Soil Treatability Studies: Mercury Study

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February 12, 2015

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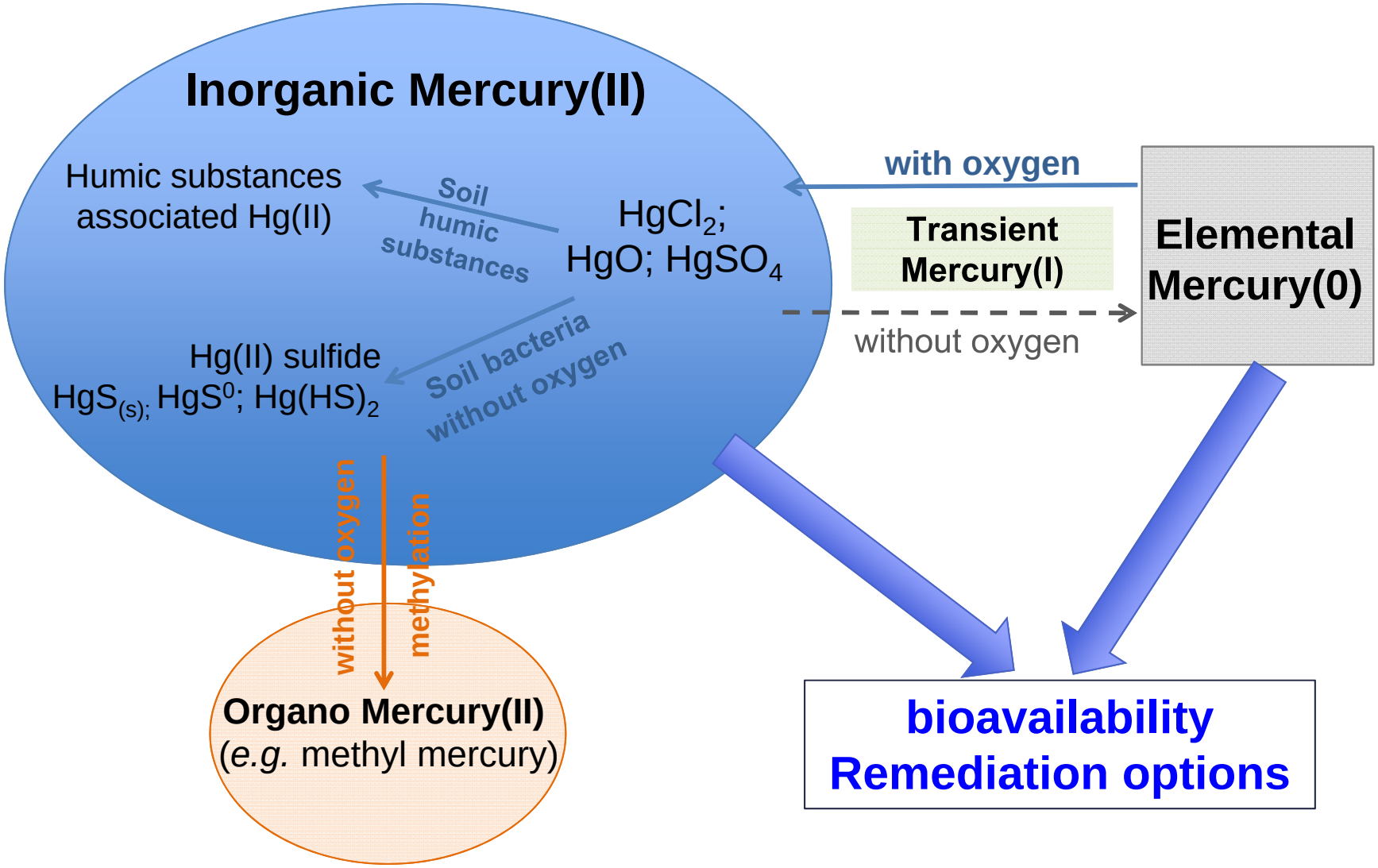
Overview of Presentation

- Mercury Study
  - Motivation for the study
  - Description of mercury chemistry
  - Mercury speciation
    - Different valence states
    - Different tendencies to become mobilized
  - Sample locations
- Results
  - Distribution of mercury in SSFL
  - Variations of mercury levels with soil depths
  - Profiles of mercury speciation in different locations
- Summary
  - Conclusions
  - Recommendations

What is Mercury Study?

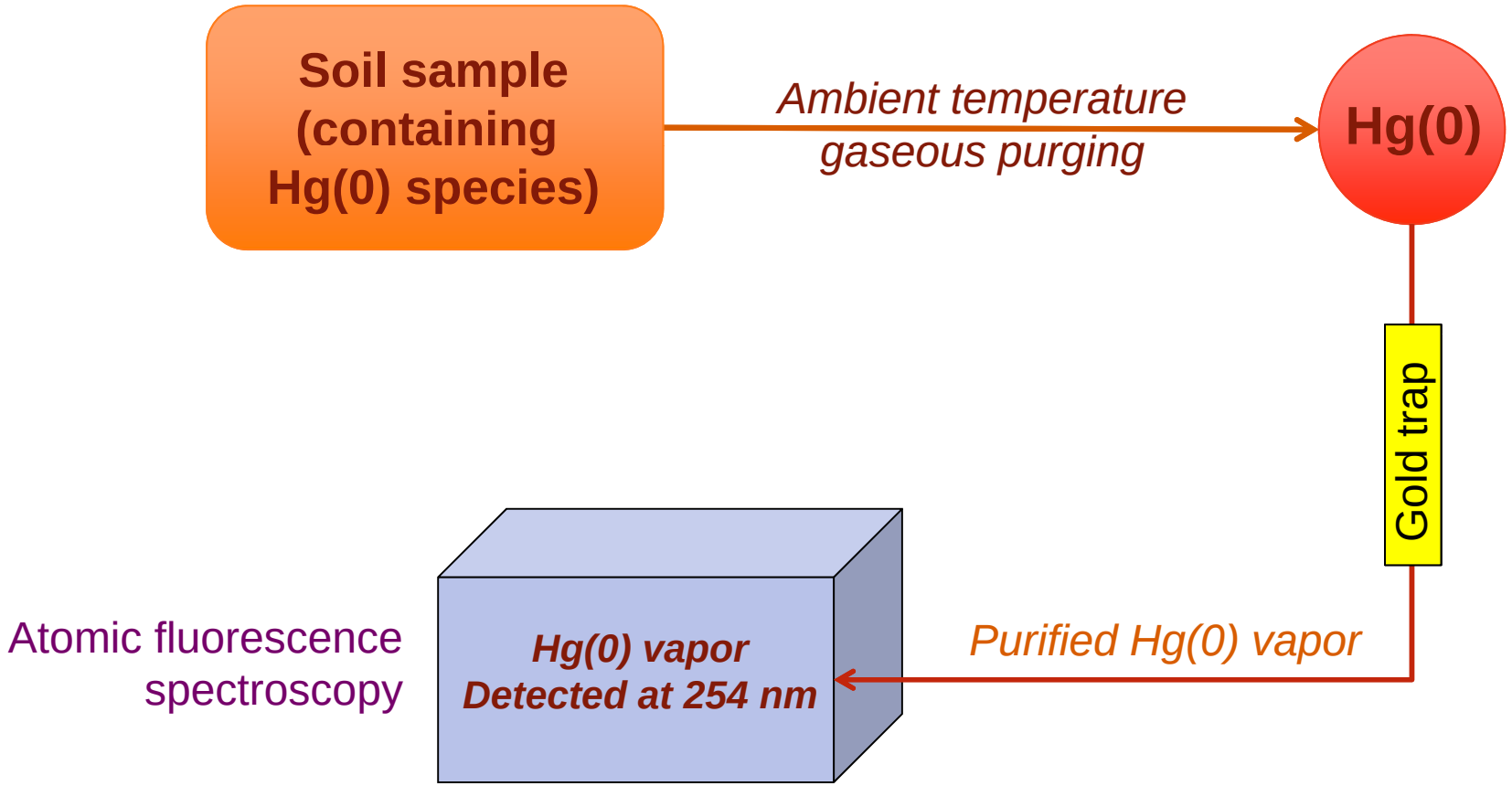
- Determine the current valence states of the spilled mercury in contaminated soil in SSFL.
- Understand the spatial distribution of valence states of mercury in different areas of SSFL.
- Quantify the speciation of mercury at different depths of contaminated soil in SSFL.
- Assess mercury remediation potential and recommend efficient mercury remediation technology.

