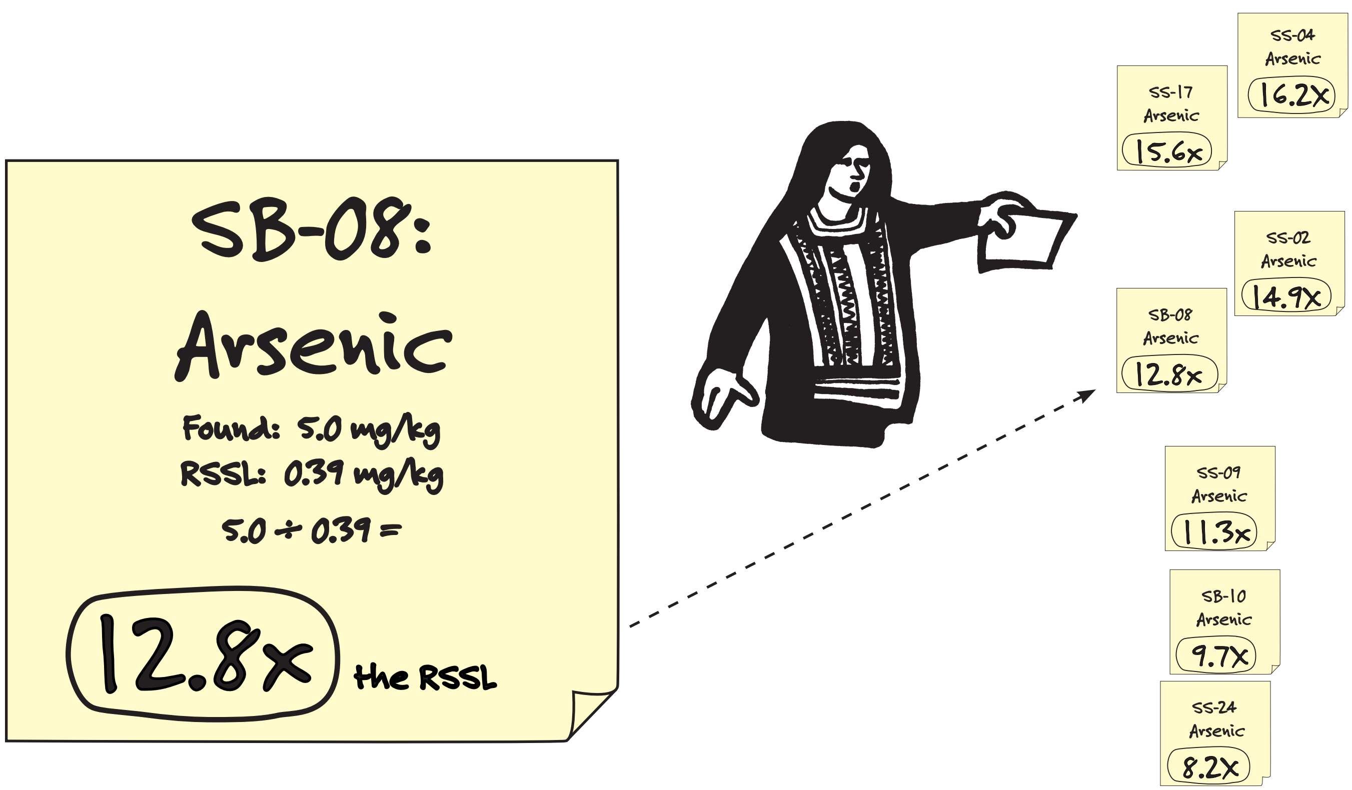
Strategies for Comparing to Standards

Here's a way to look at environmental test results, to figure out which are the most severe.

1. Choose just one contaminant in one sample. (Here, it's the arsenic level in sample SB-08.)
2. What level of the contaminant did they find in the sample? Write it on a sticky note.
3. What is the health-based standard for that contaminant? Write it on your sticky note.
4. Divide the sample level by the level of concern. Write the result on your note. Circle it.
5. Repeat the steps above for other contaminants and other samples.
6. Put the sticky notes in order from low to high on the wall or table.

SAMPLE LOCATION	SB-08	EPA R3 Residential Soil Screening Levels *
SAMPLE NUMBER	R01-081020GL-0020	
SAMPLE DEPTH	12 inches	
PARAMETER		
Aluminum	6,800	77,000
Arsenic	5.0	0.39
Barium	26	15,000
Cadmium	ND	70
Calcium	590	NL
Chromium	16	280
Cobalt	5.8	23
Copper	13	3,100
Iron	15,000	55,000
Lead	18	400
Magnesium	2,600	NL
Manganese	400	NL
Nickel	20	1,600
Silver	ND	390
Vanadium	14	550
Zinc	41	23,000
Mercury	ND	6.7

All results in milligrams per kilogram (mg/kg)



Activity Overview

Participants put data from a data table onto a map. Then they use the map to identify trends and hot spots.

When to Use It

When a group wants to look at data for geographic patterns.

Suggested companion activities:

- If the data or test results are new or confusing, precede with Making Sense of the Data.
- If the data are clear, precede with Compare to Standards, possibly at the same meeting as this activity. It is important to compare your data to health-based standards before mapping. Consult a fact sheet on the appropriate standard from the resource Limits and Levels.

Steps

1. **Launch the activity:** We have looked at our test results, and we know how they compare to [name of the health-based standard]. Now let's map the data to see if there are patterns or hot spots.
2. **In pairs or small groups:** Copy each data point to the stickers (or sticky notes). Use a separate map for each contaminant or testing date. Use colors to indicate how concerning the results are. Facilitator: give participants a color scale to use. For example:
   - Green: below the standard
   - Yellow: 1x to 5x the standard
   - Red: more than 5x the standard
3. **Debrief:**
   - What do you see? Are there trends or hot spots?
   - Could a map like this be useful in a campaign?

For the Facilitator: Supplements

Two optional supplements are included. You can use one with a group that wants practice before trying with their own data, or in a workshop setting where there are no shared data. Data sets are included with and without a comparison to standards. Use the set without the comparison to standards if you want your group to practice comparing to standards as well. The completed maps are given as examples for your reference; you do not need to give them to participants.

Smart Moves

- Use your senses
- Play with different ways to show and say it

Skill: Practice mapping data and looking for trends.

Time: 20 minutes

Materials:

Large map of the sampling area, sample locations clearly marked. If there are many contaminants in one sample location, bring more than one map.

Small sticky notes or colored stickers that will fit on the map. Red, yellow, and green are ideal.

Copies of the data

Pens or markers

Calculators, if data isn't compared to standards

Optional Supplements:
Pond Sediment (simpler)
Salvage Yard Soil (more complex).
Each includes: a blank data set, a data set compared to standards, a blank map, and an example of a completed map.

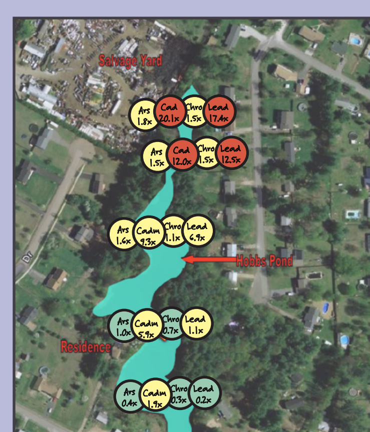
Prep

Enlarge the map, if needed

If data set is large, choose data of most concern

Plan in advance what your color scheme will be to fit your data. One example is given in (2) on left.

If using a Supplement, decide if the group will practice comparing to standards, or just mapping.



Pond Sediment

Sediment Sample Results

Contaminant	PSS-1	PSS-2	PSS-3	PSS-4	PSS-5	SQuiRTs TEL
Arsenic	10.5	8.93	9.26	5.73	2.16	5.9
Cadmium	12	7.18	5.57	3.5	1.12	0.596
Chromium	57.2	54.4	42.7	27	12.8	37.3
Lead	609	439	241	39.3	7.9	35

SQuiRTs TEL: National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables, Freshwater Threshold Effects Levels. SQuiRTs are used for comparison purposes only.

All results in milligrams per kilogram (mg/kg)

ND = Not Detected

Worksheet: Compare to SQuiRT TEL

Contaminant	PSS-1	PSS-2	PSS-3	PSS-4	PSS-5	SQuiRTs TEL
Arsenic	1.8 x					5.9
Cadmium						0.596
Chromium						37.3
Lead						35

Pond Sediment

Sediment Sample Results

Contaminant	PSS-1	PSS-2	PSS-3	PSS-4	PSS-5	SQuiRTs TEL
Arsenic	10.5	8.93	9.26	5.73	2.16	5.9
Cadmium	12	7.18	5.57	3.5	1.12	0.596
Chromium	57.2	54.4	42.7	27	12.8	37.3
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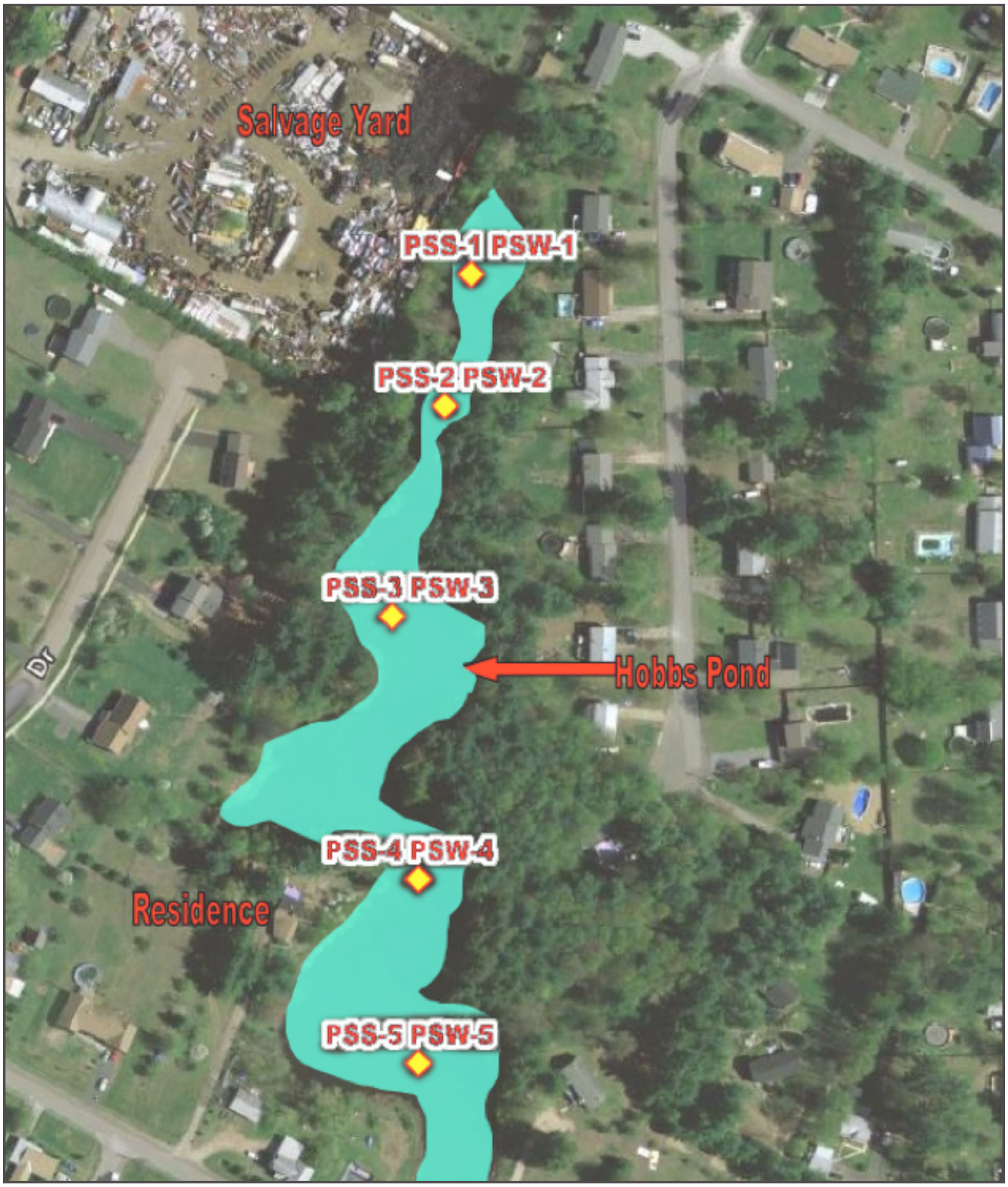
ND = Not Detected

Worksheet: Compare to SQuiRT TEL

Contaminant	PSS-1	PSS-2	PSS-3	PSS-4	PSS-5	SQuiRTs TEL
Arsenic	1.8 x	1.5 x	1.6 x	1.0 x	0.4 x	5.9
Cadmium	20.1 x	12.0 x	9.3 x	5.9 x	1.9 x	0.596
Chromium	1.5 x	1.5 x	1.1 x	0.7 x	0.3 x	37.3
Lead	17.4 x	12.5 x	6.9 x	1.1 x	0.2 x	35

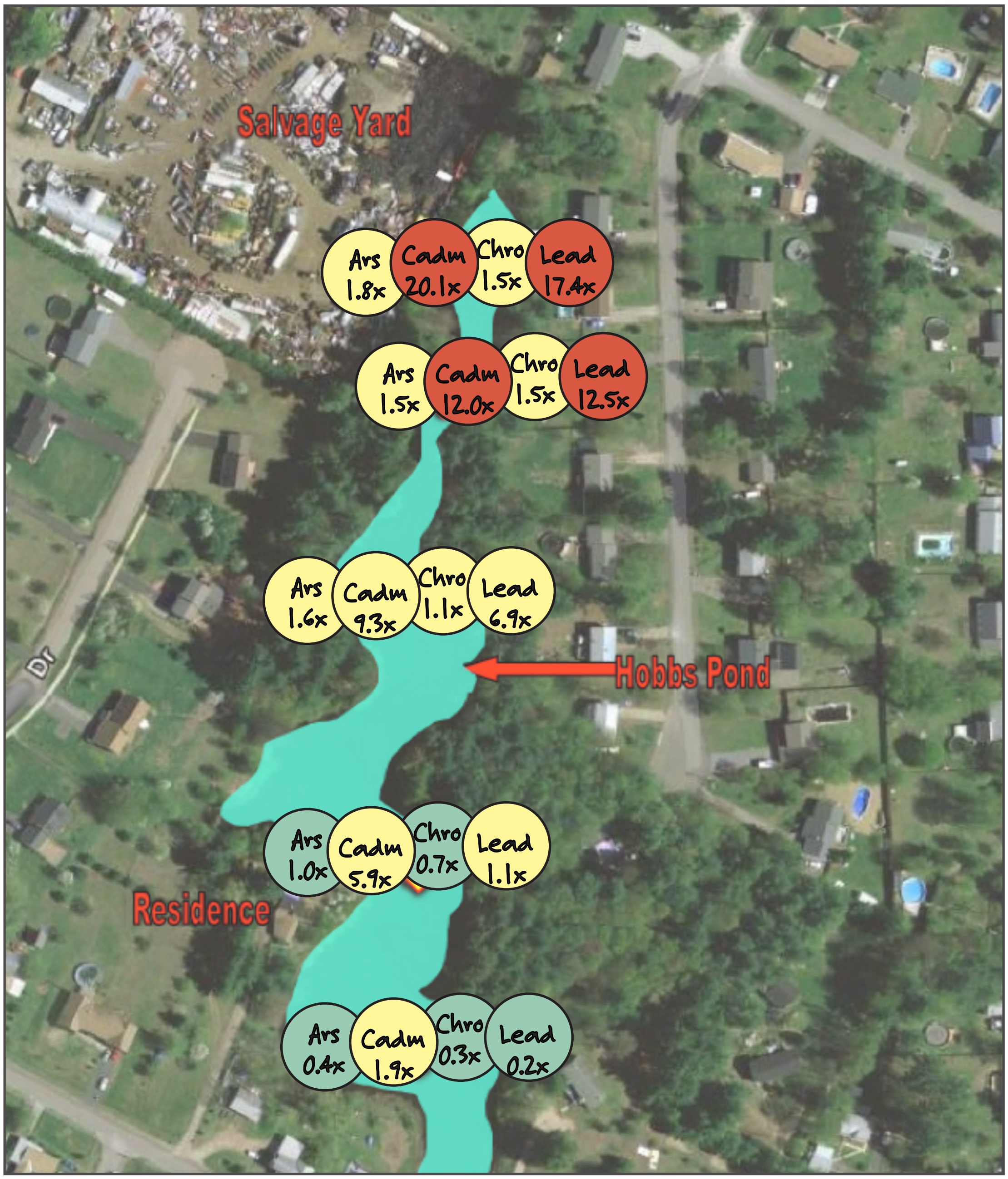
Pond Sediment



Pond Sediment

Here's a possible way to map the practice example using colored stickers:

- Green: below or equal to the TEL
- Yellow: more than the standard to 10x the TEL
- Red: more than 10x the TEL



Salvage Yard Soil

Sample Label	Arsenic in mg/kg	x SSL	Sample Label	Arsenic in mg/kg	x SSL
SS-01	7.7	19.7x	SB-09	3.9	
SS-02	5.8		SB-10	3.8	
SB-02	4.9		SS-11	ND	
SS-03	4.6		SS-12	ND	
SB-03	4.4		SS-13	3.7	
SS-04	6.3		SS-14	4	
SB-04	3.9		SS-15	ND	
SS-05	6		SS-16	6.6	
SB-05	4.1		SS-17	6.1	
SS-06	4.4		SS-18	5.5	
SB-06	3.9		SS-19	4.3	
SS-07	ND		SS-20	5.3	
SB-07	4.8		SS-21	6	
SS-08	4.9		SS-22	4.4	
SB-08	5		SS-23	3.4	
SS-09	4.4		SS-24	3.2	

Samples beginning with “SS” were taken 6 inches below the soil surface.
Samples beginning with “SB” were taken 12 inches below the soil surface.
EPA Region III Residential Soil Screening Level for Arsenic: 0.39
ND = Not Detected

Salvage Yard Soil

Sample Label	Arsenic in mg/kg	x SSL	Sample Label	Arsenic in mg/kg	x SSL
SS-01	7.7	19.7x	SB-09	3.9	10.0x
SS-02	5.8	14.9x	SB-10	3.8	9.7x
SB-02	4.9	12.6x	SS-11	ND	–
SS-03	4.6	11.8x	SS-12	ND	–
SB-03	4.4	11.3x	SS-13	3.7	9.5x
SS-04	6.3	16.2x	SS-14	4	10.3x
SB-04	3.9	10.0x	SS-15	ND	–
SS-05	6	15.4x	SS-16	6.6	16.9x
SB-05	4.1	10.5x	SS-17	6.1	15.6x
SS-06	4.4	11.3x	SS-18	5.5	14.1x
SB-06	3.9	10.0x	SS-19	4.3	11.0x
SS-07	ND	–	SS-20	5.3	13.6x
SB-07	4.8	12.3x	SS-21	6	15.4x
SS-08	4.9	12.6x	SS-22	4.4	11.3x
SB-08	5	12.8x	SS-23	3.4	8.7x
SS-09	4.4	11.3x	SS-24	3.2	8.2x

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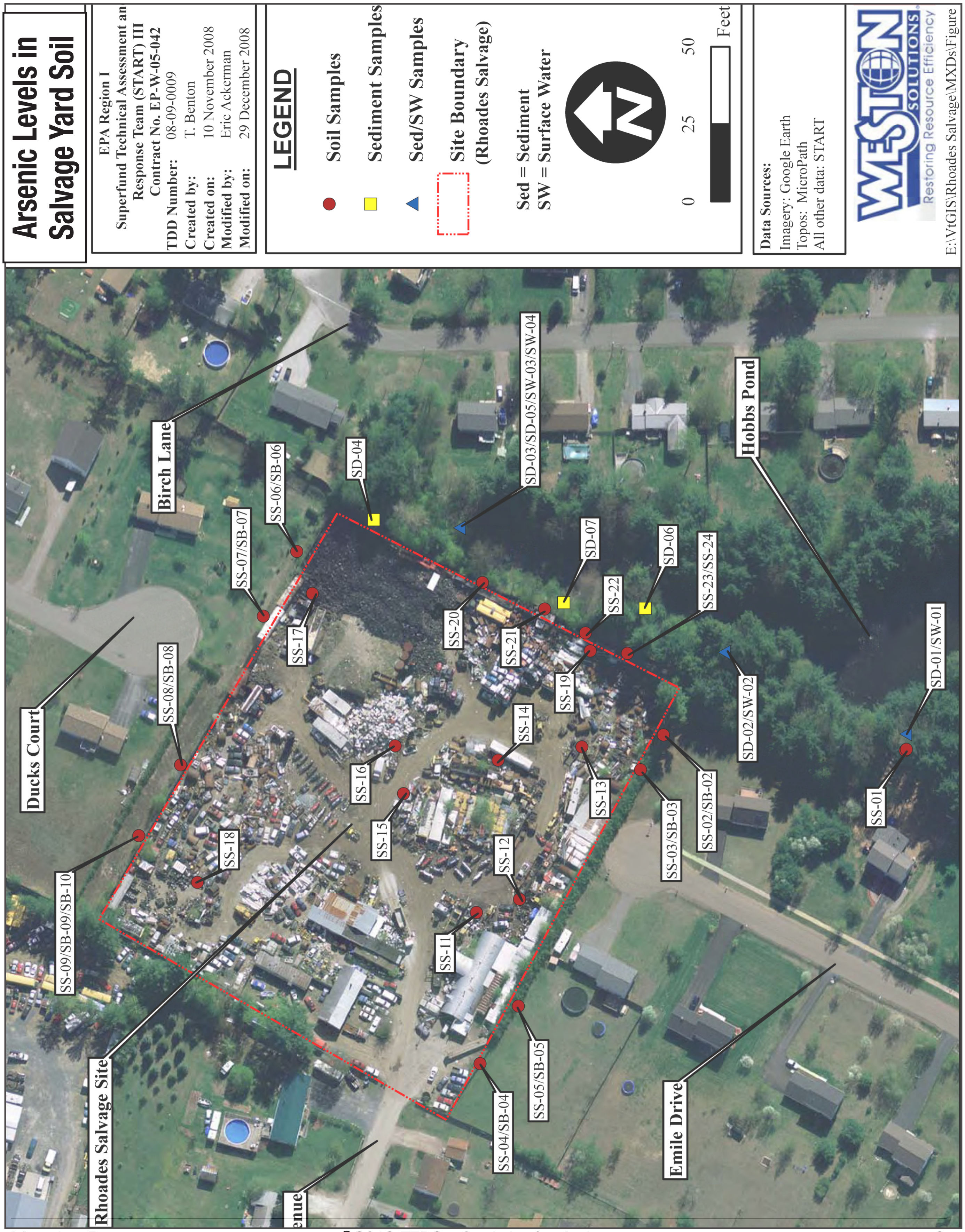
Arsenic Levels in Salvage Yard Soil
EPA Region I
Superfund Technical Assessment and
Response Team (START) III
Contract No. EP-W-05-042
TDD Number: 08-09-0009
Created by: T. Benton
Created on: 10 November 2008
Modified by: Eric Ackerman
Modified on: 29 December 2008
LEGEND
Soil Samples
Sediment Samples
Sed/SW Samples
Site Boundary (Rhoades Salvage)
Sed = Sediment
SW = Surface Water
N
0 25 50 Feet
Data Sources:
Imagery: Google Earth
Topos: MicroPath
All other data: START
WESTON SOLUTIONS
Restoring Resource Efficiency
E:\VtGIS\Rhoades Salvage\MXDs\Figure
Birch Lane
Ducks Court
Hobbs Pond
Emile Drive
Rhoades Salvage Site
enue
SS-06/SB-06
SD-04
SD-03/SD-05/SW-03/SW-04
SS-07/SB-07
SS-17
SS-20
SS-21
SD-07
SS-22
SD-06
SS-23/SS-24
SS-19
SD-02/SW-02
SD-01/SW-01
SS-01
SS-08/SB-08
SS-16
SS-14
SS-13
SS-02/SB-02
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SS-12
SS-18
SS-09/SB-09/SB-10
SS-11
SS-05/SB-05
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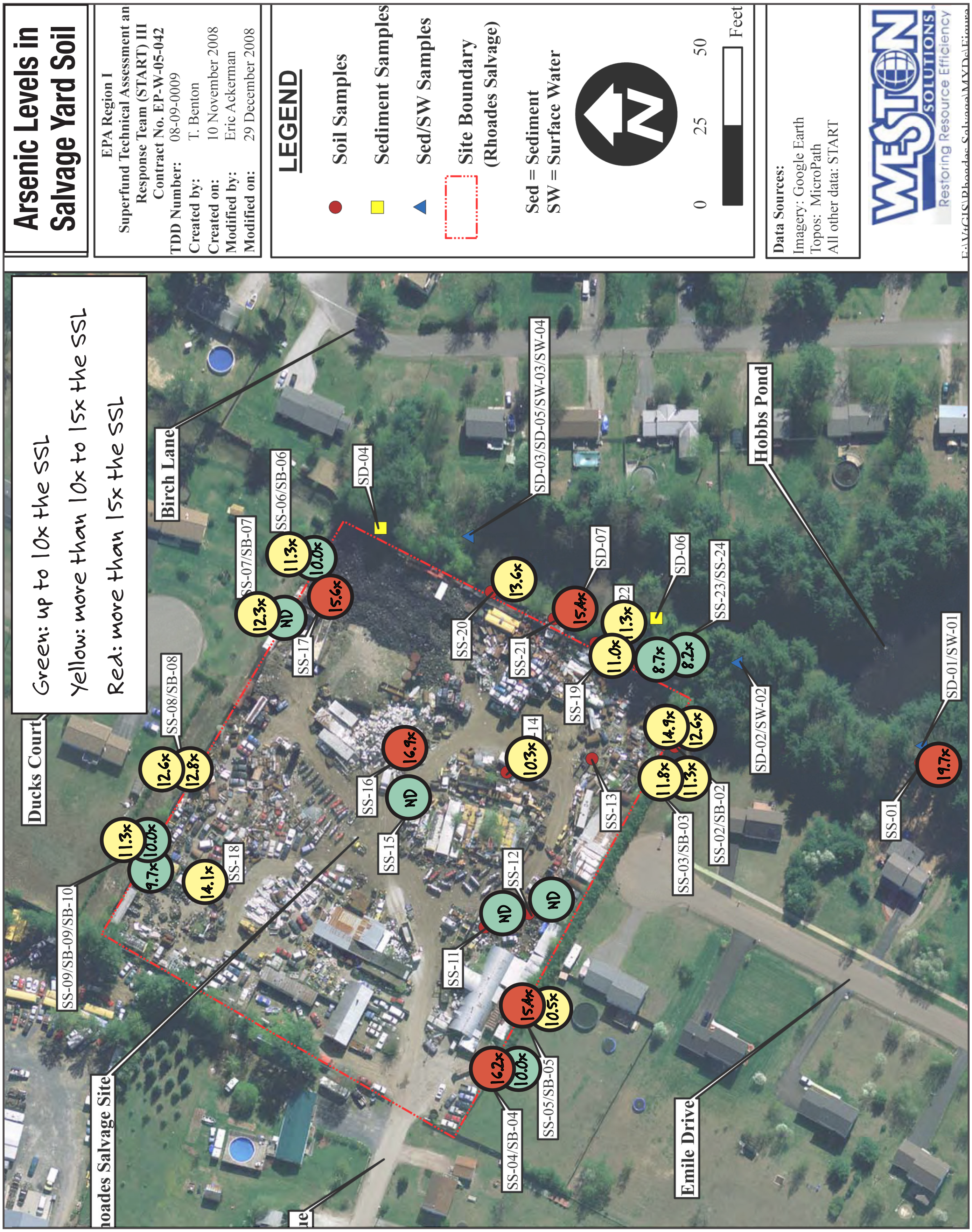
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SS-20
SS-21
SD-07
SD-06
SS-23/SS-24
SS-19
SD-02/SW-02
SD-01/SW-01
SS-01
SS-02/SB-02
SS-03/SB-03
SS-13
SS-14
SS-16
SS-15
SS-18
SS-12
SS-11
SS-05/SB-05
SS-04/SB-04
11.3x
10.0x
15.6x
12.3x
ND
13.6x
15.4x
11.3x
11.0x
8.7x
8.2x
14.9x
12.6x
11.8x
11.3x
19.7x
16.9x
10.3x
12.6x
12.8x
11.3x
10.0x
9.7x
14.1x
ND
ND
ND
15.4x
10.5x
16.2x
10.0x

Drawing Your Own Conclusions

There are many ways to interpret data. Industry, government, and media may interpret data based on their own priorities. Once you understand the units and terms, you can look deeper and draw your own conclusions. These activities help you look critically, to find the numbers you care about most, and to challenge questionable claims about the data.

Still having trouble reading data? Start with **Making Sense of the Data**

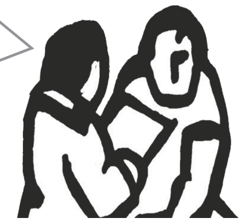
A First Look at Challenging Claims

Step through the process of finding and challenging dubious claims.

- Find numbers and data, even if they're hidden
- Make sure there's no mixup of units
- See if "typical" numbers really are typical.
- Verify that estimates or predictions are valid
- Check that the any health-based standards used were the most protective.
- Verify claim about increases or decreases
- Check for ambiguities and press for detail

After finding potential challenges, rate them based on how easy the challenge will be, and how much it might help your campaign.

The impact statement for the power plant expansion didn't account for the 300 tons of NO_X per year from the diesel trucks trucking in fuel and trucking out waste.



The report says tests didn't detect any benzene in the factory air. But the testing equipment can't detect anything below 2 ppm. That's four times the legal limit.

Arsenic levels are over the legal limit in 12 people's tap water. In one home, the level is 24 times the limit.

TCE levels are only 2% lower than this time last year. The cleanup isn't working – we need a more aggressive remediation plan.

Finding Newsworthy Data

Examine data to find and describe:

- Contaminants with the highest levels compared to legal limits
- Diseases with the highest rates compared to what's typical
- Inconsistent or fluctuating data
- Contamination or disease rates coming down too slowly or rising suddenly
- Contamination not detected, but detection limits are set above health-based standards

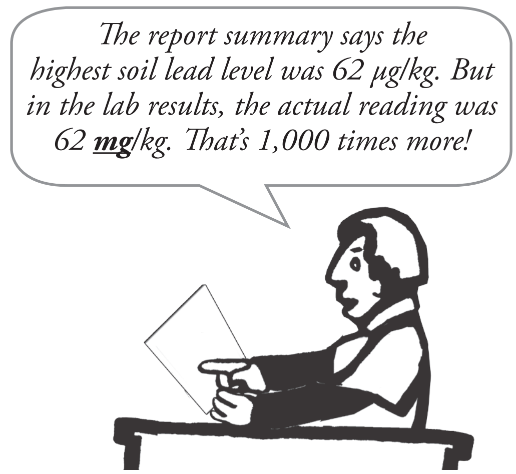
Drawing Your Own Conclusions

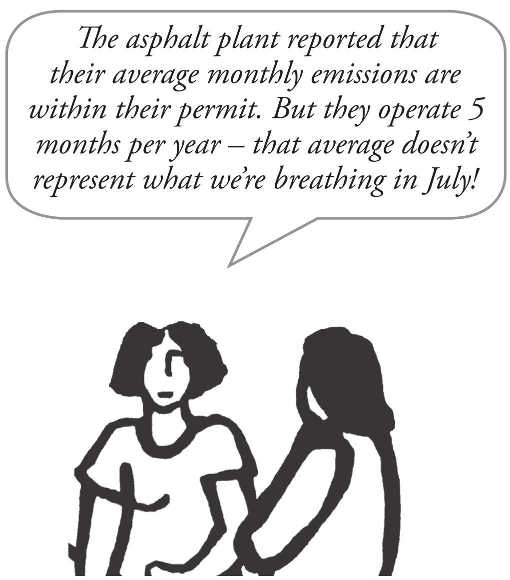
Scrutinize data for more specific mistakes, mixups, and negligence.

