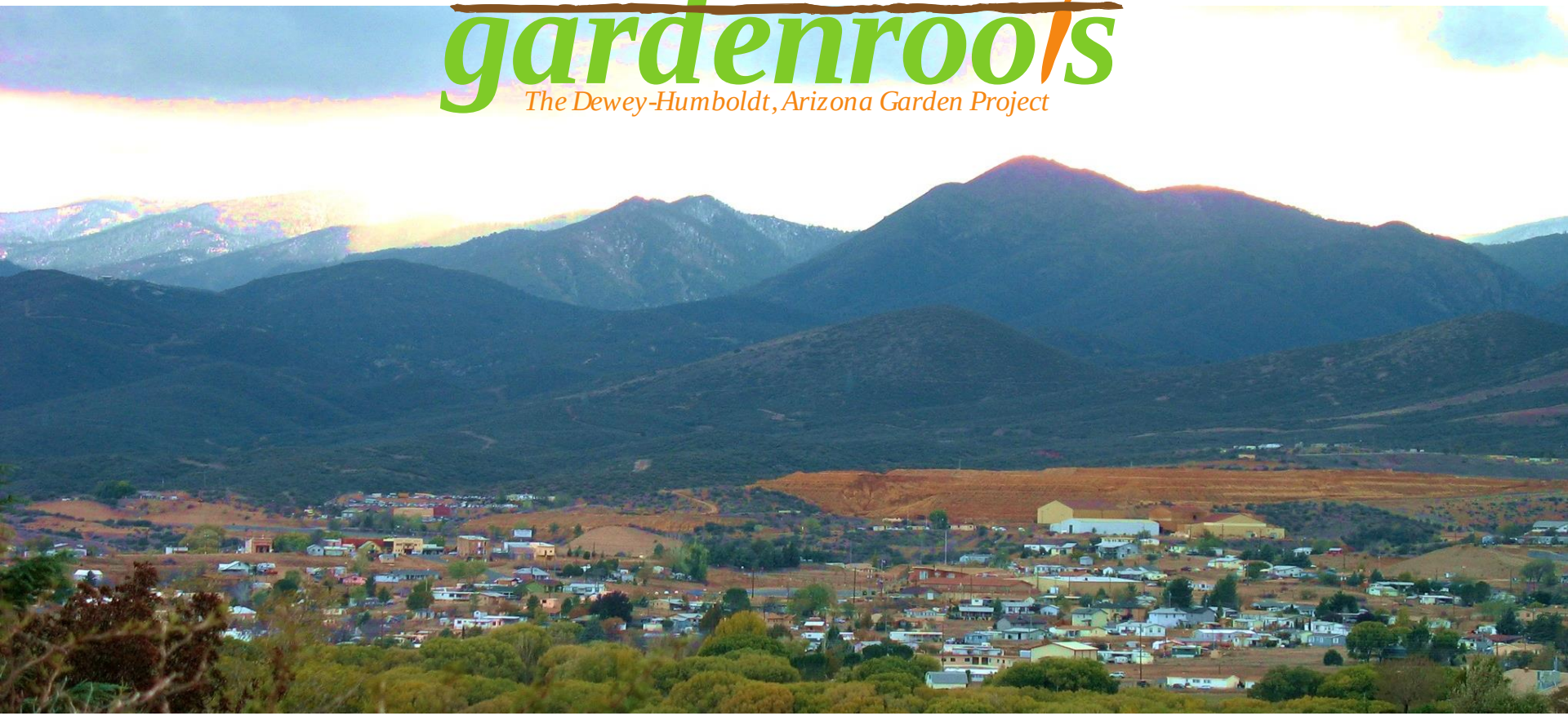
Citizen Science and Environmental Health Risk Communication at Hazardous Sites

gardenroots
The Dewey-Humboldt, Arizona Garden Project



NIEHS PEPH Webinar: Citizen Science, March 24, 2015, 1:00 - 2:30 p.m. EDT

Mónica Ramírez-Andreotta, Assistant Professor, Department of Soil, Water and Environmental Science
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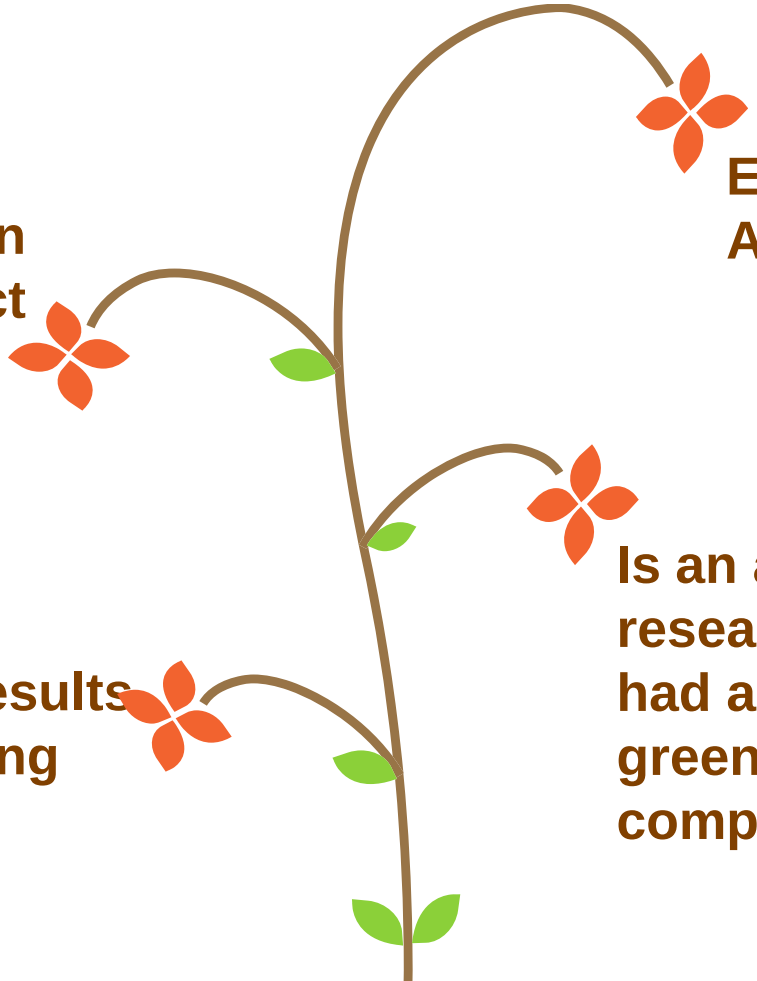
gardenroots

The Dewey-Humboldt, Arizona Garden Project



Environmental Assessment

Co-Created Citizen Science Project

Is an applied research project that had a lab, greenhouse and field component

Reporting back results and communicating risk

Iron King Mine and Humboldt Smelter Superfund Site

Images:
http://www.dcourier.com/main.asp?SectionID=1&subsectionID=1086&articleID=79743,
http://knau.org/post/dewey-humbolt-residents-worry-about-what-old-mine-has-left-behind

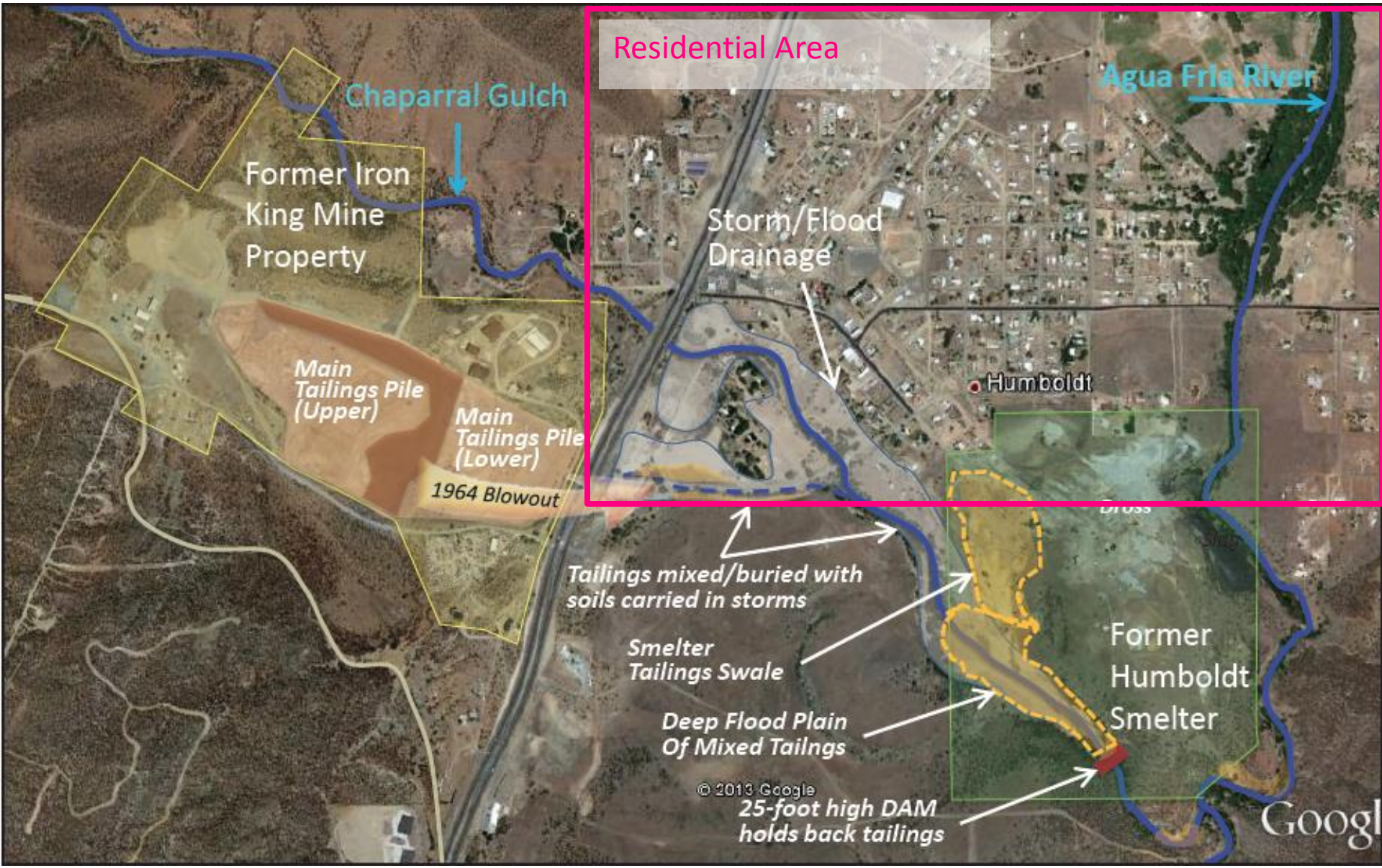


Image: EPA Fact Sheet and Meeting Notification November 2013, http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/ViewByEPAID/AZ0000309013

