

Nogales, Sonora, Mexico: Is There Something in the Water?

By: Felipe Caldeira, Laura Norman, James Callegary, Floyd Gray

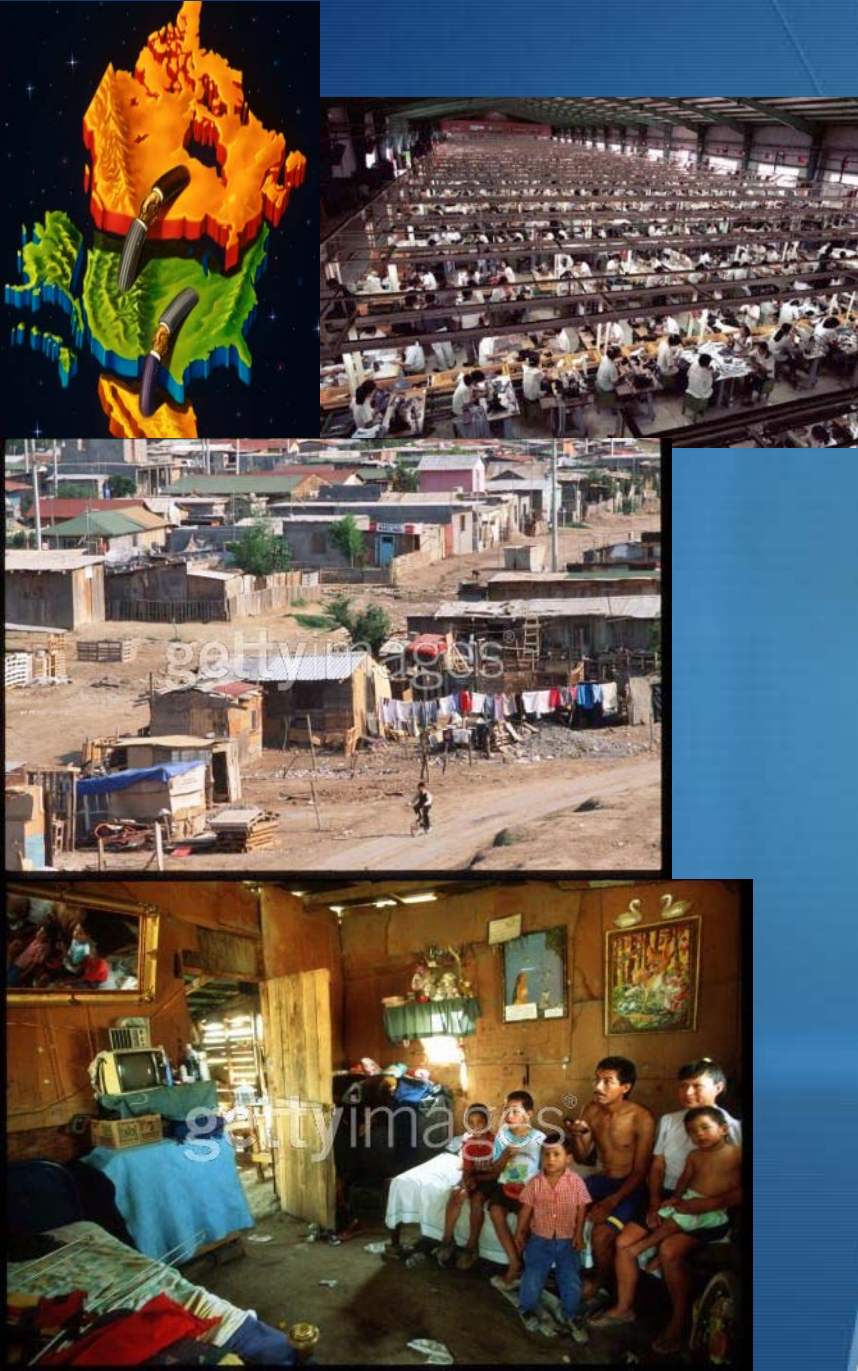
Felipe Caldeira

Graduate Research Assistant
Udall Center for Public Policy
The University of Arizona

www.u.arizona.edu/~felipec

2011 Santa Cruz River Researchers' Day – Sonoran Institute





Background

◆ Commerce and NAFTA

- ◆ Influx of migrant workers to the border.

◆ Maquiladoras

- ◆ Cheap labor
- ◆ Loose Regulation
 - ◆ Environmental and Safety

◆ Colonias

- ◆ Colonias vs Colonias Marginales
- ◆ Socioeconomic status / Socio-Environmental Vulnerability