The Summary vs. the Lab helps ensure the summary of a report accurately reflects lab data.

Inside Averages highlights ways an average can be presented as "typical" when it isn't.

Sampling Plans helps a group think about where a site should be tested for contamination. Can be used before testing, or afterwards if the sampling plan was inadequate.





Also, check out **Pieces of the Risk Puzzle** to analyze health risks.
Consider factors like toxicity, exposure, and susceptibility.
Think carefully about pursuing a health study to measure health effects.

A First Look at Challenging Claims

Facilitator Instructions

Overview

Participants identify fact-based claims by industry or government, and consider the different strategies for challenging those claims using data.

When to Use It

Anytime a community group wants to respond to a claim made by an industry or government spokesperson about environmental pollution. Claims could be in:

- a news story or press conference
- a proposal for a new or expanded project
- an environmental impact study
- a public statement or press release

After this workshop, follow up with other activities in *Drawing Your Own Conclusions*.

Skills

- Identify numbers and units involved in claims, both explicit and implied
- Identify relationships between numbers in claims
- Brainstorm predictions of how claims might be challenged, and identify additional information needed
- Decide which claims are best to challenge

Smart Moves

- Slow down.
- Talk it out.

Time: 60-75 minutes

Preparation

See *Workshop Options,* next page. Decide which option best fits your situation. Read through all relevant materials.

If using your own community situation (instead of a case study/role play) make sure you have copies of the claims you potentially want to challenge: a newspaper article, a press release, a permit document, etc.

Materials

Strategies for Analyzing Claims (1 per participant)

Analyzing Claims Worksheet (2-3 per small group, plus 1 example worksheet)

Easel and flip charts (or whiteboard)

Pens, markers, and highlighters as needed

Tables, desks, or clipboards, so participants can write on their worksheets.

If using case studies:

Role Play Instructions (1 per pair or participant)

One of the two case studies (1 participant instructions per participant, one facilitator supplement per facilitator)

- *Dangerous Fumes* (claims already chosen)
- *Trash Facility* (claims need to be identified)

Workshop Options

With a community group just getting started

1. Gather sources that have any claims you might want to challenge. For example, a company's press release, or a summary from an environmental impact statement, or a statement made by a public official.
2. Pick any claims that can be challenged. Put them in a handout or on poster paper for everyone to read.
3. Have your group read through the list of claims, and choose 4 - 6 claims they want to challenge. Then...

With a community group with a ready list of claims

4. Review *Strategies for Analyzing Claims* with the group.
5. Divide into groups of 2 - 4 people. Assign each small group one claim to analyze using the *Analyzing Claims Worksheet.* Each small group should report back to the whole group.
6. Decide which are the most strategic challenges.
7. At a later date, follow up with other *Statistics for Action* activities to help the group understand, analyze, and communicate about the issues involved in the claims. See *SfA in Action* on the SfA web site for more.

For a training or conference workshop: Using a Case Study

1. Choose one of the *Case Studies* to use, or create a similar case study with your own data.
2. Make enough copies for all participants of the *Participant Handout* for that case study, as well as *Strategies for Analyzing Claims,* and the *Analyzing Claims Worksheet*.
3. Hand out and briefly review *Strategies for Analyzing Claims* with participants.
4. Hand out the case study to all participants. Then, choose either...

Option 1: Discussion

5. Divide participants into groups of 2 - 4 people. Assign each group one claim from the case study.
6. Each group should use the *Analyzing Claims Worksheet* to analyze their claim. They can use *Strategies for Analyzing Claims* as a resource.
7. Have each small group report back what they decided about their claim. If there is time, have the whole group decide which claims they think are most worth challenging.

Option 2: Role Play

8. Hand out the *Role Play Instructions* to all participants.
9. If the workshop is small, everyone can participate in the role play. If it's large, ask for 5 - 6 volunteers to perform the role play for the rest of the group.
10. The discussion in step (4) of the role play should involve the whole workshop. If the group is struggling for ideas, you can use the facilitator resource for the role play to prompt them.
11. Debrief the activity with the group: What did you learn? What do you still wonder?

Strategies for Analyzing Claims

1) What are the numbers, even if they're hidden?

A measurable claim will talk about something that can be quantified. The real number may be implied but not shown.

Strategy: Push to get the claim as specific as possible. There's a number there somewhere. If not, justification is needed.

Mercury levels in the soil tests were all below the legal limit.

Can you spot the two missing numbers? *Mercury levels* means they tested for mercury in the soil and got numbers, even if they're not listed. *The legal limit* is a number published by a regulating agency; you can look it up.

2) What are the units?

What is being measured and how is it being measured? Units can be simple: feet, tons, jobs. They also could be a rate or ratio of other units, using "/" or "per", like *truck trips per day* or *μg/L*.

Strategy: Learn about the units, common abbreviations and symbols, and how different units relate to each other. Practice converting strange units to familiar ones. It might be easier to imagine *pounds per day* than *tons per year*.

The new power plant will reduce residential electricity rates.

Units might not be explicit. *Electricity rates* means what you pay for power. Look it up; it's usually in dollars per kilowatt-hour ($/kWh).

3) Do any numbers represent a larger set of data?

Sometimes one number is calculated from a much larger set of data. Then that number is then presented as "typical" of that data. There are different "typical" calculations: *average, mean, median, mode*. There are also ways to show varation in the data: *margin of error, standard deviation*.

Strategy: Get the original data. Find out how it was calculated, what was and was not included. Learn about the different terms and when they should be used. A median may be more representative than an average. The data might be too variable or too unreliable to summarize with one number. They may have ignored important data. Decide if the number represents what is most important in the data – you may care more about a maximum than what is "typical."

Average smokestack emissions are below the 30 ppm monthly limit.

What if the plant only operates in the summer? An average over the whole year won't show how bad it is in July. Also, if they looked at the whole county instead of just the area that was sprayed, they might not detect much pollution.

4) Are they making an estimate or prediction?

An estimate should be based on real numbers and calculations, and should account for many scenarios.

Strategy: Find the data, calculations, and assumptions they used to make the estimate. Did they assume best or worst case? Did they include what *you* care about most?

"Officials estimate that a typical resident doesn't eat more than five fish from the stream per year."

Strategies for Analyzing Claims

5) Is there a comparison to a maximum or minimum?

The claim might compare one or more measured numbers to a fixed maximum or minimum - like a legal limit, or a promised benefit. Look for language like “did not exceed” or “will be at least”.

Strategy: Are they using the most appropriate limit or standard for comparison? Even if there is a limit, does that guarantee safety? If they’re making a promise about the future, how did they make their calculations? Look out especially for “typical” numbers (see #3 above)... sometimes an average will not exceed a legal limit, but individual data points will.

> *There will be no more than 150 truck trips to the landfill per month.*

6) Is there a claim about an increase or decrease?

They may claim that “X” will increase or decrease with time.

Strategy: Ask, “Compared to what?” They might choose a number that makes their plan look good. They may say an increase is because of something they did, but maybe it would have happened anyway. If it’s a claim about the future, find out what is and is not included in their forecast.

> *The new factory complex will add 3 acres of new open space and $1 million in tax revenue for the city.*

Is that “open space” mostly parking lots? Does the increase in revenue account for a decrease in home values next to a dirty factory? Or maybe the increase in tax revenues is just from population growth, and has nothing to do with the factory.

7) What else is missing?

There may be other things about the claim that you will need to know before you challenge it. The numbers may be...

Unspecific: Someone knows the number, it’s just not shown.
Ambiguous: It’s not clear anyone knows the number.
Incomplete: The number includes some things but not others.
Subjective: Words like *reasonable*, *feasible*, and *acceptable*.

Strategy: Without any numbers, you can’t know if the claim is true, or if it will have an impact in the community. Push for precise numbers, or for a range, like “between X and Y”.

> *Pesticide use did not cause any increase in illness.*

> *We will give low-interest loans and incentives to weatherize homes.”*

> *The risk of any kind of leak from the landfill is negligible.*

8) Now, list them all!

Look at all the possible challenges and missing information you’ve identified. Write it all down. Decide which challenge will be the easiest and most useful to you.

Analyzing Claims Worksheet

1. Fill out a worksheet for each claim you think is suspicious.
2. Analyze the claim:
   - What are the **numbers and units**? They might be hidden or implied.
   - Do any numbers represent a **larger set of data**?
   - Are there **words that compare**, like *minimum, standards, limit, exceed, decrease...*?
   - Is there anything **estimated, ambiguous, subjective,** or **missing**?
3. How might you challenge the claim?
4. What other information do you need to know before challenging the claim? Where can you find that information?
5. How hard or easy will it be to challenge this claim? Rate it from 1 to 10. Would a successful challenge hurt or help your campaign? Rate it.

Claim

Analysis

Possible Challenge

Information Needed

Easy challenge? (circle)	Very Hard	1	2	3	4	5	6	7	8	9	10	Very easy
Help our campaign?	No Help	1	2	3	4	5	6	7	8	9	10	Big help

Analyzing Claims Worksheet

Example

Claim: The average levels of arsenic in the groundwater tests were all below the legal limit.

Analysis:

Levels of arsenic are numbers in the report of test results that we got last month.

The legal limit is how much arsenic is allowed in groundwater. Results are below that limit.

An average is for a lot of data - individual test results could be more than the limit.

What is the average based on? Is it over time, or is it the average of all tests?

Possible Challenge:

Maybe the average is below the legal limit, but individual results are above the legal limit.

Information Needed:

Look up federal and state standards for arsenic in groundwater.

Look through test results. Did any exceed the standards? Make sure units are all the same.

Find out how the average was calculated.

Easy challenge? (circle)	Very Hard 1	2	3	4	5	6	7	8	9	10	Very easy
Help our campaign?	No Help 1	2	3	4	5	6	7	8	9	10	Big help

Role Play

1. Read through the case study. Imagine you live in this community.
2. Choose a few people to play different roles, like community activist, parent, town council member, school nurse, factory owner, etc.
3. For 10 minutes, role-play how these people might interact at a public meeting where the claims are first presented, *before* the community is able to strategize or research data.
4. Now your whole group is a concerned community after that public meeting. You want to know how you can challenge those claims. Discuss:
   - What data would the *company* need to provide to prove their own claims?
   - How would *you* challenge each claim?
   - What data would you need to support your challenge?
   - Where would you find that data? How would you use the data?
5. Now the role-players from step 3 (above) are back at a new public meeting. This time, the community has found the data they need to make a challenge. Role-play the new public meeting.

Dangerous Fumes

The Concern

A community in Chicago is concerned about odors – possibly dangerous fumes – coming from a nearby factory. The community wants the company to address the problem. The company does not want to change anything, and claims there is no problem.

The Claims

1. Any air pollution is mostly from the highway, not from our facility.
2. Any complaints about odor are from a few sensitive people. The majority aren't disturbed.
3. The odor/fumes might smell bad, but they aren't harmful to people's long-term health.
4. Installing odor/fume control systems is too expensive/impossible. Who would pay?
5. If you are noticing fumes/odor in the summer, it's probably because of the weather. Under different wind or temperature conditions, you wouldn't be able to smell anything.

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The Claims — and Possible Challenges

1. *Any air pollution is primarily from the highway, not from our facility.*

   Find out what chemicals highways typically put in the air. Find out what kinds of chemicals might be coming from the chemical plant. Test the air for contamination when odors or strong. Show that the odors must be coming from the plant and not the highway. (Very helpful, but very difficult, time-consuming, and expensive.)

2. *Any complaints about odor are from a few sensitive people. The majority aren't disturbed.*

   Do a door to door survey of people in the area. Count how many people are bothered by the odor. Have a petition for them to sign if they want. (Somewhat easy, potentially very helpful if this is their key claim.)

3. *The odor/fumes might smell bad, but they aren't harmful to people's long-term health.*

   Find out what chemicals the plant uses or makes, and which ones are most likely to go into the air. Find out if these chemicals are dangerous or not. (Very helpful, and very easy for people who know how to use the Internet.)

4. Installing odor/fume control systems is too expensive/impossible. Who would pay?

   Try to find other similar companies or plants where they have installed fume control systems. How much did it cost? What were the benefits? (Somewhat easy, possibly helpful, but possibly not helpful if it is actually very expensive.)

5. *If you are noticing fumes/odor in the summer, it's probably because of the weather. Under different wind or temperature conditions, you wouldn't be able to smell anything.*

   It doesn't matter what the weather is. We have to live here all year. Your plant should not harm our health any time of year. (This is not really a measurable claim. It requires a moral answer rather than a factual answer.)

Trash Facility

The Concern

The company Casella owns a trash incinerator in Biddeford, Maine. They want to build a facility in nearby Westbrook that will separate recyclables from trash, and convert the remaining trash into pellets for the incinerator. Westbrook residents are concerned that the facility will add traffic and pollution. They worry it will create demand for new out-of-state trash to be trucked to Westbrook, increasing the use of the incinerator, which they want to see closed.

From “Zero Waste is Casella’s Goal”

Thursday, January 21, 2010. By Leslie Bridgers

[...] Casella’s plans to build [the] facility in Westbrook surfaced last month. Moving the trash-processing operations out of downtown Biddeford provided an incentive for that city to keep working with Casella. And, according to [Casella Development Officer Jim] Bohlig, the $15 million facility would be an asset for Westbrook, which would benefit from its tax revenue and the creation of some 30 jobs.

The facility would take in the trash that now goes to the incinerator, and, with cutting-edge technology, would sort it so that everything recyclable would be removed and the remaining waste would be condensed into pellets. The pellets would then be trucked back to the Biddeford incinerator and burned as fuel. According to Bohlig, the sorting process would remove much of the material that makes the trash emit odor and dioxins into the air - two major sources of contention Biddeford and Saco have with the incinerator. Also, by condensing the trash at a facility in Westbrook, fewer trucks would come through Biddeford’s downtown.

Bohlig insists that the burdens being lifted from Biddeford won’t cause undue harm to Westbrook. The site on County Road where the facility is being proposed already has several permits for a construction and demolition processing facility that Casella had planned to start building there in October. A traffic permit for that plant allowed 253 trucks per day. With the change in use, Casella estimates that only 167 trucks would be coming through there daily. Westbrook can also feel good about being a leader in “the clean tech revolution,” Bohlig said. Because of the technology that would be used in the new facility, he said, an additional 25,000 tons of recyclable material will be removed from the waste stream every year.” [...]

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How much more will it cost to pave the roads every year because of all the trucks? How much revenue would the town lose if residential proerty values go down 10% because of the nuisance?

"undue harm" - Can you quantify this? Exactly how much harm are we "due"?

Then Westbrook will get all those trucks, and more, both hauling trash in and hauling pellets out! And if the facility creates new demand, even more.

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Thursday, January 21, 2010. By Leslie Bridgers

[...] Casella's plans to build [the] facility in Westbrook surfaced last month. Moving the trash-processing operations out of downtown Biddeford provided an incentive for that city to keep working with Casella. And, according to [Casella Development Officer Jim] Bohlig, the $15 million facility would be an asset for Westbrook, which would benefit from its tax revenue and the creation of some 30 jobs.

The facility would take in the trash that now goes to the incinerator, and, with cutting-edge technology, would sort it so that everything recyclable would be removed and the remaining waste would be condensed into pellets. The pellets would then be trucked back to the Biddeford incinerator and burned as fuel. According to Bohlig, the sorting process would remove much of the material that makes the trash emit odor and dioxins into the air - two major sources of contention Biddeford and Saco have with the incinerator. Also, by condensing the trash at a facility in Westbrook, fewer trucks would come through Biddeford's downtown.

Bohlig insists that the burdens being lifted from Biddeford won't cause undue harm to Westbrook. The site on County Road where the facility is being proposed already has several permits for a construction and demolition processing facility that Casella had planned to start building there in October. A traffic permit for that plant allowed up to 253 trucks per day. With the change in use, Casella estimates that only 167 trucks would be coming through there daily. Westbrook can also feel good about being a leader in "the clean tech revolution," Bohlig said. Because of the technology that would be used in the new facility, he said, an additional 25,000 tons of recyclable material will be removed from the waste stream every year." [...]

What kind of jobs? Paying how much? Will they go to us, or people from out of town?

The facility will create a demand for even more trash, to keep the incinerator running

"much of..."? Be specific, we want a %.

What are the calculations and tonnages involved here? Does it include truck trips in and truck trips out? Trucks for trash, pellets, recyclables?

On what data and calculations is this number based? Is this probable, or a best-case scenario? And how many trucks will haul these 25,000 tons?

Skill: Build fluency using different words to express relationships between numbers.

Time: 15-25 minutes

Preparation

Choose which data set you'll cover:

- Environmental Test Results
- Public Health Data
- Solid Waste
- Pesticides on Food

Read the *Strategies for Reading*, and *Facilitator Resource* for that data set

Practice writing a few statements yourself

Materials

Facilitator Resource (1 per facilitator)

Data Set and *Strategies for Reading...* (1 per participant)

Pens or pencils and scrap paper (1 per participant)

Calculators (a few for the group to share)

Activity Overview

Participants read a data set, and use provided strategies to find the most striking facts in the data. Then they practice expressing those facts in different ways to see which seems most newsworthy.

When to Use It

When a group needs practice reading data, finding a notable or newsworthy fact in the data, and putting that fact into words.

Suggested companion activities:

- Use after the group is comfortable reading data tables. If not, see Making Sense of the Data
- Follow with Communicating with Numbers.

Steps

1. **Launch the activity:** Reporters will often include one or two facts or statistics in their stories. They looks for certain kinds of numbers: biggest, smallest, most typical, unusual, alarming. Our job is to give them the kinds of numbers they can use, without distorting or exaggerating. This will give us some practice doing that. (Hand out the Data Set and Strategies for Reading... If the group needs coaching, work out an example or two together.)
2. **In pairs or small groups:** Follow the strategies to find striking facts in the data. Try saying those facts in different ways, and choose the one that makes the strongest statement. (Optional: Assign each group a different kind of striking fact to find.)
3. **Debrief:**
   - How did this go? Was it hard or easy?
   - Were there ways of saying the data that were always your favorite (like percents, or __ in 10)? Or did it change for different numbers?

For the Facilitator

Pesticides on Food is the simplest data set. It's best suited for a group who won't need to read their own complex data, but who want to develop key skills. The other data sets have more challenging aspects: unfamiliar units, raw data, many options, etc.

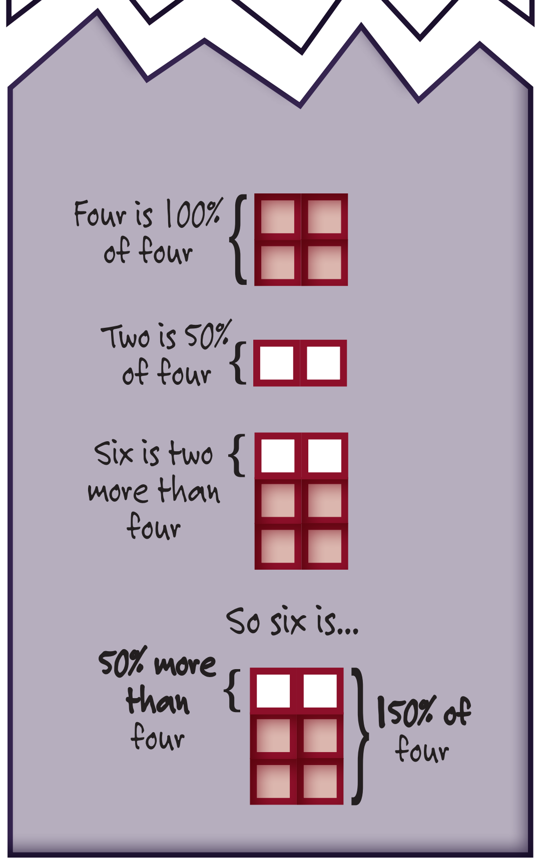
If you want to use your own data, choose which Strategies for Reading... handout is the best fit. Format your data sets so they're easy to hand out. If there are many pages, divide up the work among small groups.

Worth Noting

People get easily confused between "percent of" and "percent more/less than." A drawing can help, like the ones shown here on the right.

Smart Moves

- Play with different ways to say it
- Use friendly numbers



Strategies for Reading Environmental Test Results

1. Find something striking

For any environmental test results, look for:
- the highest result compared to its standard
- a low result for a contaminant that is still very high compared to the standard
- a contaminant not detected, but where the detection limit was higher than the standard
- a contaminant that needs a big reduction in levels to be brought down to the standard

Changes through time - For tests at one location on different dates, also look for:
- an alarming increase or unrealistic decrease in results from month to month.
- really varied results (i.e., high, to low, then back to high again)
- results not going down quickly enough in a cleanup

Changes across location - For data for one contaminant in different places, also look for:
- much higher results in one place than another
- very high results in a location where vulnerable people might be exposed (a school, home, garden, senior center, etc.)

2. Try saying it different ways

All of the newsworthy items above involve comparing one number to another. When comparing two measured numbers "A" and "B", you can say things like:
- *A is ___ more than B / less than B* [in units like μg/L or mg/kg]
- *A is ___ times B*
- *A is ___ % of B*
- *A is ___ % lower than B / higher than B*
- *To get from A to B would require a ___% reduction / increase*
- *A is bigger / smaller than B by ___ order(s) of magnitude*
- *A is [double, triple, a quarter of, half of, a fifth of, two-thirds of] B*
- [Draw a graph or infographic comparing A to B]

3. Choose the one you think makes the most newsworthy statement

Environmental Test Results

Monitoring Well -16' BGS	Groundwater Objectives	Quality PALs	Units	Baseline 1/2/2008		04/01/2008		07/07/2008		10/01/2008	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
								VOLATILE ORGANICS			
Vinyl Chloride	2	1	ug/L	**530**	25	**100**	1.0	**100**	5.0	**16**	10
1,1-Dichloroethene	7	3.5	ug/L	<	25	**1.1**	1.0	<	5.0	<	10
trans-1,2-Dichloroethene	100	50	ug/L	**70**	25	**20**	1.0	<	5.0	**19**	10
cis-1,2-Dichloroethene	70	35	ug/L	**6,800**	25	**2,100**	1.0	**160**	5.0	**2,300**	100
Trichloroethene	5	2.5	ug/L	**1,200**	25	**2,500**	1.0	**82**	5.0	**2,300**	100
Tetrachloroethene	5	2.5	ug/L	**1,800**	25	**4,100**	1.0	**330**	5.0	**2,900**	100

This is one page of groundwater test results from a site near a closed textile mill. The company knows the site is contaminated and is trying to clean it up. These data are from one groundwater monitoring well, tested for six contaminants, on four different dates.

In this table, the "Groundwater Objectives" are the state standards for groundwater. "Quality PALs" are the Preventive Action Limits, limits set at half of the state standards.

The "Limit" shown for each testing date is the detection limit used in that particular test.

"<" means the contaminant was not detected in that particular test.

Environmental Test Results

Monitoring Well -16' BGS	Groundwater Objectives	Quality PALs	Units	Baseline 1/2/2008		04/01/2008		07/07/2008		10/01/2008			
				Result	Limit	Result	Limit	Result	Limit	Result	Limit		
VOLATILE ORGANICS													
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Tetrachloroethene	5	2.5	ug/L	**1,800**	25	**4,100**	1.0	**330**	5.0	**2,900**	100		

Sample Newsworthy Facts

Tetrachloroethene has been as high as 820 times its groundwater objective.

The lowest reading for tricholoroethene, in July, was still 16 times the objective.

Even though the July numbers were much lower, the October tricholorothene levels were still 92% of the April levels – *or* – Even though the July numbers were much lower, the October tricholoroethene levels were only 8% lower than the April levels.

No 1,1-Dichloroethene was detected in January, but the detection limit was more than 7 times the PAL… so the levels could have been 7 times the PAL, but we wouldn't know, because the equipment used couldn't detect it.

The detection limits for trans-1,2-Dichloroethene were set poorly in January. They were only 50% of the PAL. In April, the detection limits were set more conservatively, at 2% of the PAL.

The levels of tetrachloroethene in October were over 60% higher than they had been in January.

In January, the levels of trans-1,2-Dicholorothene were 20 μg/L above the Quality PALs, but were still 30 μg/L below the Groundwater Objectives.

Even if the tricholoroethene returned to its July levels, we would still need to see a 94% reduction in order to meet the groundwater objectives.

The levels have since come down, but the first time they tested for cis-1,2-Dichloroethene, levels were over the groundwater objectives by two orders of magnitude.

Strategies for Reading Public Health Data

1. Find something striking

For any public health data, look for:
- the highest rates (incidence or prevalence) compared to the average (state or national)
- a disease needing a significant reduction in rates to be brought down to the average
- a disease whose rates are striking compared to those of another disease's rates

Changes through time - For data from one location over time, also look for:
- an alarming increase, or suspicious decrease in rates
- really varied rates (i.e., high, to low, then back to high again)
- rates not going down quickly enough following an alleged resolution of a problem

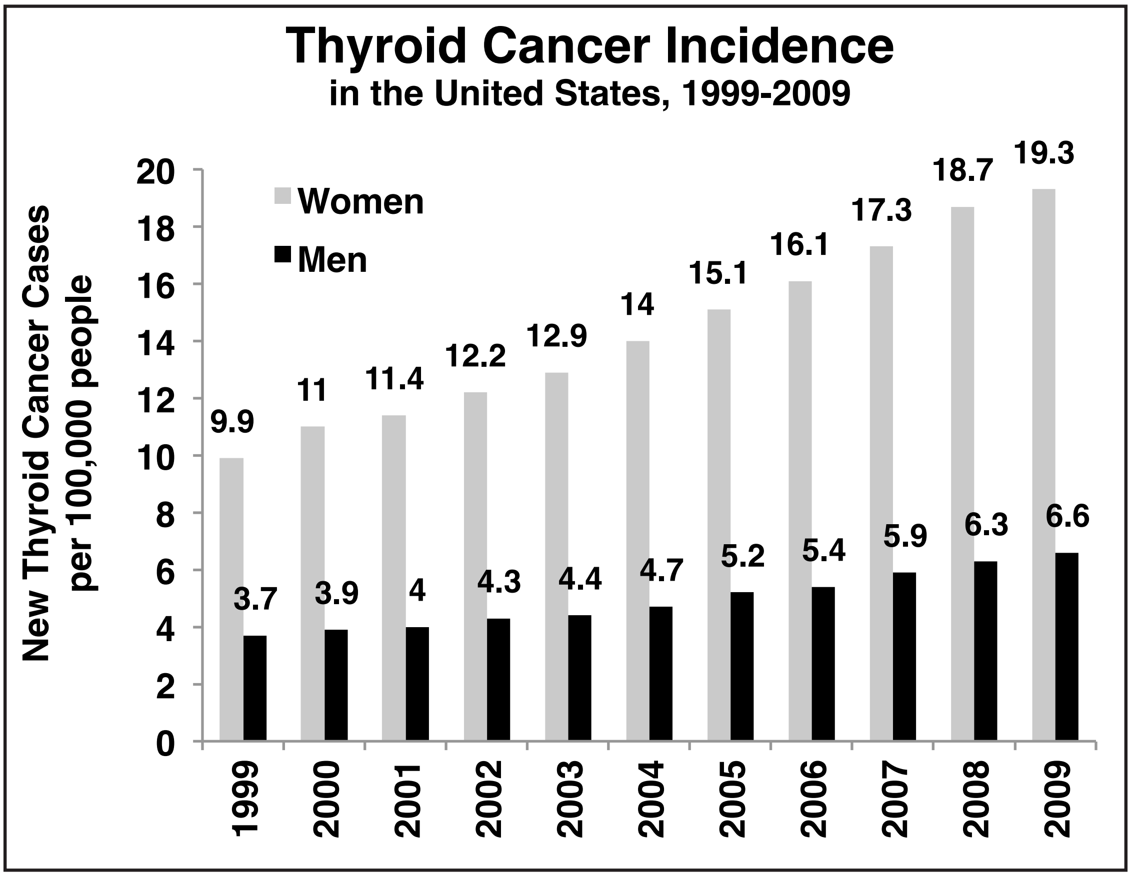
Changes across location - For data for one disease across many locations, also look for:
- much higher results in one place than another
- very high results in a location where vulnerable people might be exposed (a school, home, garden, senior center, etc.)

2. Try saying it different ways

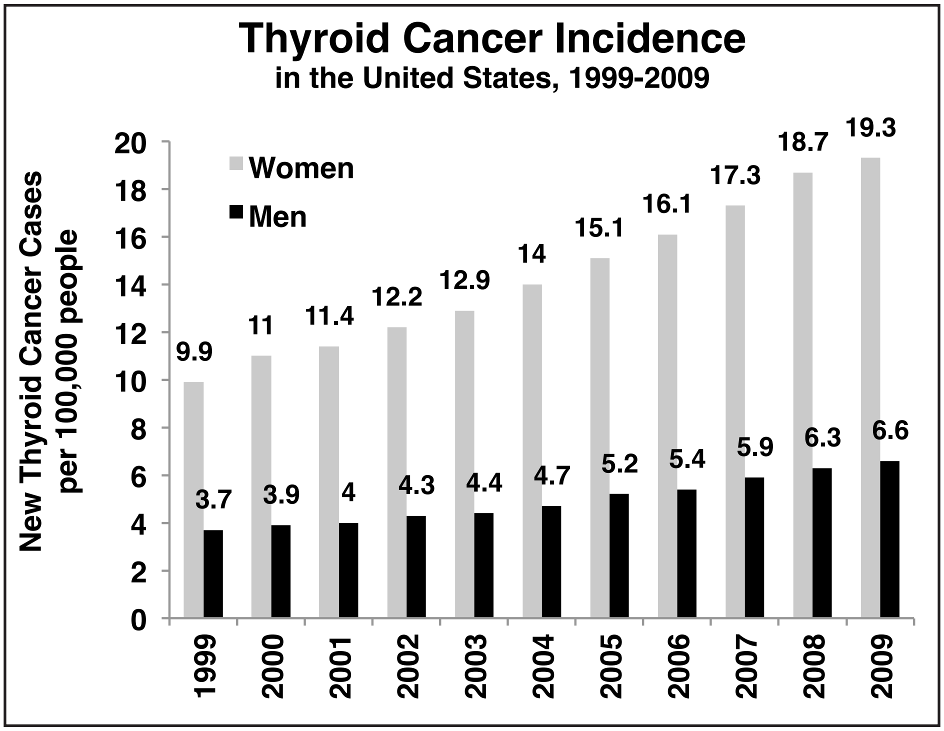
All of the newsworthy items above involve comparing one number to another. When comparing two rates "A" and "B", you can say things like:
- *A is ___ more than B / less than B* [using units like "__ new cases per 100,000 people"]
- *A is __ %, the same as __ out of 100, __ in 10, one in __, or __ in __*
- *A is ___ times B*
- *A is ___ % of B*
- *A is ___ % lower than B / higher than B.*
- *To get from A to B would require a ___% reduction / increase*
- *A is bigger / smaller than B by ___ order(s) of magnitude*
- *A is [double, triple, a quarter of, half of, a fifth of, two-thirds of] B*
- [Draw a graph or infographic comparing A to B]

3. Choose the one you think makes most newsworthy statement

Public Health Data



Public Health Data



Sample Newsworthy Facts

Women's thyroid cancer rates in the U.S. have almost doubled in ten years.

