

# Mercury Contamination in Huancaavelica, Peru:

## Community Engagement to Assessment and Remediation

- **The Environmental Health Council**
- **[www.ehcouncil.org](http://www.ehcouncil.org)**
- **[www.mercurycleanup.org](http://www.mercurycleanup.org)**

Presented by:

Bryn Thoms, RG Technical Director  
The Environmental Health Council

The Environmental Health Council is a small NGO dedicated to assessing and cleaning up heavy metal impacts from abandoned mines in Peru. We hope to grow and do more international cleanup work in developing countries.

Although I work for Oregon DEQ conducting assessment and cleanup of contaminated sites including AMLs, the work presented here is not associated with Oregon DEQ. This work is done on my own for fun (sort of) on vacations.



# Overview

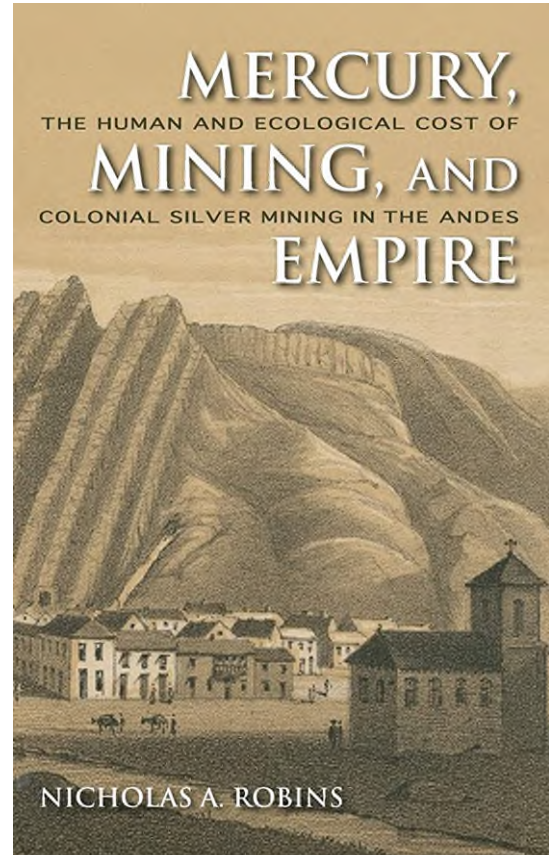
- History of Site
- Assessment and Cleanup Process
- Community Engagement
- Assessment History
- General Site Conditions
- Results of Assessment and Remedial Investigation
- Conceptual Feasibility Study and Pilot Study
- Summary and Potential Future Actions

# A Surge of Silver

- Between 1550 and 1800, 150,000 tons of silver produced in Latin America
- Accounted for approximately 80% of global production during this period
- Mercury amalgamation was the main refining process
- Much of the extraction and refining of both mercury and silver was conducted by forced indigenous laborers, under the mita system
- This was a major interest of Spanish Colonialism



Huancavelica, Peru



Potosí, Bolivia


“A living image of death, and a black shadow of hell.”

-*Friar B. Salinas y Cordoba, 1630*

- Santa Bárbara Mine AKA Mina de La Muerte
- Based on colonial records, approx. 68,000 metric tons of mercury were produced in Huancavelica between 1564 and 1810
- Nearly 17,000 metric tons of mercury vapor were released into the atmosphere between 1564 and 1810 from smelting operations in Huancavelica alone (Hagan, Robins –Aermod)
- Much of this vapor then condensed along with contaminated dust and deposited in the valley of the Rio Ichu in Huancavelica.

