# Research Area Descriptions:

RA 2: Site Characterization and Remediation

RA 3: Solvent Vapor Intrusion

RA 4: Leaking Underground Storage Tanks

RA 5: Chemicals of Immediate Concern

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# LIST OF ACRONYMS

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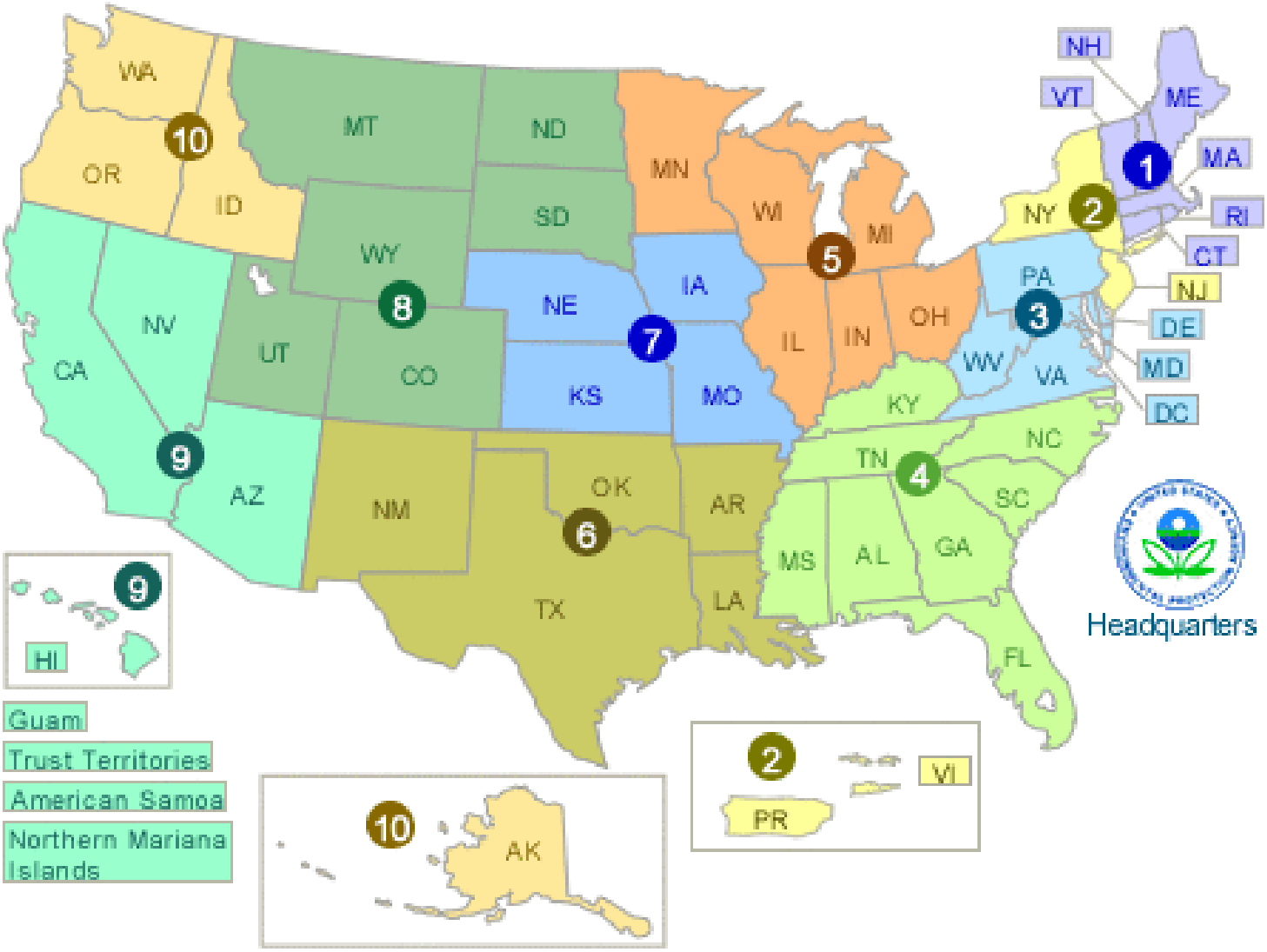
|---|---|
| AO | EPA's Office of the Administrator |
| AALM | All Ages Lead Model |
| A-E | Air and Energy Research Program |
| AOC | Area of Concern |
| ASTHO | Association of State and Territorial Health Officials |
| ASTSWMO | Association of State and Territorial Solid Waste Management Officials |
| BLL | Blood Lead Levels |
| BMP | Best Management Plan |
| BUILD | Brownfields Utilization, Investment and Local Development Act |
| C&D | Construction and Demolition |
| CBPO | Chesapeake Bay Program Office |
| CDC | Center for Disease Control and Prevention |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CSS | Chemical Safety for Sustainability |
| DoD | United States Department of Defense |
| ECOS | Environmental Council of the States |
| EPA | United States Environmental Protection Agency |
| ES | Ecosystem Services |
| FEMA | Federal Emergency Management Agency |
| FFRO | Federal Facilities Restoration and Reuse Office |
| FY | Fiscal Year |
| GIS | Geographic Information System |
| HELP | Hydrologic Evaluation of Landfill Performance |
| HERA | Health and Environmental Risk Assessment Research Program |
| HHS | United States Department of Health and Human Services |
| HSRP | Homeland Security Research Program |
| HUD | United States Department of Housing and Urban Development |
| IEUBK | Integrated Exposure Uptake Biokinetic model |
| LUST | Leaking Underground Storage Tanks |
| MIW | Mining-influenced Water |
| NARPM | National or Regional Association of Remedial Project Managers |
| NPL | Superfund National Priority List |
| OAR | EPA's Office of Air and Radiation |
| OBLR | OLEM's Office of Brownfields and Land Revitalization |
| OCR | EPA's Office of Community Revitalization |
| OCSPP | EPA's Office of Chemical Safety and Pollution Prevention |
| OECA | EPA's Office of Enforcement and Compliance Assurance |
| OEM | Office of Emergency Management |
| OLEM | EPA's Office Land and Emergency Management |
| ORCR | EPA's Office of Resource Conservation and Recovery |
| ORD | EPA's Office of Research and Development |
| OSRTI | OLEM's Office of Superfund Remediation and Technology Innovation |
| OUST | EPA's Office of Underground Storage Tanks |

| | |
|---|---|
| OW | EPA's Office of Water |
| Pb | Elemental heavy metal – lead |
| PIP | Pathfinder Innovation Project |
| PVI | Petroleum Vapor Intrusion |
| R2R2R | Remediation to Restoration to Revitalization |
| RA | Research Area |
| RARE | Regional Applied Research Effort |
| RCRA | Resource Conservation and Recovery Act |
| RESES | Regional Sustainability and Environmental Sciences Research Program |
| RFA | Request for Applications |
| RPM | Remedial Project Manager |
| SARA | Superfund Amendments and Reauthorization Act |
| SHC | The Sustainable & Healthy Communities Research Program |
| SPIRAL | Sustainability Partners Incorporating Research into Academia and Localities |
| SSWR | Safe and Sustainable Water Resources Research Program |
| STL | Superfund and Technology Liaison |
| StRAP | Strategic Research Action Plan |
| SWDA | Solid Waste Disposal Act |
| TSP | Superfund Technical Support Projects |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USGS | United States Geological Survey |
| UST | Underground Storage Tanks |
| VI | Vapor Intrusion |
| VOC | Volatile Organic Compound |

## MAP OF EPA REGIONS



# Charge Questions 1 &4: SHC Research Area 2 Description

**National Research Program:** Sustainable and Healthy Communities
**Topic:** Topic 1: Contaminated Sites
**Research Area:** Research Area 2: Site Characterization and Remediation
**Research Area Coordinator (MI):** Thomas Holdsworth, Center for Environmental Solutions and Emergency Response (CESER)
**Research Area Start Date:** 10-2018
**Research Area End Date:** 09-2022

**Overview:** This research area provides state-of-the-science methods, models, tools and technologies that OLEM uses in programmatic guidance, and that EPA decision makers use in site cleanup. Steps in the Superfund process that commonly use ORD research include 1) the remedial investigation and feasibility study (which determines the nature and extent of contamination, identifies remedial action objectives, and screens potential treatment and containment technologies), 2) the record of decision (which explains the cleanup alternatives that will be used at a given National Priorities List site), and 3) the remedial design/remedial action (which contains preparation and implementation plans and specifications for applying site remedies). The research described below will provide science-based solutions to the most challenging technical issues identified by OLEM and the EPA regional offices at large-scale, complex sites. These include how to 1) more efficiently remediate contaminated soils and sediments at Superfund sites, 2) characterize and remediate contaminated groundwater at Superfund sites, and 3) remediate mining and mineral processing sites, which typically have large footprints with large volumes of wastes that have varying geochemical compositions.

**Program/Regional/State Needs:** Improved metrics, remediation approaches, and tools are needed to assess and manage contaminant sources, quantify and understand contaminant bioavailability, and define the exposure and biological consequences at both terrestrial and aquatic sites. Existing assessment measures and tools may not be able to fully address all contaminants, conditions, and sources present at contaminated sites. The cleanup levels for common contaminants (heavy metals, organics, inorganics) at sediment and soil sites are often low and are close to or below detection limits. Improved techniques are needed to reduce detection limits and improve estimates of bioavailability at sediment sites. Guidance is needed on how to incorporate bioavailability measurements into the process of developing Remedial Action Objectives (RAO). Program managers need this work to make informed decisions about which remediation and restoration options are optimal for lowering risks to ecosystems and human health.

At many groundwater sites, remediation is limited by the extent to which complex subsurface conditions (e.g., karst environments, fractured bedrock, heterogeneous sedimentary deposits, complex contaminant mixtures, groundwater/surface water interactions) can be characterized. Timely and cost-effective remediation of contaminated groundwater can be hampered by limitations in existing technologies. To advance the practice of groundwater remediation research is needed on groundwater treatment delivery and extraction systems, chlorinated solvent plumes, and approaches to meet discharge standards.