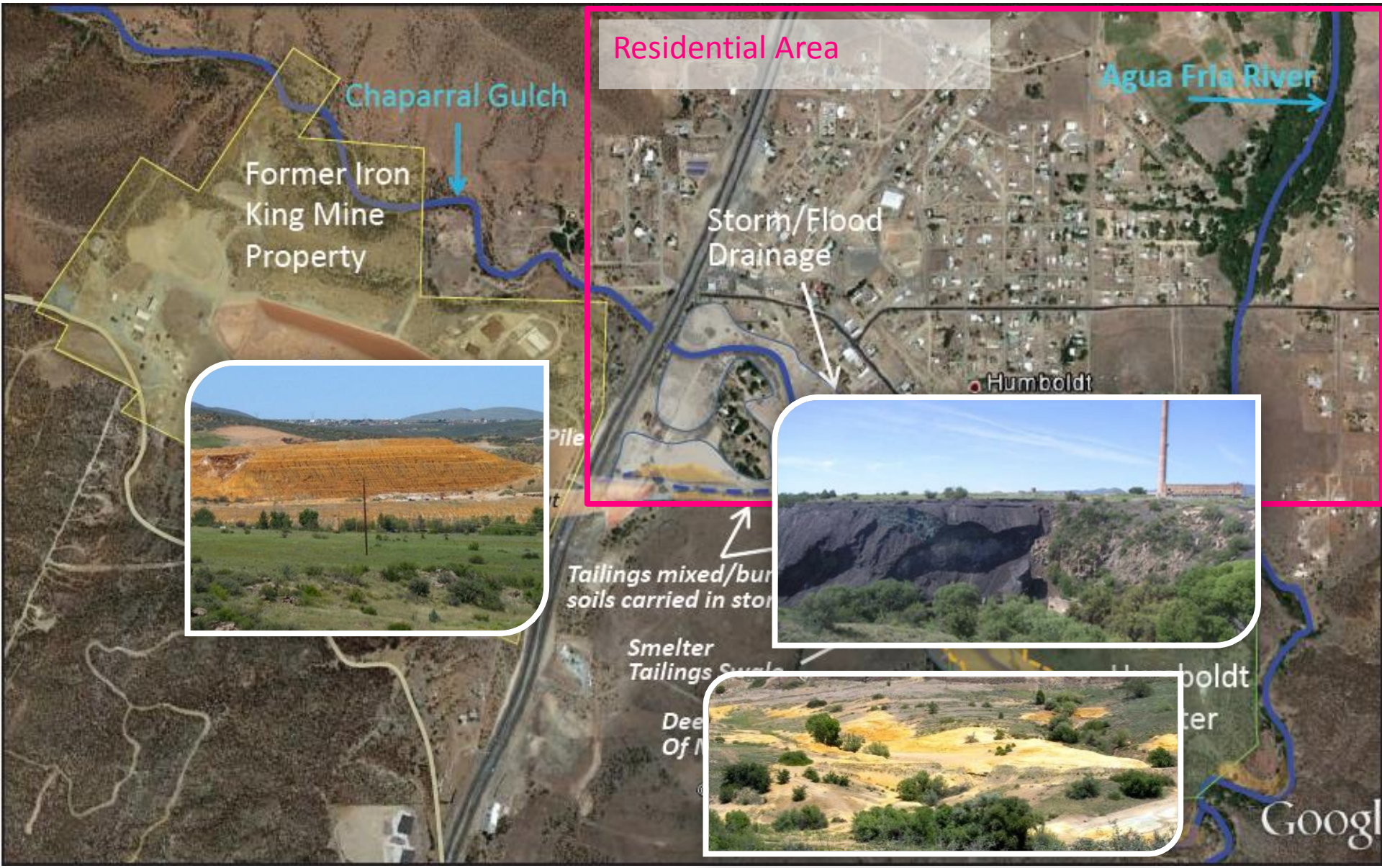
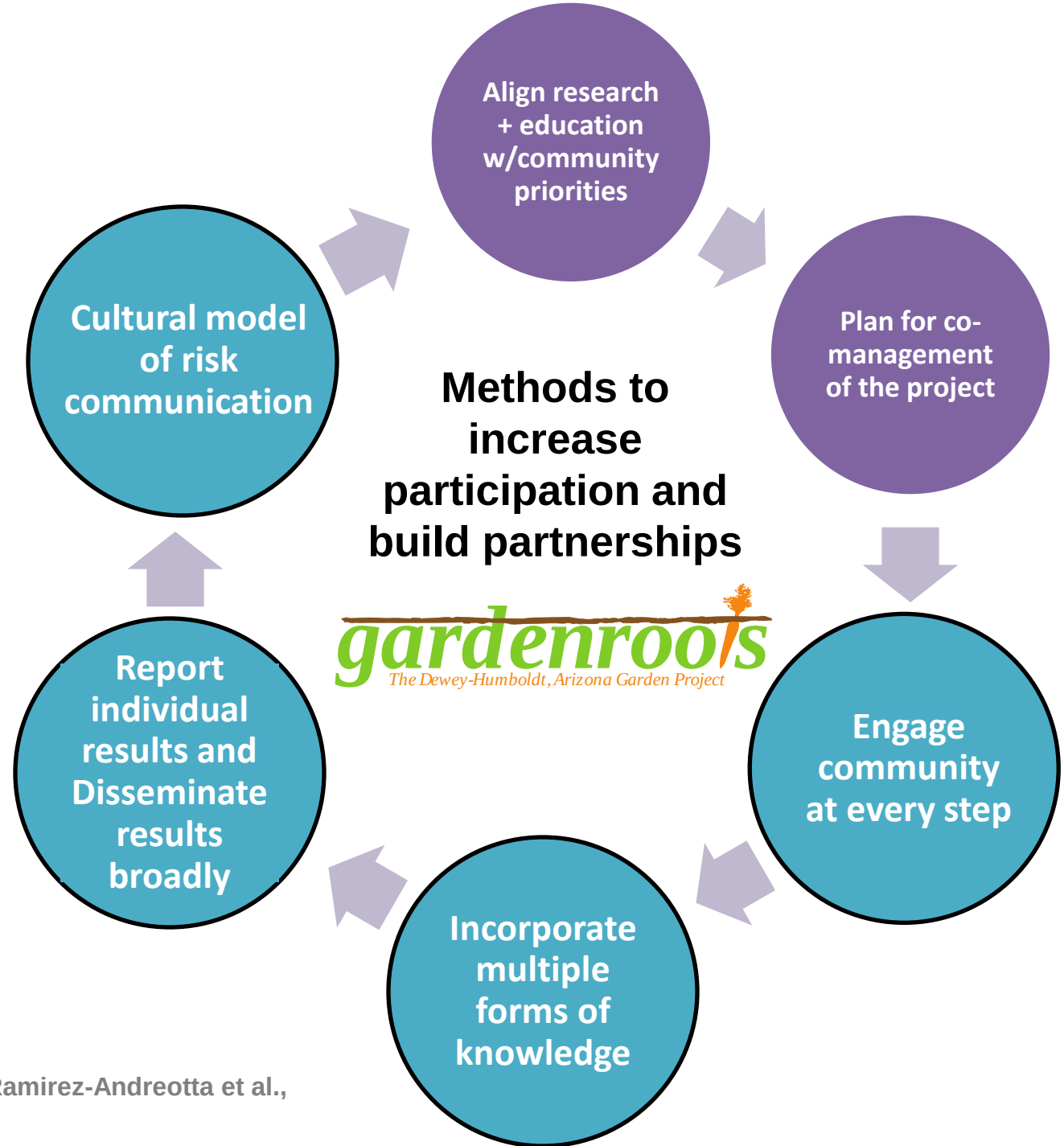


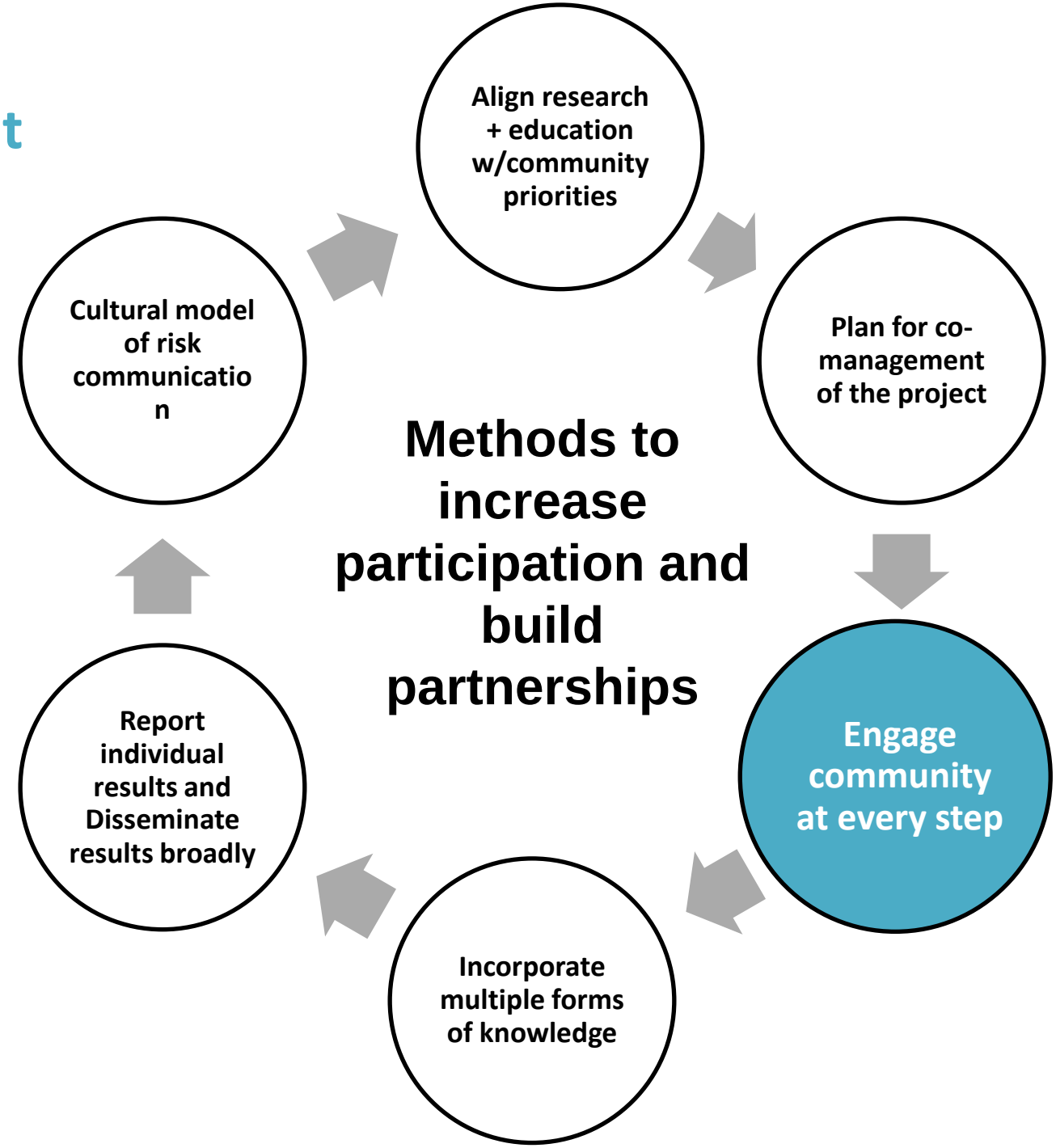
Image: EPA Fact Sheet and Meeting Notification November 2013, http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/ViewByEPAID/AZ0000309013

Working alongside a community neighboring contamination to assess and communicate risk



Israel et al., 1998; Pandya, 2012; Ramirez-Andreotta et al., 2014; Brody et al., 2014

Work alongside the community at every step of the planning and scientific process