# Santa Barbara Mine and Huancavelica

Legend

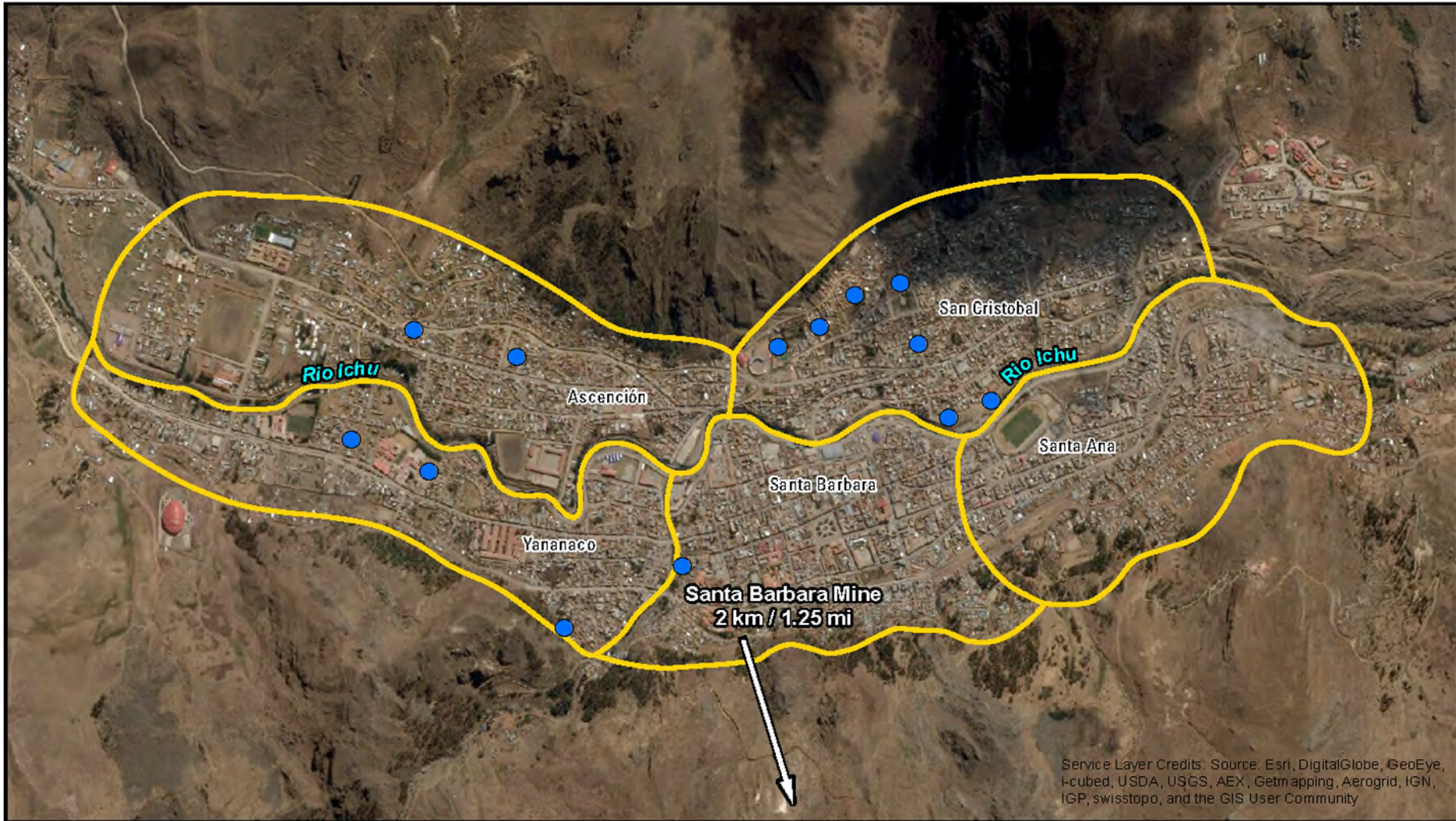
-  Huancavelica



# Entrance to Santa Bárbara Mine

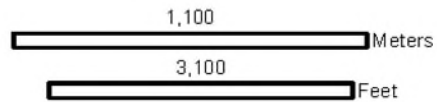






**Legend**

- Historic Furnace Location
- Ascención Approximate Neighborhood Boundary



**FIGURE 2**  
**Site Map - Huancavelica, Peru**  
 Huancavelica Mercury Project  
 Remedial Investigation

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# View of Huancavelica's Main Plaza



# View of Huancavelica



# Assessment and Cleanup Process

- Elements of US CERCLA (US Superfund) and State Cleanup Programs
- Conceptual Site Model (nature and extent of contamination)
- Human Health Risk Assessment – Exposure pathways, developed screening values
- Conceptual Feasibility Study
- Performed Pilot Study (encapsulation, interior walls and floors)
- Performance Monitoring
- Limited funding - \$10,000 per year (travel, lodging, ground transport, equipment rental, wages for local support,...)