Modifications to innovative passive treatment technologies or development of new technologies that can decrease treatment costs, treatment waste volumes, and energy usage, especially for *in situ* groundwater remediation, are desired at Superfund mining and smelter sites. Mining-Influenced Water requires long-term water treatment; therefore, control of the source(s) of mine drainage may be the most viable long-term option for remediating mining sites. To address source control, research on passivation technologies to reduce or eliminate metal leaching from waste rock ore and tailings is needed. Research also is needed to address remaining challenges of source attribution, fingerprinting, and background studies for some smelter sites. Remediation technologies and approaches that minimize treatment volumes and allow treatment or mitigation in-situ, such as through soil amendments, caps, stabilization and solidification, and other techniques offer significant opportunities for Superfund smelter sites.

**Assumptions and Constraints:** Resource reductions from the planned amount will impact the quality and content of the research generated at the milestone level. Additional FTE beyond the current output and product leads is needed to complete the deliverables. New hires, contractual support and cross training of current staff are necessary.

### CQ 4: Output 2.1: Methods, Tools, and Guidance on Remediation Options

Output Description:

SHC will evaluate, develop, validate, and demonstrate remediation alternatives and tools to reduce risk, better assess sources and exposure at contaminated sites, and connect them quantitatively to biological and human health consequences. Potential products include: 1) methods and guidance for assessing contaminant bioavailability using passive sampling; 2) advancements in assessment tools for forecasting residues in fish, shellfish, and wildlife; 3) improvements for addressing temporal and spatial variability associated with contaminant exposure; 4) demonstration studies to validate existing and newly developed assessment measures and tools; and 5) filling of key data gaps on chemicals of concern at contaminated sites, including reducing detection limits for priority contaminants.

Output Format: Peer reviewed publications, product cover sheets, webinars, workshops, internal and external reports, training
Output Lead: Robert Burgess
Output Contributors:
EPA Program/Regional or State/Tribal Partner(s): OLEM, RSLs, STLs, Regional Staff, GLNPO, States
Start Date: 10/2019
Delivery Date: 9/2020, 2021 and 2022

**Product 2.1.2: Develop methods and tools to assess and manage inorganic soil contamination and quantify and understand contaminant bioavailability**

Brief Description and Research Use: This product will provide the bioaccessibility data requested by the Regions and the Technical Review Workgroup Bioavailability Committee for Arsenic and Lead contaminated material near residential areas. ORD will develop soil bioavailability methods, quantify inorganic soil contamination and bioavailability, and provide data for use in assessing and handling contaminated sites. Research will include evaluation of bioaccessibility methods for additional contaminated materials (e.g., sediments) near residential areas. Research will also focus on refinement and evaluation of the *in vivo* bioavailability assay, including an external lab comparison for an arsenic *in*

*vivo* bioavailability assay, evaluation of single dose level model for a lead *in vivo* bioavailability assay, and evaluation of a combined arsenic and lead *in vivo* bioavailability assay, in support of contaminated site remediation. Development of a single dose level model for the lead *in vivo* bioavailability assay will reduce assay time, allow for higher throughput, and testing of more soils in support of regional offices and OLEM. The lead *in vivo* model development and improvements for evaluating lead contaminated soils and materials is a high priority for OLEM and the regional offices. Data and journal articles will be developed with and provided to regional and program office partners on development of methods to assess and manage soil contaminants and quantify contaminant bioavailability. Data will be provided to regional offices and EPA's Technical Review Workgroup Bioavailability Committee.

Product Form: Peer-reviewed publication, Product cover sheet, Data sets
Interdependencies: Research also essential to/supports: SHC Research Area 5: Chemicals of Immediate Concern: Lead and Research Area 2: Reduce Lead and Other Metal Contamination and Exposure at Former Mining, Smelter, and Mineral Processing Sites, and the EPA Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts. https://www.epa.gov/sites/production/files/2019-04/documents/leadimplementationbooklet_april2019.pdf
Partners: Decision support tools for Regional offices and OLEM, data to support lead modeling efforts at the OPPT, OW, ORD. Supports actions under the December 2018 Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts.
Start Date: 10/2019 Delivery Date: 09/2021

**Product 2.1.13: Assessment tools for heavy metal (Pb, As) bioavailability in sediments and soils**
Brief Description and Research Use: This research will provide to the regions and program office a product based on microbial ecology and genetics, geochemistry, and toxicology to assess the bioavailability of Pb, As, and potentially other heavy metals at contaminated sites. Interim Product Deliverables leading to the development of assessment tools include (1) mapping changes in microbial community diversity, and genes related to Pb and As heavy metal resistance and/or metabolic reduction of As, to delineate the extent of bioavailable contamination associated with hazardous waste sites (2) examination and validation of the In Vitro Bioaccessibility Assay (IVBA) for arsenic in sediments, which has only been validated for soils (3) determining relationships between heavy metal speciation, ingested dosages, microorganisms, and bioavailability (4) development and testing of bacterial reporter strains that "sense" bioavailable heavy metals (5) stabilizing heavy metal contamination in soils with phosphate and biochar amendments.
Product Form: Peer-reviewed publication, Summary Report
Interdependencies: Research supports and complements SHC Research Area 5: Chemicals of immediate concern – Lead, and Research Area 2: Reduce lead and other metal contamination and exposure at former mining, smelter, and mineral processing sites.
Partners: OSRTI
Start Date: 10/2019 Delivery Date: 09/2022

**CQ 4: Output 2.2: Methods and Approaches to Improve Characterization of Heterogeneous Contaminant Sites**.

Output Description:
Development of geochemical, geophysical, and modeling tools to support site characterization and the design of timely and cost-efficient groundwater remediation. This can include optimizing existing tools and designing new tools and approaches to define conceptual models at heterogeneous contaminant sites. Research may be based on numerical modeling simulations, laboratory experimentation, or field-based research.
Output Format: publication(s), EPA Technical Briefs, Webinars, NARPM presentation(s)
Output Lead: Rick Wilkin (CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM (primarily OSRTI, but also FFRRO, OBLR, and ORCR) and EPA regional offices
Start Date: 10/2019
Delivery Date: 09/2022

**Product 2.2.4: Pb Isotopes as a Tool for Source Apportionment**

Brief Description and Research Use: This product will describe to the Regions the improvements in Lead Isotope Ratios to delineate source apportionment. Requests for analytical support to measure Pb isotope ratios from site soils and groundwater are becoming frequent from our Regional partners. Lead isotope ratios can be used as a geochemical tool for constraining source apportionment. Because our clients are increasingly requesting this work there is a consequent need to communicate the method and conduct research to further refine and improve the use of Pb isotope ratios, in combination with other lines of evidence (particle morphology, micro-scale mapping, metal speciation, and trace metal ratios), to determine source apportionment. Lead isotopes are useful tools for solving a wide range of problems in environmental geochemistry due to the highly varied natural abundance of Pb and the half-lives of the radionuclides, like U and Th, that decay to different Pb isotopes. Lead isotopes are particularly useful for determining the source of Pb-containing materials in the environment. In this study, we plan to use Pb isotopes as a tool to delineate source apportionment of Pb in various studies identified by our Regional partners in combination with other techniques like trace metal abundances and ratios. This work will support other bioavailability and speciation studies being conducted by ORD. This research is needed to support current and future requests for support and analytical data, and to more fully develop and test this approach for use in source apportionment studies conducted by the agency.

Product Form: Journal article(s) on Pb isotope studies at specific sites; and synthesis factsheets on specific applications
Keywords: Lead Isotopes; Source Apportionment; Geochemical Tools
Partners: U.S. EPA Region 3, US EPA Region 8, U.S. EPA Region 7
Start Date: 10/2019 Delivery Date: 9/2022

## CQ 1: Output 2.4: *In Situ* Treatment for Mining-Influenced Waters.

Output Description: SHC will provide information focused on remediation challenges and the current state-of-the-art passive and active treatment technologies for MIW and will provide technical support and outreach on various treatment technologies. SHC will evaluate innovative technologies for treating MIW (especially *in-situ* treatment of groundwater) using field-based studies and share results from these technology pilots with all interested stakeholders. Passive and semi-passive (do not require constant human intervention) treatment technologies exist (e.g., permeable reactive barriers for groundwater, passive biochemical reactors, limestone drains), but their longevity isn't well known. Modifications to innovative passive technologies or development of new innovative technologies, especially for *in situ* groundwater remediation, are desired, especially those that can decrease treatment costs, treatment waste volumes, and energy usage on Superfund mining sites. Technical support requests relating to *in situ* groundwater remediation and *ex situ* on-site remediation of MIW frequently pertain to longevity, treatment performance, and linking site-specific characteristics with specific technologies to optimize decision making regarding cleanup.

Output Format: Proceedings Report; Technical Brief(s); Journal Articles; Webinar; Datasets
Output Lead: Rick Wilkin (CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM (primarily OSRTI, but also FFRRO, OBLR, and ORCR) and EPA regional offices
Start Date: 10/2019
Delivery Date: 9/2022

### Product 2.4.1: Synopsis of Presentations on Hardrock Mining Remediation Challenges and Treatment Technologies

Brief Description and Research Use: The product will describe to the Regions and Program Offices current technologies and challenges for treatment of Mine-Influenced-Waters (MIW) including leaching from mine wastes. This product involves planning and organizing a session at a public conference, a public symposium, or regional technical workshop(s) with webinars for public participation to examine: 1) current state-of-the-art technologies for passive treatment of MIW, especially in situ treatment for groundwater; 2) successes and failures of previous, current, and emerging technologies for eliminating leaching from mining wastes and mined surfaces; 3) challenges in remediation efforts; and 4) site-specific evaluation. A steering committee (SC) will be formed from EPA Office and Regional personnel who are involved in hardrock mining remediation issues to plan the best approach for meeting the needs of the Offices and Regions related to the topic areas above, with cost effectiveness being a key component of discussion. During FY20 it will be determined by the SC if it is practical to plan these sessions. If not, the product will be stopped. Consideration will be given to holding workshops in Regional Offices with webinar access for the public, holding one or more sessions at an existing annual conference, holding a symposium open to the public, or other option identified by the SC. Depending on the type of interaction determined to be most appropriate, it would be anticipated that workshops could be held in several regional offices where treatment of MIW is an on-going technical challenge, a symposium could be held in a location close to where there are a majority of EPA personnel involved in mining issues (e.g., Denver, CO), or a session at an upcoming existing conference would be held. A synopsis document from the presentations will be a source of pertinent information for OLEM, Regional RPMs, and States having an interest in remediation of hardrock mining sites. States and RPMs will use the information to assist in optimizing treatment decisions at their sites.