Steps in Scientific Research

Choose or define question(s) for study

Gather information and resources

Develop explanations

Design data collection methodologies

Collect samples and/or record data

Analyze samples

Analyze data

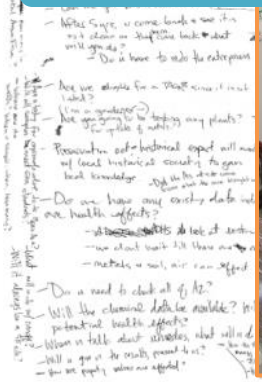
Interpret data and draw conclusions

Disseminate conclusions/ Translate results into action

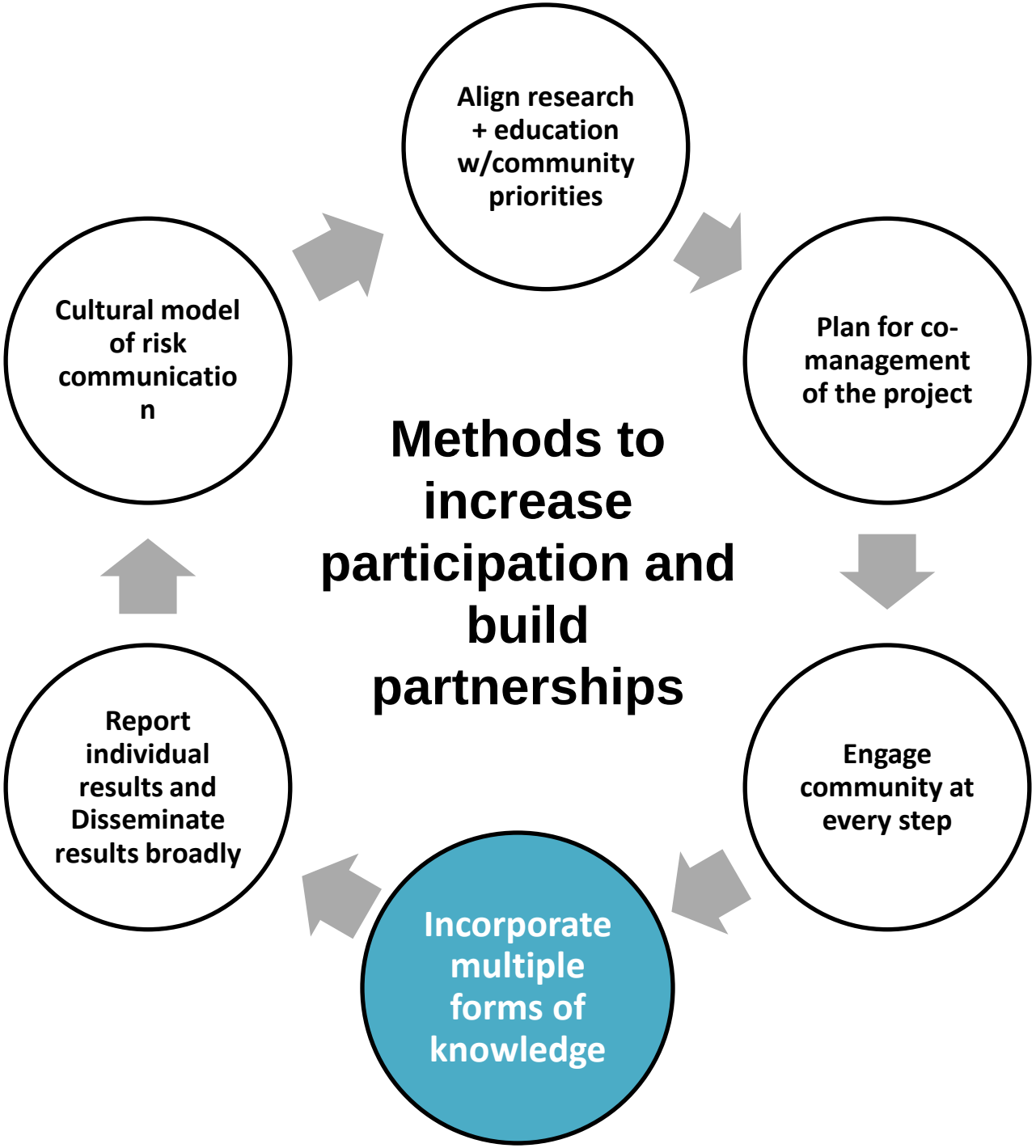
Discuss results and ask new questions

Ramirez-Andreotta et al., 2014. International Public Health Journal

Data Validation – QA/QC



Value local knowledge, historical accounts, and participant observations

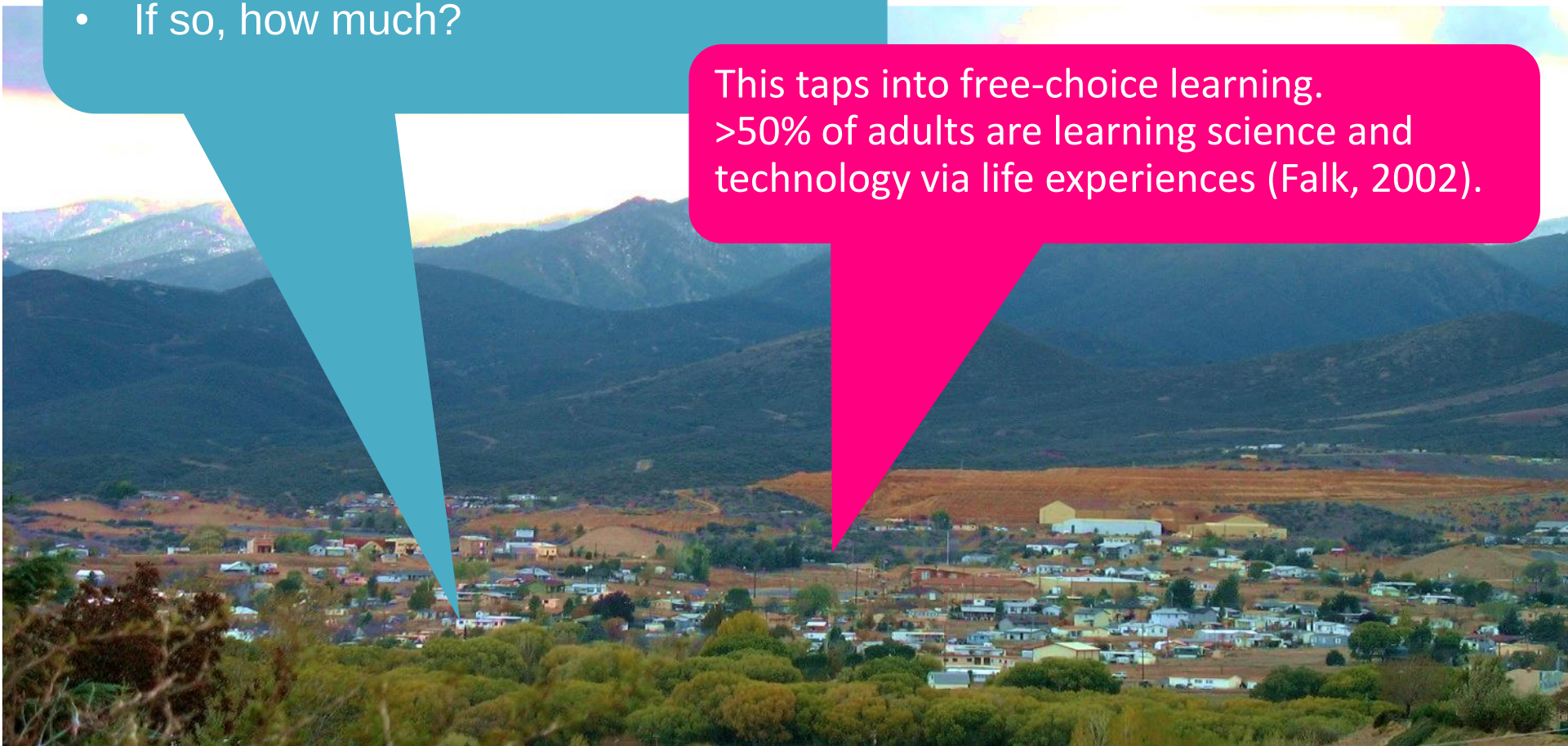


Community question(s) for study

Align research w/community priorities and local knowledge

- Are my soils safe?
- Is it safe for me to consume the vegetables from my garden?
- If so, how much?

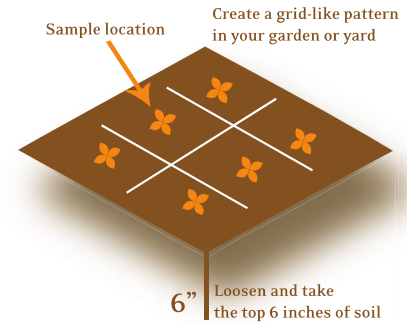
This taps into free-choice learning. >50% of adults are learning science and technology via life experiences (Falk, 2002).

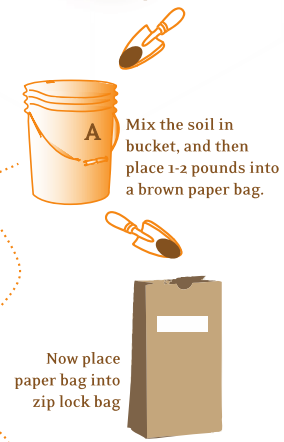


General guidance was given

1. Collecting Soil Samples from your Garden

1. Select (mark) six locations (spots) in a roughly grid-like pattern to sample in your garden.
2. Using a the hand trowel provided, loosen the top 6” of each of the six soil spots.
3. At each location take one full scoop of soil and place it into a 5-gallon bucket labeled A.
4. Mix the six soil samples thoroughly inside the bucket. This process is called sample bulking.
5. Place about 1-2 pounds of the bulked soil sample into a brown paper bag and attach the label provided.
6. Place the soil paper bag into a 1-gallon Ziploc bag making sure that the label on the brown paper bag is clearly visible.
7. Soil should now be air-dried or kept cold until you are ready to drop-off at the Yavapai County Extension Office.





2. Collecting Soil Samples from your Yard

You will do the same soil sampling process as you did above for you garden soil, but now for your yard soil. Complete steps 1-7 above, note for step 3 now use the 5-gallon bucket labeled B.

Drop-Off Checklist:
1) Garden soil sample in paper bag and then 1-gallon Ziploc bag
2) Yard soil sample in paper bag and then 1-gallon Ziploc bag
3) 3 water sample bottles in a 1-gallon Ziploc bag
4) Vegetable samples individually bagged, and then in a 1-gallon Ziploc bag

Drop off all samples at the UA Yavapai Cooperative Extension Office, 840 Rodeo Dr, Bldg C, Prescott, AZ 86305

3. Collecting Water Samples (preferably in the late afternoon)

Using the water source you use to irrigate your garden:

1. Turn on the water (hose) and allow to flow for 2-3 minutes. During this you may fill out the labels of the bottles with all the information requested.
2. Slow the flow to a small trickle and carefully fill each bottle until water overflows.
3. Once full quickly cap each bottle and seal.
4. Place the 3 bottles in a 1-gallon Ziploc bag, seal and store in a refrigerator (do NOT freeze water samples) until you are ready to drop off at the Yavapai County Extension Office.

4. Collecting Vegetable Samples

1. Collect a minimum of 4-5 ounces of 4 different vegetables (leaf, root, or fruit) from your garden and place it temporarily into a brown bag.
2. Take the vegetable sample(s) to the washing area, which should have the following (see diagram below):
   Tub 1 filled with tap water. Use brush to clean all soil off the vegetable sample and rinse.
   Tub 2 filled with provided distilled water and 1 tablespoon of bleach. Dip your sample several times in the solution.
3. Place each sample on clean paper towels and if possible allow to air dry indoors, away from dust for 30+ minutes. Additionally, clean paper towel may be used to soak up excess water as necessary. (note: plant tissue does not need to be fully dried before next step)
4. Place each vegetable sample in separate Ziploc bag(s) that have been pre-labeled, and remove all air from bag before sealing. Then place all your bagged vegetable samples in a 1-gallon Ziploc bag.
5. Promptly place the bag in the refrigerator till you are ready to drop off at the Yavapai County Extension Office.