Motivation of Mercury Study



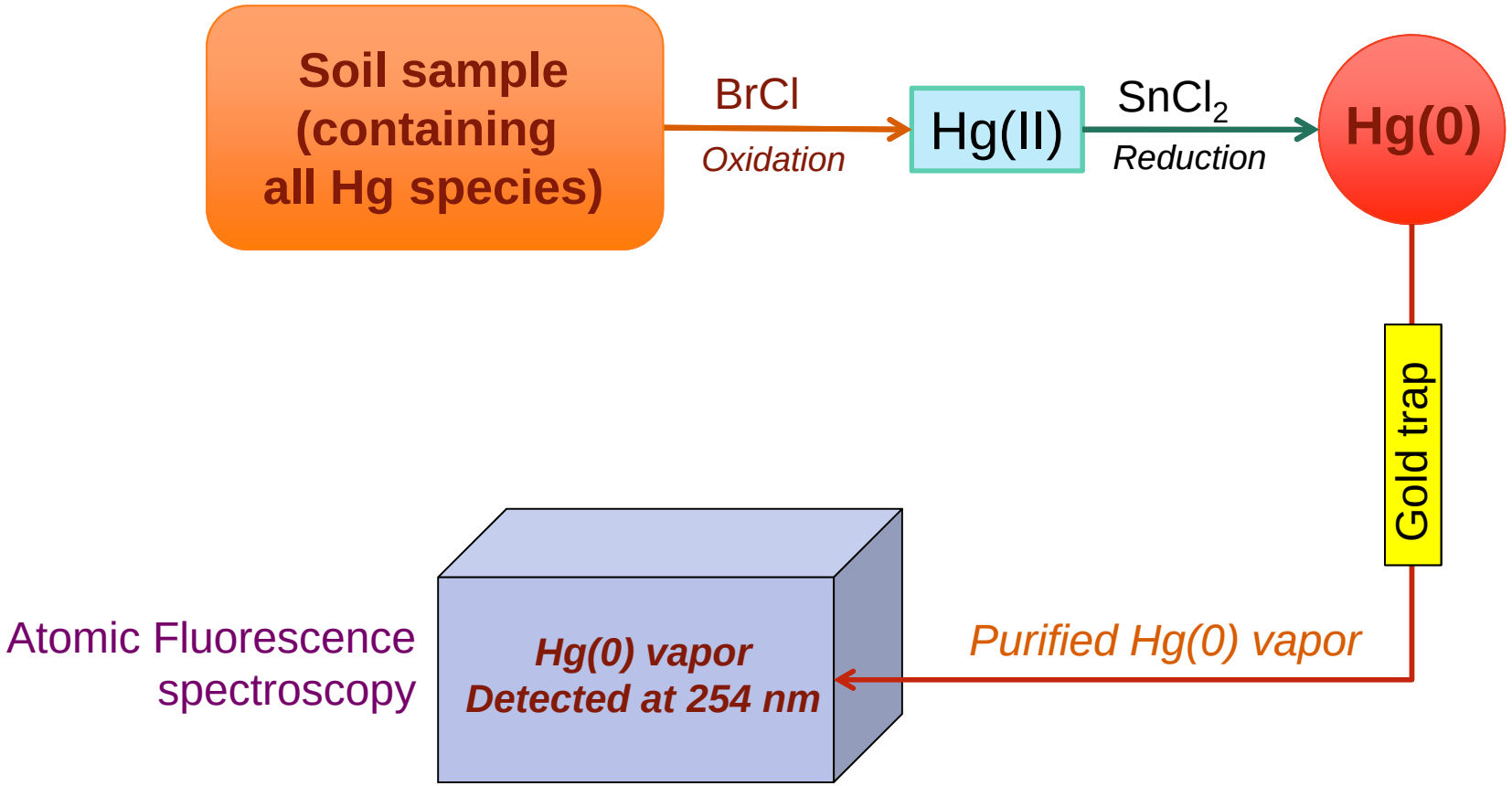
Analytical Methods – Free Elemental Mercury