Background



Background



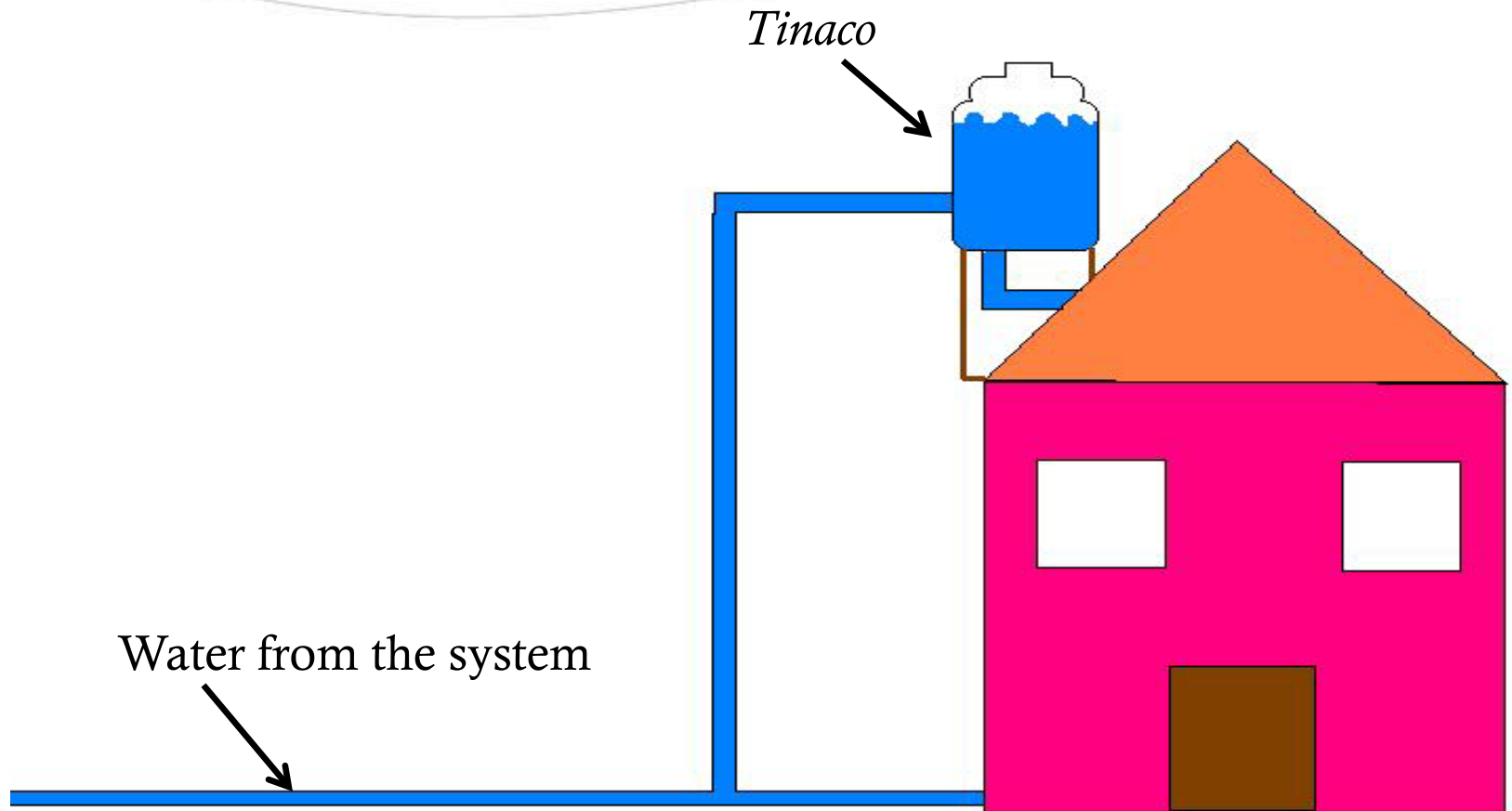
◆ Access to Water

- ◆ Full
- ◆ Part Time
- ◆ None

◆ Alternatives

- ◆ Water Trucks / *Pipas*
- ◆ Bottled Water

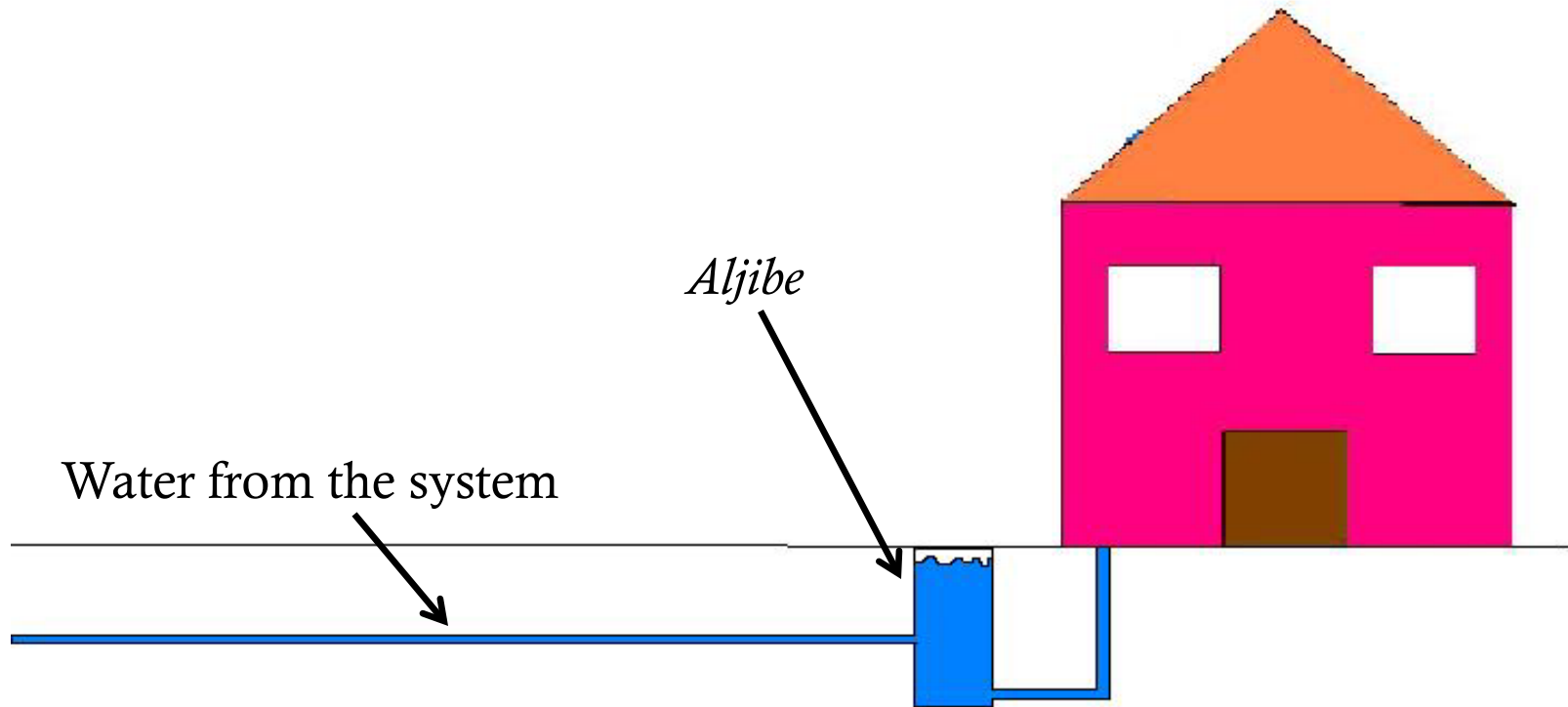
Background







Background

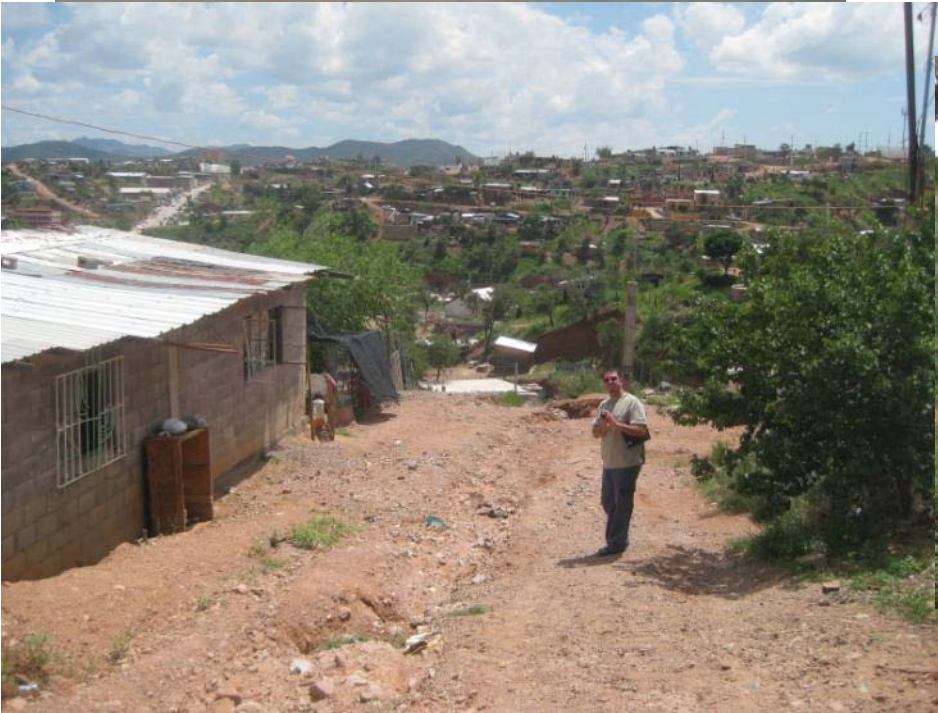




Background



- Environmental Exposure
 - ◆ Dirt Roads
 - ◆ Flooding
 - ◆ Health Effects



Hypothesis

1. Poor water quality is making people in Nogales, Sonora, sick.
 - 💧 Especially in colonias with low socioeconomic status.
 - 💧 And especially during the summer.