In 1999, one in every 10,000 women in the U.S. was diagnosed with thyroid cancer. By 2009, it was one in every 5,000.

Every year from 1999 to 2009, the incidence of thyroid cancer in women increased, by anywhere from 3.6% to 10% per year.

In 2009, men's thyroid cancer rates were just 34% of women's.

In 2009, men's thyroid cancer rates were 66% lower than women's.

In 1999, women's thyroid cancer rates were 167% higher than men's. By 2009, they were 192% higher than men's.

Strategies for Reading Solid Waste Data

1. Find something striking

For any solid waste data, look for:

- the grand totals, the maximums
- a minimum that might still be considered very high
- an alarming increase or unrealistic decrease
- fluctuating or unusual numbers (i.e., high, to low, then back to high again)
- how the waste will move around: number of trucks involved, associated exhaust and road damage, etc.

2. Try saying it different ways

Most of the newsworthy items above involve comparing one number to another.
When comparing two numbers "A" and "B", you can say things like:

- *A is ___ more than B / less than B* [in units like tons or truck trips]
- *A compared to B is the same as __ to 100, __ to 10, one to __, or __ to __*
- *A is ___ times B*
- *A is ___ % of B*
- *A is ___ % lower than B / higher than B*
- *To get from A to B would require a ___% reduction / increase*
- *A is bigger / smaller than B by ___ order(s) of magnitude*
- *A is [double, triple, a quarter of, half of, a fifth of, two-thirds of] B*
- [Draw a graph or infographic comparing A to B]

3. Choose the one you think makes the most newsworthy statement

Solid Waste

The data below are from a company that accepts municipal solid waste (MSW). One one site, there is a landfill, and a processing facility that sorts the waste. The company is proposing a big expansion. The community is concerned about the size of the landfill, and about the number of garbage trucks going in and out of the site.

Note that some MSW goes straight into the landfill. Some goes to the processing facility first, and then into the landfill. Some goes to the processing facility, and is then trucked offsite again. The top table shows the tonnages the company is currently permitted to take in. The bottom table shows the proposed tonnages.

CURRENT	**Tons Per Year**	**Tons per Day**
Into the Landfill		6 days/week
MSW directly into Landfill	24,960	80
MSW from Processing Facility to Landfill	156,000	500
Total MSW to Landfill	180,960	580
Processing Facility		
MSW to Processing Facility, going to Landfill (same as above)	156,000	500
MSW to Processing Facility, trucked offsite again	78,000	250
Total MSW to Processing Facility	234,000	750
Total to Landfill and Processing Facility		
Total tonnage going to Landfill (from MSW and Processing)	180,960	580
Tonnage to Processing Facility not being Landfilled	78,000	250
Total tonnage going to site (both Landfill and Processing Facility)	258,960	830

PROPOSED	**Tons Per Year**	**Tons per Day**
MSW into landfill and from Processing Facility	405,600	1,300
MSW into Processing Facility that is trucked offsite again	93,600	300
Total MSW to site (Landfill and Processing Facility)	499,200	1,600

Solid Waste Data

CURRENT PERMITS	Tons Per Year	Tons per Day
Into the Landfill		6 days/week
MSW directly into Landfill	24,960	80
MSW from Processing Facility to Landfill	156,000	500
Total MSW to Landfill	180,960	580
Processing Facility		
MSW to Processing Facility, going to Landfill (same as above)	156,000	500
MSW to Processing Facility, trucked offsite again	78,000	250
Total MSW to Processing Facility	234,000	750
Total to Landfill and Processing Facility		
Total tonnage going to Landfill (from MSW and Processing)	180,960	580
Tonnage to Processing Facility not being Landfilled	78,000	250
Total tonnage going to site (both Landfill and Processing Facility)	258,960	830

PERMITS REQUESTED	Tons Per Year	Tons per Day
MSW into landfill and from Processing Facility	405,600	1,300
MSW into Processing Facility that is trucked offsite again	93,600	300
Total MSW to site (Landfill and Processing Facility)	499,200	1,600

Sample Newsworthy Facts

There's already 830 tons of garbage going into the site every day. That's enough.

They're proposing to bring half a million tons of trash into the site every year.

The proposal would nearly double the total waste going into the site.

The proposal would increase the waste going into the landfill by 125%.

They proposing to put two and a quarter times as much the garbage into the landfill.

Strategies for Reading Data about Pesticides on Food

1. Find something striking

It could be a fruit or vegetable with the highest or lowest rates of pesticide residue, or one that you and your family eat frequently.

2. Try saying it different ways

The data for that food is in percents. Try expressing the percent in at least three of the ways below:

- *__ %*
- *__ out of 100*
- *__ in 10*
- *One in __*
- *__ in __* (other numbers)
- A fraction word: a *quarter, half, a fifth, two-thirds,* etc.

Write down your statements. Circle the statement that seems the strongest.

> **Example:** How many eggplants still had pesticides?
>
> - 25% of eggplants
> - 25 out of 100 eggplants
> - More than 2 in 10 eggplants
> - One in four eggplants
> - A quarter of the eggplants

3. Repeat for a few other foods.

Did you circle the same phrasing for all the foods, or did it change?

4. Compare foods to each other

If you're feeling confident, compare the data from one food to another. If you want to compare the pesticide rates of fruit "A" to the rates in vegetable "B":

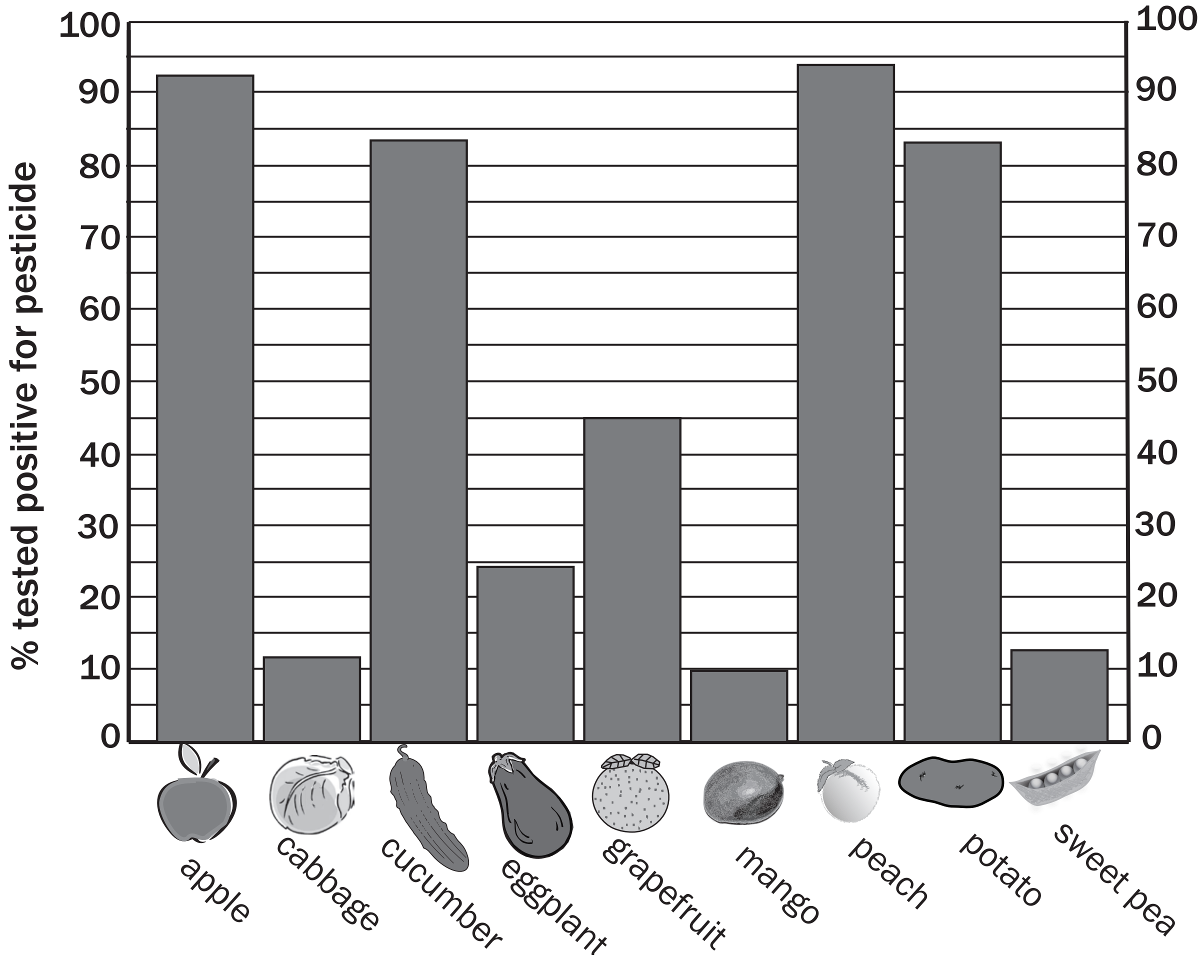
- *A is ___ times B*
- *A is ___ % of B*
- *A is ___ % lower than B / higher than B*
- *A is [double, triple, a quarter of, half of, a fifth of, two-thirds of] B*
- [Draw your own graph or infographic comparing A to B]

5. Choose the one you think makes the most newsworthy statement

Note: Fruits and vegetables are still very good for you! To reduce or avoid pesticides, wash or peel them, buy organic, or grow your own.

Pesticides on Food

An environmental organization (ewg.org) tested many fruits and vegetables in stores for pesticide residue. The graph shows what percent of fruits and vegetables still had pesticides.



Note: Fruits and vegetables are still very good for you! To reduce or avoid pesticides, wash or peel them, buy organic, or grow your own.

Inside Averages

Facilitator Instructions

Activity Overview

Participants start with a data set and its average and match them with common questionable practices used to arrive at an average. They then approach the problem from the reverse angle — starting with an average and then imagining a data set that could match it.

When to Use It

When community members are suspicious of reported results involving averages. The activity gives participants a chance to examine a data set and identify common problems, before they scrutinize their own data.

Suggested companion activities

- Precede with Making Sense of the Data; Drawing Your Own Conclusions
- Use with appropriate fact sheets from Common Units, Limits & Levels
- Follow up with Communicating With Numbers

Steps

1. **Launch the activity:** Remind participants of how averages connect with their environmental work. An average is a way to talk about a set of data (many numbers) using just one number. People often use an average as if it's representative of the whole set of data, but sometimes an average doesn't tell the whole story.
2. **In pairs or as a group:**
   - Review the key points on the strategy sheet *Challenging an Average.*
   - Examine one set of graphs. How might you challenge each graph?
   - Optional: Read one of the *Imagine the Extremes* handouts. Graph one or more ways that average could be true.
3. **Debrief:**
   - Which challenges did you use?
   - How did you check your answers?

Worth Noting

Averages are more appropriate in some situations than in others. Problems with averages might be oversights because of money or time pressure. They are not always a malicious act. If you are using local data, it will be rare to find several errors.

Smart Move

- Play with different ways to show it.
- Seek verification.

Skill: Identify, describe, and graph how an average that is presented as "typical" may not be typical.

Time: 20-40 minutes

Preparation

Choose which graph set you will use:

- Groundwater Objectives
- Truck Trips
- Sulfur Dioxide Emissions

Cut graph sets along dashed lines.

Optional: Choose an *Imagine the Extremes* to use:

- *Opacity*
- *Waste Treatment Plant*
- *Composite Soil Sample*

Materials:

Pens or markers

Calculators

Challenging an Average (1 per participant)

One of the three graph sets (1 per participant)

Optional: One of the three *Imagine the Extremes* (optional, one per participant, plus graph paper)

Challenges and Answers

These answers aren't absolute. Let participants make the case for their own challenge. If it doesn't hold up, they'll know.

Groundwater	
1, 8	8
7, 10	9
6	5

Truck Trips	
3	6
1	8, 10
7, 10	10

Air Pollution	
6	10
5, 11	1, 7
7, 10	

Challenging an Average

Testing Challenges

1. **There's not enough data –** keep testing! If there are only a few numbers, an average can be misleading. The average might change a lot with the next number.

2. **They didn't test in the hot spots.** There may be places where the levels are much higher. Without them, the average won't be accurate.

3. **They didn't test when the levels were highest.** There may be times of year when the numbers are much higher (e.g. groundwater tests in dry seasons). Without them, the average is misleading.

4. **The detection limit is too high.** There might be contamination at levels of concern, but you won't know if the equipment wasn't sensitive enough to detect those levels.

5. **They tested until they had a low number that would bring down the average.** A company may just keep measuring until getting a result below the level of concern, and stop. If the rest of the data is higher, the low reading may not be typical.

Calculation Challenges

6. **They didn't include the high number.** If one number is very different from all others, it may be considered an "outlier" – an unusual measuring mistake. If they removed an outlier from the average. they need to explain why.

7. **There's too much variation.** If the numbers are all over the place, an average may not be a good way to describe them.

8. **Average is low, but recent numbers are high.** The average might be low, but recent numbers might show an upward trend.

9. **They used the detection limit like it was zero.** If contamination is below the detection limit, that doesn't mean it's zero. A measurement below the detection limit should be included in an average as if they found contamination equal to the detection limit.

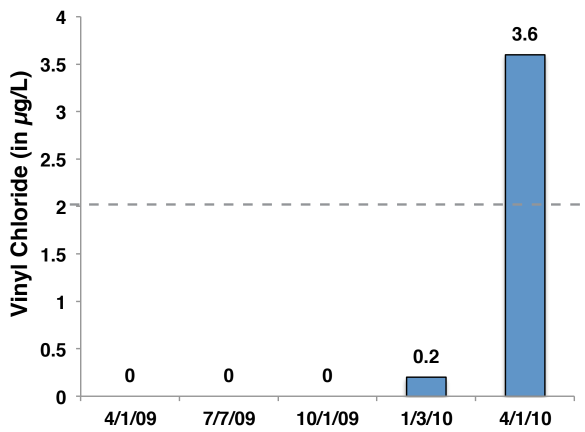
10. **An average isn't what we want here.** Sometimes the average just isn't the best summary of the data, and it's better to know the median, or the maximum, or some other number.

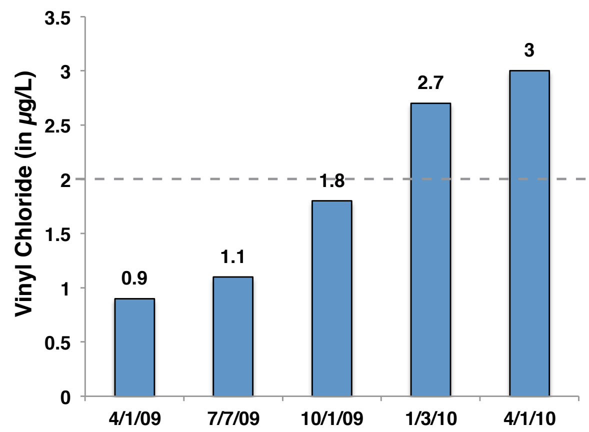
Or...this average looks OK. Sometimes the average is accurate and there's no problem with the numbers at all. Hopefully, this happens most of the time!

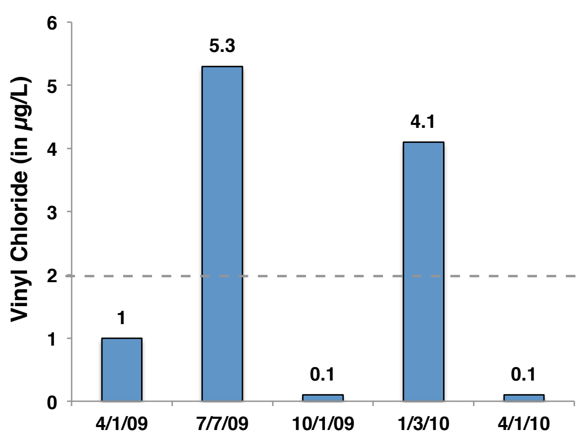
Groundwater Objectives

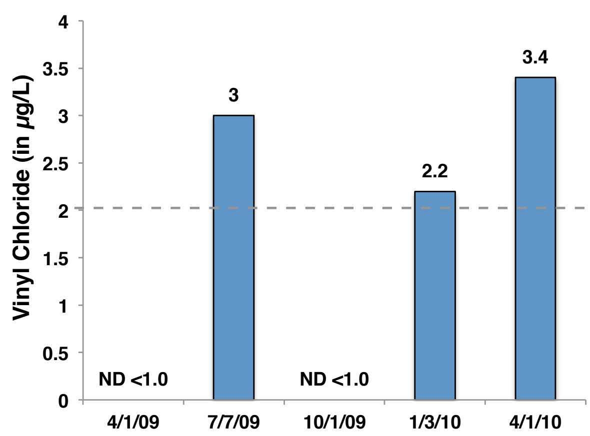
"The average vinyl chloride level in Well # MZ-17 is below the state groundwater objective of 2.0 µg/L."

"La concentración promedio del cloruro de vinilo en el Pozo #MZ-17 es inferior al objetivo estatal para las aguas subterráneas de 2.0 µg/L."

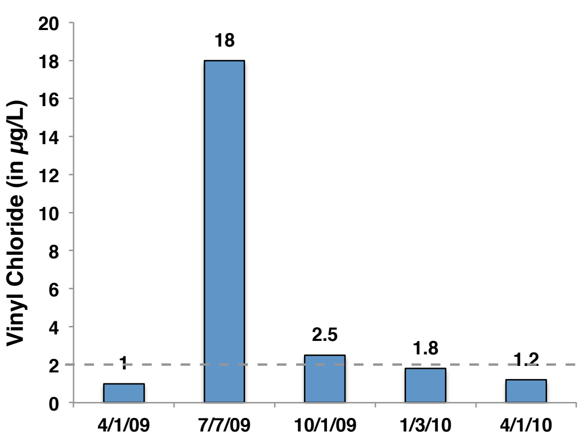


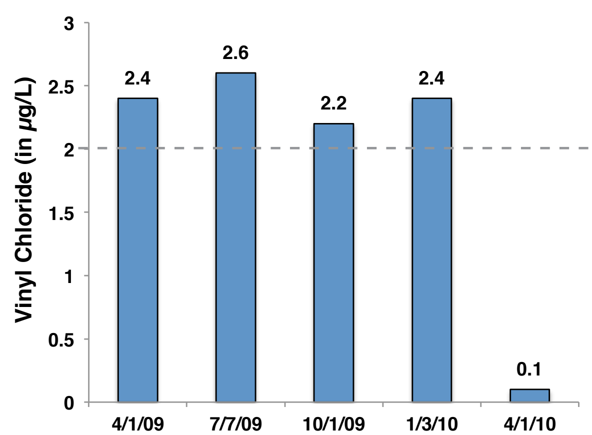






ND <1.0 = Not detectable below 1.0

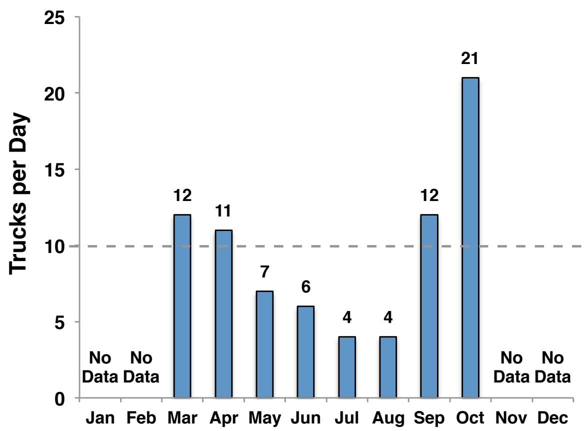


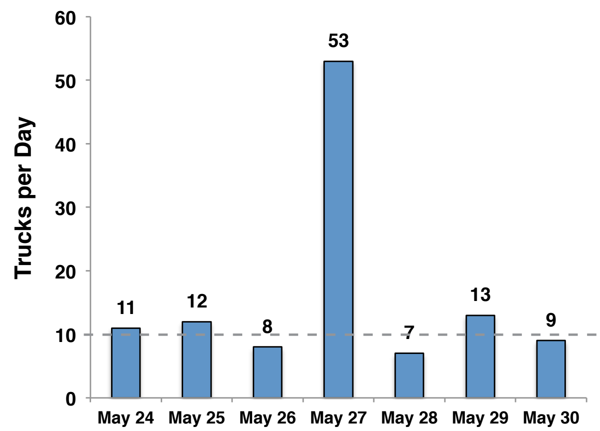


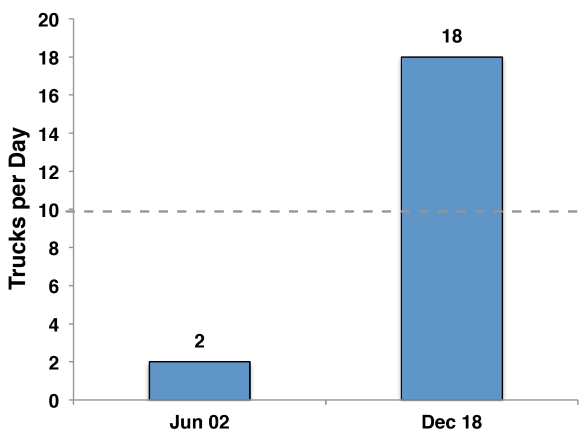
Truck Trips

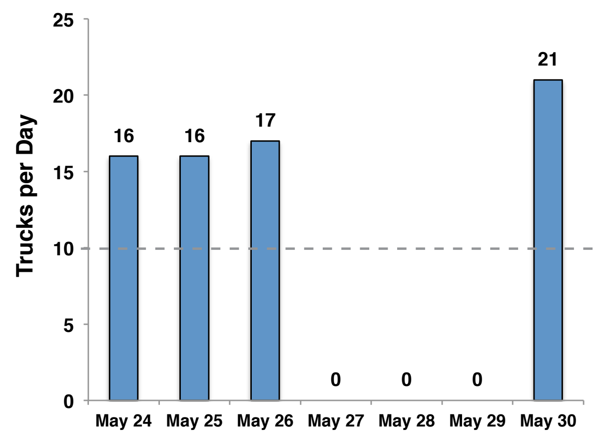
"The new landfill has added an average of only ten garbage truck trips per day."

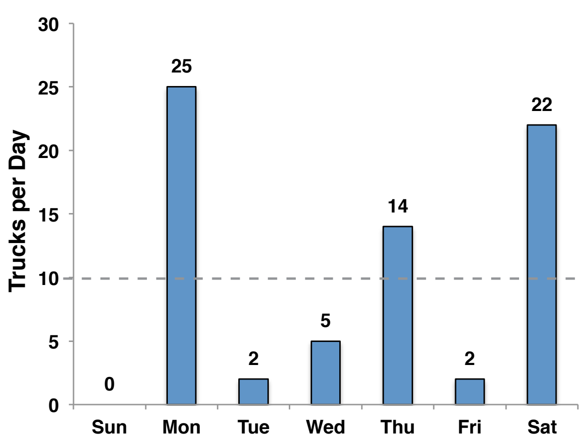
"El nuevo vertedero solo ha aumentado las descargas de los camiones recolectores de basura un promedio de diez por día."

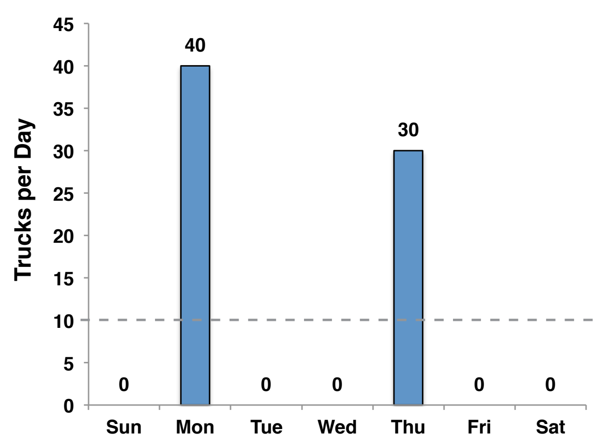








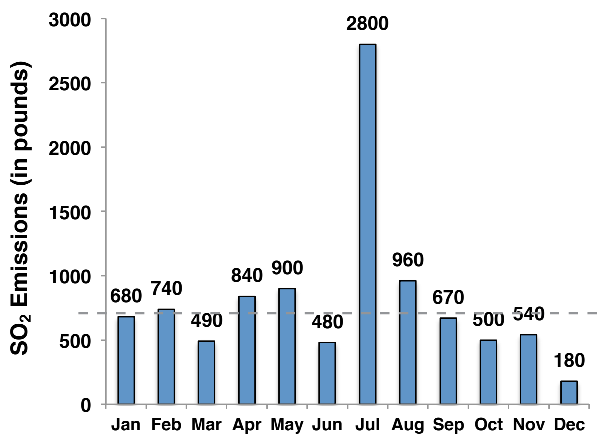


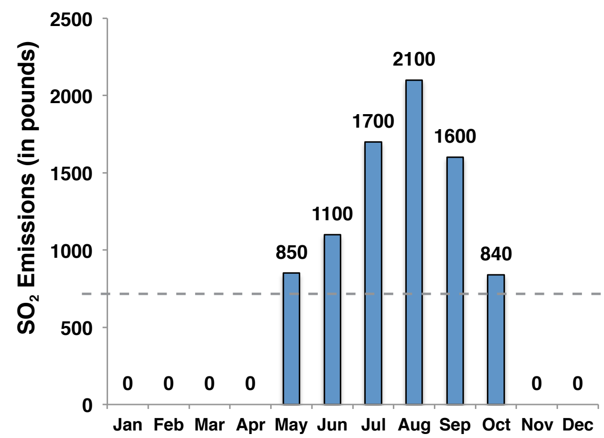


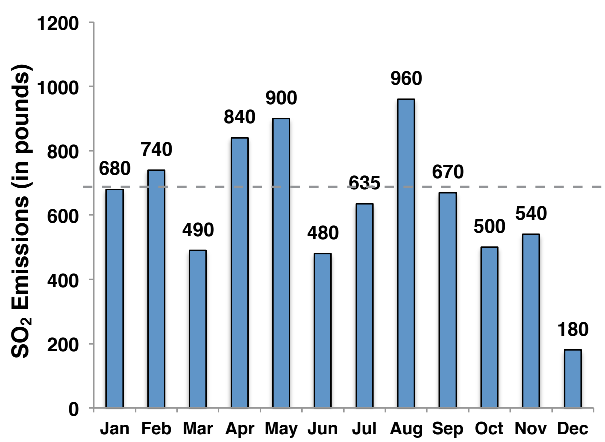
Sulfur Dioxide Emissions

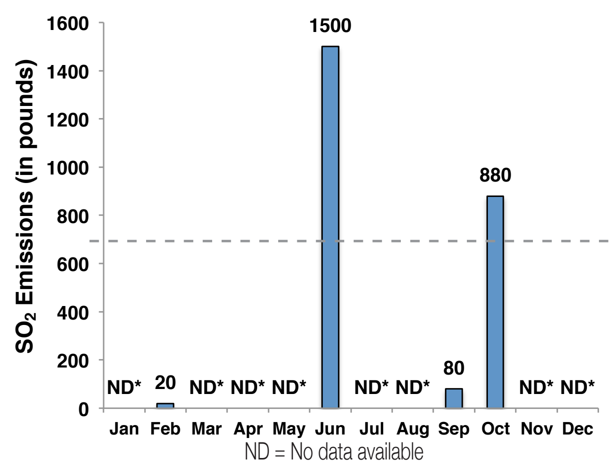
"The emissions of sulfur dioxide from our asphalt plant are within the permitted average of 700 pounds per month over a 12-month period."

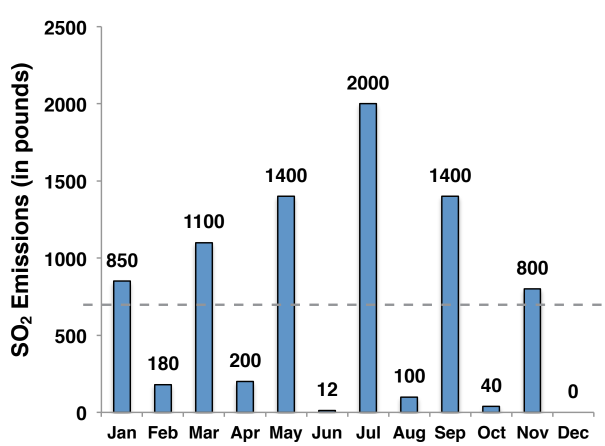
"Las emisiones de dióxido de azufre de la planta de asfalto se encuentran dentro del promedio permitido de 700 libras por mes en un periodo de 12 meses."











Imagine the Extremes: Opacity

Background

The North Carolina Division of Air Quality regulations require that visible emissions for hot mix asphalt plants have an opacity* of less than 20%, averaged over a six-minute period.

Directions

1. Imagine and describe how the readings taken by the facility employee agree with what the neighbor saw. The facility employee made six opacity observations at 1-minute intervals
2. Create a graph to show the possible levels you imagined. If you imagined more than one possible combination, make more than one graph.
3. Discuss: What concerns would you highlight in a flyer or in a letter to the editor?

Note: *Opacity means the capacity to block light. Informally we say "thick" smoke. EPA Method 9 - Visual Determination of the Opacity of Emissions from Stationary Sources requires that more opacity observations be recorded than in this example: at 15-second intervals for a total of 24 observations over 6 minutes. Violations of opacity standards indicate hazardous conditions.

Imagine the Extremes: Waste Treatment Plant

Background

A municipal sewage treatment plant in Mississippi directs its treated waste into an artificial lagoon near a river. The treated wastewaster isn't safe for any use, but there are still standards for the average and maximum contamination that can be in the wastewater befvore it can be released as effluent into the river.

Table 2-3 shows the average and maximum monthly levels of fecal coliform (bacteria found in sewage) legally allowed in the lagoon.

Table 2-3. South Lagoon Permit Limits

Effluent Parameters		Permitted	Units
Fecal Coliform (May - Oct)	*avg*	200	# col / 100 ml
	max	400	

Table 2-4 shows the actual average monthly levels of fecal coliform in the lagoon in a six-month period. The table also gives a range, showing the lowest and highest monthly levels.

Table 2-4. South Lagoon Performance

Effluent Parameters		Reported Values	Units
Fecal Coliform* (May - Oct; avg)	*avg*	273	# col / 100 ml
	range	20 - 860	

*Average and range omit one extreme value of 8512 col/100 ml reported on 6/30/2010.