EPA method 1631: Elemental mercury Hg(0) volatilization and CV-AFS

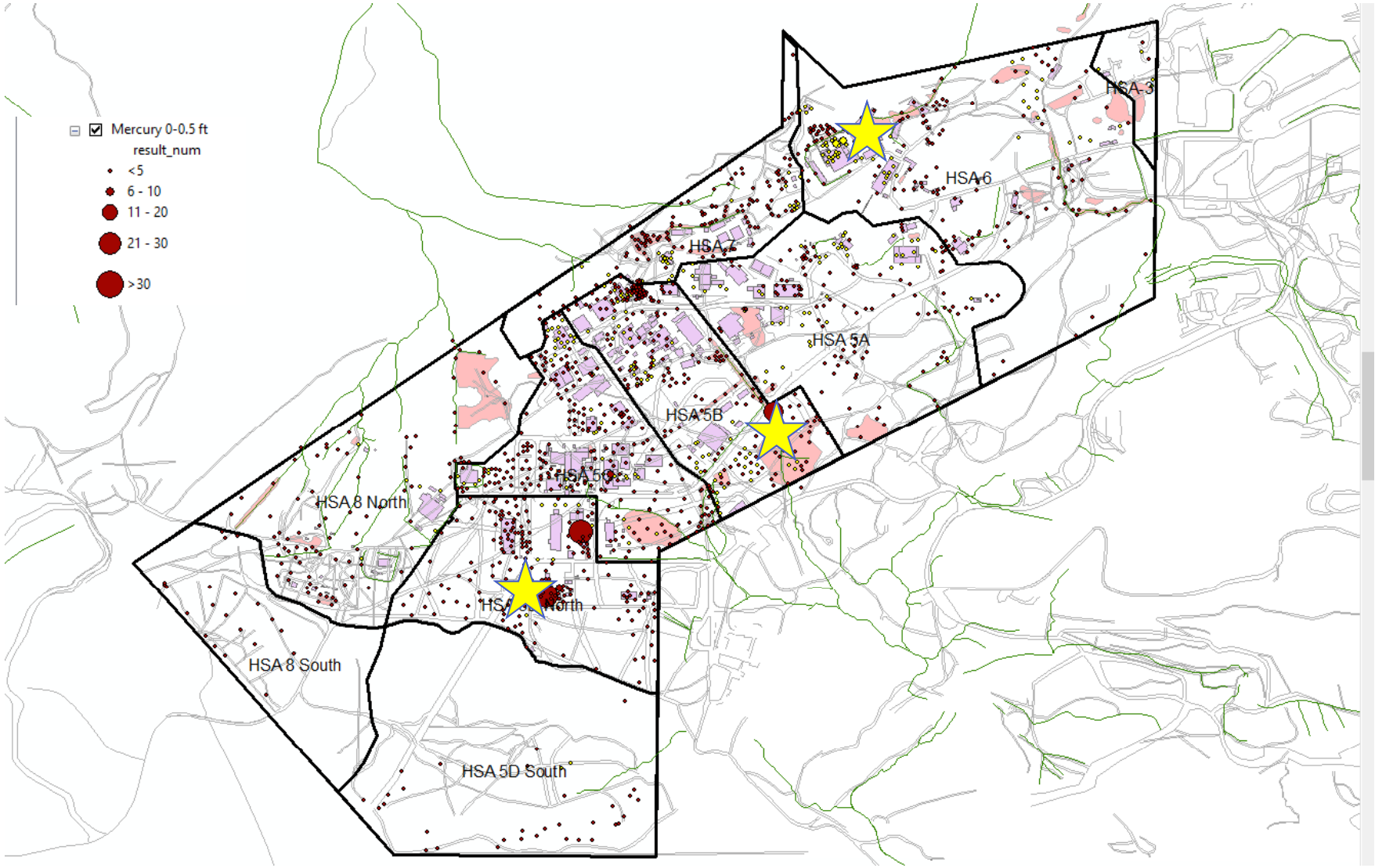


Analytical Methods – Total Mercury

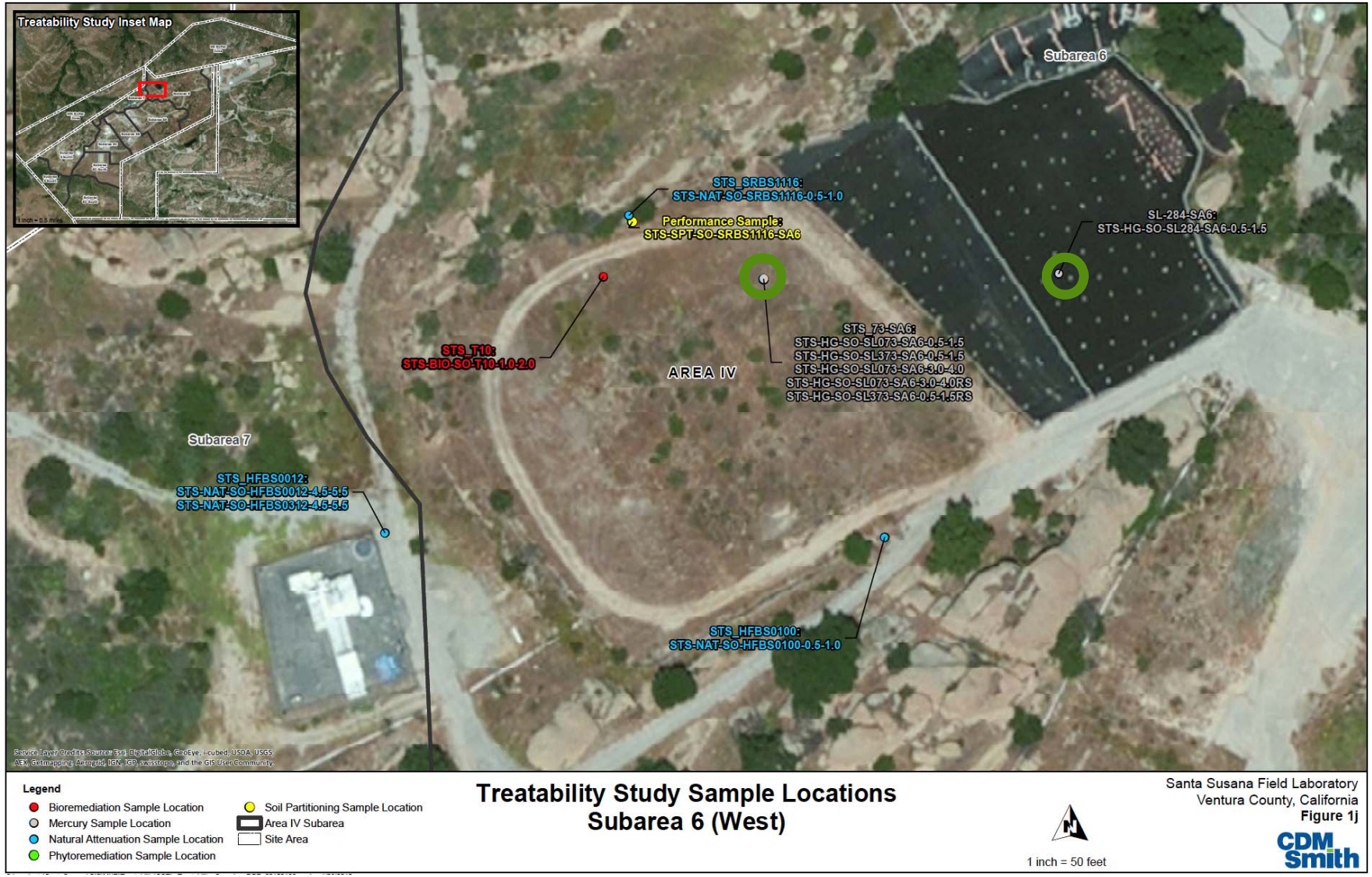
EPA method 7471A: cold-vapor atomic fluorescence spectroscopy (CV-AFS)



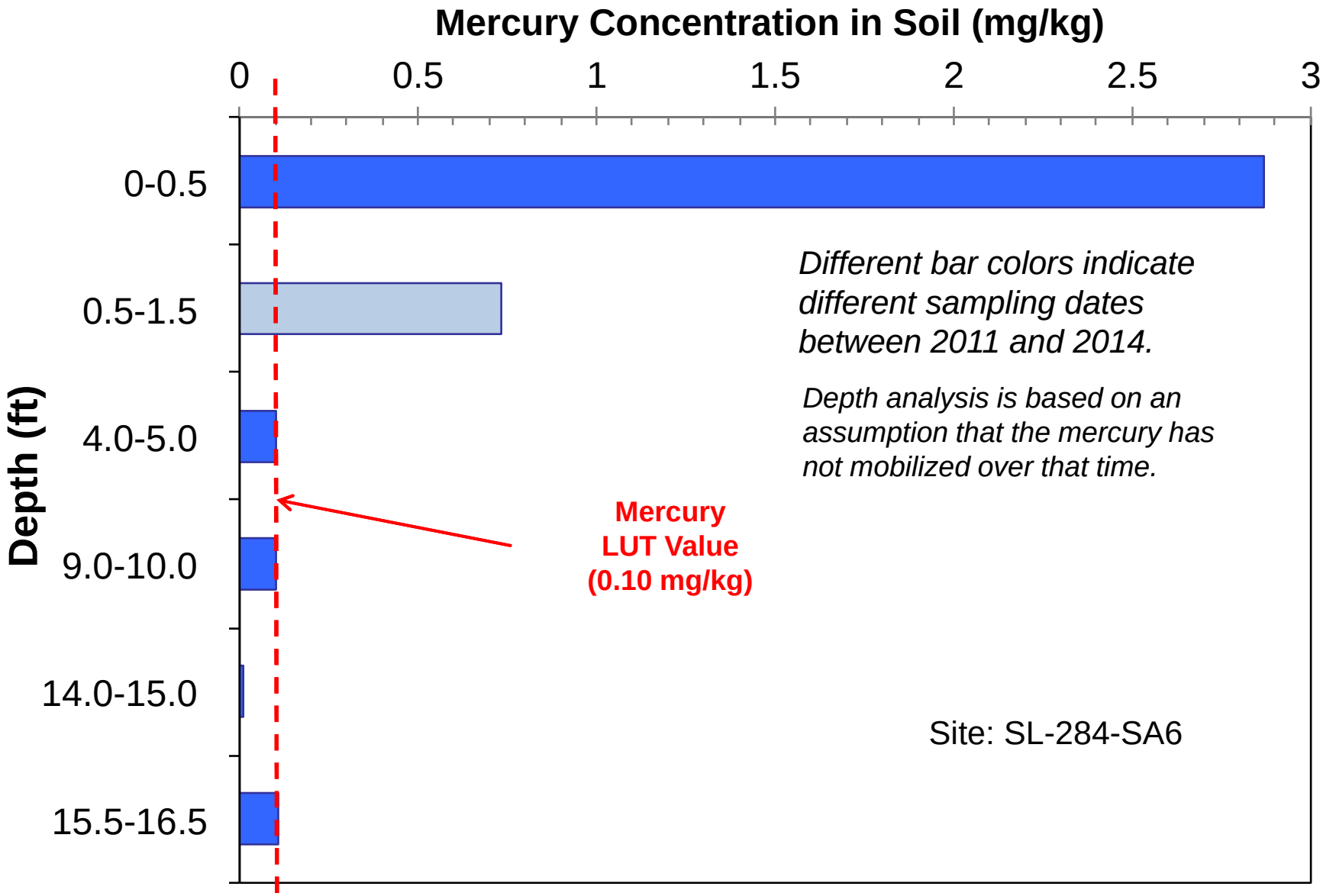
Results - Total Mercury Spatial Distribution