Methods: Binational Collaboration

- ◆ Binational Health Council/Consejo Binacional de Salud (COBINAS)
- ◆ Organismo Operador Municipal de Agua Potable, Alcantarillado Y Saneamiento de Nogales, Sonora (OOMAPAS)
- ◆ Instituto Municipal de Investigacion Y Planeacion del Gobierno Municipal de Nogales
- ◆ Centro de Salud Urbano de Nogales
- ◆ The University of Arizona
 - ◆ College of Public Health
 - ◆ Udall Center for Public Policy
- ◆ The United States Geological Survey



Gobiernos Locales Digitales
NOGALES

Methods

- ◆ Academic Participation
- ◆ Literature Review
- ◆ Study Design
- ◆ Binational Health Professional Participation (COBINAS)
- ◆ Survey Review, Revision, Translation
 - ◆ AZDHS, COPH, Focus Groups, Gobierno de Nogales
- ◆ Mexican Authorization (OOMAPAS)
- ◆ IRB Approval
- ◆ Community Members Input and Collaboration
- ◆ Lab Agreement with OOMAPAS
- ◆ Volunteer Coordination
- ◆ Collect samples
- ◆ Analyze water samples
- ◆ Document findings
- ◆ Follow up

Methods

- ◆ 40 households (proposed)
 - ◆ 20 from *colonia marginal* (Colosio)
 - ◆ 20 from *colonia* Lomos de Fatima
- ◆ Sample for microbes
 - ◆ *E.coli*
 - ◆ Total Fecal Coliforms
 - ◆ Conduct replicates and blanks
- ◆ Sample for metals and other elements of interest
 - ◆ Arsenic, Mercury, Lead
 - ◆ Chloride, Sulfate
- ◆ Survey
 - ◆ Quality of Life
 - ◆ Prevalence of diarrhea
 - ◆ Perceptions of Problems and Solutions

Methods: Water Quality--Metals

Contaminant	Maximum Contaminant Level (mg/L)	Potential Health Effects from Long-Term Exposure	Sources of Contamination in Drinking Water
Arsenic (As)	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass and electronic production wastes
Chloride (Cl)	250mg/L	Dehydration	Byproduct of chlorine, inorganic fertilizers, landfill leaches, septic tank effluent, animal feeds, industrial effluents, irrigation drainage.
Cadmium (Cd)	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Copper (Cu)	1.3	Gastrointestinal distress; liver or kidney damage	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (Hg)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Lead (Pb)	0.015	Delays in physical or mental development in children; kidney problems; high blood pressure in adults	Corrosion of household plumbing systems; erosion of natural deposits
Antimony (Sb)	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Selenium (Se)	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Sulfate (SO ₄)	250	Diarrhea	Erosion of natural deposits

-  Arsenic, Lead, Mercury
 -  Industrial Contamination
 -  Naturally present
 -  Carcinogens
 -  Complicated health problems

-  *E.coli* and Total Fecal Coliforms
 -  Animal Contamination
 -  Agricultural Runoff
 -  Sewage
 -  Strain on the system
 -  Increased exposure

Methods: Seasonal Variability

- 3 trials in each household in the summer
- 3 trials (proposed) in each household in the winter
- What happens during monsoon season vs. dry winter season?
- Climate change implications

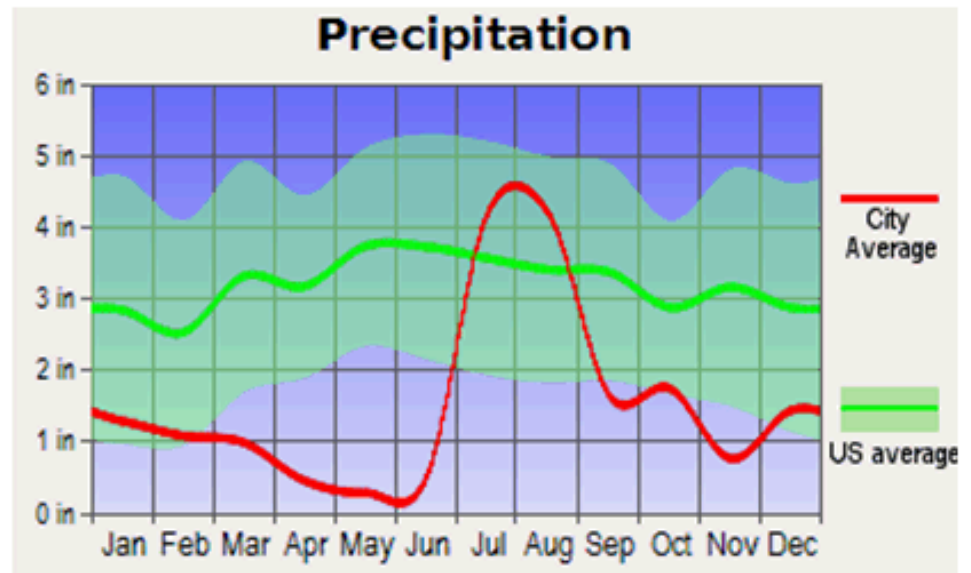
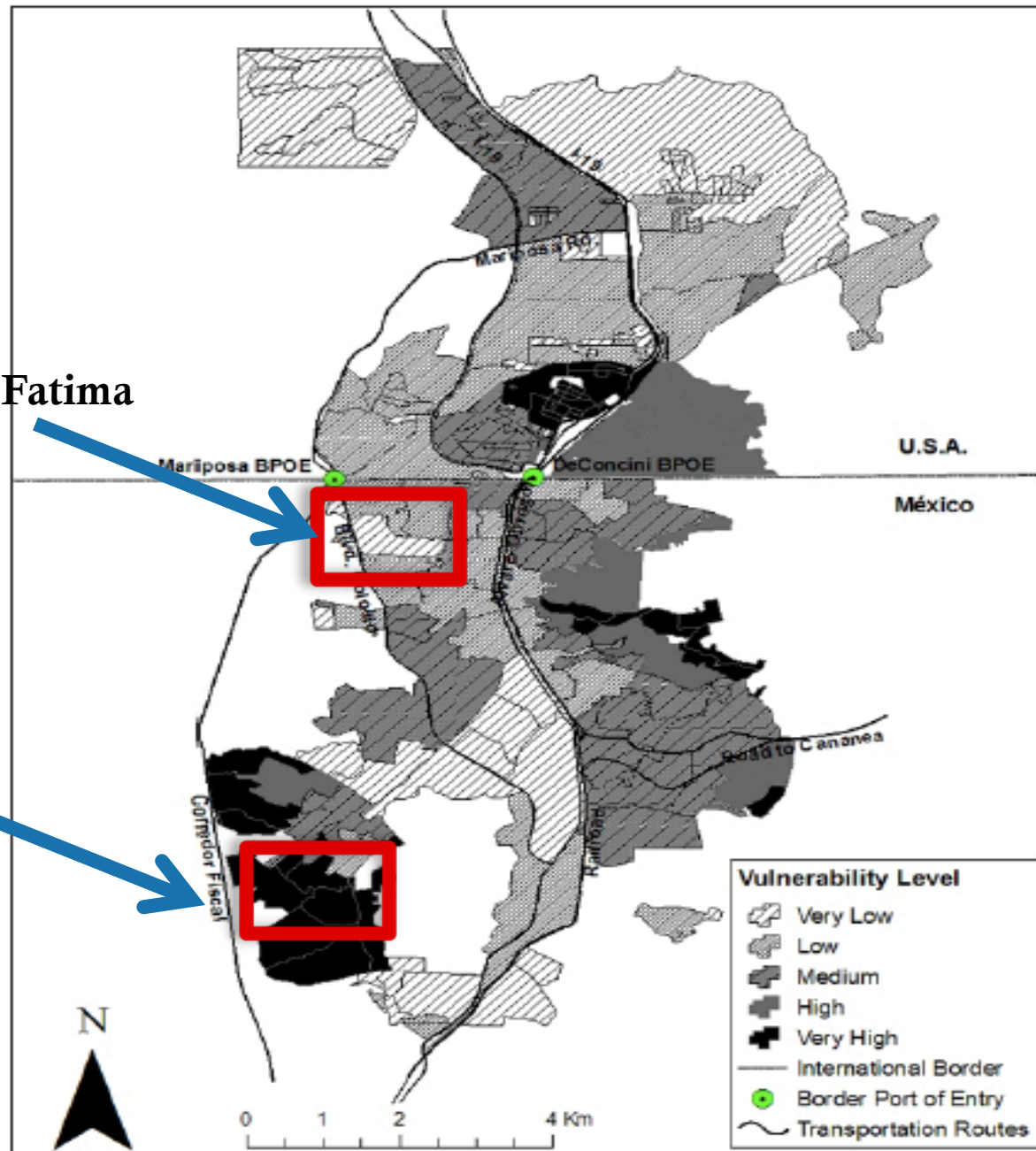


Figure 2. Socio-Environmental Vulnerability Levels in Ambos Nogales

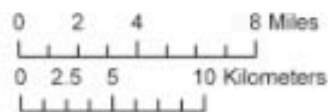
Lomas de Fatima

Colosio



Lara-Valencia, F., DeClet-Barreto, J., & Keys, E. (2008). Spatial equity and transportation hazard along cross-border trade corridors: the case of ambos Nogales. *Journal of Borderland Studies*, 23(2), 1-16.