Product Form: Synopsis Report from Presentations
Partners: OLEM, EPA National Mining Team (includes members from multiple offices: OLEM, OECA, OAR, OW, OCSPP, AO, Regional RPMS)
Start Date: 10/2019 Delivery Date: 09/2022

**Product 2.4.2: Use of Innovative Substrate and Material Mixtures in Vertical Wetlands and Biochemical Reactors to Adsorb Metals and Stablized Contaminants in Mining-Influenced Water (MIW) in Active and Abandoned Mining Sites**

Brief Description and Research Use**:** This product will describe to the Regions and Program Offices how innovative design by adding locally available materials to mine waste technologies will allow the final discharges of MIW to meet state regulations in fully passive systems. Mining-impacted water containing high concentrations of metals and sulfate is usually treated in passive anaerobic bioreactors. In field applications, is difficult to obtain the low concentrations of metals required by the state's surface water regulations in a consistent manner. There are some metals considered more difficult to remove than others. For example, zinc and manganese are known to be difficult to remove and to obtain low effluent concentrations. At the same time zinc and manganese are regulated for surface water discharges and the bioreactors have problems to comply with those standards. Hence, a polishing step of the effluent of the passive bioreactors is needed to comply with surface water benchmarks. In this research we will investigate the use innovative design by adding locally available materials to contain metals and other elements to allow the final discharges of water to meet state regulations in fully passive systems. All responsible parties involved in mining-impacted water remediation (state and federal agencies, consulting firms, regulators, etc.) and the communities, businesses and visitors will benefit of reducing contaminants in waters to surface water benchmarks in sites affected by mining and other metal industries operations.

Product Form: Journal Articles, Internal Report, Datasets
Partners: Region 10, OLEM
Start Date: 10/2019 Delivery Date: 9/2022

**Product 2.4.3: Geochemical Characterization of Acid Mine Drainage**

Brief Description and Research Use**:** This product will describe to the Regions and Program Office technical guidance on procedures for groundwater sampling at mine sites. Limited groundwater characterization is typical at mining sites; wells are often deep, and some wells may be completed into mine workings. The depth of wells complicates standard sampling approaches that are adopted at other types of hazardous waste sites, particularly when wells are placed into fractured rock. In addition, water chemistry at mining-impacted sites is often challenging as well and includes issues such as: low pH, high solute concentrations, and high iron concentrations. Modified sample preservation routines are often needed to handle these specific features to ensure the collection of valid data needed for developing conceptual site models and investigate potential remedial alternatives. Our regional partners have requested technical guidance on procedures for groundwater sampling at mine sites. This research will review of methods [standard and emerging] for characterizing this water-type for contaminants; including chemical properties; trace & major ion signatures, and isotopic signatures. These data are often the foundation for evaluating/selecting treatment options. This output will also evaluate geochemical methods of assessing mine-impacted groundwater discharge to surface water

and will involve field-scale studies. The products will provide context for the generation of acid mine drainage via water-rock interactions.

Product Form: Summary Report(s); webinar
Partners: OLEM; Regions 8, 9, and 10; Idaho Department of Environmental Quality
Start Date: 10/2019 Delivery Date: 9/2022

**Product 2.4.4: Evaluation of a Permeable Reactive Barrier for Treatment of Acidity and Heavy Metals in Groundwater**

Brief Description and Research Use**:** This product will describe to the Regions and Program Offices the long-term results from a permeable reactive barrier (PRB) for acidic and metal rich groundwater. A PRB composed of cow manure-wood chips-limestone gravel was installed at the Delatte Metals SF Site in Region 6 in 2003. The PRB treats acidic groundwater (pH ~ 3) containing aluminum, lead, cadmium, nickel, and zinc. Long-term monitoring studies of the PRB have included water quality, hydrologic, and geophysical assessments. The PRB is intended to treat groundwater prior to discharge into an adjacent neighborhood creek (Selsers Creek). Groundwater impacted with sulfuric acid and heavy metals enters the PRB under natural hydraulic gradient conditions. Upon entering the PRB, the acid is neutralized by the limestone and by bicarbonate generated from microbially-mediated sulfate reduction. Microbes consume the cow manure using sulfate (from the sulfuric acid) as an electron acceptor to form sulfides (i.e., sulfate reduction). The sulfides then react with metals such as Pb, Cd, Ni, and Zn to form sparingly soluble metal-sulfides that precipitate out of solution. This research will provide long-term results of the carbon-based PRB for treated acidic, metal-rich groundwater typical of acid mine drainage.

Product Form: Journal Article or Summary Report
Partners: Region 6, LA DEQ, OLEM
Start Date: 10/2019 Delivery Date: 9/2022

## CQ 1: Output 2.5: Innovative Technologies to Eliminate or Control Mining Wastes as Sources of Water Contamination

Output Description: SHC will develop and evaluate innovative technologies for source control. SHC will provide an understanding of current technologies for coating or altering the geochemical characteristics of mining waste materials or mined surfaces (e.g., tailings, waste rock, underground tunnels) to minimize or eliminate generation of MIW, accompanied by technical support to evaluate use of any of these technologies at Superfund sites. Additionally, SHC will explore characterization options that may improve targeting sources to control. SHC will conduct field pilot testing of innovative source control technologies with the EPA regional offices and share findings with all stakeholders.
Output Format: Technical Brief(s); Journal Articles; Webinar; Datasets
Output Lead: Barbara Butler (CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM (primarily OSRTI, but also FFRRO, OBLR, and ORCR) and EPA regional offices
Start Date: 10/2019 Delivery Date: 9/2022

**Product 2.5.1: Evaluation of Environmentally-Stable Surface Coating Materials and Application Methods to Isolate Mine Waste and Mined Surfaces from Weathering**

Brief Description and Research Use: Three products (IPD1, IPD2, IPD3) will be described for the Regions and Program offices regarding coating materials and application methods. Eliminating or minimizing production of MIW by passivating surfaces of mined rock (tunnels, adits) or mining wastes (waste rock, tailings) may be the most viable long-term option for these sites. There is interest in determining what types of coatings are available for use, their mechanisms of operations, and how effective they are under various geochemical and atmospheric conditions – i.e., durability and longevity. Potential passivation mechanisms include direct coating to eliminate interaction of the reactive surface with air or water, binding with surface minerals to form an impenetrable layer to eliminate air and water exposure of minerals, or perhaps technologies exist that can modify the microbial community such that microbially-enhanced iron oxidation is minimized, slowing the formation of mine drainage (oxidation of ferrous iron is a million times faster in the presence of iron oxidizing bacteria). Interim Product Deliverable 1 **(Innovative Technology Development):** Biological extra-cellular coatings, such as microbially-induced carbonate precipitation, will be the focus. Bio-cementing of waste rock has been initiated by EPA at Montana State University and Montana Tech at laboratory scale; additional laboratory testing is required for firmly establishing colonization for effective coating coverage and controlling pH sensitivity. If an effective coating can be established in the laboratory, then limited field application will be evaluated in the last year of the planned research. Essential to this research is whether a permanent bio-cementing cover material can be easily applied (e.g. manual spray tanks, helicopter application, broadcast spray units) to the contaminated areas to serve as a permanent cover to minimize leaching from precipitation and weathering. A summary report or journal article on the coatings will be completed. Interim Product Deliverable 2 **(Pilot Testing):** An Engineering Issue Paper will provide results from pilot testing of *innovative commercially-available* coatings (to be determined through vendor websites, market research, and discussions with Regional Offices where test sites are located) on tunnel or adit surfaces, waste rock piles, or tailings piles to eliminate or minimize release of elements from those sources. Monitoring of each field pilot is anticipated to be conducted over a full calendar year to allow evaluation of seasonal influences on the durability and longevity of the coatings. In testing of coatings on mined surfaces (e.g., tunnel walls) in an area where hydrology is well-characterized, dewatering may be conducted to expose additional reactive or transmissive areas than what is currently exposed, the coating applied, and the mine reflooded. It's anticipated that partners will use the results from the pilot testing to determine 1) if tested materials are suitable for use at their sites or at other sites, 2) if additional mining materials/surfaces should be tested also (e.g., if a technology's effectiveness is influenced by specific waste or surface material properties); or 3) if additional technologies should be tested (e.g., if results indicate unsuitability of a coating tested). Interim Product Deliverable 3**(Historical Case Studies):** Coating surfaces to eliminate or reduce their reactivity is a known technology that hasn't had much use at abandoned mining sites. It isn't known if that lack of use is because historically-available materials are not effective, if they are too difficult to effectively apply in-mine or on most exposed surfaces of waste materials, or if they have simply been overlooked in favor of removal and burial of waste materials and treatment of mine drainage from adits and tunnels. This summary report or journal article will examine the current state of knowledge from review of existing case studies that have investigated using coatings on in-mine surfaces or on solid mining wastes. Additionally, this report will investigate whether case studies have been conducted where mine workings have been dewatered to expose reactive or transmissive areas with application of coating/passivation material and then reflooded. It is anticipated that this product will

identify if any historical coating/passivation technologies are worthwhile to be field tested in the last year of Interim Product 2.