Vegetable Washing Area as described in Steps 2 and 3

General guidance was given

1. Collecting Soil Samples from your Garden

1. Select (mark) six locations (spots) in a roughly grid-like pattern to sample in your garden.
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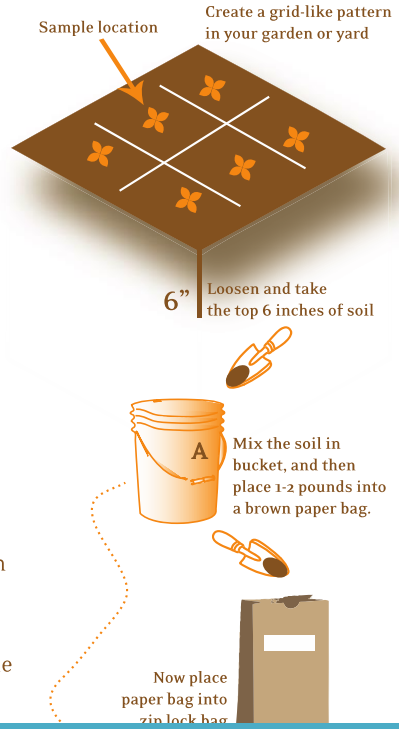

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   Tub 2 filled with provided distilled water and 1 tablespoon of bleach. Dip your sample several times in the solution.
3. Place each sample on clean paper towels and if possible allow to air dry indoors, away from dust for 30+ minutes. Additionally, clean paper towel

Participants decided where to select soil samples and which vegetables to analyze

Drop-Off Checklist:
1) Garden soil sample in paper bag and then 1-gallon Ziploc bag
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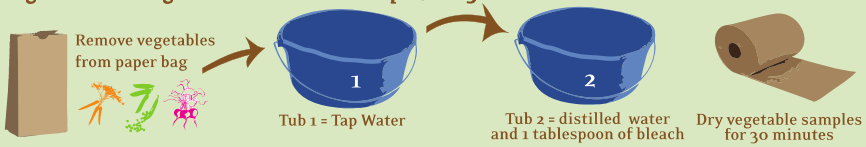
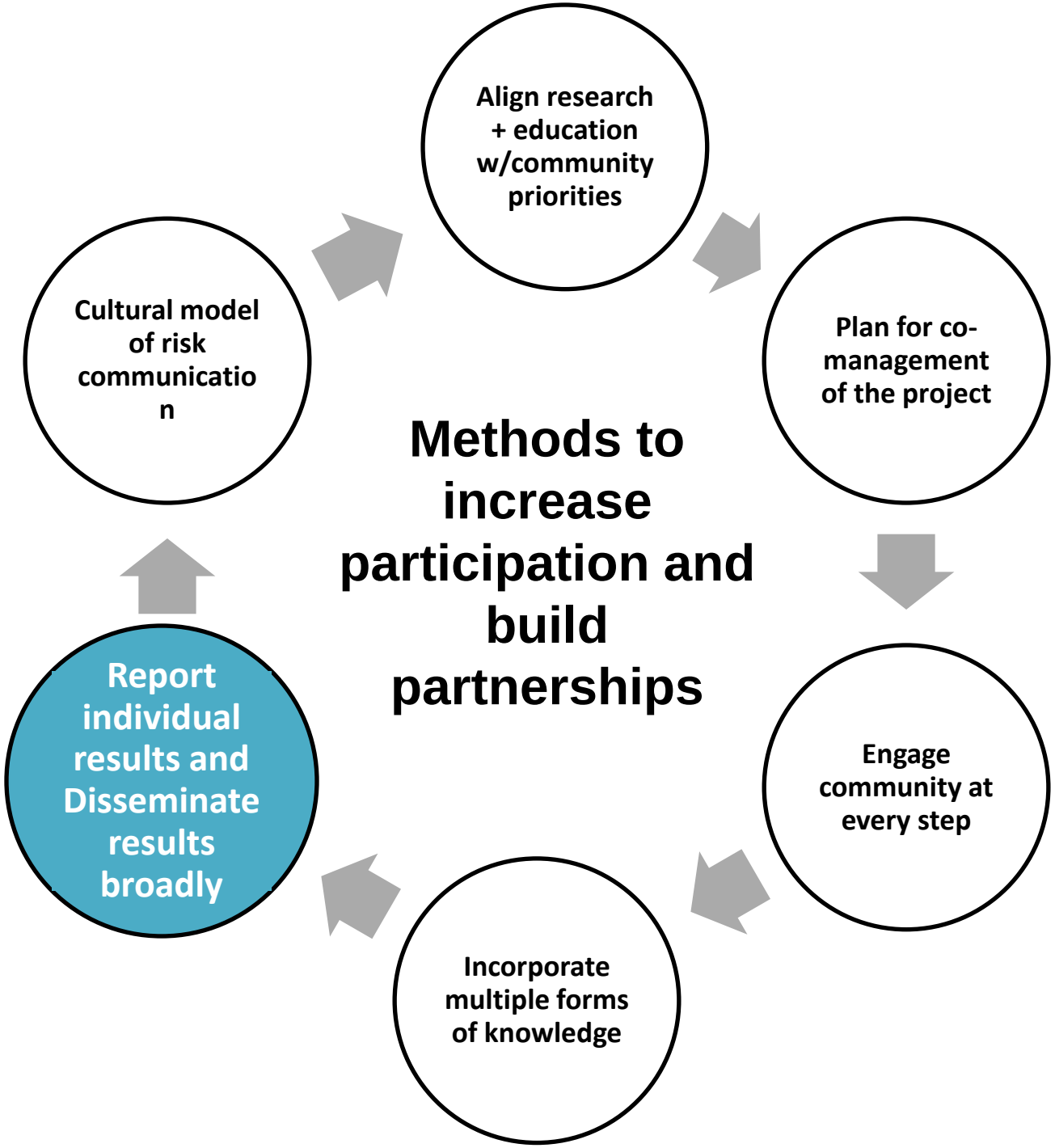
Vegetable Washing Area as described in Steps 2 and 3



Report back initiatives should be relevant to community priorities and the new information should be applicable.



Reporting data

Typical participant questions about personal exposure results, Brody et al., 2007	Information provided to *Gardenroots* participants
Description	
What did you find? What did you look for?	Concentration of arsenic (contaminant of concern) and 19 other elements of potential interest
How much?	Concentrations for all 20 elements were presented in a chart for all their vegetables, soil and water samples analyzed.
Analysis/Comparison	
Is that high?	Arsenic concentrations observed in vegetables from the USDFA Market Basket Study were used for comparison. Regional soil screening levels and the maximum contaminant levels in water was provided.
Is that safe?	Chart exhibiting how much of the vegetable can be consumed from their garden at various excess target risks
What should I focus on?	Participants were able to compare the risk posed from each exposure route (water, soil, vegetable) and the arsenic concentration in each vegetable to then decide where to focus mitigation efforts
Where did the chemical come from?	Participants identified their gardens as potential sources of arsenic and initially asked the research question
Recommendation	
What can/should I do?	Exposure reduction/precautionary strategies were provided such as: recommended gardening practices handouts were generated to guide gardeners, “Arizona Know Your Water” and “Arizona Know Your Well Water” guides

Ramirez-Andreotta MD et al. 2014. Building a co-created CS program with gardeners neighboring a Superfund site: The Gardenroots case study. In: Public Health: Improving Health via Inter-Professional Collaborations, (Caron RM, Merrick J, eds).

Results for Lunch

Your Soil, Water and Vegetable Outcomes

gardenroots

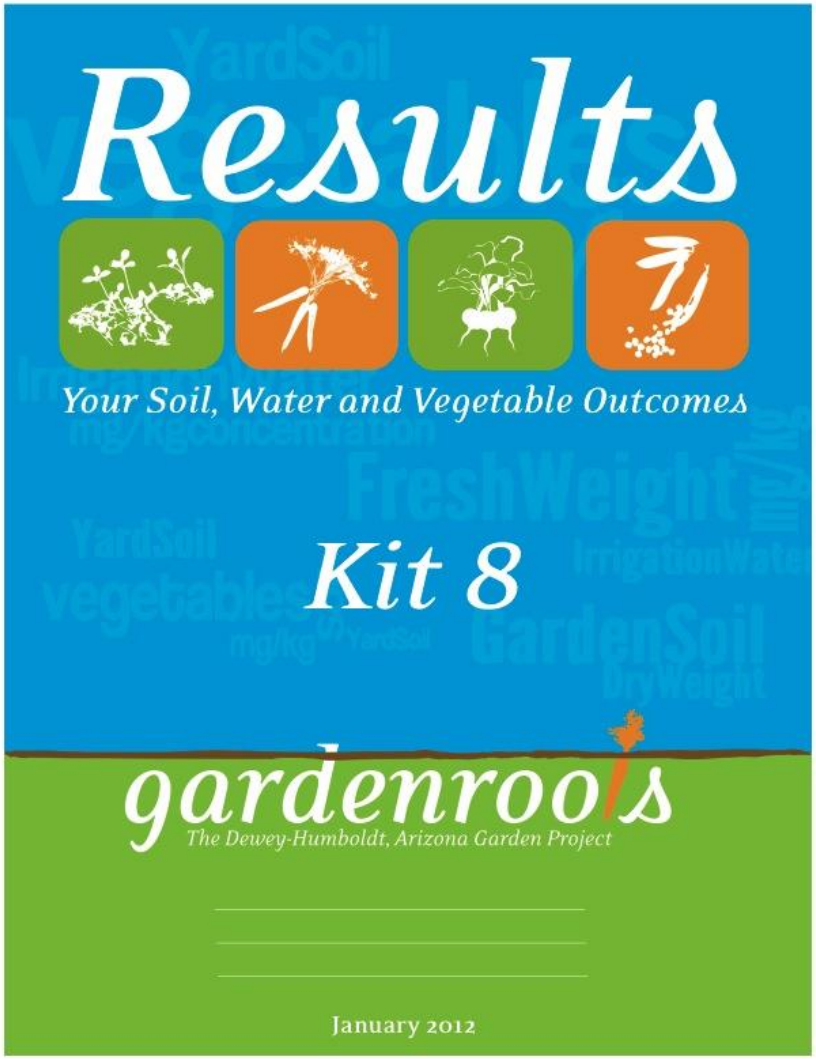
The Dewey-Humboldt, Arizona Garden Project

Saturday January 28, 2012
11:00AM to 2:00PM

Dewey-Humboldt Town Library
2735 S. Corral Street

Culminating experience of the project. Food! Open Discussions! Presentations!

Reporting All Results and Potential Risks at the Individual/Household Level



- The metal(loid) concentrations in their soil, water and vegetables
- How much they can eat at various target risks
- Estimated risks associated with soil, water and vegetables → allowed participant to compare risks posed by the different exposure routes
- Nutritional content in vegetables

Examples

Soils

Arsenic is a solid substance (metalloid) naturally existing in the Earth's crust and in crushed rock. Arsenic exposure is natural but can be increased as a result of human activities.

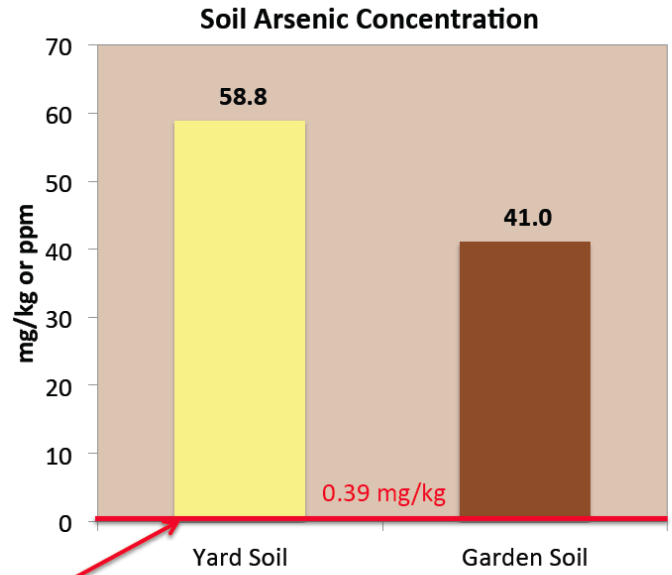
The concentration of arsenic in soil varies widely, generally ranging from about 1 to 40 mg/kg with an average level of 5 mg/kg. In general, Yavapai County has naturally occurring arsenic due to the geology in the area, which can lead to higher concentrations in soil and water.

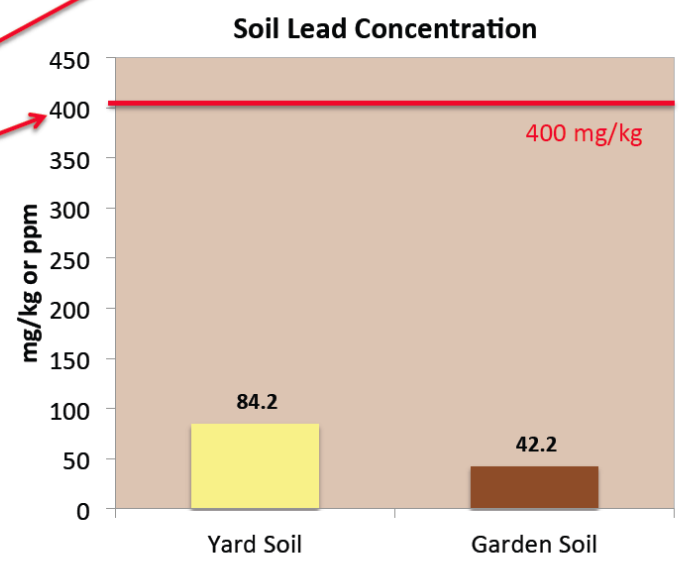
U.S. EPA Residential Regional Screening Levels

Lead is a metal in the earth's crust that is normally found with other metals such as zinc, silver, and copper.