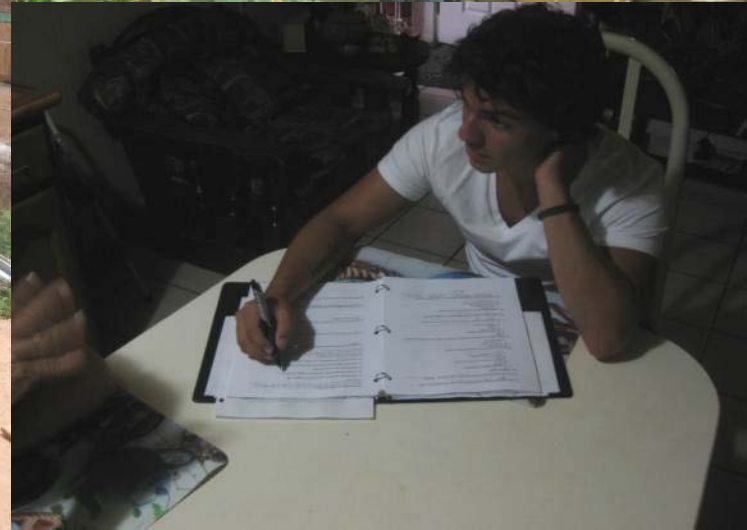
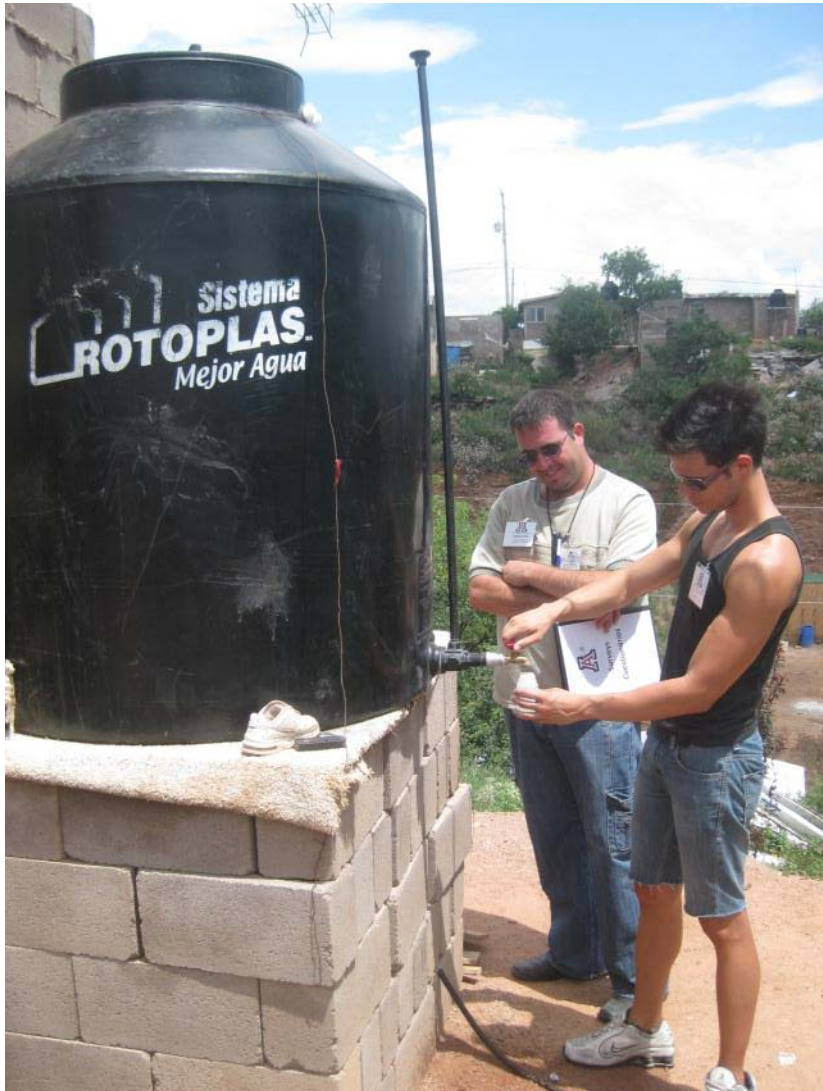
AMBOS NOGALES WATERSHED







Field Work

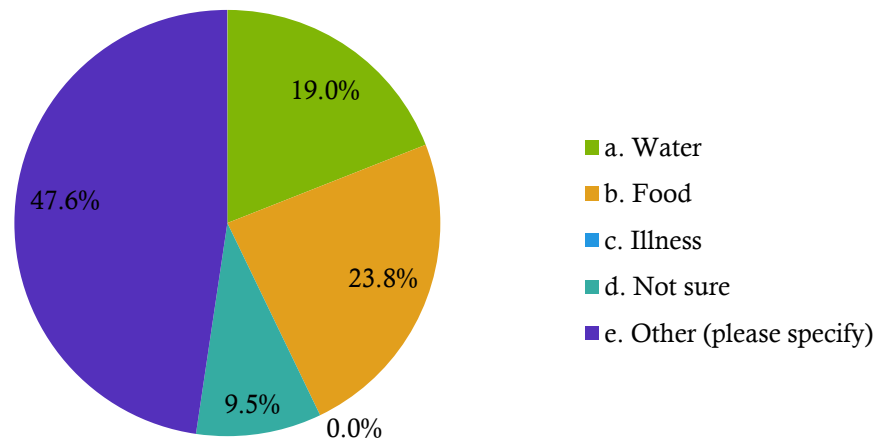


Results - Survey

Table 3. Diarrhea and Water Perceptions

Question	Episode of diarrhea in the past 4 weeks		Hospitalized due to diarrhea		Missed work or school		Claim water as the cause		Claim water can make them sick		Sees diarrhea as a problem rather than natural occurrence	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Colosio (n=14)	5	9	2	5	1	13	3	11	9	5	11	3
Fatima (n=7)	4	3	2	5	0	7	3	7	5	2	5	2

What would you say was the cause of the episode(s) of diarrhea experienced by you or the household?