Product Form: Journal articles, Engineering Forum Technology Summary Paper; summary reports; webinars, presentations or session at NARPM
Partners: Region 8, OLEM
IPD 1: Start Date: 07/2020 Delivery Date: 07/2022
IPD 2: Start Date: 07/2020 Delivery Date: 09/2022
IPD: Start Date: 10/2019 Delivery Date: 9/2023

**Product 2.5.2: Groundwater/Surface Water Contaminant Flux Characterization Toolbox for Mine Sites**
Brief Description and Research Use: The product will provide to the Regions and Program Office a training workshop and summary report regarding contaminant flux tools applied at mine sites. The research will optimize methods for integrating measurement of groundwater flux and water quality indicators to assess magnitude and spatial distribution of subsurface contaminant flux to surface water. The research will include webinar-based and hands-on training to Regional and State personnel for methods to implement data collection and interpretation. The research fulfills the technical need for cost-effective methods to assess potential impacts of shallow subsurface contaminant transport and to monitor performance of remedial actions to control this pathway to surface water at mine waste sites.

Product Form: Internal Report and training workshop
Interdependencies: Supported by OP-6, Product 5 (Arsenic Biosensor - Field Test)
Partners: OLEM, Region 8, Colorado Department of Public Health and Environment, Region 10
Start Date: 10/2019 Delivery Date: 9/2022

## CQ1: Output 2.6: Technologies, Sampling Methods, and Exposure Models for Reducing Metal Contamination and Exposure at Smelter Sites.

Output Description: SHC will conduct research and provide technical support regarding current technologies for addressing metal contamination in the cleanup of soil and dust. SHC will also provide support for sampling methods and characterization tools. SHC will conduct field testing of *in-situ* technologies to mitigate exposure of contaminants from soils and groundwater plumes. This can include innovative, cost-effective methods that immobilize, encapsulate, or significantly reduce bioaccessibility of lead and other soil contaminants *in situ* to prevent or mitigate lead exposure risk.
Output Format: Internal Report; Technical Brief(s); Journal Articles; Webinar; Datasets
Output Lead: Barbara Butler(CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM (primarily OSRTI, but also FFRRO, OBLR, and ORCR) and EPA regional offices
Start Date: 10/2019
Delivery Date: 9/2022

**Product 2.6.1: Soil Amendment Technologies to Stabilize Mercury: Sediment, Soil, Mine Tailing and MIW Remediation**

Brief Description and Research Use: The product will describe to the Regions and Program Office how soil amendments can be used to stabilize mercury sources and reduce transport. Hundreds of thousands of mercury (Hg) contaminated sites within the US have contributed to elevated fish methylmercury (MeHg) concentrations in downstream waterbodies. These sites include abandoned mines and former industrial/manufacturing facilities—only a small fraction of which are currently being remediated. Challenges that hinder remediation include: limited funding, remote locations, limited access, and/or moderate levels of contamination that have been dispersed over large areas surrounding the original source. As such, there is a need to identify remediation options that reduce the mobility of Hg that are cost-effective and can be applied broadly. The current product will identify how soil amendments can be used to stabilize mercury sources and reduce offsite transport, establish geochemical conditions that govern demethylation of mercury in freshwater environments for modeling demethylation rates, and review techniques and practices for establishing relationships between biological concentrations of mercury and sediment/water concentrations of mercury.

Product Form: Journal article(s), webinar
Partners : Region 10, Region 3 , Region 4 , Region 9 , Region 10
Start Date: 10/2019 Delivery Date: 09/2022

**Product 2.6.2: Standardizing Selection of Soil Amendments for Remediation of Sediments, Soils, and Mine Spoils**

Brief Description and Research Use: The product will describe to the Regions and Program Offices a literature review, review of previous site amendment applications, and conduct a case study around a specific site. The first objective would be to review scientific and Superfund literature where soil amendment practices have been used to remediate soils, sediment, and waste rock (spoil). Geochemical characteristics of the media (soil, sediment, spoil), contaminant, and amendment will be cataloged along with all experimental outcomes. This exercise will be used to identify key parameters that would be useful for amendment selection. The second objective will be to revisit sites that have been previously remediated using amendments and evaluate the status to determine if the amendment is still effective and if identified variables were key predictors of success. The third portion of the product would use the Coeur d'Alene River Basin (CRB) in Idaho, OU3 for the Bunker Hill Superfund Site, as a case study site for verifying identified key parameters and potentially determining additional ones for amendment selection.

Product Form: Journal article(s), webinar
Partners: Region 10
Start Date: 10/2019 Delivery Date: 09/2022

**Product 2.6.3: Groundwater Contaminant Issues at Smelter Sites**

Brief Description and Research Use: The product will describe to the Regions and Program Offices the geochemistry at smelter sites, describe characterization tools and review groundwater technologies at smelter sites. Groundwater contaminant plumes at many mineral processing and former smelter sites

are large and they are often near residential communities. At these sites, groundwater plumes typically originate via leaching of mineral processing by-products present at the surface or buried in the unsaturated zone, such as slag, dross, and speiss. Larger plumes often include metals and metalloids that are mobile over a range of pH and oxidation-reduction conditions, such as arsenic, selenium, molybdenum, uranium, and antimony. Heavy metals like lead, zinc, and cadmium are typically associated with more isolated, low pH zones influenced by on-site acid-production plants. Because these sites often have long and complex histories of industrial activity, groundwater contamination can stem from practices that extend back over a century. Restoring groundwater is challenging. Common approaches for groundwater remediation begin with removing source materials and/or isolating sources beneath the groundwater table when removal is impractical. Downgradient from source areas, technologies such as pump-and-treat, permeable reactive barriers, sparging, chemical injections, and monitored natural attenuation are candidate approaches. Issues related to co-contaminant behavior need to be considered in selecting treatment technologies (e.g., Wilkin et al. 2018; *Appl. Geochem.*, v. 89, p. 255-264). This research will: 1) examine the underlying geochemistry that creates the problem; 2) discuss characterization tools that can be used to estimate contaminant migration in the subsurface; and, 3) review technologies for dealing with groundwater contaminant issues at mineral processing facilities.

Product Form: Summary Report
Partners: Region 8, OLEM
Start Date: 10/2019 Delivery Date: 09/2022

**Product 2.6.4: Arsenic Biosensor**
Brief Description and Research Use: The product will describe to the Regions and Program Office the progress in developing a disposable enzyme sensor. The research aims to develop a disposable enzyme sensor for field determination of As(III). Testing will be conducted on groundwater from mineral processing sites where large, high-concentration arsenite plumes are encountered. These samples will provide a range of water-types that will be used to test potential interferences and method performance. This sensor will facilitate the understanding of arsenic mobility and sequestration in groundwater, as the transportation of arsenic is mainly in the form of As(III). This tool will reduce the cost of site characterization and remediation evaluation for anthropogenic arsenic sources, thereby support the restoration of these superfund sites as authorized by Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Product Form: Enzyme sensor for arsenite, report, fact sheet, dataset
Partners: OLEM, Region 8, Region 1, MA DEP
Start Date: 10/2019 Delivery Date: 09/2021

**Product 2.6.5: Hyperspectral analysis for characterizing abandoned mine sites**
Brief Description and Research Use: The product will describe to Regions and Program Offices the findings from the use of a handheld hyperspectral instrument at mine sites. Current methods of characterizing soil concentrations using direct soil analysis using traditional or incremental soil sampling (ISM) approaches are both costly and time consuming on large mining sites. Development of hand-held spectroradiometers of high spectral resolution (1 nm) for field measurement and

miniaturization of hyperspectral sensors, has provided new opportunities for georeferenced hyperspectral image collection at centimeter-level spatial resolution. Using this tool, the spectrum for each chemical/mineral of interest at each site might be able to be identified, which is necessary before using existing airborne spectrometer technologies. The purpose of this product is to use a handheld field hyperspectral instrument at mine sites to identify the specific spectral bands for minerals that could then be used with other airborne hyperspectral tools to accurately survey concentrations over a wide area. The outcome is to identify the spectrum at which minerals of interest can be identified in soils. Field and homogenized/dried soil hyperspectral reflectance values would be compared to results from laboratory analytical data to further develop a spectral reflectance/concentration correlation for minerals as described by Yun, Z.W., et. al., 2005.

Product Form: Dataset, EPA report
Partners OLEM, Region 10, Region 9, National Mining Team
Start Date: 10/2020 Delivery Date: 09/2022

# Charge Question 3: SHC Research Area 3 Description

**National Research Program:** Sustainable and Healthy Communities
**Topic:** Contaminated Sites
**Research Area:** Research Area 3: Vapor Intrusion
**Research Area Coordinator (MI):** Jennifer Cashdollar, Center for Environmental Measurement and Modeling (CEMM)
**Research Area Start Date:** 10-2018
**Research Area End Date:** 09-2022

**Overview**
Vapor intrusion (VI) is the migration of vapor-forming chemicals from a subsurface source into an overlying building or structure via any opening or conduit. Industrial chemicals (e.g., volatile organic chlorinated solvents) released into the subsurface may form hazardous vapors that migrate through the vadose zone and eventually enter buildings through openings and conduits such as cracks, seams, foundations, sump pits, utility vaults, floor drains, and sewer lines. Cost-effective, reliable, and documentable means to identify, monitor, and control VI are needed to: (a) reduce exposures; (b) reduce contaminant sources; and (c) define sampling strategies that address when, where, and how to sample.

**Program/Regional/State Needs**
There are multiple research needs to improve guidance on vapor intrusion. These research needs generally fall into two broad categories that include characterizing VI and remedying VI.

Characterization of VI is a complex process which includes many factors beyond just measuring volatile organic compounds (VOCs) in the indoor air. Past research efforts in highly instrumented residences, such as the Indianapolis duplex and the Arizona State University Sun Devil Manor (in Layton, UT), have shown great variability in VOC concentrations through time and space within and around the building. Temporally, pulsed vapor intrusions occur, and it is not always a steady vapor flow from groundwater through the soil and into the building. The pulsed VI can be the result of: pressure and temperature differences between indoors and outdoors as weather fronts pass through the area, seasonal usage of HVAC systems, or other driving forces such as building characteristics. To address some of the temporal variability issues, research is needed to identify indicators, tracers, and surrogates (ITS), such as radon and pressure differential, that may provide us a better understanding whether timing of sampling impacts the conclusions on the potential for capturing the most adverse vapor intrusion exposure scenario so that the assessment of the need for mitigation and/or remediation can be most accurately made.