# Community Engagement

- Public Meetings
- Local knowledge (archeologist and hospital staff)
- Coordination with University of Huancavelica and City staff
- Local physician was strong advocate and well respected in the community



# Early Assessment Work (2009 to 2013)

- UN Mercury Exposure Health Questionnaire (60 homes)
- Outdoor soil samples (about 10)
- Indoor soil samples (walls, floors, dust, vapor – 60 homes)
- Several academic studies on historic contamination (Hair analysis, Hg bioaccessibility, Hg speciation, air model of historic conditions), Nicole Hagan, Nick Robins, Heileen Hsu Kim

# More Recent Assessment Work (2015 to 2020)

- Assessment of homes in Sacsamarca near Santa Barbara Mine
- Outdoor soil samples (50 developed background)
- Indoor soil samples (walls, floors, dust, vapor – another 20)
- Pilot Study (stucco on walls, concrete floors)
- Coordination with federal agencies
- Assessment of school grounds, river sediment, fish





Attempts to cover wall

Exposed earthen wall

2015/03/02







Exposed earthen floor

2015/03/02

# Conceptual Site Model

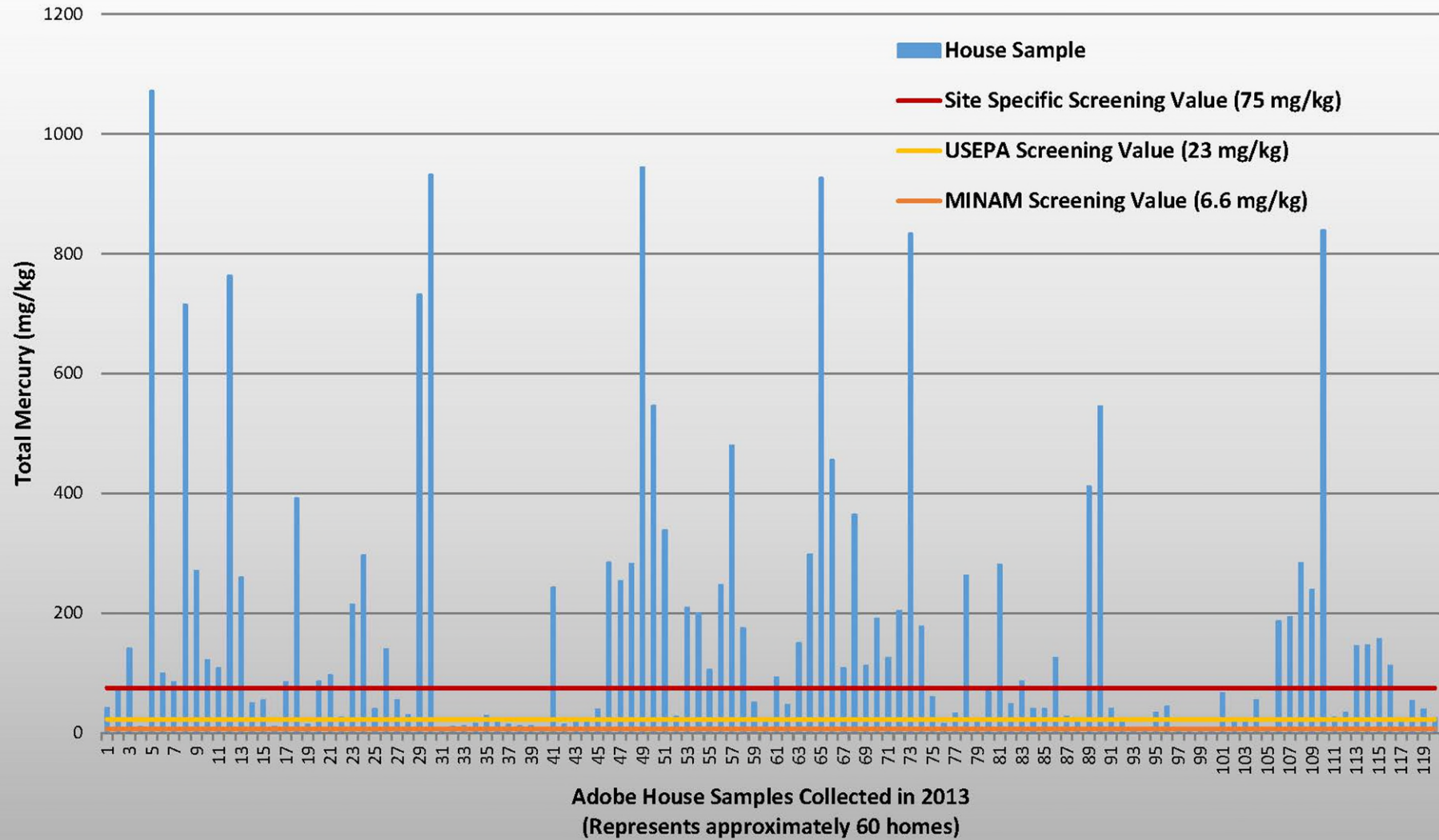
- Local soil contaminated
- Soil used for construction of homes
- Incidental ingestion of contamination dust (indoor and outdoor)
- Inhalation of mercury vapor
- Ingestion of locally sourced contaminated food