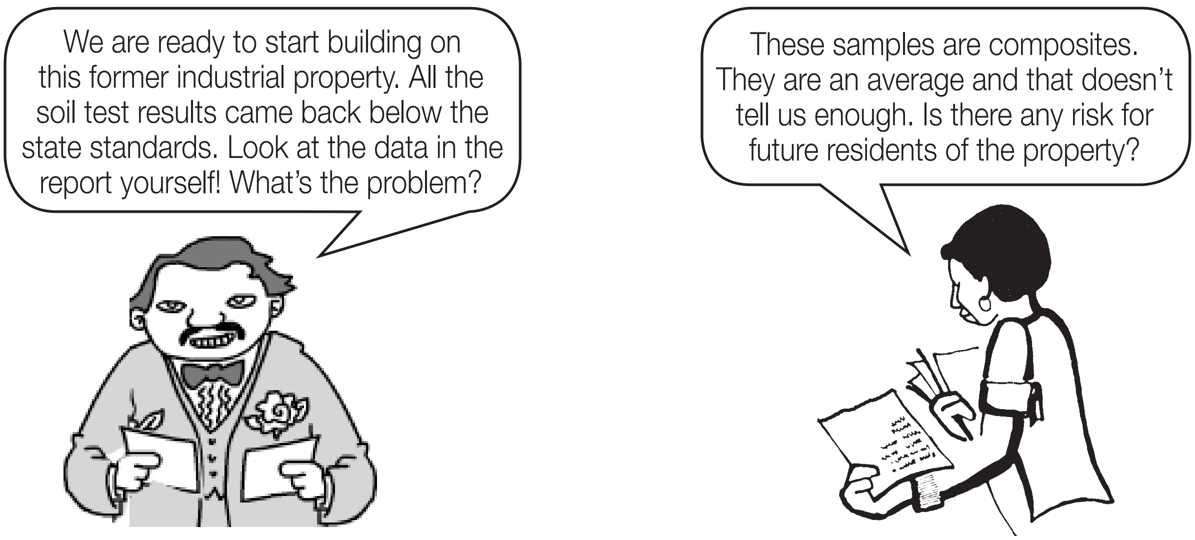
Directions

1. Imagine and describe possible levels for the six-month period.
2. Create a graph to show the possible levels you imagined. If you imagined more than one possible combination, make more than one graph.
3. Discuss: What concerns would you highlight in a flyer or in a letter to the editor?

Imagine the Extremes: Composite Soil Sample

Background

Sometimes an average isn't calculated from numbers. Soil samples from various depths or locations can be mixed together into a "composite" sample. The lab tests the composite, and reports only one result, which is effectively an average of the individual samples.



Samples from the site were taken at depths of 0", 12", 24", and 36". These were combined into a single composite sample and analyzed for lead. The result was 267 mg/kg, which is below the residential standard in this state (300 ppm).

Directions

1. Imagine and describe the what the four levels in each soil sample might have been before they were combined in a composite.
2. Create a graph to show the possible levels you imagined. If you imagined more than one possible combination, make more than one graph.
3. Discuss: What concerns would you highlight in a flyer or in a letter to the editor?

Graph Worksheet

Can you imagine how they might have reached the average? Make a graph below. Label the different parts of your graph, and add a line showing the average.

The Summary vs. The Lab

Facilitator Instructions

Activity Overview

Reports of environmental tests often contain a complete list of results written by a laboratory, and a summary of the most important results written by a government agency or other consultant. In this activity, participants practice checking to see if the summary matches the lab results, or if there are mistakes.

When to Use It

When participants doubt that the summary of lab results is accurate. Also, when groups want to keep a close eye on the testing process and need tips about what to look for.

- Precede with A First Look at Technical Documents, Converting Between Units, and relevant handouts from Common Units.
- Follow up by checking your own data set, and Compare to Standards

Steps

1. **Launch the activity:** Most regulators only read the summary of environmntal test results, so it's important to make sure the summary is accurate. Mistakes are rare, so for practice, here is a sample data set that is known to have mistakes.
   (Hand out Strategies for Checking Summaries of Lab Results and the Sample Pages from the consultant summary and lab results. Model the process by following the Strategies for one contaminant.)
2. **In pairs or as a group:** Check at least two rows and make a note of any problems.
3. **Debrief:** What did you notice? What were some of the mistakes? Any tips you want to share?

For the Facilitator

"Mistakes" in this activity include:

- the wrong soil depth is recorded in the header
- the values for 2nd and 3rd contaminants are reversed
- the value for the Benzo[b]flouranthane standard is written as if it's the lab result
- the TPH-DRO value was "converted" to mg/kg with the other data, but it was already in mg/kg
- the digits for the napthalene lab result are transposed
- the lab result for dibenzo[ah]anthracene is off by a factor of 10
- benzo[a]pyrene is over the standard, but is not in boldface

Smart Moves

- Slow down
- Seek verification

Skill: Identify possible discrepancies between raw lab data and summaries of that data.

Time: 20-30 minutes

Preparation

Read through the activity. Try it yourself.

Optional: If you follow this activity by looking at your own local test results, identify the summary and full lab results sections of your data.

Materials

Strategies for Checking Summaries of Lab Results Handout (1 per participant)

Sample Pages from the Summary and Lab Results (1 of each per participant, single-sided)

Highlighters, pens, or markers

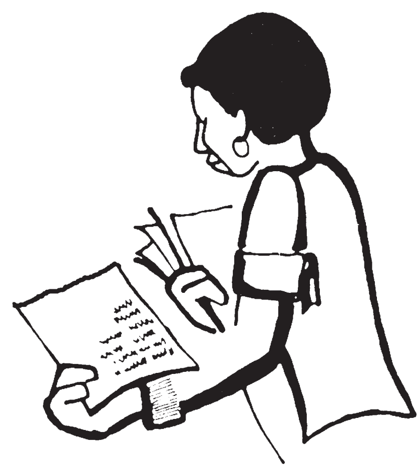
Optional: The corresponding sections from your own report of lab results.

Sample ID Depth Date	B-5 (0-3 feet) 2/26/10	Tier I SROs Residential Standards*
		Ingestion
Acenaphthylene	<0.050	2,300
Benzo(a)anthracene	6.38	1.1
Benzo(a)pyrene	6.78	1.3
Benzo(b)flouranthene	1.5	~~1.5~~
Dibenzo(a,h)anthracene	<0.023	0.2
Flouranthene	3.2	3,100
Indeno(1,2,3,-cd)pyrene	.0778	0.86
Naphthalene	.227	1,600
TPH-DRO	1,060	---

Strategies for Checking Summaries of Lab Results

A report of environmental test results has many pages of detailed lab results, written by lab scientists. It also usually has a short summary of the most important results, written by a consultant. Many officials will only read the summary. Vigilant community organizations should verify it really is a complete and accurate summary of the results.

Below are some tips to guide you. First, make a hard copy of the report, and separate the sections. Start reading the summary. Then...



1. Find that sample. When the summary mentions the results of a particular sample, stop. Find the page in the detailed lab results that matches that sample. Verify you have the right one: there should be a name or ID for the sample, and maybe information about sample depth and location, to help confirm it's a match.

2. Leave nothing (important) behind. Every contaminant and sample found to be above the reporting limit or detection limits should appear in the summary. If some contaminants were "not detected," it's OK if they don't appear in the summary.

3. Check the units. The person writing the summary might have converted the lab results to a different set of units in the summary (for example, from µg/kg to mg/kg). This is OK, but make sure all the numbers were converted accurately (for example, 400 µg/kg should become 0.4 mg/kg.)

4. Match the numbers. If the units are the same, then the numbers for each contaminant in the lab results should match the numbers for the same contaminant in the summary. Make sure no numbers were accidentally swapped, or copied incorrectly.

Page from the Summary

Sample ID Depth Date	B-5 (0-3 feet) 2/26/10	Tier I SROs Residential Standards*
		Ingestion
Acenaphthylene	<0.050	2,300
Benzo(a)anthracene	**6.38**	**1.1**
Benzo(a)pyrene	6.78	1.3
Benzo(b)flouranthene	**1.5**	**1.5**
Dibenzo(a,h)anthracene	<0.023	0.2
Flouranthene	3.2	3,100
Indeno(1,2,3,-cd)pyrene	.0778	0.86
Naphthalene	.227	1,600
TPH-DRO	1,060	---

NOTES:
All results listed in mg/kg
"<" indicates that analyte was not detected at stated detection limit
* These standards are for the state of Illinois
Bolded, shaded print indicates analyte exceeded Tier 1 Soil Remediation Objectives

Page from Lab Results

Client Sample ID: B-5 (3-6)

Lab Sample ID: 0022603-13 (Soil)

Analyte	Result	Reporting Limit	Units	Dilution
Volatile Organic Compounds				
Xylenes, total	ND	5	ug/kg dry	1
Polynuclear Aromatic Compounds by GC/MS with Selected Ion Monitoring				
Acenaphthene	**1260**	50.0	ug/kg dry	1
Acenaphthylene	ND	50.0	ug/kg dry	1
Anthracene	**2690**	83.0	ug/kg dry	1
Benzo (a) anthracene	**6780**	8.50	ug/kg dry	1
Benzo (a) pyrene	**6380**	15.0	ug/kg dry	1
Benzo (b) fluoranthene	**10300**	11.0	ug/kg dry	1
Benzo (g,h,i) perylene	**2910**	25.0	ug/kg dry	1
Benzo (k) fluoranthene	**3300**	11.0	ug/kg dry	1
Chrysene	**7990**	50.0	ug/kg dry	1
Dibenz (a,h) anthracene	**233**	20.0	ug/kg dry	1
Fluoranthene	**25400**	50.0	ug/kg dry	1
Fluorene	**1510**	33.0	ug/kg dry	1
Indeno(1,2,3-cd)pyrene	**2920**	25.0	ug/kg dry	1
Naphthalene	**272**	50.0	ug/kg dry	1
Phenanthrene	**9540**	33.0	ug/kg dry	1
Pyrene	**19700**	50.0	ug/kg dry	1
Total Petrolium Hydrocarbon				
DROs	**10600**	40.0	mg/kg dry wt.	1
GROs	**22.4**	2.00	mg/kg dry wt.	1

Activity Overview

Participants look at a map, consider where contamination or potential exposure may be, and mark where they would want to take samples.

When to Use It - Before giving input on plans for:

- testing an exposure site (e.g., school, home, garden) to see if offsite contamination is intruding
- a study design for the cleanup of a hazardous site
- challenging an official sampling plan that might be inadequate

Suggested companion activities:

- Use with other activities from Drawing Your Own Conclusions
- Consult SfA's Soil Quality Guide: Digging in the Dirt for an overview of steps and how the community can give input at the different stages.

Steps

1. **Launch the activity:** Sampling plans try to answer 3 questions:
   - Where did the contamination come from?
   - Where are people exposed to it?
   - Is the contamination moving off site?
2. **In pairs:** Distribute small copies of the map of the area, or show one large map. First, label the map with sticky notes telling what people know about the testing area. Use the 3 questions as a guide. For reviewing a proposed sampling plan, ask whether the plan will answer the 3 questions. Use mark other places they should sample.
3. **Debrief:**
   - Did we get everything? Is there anything missing?
   - If the final sampling plan only calls for [four, eight, half as many] samples, which of these would we keep and which could we skip?

Worth Noting

The example shows a small site, but you can also use this for a large area surrounding a smokestack. In large areas, it's not practical to sample everywhere, but you can take a first set of samples, and the results will help decide where to take a second set of samples later. Some questions may be more important, depending on the situation. A group living near a fenced-off site may not care where contamination is on the site, but they may care much more about off-site migration. Be prepared to respond to group priorities.

Smart Moves

- Use your senses
- Talk it out

Skill: Identify suspected sources of contamination and points of exposure in a contaminated site. Create plan for testing.

Time: 20-30 minutes

Preparation

Identify the area where you want to take samples (or where samples have already been taken). Find a printable map of the area.

Write the three questions from Step 1 on large paper. Post in the room.

Materials

One large map of the area and/or small copies of the map to hand out (1 per pair or participant)

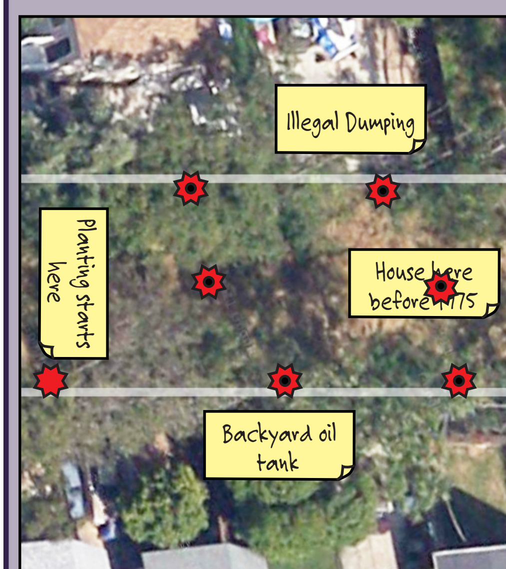
Large paper with questions from Step 1

Sticky notes of different sizes

Small stickers (dots, stars, etc.) to represent possible sampling locations.

Markers and pens

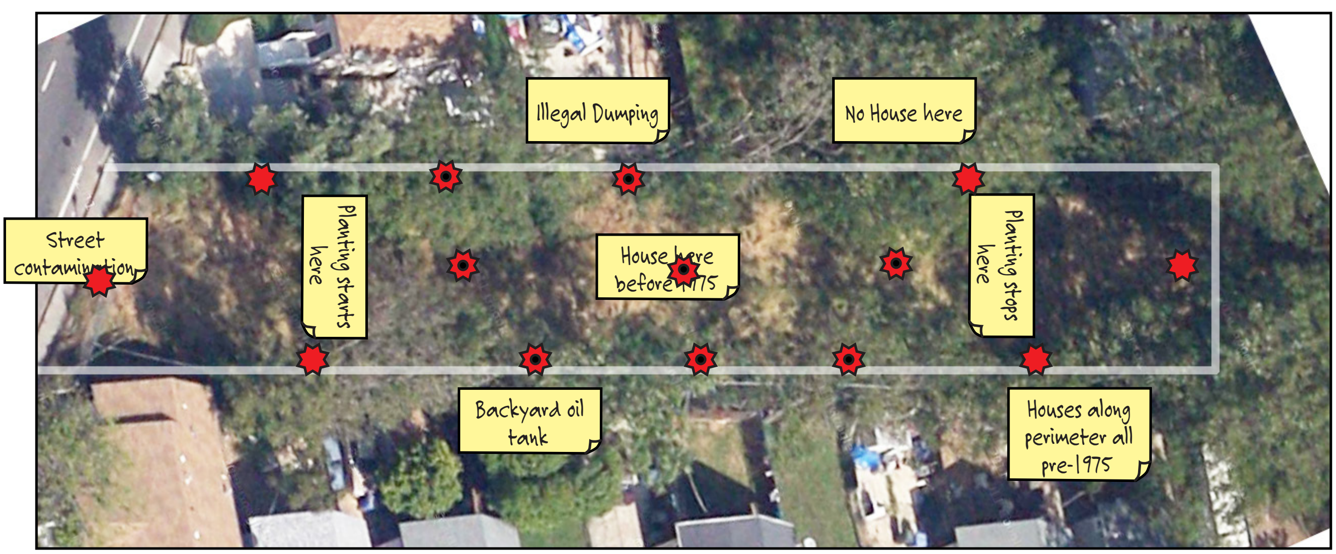
Optional: Copies of the Example for all participants.



Example: Turning an abandoned lot into a community garden

1. Label your map with what you know about the history and planned uses for the site or neighborhood. Your labels should help you guess:
   - Where did the contamination come from?
   - Where are people exposed to it?
   - Is the contamination moving off site?

2. Then use stickers (or pencil, then marker) to mark all the places you think they should test. If you might not be able to test all of them, mark the most important ones.



Why is it so hard to get a simple answer about risk? Risk assessors put many pieces together to try to see the whole picture. Asking "Am I at risk?" is really asking:

"If I am *exposed* to a certain *concentration* of a *hazardous toxin*, and my body gets a *dose* of it, what is the *probability* that I will be *susceptible* to a *severe effect*?"

Many of these "pieces of the risk puzzle" involve a standard to which you can compare your own situation. As each comparison goes up or down, so does the level of risk.

Hazard / Toxicity: *How toxic?*

Compare the Reference Dose (RfD) for your toxin to the RfD for other similar toxins. The most toxic contaminants will have the lowest RfD.

As Toxic As...? data *EPA IRIS*

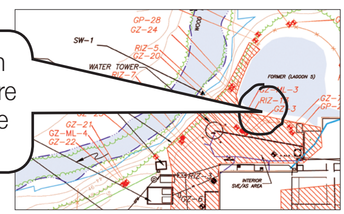
The RfD for Aroclor-1254 is 30 times smaller than the RfD for cyanide. So Aroclor-1254 is 30 times more toxic than cyanide!

Concentration: *How much? What levels?*

Compare test results to a comparison value or legal limit. Was it under or over the limit? How much?

Compare to Standards data *ATSDR ToxFAQs*

The TCE levels in well #5 were more than 10 times the legal limit!



Exposure Type: *How does it get in me?*

Research how easily the toxin gets into the body in different ways: Touching, eating, breathing, drinking.

Risk: Points of Contact data *ATSDR ToxFAQs*

The factory is closed, but winds keep blowing factory dust towards my house. I wonder if it's in the ground water too...

Exposure Time: *How often? For how long?*

Longer exposure means more risk. You can be at risk from acute exposures (intense, for a short time) or chronic exposures (light, over a long time).

Exposed!

The air is bad where I work... but how long am I exposed? Hmmm... 40 hours a week, 52 weeks per year, minus vacation and holidays...

Dose / Body Burden: *How much <u>did</u> get in me?*

Dose is the amount of toxin absorbed per kilogram body mass; compare to Reference Dose (RfD) for that toxin. Body burden is the concentration of a toxin in body fluids or tissue, as determined by medical tests; compare to public health guidelines.

data *EPA IRIS Summary*

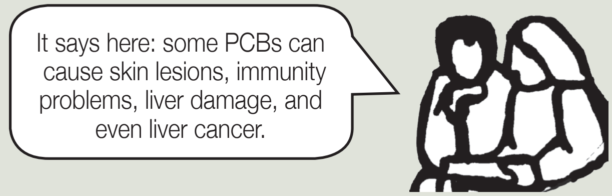
There's lead paint in my house, so I get my kid tested. The CDC says that over 10µg/dL is unsafe. Fortunately, his levels were less than 1 µg/dL.

To explore all topics below, see: *A First Look at Health Studies*

Health Effect or Outcome: *What could happen to me?*

Different toxins and exposures may have different effects: Cancer, asthma, reproductive, immunity, etc.

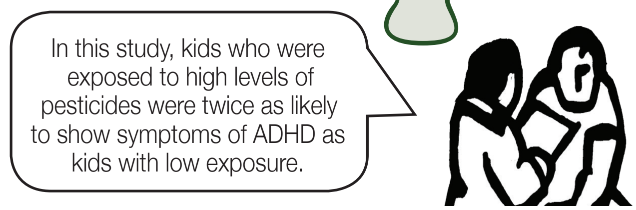
data *ATSDR ToxFAQs*



Probability: *What percent get sick? With what?*

Compare your risk factors with other cases of similar exposures and outcomes: How many were affected?

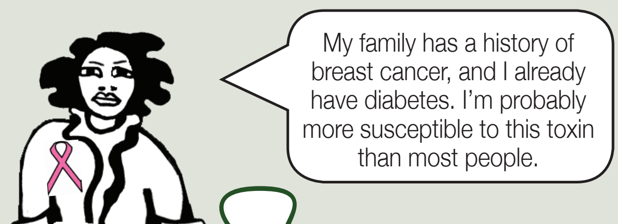
data *EPA IRIS Summary*



Susceptibility: *Am I more at risk than others?*

The probability of some effects varies with factors like age, weight, sex, reproductive stage, diet, smoking, combinations with other toxins, and family history.

data *ATSDR ToxFAQs*



Uncertainty: *Is this the key concern?*

We're surrounded by toxins. It's hard to prove a health problem comes from just one thing.

***Statistics for Action* Activities:** sfa.terc.edu/materials/activities.html

Activities for each component of risk that can help you explore that component in greater depth.

data ***Statistics for Action* Data:** sfa.terc.edu/data/public.html

ATSDR ToxFAQs and ATSDR Toxicological Profiles: ToxFAQs are an alphabetical list of toxins, each with a short, simple description of where it's found, how it can harm people, and any relevant regulations. Toxicological profiles are similar but with much more technical and medical detail.

EPA Standards: Maximum Contaminant Levels (MCLs) in drinking water, soil screening levels, air quality standards. Also, check your state's environmental department; they may have stricter standards.

EPA IRIS (Integrated Risk Information System) Summary: Summaries about risk from specific toxins, like Reference Dose (RfD), Reference Concentration (RfC), Cancer Slope Factor, Unit Risk Factor.

CDC WONDER: Wide-ranging Online Data for Epidemiologic Research. Data about disease and mortality by county. Your state public health department may have data on a town-to-town levels.

Activity Overview

Participants considering a health study review the major concepts in environmental health: exposure and outcome. They analyze their own situation (or a sample) using key health study considerations, and rate the advantages and disadvantages of specific health study types for that situation.

When to Use It

When community members believe that contaminated air, soil, or water (or a combination) is affecting people's health, and they want a health study to show those effects.

This workshop was created to supplement the publication *Is a Health Study the Answer for Your Community? A Guide for Making Informed Decisions* by Madeleine Kangsen Scammell and Gregory J. Howard, 2013, under a Creative Commons BY-NC-ND 3.0 Unported License. Available at www.busrp.org/hsg

Skills

This workshop will help community members to:

- Describe exposure and outcome as major concept in environmental health.
- Identify pros and cons to doing a health study
- Identify sources for relevant, existing data
- Learn strategies other communities have used to handle similar issues

Smart Moves

- Slow down
- Talk it out
- Seek verification

This workshop was developed in part by the Boston University Superfund Research Program Community Engagement Core via grant # 5 P42 ES007381 from the National Institute of Environmental Health Sciences (NIEHS), NIH and via grant # 5 R25 ES12084 from NIEHS.

Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIEHS, NIH, or NSF.

Time: 75-90 min

Preparation

Read through all the materials and familiarize yourself with all the information. You will need to decide:

- which *Health Study Story* you will have participants read
- which health study types from *Overview of Health Study Types* to assign during the workshop. Some may apply to your situation, and some may not.
- This workshop assumes participants are motivated by their own community health situation. If there is no single shared situation, choose a *Sample Community Health Scenario* to use as an example.
- For a comprehensive overview of the ideas covered in this workshop, read the publication I*s a Health Study the Answer for Your Community? A Guide for Making Informed Decisions* (details on left).

Materials

Facilitator Instructions (4 pages, including this page)

Health Study Stories (3 pages, choose and print one)

Health Study Strategies (1 page, one per participant)

Overview of Health Study Types (4 pages, one set per participant)

Health Study Worksheet (1 page, one per participant)

Sample Community Health Scenarios (1 page)

If applicable, copies of Sample Community Health *Scenarios* (one per participant)

Pens

Clipboards, if the space does not have tables

Easel (or whiteboard) and three prepared flip charts:

- One labeled "Exposure," "Outcome," and "E-O Relationship" (shown next page)
- One with questions for discussion listed in Step 3
- One with headlines from Key Considerations

Optional: *Expert Advice on Health Studies* video on sfa.terc.edu can be used to support the *Overview of Health Study Types* handout. Requires equipment needed to view internet video.

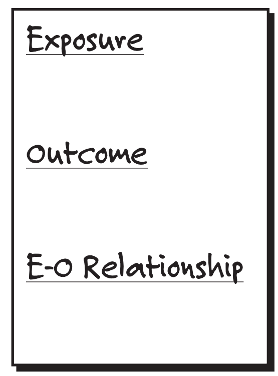
Optional: *Will the Health Study Prove Liability* video on sfa.terc.edu can be used to support the Wayland, MA story in *Health Study Stories.* Requires equipment needed to view internet video.

Step 1: Setting the Stage (5 minutes)

Welcome participants and remind everyone of the group's main concerns and goals, and how today's workshop relates to the goals. Tell participants they're going to learn about different kinds of health studies today, to see if a health study might help the group. This workshop just gives an overview; it won't cover *how* to do a health study. The workshop was created with input from public health experts who help communities decide whether or not a health study is right for them. The goals will be to try to answer five questions:

- What is studied in a health study?
- How can a health study help or hurt an environmental campaign?
- What kinds of health studies are there?
- Which health studies might fit with our community situation?
- How could those studies help or hurt our campaign?

Step 2: Exposure and Outcome (10 minutes)



A health study usually studies one of three things – an exposure, an outcome, or a relationship between exposure and outcome. [Refer to labeled flip chart.]

An *exposure* is a way something harmful can get into a person's body. Ask: *Can anyone think of something people do that could be a harmful exposure?* If needed, offer examples like:

- smoking cigarettes
- drinking contaminated well water
- touching, breathing, or eating dust from lead paint.

(Note: cigarette smoke, contaminated well water, and lead paint *alone* are not exposures. An exposure must include both a toxin *and* a pathway into the body.)

An *outcome* is a health effect. Ask: *Can anyone can think of a negative health effect?* If needed, offer examples like:

- lung cancer
- asthma
- learning disabilities

Step 2 (continued)

Other health studies study the *relationship between an exposure and an outcome*. Ask: *Can anyone can think of a well-known relationship between an exposure and a negative health effect?* If needed, offer examples like:

- Children exposed to lead have an increased risk of lower IQs and learning disabilities
- Cigarette smoking increases the risk of lung cancer
- A diet high in salt and fatty foods increases the risk of heart disease

Proving a relationship between an exposure and an outcome is very hard to do. Well-known relationships like these are not discovered by just one study, but by *many* studies over many years. Fortunately, that past work makes other health studies less complicated. For example, if a study finds lead contamination in your drinking water, you *don't* need to prove it is harming you, because we already know that lead in drinking water is harmful.

Step 3: Lessons from Other Communities (15 minutes)

Choose one story (or more, if time allows) from the resource *Health Study Stories*. Before the story, ask participants to consider the three questions below (also written on flip chart).

- What did the community expect to find out about exposures and outcomes?
- What did the study actually find?
- How did the study affect their campaign?

Ask a participant to read the story aloud. After the story, revisit the three questions.

After discussion, give participants the *Health Study Strategies* handout. Briefly review the points. Don't have a discussion about them now, but invite the group to keep these considerations in mind as you review health study types. When possible, connect them to observations participants just shared about the story from *Health Study Stories*.

- Set clear goals for your campaign
- Craft the right question for the study
- Be sure the study can answer your question
- Prepare for different possible results
- Choose your collaborators wisely
- Be part of the study process

Step 4: Reviewing Possible Health Studies (25 minutes)

[Optional: show Expert Advice on Health Studies at sfa.terc.edu/materials/video.html to see a public health expert describing these studies.]

Give participants the *Overview of Health Study Types* handout (4 pages).

There are many different types of health studies out there. Some take hours to conduct, others take years. Some can be done by anyone for free, some need a team of professionals with a big budget. Some are more easily discredited or attacked than others. The audience for the results of the study is also important: Does the evidence need to be strong enough to prove something in a court of law, or just enough to convince the public?

Have participants divide into pairs or small groups. Assign each group (or have each group volunteer for) *one* type of health study to review. If there are health study types that clearly do not apply to your situation, do not assign them.

While the groups are reading, hand out one *Health Studies Worksheet* to each group. Ask each group to fill out the worksheet applying their health study type to the community situation.

Step 5: Debrief (20 minutes)

Start with a lightning round: Give each group up to two minutes to report back about their study type, and why they think it would (or would not) be a good fit.

After the lightning round, ask if any of the study types seem promising. Allow for a longer discussion for that study type, guided by the *Worksheet* questions and *Health Study Strategies.*

Finally, take stock. Is there consensus in the group to pursue a health study?

Step 6: Next Steps (as needed)

Health study: If participants make the decision to continue pursuing a health study:

- Document the goals the group identified.
- What steps are needed to follow up on the group's choices?
- Who will take on different tasks?
- What is a reasonable timeline for each step?

During or after the meeting, you can make a note of any other *Statistics for Action* activities you think might be relevant or helpful for the group. Suggest these activities to the participants or the group leaders as possibilities for future meetings.

No health study: If participants have determined it is not a good idea to move forward with a full-blown health study, individuals may feel deflated. Be ready to divert the disappointment. Redirect the energy by suggesting a special meeting to work on a media campaign. You could profile people who are sick or create an oral history of the community's health. Channel the energy in a way that will move their campaign forward.

Health Study Stories

These stories generated via grant number 5 R25 ES12084 from the National Institute of Environmental Health Sciences (NIEHS), NIH and published as: Scammell M, Senier L, Darrah-Okike J, Brown P, Santos S. 2009. Tangible Evidence, Trust and Power: Public Perception of Community Environmental Health. *Social Science & Medicine*. January 2009. 68(1): 143-153.

Wayland, MA

[Optional: show the video *Will the Health Study Prove Liability?* at sfa.terc.edu/video/ to watch a Wayland resident tell the story herself.]

Linda Segal in Wayland, MA had heard anecdotal evidence making her believe that cancer rates in her area were higher than normal. She believed it was related to a nearby Dow Chemical research laboratory site. The Dow lab had operated for many years, but was now closed and the site potentially needed a cleanup. Linda and a local group requested a health study, to find out if the Dow site was responsible for the cancer. After two years of silence, the state Dept. of Public Health (DPH) contacted them saying, "We're about to start your study."

The DPH said that it would be very hard to prove that cancer rates were higher in Wayland than in nearby towns. The data about incidence of specific cancers were incomplete; at the time the lab was operating, insurance companies weren't required to report all cancers to the Centers for Disease Control. Also, people had moved in and out of the community over many years, so it was difficult to identify people who were only affected by local pollution. In the data that were available, there was no cancer cluster among long-term residents that was significant enough to warrant a more detailed study.[1]

Most of the presumed exposure from the Dow plant had been from air contamination. Since the plant was closed, this was difficult to measure. Residents wondered about looking for evidence of historic air pollution in the soil and trees, but other polluters had been operating in the area at the same time. Proving the contamination came from Dow would be very difficult. Eventually, significant contamination was found on the site, and it was cleaned up. But the purpose of the cleanup was to avoid future exposures, not because a health study had linked contamination to existing health problems.

1. Massachusetts Department of Public Health (MDPH). 2001. Assessment of Cancer Incidence and Exposure Opportunities from the Former Dow Chemical Site in Wayland, MA 1982-1994, 1995.

Cape Cod, MA

A statewide study of cancer prevalence in Massachusetts showed that Cape Cod had unusually high cancer rates. A community group wondered if the cancer was related to chemicals used in cranberry bogs, which are common there. A case-control health study was done in 1990. It looked at data about people who were diagnosed between 1983-1986 with at least one of eight types of cancer, to see if they had more exposure to cranberry bogs than people who did not have cancer. The study found that people who had lived within a half-mile of a bog were more than twice as likely to develop brain cancer. There was no association between bogs and other cancers. Initial results of the study were available in 1991, but it wasn't formally published until 1996.[2]

Critics of the study called it "junk science" and claimed that it was "actually a survey" and not a study, that the number of people sampled was small, that it did not account for other risk factors, and that it included people who had only lived in the area for a few years.[3]

2. **Aschengrau, A., Ozonoff, D., Coogan, P., Vezina, R., Heeren, T., & Zhang, Y (1996). Cancer Risk and Residential Proximity to Cranberry Cultivation in Massachusetts.** *American Journal of Public Health*, **Vol. 86, No. 9, 1289-1296**
3. **Putnam, B. (2004, January 16) When science isn't science, but junk.** *Cape Cod Times*.

Health Study Stories

These stories generated via grant number 5 R25 ES12084 from the National Institute of Environmental Health Sciences (NIEHS), NIH and published as: Scammell M, Senier L, Darrah-Okike J, Brown P, Santos S. 2009. Tangible Evidence, Trust and Power: Public Perception of Community Environmental Health. Social Science & Medicine. January 2009. 68(1): 143-153.

North Shore, MA

Mass DPH Study: In 1997 the Massachusetts Cancer Registry released a report on cancer incidence statewide. Residents of Marblehead and Swampscott learned their towns had high incidences of some cancer types. They suspected the nearby coal-fired power plant in Salem was the cause. They asked their State Representative and Board of Health to request a study from the state Department of Public Health.