All the soils in the world contain small amounts of naturally occurring lead with an average of 10 mg/kg.

The graphs below show the concentrations of arsenic and lead in the yard and garden soil samples you provided.





- Elemental information
- Naturally occurring levels
- Brief explanation

Contaminants of concern and reference values visually displayed

Examples

Element Concentrations in your Yard and Garden Soil Samples

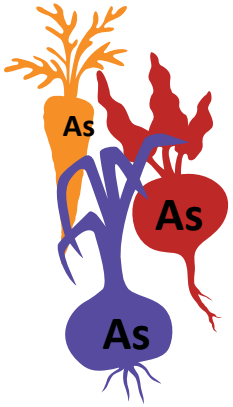
Element	Yard Soil	Garden Soil	U.S. EPA Residential Regional Screening Level (mg/kg or ppm)
Arsenic	58.8	41.0	0 .39
Barium	373	346	15,000
Beryllium	0.634	0.879	160
Cadmium	1.34	0.862	70 (Diet)
Calcium	11,500	7,490	No screening level
Chromium	40.1	39.2	No screening level for total chromium
Cobalt	17.6	20.2	23
Copper	174	119	3,100
Iron	47,500	42,400	55,000
Lead	84.2	42.2	400
Magnesium	4,810	5,370	No screening level
Manganese	2,690	2,680	1800 (Non-diet)
Mercury	0.0692	0.0374	10
Molybdenum	0.950	0.738	390
Nickel	30.3	33.1	1500 (Soluble salts)
Phosphorous	1,480	1,420	No screening level
Potassium	4,210	4,060	No screening level
Selenium	1.83	2.01	390
Sodium	128	156	No screening level
Zinc	336	171	23,000

All concentrations and reference values

pH Values in your Yard and Garden Soil Samples

pH	Yard Soil	Garden Soil	USDA Natural Resources Conservation Service - Optimal Range for Crops
	7.63	7.57	6 - 7.5

In addition to concentration data, all methods and mathematical equations used for exposure assessment and risk characterization were given



Bioavailability of arsenic

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This was important in order to build their capacity when working with regulatory agencies.

Scale Image source: http://www.healthycheck.net, Sand Clock: http://all-free-download.com/free-icon/vista-icon/sand_clock_5101.html, Measuring cup:http://www1.free-clipart.net/gallery2/clipart/Household/Kitchen/Measuring_Cup_2.jpg

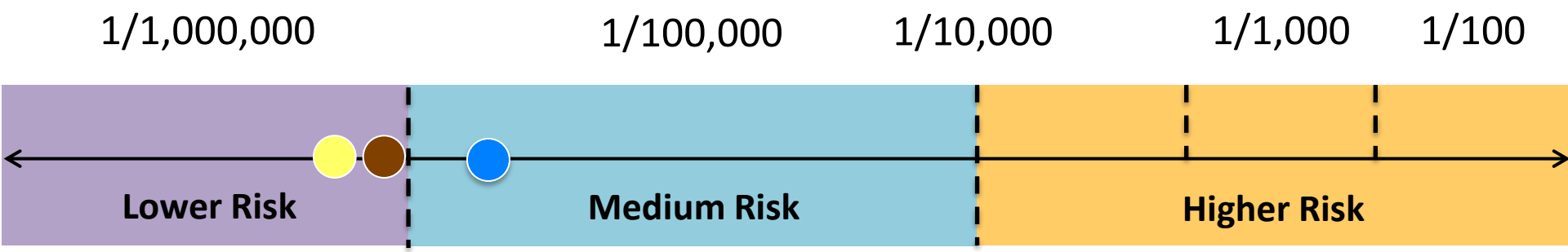
Individual Booklet: Soil and Water

Risk Characterization for Arsenic: Cancer			
	Yard Soil	Garden Soil	Scenario: Accidental soil ingestion while gardening
Incremental Excess Lifetime Cancer Risk	15 out of 1,000,000	9 out of 1,000,000	

Risk Characterization for Arsenic: Cancer		
Incremental Excess Lifetime Cancer Risk	5 out of 100,000	Scenario: Drinking 2 liters/day

Legend

- Yard Soil
- Garden Soil
- Irrigation Water



Compared *Gardenroots* to a nationwide study for reference

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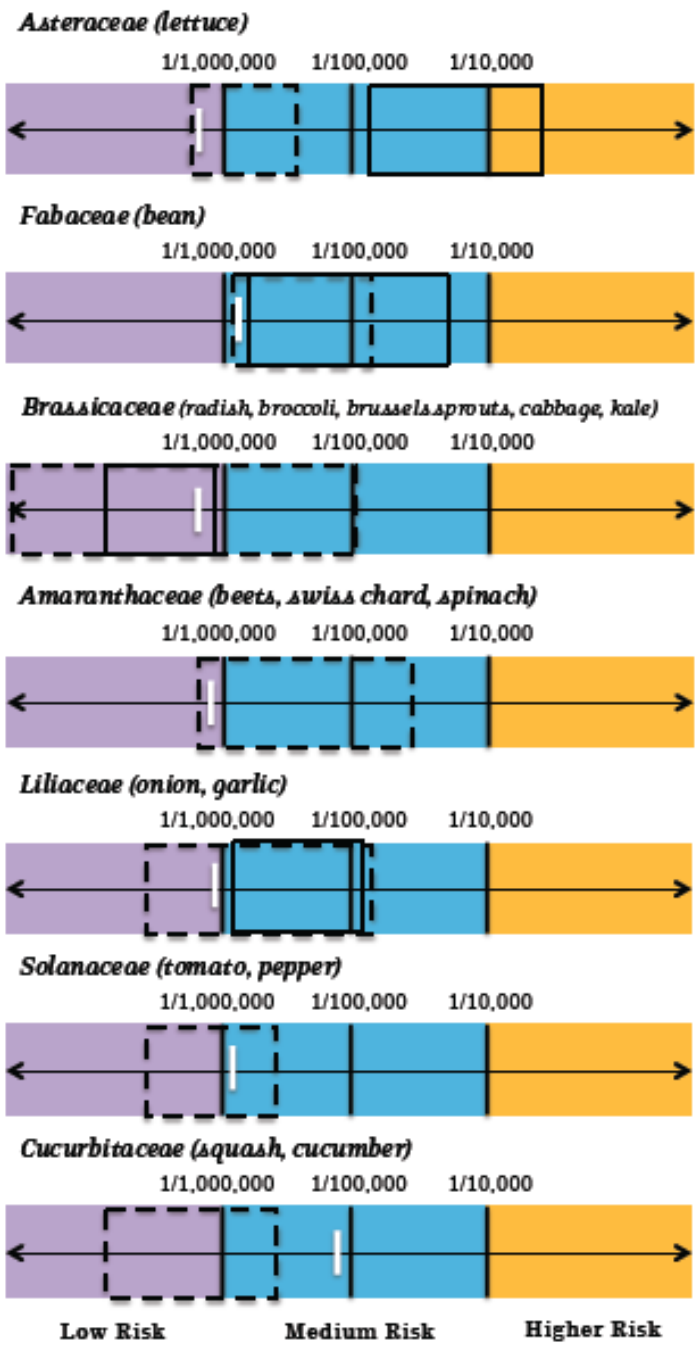
The Dewey-Humboldt, Arizona Garden Project

U.S. Food and Drug Administration
Protecting and Promoting *Your* Health

Total Diet Study – Market Baskets

Summary Report of all Data and Potential Risk

Potential risk associated with vegetable families



The risk ranges are shown in the dashed boxes for home garden vegetables and solid boxes for the greenhouse vegetables. The white line is for comparison, and represents the average number of excess cancer cases using the average arsenic concentrations for vegetables (in the given plant family) purchased in U.S. grocery stores (U.S. Food & Drug Administration's Market Basket study). The risk calculations include the measured arsenic concentrations from the home garden vegetables and the assumptions below:

- A U.S. EPA intake rate for the vegetable, water or soil (incidental) one would be consuming daily
- Body weight (60 kg = 132 lbs.)
- Life span equal to 78 years
- Eating that vegetable, drinking the water or incidentally ingesting soil 350 days out of the year for 30 years
- U.S. Environmental Protection Agency's cancer slope factor
- Bioavailability of arsenic once it's in your body

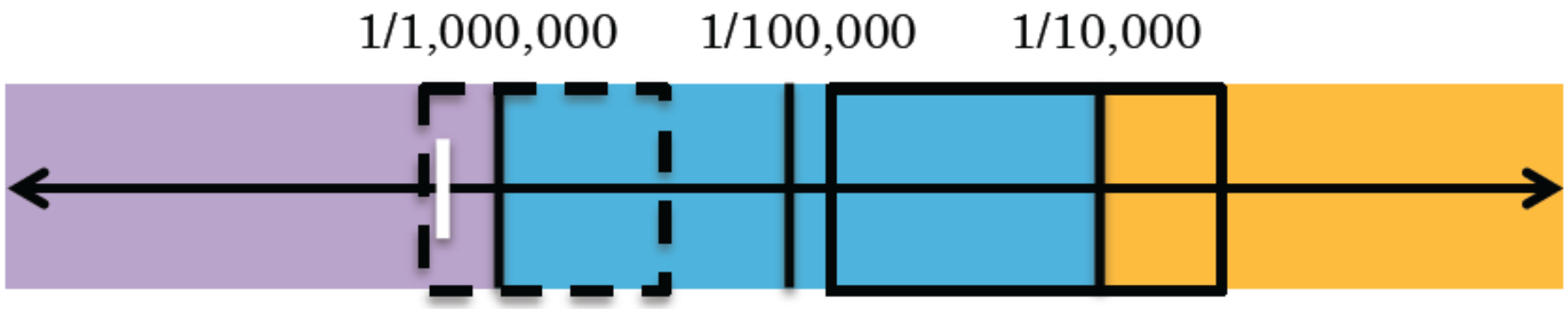
There are uncertainties associated with the calculations, for example an individual living in the area will be eating the vegetable for 350 days a year for 30 years. This is unlikely due to limited vegetable growing seasons and changes in garden productivity. Therefore, the calculated risks are conservative, and the actual risk values would most likely be smaller.

Reading the figures

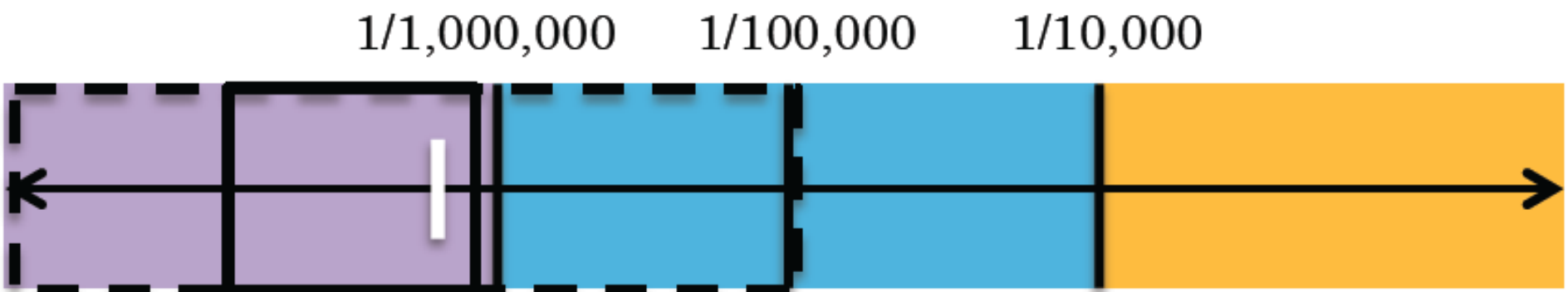
When you see 1/1,000,000 that means 1-in-a-million excess cancer cases above our already existing cancer risk.