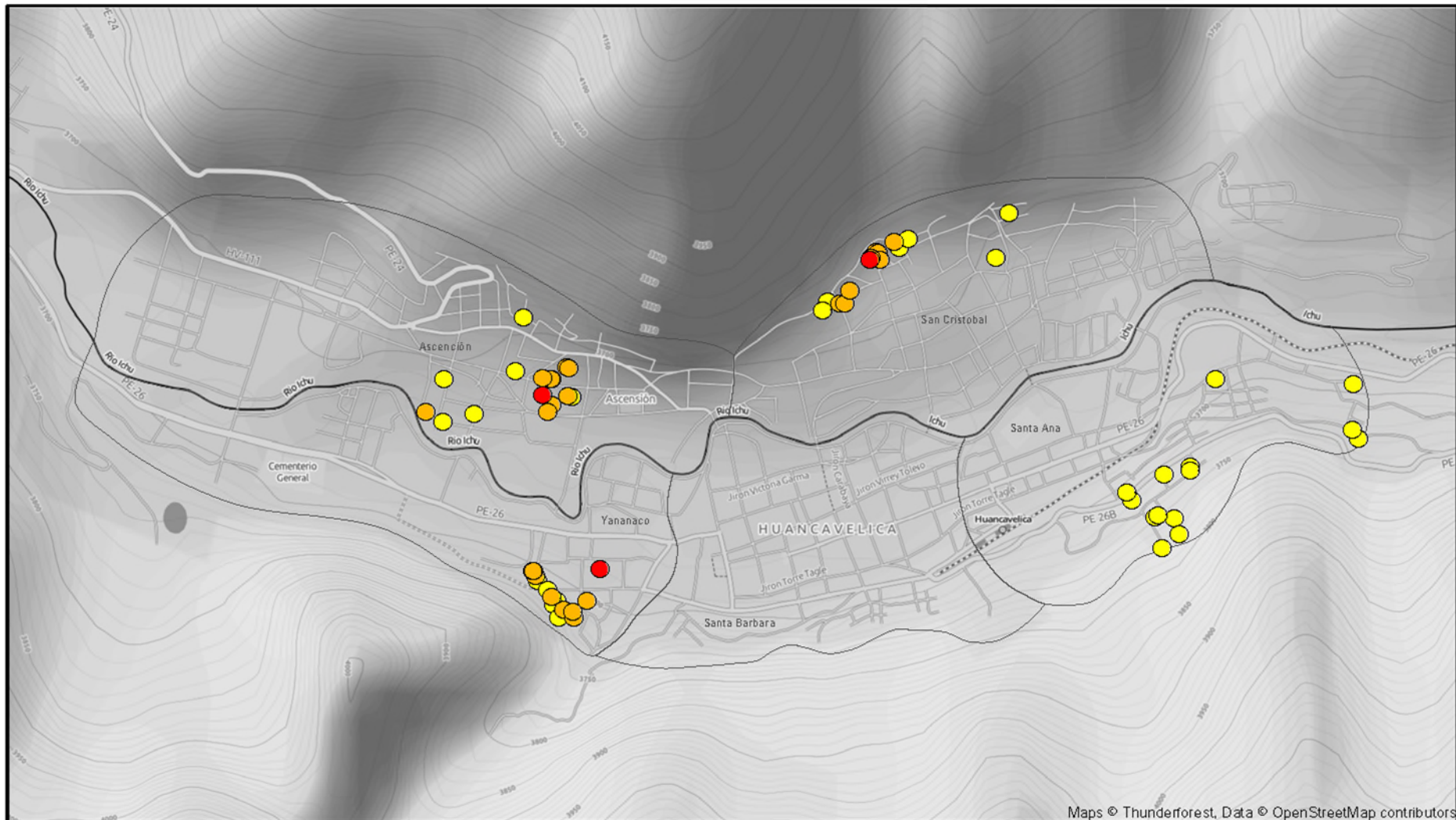
# Sample Collection





# Total Mercury (mg/kg) in Adobe House Samples Huancavelica, Peru



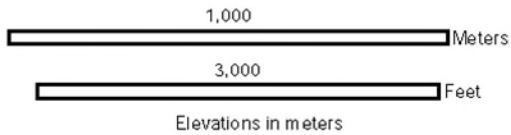