The 1999 study looked at breast cancer, leukemia, and melanoma incidence in these two towns, to see if there was a geographic pattern to those diseases. The study found no obvious geographic pattern of disease in either town, including the areas most impacted by the power plant. It attributed the cancers to other risk factors.[4]

The study took a long time, and residents were disappointed with the results. Proponents of the power plant used the inconclusive results to claim that the study had shown the plant was not a public health problem.

4. Massachusetts (1999). Evaluation of Breast Cancer, Leukemia, and Melanoma Incidence in Marblehead and Swampscott, Massachusetts 1987–1994 (p. 52). Boston: Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Community Assessment Unit.

Harvard Study: Shortly afterward, the Clean Air Task Force commissioned a study of the health effects from the same power plant. The study was conducted by the Harvard University School of Public Health. The study used a computer model to estimate the concentrations of the three biggest air pollutants from the Salem Harbor power plant: sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter (PM_{10}). The study then estimated the health effects of those emissions from the plant, looking at respiratory and cardiovascular outcomes instead of cancer.

The study found that the air concentration of PM_{10} and SO_2 was greatest within 5 miles of the plant, as were the health impacts. Estimated impacts per year from the power plant included: 53 premature deaths; 570 ER visits; 14,400 asthma attacks; and 99,000 daily incidents of upper respiratory symptoms.[5]

The community group felt validated by the results, and staged a protest, planting 53 crosses near the plant to symbolize the estimated dead. Critics claimed that the results were fabricaed by a computer model, and not based on any real data.

5. Levy JI, Spengler JD, Hlinka D, Sullivan D. Estimated Public Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plants. Boston: Harvard School of Public Health; 2000. p. 68.

Duxbury, MA

"Jill" (not her real name), an activist in Duxbury, MA, spent years pressuring the state to do a health study to see if local childhood leukemia was caused by a nearby nuclear power plant. They finally agreed, and began a study, but Jill suddenly reversed course. She saw the study design, and knew the study did not have enough *study power* – it didn't include enough cases of childhood leukemia to detect a statistical relationship, and so the study was doomed to find nothing. Jill had no doubt the leukemia was linked to the power plant. However, she also knew that if the study was allowed to continue, it would be unable to find a relationship, and that would be wrongly interpreted as proof the power plant did not cause leukemia. She and other members of the community realized that a poorly-designed study would hurt them, so they reversed course, and stopped the same study they fought so hard to get started.

Health Study Stories

Woburn, MA

In the late 1970s, residents in Woburn, Massachusetts, raised concerns over environmental contaminants (particularly solvents in the water supply) and health. They suspected higher than normal cancer rates, especially in children. A couple of residents went door-to-door to identify cases. They then mapped the cases using pins on a wall map, and by visual inspection it appeared that the cases were clustered in the eastern part of town. In response to these concerns, the Massachusetts Department of Public Health, with help from the CDC, investigated cancer incidence for childhood leukemia, liver cancer, and kidney cancer between 1969 and 1978. Analysis showed that childhood leukemia rates were elevated, specifically on the eastern side of town. Kidney cancer incidence was also higher than expected compared to national rates. However, the study reported that it could not link any particular environmental exposure to the elevated cancer.[6] In 1979, two municipal water wells were closed after tests showed they were contaminated by industrial chemicals.

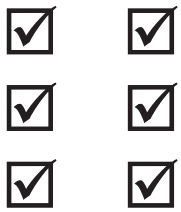
In 1980, a group of residents then initiated their own further study with researchers at Harvard School of Public Health to investigate whether use of tap water from public wells, which was contaminated with solvents (tricholorethylene and perchloroethylene), was related to the cancers. The research, released in 1984, found an association between risk of childhood leukemia and maternal consumption of drinking water from two specific contaminated wells. It also linked certain birth defects and fetal and infant death with consumption of this water. [7] Throughout the process, other people in the community opposed and threatened the group pursuing the study, because of worries about the property value of their homes, and about losing jobs.

A lawsuit was brought in 1982, and finally settled in 1986. The settlement was smaller than had been hoped, and only one of the two potentially responsible companies was found liable. The companies admited that contamination was present and had caused illness, but there was no proof the contaminants had come from their properties. The trial gained national attention, and was made into a book and movie, both entitled *A Civil Action.* Seeking funding for cleanup, the U.S. Environmental Protection Agency sued and received a bigger settlement in 1991, from four companies.[8]

In 1997, the Massachusetts Department of Public Health published the results of a case-control study, which confirmed the results of the community study. Children whose mothers drank contaminated well water while pregnant had an eight-fold risk of cancer compared to children of mothers who had not been exposed.[9] The community's suspicions were validated, but that confirmation came almost 20 years after the first suspicions, and long after the legal cases had been settled.

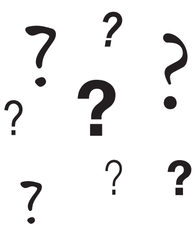
6. Parker GS, Rosen SL. 1981. Cancer incidence and environmental hazards 1960-1978. Massachusetts Department of Public Health.
7. S. W. Lagakos, B. J. Wessen and M. Zelen, (Sep. 1986) An Analysis of Contaminated Well Water and Health Effects in Woburn, MA. *Journal of the American Statistical Association*, Vol. 81, No. 395, pp. 583-596
8. Woburn Trial Chronology, Science Education Resource Center at Carleton College. serc.carleton.edu/woburn/issues/woburn_trial_chronology
9. Massachusetts Department of Public Health, Woburn Childhood Leukemia Follow-Up Study, Volume I (July 1997)

Health Study Strategies



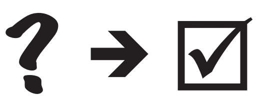
Set Clear Goals

Clarify your goals, and how a study may – or may not – support them. Examine each goal. Do you need information from a health study to reach that goal? What audience do you want to convince, and what proof do they need? If you don't need that information, and if your audience doesn't require rigorous scientific proof, use other methods to reach your goals.



Craft the Right Question

"What do you want to know?" or "What does the group need to know?" Then refine your question further. Decide if you are focused on an outcome or exposure. The process of refining your question will lead to a better study design and from that will come more useful study results.



Be Sure the Study Answers Your Question

There are many study types out there. Can any of these studies answer your question and help you meet your goals, on a timeline and budget you can afford?

Prepare for the Results

Sometimes health study results can help you reach your goal. Other times they will block progress. Think through the positive and negative things a study might do before pursuing one. If a study is already underway, what will you say about various kinds of results? What might your opponents say?

Choose your collaborators wisely

Health studies can be conducted by government agencies, private companies, not-for-profit organizations, research institutions, or community members. Before starting, research the organization's history, commitment to the community, and funding sources.

Be Part of the Process

No matter who administers your study, set expectations for communication and decision-making early in the process. Being clear will keep the community's interests and priorities at the center.

Overview of Health Study Types

This resource taken from *Is a Health Study the Answer for Your Community? A Guide for Making Informed Decisions* (Chapter 4, p. 75) by Madeleine Kangsen Scammell and Gregory J Howard et. al., 2013, under a Creative Commons BY-NC-ND 3.0 Unported License. Available at www.busrp.org/hsg

Study Type	Result	Time	Cost	Expertise
Mapping				
Mapping (exposure, outcome, both)	map(s), visual data	⌛	$	?
Studies of Exposure				
Environmental Monitoring Study	concentrations in environmental media	⌛	$ $	? ? ? ?
Body Burden Study	concentrations in bodily tissue or fluid	⌛	$ $ $	? ? ?
Environmental Impact Statement †	description of potential impact of environmental changes	⌛⌛⌛	$ $ $	? ? ? ?
Studies of Contaminated Sites				
Human Health Risk Assessment *	Analysis of possible exposures and outcomes	⌛⌛	$ $	? ?
Public Health Assessment †	Analysis of possible outcomes from known exposures	⌛⌛	$ $	? ?
Studies of Outcome				
Community survey *	survey responses, maybe qualitative	⌛⌛	$	? ?
Analysis of Registry or Vital Events Data *	SIR, SMR	⌛	$	
Studies of Exposure-Outcome Relationship				
Ecologic Study *	correlation between expsoure & outcome	⌛⌛⌛	$ $ $	? ? ? ?
Cohort Study *	relative outcome risk, exposed vs. non-exposed	⌛⌛⌛⌛	$ $ $ $	? ? ? ?
Case-control Study *	odds ratio of exposure, outcome vs. no outcome	⌛⌛⌛⌛	$ $ $ $	? ? ? ?

* Epidemiologic studies. † Sites or behavioral studies

⌛ = weeks or a few months.

⌛⌛⌛⌛ = At least a few years

? = some expert advice, maybe via phone or internet

? ? ? ? = consulting firm, university, government professionals

$ = $100 - $1,000

$ $ $ $ = more than $100,000

Overview of Health Study Types

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Studies Mapping Exposure and/or Outcomes

Exposure mapping helps show sources of pollution and identify patterns of exposure. It can be done either by community groups or by scientists. Some exposures are obvious; others require data from an environmental agency or other source.

- *Some drinking water wells have been closed as a result of contamination. Where are these wells, in relation to homes and schools?*
- *Which neighborhoods are closest to the farms where sludge is sprayed?*
- *Are there more smoke-spewing industries in our area than in other parts of the state?*

Outcome mapping helps show patterns of health problems in an area. It can be done either by community groups or by scientists, but it does require that you already have the data, perhaps from a survey or registry.

- *Where are the lung cancer cases located in our neighborhood?*
- *Are there clusters of leukemia in our county, or is it evenly distributed?*

Exposures and outcomes on one map help show patterns that point towards an exposure-outcome relationship. This can help justify a more detailed study.

- *The west side of town has more cases of brain cancer for its population than other neighborhoods. Does it also have more hazardous waste sites?*
- *Are there more breast cancer cases near the underground plume of contamination compared to areas with no ground water contamination?*
- *Do cases of cardiovascular disease mortality appear to be higher downwind of the coal-fired power plant?*

Overview of Health Study Types

This resource taken from *Is a Health Study the Answer for Your Community? A Guide for Making Informed Decisions* (Chapter 3, pp. 35 & 38) by Madeleine Kangsen Scammell and Gregory J Howard et. al., 2013, under a Creative Commons BY-NC-ND 3.0 Unported License. Available at www.busrp.org/hsg

Studies of Exposure

Environmental monitoring studies measure levels of chemicals or other toxins in the environment. Samples of air, water, soil, or food can be examined for contamination.

- *Is there lead in my garden soil? How much?*
- *Is there mold in the air I am breathing? How much?*
- *Are there hazardous chemicals in my drinking water? Which ones and how much?*

Body burden studies measure chemicals in a person's body. Samples of body tissue or fluids (blood, urine, saliva, hair, nails, or breast milk) can be tested.

- *Is there lead in my blood? How much?*
- *Does my hair show that I've been exposed to mercury? How much?*
- *Am I passing PCBs to my baby through my breast milk?*

Environmental impact statements try to describe the possible environmental and health impacts of a new development, or a modification of an old one. They are not technically exposure studies, but the results may be useful in thinking about exposure.

- *How will building a power plant here affect the air quality in this area?*
- *How will storm water runoff from the new parking lot affect pollution in the river?*
- *When they clean up the old factory, will all that contaminated dust go into the air?*

Studies of Contaminated Sites

Risk assessments describe contamination at a site, estimate how people might be exposed, and estimate the probability of health hazards from that exposure.

- *What are the chances of getting cancer from the levels of TCE in our drinking water?*
- *Is the abandoned factory site dangerous for my children, if they don't go on the site itself?*

Public health assessments take existing information about contamination levels at a particular site, and look into the details of exposure.

- *What are people's actual exposures to this site?*
- *Have people's actual exposures to this site made them sick?*

Overview of Health Study Types

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Studies of Outcomes

Community surveys can help you learn about health problems in your area, by going door-to-door or by making phone calls.

- *What health problems are residents of our street experiencing?*
- *What health problems are of concern to my neighborhood?*

Analysis of disease registry data or vital events data lets you compare known death rates or the rates of certain diseases (mostly cancer) with rates in other areas. Some data is publicly available online; other data is only accessible to researchers at universities.

- *Does our county have a higher rate of lung cancer than the state average?*
- *Are people dying younger in my city than in other cities?*

Studies of Exposure-Outcome Relationships

Ecologic studies ask whether there is an association between a particular exposure and a particular health outcome, across a set of large geographic areas like towns or counties.

- *Do cities in this state with high brain cancer rates also have more hazardous waste sites?*
- *Across the U.S., do counties with a coal-fired power plant have higher rates of asthma?*

Cohort studies follow a group of people over time, some of whom were exposed to a hazard and others were not, and compares the health outcomes.

- *Are the people who lived near the hazardous waste site 20 years ago more likely to have had cancer than people who lived far from the site?*
- *In the next five years, what will happen to people who are exposed to this radiation source compared with people who are not exposed to it?*

Case-control studies compare people who have had a specific illness or condition with people who do not.

- *Were adolescents who have learning disabilities more exposed to lead paint as toddlers, compared with adolescents who do not have learning disabilities?*
- *What differences in lifestyle, behavior, genetics, or environmental exposures exist between women with breast cancer compared to women who do not have breast cancer?*

Health Study Worksheet

1. In this situation, what are...
   ...the **exposures** of concern? (Known, or suspected)

   ...the **outcomes** of concern? (Already evident, or feared)

   ...reasons to think there is a **relationship** between these exposures and outcomes?

2. What **question** about this exposure and outcome do you want a health study to answer?

3. Pick one **health study type** you think might answer your question. Which did you choose?

4. What are your ultimate **campaign goals**?

5. The results of a health study might show the problem you suspect, or show that there is no problem, or results may be inconclusive (showing not enough evidence either way). How might each of these results help or hurt your goals? Include factors like time and expense.

	Help?	Hurt?
Shows problem		
Shows no problem		
Inconclusive (not enough evidence)		

Sample Community Health Scenarios

These scenarios accompany the workshop *A First Look at Health Studies* and can be used when a group does not share a common community health concern. The examples are all from real communities, though some happened many years ago and have since been resolved.

Lindsay, CA

Lindsay, California, is a small town with hundreds of acres of orange groves. To make a "perfect"-looking orange, growers use chlorpyrifos to keep insects off the orange trees. The Environmental Protection Agency banned the use of chlorpyrifos in homes and apartments in 2001, because it poses severe health risks to children. But California orange growers still use chlorpyrifos. It is common for people in Lindsay to feel sick when the orange groves are sprayed. People report headaches, blurry vision, weakness, and vomiting after the spray is used. Some residents wanted to know if the insecticide is getting into their bodies, and if so, how much.

Anniston, AL

Anniston, Alabama, used to be the site of a manufacturing plant. The plant was contaminated with cancer-causing chemicals called PCBs. Residents have not noticed any particular health effects, but they wonder if they are at risk from the contamination.

Corrales, NM

For a few years, residents have been having symptoms like fainting, rashes, seizures, and irritations of the nose, throat and lungs. There have been miscarriages and birth defects. Some people blame the Intel plant located 100 yards uphill, but Intel supporters want to ignore residents' concerns. *The Albuquerque Journal* quoted a state representative who said only a "handful of crazies" had complaints.

Monticello, UT

The community is the site of a former uranium mill that operated from 1940 through 1962. Uranium mining waste accumulated in large piles on the mill property, and dust from these piles blew throughout the town for many years. There was considerable contamination of nearby residential property, grazing lands, and streams. In addition, mill tailings were used to make cement sidewalks and the grout used in fireplaces and chimneys of some homes. The town was eventually designated a Superfund site, and widespread environmental testing and mapping were carried out in the early to mid-1990s. A cluster of leukemia was identified in the late 1960s in one small part of town, a short distance from the mill, but the number of cases was small and no conclusions were drawn about exposure to uranium dust or other potential causes. Residents want the town cleaned up, but they think nobody will pay for it unless a health study shows an ongoing health problem.

Ashland, MA

The Nyanza Chemical Waste Dump site operated in Ashland from 1917 to 1978. During that time, local children routinely played on and near the site, coming in contact with both waste lagoons and a small stream (nicknamed "Chemical Brook") into which partially treated chemical wastes were dumped. Many years later, Ashland residents documented five cases of soft tissue sarcoma (a rare form of cancer) in young men who had played on the site as children from 1965-1985. Residents want to know if the companies who dumped chemicals are responsible for their health problems.

Sp

Exposed!

Facilitator Instructions

Activity Overview

Participants read about four children who spend time at or near a contaminated place. Then they guess which child has the longest exposure, and verify with a calculator.

When to Use It

When reviewing or preparing input on a risk assessment. Community members need to think about how long they are typically exposed to contamination.

Suggested companion activities:

- See Pieces of the Risk Puzzle for other activities that fit your situation

Steps

1. **Launch the activity:** A risk assessor needs to know all the ways people could come into contact with contamination. They pay special attention to children (called "sensitive receptors"). Community members play an important role by calling attention to how much time children spend near a contaminated site. Information about just one person's exposure can change the way a site is handled.
2. **In pairs or as a group:** Read the stories. First, make a guess from the description about which children spend the most time exposed to contamination. Then, work it out mathematically.
3. **Debrief:**
   - How did your guess compare to what you actually calculated?
   - (If applicable) How does this relate to our own situation? Does anyone in the community have longer exposures than typical?

Worth Noting

Participants often confuse "every day" (7 per week) and "on weekdays" (5 per week). Be ready to help with this.

If community members do not have exact figures for exposure time, they can estimate "no more than ..." or "not less than ..."

EPA usually talks about risk in terms of "Average Daily Exposure." To calculate this for this activity, divide the "hours per year" answers on the right by 365 days per year, to get an answer in hours per day.

Length of time is just one factor professionals use in assessing risk. See the resource Pieces of the Risk Puzzle for other risk factors.

Smart Moves

- Seek verification
- Talk it out

Skill: Use community-based knowledge to inform a risk assessment

Time: 20-30 minutes

Preparation

Choose which of the four examples you would like your group to work on:

- Orchard (Soil)
- Community Garden (Soil)
- Park by The Paint Factory (Air). Also in Spanish.
- Pond (Water/swimming). Also in Spanish.

Materials

Participant instructions (1 per pair)

Pieces of the Risk Puzzle (1 per participant)

Calculators

Scrap paper, pens or pencils

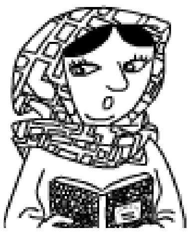
Ellen's total exposure is 2 hours
times 7 days per week
times 12 weeks
then divide by 2 to get half the days

Answers (in hours per year)

Orchard		Park / Parque	
Rodrigo	39	Rodrigo	52
Sofia	30	Sofia	30
Ellen	84	Ellen	84
David	87	David	87

Garden		Pond / Estanque	
Rodrigo	24	Rodrigo	24
Sofia	27	Sofia	27
Ellen	84	Ellen	84
David	35	David	54

The Orchard (Soil)



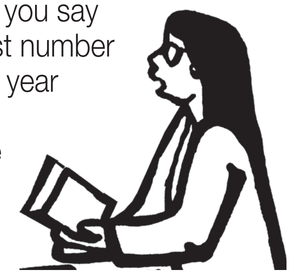
Arsenic is very dangerous. We're worried about the arsenic levels on the orchard property.

Parent

My buddies and I go there all the time.

Rodrigo

What would you say is the highest number of hours per year that children spend in the orchard?



Risk Assessor

Which child spent the most time in the orchard? Make a guess first.

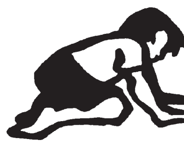
Then calculate it. Is your final answer the same as your first guess?

Rodrigo Played in the orchard for 6 hours every day on his 6-day spring break. Also came to the orchard to pick apples for about a half hour, about 5 times in October.	**Sofia** Walked through the orchard every day going to and from school. It took her about 5 minutes to cross the orchard going one way. There are 180 school days per year.
Ellen Sat beneath her favorite tree in the orchard for about 2 hours a day on warm days in the summer, which was about half of the days during her 12-week vacation.	**David** Went jogging around the orchard for about a half hour each weekday morning, about 8 months per year.

The Community Garden (Soil)

Parent

They found small amounts of lead in the soil in our local community garden! Many of us take children with us when we garden. Are they at risk?



Sofia

I like to play with the hose and the mud at the garden!

What would you say is the highest number of hours per year that children spend in that garden?

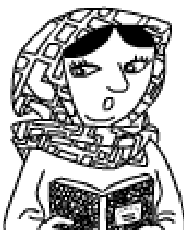
Risk Assessor

Which child spent the most time in the garden? Make a guess first.

Then calculate it. Is your final answer the same as your first guess?

Rodrigo Visited his relatives for 6 days and played in the garden each day for four hours, digging tunnels and roads for his toy trucks.	**Sofia** Watered and weeded with her dad for an hour every Monday, Wednesday, and Friday, for 9 weeks in the summer.
Elena Was everyone’s favorite helper, digging holes and planting seeds by hand with her mom. Elena was there when the weather was nice, about half the days during her 12-week summer vacation. She spent about 2 hours a day there.	**David** Waited in the garden for his mom after school for about a half hour each weekday afternoon, for 8 weeks in the spring and 6 weeks in the fall. While waiting, he usually sifted through the dirt looking for ‘buried treasure.’

The Park by the Paint Factory (Air)



The paint factory is very close to the park our children play in. There are Volatile Organic Compounds (VOCs) in the air in that area.

Parent

My buddies and I play ball in that park all the time.

Rodrigo

What would you say is the highest number of hours per year that children spend in that park?

Risk Assessor

Which child spent the most time in the park? Make a guess first.

Then calculate it. Is your final answer the same as your first guess?

Rodrigo Played in the park for 6 hours every day on his 6-day spring break. Also went there for eight 2-hour baseball games over the summer.	**Sofia** Walked through the park every day going to and from school. It took her 5 minutes to cross the park going one way. There are 180 school days per year.
Ellen Sat beneath her favorite tree in the park for about 2 hours a day on warm days in the summer, which was about half of the days during her 12-week vacation.	**David** Went jogging around the park for about a half hour each weekday morning, about 8 months per year.

The Pond (Water)

They found arsenic in the pond near our house! So many neighborhood children swim there. Are they at risk?

Parent

My buddies and I swim in that pond all the time.

Rodrigo

What would you say is the highest number of hours per year that children spend in that pond?

Risk Assessor

Which child spent the most time in the pond? Make a guess first.

Then calculate it. Is your final answer the same as your first guess?

Rodrigo Swam in the pond for 4 hours every day on his 6-day visit with his relatives.	**Sofia** Took one-hour swimming lessons every Monday, Wednesday, and Friday for 9 weeks in the summer.
Ellen Ellen liked to swim in the pond a lot, but only when it was hot. That was about half the time during her 12-week summer vacation. On hot days, she spent about 2 hours a day swimming.	**David** Swam laps in the pond for about a half hour each weekday morning, about 5 months per year.

Risk: Points of Contact

Facilitator Instructions

Activity Overview

Participants rate several everyday activities that pose various levels of risk of exposure to contamination. They check their ratings against that of a public health professional.

When to Use It

When the community faces a toxic threat and the group needs more familiarity with the contaminants of concern and the concept of risk stemming from exposure, and/or when reviewing or preparing input on a risk assessment.

Suggested companion activities

- Precede with Pieces of the Risk Puzzle
- Use with Exposed!, As Toxic As ... ?, and *The Change Agent: Staying Safe in a Toxic World* pp. 22-23 (for benzo[a]pyrene)

Steps

1. **Launch the activity**: Contaminants only pose a risk when people are exposed—when there's a point of contact between a person and the contaminant. For example, cigarettes cause cancer when people smoke them, but not when they are sitting on a shelf.
2. **In small groups:** Depending on the contaminant, the exposure pathway makes a big difference. Look at the different activities and put them in order from highest to lowest risk.
   Next, read the fact sheet for [contaminant]. Do you want to change your answers?
   Finally, read *Check Your Answers* for the contaminant to compare with a professional's opinion.
3. **Debrief:**
- What exposure pathways were new to you? What surprised you?
- How does this relate to your own situation?

Worth Noting

Eating or drinking contaminated food or water is often (but not always) high-risk. Risks for breathing, showering, or skin contact vary. For example, lead does not evaporate as easily as VOCs. So, if the soil beneath a home is contaminated with lead, breathing the air in that home may pose little risk. Remember that exposure is just one factor in calculating risk. See Pieces of the Risk Puzzle for the bigger picture.

Smart Moves

- Seek verification
- Talk it out

Skill: Explain how an environmental contaminant might harm you through different daily activities.

Time: 15 minutes

Preparation

Choose the contaminant you will use:

- Volatile Organic Compounds (VOCs)
- Polychlorinated Biphenyls (PCBs)
- Arsenic
- Benzo[a]pyrene, a Polycyclic Aromatic Hydrocarbon (PAH)

If none fit your situation, or for Spanish versions, use an ATSDR ToxFAQ for relevant contaminants: http://www.atsdr.cdc.gov/toxfaqs/index.asp

Cut out points of contact strips along dashed lines.

Materials

Points of contact strips, (one set per small group)

Fact Sheet for the contaminant, backed with *Check your Answers: [Contaminant]* (1 per participant).

Optional: ToxFAQ for these or local contaminants (1 per participant)

Ingesting (drinking or cooking with) contaminated water

Showering in contaminated water

Swimming or wading in contaminated water

Working or playing in contaminated dirt

Using contaminated water for cleaning or laundry

Eating food grown in contaminated soil or watered with contaminated water

Living or working in a building where contaminants are present in the air

Living or working in a building where the soil beneath the building is contaminated

Fact Sheet: Volatile Organic Compounds (VOCs)

Volatile Organic Compounds (VOCs) are a category of chemicals including benzene, trichloroethylene (TCE), tetrachloroethylene (PERC), vinyl chloride, and styrene.

Sources: Paints, solvents, wood preservatives, aerosol sprays, cleansers and disinfectants, air fresheners, stored fuels and automotive products, glues, dry-cleaned clothing.

Physical Properties: VOCs volatilize (evaporate and go into the air) very easily. Some can dissolve in water.

Exposures: Mostly from breathing in VOC vapors in enclosed spaces. Vapors may come directly from stored VOCs, or from contaminated water or soil. You can also be exposed by touching or ingesting contaminated water or soil.

Health Effects: Eye, nose, and throat irritation; headaches, dizziness, nausea; damage to liver, kidney, and central nervous system. Some VOCs cause cancer in animals; some may cause cancer in humans.

Check Your Answers: Volatile Organic Compounds (VOCs)

Compare your ratings to those of Andrew Friedmann. He audits the handling of hazardous waste sites for the Massachusetts Department of Environmental Protection. (On a scale of 1 to 10, the least risky exposure is a 1, and the most risky is a 10.)

Type of Exposure	Risk	A risk assessment professional speaks:
Living or working in a building where contaminants are present in the air	10	Breathing in VOCs in air can result in high exposures. Fumes are easily absorbed by the lungs. Tip: Remove VOC sources or seal them carefully. Keep air clean with fresh air from outside.
Living or working where the soil beneath the building is contaminated	8-10	VOCs can evaporate and come up from the basement or outside. Tip: Test indoor air for contamination. Use a fan to vent basement air directly to the outside.
Ingesting (drinking or cooking with) contaminated water	9	Some VOCs dissolve in water. Tip: If tap water is contaminated, drink & cook with bottled water. If you can't, filter the water. If you can't filter it, heat it and let it sit in a ventilated place before drinking, so VOCs can evaporate.
Showering in contaminated water	5-6	VOCs can enter the body through breathing, through drinking, and, to a limited extent, through the skin. Tip: Take shorter showers, ventilate your bathroom well, don't drink from the shower head.
Working or playing in contaminated dirt	5	VOCs can enter your body if you accidentally get soil in your mouth or touch the soil with bare skin. Tip: Don't let small children play in contaminated soil. Adults should wear gloves and shoes.
Swimming or wading in contaminated water	4	Same exposures as showering, but outdoor air is better ventilated. Tip: Don't swallow any water. Risk from skin exposure is lower.
Using contaminated water for cleaning or laundry	1-2	Could release vapors, but the activity is short. Tip: Ventilation in the laundry room will help reduce any exposure.
Eating food grown in contaminated soil or with contaminated water	1	VOCs are not thought to accumulate much inside plants. You are more at risk from contamination on the surface of the plant. Tip: Peel food or wash it well.

Fact Sheet: Polychlorinated Biphenyls (PCBs)

Examples: PCB is a category including 209 different chemicals with similar properties, but it's rare to talk about an individual PCB. PCBs are all generally regulated the same way.

Sources: PCBs were used for most of the 20th century to cool and stabilize large electrical power equipment, like the industrial transformers at power stations or on utility poles. PCBs are sometimes known by trade names like Aroclor (Monsanto) and Pyrenol (General Electric). Many factories that put PCBs in electrical equipment are now very contaminated. PCBs were *not* usually used in household electronics like radios and TVs. PCBs were banned by the U.S. Congress in 1979, but they are still present in old power equipment. They might be found in rivers or ponds near contaminated sites, but they are rarely found in tap water or well water.

Physical Properties: PCBs don't break down easily, and stay in the environment for a long time. Like oil, PCBs do not mix easily with water, but unlike oil, they sink in water. Small amounts can stay in water, especially moving water like a river. They can also build up in animals like fish that swim in PCB-contaminated water. PCBs are semi-volatile, meaning, they can go into the air if it is hot or windy.

Exposures: You can be expoosed to PCBs by breathing in contaminated air, eating contaminated food or water, or from touching contaminated soil or old electrical equipment containing PCBs. PCBs are stored in the fat in your body. PCBs can go from mother to child while breastfeeding.

Health Effects: Some PCBs are much more toxic than other PCBs. Some are very similar to dioxin (one of the most toxic chemicals of all) and can give you cancer. PCBs can also affect your immune and reproductive systems. Studies have shown that babies exposed to PCBs in utero had a lower birth weight, and had mental and physical development problems.

Check Your Answers: Polychlorinated Biphenyls (PCBs)

Compare your ratings to those done by Wendy J. Heiger-Bernays. She's an Associate Professor of Environmental Health at the Boston University School of Public Health. (On a scale of 1 to 10, the least risky exposure is a 1, and the most risky is a 10.)

<table>
<tr><th>Type of Exposure</th><th>Risk</th><th>A public health professional speaks:</th></tr>
<tr><td>Eating food grown in contaminated soil or with contaminated water (meat only)</td><td>8</td><td>Eating animal meat, including fish, is the big source of exposure for most people. PCBs build up in animal fat. Animals higher on the food chain will have more PCBs.

Tip: Avoid eating meat from any contaminated area.</td></tr>
<tr><td>Swimming or wading in contaminated water</td><td>4-6</td><td>PCBs are found on the bottom of rivers and ponds. If you stir up the bottom, PCBs can be absorbed through the skin.

Tip: Avoid swimming or wading in contaminated areas.</td></tr>
<tr><td>Working or playing in contaminated dirt</td><td>6</td><td>PCBs can be absorbed through the skin.

Tip: Wear gloves, and wash hands well before eating. Keep children away from contaminated soil.</td></tr>
<tr><td>Living or working in a building where contaminants are present in the air</td><td>6</td><td>PCBs might go into the air in a contaminated building, or if old electronics containing PCBs get broken open. They might also be present in old building materials.

Tip: If you know there are PCB sources nearby, have your building air tested. If PCBs are in the air, improve the ventilation.</td></tr>
<tr><td>Living or working where the soil beneath the building is contaminated.</td><td>5</td><td>If PCB levels are low, and you don't have direct contact with the soil, the risk is low. Dust from outside can come inside, though.