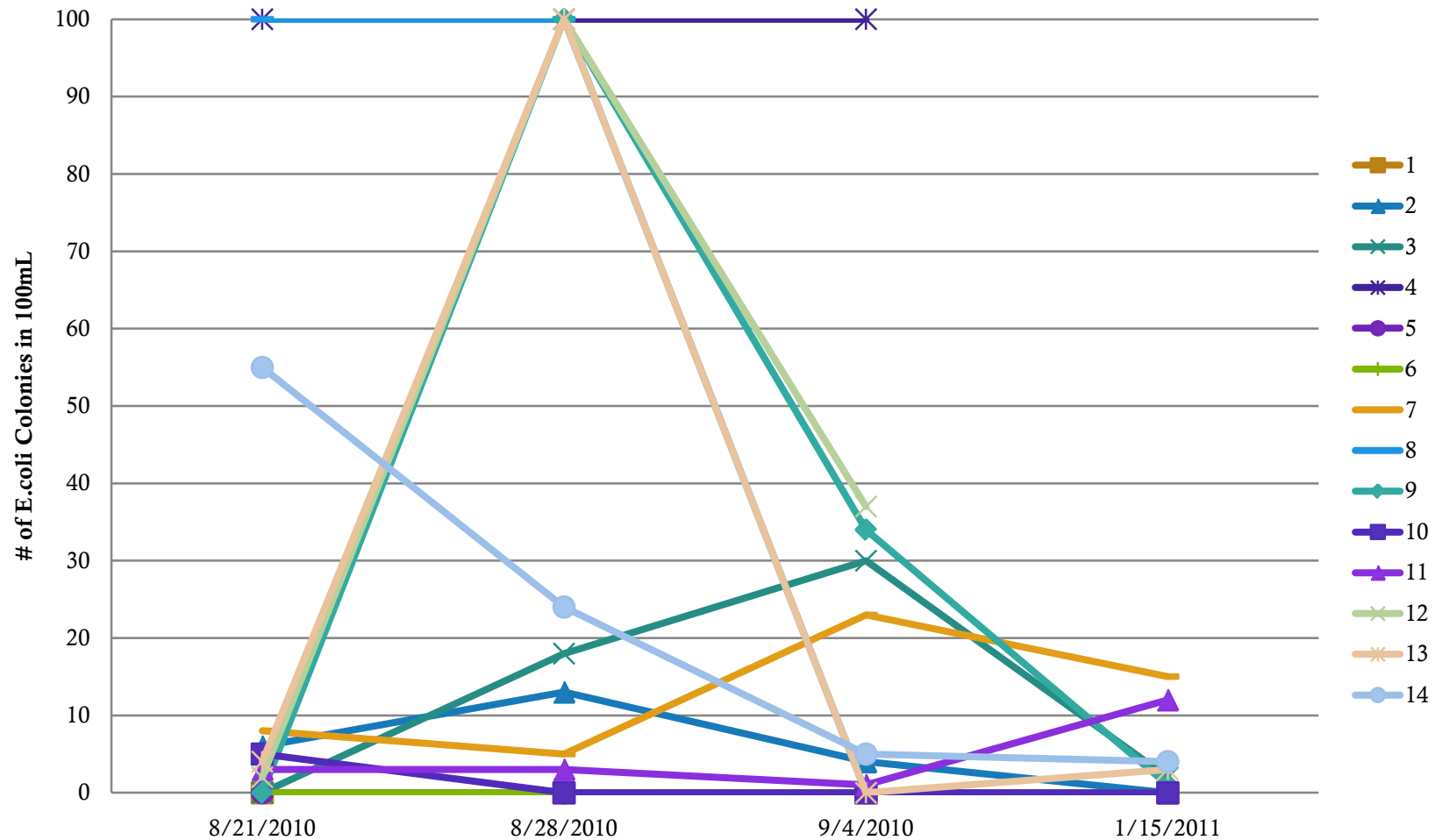
- Rate of diarrhea high
- Treatment Expensive
- Water quality perceptions high
- Minimal interest in disinfecting further

Results – Water Quality

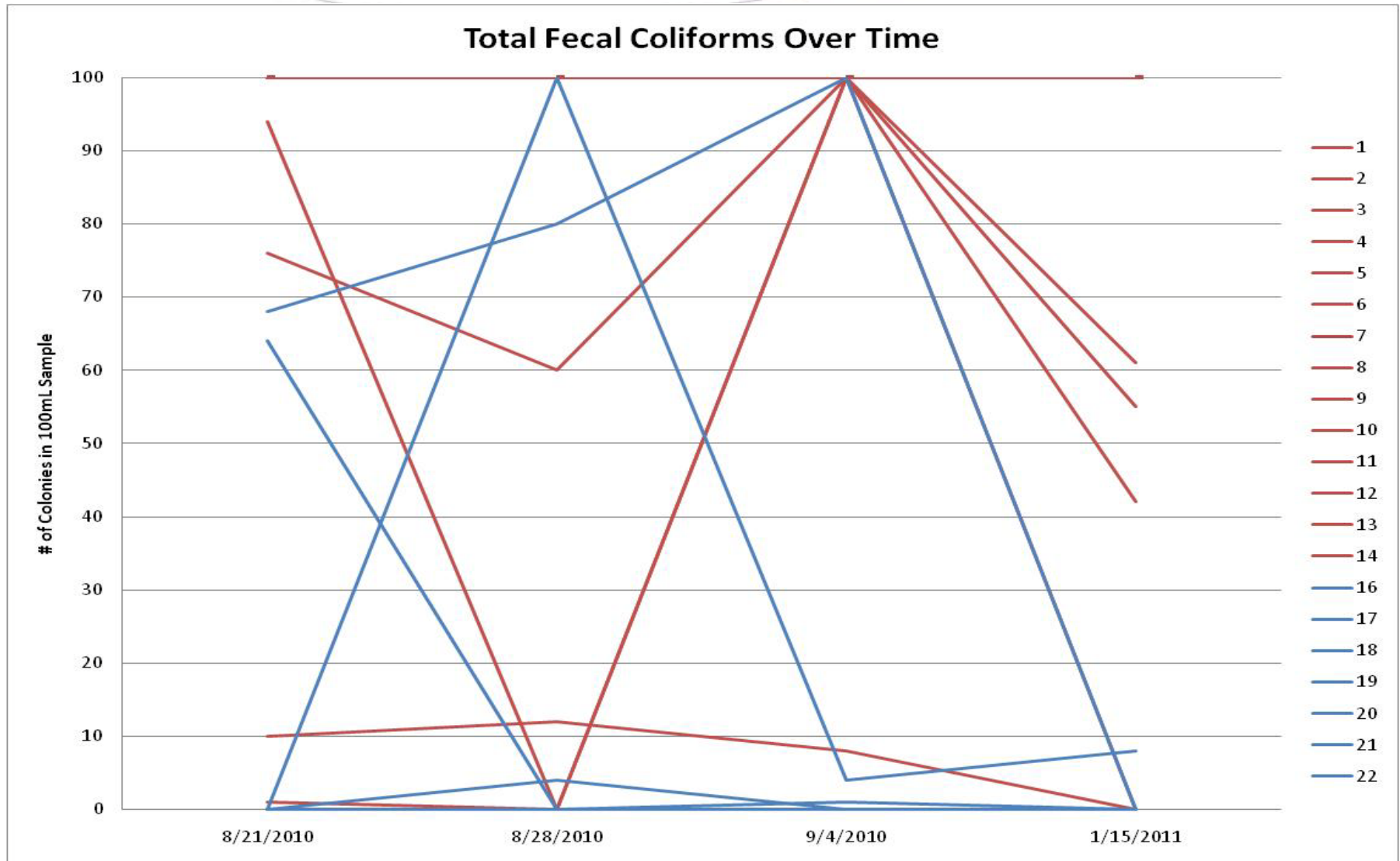
	8/21/2010		8/28/2010		9/4/2010		1/15/2011	
HHID	E.coli Colonies per 100mL	Total Fecal Coliforms per 100mL	E.coli Colonies per 100mL	Total Fecal Coliforms per 100mL	E.coli Colonies per 100mL	Total Fecal Coliforms per 100mL	E.coli Colonies per 100mL	Total Fecal Coliforms per 100mL
1	0	10	0	12	0	8	0	0
2	6	>100	13	>100	4	>100	0	0
3	0	>100	18	>100	30	>100	2	>100
4	>100	>100	>100	>100	>100	>100	NA	NA
5	0	1	0	0	0	0	NA	NA
6	0	0	0	0	0	>100	0	61
7	8	>100	5	>100	23	>100	15	>100
8	>100	>100	>100	>100	0	>100	NA	NA
9	0	>100	>100	>100	34	>100	1	>100
10	5	94	NA	NA	0	>100	0	55
11	3	76	3	60	1	>100	12	>100
12	2	>100	>100	>100	37	>100	NA	NA
13	4	>100	>100	>100	0	>100	3	>100
14	55	>100	24	>100	5	>100	4	42
16	0	64	0	0	0	1	0	0
17	0	0	0	4	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	>100	0	4	0	8
20	0	0	NA	NA	NA	NA	0	0
21	0	68	0	80	0	>100	0	0
22	0	0	0	0	0	0	0	0