Spatial variability has always been a concern for sampling with the goal of best representing what is present near, in, and under the building. Varying geologies, building structures, and the presence of preferential pathways all confound the spatial characterization of VI. Research on improved sampling techniques including subslab sampling standardization, large volume sampling, and in-field sampling and testing of fieldable instrumentation, are necessary to address this issue.

Remediation of VI to reduce or eliminate exposures to VOCs while simultaneously reducing the source term (if possible) is the goal of any remedial program. The determination of the efficacy of soil vapor extraction and subslab depressurization requires further confirmation as well as examining the use of air treatment units for temporary relief of exposure to VI contaminants is essential.

Most of the chemical vapor intrusion research has been performed on residential structures, but large non-residential buildings are also affected. Commercial buildings can overlay the original contaminant-release site, which can be fundamentally different from the more typical dilute/dissolved groundwater-sourced vapor intrusion into homes. Large commercial buildings also have different zones within the building (i.e., office space, storage area, production space, etc.) that influence VI and the movement of VOCs within the structure. Research on cost-effective methods for assessing and mitigating large commercial and multi-unit residential buildings is needed.

> **Note:** With the selection of a suitable large building for research, many of these research needs can be met at one location. It is anticipated that many of these potential products listed below will be developed from a single research effort at a single (or potentially multiple) location. They are not a series of 9 individual research efforts/experiments.

**Assumptions and Constraints**

Assuming a modest time until award of the contract task order, the two primary constraints related to this task are identifying a suitable site and then obtaining unfettered access to the site for a year plus (minimum) required to conduct the research. Availability of researcher's time and functionality of the analytical instrumentation are assumed to be adequate. A later constraint will be obtaining the services of a qualified modeler to assist in the preparation of Product 1 under Output 3 as none of the Output leads are modelers.

## CQ 3: Output 3.1: Characterize Vapor Intrusion in Large Multi-Compartment Buildings

Output Description: There are multiple research needs to improve guidance on vapor intrusion. Nearly all chemical vapor intrusion research has been performed on residential structures, but large non-residential buildings are also affected. Commercial buildings can overlay the original contaminant-release site, which can be fundamentally different from the more typical dilute/dissolved groundwater-sourced vapor intrusion into homes. Research on cost-effective methods for assessing and mitigating large commercial and multi-unit residential buildings is needed. This research will help document the source of and possible control of VI exposures. Through research in this output, SHC, in conjunction with EPA program and regional offices, will identify and gain access to a large building that is experiencing VI. SHC will conduct field-based studies to evaluate the factors affecting VI into the building, including weather and building-related parameters, as well as surrogate measures that could provide valuable information on when and if vapor intrusion will occur. With the selection of a suitable building for research, many of these research needs can be met at that location. Each of the products presented under this output will provide one piece of the puzzle when dealing with large buildings. A cumulative final report including the entire dataset will be produced. It is desirable that along with the selection of an appropriate large building that a residence (or similar small structure) be available for monitoring, in the same general vicinity over the same contaminant groundwater plume, for comparison purposes of building characteristics and operation on resultant VI.

Output Format: The final product for this output will be an EPA project report that will include the associated complete database.
Output Lead: Brian Schumacher, (CEMM)
EPA Program/Regional or State/Tribal Partner(s): OLEM, R9, R7
Partner Engagement Plan: RACT will continue to meet on a quarterly basis to give updates on status of research area deliverables, and to get input from partners on any challenges, changes in direction, scope, etc. ORD researchers intend to hold a face-to-face meeting with our partners in Washington, DC. Research findings will be presented during regular VI workgroup calls, at international meetings, and possibly NARPM annual meetings.
Start Date: 10/2019
Delivery Date: 09/2022 (tentative)

**Product 3.1.1: Distribution Indoor Air Concentrations of VOCs and Radon in a Compartmentalized Warehouse**
Brief Description and Research Use: Research will examine building structural and operational influences on VI. Compartmentalization influence with separate HVAC systems will be explored. Preferential pathways, if present, and their influence on indoor air quality will be defined. Investigation into which parameters (i.e., weather-based conditions) can be used to predict when and where to sample will be undertaken.
Product Form: Peer-reviewed journal article
Partners: OLEM, Region 9, Region 7
Start Date: 10/2019
Delivery Date: 09/2022

**Product 3.1.2: Impact of Multiple HVAC Systems on Indoor Air VOC and Radon Concentrations During Seasonal Usage**
Brief Description and Research Use: Influences of heating and cooling systems on chemical and radiological VI concentrations will be examined.
Product Form: Peer-reviewed journal article
Partners: OLEM/OSRTI/ARD ORCR/PIID, OEM, Region7/LSASD
Start Date: 10/2019
Delivery Date: 09/2022

**Product 3.1.3: Pulsed Vapor Intrusion During Summer and Winter Intensive Sampling Events**
Brief Description and Research Use: Through extensive and intensive monitoring of contaminants, differences between warm and cold season HVAC usage (as well as weather effects) and the flux of VOCs/radon into the structure will be examined. Determination of potential cause-and-effect relationships will be explored for use as predictor of when to sample

Product Form: Peer-reviewed journal article
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD ORCR/PIID, OEM Region 9, Region 7
Start Date: 10/2019
Delivery Date: 09/2022

**Product 3.1.4: Systematic Review of Air Sampling Methods for Vapor Intrusion**
Brief Description and Research Use: The review/literature search will provide vital information to build a larger database of air sampling methods employed in different building types; following regional, seasonal, and meteorological conditions; and to help parameterize key inputs to VI models. Through extensive and intensive monitoring of contaminants, differences between warm and cold season HVAC usage (as well as weather effects) and the flux of VOCs/radon into the structure will be examined. Determination of potential cause-and-effect relationships will be explored for use as predictor of when to sample
Product Form: Peer-reviewed journal article
Partners: OLEM/OSRTI/ARD ORCR/PIID, R9, R7
Start Date: 10/2019
Delivery Date: 3/2022

## CQ 3: Output 3.2: Field Testing and Data to Update Guidance on Subslab Sampling of Soil Gas

Output Description: There are no specific consensus methods regarding how to collect subslab soil gas samples (e.g., the soil gas immediately beneath a building), in part because there is not an obvious consensus about which sampling method (e.g., grab samples, long-term passive samplers) and duration yield the most representative data for purposes of estimating mass flux via soil gas entry and for comparing to indoor air concentrations. Through research under this output, SHC will develop a database, based on field testing and monitoring of subslab soil gas collections, to allow us to better describe the temporal and spatial variability beneath a building. Sampling approaches relevant to acute and chronic risk will be addressed when possible. General sampling practice for subslab (immediately below foundation) soil gas (e.g., small volumes, sometimes with grab samples rather than time-integrated samples) may conflict with field evidence at one intensely monitored house, which appears to show that subslab vapor concentrations can vary spatially and temporally underneath residential buildings. Appropriate data from a variety of buildings and subsurface settings might provide evidence for improving current sampling practices. Each of the products presented under this output will provide one piece of the puzzle when dealing with large buildings. A cumulative final report including the entire dataset will be produced.

Output Format: EPA Project Report and associated dataset (see Product 3)
Output Lead: Brian Schumacher(CEMM)
EPA Program/Regional or State/Tribal Partner(s): OLEM/OSRTI/ARD ORCR/PIID OEM R9R7
Partner Engagement Plan: RACT will continue to meet on a quarterly basis to give updates on status of research area deliverables, and to get input from partners on any challenges, changes in direction, scope, etc. ORD researchers intend to hold a face-to-face meeting with our partners in Washington, DC. Research findings will be presented during regular VI workgroup calls, at international meetings, and possibly NARPM annual meetings.
Interdependencies: Site selection and access for Product 1
Start Date: 04/2020
Delivery Date: 09/2021

**Product 3.2.1: Influence of Sampling Collection Times and Volumes on Subslab Soil Gas Concentrations**
Brief Description and Research Use: By measurement, evaluate in multiple buildings, each known to be subject to soil gas intrusion, how the subslab vapor concentration varies with sample duration (time integration period) and over the building footprint. Additionally, in 2010, a new sampling method was proposed based on a concept of collecting/extracting a large volume of soil gas from beneath the floor slab of a building to provide a spatially averaged subslab concentration (i.e., high purge volume sampling) which merits further evaluation.
Product Form: Peer-reviewed journal article
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD ORCR/PIID, OEM R9, R7
Start Date: 04/2020
Delivery Date: 09/2021

**Product 3.2.2: The Representativeness of Soil Gas Concentrations Related to Subslab Sample Collection Methodology**
Brief Description and Research Use: Obtaining a representative sample, or a representative database, is essential in determining whether remedial action needs to be taken. Data will be examined to identify which sampling method(s) provide the most representative dataset.
Product Form: Peer-reviewed journal article
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD ORCR/PIID OEM R9 R7
Start Date: 04/2020
Delivery Date: 09/2021

**Product 3.2.3: Subslab Sampling Standardization – Recommendations**
Brief Description and Research Use: This is the culmination report of all research efforts related to this output. The report will include the final dataset.
Product Form: EPA project report
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD ORCR/PIID OEM R9 R7
Start Date: 04/2020
Delivery Date: 09/2021

## CQ 3: Output 3.3: Data and Models of Temporal and Spatial Variability in Vapor Intrusion

Output Description: There is no unified-coherent theory or consensus about the causes of temporal and spatial variability in vapor concentrations in indoor air arising from soil gas intrusion versus conduit (preferential pathway) gas intrusion, and their relative importance in various geological and geographic settings. There is no common metric(s) for evaluating and communicating the relative importance among the primary causes of the variability. Through research under this output, SHC will measure and model spatial and temporal variability in VI with a focus on common pathways in homes and buildings, including migration of the contaminant from the groundwater or vadose zone source, through the soil, or along utility conduits, and into the building. SHC will also support the collection of concurrent

chemical indoor air samples and indicator, tracer, and surrogate measurements in a wider variety of buildings and settings than have been studied to-date.
Output Format: EPA project report and model with associated dataset
Output Lead: Brian Schumacher (CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM/OSRTI/ARD ORCR/PIID OEM R9/ R7
Partner Engagement Plan: RACT will continue to meet on a quarterly basis to give updates on status of research area deliverables, and to get input from partners on any challenges, changes in direction, scope, etc. ORD researchers intend to hold a face-to-face meeting with our partners in Washington, DC. Research findings will be presented during regular VI workgroup calls, at international meetings, and possibly NARPM annual meetings.
Interdependencies: Site selection and access for Product 1
Start Date: 08/2020
Delivery Date: 09/2023