Tip: If contamination is high, use air filters inside to take dust out of the air. If your work stirs up dust, wear a mask and gloves.</td></tr>
<tr><td>Eating food grown in contaminated soil or with contaminated water (vegetables only)</td><td>2
(plants)</td><td>Vegetables aren't known to soak up PCBs from the ground. However, contaminated soil can get on the food.

Tip: Use raised beds or mulch in gardens. Wear gloves while gardening and keep the soil wet to reduce dust. Keep children away from contaminated soil. Wash food before eating.</td></tr>
<tr><td>Showering in contaminated water</td><td>2</td><td rowspan="3">PCBs are unlikely to be in tap or well water. It is only a concern if the water comes directly from a river or lake without treatment. Contamination is only very high in rare cases. In those cases, avoid all contact.</td></tr>
<tr><td>Using contaminated water for cleaning or laundry</td><td>2</td></tr>
<tr><td>Ingesting (drinking or cooking with) contaminated water</td><td>1</td></tr>
</table>

Fact Sheet: Arsenic

Sources: Occurs naturally in soil. Inorganic arsenic compounds are mainly used to preserve wood. Organic arsenic compounds are used as pesticides, mainly on cotton fields and in orchards.

Physical Properties: Arsenic is a heavy metal. Many common arsenic compounds (called "arsenates") can dissolve in water. Most of the arsenic in water end up in soil or sediment. Arsenic does not easily volatilize (evaporate and go into the air) but arsenic dust can be blown into the air by wind, construction, or industrial processes.

Exposures: Arsenic may enter the air, water, and land from wind-blown dust and get into water from runoff and leaching. Rain and snow remove arsenic dust particles from the air.

Health Effects: Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs, and may eventually cause lung cancer. Ingesting (eating or drinking) very high levels of arsenic can be deadly. Exposure to lower levels can make you sick and vomit. Inorganic arsenic can give you cancer of the skin, liver, bladder, and lungs. It can damage your blood cells, which hurts your immune system. Damaged blood cells also make it harder to get oxygen to all parts of your body, hurting your heart and blood vessels, and causing tingling in your hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can darken your skin and cause small "corns" or "warts" on your hands, feet, and body. Touching inorganic arsenic may cause redness and swelling.

Check Your Answers: Arsenic

Compare your ratings to these ones by Jim Luker, an Environmental Professional. (On a scale of 1 to 10, the least risky exposure is a 1, and the most risky is a 10.)

Type of Exposure	Risk	An environmental professional speaks:
Ingesting (drinking or cooking with) contaminated water	9	Food and water are major sources of exposure. Ingesting high levels can result in death. Consuming arsenic for a long time can cause digestive problems, anemia, skin discoloring, and nerve and organ damage. Tip: If you suspect contaminated food or water, avoid eating or drinking it and have it tested immediately.
Living or working in a building where indoor air is contaminated	8	This is rare, because an industrial process or continuous wind is needed to keep arsenic in the air. But if it does happen, breathing arsenic dust (including fine sawdust) can cause lung irritation or lung cancer. Tip: Wear a facemask if working around arsenic dust.
Working or playing in contaminated dirt	8	You can be exposed by accidentally eating soil or touching it with bare skin. High levels can cause illness, cancer, or death. Lower levels irritate skin. Tip: If the contamination is only moderate, adults working with the soil can wear gloves and facemasks and avoid dusty conditions to reduce exposure. Children should never play in soil with arsenic contamination.
Showering in contaminated water	6	Breathing arsenic in the shower is unlikely. High levels of arsenic may irritate or damage your skin, or you could accidentally swallow some. Tip: Avoid showering in highly contaminated water. Consider filtering less-contaminated water.
Swimming or wading in contaminated lake or pond	6	Same exposures as with showering. Swimming is riskier than wading because there is more contact. Swimmers swallow a little water, too. Tip: If you regularly swim or wade in a lake, have the water tested.
Eating food grown in contaminated soil or with contaminated water	6	Plants can pick up arsenic from the soil. Vegetables grown in the ground (carrots, potatoes) absorb more arsenic than on-the-vine vegetables (tomatoes, beans). Plants high in iron (spinach) absorb the most arsenic. You can also be exposed by touching or breathing in contaminated dirt while gardening. Tip: If soil is contaminated, grow lower-risk plants. Use raised-bed gardens with clean soil. Wear gloves and facemask while gardening. Keep the soil wet to reduce dust. Wash vegetable throughly before eating.
Using contaminated water for or laundry	1	Arsenic does not volatilize. If levels are very high, your skin might be harmed. Tip: Avoid drinking shower water. Take short showers in contaminated water.
Living or working where the soil beneath the building is contaminated.	1	Arsenic does not volatilize. Risk is small unless there is arsenic dust in the air. Tip: Avoid direct contact with contaminated soil and dust.

Fact Sheet: Benzo[a]pyrene, a PAH
(Polycyclic/Polynuclear Aromatic Hydrocarbon)

Benzo[a]pyrene is one of many Polynuclear Aromatic Hydrocarbon (PAHs). Some of this information is about benzo[a]pyrene specifically, and some is generally true about PAHs.

Sources: PAHs come from burning something. They are found in smoke (including cigarette smoke), as well as ash, tar, asphalt, creosote, and waste from any industrial process that involves fire or burning. Grilling meat and vegetables also creates PAHs. PAHs enter the air mostly as releases from forest fires, burning coal, automobile exhaust, and volcanoes.

Physical Properties: PAHs go into the air when they are created, then they settle into soil and water. Some PAHs can volatilize easily (evaporate and go into the air) even after they have settled, but benzo[a]pyrene does *not* volatilize easily. It tends to stick to soil.

Exposures: Mostly from breathing in smoke, fumes, and car exhaust. Some exposure from ingesting (eating or drinking) contaminated soil or water. PAH levels are generally higher in cities than in rural areas. People who work around sources of PAHs have higher exposure. Contaminated soil can also blow in the wind, and be carried from place to place on people's shoes and clothes. PAHs can accumulate in fish and shellfish in a way that concentrates the PAHs.

Health Effects: Exposure to benzo[a]pyrene can cause cancer, as well as reproductive and developmental difficulties.

Check Your Answers: Benzo[a]pyrene

Compare your ratings to these ones by Jim Luker, an Environmental Professional. (On a scale of 1 to 10, the least risky exposure is a 1, and the most risky is a 10.)

Type of Exposure	Risk	An environmental professional speaks:
Living or working in a building where contaminants are present in the air	9	Exposure is very high if you breathe PAHs close to their source. Tip: If you smell smoke or something burning, that may mean PAHs. Identify the source. If PAHs are coming from outside, close windows that face the source. If an old furnace is the cause, replace it. Use home air filters, especially in bedrooms. If exposed at work, ask your employer about testing the air.
Working in or playing in contaminated dirt	8	Benzo[a]pyrene sticks to soil.You can be exposed by touching soil, or eating with dirty hands. Small children are most vulnerable. Tip: Wear gloves if working in contaminated soil. Wash hands well before eating. Keep children away from contaminated soil.
Ingesting (drinking or cooking with) contaminated water	7-8	Ingesting PAHs can cause cancer and reproductive problems. Tip: Avoid drinking water with PAHs. When you grill food over flame, don't char or blacken the food. Avoid fish and seafood from contaminated waters.
Showering in contaminated water	7	Benzo[a]pyrene does not volatilize, so you probably won't breathe it while showering unless contamination is high. But skin contact may lead to rashes and possible skin tumors. Tip: Have your water tested if you suspect it may be impacted.
Swimming or wading in contaminated water	7	This leads to similar types of exposure as showering. Tip: Avoid touching water that has high levels of PAHs.
Using contaminated water for cleaning or laundry	3	Bezno[a]pyrene does not easily volatilize. It might release vapors into the building if concentrations are very high. Tip: Make sure your laundry room is well-ventilated.
Living or working in a building where the soil beneath the building is contaminated	3	Benzo[a]pyrene does not easily volatilize. Unless contaminated soil itself is blown into the air as dust, you probably won't inhale it. Tip: Avoid directly breathing or touching contaminated dust or soil.
Eating food grown in contaminated soil or with contaminated water	3	PAHs don't accumulate much inside plants unless levels are very high in the soil or water. You are more at risk from contaminated soil on the surface of the plant or fruit. Tip: Wash your food and hands well with soap and water.

As Toxic As...?
Facilitator Instructions

Activity Overview

Participants make statements about the toxicity of an unfamiliar contaminant by comparing its health-based standard (MCL, RSSL, RfC, or RfD) with the same standards for more familiar contaminants like lead, mercury, arsenic, and cyanide.

When to Use It

When you are trying to call attention to a dangerous contaminant that is not widely known. It is particularly useful when there are reports of tests finding the contaminant, but little detail about where and how much.

Suggested companion activities:

- Use with other activities in Pieces of the Risk Puzzle and the fact sheet from Limits & Levels for the health-based standard you're comparing.
- Follow up with activities in Communicating with Numbers

Steps

1. **Launch the activity**: Who'd heard of [example contaminant of concern] before it was found here? Is it really toxic, or not a big deal? One way to find out: compare it to other toxic substances. The EPA and state agencies set health-based standards for contaminants in [as fits: water, soil, air, our bodies]. If the 'safe' level of a contaminant is very small, that means even a small amount could be harmful. You might know that mercury, arsenic, lead, and cyanide are very toxic. So we're going to compare the [as fits: MCL, RSSL, RfC, RfD] for our contaminants to those toxic substances to see what's most toxic.
2. **In pairs:** Hand out the *Worksheet*, and ToxFAQs on the contaminants of concern. Participants compare using the worksheet.
3. **Debrief:** When people seem ready, ask,

- Which contaminants were the most toxic?
- How did different people compare the standards?
- Which comparisons will best help our campaign? (If applicable)

Worth Noting

Toxicity is just one factor professionals use in assessing risk. See the resource Pieces of the Risk Puzzle for other risk factors.

Different health based-standards have different health and legal implications. See the resource Limits & Levels for more information.

Smart Moves

- Compare it
- Play with different ways to say it

Skill: Describe toxicity by comparing unfamiliar contaminants to familiar toxins

Time: 15 minutes, plus 5 minutes per contaminant.

Preparation

Review the *Facilitator Supplement* for more context

List the community's contaminants of concern. Choose the appropriate health-based standard. Find that standard for each contaminant. Review the *Limits & Levels* fact sheet about the standard.

If there's no single community situation, use either Data Set: *VOCs in Water* or *PCBs in Soil*

Find the ToxFAQ for each contaminant www.atsdr.cdc.gov/toxfaqs/

Materials Needed

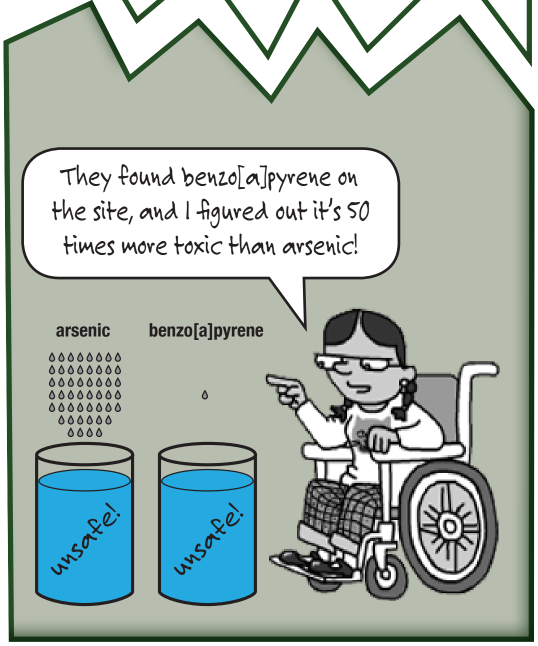
List of community's contaminants and standards, or one of the data sets (one per participant)

Worksheet for the standard that is relevant to your situation (one per participant, more if there are many contaminants)

ToxFAQs for the contaminants of concern

Calculators & pens

Fact sheet from *Limits and Levels* about the health-based standard



Health-Based Standards

You can compare the toxicity of two different contaminants using health-based standards:

- Maximum Contaminant Levels (MCLs) for water, especially drinking water
  water.epa.gov/drink/contaminants
- Residential Soil Screening Levels (RSSLs) for soil, especially soil near people's homes
  epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/
- Reference Concentrations (RfCs) for inhalation of air, or similar state air standards
  epa.gov/iris/subst or oehha.ca.gov/air/allrels.html for California's air standards
- The Reference Dose (RfD) for a contaminant that goes into the body in any form
  epa.gov/iris/subst

There are other standards, but these are the most common. For information on each standard, see the resource *Limits and Levels.* Many states have their own standards for water, soil, and air contamination.

Comparing Like to Like

Compare contaminants using the same kind of standard, published by the same people. Don't use a federal standard for one contaminant and a state standard for another other.

Be sure you're using the same units. One MCL may be in mg/L and another in µg/L. Make the conversions yourself before giving to a group, unless you want your group to practice the conversions.

Which one is more toxic?

People have a hard time understanding how a smaller standard can mean more toxic. If people seem confused, make an analogy using coffee, or alcoholic drinks: if the drink is very strong, it only takes a small amount to have an effect. There are other analogies: Concentrated laundry detergent, higher-fat food where a small amount has more calories, etc. Choose one that works for your group.

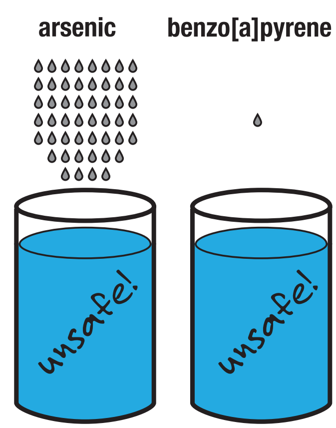
The instructions suggest dividing, but to compare toxicity, but participants may have other ways of finding the answer (like multiplying up).

Example

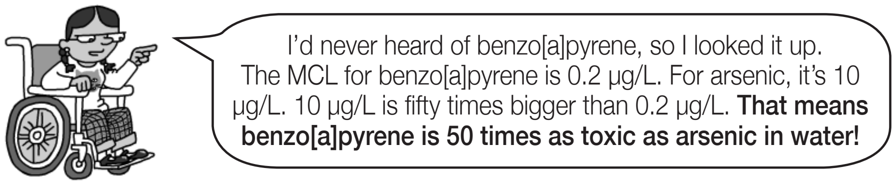
The MCL for arsenic (10 µg/L) is 50 times bigger than the MCL for benzo[a]pyrene (0.2 µg/L).

That means if it takes *fifty* drops of arsenic to make some amount of water unsafe to drink, it would take only *one* drop of benzo[a]pyrene to make the same amount of water unsafe to drink.

So you can say, "benzo[a]pyrene is 50 times more toxic than arsenic in water!"



MCLs and GWOs



1. Choose an unfamiliar contaminant.
2. Compare the MCL for the contaminant to the MCL for mercury, arsenic, lead, or cyanide. One way to compare is to divide the larger MCL by the smaller one. The answer will tell you how much more toxic one is than the other is in water.
3. Fill out one of the sentences below with that information. The one with the smaller MCL is more toxic. You may want to round your number up or down.
4. Repeat for other contaminants. Which statements seem most impressive?

____________________ is _______ times as toxic as __________________ in drinking water.

____________________ is _______ times as toxic as __________________ in drinking water.

____________________ is _______ times as toxic as __________________ in drinking water.

____________________ is _______ times as toxic as __________________ in drinking water.

____________________ is _______ times as toxic as __________________ in drinking water.

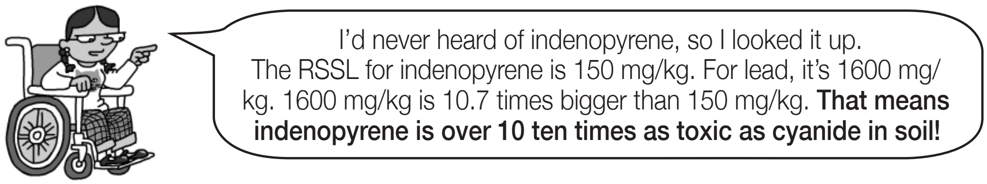
____________________ is _______ times as toxic as __________________ in drinking water.

____________________ is _______ times as toxic as __________________ in drinking water.

____________________ is _______ times as toxic as __________________ in drinking water.

EPA Maximum Contaminant Level (MCL) & Ground Water Objectives (GWO) for GW-1		
Mercury	**2 µg/L**	The EPA's MCLs are legal limits for any kind of drinking water. GW-1 is a category for underground water that might be used for drinking water. The two levels are the same; both are meant to be health-protective and should not be exceeded. MCLs are measured in micrograms (µg) of the toxin per liter of water. http://water.epa.gov/drink/contaminants
Arsenic	**10 µg/L**	
Lead	**15 µg/L**	
Cyanide	**200 µg/L**	

RSSLs



1. Choose an unfamiliar contaminant.
2. Compare the RSSL for the contaminant to the RSSL for mercury, arsenic, lead, or cyanide. One way to compare is to divide the larger RSSL by the smaller one. The answer will tell you how much more toxic one is than the other is in water.
3. Fill out one of the sentences below with that information. The one with the smaller RSSL is more toxic. You may want to round your number up or down.
4. Repeat for other contaminants. Which statements seem most impressive?

__________________ is _______ times as toxic as ________________ in soil.

__________________ is _______ times as toxic as ________________ in soil.

__________________ is _______ times as toxic as ________________ in soil.

__________________ is _______ times as toxic as ________________ in soil.

__________________ is _______ times as toxic as ________________ in soil.

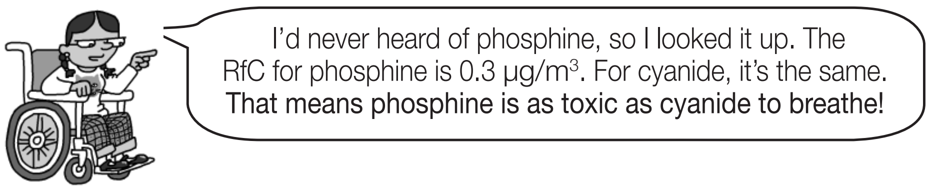
__________________ is _______ times as toxic as ________________ in soil.

__________________ is _______ times as toxic as ________________ in soil.

__________________ is _______ times as toxic as ________________ in soil.

<table>
<tr><th colspan="3">EPA Residential Soil Screening Levels (RSSLs)</th></tr>
<tr><td>Mercury</td><td>5.6 mg/kg</td><td rowspan="4">The EPA Region III Soil Screening Levels are widely used for comparison purposes. If a tested level exceeds a screening level, it's not necessarily dangerous, it just signals a need for more testing. RSSLs are measured in mg of the toxin per kg of soil.
epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/</td></tr>
<tr><td>Arsenic</td><td>0.39 mg/kg</td></tr>
<tr><td>Lead</td><td>400 mg/kg</td></tr>
<tr><td>Cyanide</td><td>1600 mg/kg</td></tr>
</table>

Reference Concentration (RfC) for Inhalation



1. Choose an unfamiliar contaminant.
2. Compare the RfC for the contaminant to the RfC for mercury, arsenic, lead, or cyanide. One way to compare is to divide the larger RfC by the smaller one. The answer will tell you how much more toxic one is than the other is in water.
3. Fill out one of the sentences below with that information. The one with the smaller RfC is more toxic. You may want to round your number up or down.
4. Repeat for other contaminants. Which statements seem most impressive?

__________________ is ______ times as toxic as ________________ to breathe.

__________________ is ______ times as toxic as ________________ to breathe.

__________________ is ______ times as toxic as ________________ to breathe.

__________________ is ______ times as toxic as ________________ to breathe.

__________________ is ______ times as toxic as ________________ to breathe.

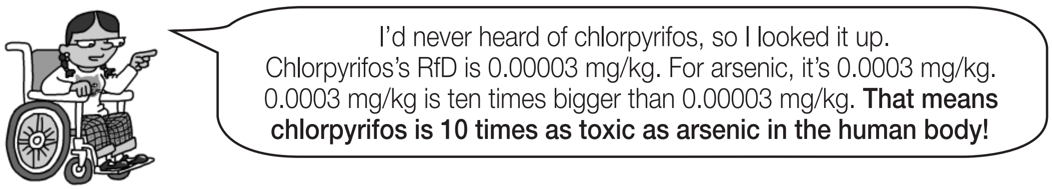
__________________ is ______ times as toxic as ________________ to breathe.

__________________ is ______ times as toxic as ________________ to breathe.

__________________ is ______ times as toxic as ________________ to breathe.

Reference Concentration (RfC) for Inhalation		
Mercury	**0.03 µg/m^3 (EPA RfC)**	RfC is a concentration of a toxin in the air that is unlikely to cause non-cancer health problems, even if a person breathes that concentration their entire life. In different states, it's known by different names. It is usually measured in mg/m^3 or µg/m^3. epa.gov/iris/subst State also make their own. See oehha.ca.gov/air/allrels.html
Arsenic	**0.015 µg/m^3 (California REL)**	
Lead	**0.15 µg/m^3 (NAAQS)**	
Cyanide	**0.3 µg/m^3 (Mass. DEP AAL)**	

Reference Dose (RfD)



1. Choose an unfamiliar contaminant.
2. Compare the RfD for the contaminant to the RfD for mercury, arsenic, lead, or cyanide. One way to compare is to divide the larger RfD by the smaller one. The answer will tell you how much more toxic one is than the other is in water.
3. Fill out one of the sentences below with that information. The one with the smaller RfD is more toxic. You may want to round your number up or down.
4. Repeat for other contaminants. Which statements seem most impressive?

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

__________________ is ______ times as toxic as ________________ in the body.

EPA Reference Dose (RfD)		
Mercuric Chloride	**0.0003 mg/kg/day**	The RfD for a substance is set to be the most of a toxin that a person can consume every day for their whole life without any ill effects. It is an estimate, based on animal studies. It's measured in mg of the toxin per kg of body weight, because larger people are less affected by the same amount of toxin. epa.gov/iris/subst
Inorganic Arsenic	**0.0003 mg/kg/day**	
Lead	**No Safe Level**	
Cyanide	**0.0006 mg/kg/day**	

VOCs in Water

In this example, "Groundwater Objectives" are equivalent to Maximum Contaminant Levels.

GP-26 Shallow Aquifer Monitoring Well Screen From 4'-16' BGS		RIDEM GA Groundwater Objectives	RIDEM Groundwater Quality PALs	Units		
EPA 8260						
	Vinyl Chloride	2	1	ug/L		
	1,1-Dichloroethene	7	3.5	ug/L	<	2
	trans-1,2-Dichloroethene	100	50	ug/L		
	cis-1,2-Dichloroethene	70	35	ug/L		
	Trichloroethene	5	2.5	ug/L		
	Tetrachloroethene	5	2.5	ug/L		

Notes:
PAL = RIDEMs Preventative Action Limit

PCBs in Soil

TABLE 5

**SUMMARY OF POLYCHLORINATED BIPHENYL RESULTS
SOIL SAMPLES
RHOADES SALVAGE
MILTON, VERMONT**

SAMPLE LOCATION SAMPLE NUMBER DEPTH	SS-15 R01-081020GL-0028 6 inches	SS-16 R01-081020GL-0029 6 inches	SS-17 R01-081020GL-0030 6 inches	EPA R3 Residential Soil Screening Levels	EPA R3 Industrial Soil Screening Levels
COMPOUND					
Aroclor-1242	ND	0.20	ND	0.22	0.74
Aroclor-1254	0.15	0.16	0.17	0.22	0.74
Aroclor-1260	0.14	0.10	ND	0.22	0.74

NOTES:

1) Samples analyzed by U.S. EPA Office of Environmental Measurement and Evaluation (OEME) using EPA Region I SOP, PESTSOIL2.SOP, PCBs Medium Level in Soils and Sediments.
2) All Results in Milligrams per Kilogram (mg/Kg).
3) EPA R3 = U.S. EPA Region III
4) EPA R3 Residential and Industrial Screening Standards are used for comparison purposes only.
5) ND = Not Detected.
6) Note that summary tables do not include samples in which no analytes were detected. Refer to Appendix E for all analytical data results.

Communicating with Numbers

How do you turn data and number facts into a compelling message? Start by considering:

Who is your target audience?

An official or board/commission – elected or appointed, seasoned or new
Regulators with technical knowledge
Reporters with no technical background
The general public – informed, apathetic, outraged but uninformed

What is your audience's attitude?

They agree and just need to be supported or spurred to action
They disagree and need to be convinced or pressured
They're unaware and need to be alerted

What is the setting?

A public hearing or meeting
A private meeting or interview
A flyer, fact sheet, or newspaper ad
A rally or press conference

What is the format?

Spoken: How much time will you have?
Printed: How much space? Black and white? Text only? Color graphics?

Memorable Messages and **Memorable Graphs** can jump-start creative thinking about ways to present a key fact. If you don't have time or a group to do the activities, each has a handout offering tips for making memorable messages and graphs: choosing strategies, avoiding common pitfalls, and polishing your message and graphics.

Design a Fact Sheet pulls together all the work you've done above into a single fact sheet or poster.

Too soon? If you haven't found the key facts you want to highlight, look through the activities and resources in:

Drawing Your Own Conclusions and **Pieces of the Risk Puzzle**. Analyze your situation to find newsworthy data or claims to challenge.

Communicating

Memorable Messages

Facilitator Instructions

Overview

Participants look at examples of how one fact can be presented in many different ways. They discuss which they find most powerful, and why.

When to Use It

When you have key facts or data that you want to communicate to officials or the general public, but the facts as they are don't make a powerful-sounding media message.

Suggested companion activities: See Communicating With Numbers.

Steps

1. **Launch the activity:** Effective campaigns have memorable messages. What is a number or statistic that really stuck with you, and why? (Prompt with an pre-prepared example or two, or a story in which using a memorable stat helped a campaign.)
2. **In groups of 4-6:** Here is a set of statements. In each set, the fact is in a gray box; the others are based on that fact. Which statements make the most effective messages? Why? Arrange the statements from most to least effective.
3. **Debrief:**
   - Which were most and least effective? Was there disagreement?
   - How would you improve any of these?
   - What makes a statistic into an effective message?

Take notes on that last question. Distribute Strategies for Making Memorable Messages. Is there overlap between the group's ideas and those ideas on the handout? Encourage people to add their own wisdom to the handout.

Worth Noting

If the group seems ready, you can immediately follow by having them practice making memorable messages using their own data. Distribute Benchmark Numbers to give the group some numbers to play with. If the group isn't yet comfortable with the math and science involved in their situation, try other SfA activities first.

Smart Moves

- Use friendly numbers
- Talk it out
- Compare it to what you already know
- Play with different ways to show it and say it

Skill: Restate facts and data in more vivid ways.

Time: 30-45 minutes

Preparation

Choose which message set(s) to use:

1. *How toxic is dioxin?*
2. *How many truck trips for the new incinerator?*
3. *How much over the limit?*
4. *How many kids have asthma?*
5. *How much energy does recycling save?*
6. *How many pesticides cause cancer?*
7. *How big was the oil spill?*

Copy card sets and cut up along dashed lines.

Come with an example or two of a number or statistic that made an impression on you.

Materials

Card sets (one per small group)

Strategies for Making Memorable Messages (one 2-sided handout per participant)

Optional: Flip chart and markers for debrief

Optional, if creating your own messages:

- Benchmark Numbers (one 2-sided handout per participant)
- Optional: Calculators to share

A year's worth of trucks, lined end to end, would fill Route 7 from the Sandy River to the county line.

Strategies for Making Memorable Messages

The numbers in pollution science can be so big or so small, they're hard to imagine. Numbers are more powerful when people can picture seeing and touching them. Throughout the process, think about the audience for your message and what they care about most.

1. Choose a Strategy

Use familiar units. Convert to units that your audience might hear or see in everyday life.	Cubic meters kilometers kilograms	Gallon milk jugs, sugar packets, teaspoons, football fields, 50-gallon drums
Make it local. Use distances, areas, volumes, and heights based on things familiar to your audience.	245 miles 12.3 million gallons	...would reach from Bob's gas station to Dora's Deli. ...would fill Memorial Stadium.
Make it personal. Divide the amount up among the people who will be impacted. Divide it up per person, household, or town.	1,300 tons of trash per day	150 pounds of trash per person, every day
Use time to scale up or down.	800,000 tons of toxic waste per year	One and a half tons per minute. Fifty pounds per second.
Use the problem to your advantage. Include negative images from the problem that are likely to trouble your audience.	40 truckloads of coal per day	A year's worth of trucks, lined end to end, would fill Route 7 from the Sandy River to the county line.
Show the trade-offs with money.	Incinerator provides $24,000 in tax revenue	...sounds like a lot, but it's only $32 per resident. You can barely buy a cake for that!

More Strategies for Making Memorable Messages

2. Check for Common Pitfalls

Make sure it makes sense. Use an example that makes sense for your situation. So if you're talking about a part per million in water…

NO: One pancake in a stack a mile high	YES: One drop in an Olympic swimming pool

Compare to things with a standard size.

NO: Trees, city blocks, houses, lakes	YES: Football fields, gallons, pounds

Focus on understanding. A bigger number doesn't mean bigger impact.

NO: 136,800 minutes	YES: Over three months

Be careful with length, area, and volume. A ratio between lengths changes when you switch to area or volume

NO: 100 cm in a m so 100 cm^3 in a m^3	YES: 100 cm in a m, but 1,000,000 cm^3 in a m^3

3. Polish Your Message

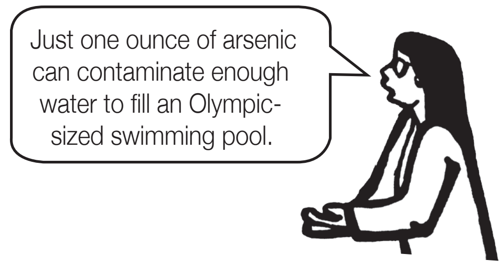
Use friendly numbers. When possible, round off your final number.

NO: 197 tons, 2,480,000 people	YES: 200 tons, two and a half million people

Use familiar fractions, ratios and percents instead of decimals or numbers that are hard to picture.

NO: 12.4% of town residents	YES: About one in eight town residents

Benchmark Numbers



Comparing numbers to familiar, local, or impressive things helps make a message memorable. Below are some ideas to help you get started. See the rest of this activity for more of examples of how these might be used. Grab a calculator and keep notes, so you don't lose track of what your numbers represent.

A few common units and conversions: This list is just a sample to get you thinking. Check the internet for more conversions.

Mile	5,280 feet = 1.61 km = 1610 m
Pound	16 ounces = 453.6 grams = 0.4536 kg
Acre	66 ft x 660 ft = 43,560 sq ft = 1/640 of a square mile = 0.40 Hectares
Hectare	100 m^2

Cubic foot	7.48 gallons
Cubic meter	1,000 Liters = 264 gallons = 35.3 cubic feet
1 gallon	= 3.8 L = 4 quarts = 8 pints = 16 cups = 128 fluid ounces = 256 tablespoons = 768 teaspoons = 75,708 drops

Everyday items: Here are a few things most people have seen, touched, picked up, or walked by. What are other things you see and touch that have a standard size?