Results – Water Quality

E.coli Colonies Over Time In Colosio



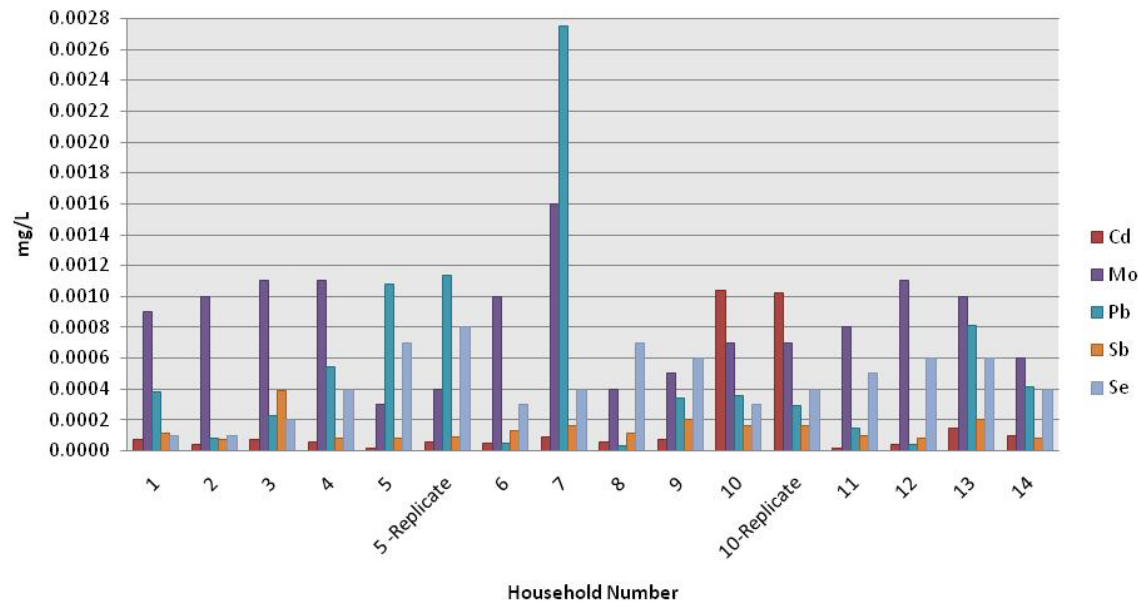
Results – Water Quality



Results – Water Quality

Colonia	House #	Arsenic (As) mg/L	Cadmium (Cd) mg/L	Chloride (Cl) mg/L	Copper (Cu) mg/L	Mercury (Hg) mg/L	Manganese (Mn) mg/L	Molybdenum (Mo) mg/L	Lead (Pb) mg/L	Antimony (Sb) mg/L	Selenium (Se) mg/L	Tin (Sn) mg/L	Sulfate (SO4) mg/L	Zinc (Zn) mg/L
		EPA: 0.010 mg/L	EPA: 0.005 mg/L	EPA: 250 mg/L	EPA: 1.3 mg/L	EPA: 0.002 mg/L	EPA: 0.05 mg/L		EPA: 0.015 mg/L	EPA: 0.006 mg/L	EPA: 0.05 mg/L		EPA: 250 mg/L	EPA: 5 mg/L
Colosio	1	0.000670	0.000070	29.2	0.0372	< 0.0002	0.0025	0.0009	0.00038	0.00011	0.0001	0.0243	45.2	0.0522
Colosio	2	0.000430	0.000040	30.9	0.0035	< 0.0002	0.0022	0.0010	0.00008	0.00007	0.0001	0.0104	48.1	0.0091
Colosio	3	0.000560	0.000070	29.2	0.0114	< 0.0002	0.0045	0.0011	0.00023	0.00039	0.0002	0.0282	47.8	0.0341
Colosio	4	0.000530	0.000060	42.6	0.0032	< 0.0002	0.0011	0.0011	0.00054	0.00008	0.0004	0.0024	74.6	0.0187
Colosio	5	0.003040	0.000020	8.27	0.1380	< 0.0002	0.0009	0.0003	0.00108	0.00008	0.0007	0.0058	4.49	0.0110
Colosio	5 -Replicate	0.003050	0.000060	8.29	0.1400	< 0.0002	0.0019	0.0004	0.00114	0.00009	0.0008	0.021	4.52	0.0260
Colosio	6	0.000520	0.000050	31.3	0.0059	< 0.0002	0.0037	0.0010	0.00005	0.00013	0.0003	0.0196	48.3	0.0168
Colosio	7	0.000880	0.000090	31.1	0.0060	< 0.0002	0.0055	0.0016	0.00275	0.00016	0.0004	0.0261	46.5	0.0276
Colosio	8	0.003380	0.000060	7.51	0.0013	< 0.0002	0.0005	0.0004	0.00003	0.00011	0.0007	0.004	2.49	0.0121
Colosio	9	0.003140	0.000070	9.97	0.0116	< 0.0002	0.0040	0.0005	0.00034	0.00020	0.0006	0.0337	7.41	0.0265
Colosio	10	0.000410	0.001040	22.8	0.0039	< 0.0002	0.0038	0.0007	0.00036	0.00016	0.0003	0.0156	37.3	0.1700
Colosio	10-Replicate	0.000380	0.001020	22.8	0.0013	< 0.0002	0.0029	0.0007	0.00029	0.00016	0.0004	0.0006	37.6	0.1690
Colosio	11	0.001080	0.000020	37.8	0.0013	< 0.0002	0.0009	0.0008	0.00015	0.00010	0.0005	0.0158	56.4	0.0091
Colosio	12	0.000600	0.000040	41.4	0.0023	< 0.0002	0.0012	0.0011	0.00004	0.00008	0.0006	0.0016	72.1	0.0097
Colosio	13	0.000610	0.000150	34.8	0.0132	< 0.0002	0.0099	0.0010	0.00081	0.00020	0.0006	0.067	51.6	0.0607
Colosio	14	0.004180	0.000100	5.79	0.0049	< 0.0002	0.0028	0.0006	0.00041	0.00008	0.0004	0.0234	3.54	0.0476
Lomas	16	0.008640	0.000040	9.95	0.0334	< 0.0002	0.0013	0.0005	0.00136	0.00012	0.0005	0.0278	8.93	0.0410
Lomas	16-Replicate	0.007960	0.000080	9.96	0.0412	< 0.0002	0.0056	0.0007	0.00102	0.00025	0.0007	0.0523	8.93	0.0591
Lomas	17	0.013600	0.000050	18.3	0.0085	< 0.0002	0.0010	0.0030	0.00050	0.00015	0.0007	0.005	17.4	0.0534
Lomas	18	0.002760	0.000030	7.86	0.21000	< 0.0002	0.0009	0.0016	0.00060	0.00031	0.0017	0.0011	35.1	0.0414
Lomas	19	0.003790	0.000060	7.74	0.1610	< 0.0002	0.0029	0.0017	0.00132	0.00041	0.0017	0.0223	36.5	0.0559
Lomas	19-Replicate	0.003750	0.000080	7.6	0.1620	< 0.0002	0.0025	0.0018	0.00149	0.00036	0.0017	0.0179	36.8	0.0298
Lomas	20	0.003370	0.000030	7.41	0.0048	< 0.0002	0.0005	0.0016	0.00015	0.00035	0.0017	0.004	36.3	0.0343
Lomas	20-Replicate	0.003320	0.000170	7.46	0.0183	< 0.0002	0.0058	0.0017	0.00124	0.00042	0.0017	0.0669	36.5	0.0833
Lomas	21	0.003610	0.000150	7.24	0.0061	< 0.0002	0.0012	0.0018	0.00108	0.00031	0.0016	0.0044	34.7	0.0514
Lomas	22	0.003260	0.000040	7.45	0.0149	< 0.0002	0.0005	0.0016	0.00021	0.00035	0.0018	0.0088	36.2	0.0248