Summary Report of all Data and Potential Risk

Asteraceae (lettuce)

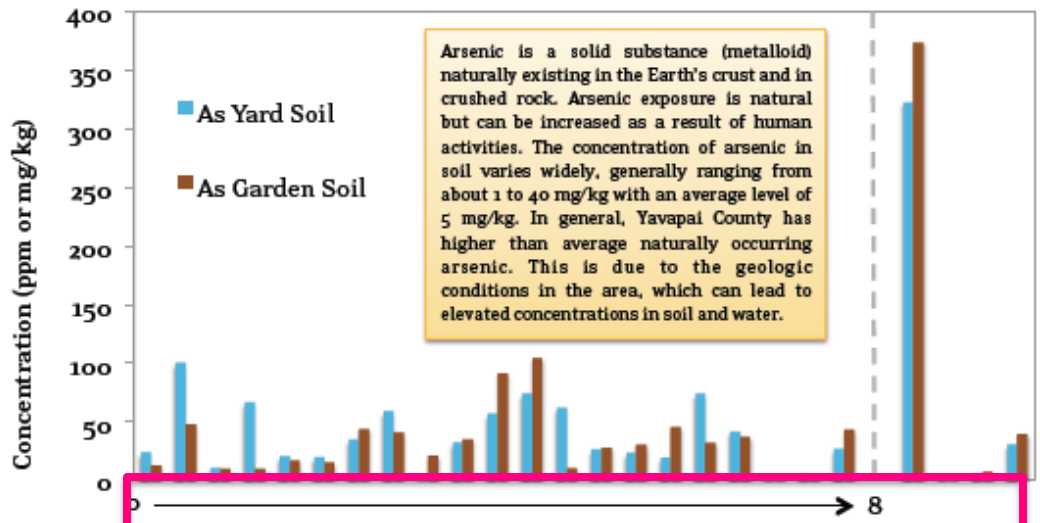


Brassicaceae (radish, broccoli, brussels sprouts, cabbage, kale)



Summary Report of all Data and Potential Risk

Concentration of arsenic in home yard and garden soils

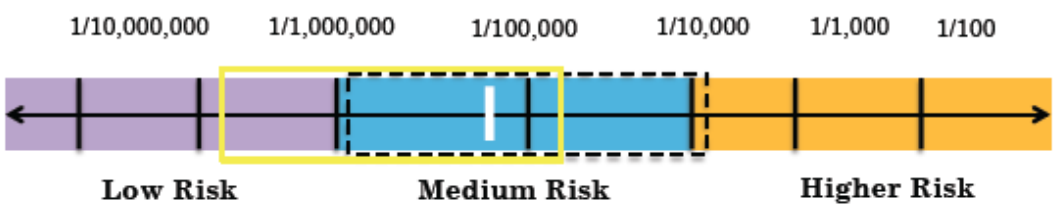


Arsenic concentrations in home garden and yard soils of participants. Distance from the Iron King mine tailings increases along the x-axis, from 0 to 8 miles in the northeast direction. The four samples to the right of the dotted line are sample locations towards the southeast, northwest, north and south of the tailings.

Gardenroots participants hypothesized that the closer to the tailings a home was, the higher the arsenic concentration would be in the soils. There is no obvious pattern to support this hypothesis. It should be noted that: 1) the number of *Gardenroots* samples is not sufficient to truly characterize the spatial distributions; 2) wind direction in the area changes seasonally; and 3) this area has been affected by both smelting and mine tailings, which produce different sized particles that can experience different levels of transport by wind.

It was also hypothesized that the garden soils would have a lower soil arsenic level than the yard soils, given that the garden soils would be mixed with garden amendments. Interestingly, the average soil arsenic concentration in the yard soils (46.0 mg/kg) and garden soils (44.1 mg/kg) are similar, and 12 of the 25 home garden soil samples had a greater soil arsenic concentration than the yard soils. This highlights that commercially available and other local gardening amendments may contain arsenic.

Using the arsenic concentrations found in the garden soils, the potential risk was calculated using the same calculation described on page 5. Below, in the dashed box is the excess cancer risk range associated with those concentrations. The white line represents the potential excess cancer risk associated with the arsenic Arizona Soil Remediation Standard (10 mg/kg). The yellow box represents the potential excess cancer risk associated with the U.S. EPA Residential Regional Screening Level range (0.39 mg/kg to 39.0 mg/kg).

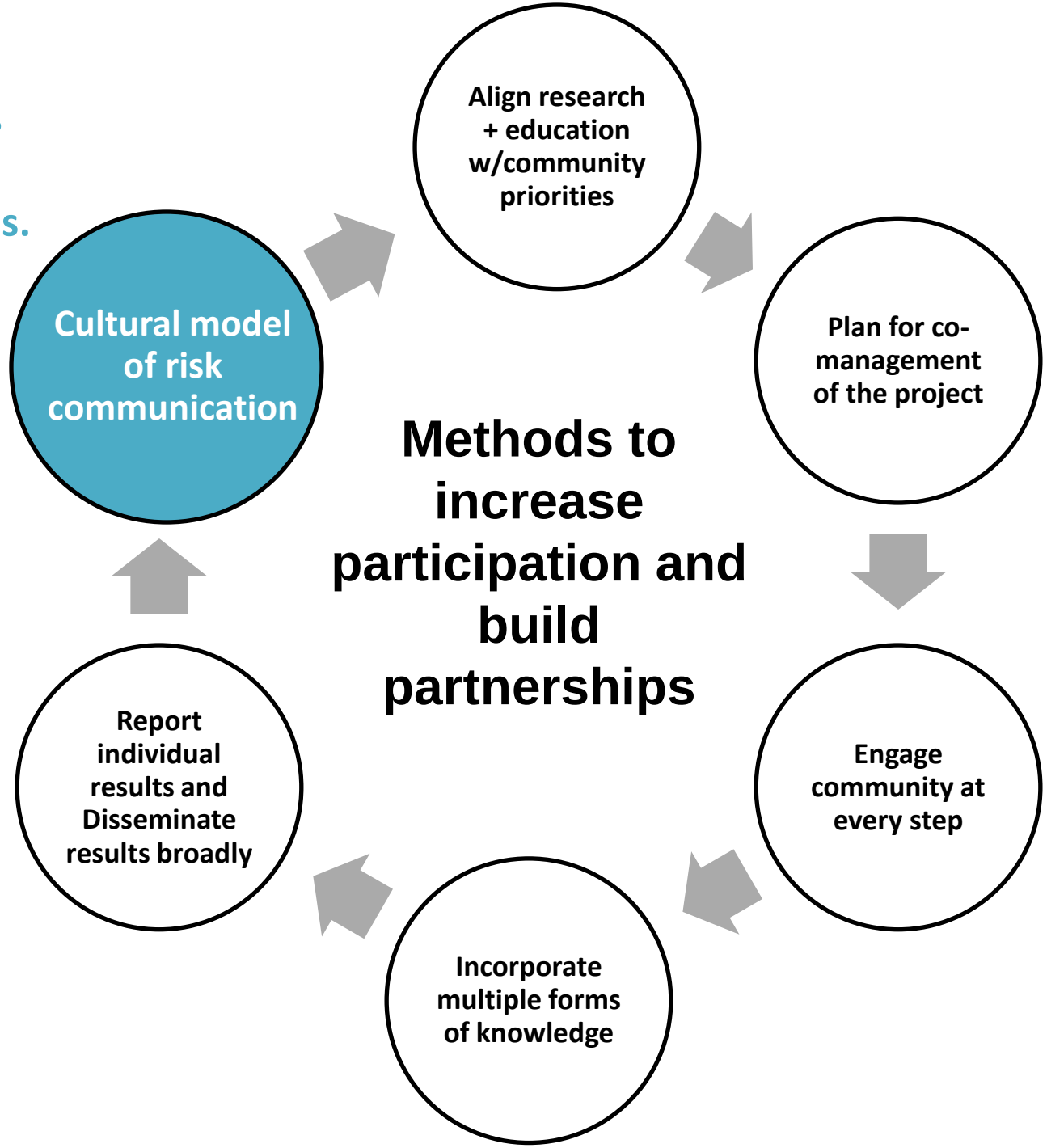


Data organized based on participant's hypotheses and initial observations

Risk communication is tailored to community's need so they may make more informed decisions.

Specific steps are presented to assert control and reduce exposure to potential environmental hazards

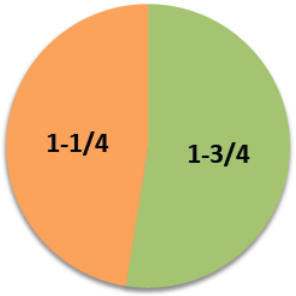
Involve affected groups in judgments of acceptable and unacceptable risks



Vegetables

Using the USDA recommendation, and the measured arsenic concentration from your vegetables, the pie chart below shows how much you can safely eat from your garden at a target risk of 1/100,000.

Kale



Your Garden

Other

You can safely eat up to 1-3/4 cups of Kale weekly from your garden; the rest should be store bought (USDA recommends 3 cups/week of "Raw Leafy Green Vegetables").

How much to eat from garden?

Concentrations of All Measured Elements (Fresh Weight, mg-element/kg-vegetable)	
Element	Kale
Arsenic	0.0371
Barium	0.941
Beryllium	≤LOD
Cadmium	0.00861
Calcium	2,540
Chromium	0.0129
Cobalt	≤LOD
Copper	0.426
Iron	6.07
Lead	0.00799
Magnesium	350
Manganese	2.70
Molybdenum	0.00210
Mercury	0.294
Nickel	0.0127
Phosphorous	569
Potassium	5,300
Selenium	0.0357
Sodium	249
Zinc	4.14

All raw values

But wait!

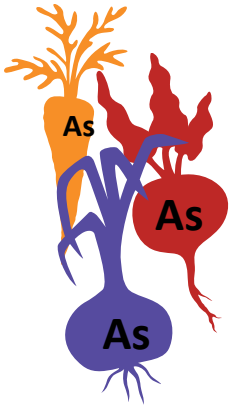
Allowed them to decide for themselves

"It is your choice to decide what target risk you want to use to make decisions about how many cups per week to consume from your garden."

Amount You Can Eat from Your Garden Based on a Cancer Target Risk

Location	Target Risk 1/1,000,000	Target Risk 1/100,000	Target Risk 1/10,000	USDA Recommended Amount (cups/week)
Onion				
Your Garden	3/4	7	70	4 cups/week total of "Other Vegetables"
Lettuce				
Your Garden	1/2	5	50	3 cups/week total of "Raw Leafy Dark Green Vegetables"
Tomato				
Your Garden	1-1/2	15	150	5 cups/week of "red and orange vegetables"

Explained how exposure assessments are conducted to build their capacity when working with regulatory agencies.