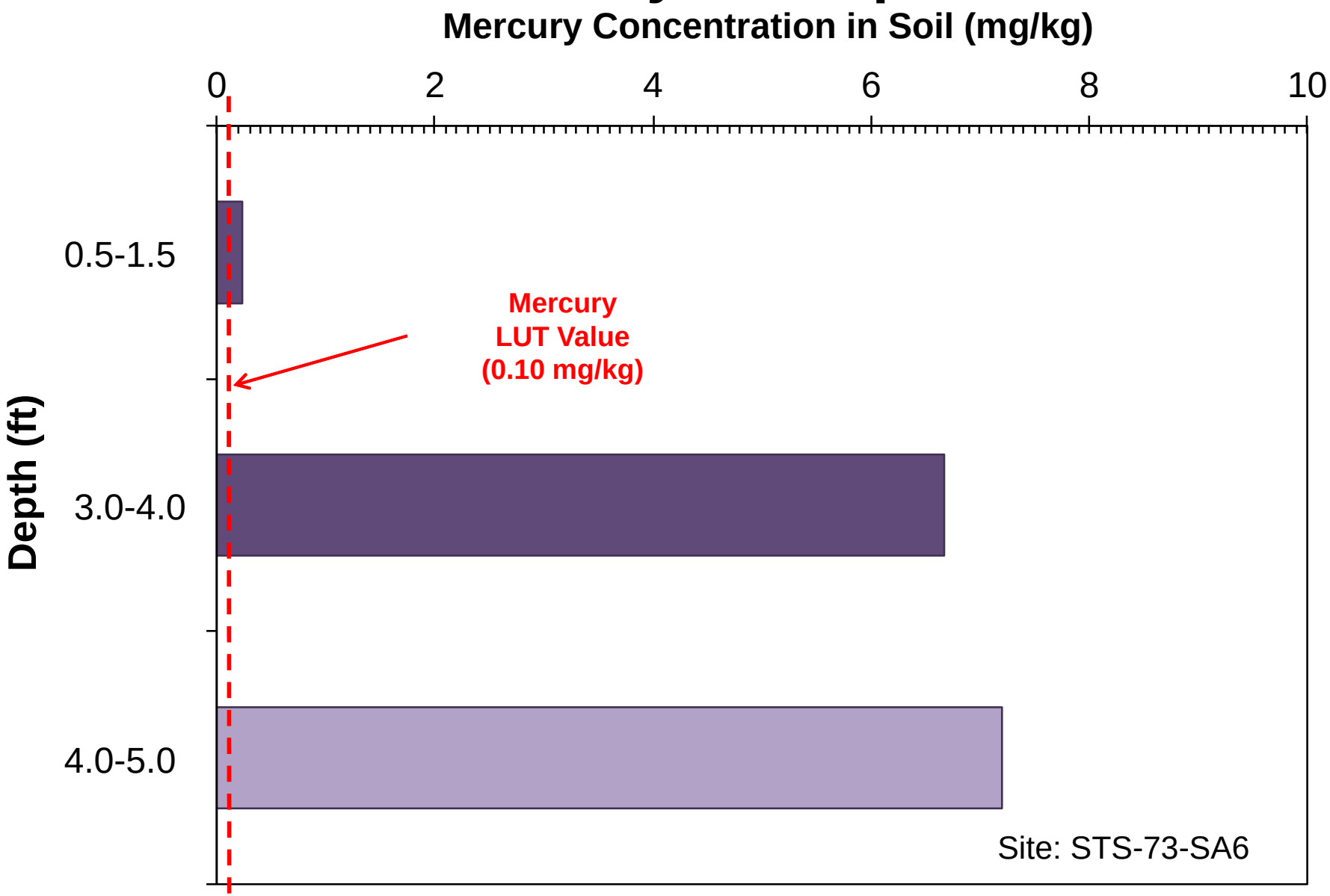
Mercury Speciation Sampling Area #1



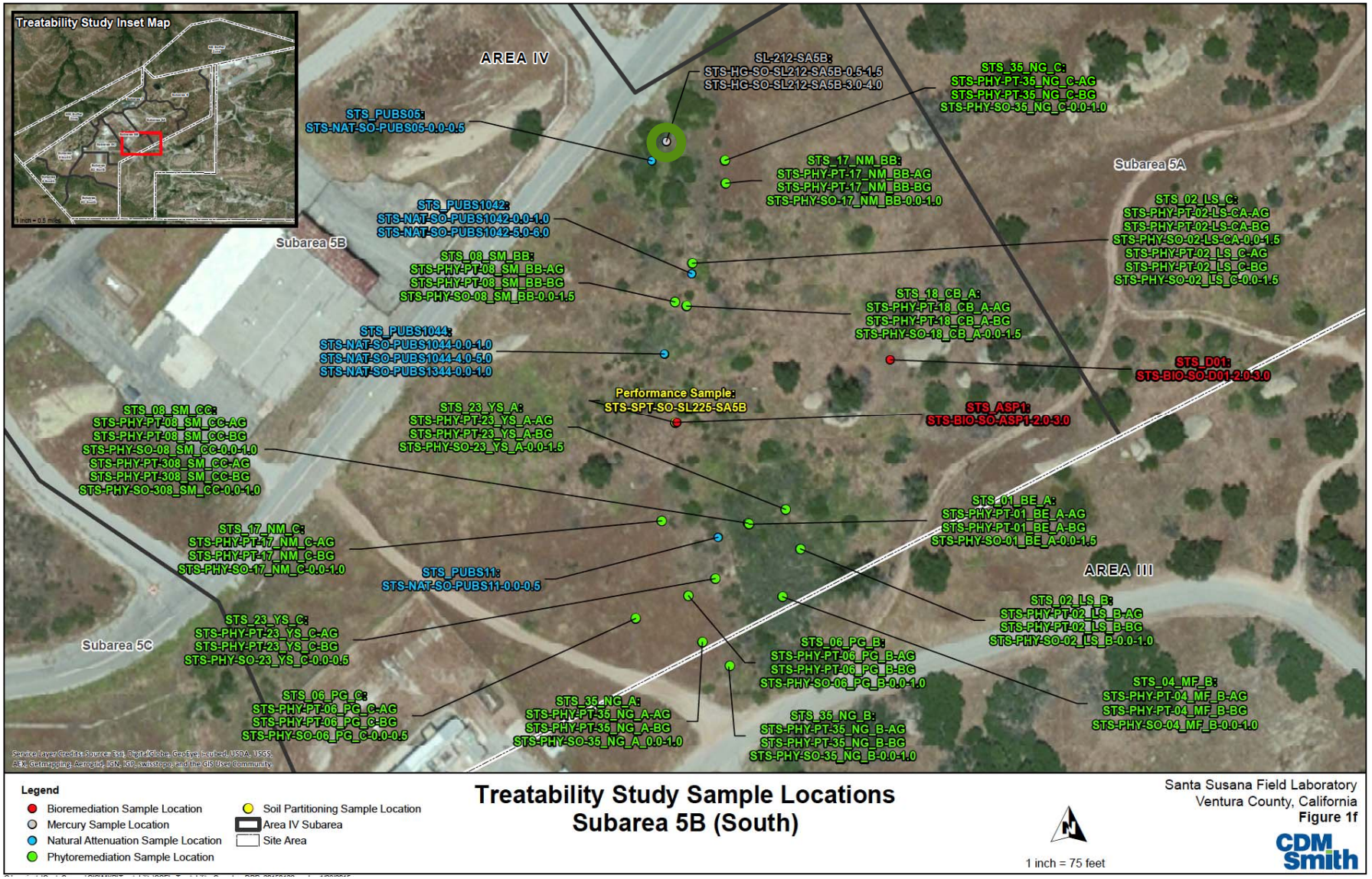
Results - Total Mercury *vs.* Depth



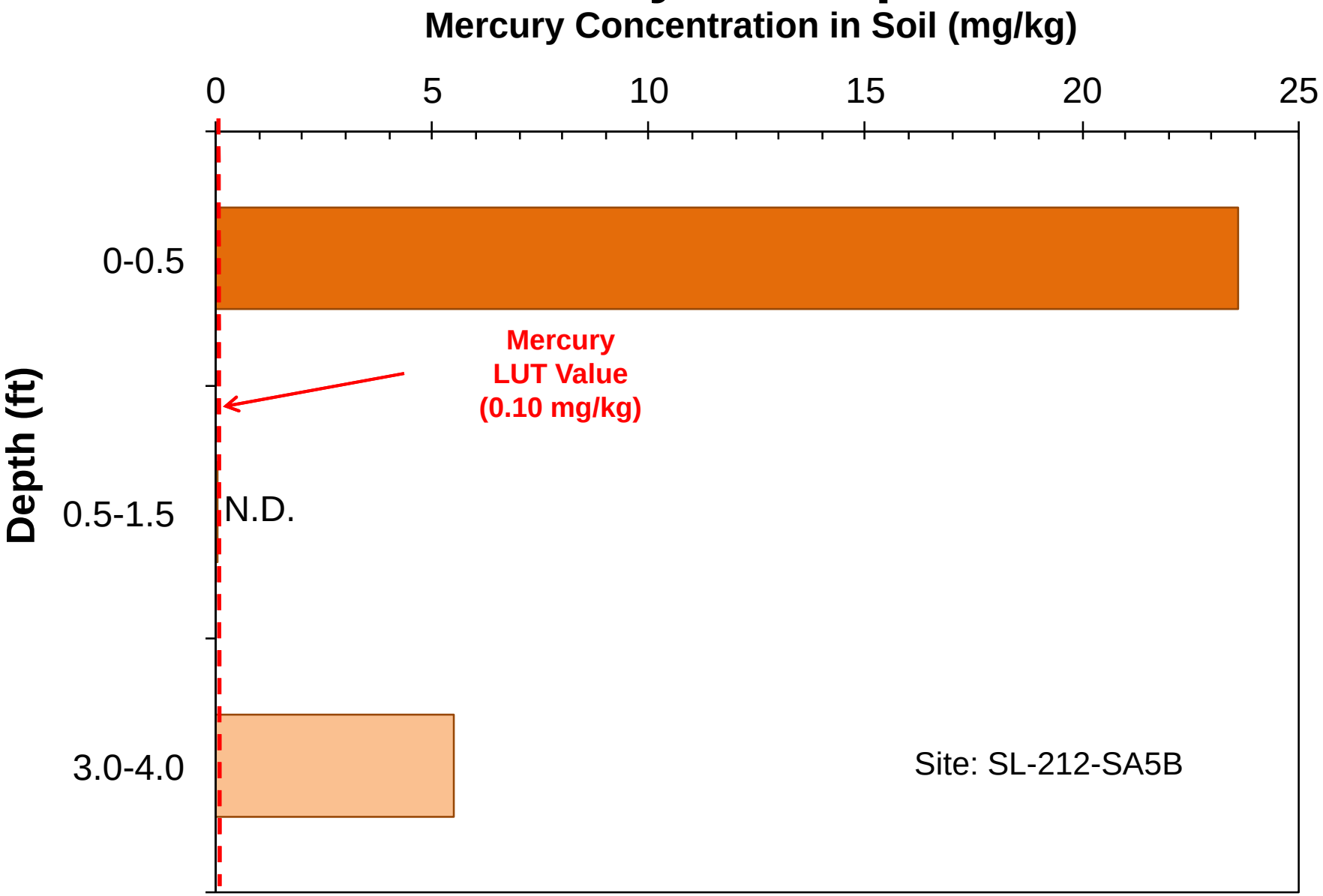
Results - Total Mercury *vs.* Depth



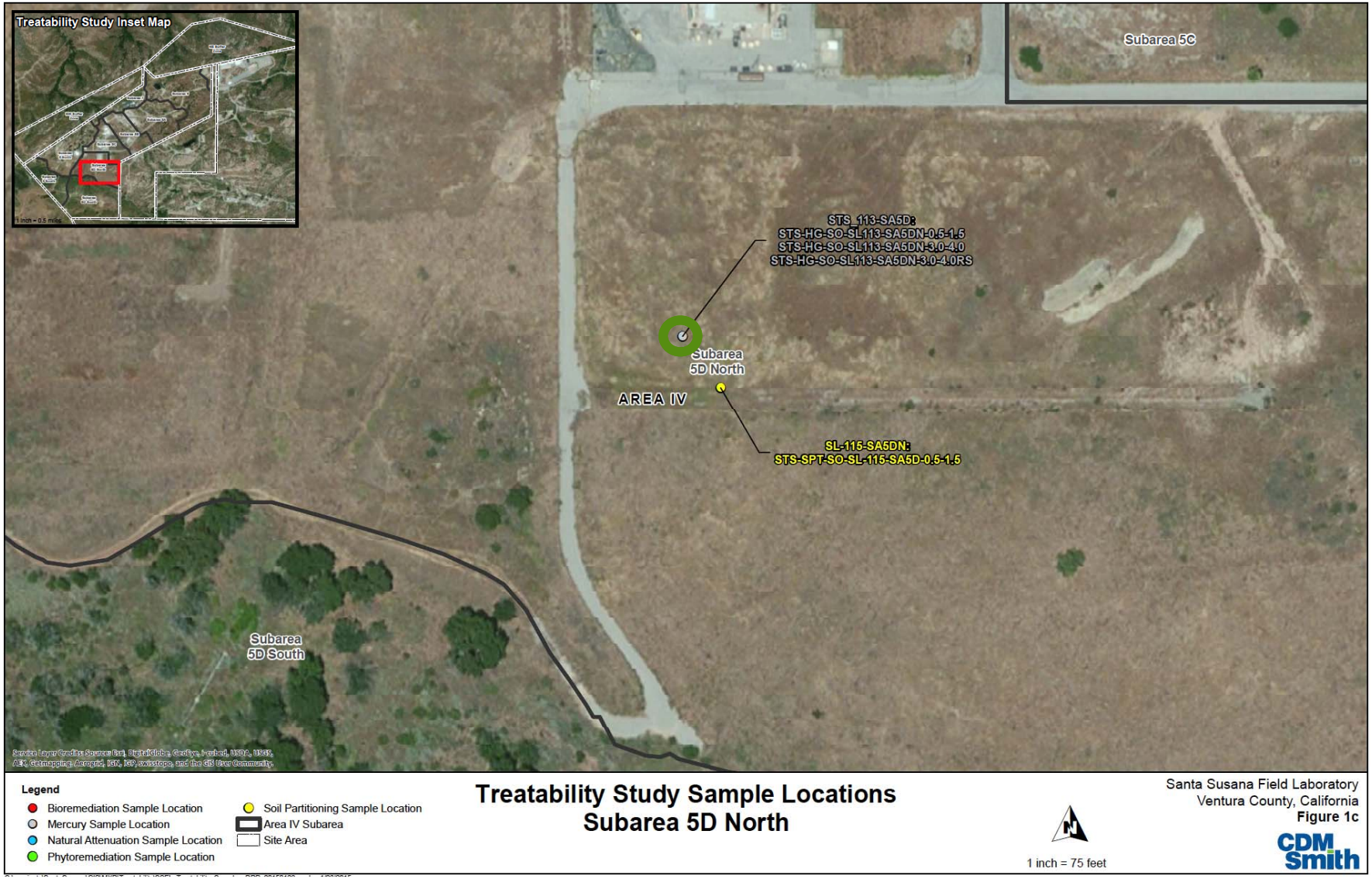
Mercury Speciation Sampling Area #2



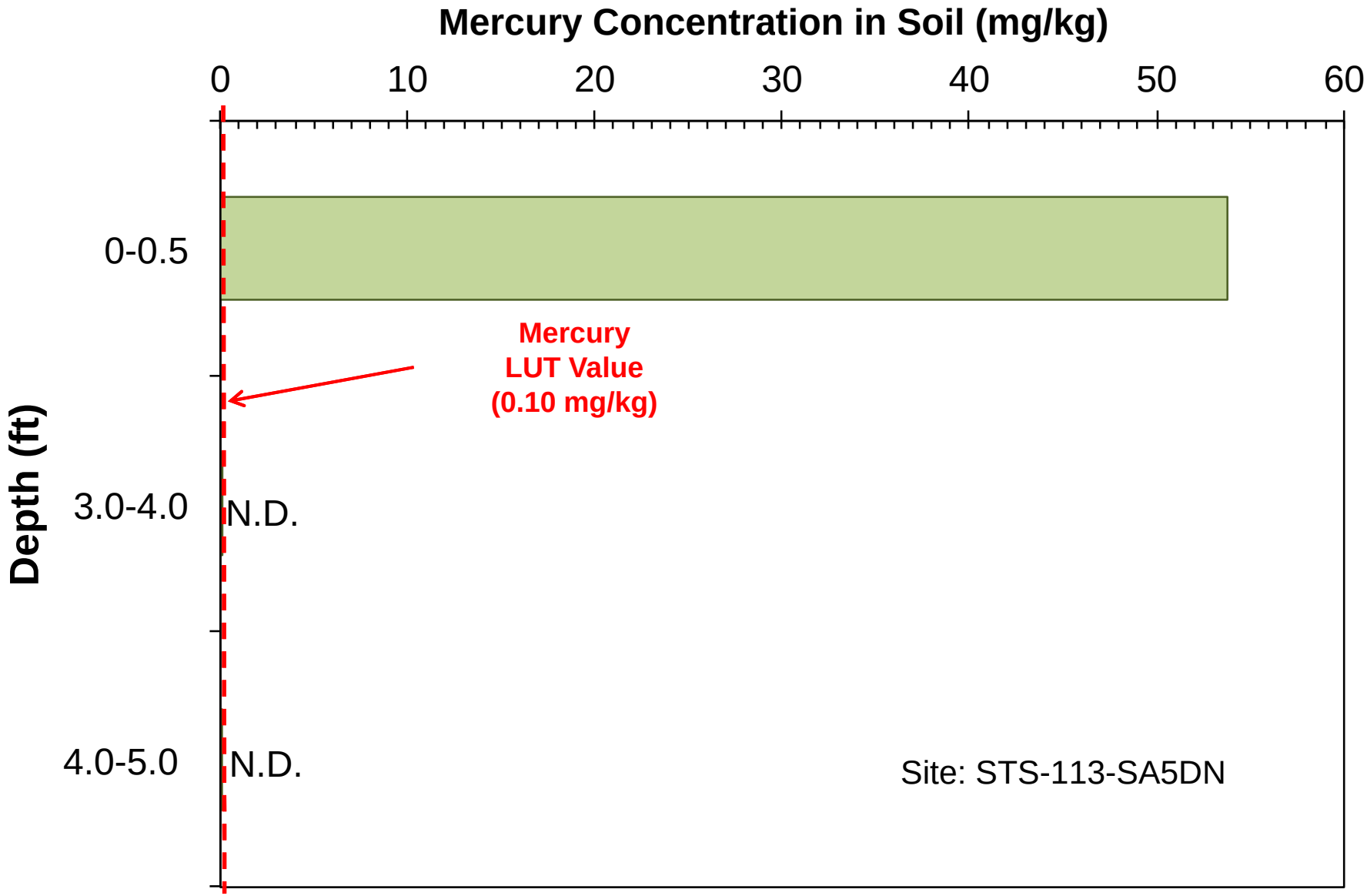