Pea	0.28" - 0.43" diameter
Dime	Diameter 0.705", Thickness 0.053", Weight 2.268 g
One Sheet of Letter-size paper	Single sheet: 8.5" x 11" Thickness: 0.0038", 0.01 lbs (4.5 g).
One Ream (500 sheets) of paper	8.5" x 11". 1.9" thick. 5 lbs.
US paper money	2.61" x 6.14", 1 gram
Index card	4" x 6"
Deck of Cards	2.5" x 3.5" x 0.625", 3.3 ounces
iPhone	4.8 ounces
Average newborn	7.5 lbs
Can of Coca-Cola	12 fluid ounces
Red Clay Brick	3.625" x 7.625" x 2.25", about 5 lbs
Typical toilet flush	Older: 3-4 gals. After 1994: 1.6 gals.
Gallon milk jug	8 pounds

Cinder block	33 lbs.
Kitchen trash bag	13 gallons
Trash barrel	32 gallons
Typical bathtub	About 50 gallons
Utility/Phone pole	40 ft (35 ft are above ground)
VW Beetle	2,939 lbs (1.47 tons)
Ford F-150 Truck	4,685 lbs (2.34 tons)
School bus	8' wide, 10' high, 24'-40' long, 23,000–29,500 pounds fully loaded
Football field	No end zones: 300'x160', 1.1 acres. w/end zones: 360' x 160', 1.32 acres
Tanker truck tank	5,500 to 9,000 U.S. gallons
Olympic-size Swimming Pool	2,500 m^3 = 2,500,000 L = 660,430 gal
Acre-foot	325,851 gallons (volume of water covering an acre of land one foot deep)

More Benchmark Numbers

Impressive Numbers: Sometimes you just want to underscore the relative size something by comparing it to something really big. Or, break down a huge number by saying how much there would be per person, or per mile.

U.S. Population	308,745,538 (2010 Census)
Passenger vehicles in the U.S. (cars and small trucks)	254,212,610 (US Bureau of Transportation Statistics, 2009)
Pop. of New York City	8,244,910 (2011 US Census est.)
Number of post offices	26,927 (2011)
Madison Square Garden	19,763 seats
Empire State Building	1250 ft

Span of the Grand Canyon at its widest point	18 mi
New York to San Francisco	2,563 mi
Circumference of the earth	24,900 mi
From Earth to the Moon	220,000 mi
Rhode Island	1,214 sq. mi
Texas	268,581 sq mi

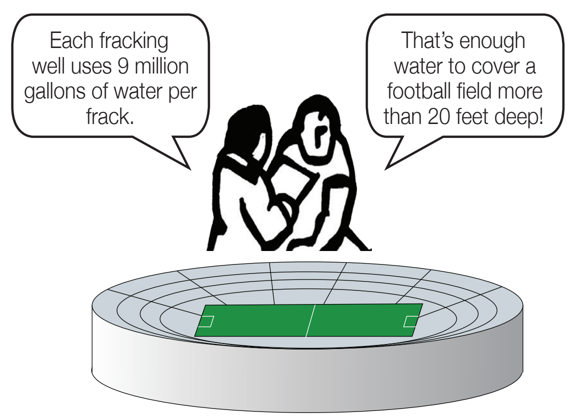
Close to Home: The best references are most familiar or known well by your target audience.

- Population of your town, county, or state
- Seats at a local stadium, or school auditorium
- Height of a well-known local building
- Distance between landmarks in your town
- Distance from your town to the nearest city
- Area of your town, county, or state
- Area of the high school gym floor

- Area of a stretch of street (length x width)
- Price of a coffee (or hamburger) at a local restaurant
- Annual town budget for [a particular service]
- Median home value or tax bill in your town
- Cost of a gallon of gas today
- Typical local garbage truck (weight, capacity)
- Profits or CEO salary of a polluting company

An extra challenge: Another dimension!

For most of these, you need to compare like to like: length to length, volume to volume, weight, etc. But if you're skilled you can combine dimensions: The area of a rectangle is its length times its width (using the same units). Give that area a height or a depth and you can calculate a volume. With that, you can say things like...



Set 1: How toxic is dioxin?

The legal limit for dioxin in drinking water is 0.00003 µg/L. That's the same as 1 gram of dioxin added to 8.8 billion gallons of water.	1 gram of dioxin is enough to poison the amount of water one American would use in 15,000 years.
1 gram of dioxin is enough to poison the water that 15,000 Americans – the population of [nearby town] – use in one year.	1 gram of dioxin is enough to make 33 billion liters of soda unsafe to drink.
1 gram of dioxin would poison over 13,000 Olympic-sized swimming pools' worth of water.	It's like one dime poisoning the entire U.S Federal Budget.

Set 2: How many truck trips for the new incinerator?

The new incinerator would take in 3600 tons of construction and demolition waste per day. A standard garbage truck holds about 25 tons.	The new incinerator would add 144 garbage truck trips per day.
The new incinerator would add over a thousand garbage truck trips per week.	The new incinerator would add over fifty thousand garbage truck trips per year.
During the daytime, garbage trucks would be going in or out of the new incinerator plant every two and a half minutes, on average.	The new incinerator would add a thousand garbage truck trips per week. Lined up end to end, those trucks would fill Route 7 from City Hall to the county line.

Set 3: How much over the limit?

The legal limit for TCE in drinking water is 5 μg/L. **Local tap water tests found TCE levels as high as 200 μg/L.**	Testing found TCE as high as 4000% of the legal limit.
Testing found TCE as much as 40 times the legal limit.	Tests showed that some TCE levels were 195 μg/L over the limit.
If the legal limit is like a measuring cup's worth of TCE, what the tests found was like two and a half gallons' worth!	There's enough TCE in David's tap water to make his family sick 40 times over.

Set 4: How many kids have asthma?

A new health study surveyed the parents of 335 children in one community. Of these children, 81 had been told by a health care worker that they had asthma.	81 out of 335 children in our community have asthma.
24.2% of children in our community have asthma.	One in four children in our community have asthma.
A quarter of the children in our community have asthma.	Think of four kids in our community: Your daughter, your neighbor's son, the paper boy, your niece. Now pick one of them. You just chose the next child to get asthma.

Set 5: How much energy does recycling save?

Making a plastic bottle from new materials uses 5200 BTUs of energy. **Making a plastic bottle from a recycled bottle only uses 1400 BTUs.**	Recycling a plastic bottle saves 73% of the energy used to make a new plastic bottle.
Making a bottle from new plastic takes uses three times as much energy as using recycled plastic.	With the energy it takes to make one bottle from new plastic, you can make *three* bottles with recycled plastic.
The energy you save by recycling a plastic bottle could power a 60-W lightbulb for half a day.	The energy you save by recycling a plastic bottle could bring three gallons of water to a boil.

Set 6: How many pesticides cause cancer?

17 of 32 of LawnCo pesticide products contain possible carcinogens. **9 of 32 LawnCo pesticide products contain known or suspected reproductive toxins.**	53% of LawnCo pesticides contain possible carcinogens, and 28% contain reproductive toxins.
More than half of LawnCo pesticides contain possible carcinogens, and more than a quarter of them contain reproductive toxins.	One in two LawnCo pesticides contain possible carcinogens, and one in four contain reproductive toxins.
Flip a coin... Heads: your LawnCo pesticide causes cancer. Tails: it doesn't. Do you want to take that chance?	

Set 7: How big was the oil spill?

The 2010 BP oil spill in released an estimated 172 million gallons of oil into the Gulf of Mexico. That's enough oil to...	...fill the Giant Ocean Tank at the New England Aquarium 866 times.
...fill over a million bathtubs, 22 inches deep.	...fill a billion 22-ounce soft drink cups – more than three for every person in America.
...run through 26.4 million eight-minute showers – three for every person in Massachusetts.	...fill 264 Olympic-sized swimming pools.

Memorable Graphs

Facilitator Instructions

Overview

Participants look at graphic examples of how a fact or data set can be presented. They discuss which they find most effective, and why.

When to Use It

When you have key facts or data that you want to communicate to officials or the general public, and you need inspiration or ideas for how to present the data visually.

Suggested companion activities: See Communicating With Numbers.

Steps

1. **Launch the activity:** They say a picture is worth 1,000 words. Does anyone have an example of a graph or visual of a fact that that really made an impression on you? What, and why? (Prompt with an pre-prepared example or two.)
2. **In groups of 4-6:** These cards describe a community situation with data, and then show different graphic ways of representing the data. Which shows the message most effectively? Why? Arrange the graphs from most to least effective. (Note: Sets 6 and 7 have a different purpose; see notes on right and in each set.)
3. **Debrief:**
   - Which were most and least compelling? Was there disagreement?
   - How would you improve any of these?

After all groups have reported back, discuss: What makes a good visual representation of data? What makes a bad or confusing graph? Take notes on flip chart paper.

Distribute the Strategies for Making Memorable Graphs handout. Is there overlap between the group's ideas and those ideas on the handout? Encourage people to add their own wisdom to the handout.

For the Facilitator

If the group seems ready, you can immediately follow by having participants practice sketching draft graphs using their own data. If the group isn't yet comfortable with the math and science involved in their situation, try other activities first.

Smart Moves

- Talk it out
- Play with different ways to show it and say it

Skill: Think creatively and critically about different ways to graph facts & data.

Time: 30-45 minutes

Preparation

Choose which card set you will use:

1. *Children with Asthma*
2. *Incinerator Ash*
3. *Truck Traffic*
4. *Pesticides and ADHD*
5. *Landfill Expansion*
6. *Thyroid Cancer Incidence (balancing trend-showing vs. credibility)*
7. *Turning a Brownfield Site Into a Park (choosing a combo of data for visual impact)*

Copy card sets and cut up along dashed lines.

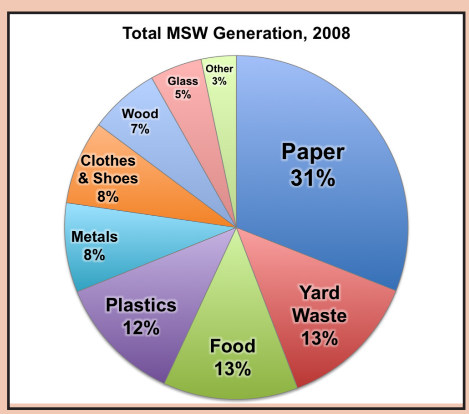
Come with an example or two of a graph that made an impression on you.

Materials & Prep

Card sets (one per small group)

Strategies for Making Memorable Graphs (4 pages, 1 set per participant)

Optional: Flip chart and markers for debrief



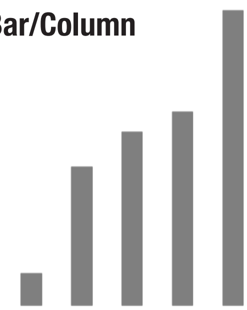
Strategies for Making Memorable Graphs

1. Choose Your Message and Graph Type

Choose the message you want your graph to support. A description of a compelling fact or trend might lead to a powerful image. Try different ways of showing a percent, ratio, or raw number. Sharp increases and simple ratios make striking visuals.

Choose a graph type that makes the most sense for your data. Here are some common types:

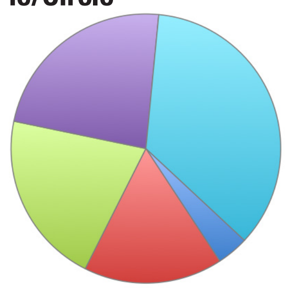
Bar/Column



Compares amounts in different categories.

Example:
Levels of PAHs in different soil samples.

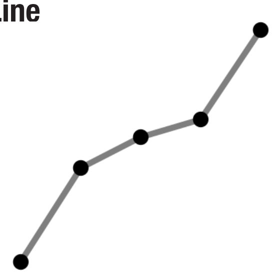
Pie/Circle



Compares parts of a whole, everything adds to 100%.

Example:
% of expenses in different categories of a city budget.

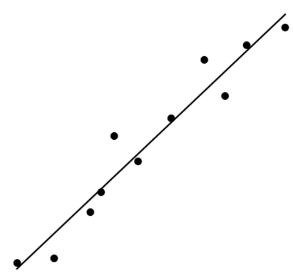
Line



Shows changes over time or distance.

Example:
Monthly arsenic levels in a well for a year.

Scatterplot



Shows a possible relationship between two different measurable things.

Example:
Lead levels in a person's blood vs. distance from the person's house to a junkyard.

Infographic

Uses icons or an image to show a ratio or relationship.

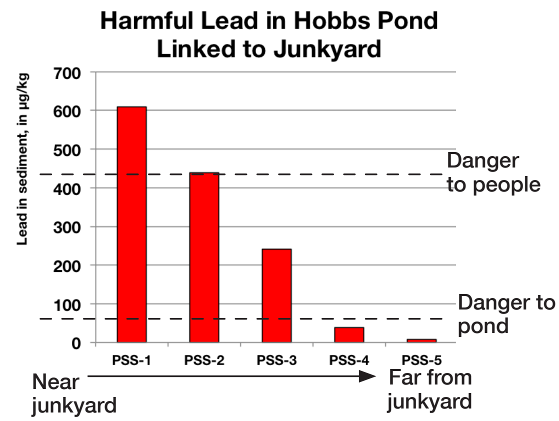
Example:
Community members in Boston did a health survey and found that 81 out of 355 children had asthma. They found this was about the same as one in four.

Strategies for Making Memorable Graphs

2. Make a Rough Draft

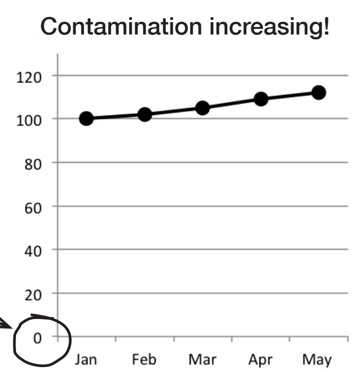
Choose a title that sums up what's on the graph, and why the reader should care.

Label it. Make it clear what each axis and graphic represents. Label key points to give the reader context.

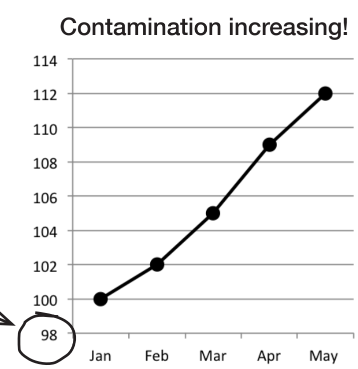


Choose a scale that makes it clear how the data support your message. However, if it looks like you're exaggerating, it could hurt your credibility.

Same data, different scales

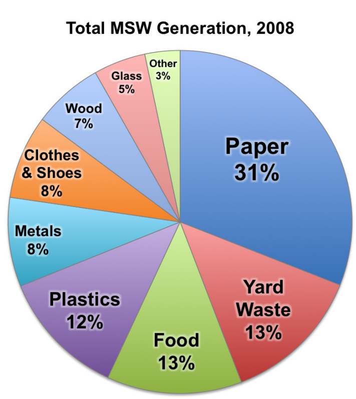


Y-axis starts at zero.



Y-axis starts at 98.

Put your data in order. Most data sets will have a natural order, from earliest to latest, or nearest to farthest. If there's no natural order, sort the data from largest to smallest.



Categories in order by size

Proportional word size

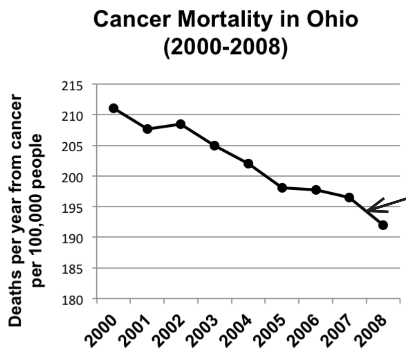
Labels on the chart, not in a legend

Numbers included

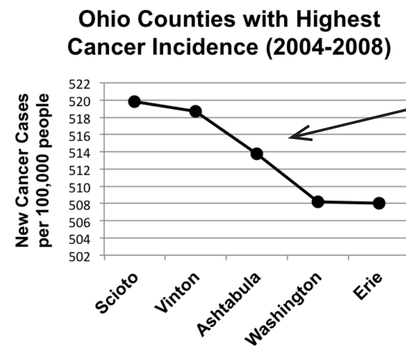
Strategies for Making Memorable Graphs

3. Avoid Pitfalls and Make Trade-Offs

Check all the parts of the graph for meaning.
A spreadsheet program can create a graph, but only a person can judge if it makes sense.

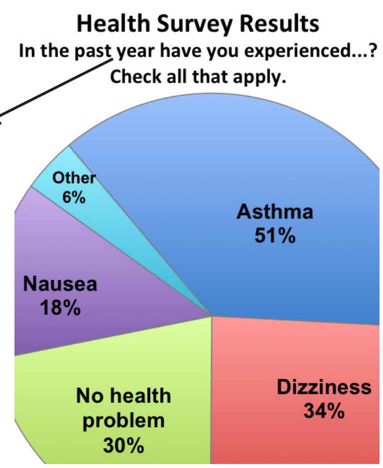


Line helps readers see change in mortality over time



Line makes it seem like cancer incidence is decreasing. But in reality there is no "trend." The data are from counties scattered across the state, from the same range of years.

Pie chart pitfalls. Use pie charts only if the categories are distinct (no overlaps) and the numbers add to 100%.



"Check all that apply" means totals may add up to *more* than 100%

A column chart might be better. Or one circle graph for each health effect.

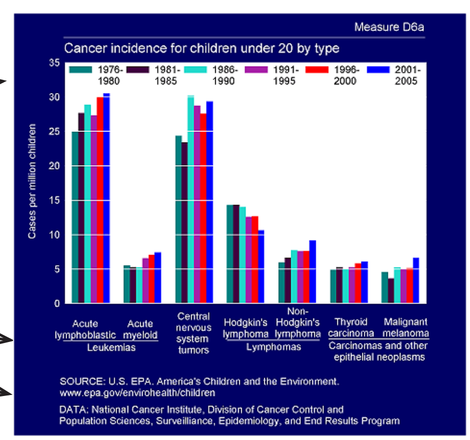
Detailed color graphics vs. black & white.
Color and pictures make an attractive final product for a big poster. Plan ahead, though: they can be expensive, and don't photocopy well in black & white.

Comprehensive data vs. key points.
Gauge your audience's interest and attention span. Will a typical reader take the time needed to read all the data you have? For most audiences, just focus on the most convincing stats.

Many data sets

Many categories

Many citations

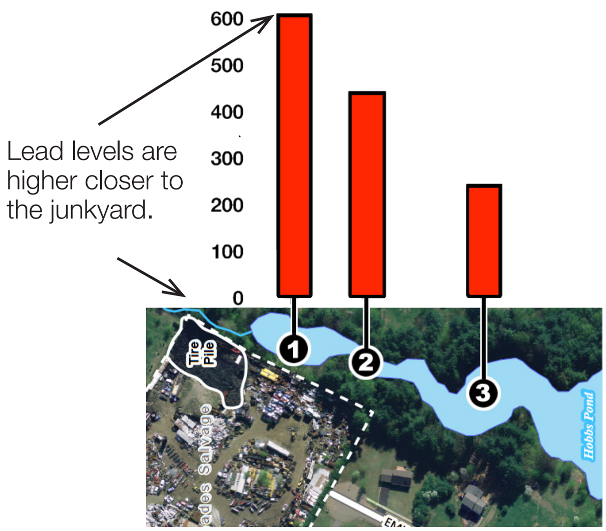


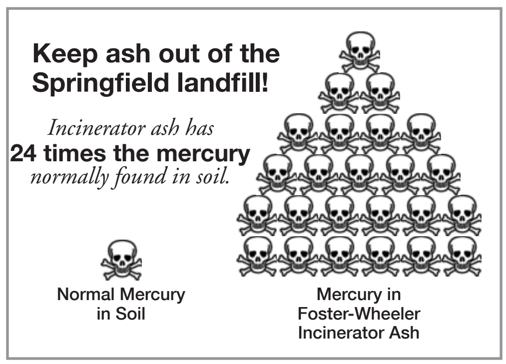
Strategies for Making Memorable Graphs

4. Revise and Polish

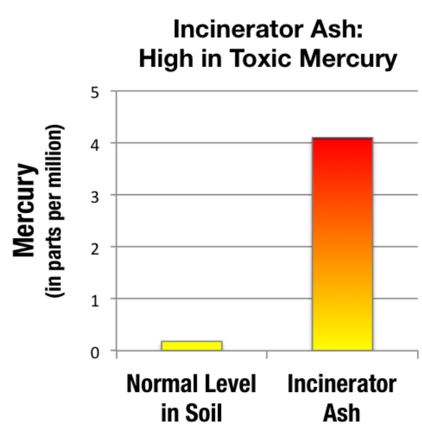
Use visuals that support your message. Make lines or colors bolder for more serious results. Replace bars with little icons, like trucks or skulls or dollar bills. A map can help readers put the data in context.

Adjust for people's instincts. Many people expect that more is better, so if more is bad, make that clear.





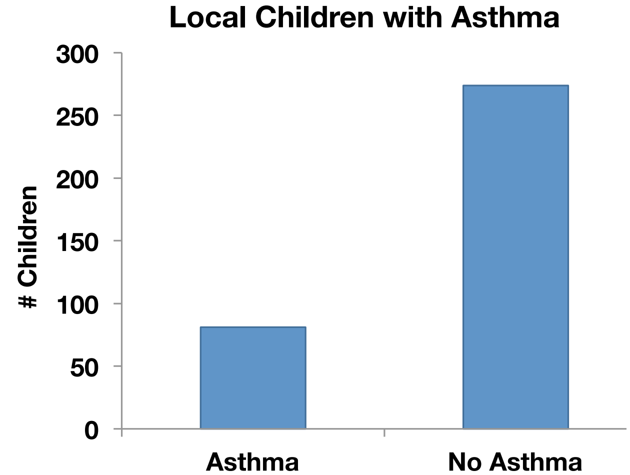
Help people see the pattern. Use a key or legend if needed, but it's faster to understand a chart if you put labels, data, and graphics together so keys aren't needed. If your data are scattered, you can add a line to show the trend. Use computer spreadsheet software to make it accurate.

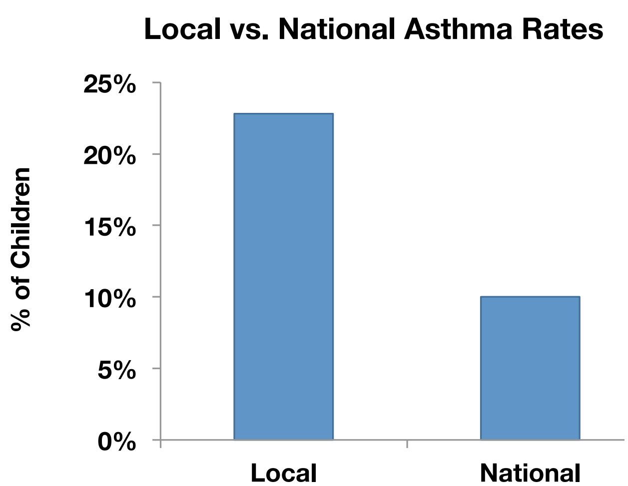


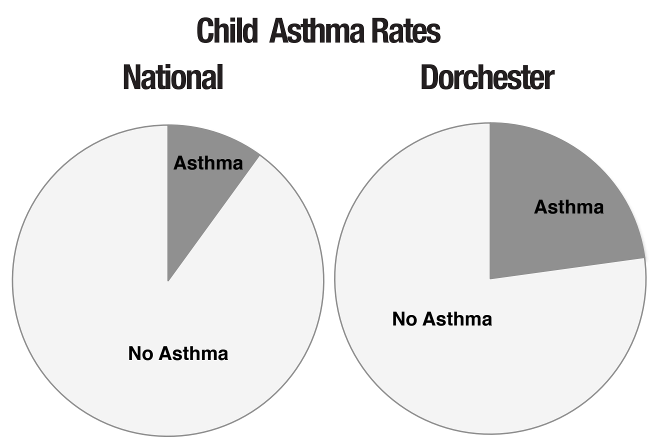
Final check. Look at your graph for five seconds. Look at it again from across the room, in a mirror, or upside down. Can a reader get the message quickly? Edit to strengthen the features that communicate your message, remove things that don't. Look again; make final tweaks.

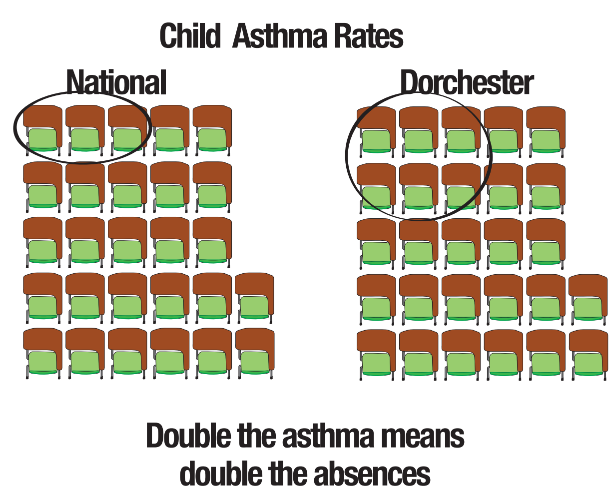
Set 1: Children with Asthma

In 2006, the Boston Urban Asthma Coalition did a health survey in the Dorchester neighborhood. The survey found that 81 out of 355 children (22.8%) had been diagnosed with asthma. The statewide rate is 10.8%





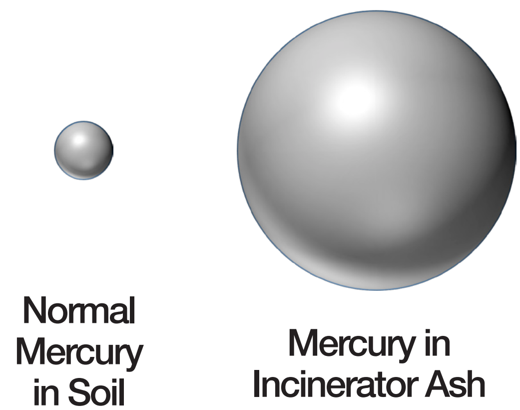


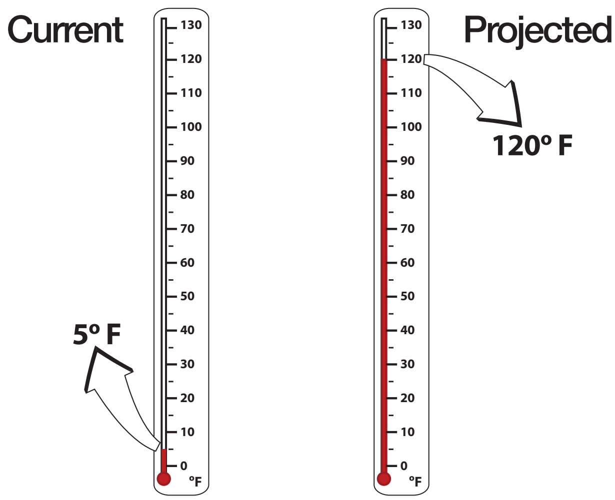


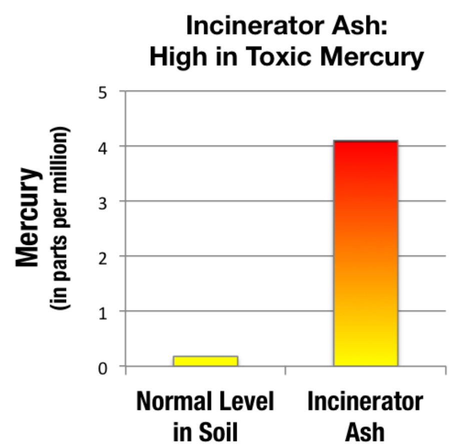
Data Sources: Community survey, http://matracking.ehs.state.ma.us/Health_Data/Pediatric_Asthma.html

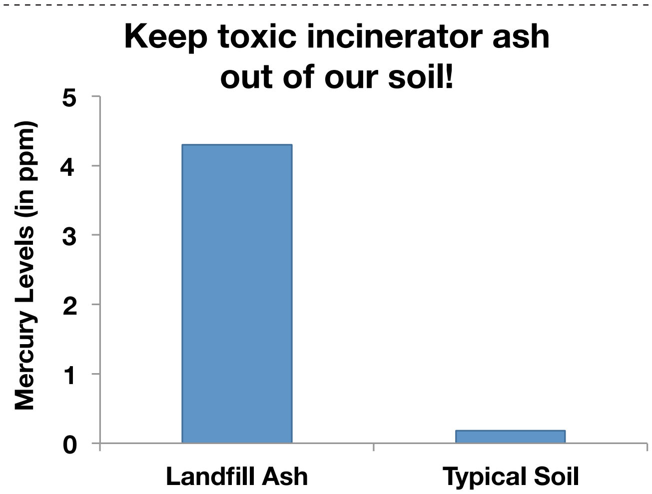
Set 2: Incinerator Ash

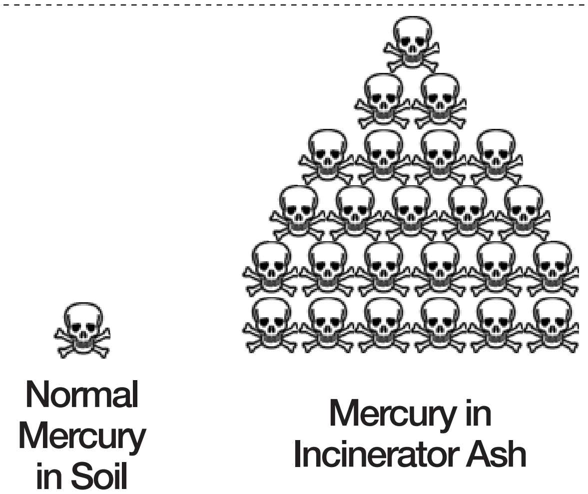
A local landfill company wants to accept ash from an incinerator. The ash has 4.3 ppm of mercury. Normal soil in the area is only 0.18 ppm mercury. Neighbors don't want mercury levels in their soil to increase.