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**Legend**

- $\text{mg/kg}^i$  < 75<sup>ii</sup>
- 75 - 770
- < 770<sup>iii</sup>

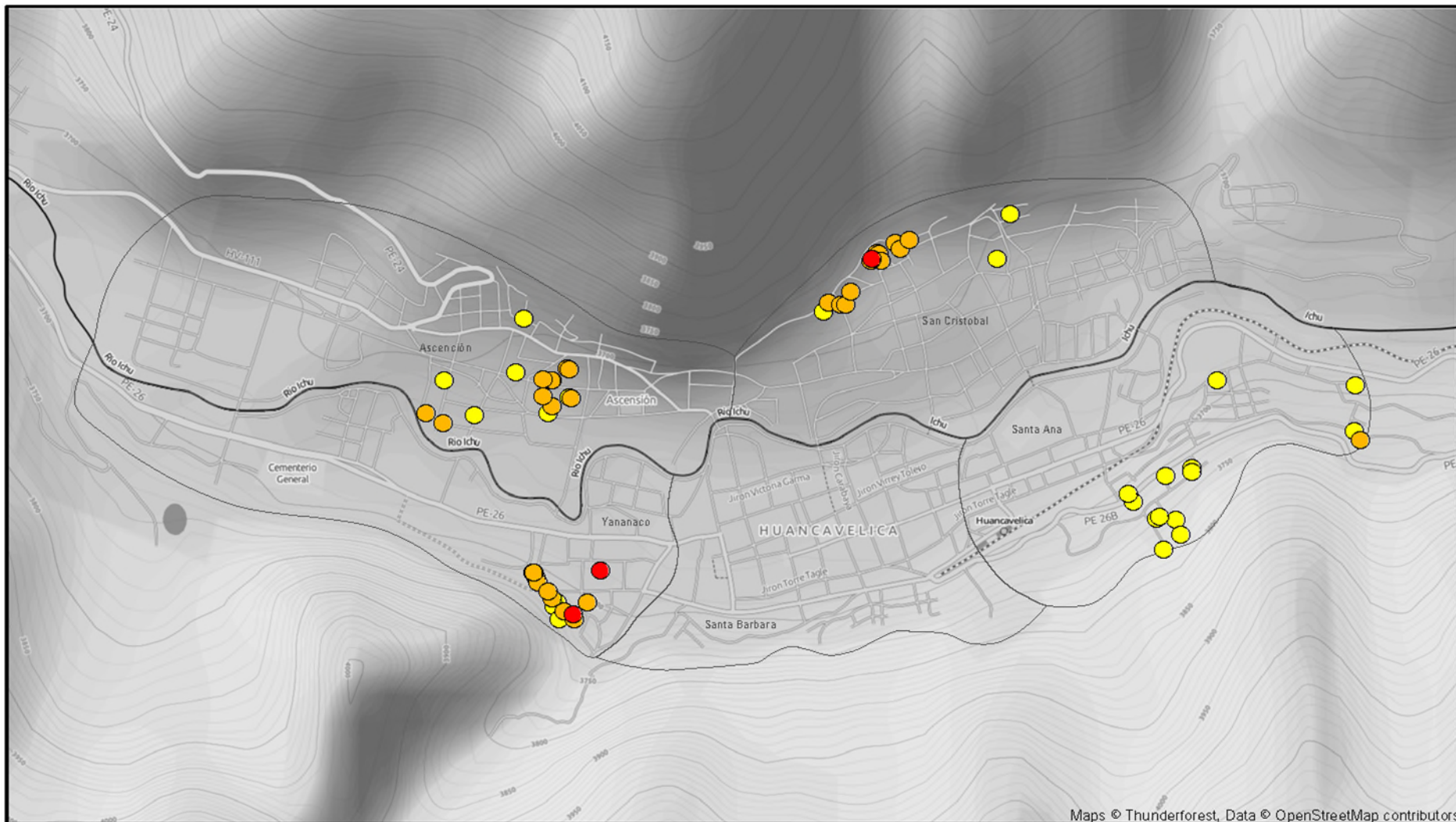
Ascension Approximate Neighborhood Boundary