Results - Total Mercury *vs.* Depth



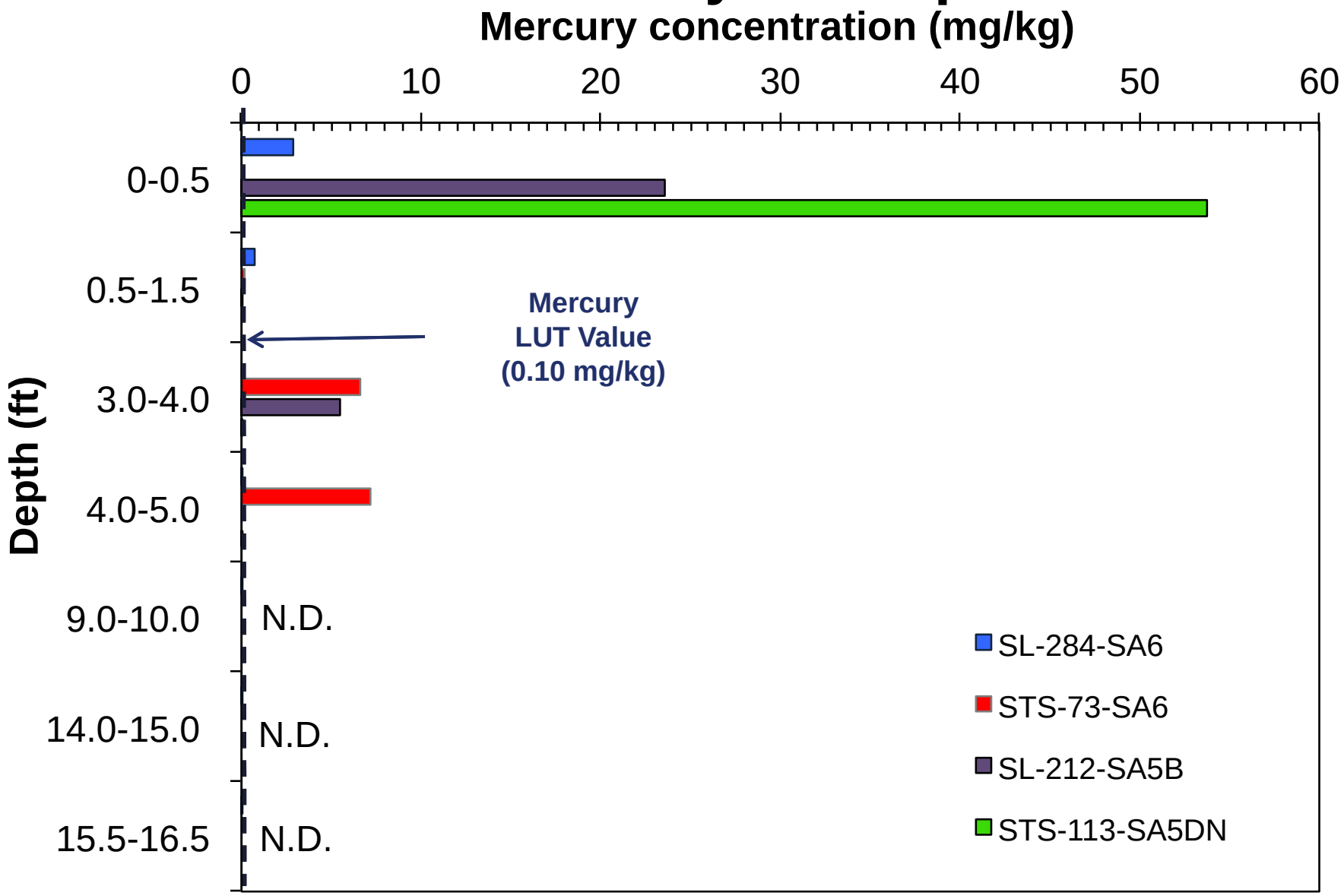
Mercury Speciation Sampling Area #3



Results - Total Mercury *vs.* Depth



Results - Total Mercury *vs*. Depth

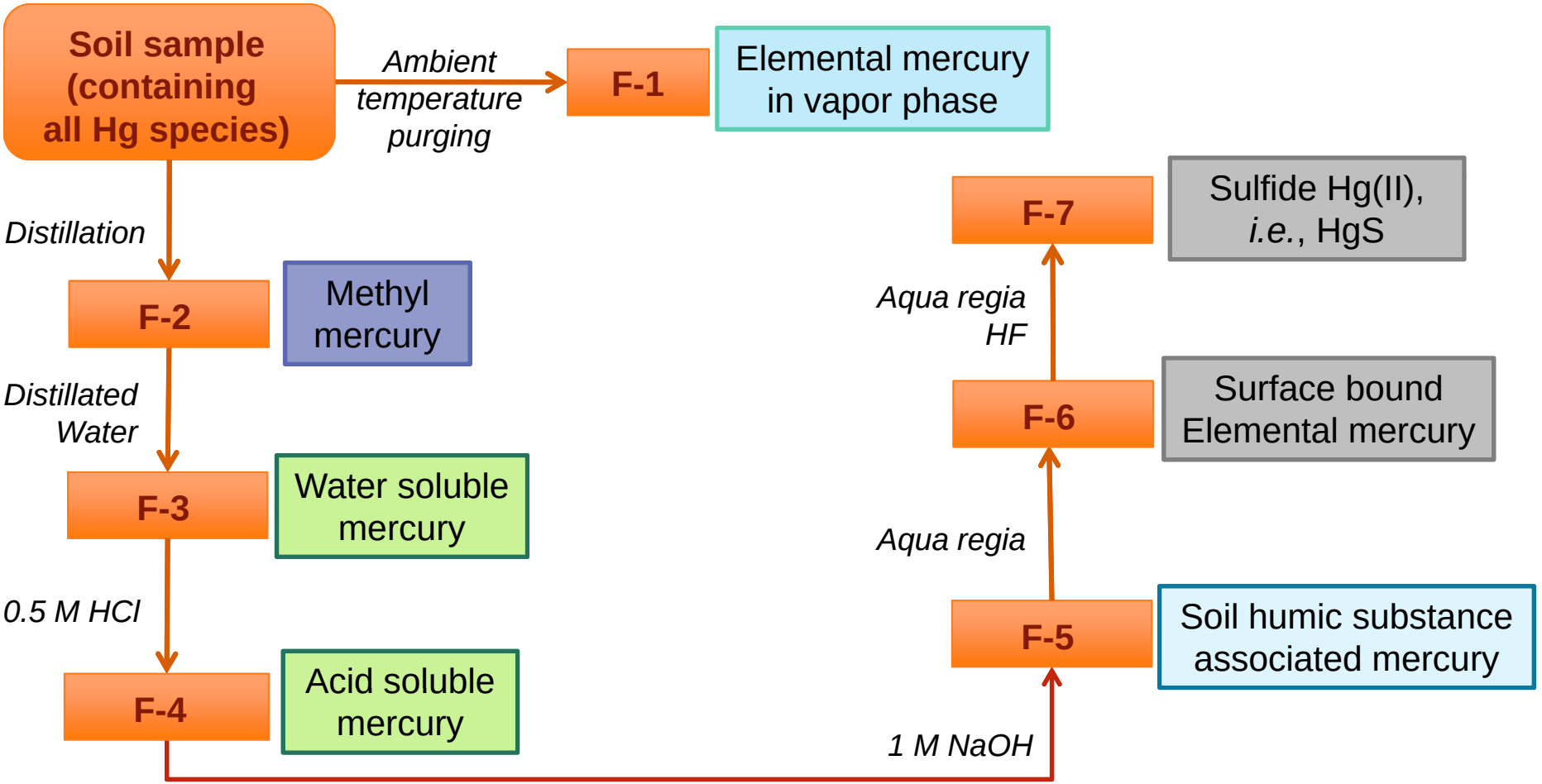


Results - Total Mercury Depth Analysis

- Total mercury was detected across multiple locations in SSFL.