Metal Concentrations in Colosio

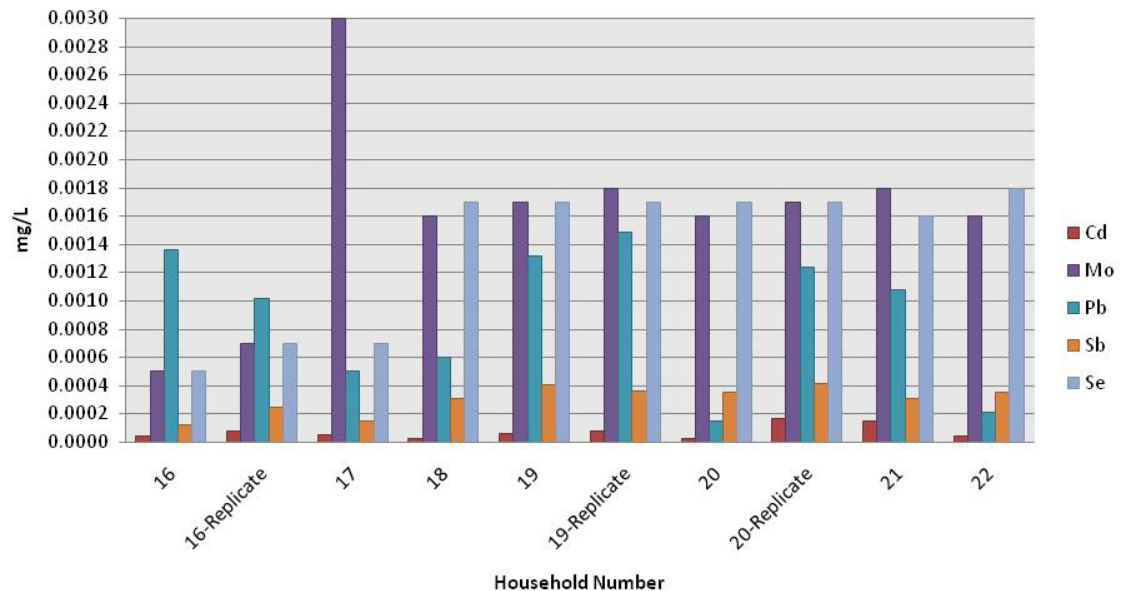


Higher in Colosio
Cd

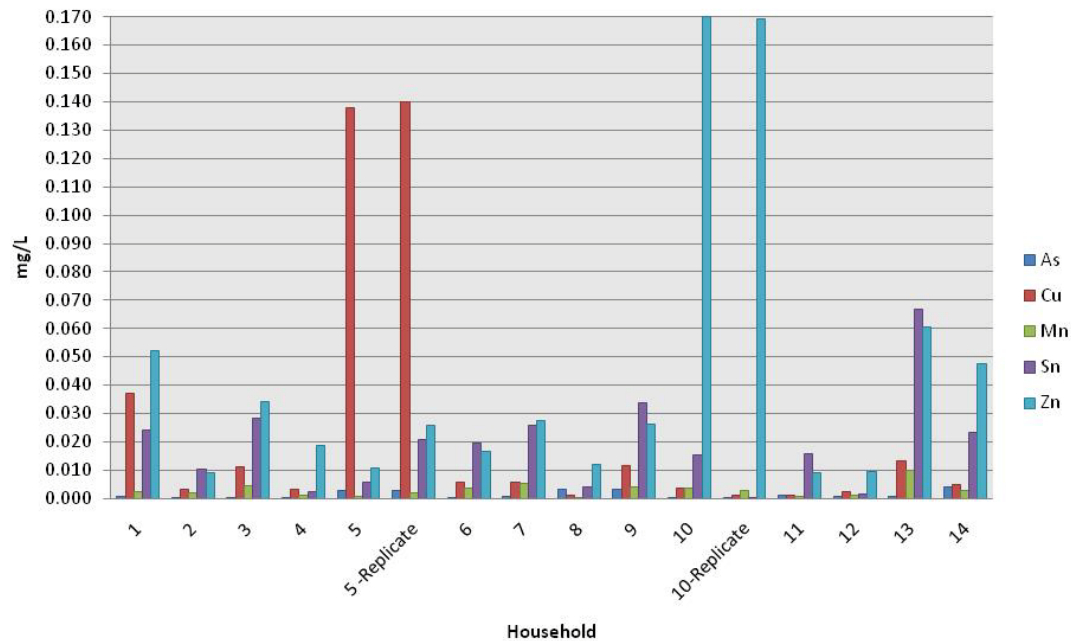
Higher in Lomas

Mo
Pb
Sb
Se

Metal Concentrations in Lomas



Metal Concentrations in Colosio

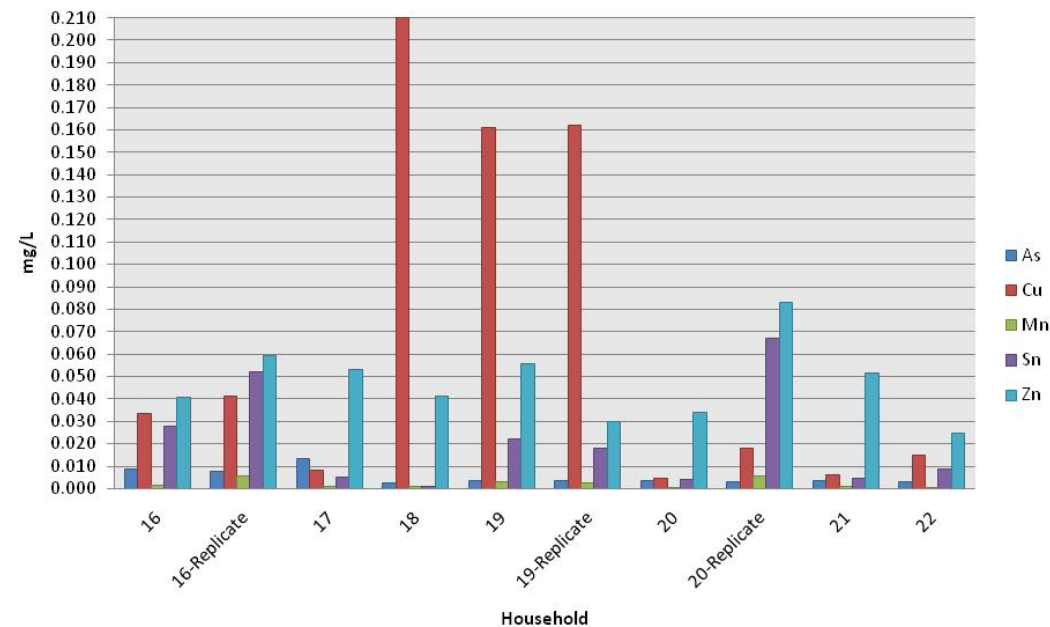


Higher in Colosio
Mn

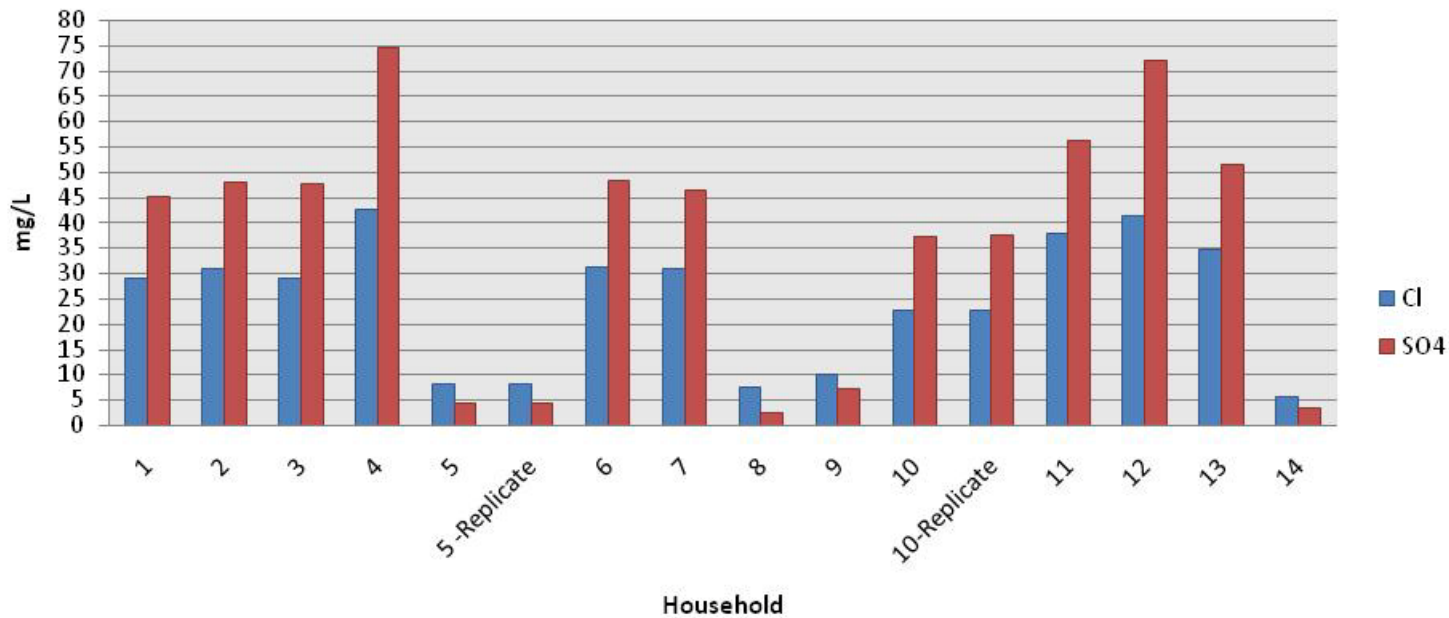
Higher in Lomas

As
Cu
Sn
Zn

Metal Concentrations in Lomas



Anion Concentrations in Colosio

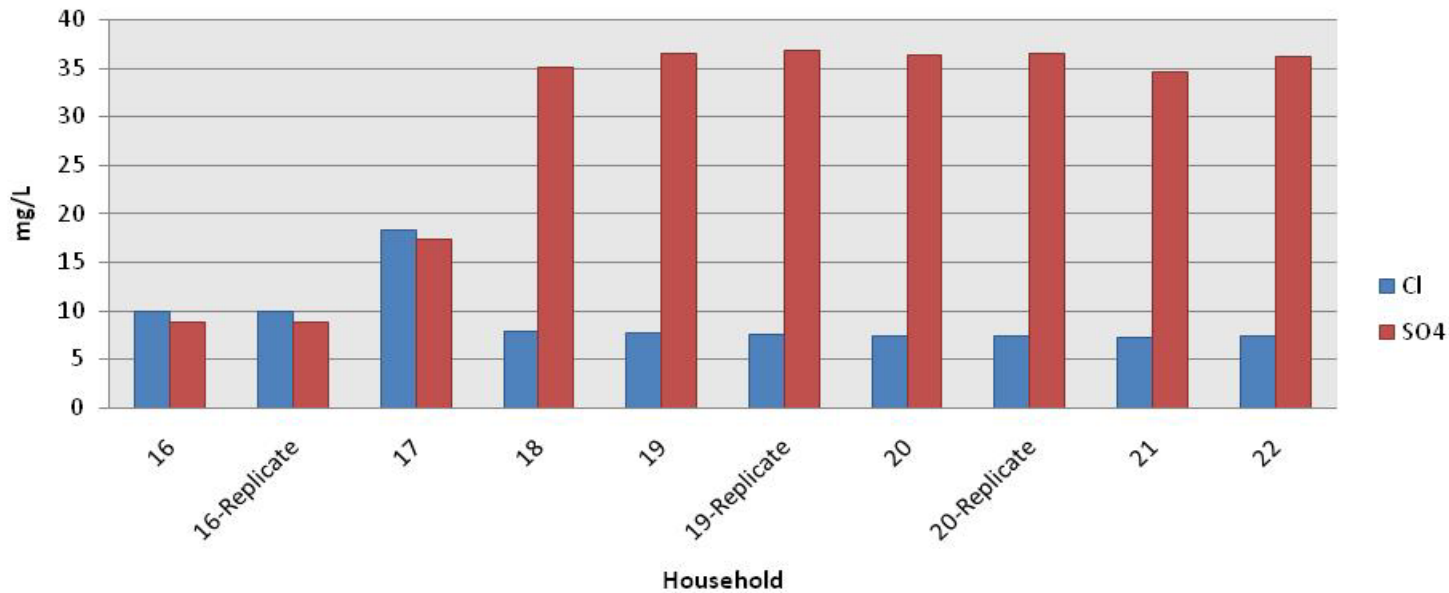


Higher in Colosio

Cl

SO4

Anion Concentrations in Lomas



Discussion

		Reported Episode of Diarrhea		
		Yes	No	Totals
E.coli	Present	5	4	9
	Not Present	5	7	12
	Totals	10	11	21

- ◆ No direct relationship between rate of diarrhea and water quality
 - ◆ Trend in the right direction.
- ◆ Contaminants higher in summer
- ◆ Contamination in storage tanks higher
- ◆ Microbial contamination in pipes low
- ◆ Less access to water = higher vulnerability to contamination
- ◆ Higher metal concentration in piped water (well below standards)
- ◆ No contamination found in blanks (household bottled water)

Discussion