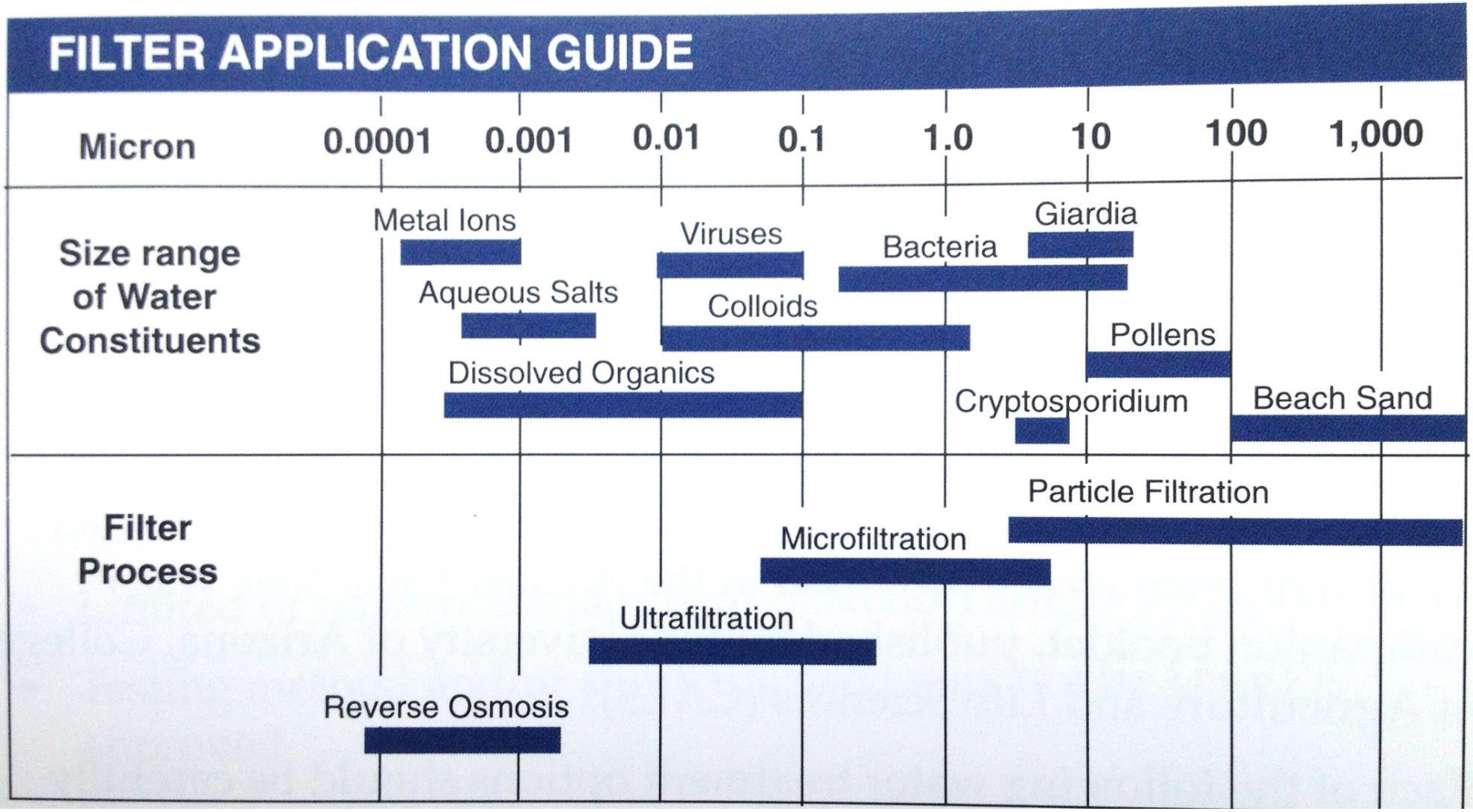


Bioavailability of arsenic

Participants recalculated their potential exposure and risk by changing the assumptions to suit their behavior

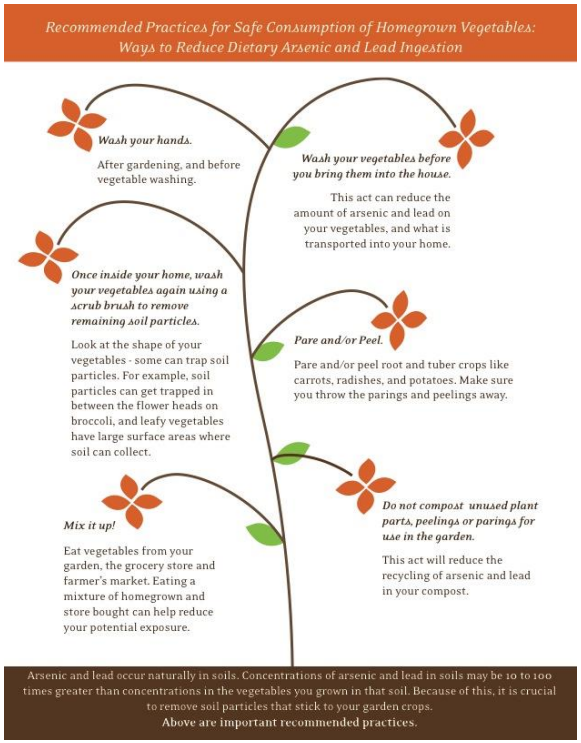
Scale Image source: http://www.healthycheck.net, Sand Clock: http://all-free-download.com/free-icon/vista-icon/sand_clock_5101.html, Measuring cup:http://www1.free-clipart.net/gallery2/clipart/Household/Kitchen/Measuring_Cup_2.jpg

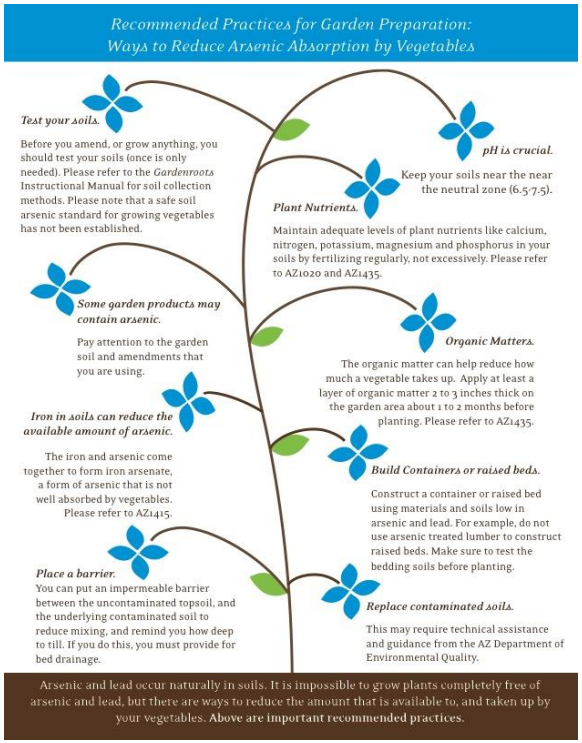
Present Solutions and Recommendations

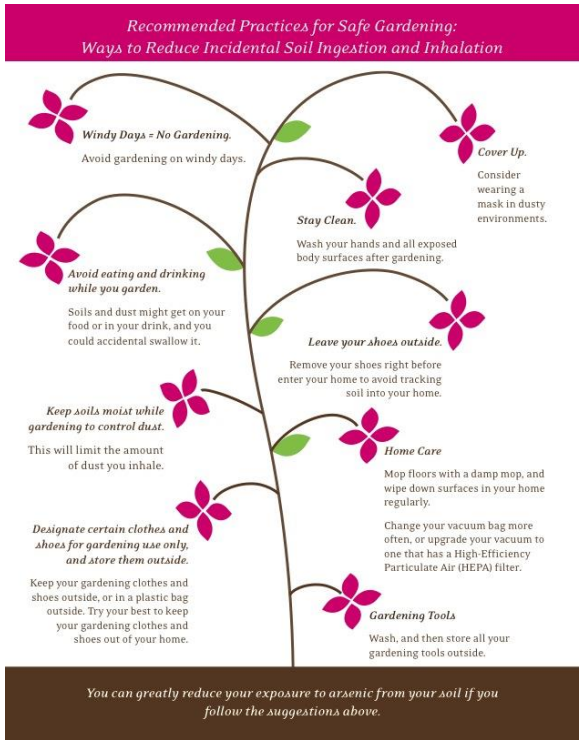


Water Testing and Treatment Systems

Present Solutions and Recommendations







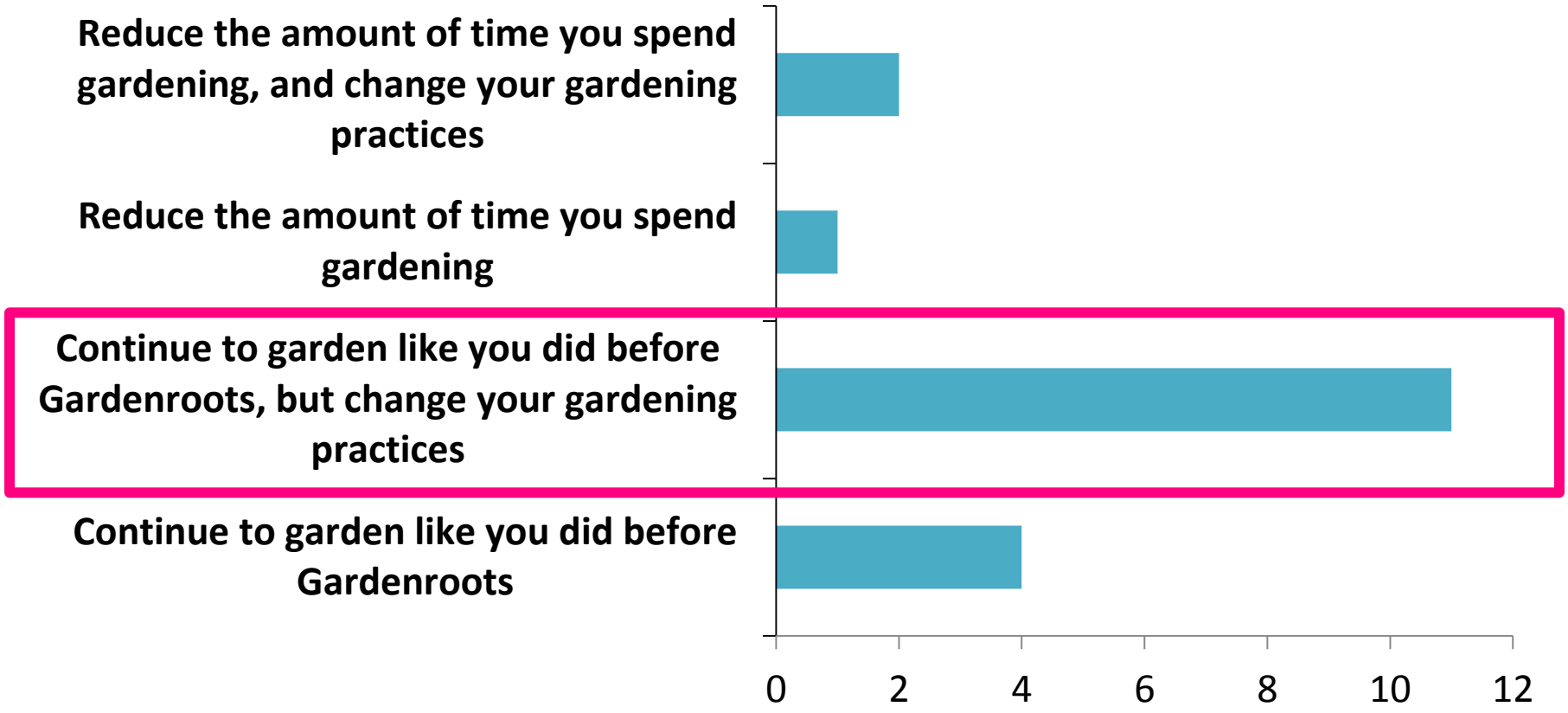
Safe Consumption of Homegrown Vegetables

Garden Preparation

Safe Gardening

Did this Risk Communication Method Work?

Now that you have the results from your garden, will you:



Ramirez-Andreotta MD et al. 2014. Building a co-created CS program with gardeners neighboring a Superfund site: The Gardenroots case study. In: Public Health: Improving Health via Inter-Professional Collaborations, (Caron RM, Merrick J, eds).