- At 3 sampling locations, mercury concentrations were highest at the surface and decreased with depth in soil.
  - Total mercury exceeded LUT Value (0.10 mg/Kg) in top soil layers.
  - Total mercury was below detection limit at soil depths below 9 ft.
- In 1 sampling location (STS-73-SA6), mercury concentrations were lowest at the surface and increased with soil depth.
  - Total mercury at the surface was below LUT Value.
  - Total mercury exceeded LUT Value (0.10 mg/Kg) in soil at depths between 3 and 5 ft.

Analytical Methods – Mercury Speciation

Sequential extraction of soil sample

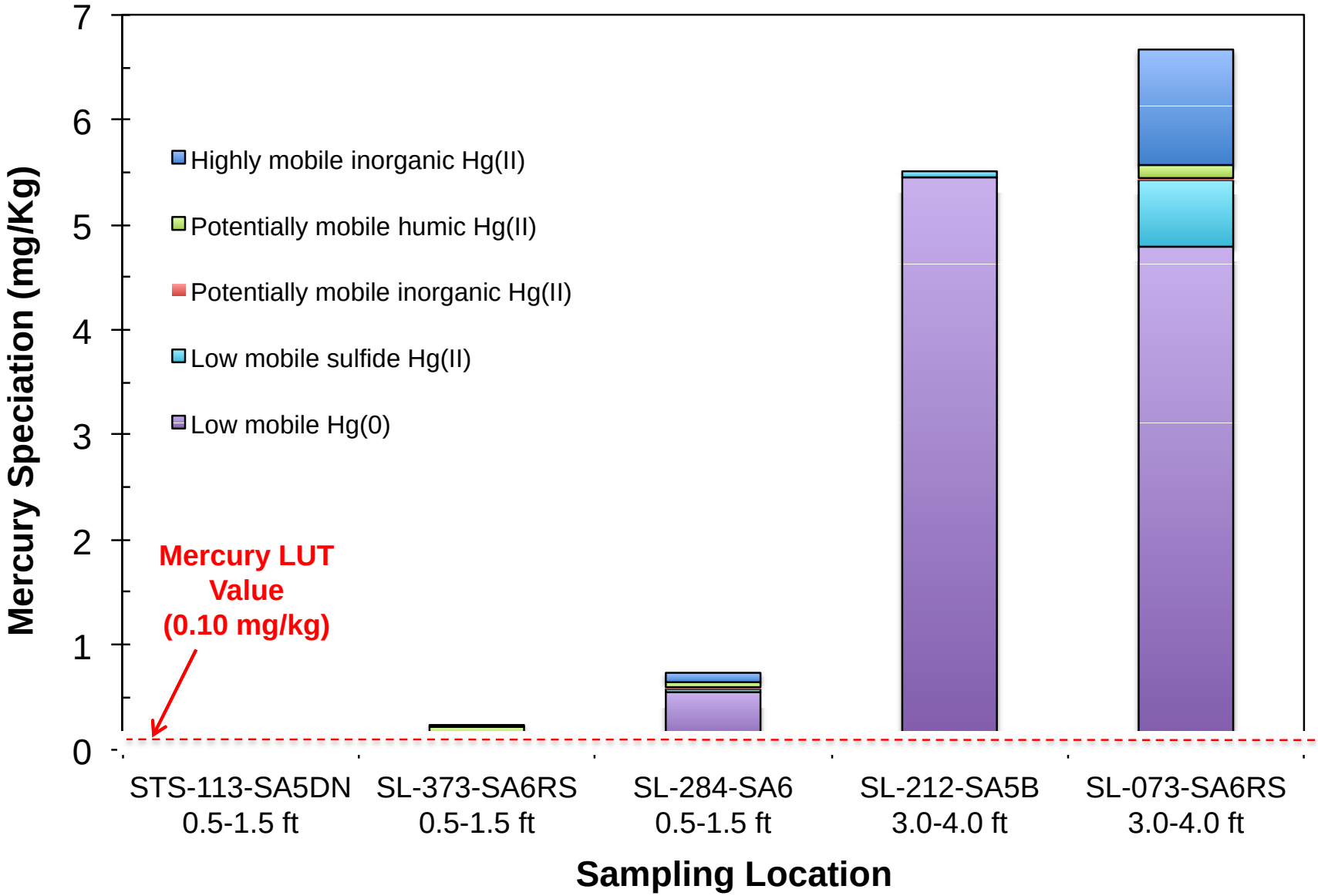


Boszke, et al, *Environ. Geol*. **2008**, 55, 1075-1087.

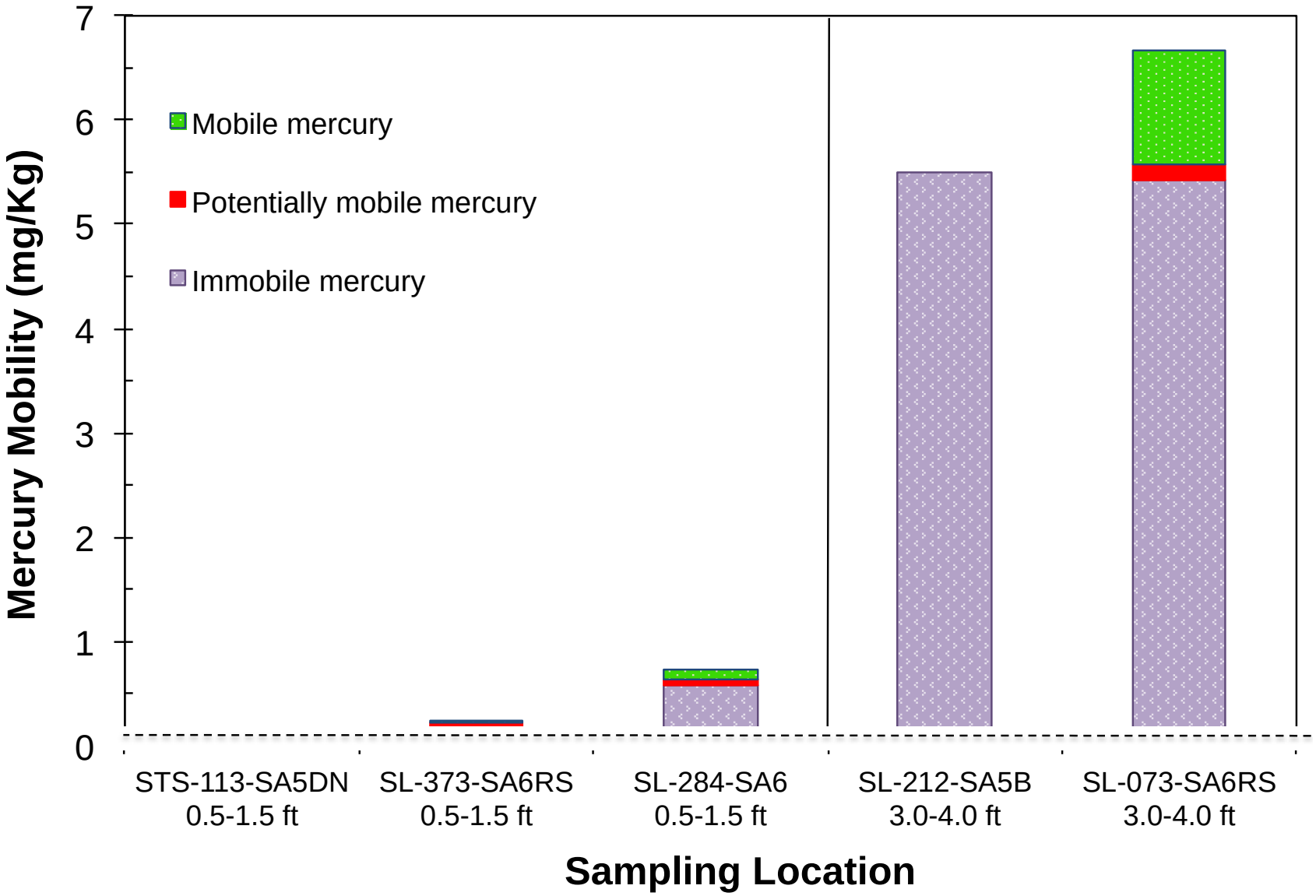
Mercury Speciation *vs.* Mobility in Soil