**Product 3.3.1: Subslab VOC Concentration Variability under a Large Building**
Brief Description and Research Use: The influence of building structure and subslab integrity will be examined as it affects spatial variability of VOCs. Identification of preferential pathways influences may be realized. This work will also include the collection of concurrent chemical indoor air samples and indicator, tracer, and surrogate measurements in a wider variety of buildings and settings than have been studied to-date.
Product Form: Peer-reviewed journal article and potential model
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD ORCR/ OEM R9 R7
Start Date: 08/2020
Delivery Date: 09/2022

**Product 3.3.2: Estimation of the Number of Samples to Collect to Characterize VI under a Large Building**
Brief Description and Research Use: Data will be examined to determine the number of samples necessary to characterize given area based on variability of VOC concentrations. Seasonal variability may be an important component as well. This work will also include the collection of concurrent chemical indoor air samples and indicator, tracer, and surrogate measurements in a wider variety of buildings and settings than have been studied to-date.
Product Form: Peer-reviewed journal article
Key Words: statistical sampling, vapor intrusion, sampling numbers
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD ORCR/ OEM R9R7
Start Date: 08/2020
Delivery Date: 10/2021

**Product 3.3.3: Seasonal and Spatial Variability of Indoor Radon and VOC Concentrations Due to Vapor Intrusion**
Brief Description and Research Use: Culmination report looking at temporal and spatial variability related to VOC and radon vapor intrusion. This work will also include the collection of concurrent

chemical indoor air samples and indicator, tracer, and surrogate measurements in a wider variety of buildings and settings than have been studied to-date.
Product Form: EPA project report, model, and associated database
Interdependencies: Site selection and access for Product 1
Partners: OLEM/OSRTI/ARD OLEM OLEM R9; R7
Start Date: 08/2020 Delivery Date: 05/2022

# Charge Question 2: SHC Research Area 4 Description

**National Research Program:** Sustainable and Healthy Communities
**Topic:** Topic 1: Contaminated Sites
**Research Area:** Research Area 4: Leaking Underground Storage Tanks
**Research Area Coordinator (MI):** Thomas Holdsworth, Center for Environmental Solutions and Emergency Response (CESER)
**Research Area Start Date:** 10/2018
**Research Area End Date:** 09/2022

**Overview**
There are more than 550,000 active Underground Storage Tanks (USTs) nationwide storing petroleum and other hazardous substances, and about 65,000 sites with confirmed leaks needing to be cleaned up. Corrosion can be a potentially significant problem in active USTs, especially for certain fuels. Leaks can lead to serious environmental and health risks, including the contamination of ground water, the source of drinking water for nearly half of all Americans. Addressing this nationwide problem of leaking USTs is a high priority for EPA's Office of Land and Emergency Management, states and tribes. ORD is providing support to better understand and minimize the potential for corrosion in the infrastructure, the impact of these releases, and solutions to manage these sites.

**Program/Regional/State Needs**
The use of modeling and geographic information systems (GIS) is increasingly being considered as a cost-effective supplement to assist in determining ground water vulnerability. The utility of these approaches includes improving the geospatial resolution of the location of tank facilities, identifying sites that may impact ground water supplies, improving site characterizations, and triaging site cleanups. The use of existing and new models can address data gaps on geospatial information on underground storage tank sites and provide improved hydrogeological geospatial data for these sites. This data will be useful to UST, water, planning, and emergency response professionals at local, regional, and national scales. Training of state, regional, and tribal staff is also necessary to ensure that these approaches are applied appropriately, and the results are usable for assessing potential impacts due to contamination from leaking USTs.

These efforts on improved geospatial data will significantly advance efforts in understanding and managing hydraulic control at underground storage tank sites due to extreme weather events. With increasing precipitation events and flooding (fluvial, pluvial, coastal, and ground water) events, improved approaches are needed to understand the potential threat of these events and how best to minimize the impacts to the tank's infrastructure.

Controlling water on site is critical for underground storage tank sites as water ingress is a major cause for corrosion in tank systems. In addition to water, some fuels (e.g., ultra-low sulfur diesel, ethanol blends greater than E10, and biodiesel) have been recognized as potentially being incompatible with various UST system components. Corrosion may occur and can result in releases of automotive fuels from USTs into the environment.

With advancement in remedial approaches to cleanup of leaking UST sites, keeping abreast of these advancements is difficult for EPA regions and state staff. Additionally, OUST has produced a number of technical guidance documents over the years to assist state UST programs in preventing leaks and cleaning up releases from leaking USTs. Some of OUST's technical guidance manuals were published several years ago, e.g. the Flood Guide, and need updating to include information about the latest advances.

These efforts build on ORD's long term research in this area to protect ground water potentially impacted by these sites through improved site assessments and risk management solutions. This work is in support of the Subtitle 1 of SARA, Subtitle 1 of SWDA, and the 2015 UST regulation.

**Assumptions and Constraints**
ORD and OUST will be working with other federal and state partners in collaboration on this research. This will include developing joint lab and field research efforts, and particularly working with States on existing tank sites. These products will be dependent upon these collaborations.

## CQ 2: Output 4.1: Models, Metrics, and Spatial Tools to Evaluate Ground Water Vulnerability

Output Description: ORD will develop tools to assist the states, tribes, and the EPA regional offices in identifying vulnerabilities to ground water from leaking UST sites or from changing conditions affecting functioning UST systems. This will include evolving flood or saltwater intrusion zones. As new methods have identified ground water wells nationally, this data combined with improved geospatial data on underground storage tank sites, and USDA and USGS national soil and ground water data will be used to develop a ground water vulnerability model at local, state, and national scales. ORD and OUST will develop training on these tools to assist states, Regions, and tribes in site cleanups and in assessing potential cumulative impacts to ground water supplies.
Output Format: EPA report
Output Lead: Fran Kremer (CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM/OUST; Region 7; Association of State and Territorial Solid Waste Management Officials (ASTSWMO); DOD
Partner Engagement Plan: ORD has consistent communication with OLEM/OUST, Regional, and State partners. The ORD/OLEM partnership on Tanks research over several decades has resulted in research that is planned and executed together to meet the needs of the states and tribes in addressing underground storage tank sites.
Start Date: 10/2019
Delivery Date: 09/2022

**Product 4.1.1: Ground Water Vulnerability Model: Underground Storage Tanks**
Brief Description and Research Use: This product will present the Program Office with a dataset that will be incorporated into the national UST database. Releases from underground storage tanks pose a threat to aquifers and drinking water supplies nationally. Conditional on geography, soil conditions, aquifer media, etc., the severity of risk varies by site and proximity to leaking USTs. The UST ground water vulnerability model will give a dynamic representation of the relative risk a potential UST release could have to ground water. The model will be validated through empirical plume length, depth, and

attenuation rate data. This model will allow the assessment of the UST contaminant release potential for a hydrogeologic setting to be systematically evaluated by state and tribal partners.
Product Form: The spatial dataset created will be published on the GeoPlatform and integrated with the national database on underground storage tank infrastructure product.

Interdependencies: Completion of national underground storage tank infrastructure database in FY20
Partners: OLEM/OUST; ASTSWMO; R2 Disaster Coordinators
Start Date: 10/2020 Delivery Date: 09/2023

**Product 4.1.2: National Assessment of Fluvial and Coastal Flooding on Tanks Infrastructure**
Brief Description and Research Use: This product will provide the Program Office with a dataset correlating tank infrastructure data with flood forecasts. The tank infrastructure is especially prone to accidental release when exposed to environmental stress associated with flooding. Building on the national database of UST infrastructure, this product will provide a nationwide assessment of USTs' vulnerable to flooding events. This product will correlate tank infrastructure data with flood forecasts as well as real time flood events so state agencies and owner/operators can better assess risk and devise precautionary measures to flood-proof their USTs. This will include NOAA and FEMA forecasts for fluvial and coastal flooding, and real time data from USGS on flooding conditions affecting tank facilities. Additionally, these efforts will also assist emergency response personnel in quickly locating facilities at risk and improve response efforts.
Product Form: This data will be published to the GeoPlatform in a web mapping application.
Partners: OLEM/OUST; ASTSWMO
Start Date: 10/2019
Delivery Date: 09/2021

**Product 4.1.3: National Database on Underground Storage Tank Infrastructure**
Brief Description and Research Use: This product will provide the Program Office a national spatial database of USTs. Working with state partners, this dataset will be the first comprehensive national assessment of underground storage tanks, underground storage tank facilities, and leaking underground storage tanks. These spatial datasets will allow OUST, States, and stakeholders the ability to assess vulnerability, prioritize cleanup efforts, and better quantify risk to aquifers and drinking water supplies. Additionally, this database will provide key data on the tanks infrastructure nationally.
Product Form: These data will be published to EPA's GeoPlatform and available for both download and in a web mapping application.
Partners: OLEM/OUST; ASTSWMO
Start Date: 10/2019
Delivery Date: 09/2020

## CQ 2: Output 4.2: Updates to Technical Guidance Manuals and Evaluations of Risks to UST Systems Due to Compatibility with Fuel Formulations

Output Description: ORD will assist OUST, EPA regional offices, states, and tribes in assessing developments in prevention and cleanup. ORD will collaborate with OUST to create new technical and policy documents or update technical guidance documents with new information and recent site management advances as needed. ORD will also develop approaches to assist the states in assessing

fuel compatibility and fuel corrosion issues with existing UST system components to prevent releases, including extreme precipitation events.
Output Format: EPA report
Output Lead: Fran Kremer (CESER)
EPA Program/Regional or State/Tribal Partner(s): OLEM/OUST; Region 7; ASTSWMO; DOD
Partner Engagement Plan: ORD has consistent communication with OLEM/OUST, regional, and state partners. The ORD/OUST partnership on Tanks research over several decades has resulted in research that is planned and executed together to meet the needs of the states in addressing Tank sites. Additionally, an Inter-Agency Agreement will be developed to directly collaborate with DOD.
Start Date: 10/2019
Delivery Date: 09/2022