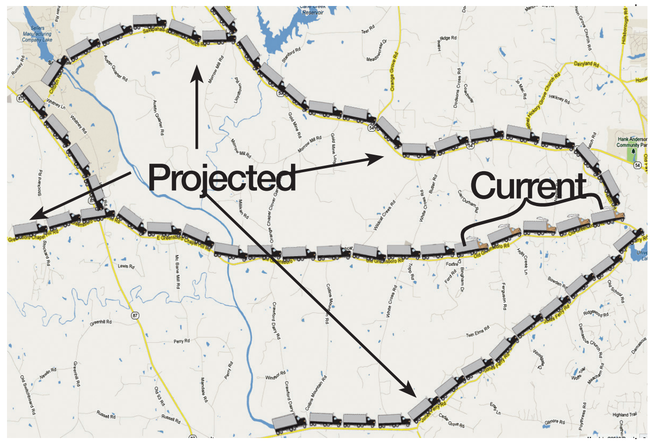


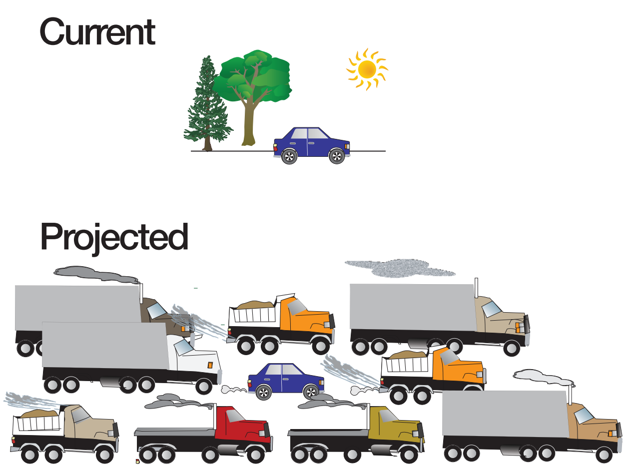


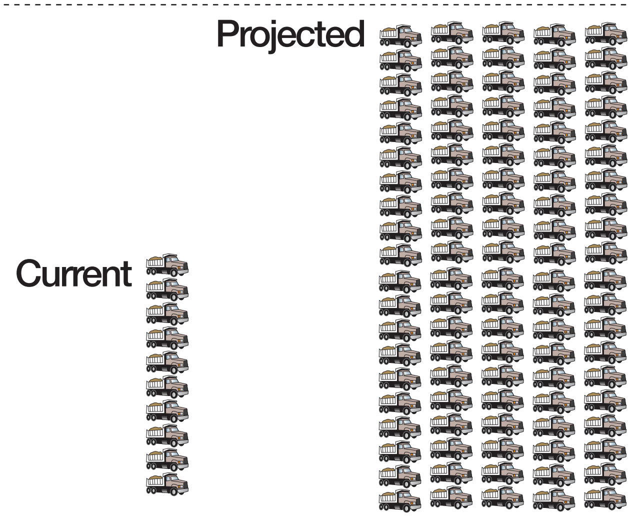
Data Source: http://www.americanhealthstudies.org/wastenot/wn318.htm

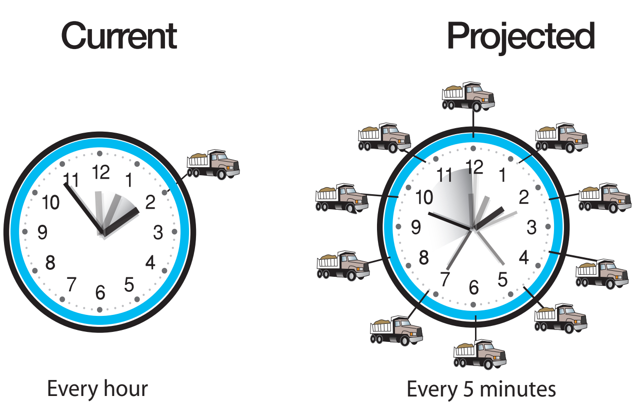
Set 3: Truck Traffic

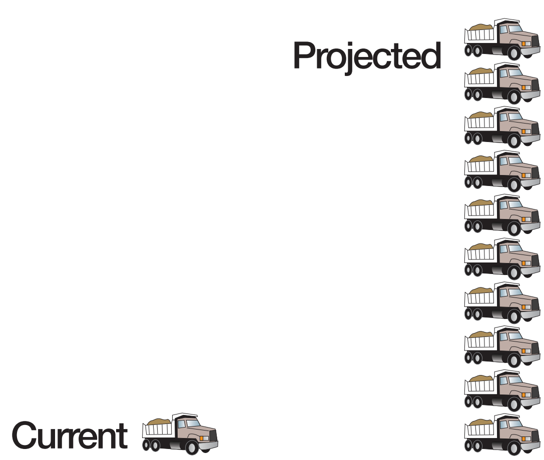
Projections show that a proposed new power plant would cause a tenfold increase in truck traffic on a small county road.







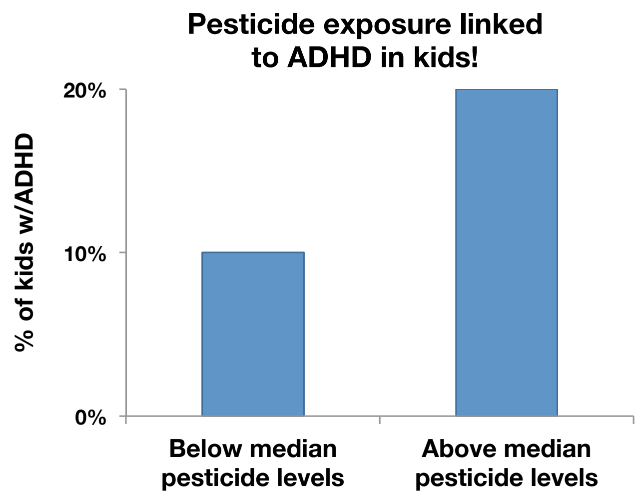


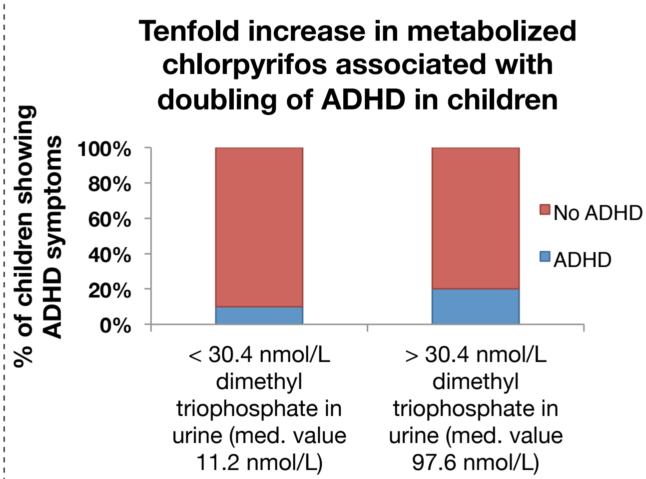


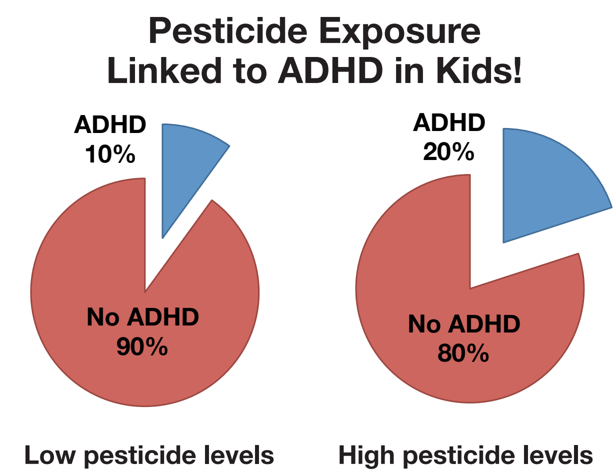
Data Source: Hypothetical

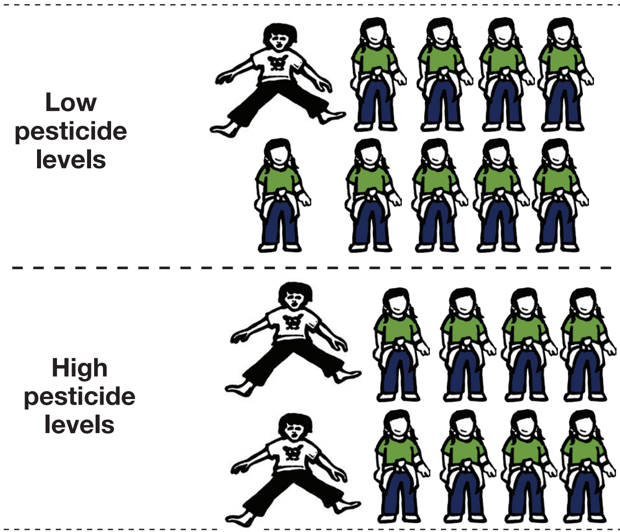
Set 4: Pesticides and ADHD

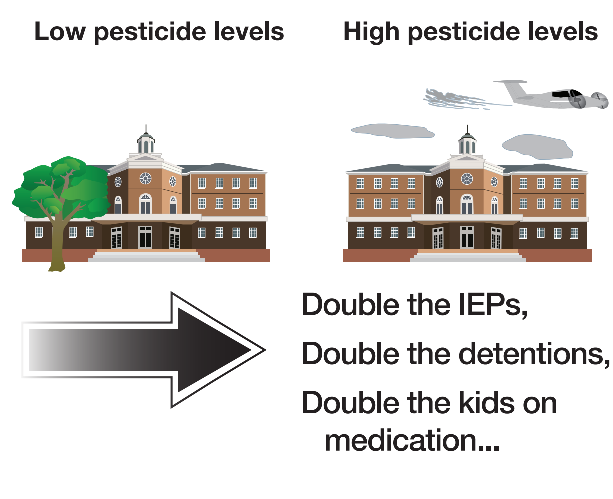
One study showed that children with higher-than-median levels of the pesticide *dimethyl triophosphate* were almost twice as likely to develop ADHD as chidren with lower or undetectable levels of the pesticide.







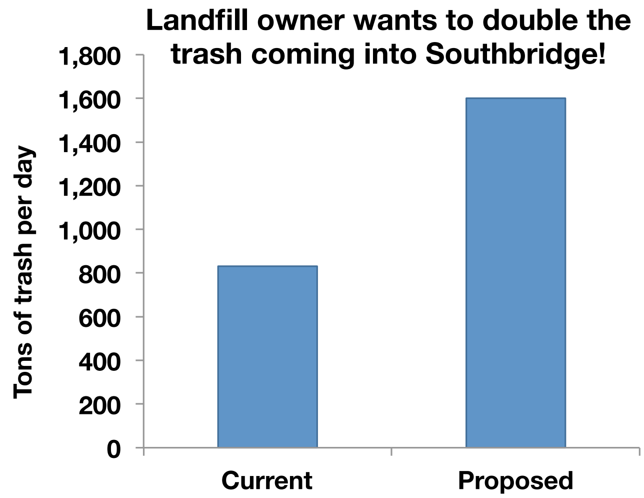


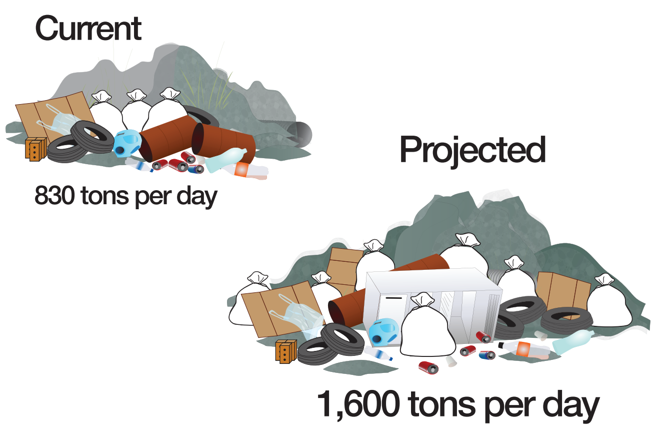


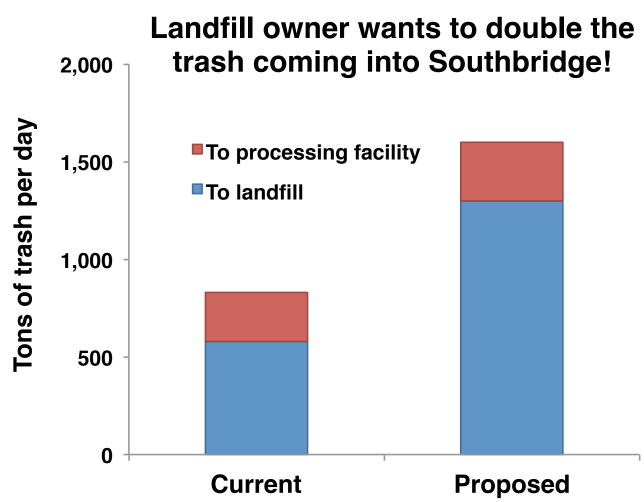
Data Source: http://pediatrics.aappublications.org/content/125/6/e1270

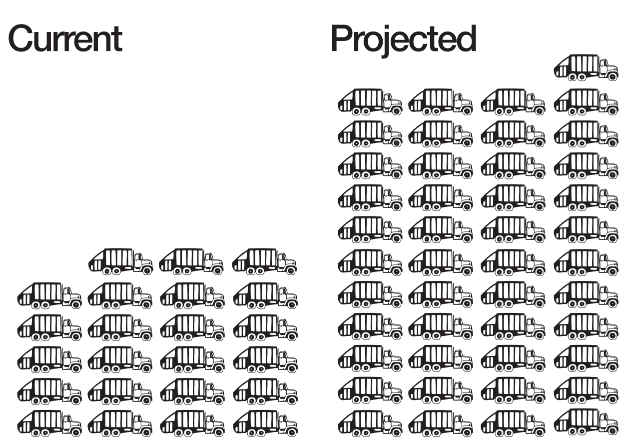
Set 5: Landfill Expansion

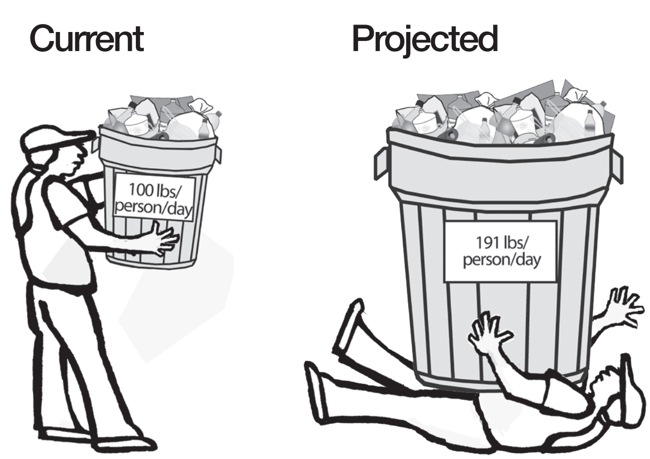
A landfill operator wants to increase their trash intake from 830 tons per day (258,960 tons per year) to 1,600 tons per day (499,200 tons per year).









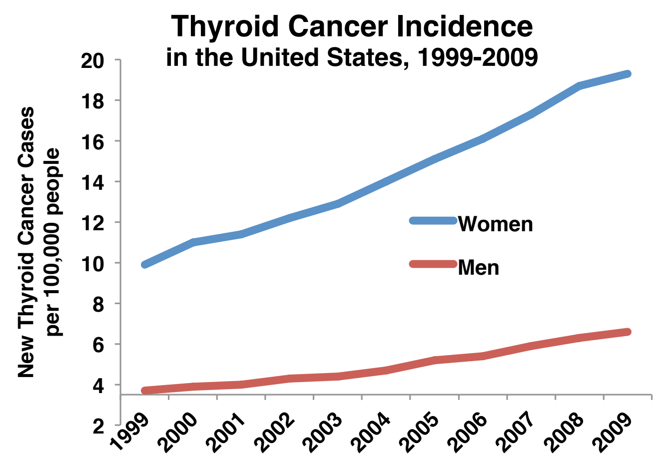


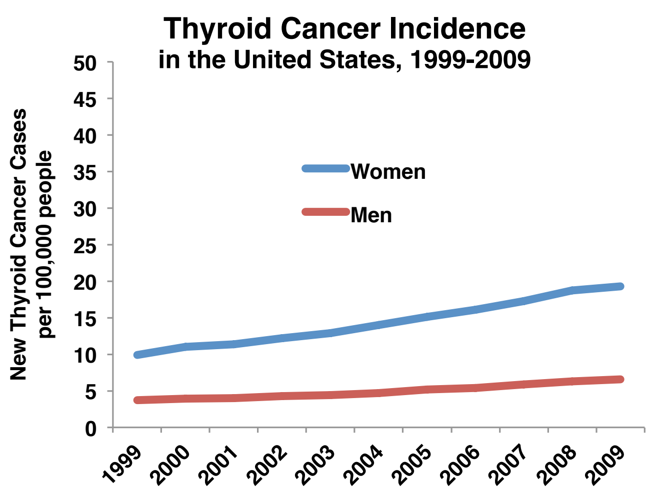
Data Source: Landfill in Southbridge, MA

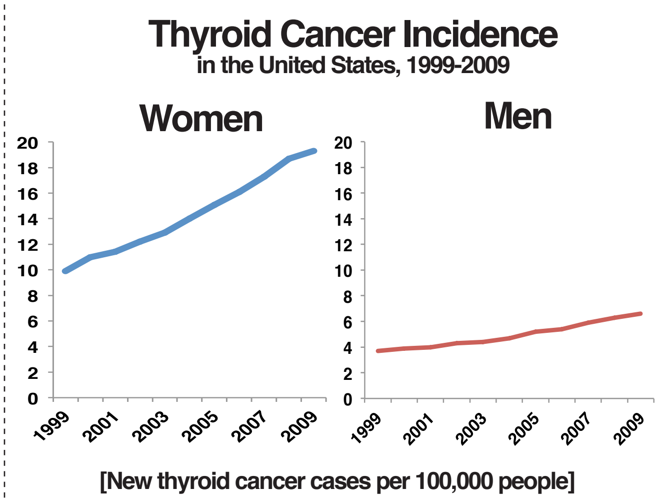
Set 6: Thyroid Cancer Incidence

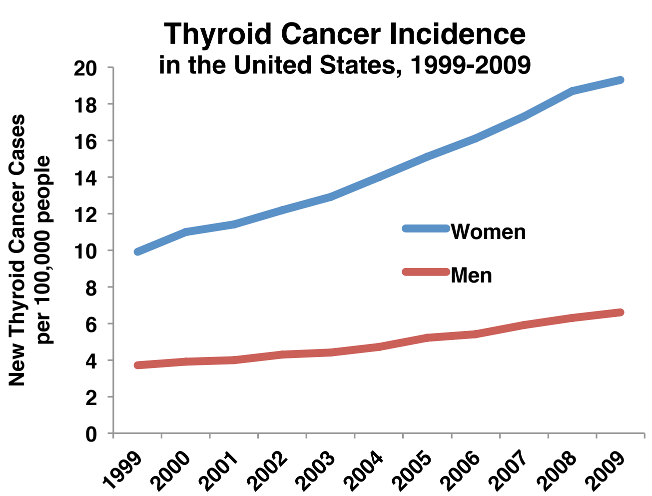
Since 1990, thyroid cancer rates have been rising more dramatically in women than in men.

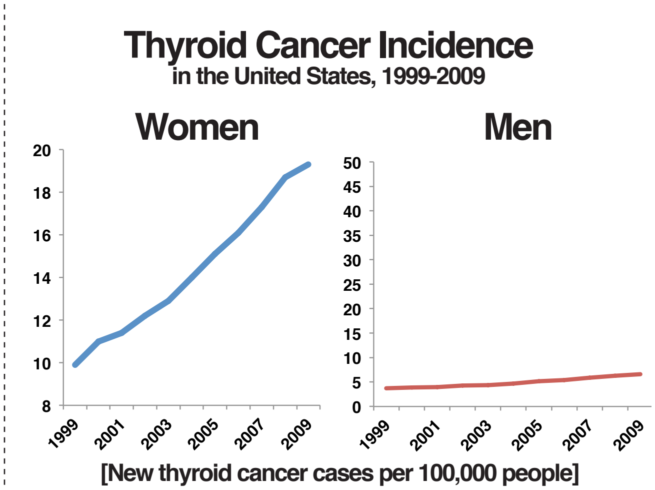
Some of these graphs show a clear trend, but critics might say the graphs have been manipulated to exaggerate the effect. Which do you think is both clear and credible?









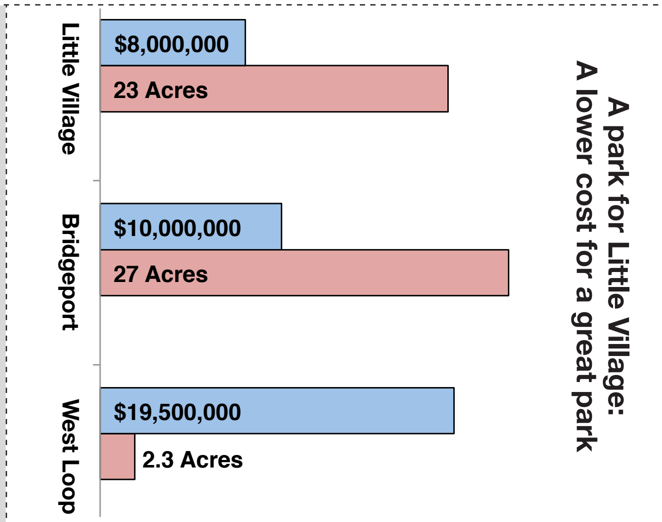


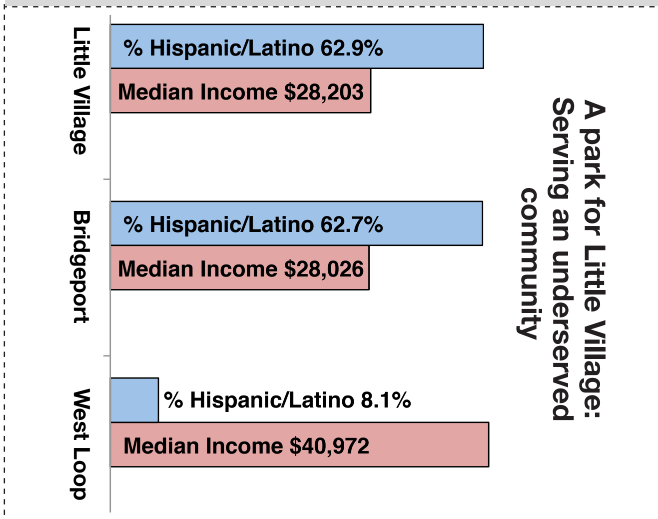
Data Source: www.cancer.org/Research/CancerFactsFigures/ACSPC-031941

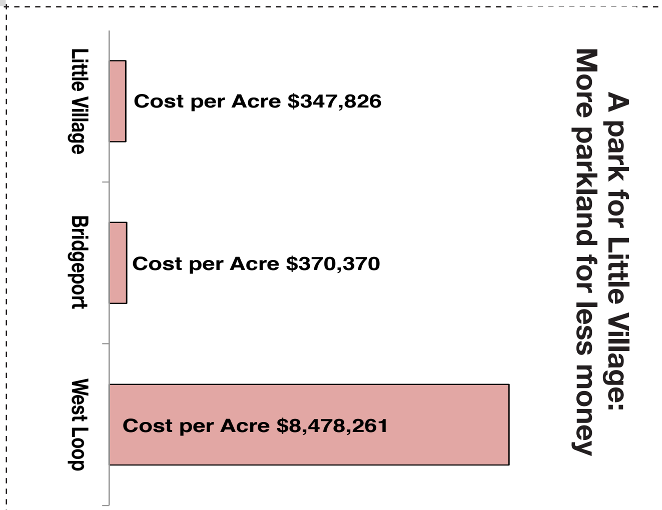
Set 7: Turning a Brownfield Site into a Park

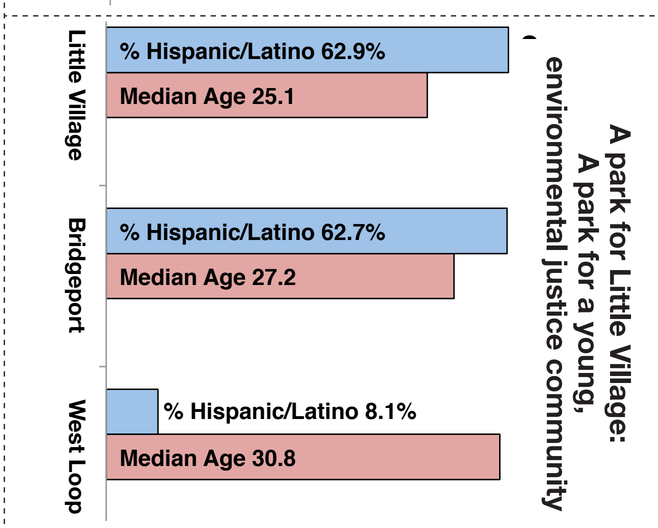
A group in the Little Village neighborhood of Chicago wants the city to fund a plan to turn a local brownfield site into a park. They are comparing their proposed park to two other recently-approved parks.

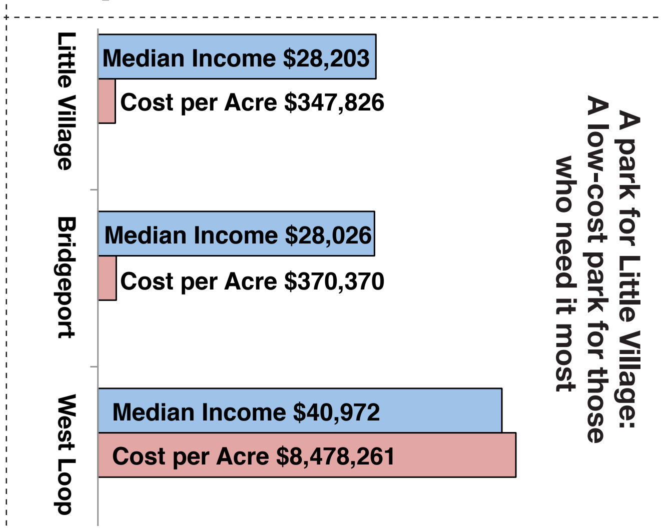
This group has lots of data about cost and community need. Which combination of data is most effective?











Data Sources: census.gov, lvejo.org

Design a Fact Sheet
Facilitator Instructions

Activity Overview

Participants create a fact sheet for their cause based on a template.

When to Use It

When a group has a short list of compelling facts and graphics, and wants to put them into a fact sheet to inform people and spur them to action.

Suggested companion activities:

- See Communicating with Numbers for a big-picture view.
- If using this activity in a conference workshop, see Memorable Messages and Memorable Graphs for examples.

Steps

1. **Launch the activity:** Now that we know the key information we want to communicate, let's create a fact sheet supporting our message with talking points.
   Distribute the handouts. Review features of a good fact sheet listed. Complete Strategy #1 (regarding audience) as a group.
2. **In pairs or small groups:** Use the rest of the strategies to create a fact sheet. If the whole group identified more than one audience, each small group can choose a specific target audience.
3. **Debrief:** Pass around the fact sheets so every group can look quickly at the work of every other group. When finished, ask:
   - Which version is most complete?
   - Which one has part that will really convince our target audience to take action?

Ask the group to agree to a final draft that merges the best from all versions, without putting too much on one page. Ask for a volunteer to create a final version, and to save anything that didn't fit here, but might be useful down the road.

For the Facilitator

If there are multiple target audiences or action steps needed, then you may need more than one fact sheet; e.g., a simple one to get people to a public hearing, and a more detailed one to use at the hearing.

Smart Moves

- Play with different ways to show it and say it
- Talk it out

Skill: Connect a statistic and a visual to illustrate a problem, solution or needed action.

Time: 30-45 minutes

Preparation

Gather a short list of data, interpretations, facts, and graphs generated for the campaign.

Review all materials before the meeting.

If using at a conference workshop, pick a campaign that has many facts in its favor, too many to fit on one fact sheet.

Materials

Fact Sheet Strategies (1 per pair or participant)

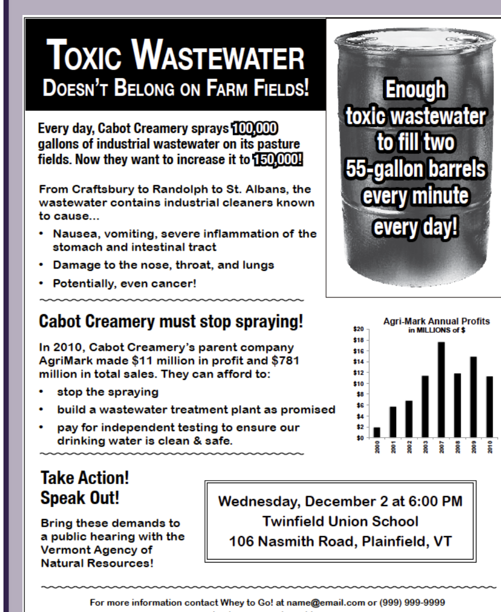
Fact Sheet Template (1 per pair or participant)

Sample Fact Sheet (1 per pair or participant)

Pens, pencils, markers

Optional: Scissors and tape or glue stick

Optional: Calculators, Graph paper



TOXIC WASTEWATER
DOESN'T BELONG ON FARM FIELDS!

Every day, Cabot Creamery sprays 100,000 gallons of industrial wastewater on its pasture fields. Now they want to increase it to 150,000!

From Craftsbury to Randolph to St. Albans, the wastewater contains industrial cleaners known to cause...

- Nausea, vomiting, severe inflammation of the stomach and intestinal tract
- Damage to the nose, throat, and lungs
- Potentially, even cancer!

Cabot Creamery must stop spraying!

In 2010, Cabot Creamery's parent company AgriMark made $11 million in profit and $781 million in total sales. They can afford to:

- stop the spraying
- build a wastewater treatment plant as promised
- pay for independent testing to ensure our drinking water is clean & safe.

Take Action!
Speak Out!

Bring these demands to a public hearing with the Vermont Agency of Natural Resources!

Wednesday, December 2 at 6:00 PM
Twinfield Union School
106 Nasmith Road, Plainfield, VT

For more information contact Whey to Go! at name@email.com or (999) 999-9999
wheytogovermont.weebly.com

Fact Sheet Strategies

Features of a Good Fact Sheet

- States a problem that speaks to the audience's concerns
- Proposes a solution
- Includes supporting data (numbers, visuals, and words). Verifiable facts build credibility. Choose them with care, because many people won't bother to read dense text.
- Asks the audience take a specific action to solve the problem
- Lists a contact person and where to find more information

Strategies

1. Identify the target audience for your fact sheet. What kind of information or visuals will get their attention? Consider when and how they will get the fact sheet.
2. List the problem, solution, supporting facts, and actions needed.
3. Prioritize: Which facts, charts, and visuals best support your position or claims?
4. Use the fact sheet template to organize your ideas. Or, use a blank piece of paper to experiment with different layouts.

Note

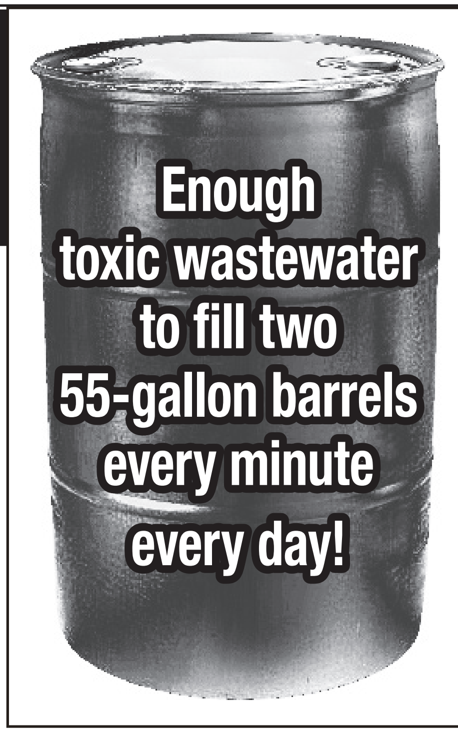
If you brainstorm messages or images that don't fit, keep them! Use them later in a press release or presentation.

Fact Sheet Template

Slogan	Logo image or chart
Problem Statement	
• Facts, statistics, & graphs showing the problem • •	
Solution Statement	
• Facts, statistics, and graphs supporting the solution • •	
Take This Action! • Details	
For more information contact [organization] at [contact info] or [web site]	

Sample Fact Sheet

TOXIC WASTEWATER
DOESN'T BELONG ON FARM FIELDS!



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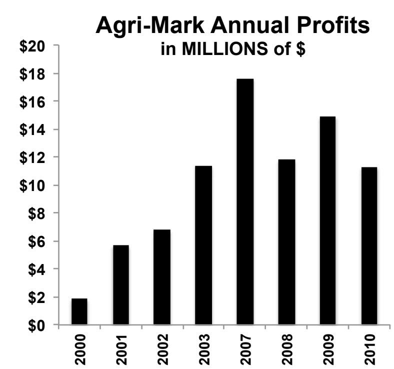

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