Fraction	Mercury speciation	Mobility in soil	Bioavailability	Phytoremediation
F-1	Elemental mercury (vapor phase)	✔✔✔	✗	✗
F-2	Methyl mercury	✔✔✔	✔✔	✔✔
F-3	Water soluble mercury	✔✔✔	✔✔✔	✔✔✔
F-4	Acid soluble mercury	✔	✔	✔
F-5	Soil humic substance associated mercury	✔	✔	✔
F-6	Elemental mercury (surface bound)	✔	✗	✗
F-7	Mercury sulfide	✔	✔	✔

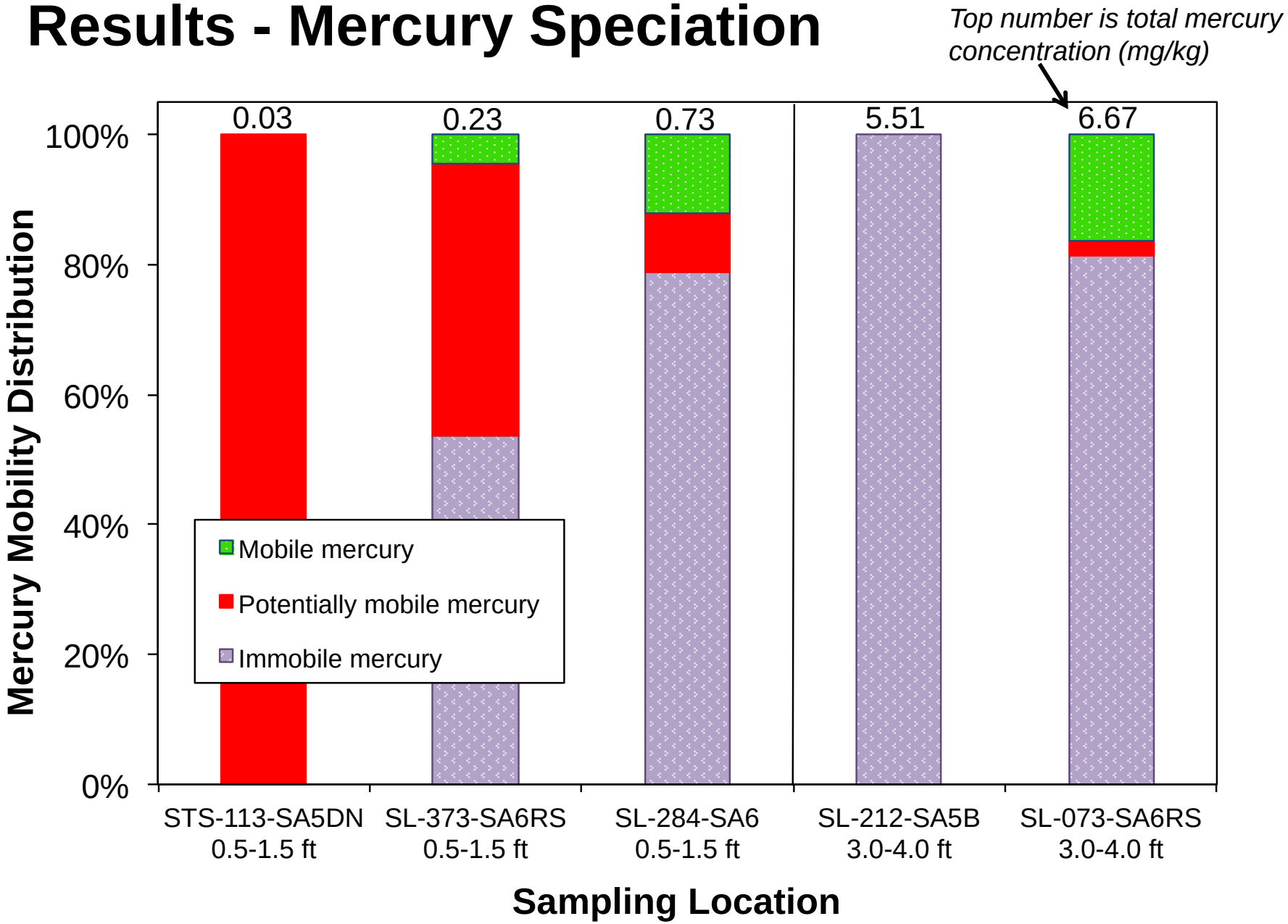
Results - Mercury Mobility



Results - Mercury Mobility



Results - Mercury Speciation



Results - Valence States of Mercury

- **Elemental mercury**
  - Samples from 4 selected sites
  - Elemental mercury in vapor phase was not detected
  - Elemental mercury bound to surface was detected at soil depths between 3.0 and 4.0 ft
- **Methyl mercury**
  - Trace amounts at 2 sites (SL-212-SA5B and SL-284-SA6)
  - Only accounted for 0.003% of total mercury
  - Occurrence at soil depths between 3.0 and 4.0 ft
- **Ionic Mercury**
  - Detected at different soil depths
  - Existed in organic and inorganic mercury complexes
  - Accounted for a majority of the total mercury on top soil between 0 and 1.5 ft

Assessment on Mercury Distribution

- With respect to soil depth profile, the majority of total mercury was distributed in soil with depths between 0 and 4 ft.
- In top soil layers between 0 and 1.5 ft, a large percentage of total mercury (between 30% and 100%) exists as soluble Hg(II) and soil humic substances associated Hg(II).
  - Indicative of mercury that can be bioavailable.
  - Both sites in subarea 5 and 6 (SL-113-SA5DN and SL-284-SA6) has large percentage of mobile mercury in top soil.
- In soil with a depth below 3 ft, total mercury exists predominantly as elemental Hg(0) that is bound to soil particle surfaces.
  - Indicative of immobile fraction of mercury
  - The mercury release site in subarea 6 (SL-284-SA6) has the highest surface-bound elemental Hg(0).

Assessment on Mercury Remediation

- Soil washing and phytoremediation can be a viable treatment for mercury remediation in surface soil layers.
  - Presence of a large fraction of mobile forms of mercury
  - Associated with soluble salts and soil organic matter
  - Soil washing is potentially applicable, but require additional tests
- Bioremediation or phytoremediation is not likely be effective for deep soil.
  - Predominance of immobile mercury that is mostly in elemental valence state and tightly bound to soil particles
  - Thermal treatment can be an alternative to remediate mercury in deep soil, especially at the original release site in subarea 6, but require additional lab tests for treatability.
  - Soil size partitioning has the potential to reduce volume for thermal treatment. Additional tests on mercury size distribution is necessary.

Thank you.

Questions