**Product 4.2.1: Current Best Practices in Maintaining Hydraulic Control at Fueling Facilities**
Brief Description and Research Use: This product will provide the Program Office with a report summarizing best practices in maintaining hydraulic control at fueling facilities. Hydraulic control at fueling facilities is necessary for onsite maintenance of critical tanks facility infrastructure and for controlling onsite and offsite hydrocarbon contamination. Best practices at fueling facilities minimize consequences of extreme precipitation and flooding. Flooding can be due to pluvial, fluvial, coastal, and ground water flooding events. Impacts from flooding at tank facilities includes pipe separation, tank rupture/buoyancy, and sediment infiltration. These impacts can further impair surface and ground water quality. A review of federal, state, and local agency, commercial, industrial, and academic sources will summarize recommended best practices for 1) general fueling station hydraulic control design (canopies, surfacing materials, drainage, routing, grading), and 2) operation and maintenance practices (housekeeping, spill response, drain management, runoff containment). Identification of the impact of extreme weather events and aging systems on hydraulic control will be addressed. Lastly, ORD will work with OUST in updating the UST Flood Guide.
Product Form: EPA report
Partners: OLEM/OUST; Michael Pomes, Region 7; ASTSWMO
Start Date: 10/2019
Delivery Date: 09/2020

**Product 4.2.2: Diving Ground Water Plume Application**
Brief Description and Research Use: This product will provide the States, Regions, and Program Office with a model for estimating ground water plume diving. Ground water plumes can dive due to aquifer recharge from extreme precipitation events. Additionally, ground water injections occurring at or near the site can alter contaminated plumes. The Plume Diving Calculator can estimate the prospects for plume diving assuming simplified flow in a water table aquifer. Inputs to the calculator are the hydraulic conductivity, recharge rate, and head at two points in the aquifer. Taken together, these parameters determine flow in the aquifer, so a means of calculating the flow is needed. The calculator will be fully developed and field tested at sites in collaboration with the states. Sites will be selected that are representative of various recharge scenarios as well as site conditions.
Product Form: Web-based application
Partners: OLEM/OUST; ASTSWMO
Start Date: 10/2019
Delivery Date: 09/2022

**Product 4.2.3: Identify Corrosion Processes Occurring in Underground Storage Tank Systems Based on Infrastructure and Fuel Type**

Brief Description and Research Use: This product will describe for the States, Regions, and Program Office corrosion processes occurring in UST systems based on infrastructure and fuel type. Research is needed for on a range of fuel types and tank types and the use of laboratory and field methods to identify corrosion. This effort will build on earlier work in identifying methods to assess corrosion processes. Research will include degradation mechanisms and the monitoring techniques to assess corrosion to prevent leaks from occurring. Microbially influenced corrosion is an important process in tank corrosion especially with certain fuels. New corrosion phenomena of fueling and vehicle infrastructure come at a critical time for global automotive fleet transitions.
Product Form: EPA external report
Interdependencies: Dependent upon earlier project identifying corrosion methods (Product 4)
Partners: OLEM/OUST;, Region 7; ASTSWMO; DOD
Start Date: 10/2019
Delivery Date: 09/2023

**Product 4.2.4: Identify Methods to Assess Corrosion Processes Based on Tank Infrastructure and Fuel Type**

Brief Description and Research Use: This product will describe for the States, Regions, and Program Office methods for assessing corrosion processes based on tank infrastructure and fuel type. To assist the States, methods need to be identified to assess corrosion and material degradation of underground storage tanks to identify vulnerable tanks before leaks occur. These tanks store the nation's transportation fuel and are found in every community across the country. Fuel formulations often have unintended, challenging effects on existing infrastructure systems. Corrosion of underground storage tanks or release prevention equipment can cause fuel leaks leading to contamination of soil and ground water. An assessment will be made of existing methods used to determine corrosion and their potential application for in situ applications in determining corrosion. In addition to DOD, ORD and OUST will coordinate this research with the certifying organization responsible for certifying tank infrastructure.
Product Form: EPA external report
Partners: OLEM/OUST; Region 7; ASTSWMO, DOD
Start Date: 10/2019
Delivery Date: 09/2022

## Charge Question 4: SHC Research Area 5 Description

**National Research Program:** Sustainable and Healthy Communities
**Topic:** Topic 1: Contaminated Sites
**Research Area:** Research Area 5: Chemicals of Immediate Concern
**Research Area Coordinator (MI):** Jennifer Cashdollar, Center for Environmental Measurement and Modeling (CEMM)
**Research Area Start Date:** 10-2018
**Research Area End Date:** 09-2022

**Overview**
The United States has made tremendous progress in lowering childhood blood lead levels primarily due to the implementation of multiple laws and regulations aimed at reducing lead exposure. Despite the overall decline of blood lead levels over time, lead exposure remains a significant public health concern for people of all ages because lead hazards persist in the environment. The Federal government has made mitigating children's lead exposure one of its top priorities. About 3.6 million U.S. families with a child younger than 6 years of age live in residences with one or more conditions that can expose their child to hazardous levels of lead. Sources such as drinking water contaminated by old lead service lines, household lead paint, soils contaminated by past hazardous industry sites, and the use of leaded fuels remain a source of exposure. Other sources of lead can also contribute to a child's lead risk, including food, folk-remedies, cultural products, consumer products, recreational activities such as hunting and stained glass making, and take-home exposure of lead from occupational sources.

Per- and poly-fluoroalkyl substances (PFAS) are a large group of several thousand industrial chemicals that are used in many consumer products and industrial and manufacturing applications. Contributors to environmental releases include: 1) fire training and fire response; 2) industrial releases from primary and secondary production and manufacturing; 3) landfills; and 4) wastewater treatment operations. The ubiquitous nature of PFAS-containing products, their resistance to metabolic and environmental degradation, their mobility, and their potential for bioaccumulation and toxicity present serious environmental challenges. Approaches are needed to effectively treat PFAS in source areas, dilute plumes, and extracted groundwater.

**Program/Regional/State Needs**
This research directly supports Goal 4 of the Federal Action Plan to Reduce Childhood Lead Exposure[1]: Support and conduct critical research to inform efforts to reduce lead exposures and related health risks
SHC research will inform pending Agency actions on lead including:

- Revision of the Lead and Copper Rule (OW-SDWA)
- Lead-Free Rule for New Home Fixtures: Use of Lead Free Pipes, Fittings, Fixtures, Solder and Flux for Drinking Water (OW-SDWA)

[1] https://www.epa.gov/lead/federal-action-plan-reduce-childhood-lead-exposure

- Revision of Technical Guidance on 3Ts (Training, Testing, Telling) for reducing lead in drinking water in schools (OW)
- Steam Electric Effluent Limitations Guidelines (OW-ELG)
- Revision of Residential Lead Dust Clearance Standards (OCSPP-TSCA)
- Updated Scientific Considerations for Lead in Soil Cleanups (OLEM-CERCLA/RCRA)

ORD is participating in cross-EPA and cross-Federal agency efforts to address environmental issues arising from the PFAS class of emerging contaminants. SHC is focused on: 1) providing technical support; 2) site characterization, especially for contaminated sites, landfills, and in contaminated groundwater; and 3) characterizing multimedia human and ecological exposure to PFAS. SHC's primary interest is in PFAS found in contaminated sites and sediments, solid waste, landfills and surrounding environmental media (soil, groundwater), leachates, and landfill gas. This research will extend the current understanding of sources, fate and transport, remediation, and exposure beyond perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). It should provide information on other PFAS including but not limited to: perfluoroalkyl acids (PFAAs); per- and poly-fluorinated carboxylic acids, sulfonic acids, and ethers; per- and poly-fluoropolyethers (PFPE); and PFAS precursors, byproducts, and transformation products. SHC's research in this area is consistent with the EPA's Per- and Poly-Fluoroalkyl Substances Action Plan[2] that notes the potential exposure hazard presented by landfill leachate and the scarcity of exposure data on PFAS.

**Assumptions and Constraints**

Assumptions include adequate FTE and funding to support research efforts leading to the planned products, that product leads and product contributors will be supported by line management in the new ORD organizational structure; that appropriate instrumentation is available to carry out planned work; that researcher's time towards research efforts is adequate and accounted for.