<sup>i</sup>mg/kg = milligrams per kilogram or parts per million  
<sup>ii</sup>75 mg/kg = site specific screening level for residential use  
<sup>iii</sup>770 mg/kg = site specific screening level for occupational use

**FIGURE 6**  
**Total Mercury in Floors**  
**Huancavelica Mercury Project**  
**Remedial Investigation**

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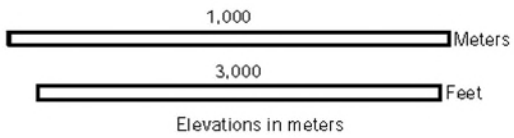


Maps © Thunderforest, Data © OpenStreetMap contributors

**Legend**

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**FIGURE 5**  
**Total Mercury in Walls**  
**Huancavelica Mercury Project**  
**Remedial Investigation**

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# Results of Remedial Investigation

- Total mercury in outdoor soil ranged from 0.1 to 1200 milligrams per kilogram (mg/kg)
  - Site-specific screening value (occupational exposure) = 770 mg/kg
- Total mercury in indoor walls and floors ranged from 2.4 to 1072 mg/kg
  - Site-specific screening value (residential exposure includes children) = 75 mg/kg
  - MINAM screening value = 6.6 mg/kg
- Mercury vapor in homes ranged from the 20 to 5100 nanograms per meter cubed (ng/m<sup>3</sup>)
  - The World Health Organization screening level for chronic exposure = 200 ng/m<sup>3</sup>
- 75% of the homes studied have mercury in walls, floors, or indoor air above these screening levels
- Estimated population exposed to mercury above international standards is 19,000 people (2015 estimate).

# Conceptual Feasibility Study

## Remedial Action Alternatives:

1. Encapsulation with concrete floor and geotextile/plastic wall covering.

Estimated cost is about 1100 USD per home.