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The Dewey-Humboldt, Arizona Garden Project

Individual Outcomes – Increased understanding of soil contamination, food quality, and the scientific process

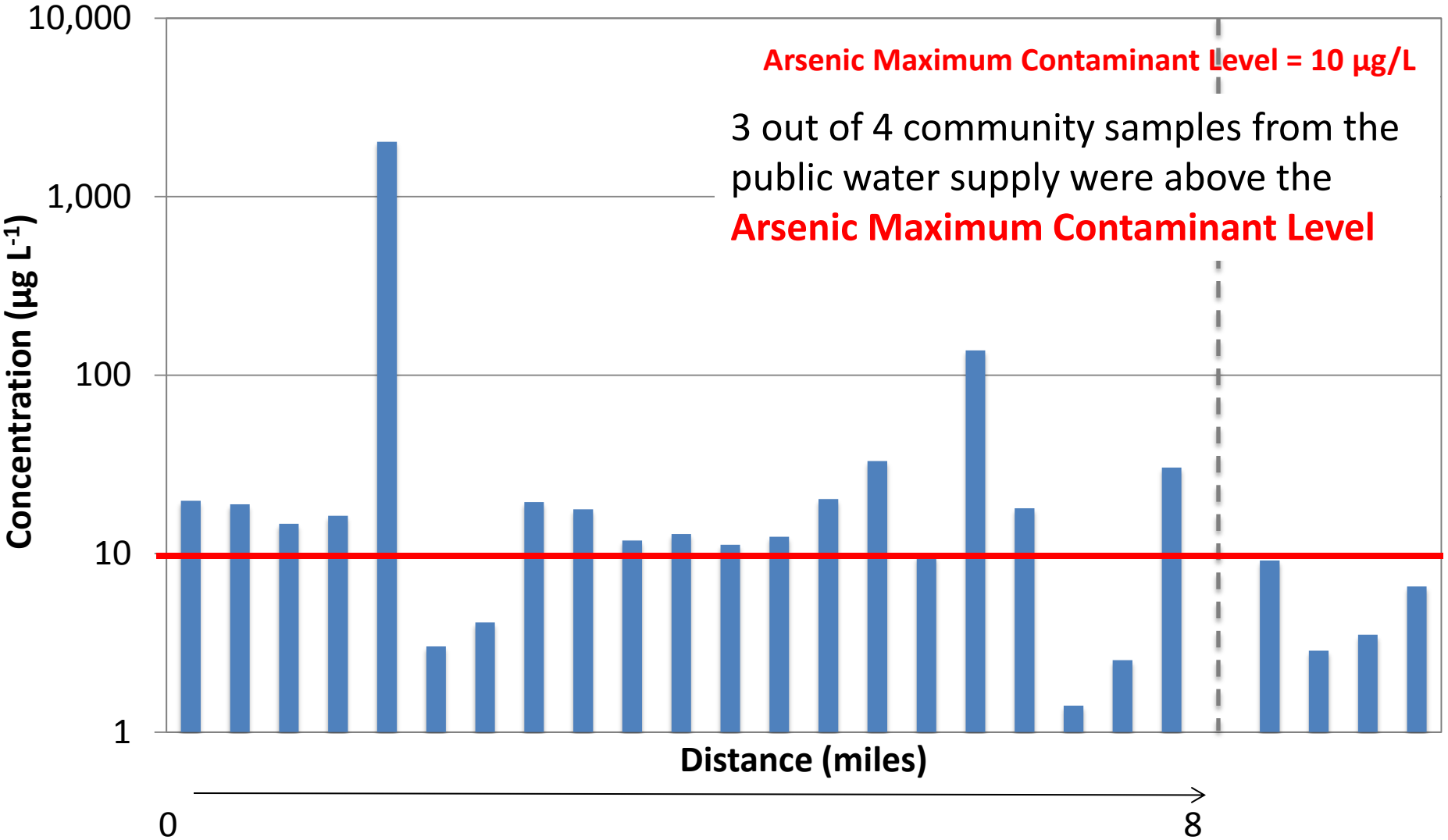
Programmatic Outcomes – Advanced our understanding of soils, uptake of arsenic by vegetables, exposure and risk

Community Outcomes – Increased social capital and community capacity (i.e. community networking and participation in resource-related issues

Outcomes

Did this Risk Communication Method Work?

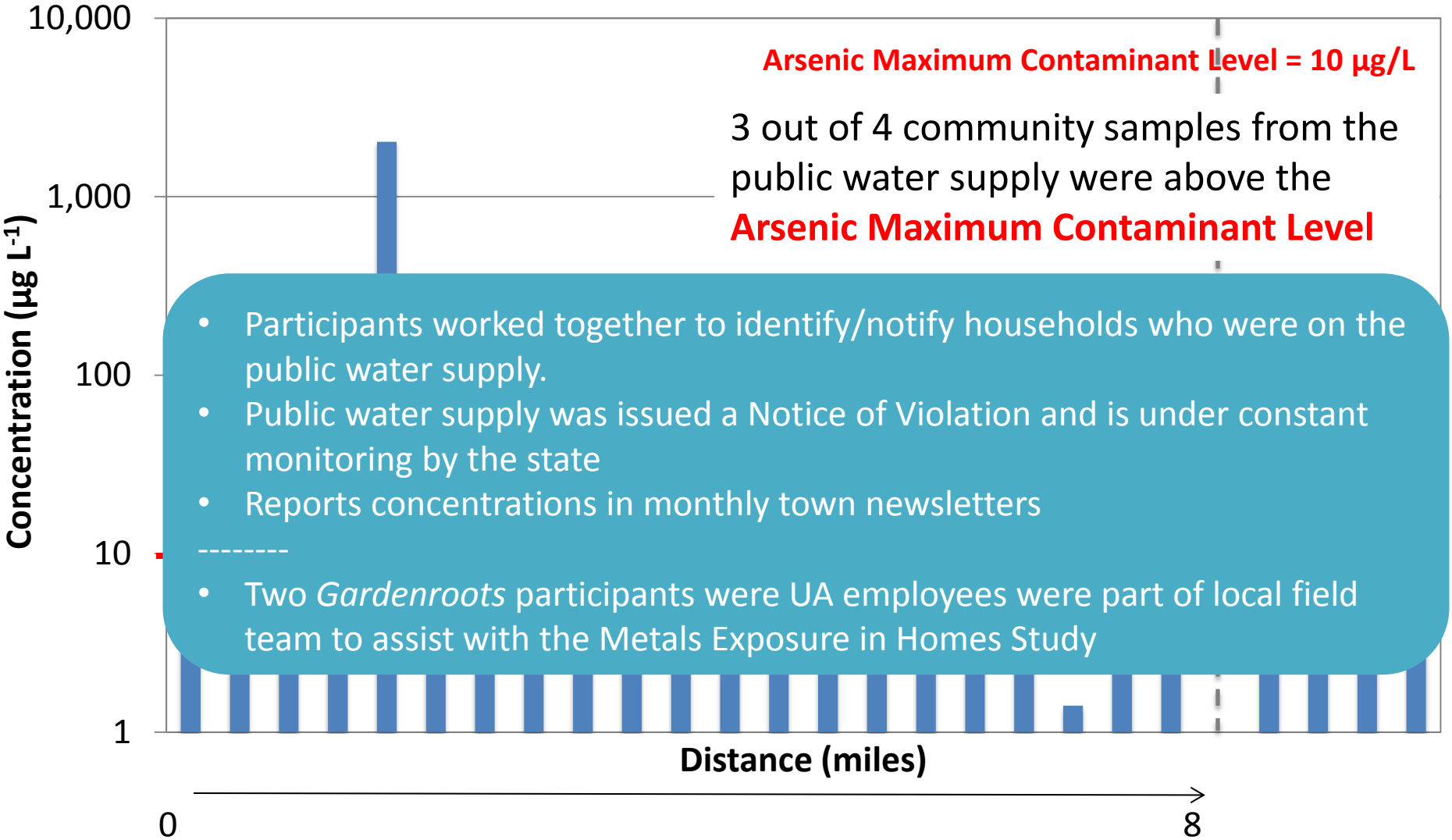
Outcomes: *Environmental Action and Social Capital*



Ramirez-Andreotta et al., 2013

Did this Risk Communication Method Work?

Outcomes: *Environmental Action and Social Capital*



- Participants worked together to identify/notify households who were on the public water supply.
- Public water supply was issued a Notice of Violation and is under constant monitoring by the state
- Reports concentrations in monthly town newsletters

- Two *Gardenroots* participants were UA employees were part of local field team to assist with the Metals Exposure in Homes Study

Ramirez-Andreotta et al., 2013

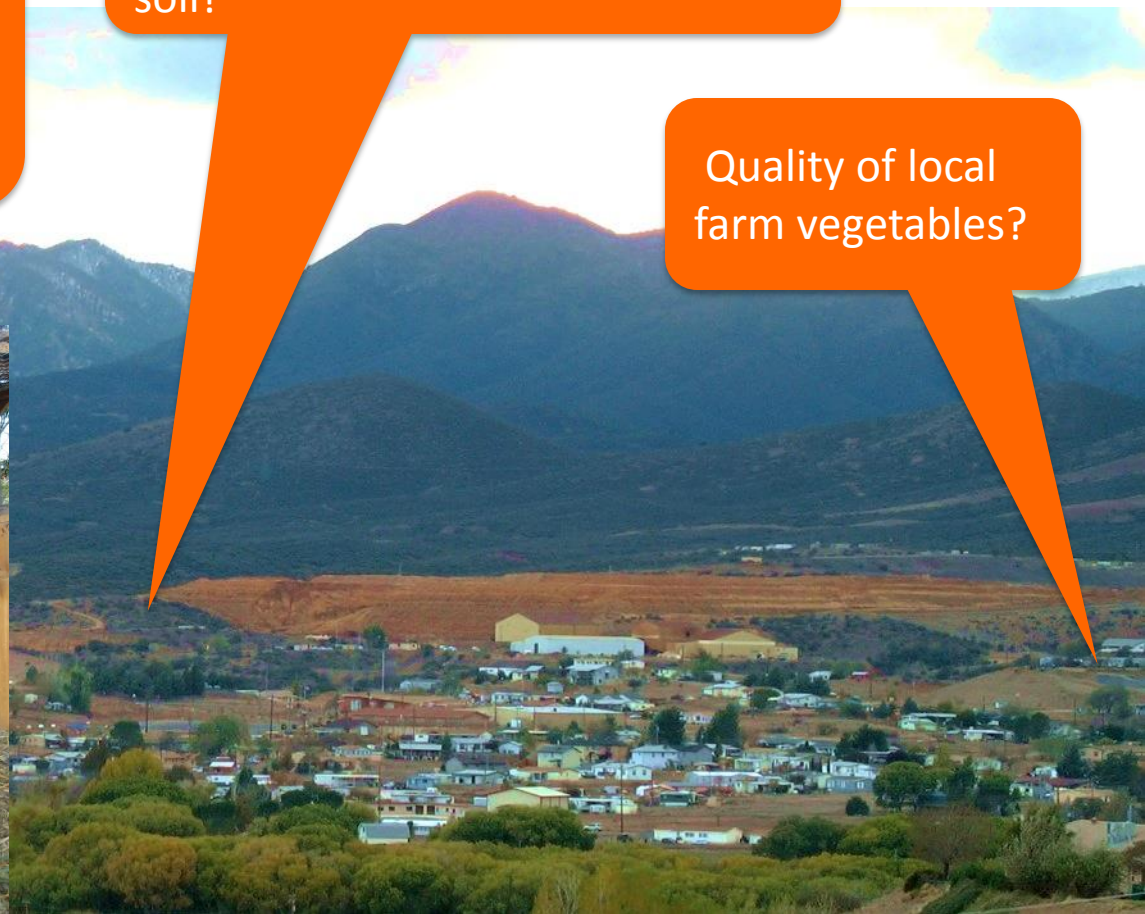
Did this Risk Communication Method Work?

Outcomes: *Generated New Participant Inquiries*

Concentrations of arsenic and heavy metals in chicken eggs? Correlation between the exposure pathways and the concentrations observed in eggs?

Do cinder blocks in a raised garden bed contributed arsenic to their soil?

Quality of local farm vegetables?



Did this Risk Communication Method Work?

Outcomes: *New participant inquiries informed how to disseminate results broadly, additional community gatherings where hosted for the town and across the state of AZ*

What was the spatial distribution of participants?

What were the most commonly grown vegetables in our community?

How does the arsenic concentration found in my vegetables compare to others?

What was the range and average arsenic concentraton found in our irrigation water?

What was the range and average arsenic concentration found in our garden soils?

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A Complete Overview of the Dewey-Humboldt, Arizona Garden Project

Special Thanks to the Dewey-Humboldt, AZ Community

Thank you for your time and consideration.

Contact Information

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