- ◆ Poor water quality is making people in Nogales, Sonora, sick.
 - ◆ Especially in colonias with low socio economic status.
 - ◆ And especially during the summer.
- ◆ Results Show:
 - ◆ Rate of diarrhea high, especially in Colosio resulting in 11 hospitalizations.
 - ◆ Microbial contamination higher in Colosio, a colonia with low socio economic status and no access to piped water.
 - ◆ Microbial contamination was higher in the summer and no diarrhea reported in the winter.

Future Considerations

Suggestions for Management

- ◆ Water Delivery
 - ◆ Should delivery be extended?
 - ◆ Should regulation be more enforced for *pipas*?
 - ◆ Costs?
- ◆ Sanitation Practices
 - ◆ Health education
 - ◆ Promotora model
 - ◆ Regular maintenance of *tinacos*?
 - ◆ Flocculent Use?

Implications

- ◆ Climate change
 - ◆ Local awareness and impact
 - ◆ Extended monsoons
 - ◆ Flooding
 - ◆ Strain on the system
 - ◆ Increased exposure

Thank you!

Felipe Caldeira
www.u.arizona.edu/~felipec

Graduate Research Assistant
Udall Center for Public Policy

Masters Candidate in Public Health
at the University of Arizona

felipec@email.arizona.edu