1. Encapsulation with concrete floor with the walls with plaster. Tested in the pilot study.

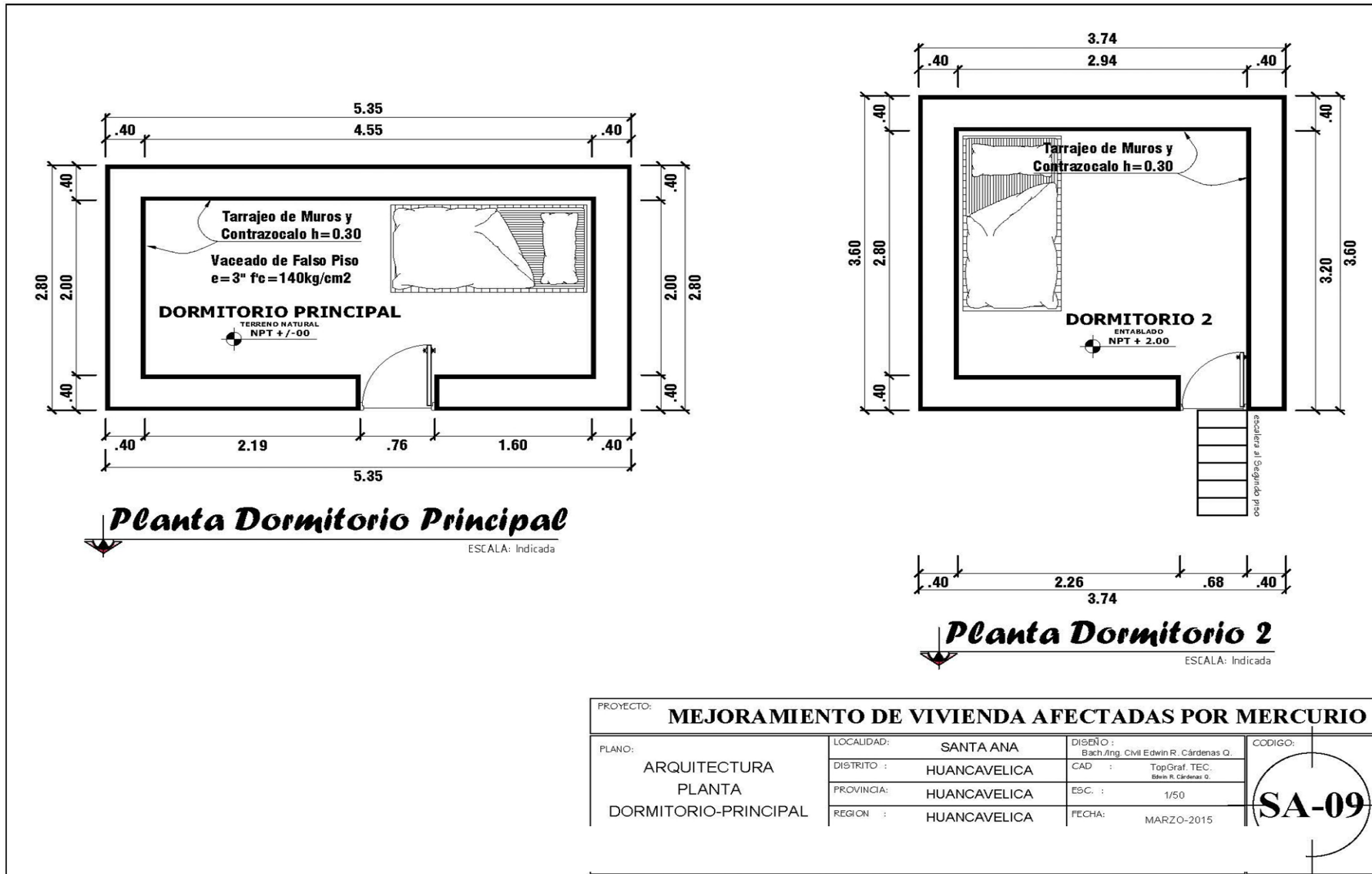
Estimated cost is about 1400 USD per home.

1. Remove and replace home – Completely removing the home and constructing a new home with new uncontaminated material.

Estimated cost is about 18,000 USD.

Based on the effectiveness and durability of the concrete/plaster encapsulation, this appears to be an effective alternative that is protective, reliable, culturally relevant, easily implemented and is moderate to low cost.

# Sample Plan for Prioritized Home



# Engineer and Construction Team



# Pilot Study - Encapsulation



# 2015 Pilot Study of Results

- Six homes received ½ inch of gesso plaster (stucco) and 3 inch layer of concrete on the floor.
- This intervention effectively eliminates indoor sources of contaminated soil and dust.
- Mercury vapor reduced, although two homes had a slight increase in Hg vapor.
- Mercury vapor concentrations were below the WHO screening value of 200 ng/m<sup>3</sup> for chronic exposure.
- This field work also involved the collection and additional analysis of samples of tailings, travertine, soil and adobe which revealed had elevated concentrations of As, Hg, and Pb.

# Conclusions

- Population of about 50,000 people, outdoor daily exposure
- Approx. 50% to 75% may live in homes above Peru Federal, WHO, and USEPA residential screening values
- Outdoor soil is slowly getting capped with new roads
- About 5000 homes may need to be remediated
- School playgrounds and parks still need clean soil
- No action from federal agencies

# Future Actions

- Conduct national and international outreach to build awareness and secure funding for remediation.
- Build a local sustainable program that incorporates assessment and remediation of homes.
- Further assess other risks such as mercury in food, lead and arsenic in soil/adobe.
- Continue assessment and remediation of individual homes.
- Continue local outreach to provide awareness and education of the risks of mercury exposure as well as ways to reduce one's risk.



# Questions?



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