## CQ 4: Output 5.1: Collaborative Science-Based Approaches and Results to Identify High Lead (Pb) Exposure Locations in the U.S. and Key Drivers at those Locations

Output Description:

This Output will produce collaborative science-based approaches and apply results to identify high lead (Pb) exposure locations in the U.S. and key drivers (e.g. housing-related and environmental sources) at those locations. The approaches will be developed and enhanced iteratively, using available housing, sociodemographic, environmental, and states' blood lead level (BLL) data at census tract level in new applications of geospatial and statistical methods and models. New map layers will be developed for Pb sources at different geospatial scales, for use in Pb modeling and mapping. Collaborative engagement with EPA Regional and Program Offices, State and Federal partners, and others will be critical to this Output to produce results informing EPA/stakeholder joint planning discussions. Results will include geospatial data for visualizing high Pb exposure locations, and data analyses to help identify key drivers at those locations and inform effective targeting and exposure reduction efforts. This Output responds to EPA's priority for identifying U.S. communities with the highest risk of childhood lead exposure. This is a goal listed in interagency lead collaboration efforts (e.g. Federal Lead Action Plan Goal 4, action 2: "Generate data, maps, and mapping tools to identify high exposure communities or

[2] https://www.epa.gov/pfas/epas-pfas-action-plan

locations…"). Identifying locations with highest potential for children's exposures and blood lead levels will assist with targeting and prioritization for lead exposure risk reduction, prevention, and mitigation efforts.
Output Format: Briefing package summarizing the approaches and results, with a compilation of data (statistical and modeling analyses), maps, presentations, journal publications
Output Lead: Valerie Zartarian, (CPHEA)
EPA Program/Regional or State/Tribal Partner(s): Regional Lead teams: Regions 1, 5, 6, 7states (e.g. ASTHO/ECOS partners); Regional state partners such as OH DH and OH EPA; Program Offices; Federal agency partners (e.g. HUD; CDC; NIEHS/ATSDR)
Partner Engagement Plan: Continuing engagement with Regional and State partners, with Program Offices engaged; continued engagement with Federal partners through the Federal Lead Action Plan Goal 4, Action 2 workgroups; and with State and Regional partners via the ASTHO/ECOS-ORD MOA pilot project on Pb mapping
Interdependencies: RA5 Output 2 Product 6; SSWR Output 20
Start Date: 10/2018
Delivery Date: 09/2021 with interim briefing materials on progress

**Product 5.1.1: Development and application of methods for identifying high exposure lead (Pb) locations and the key drivers at those locations**
Brief Description and Research Use:
Generate and provide data, maps, methods, and information that can be used by EPA regional offices and their state and federal partners to help identify potential Pb focus communities for taking actions to reduce exposures and blood lead levels. This product aims to advance synergized approaches across EPA and other agencies.
Milestones:

- Briefing sheet on ORD/Regional approach and plans for states engagement approved by EPA/AO (Q2 FY19)
- Iterative ORD presentations provided to Regional offices based on collaborative engagement discussions and sharing of initial analyses and draft results with Regions and their state/federal partners (see Product 2)
- May 29-30 2019 EPA Pb Mapping Coordination Workshop co-led by ORD
- July 2019 NEHA (National Environmental Health Association) conference Pb mapping session with EPA/ORD, CDC, HUD presentations
- ORD journal manuscript on MI Pb geospatial and modeling data analyses, with Region 5 and state collaborators (Q1 FY2020)
- Briefing for Administrator and senior leadership on coordination of EPA Pb mapping efforts, based on the May 29-30, 2019 EPA workshop co-led by ORD (Q1 FY2020)
- Plenary presentation at December 4-5, 2019 interagency Pb research workshop on EPA/ORD Pb mapping efforts and interagency session co-led by ORD
- ORD journal manuscript on OH Pb geospatial/modeling data analyses, with Region 5 and state collaborators (Q2 FY2020)
- ASTHO/ECOS/ORD MOA pilot – webinar with states and other deliverables on data sharing and risk communication (Q3 FY2020)

- Incorporation of data from HUD, CDC, and other partners through interagency collaborations (Q2-Q3 FY2020)
- July 2020 NEHA conference session on Federal Lead Action Plan Research Goal 4 workshop including next steps for interagency Pb mapping coordination efforts
- Generation of new spatially-derived independent or explanatory variables for evaluation in BLL multivariate modeling and other lead modeling efforts in geographies where BLL data is available (Q4 2020 with interim results)
- New spatial/GIS data layers of Pb sources in collaboration with OMS, OECA, Regions, and other partners for use in Pb mapping efforts/tools (Q4 2020 with interim results)
- Incorporation of data from HUD, CDC, and other partners through interagency collaborations (Q2 FY2020)
- Interagency journal manuscript on scientific approaches and challenges for identifying high Pb exposure locations and the key drivers (Q1 FY2021)
- Collaborative case studies for selected states based on available data, dates TBD through FY2021

Product Form: Summary report identifying/compiling conference sessions and presentations, peer-reviewed reports and publications, data/information, interagency workshop and webinars
Interdependencies: supported by and informs other Output 1 and 2 products
Partners: Region 5 Region 7 Region 1 Region 6 Region 5 state partners; Region 7 federal partners (e.g. ATSDR);, HUD;, CDC;, NIEHS;
Start Date: 10/2018
Delivery Date: 09/2021 with interim milestone deliverables

**Product 5.1.2: Technical support to Regions to identify high lead exposure locations and key drivers in those locations (utilizing Product 1 approaches)**

Brief Description and Research Use:
This product will provide results of a new collaborative science-based approach including geospatial analyses, modeling, and GIS maps to support Regional and states' efforts to identify potential Pb focus areas (e.g. disproportionately impacted communities) for various drivers (e.g. regulatory, environmental justice, ongoing partnerships). The generalizable approach includes the following: analyzing, for specific states, convergences of available housing, sociodemographic, and BLL data at census tract level; collaborating with Regions and their partners for local environmental knowledge and data, to inform modeling and data analysis efforts for identifying key drivers in high exposure locations; engaging with Federal partners (e.g. HUD, HHS) on data sharing; and enhancing available models to assess exposure pathways (depends on local data). This product is in response to requests from multiple EPA Regional offices (Regions 1, 5, 6, 7) which have approached ORD for technical support to address their needs to identify Pb focus communities and key factors to inform decisions, drive action, and focus data/research efforts.
Milestones:

- Briefing sheet on ORD/Regional approach and plans for states engagement approved by EPA/AO (Q2 FY19)
- Region 5 – invited presentations with draft maps for OH, MI, WI, MN, IL, IN for State partners; April 2019; May 2019; July 2019; September 2019; others TBD
- Region 7 – invited presentation with draft NE, KS, IA, MO results for Federal Pb Task Force meeting with Region 7 RA, HHS, HUD, per technical assistance request; delivered April 2019; other TBD

- Region 1 – draft VT Pb maps to inform RRP discussions, per technical assistance request; delivered May 2019; other TBD
- Region 6 – draft maps for TX, LA, OK, AK for R6 meeting with State partners, per technical assistance request; delivered Sept 2019; other TBD
- Follow-up meetings with regional offices and their state partners as the methods are refined and more data are shared through intra- and inter-Agency collaborations (links to Product 1) - dates TBD

Product Form: Summary report on ORD technical support provided to the Regional offices, compiling data (statistical and modeling analyses), maps, presentations, and partners' feedback
Interdependencies: supported by and informs other Output 1 and 2 products
Product Lead: Valerie Zartarian (CPHEA)
Partners: Region 5 Region 7 Region 1 Region 6); states (e.g. ASTHO/ECOS partners; Regional state partners such as OH DH and OH EPA); Federal agencies (e.g. HHS, HUD)
Start Date: 10/2019
Delivery Date: Q3 2020; potential future deliverables TBD depending on additional Regional needs and Product 1

### CQ 4: Output 5.2: Methods and Data on Key Drivers of Blood Lead Levels in Children

Output Description: Data are needed to determine key drivers of blood lead levels from multimedia exposures, including the relative contributions to BLL from major sources and exposure pathways, to inform effective risk reduction strategies at national and local scales. These data are also needed to enhance and apply multimedia exposure modeling (i.e., the Integrated Exposure Uptake Biokinetic (IEUBK) model and All Ages Lead Model [AALM]) for regulatory determinations by reducing uncertainty, especially for the most at-risk groups, and for use in computing cleanup levels at Superfund and other contaminated sites. Through research under this output, SHC will provide distributional (location specific) estimates of lead in soil, dust, drinking water, and food and will develop methods to estimate bioaccessibility of lead from soil and dust under different soil chemistry conditions and under different biological conditions. SHC will explore the best methodologies and approaches to obtain field data for soil and dust ingestion rates as a function of life stage, geographic factors, socioeconomic factors, and factors in the built environment. In conjunction with HHERA Output 2.1, SHC will develop innovative methods for evaluating exposure factors and assess impacts of risk management or mitigation actions on lead exposure risk or blood lead levels. The data obtained from research in this output will also feed into HHERA Output 4.1 as critical inputs to lead exposure and pharmacokinetic models to predict blood lead levels. The research also ties to SSWR Research Area 7 on Water Treatment and Infrastructure, specifically the output "Resources and tools for characterizing and mitigating lead in drinking water distribution systems and premise plumbing." This work directly feeds into Goal 4, Action 3 (Generate data to address critical gaps for reducing uncertainty in lead modeling and mapping for exposure/risk analyses and for estimating population-wide health benefits of actions to reduce lead exposures) of the Federal Action Plan to Reduce Childhood Lead Exposure.
Output Format: Publications and datasets
Output Lead: Lindsay Stanek, (CPHEA)
Output Contributors: Karen Bradham, NERL/EMMD (CEMM/WECD/MMB); Cavin Ward-Caviness,
EPA Program/Regional or State/Tribal Partner(s): (OLEM); (OCHP); (Region 5); (Region 9); (Region 9 (HUD)

Partner Engagement Plan: Partners will be kept abreast of current activities through the RACT, as well as through other existing workgroups, including the Technical Workgroup for Metals, Lead and Bioavailability Subgroups. Presentations will also be given through the SHC webinar series to provide updates and opportunities for feedback.
Start Date: 09/2019 Delivery Date: 12/2023

**Product 5.2.1: Evaluate soil and lead speciation to aid in contaminated soil remediation technology development.**
Brief Description and Research Use: This product will provide estimates of bioavailability and bioaccessibility of a variety of lead phosphate and iron complexes. It will be delivered to improve understanding of lead speciation associated with phosphate and iron soil amendments to aid in contaminated soil remediation technology development. This product will provide the bioavailability, bioaccessibility, and speciation data for lead phosphate and iron complexes that potentially reduce lead bioavailability and bioaccessibility of contaminated soils. Samples will be obtained through partnership with the University of South Australia. Solid phase speciation will be conducted to evaluate the transformation of the lead soils treated with phosphate and iron in vivo and the interaction of these minerals with soil chemistry in forming lead complexes. These data will be used in supporting lead contaminated clean up levels and to inform development and use of sequestration or other remediation technologies. These data will be provided to OLEM's Technical Review Workgroup, Bioavailability Committee to aid in predicting locations with known lead sources that have potential for high bioavailabilities and, therefore, elevated exposure risk. The product will include journal articles, which will be developed and provided to Regional and Program office partners on lead soils treated with phosphate and iron to aid in development of soil remediation technologies. Information may be used to determine if these technologies can be extended to other locations after considering the site-specific lead sources.

Product Form: Peer reviewed publications, dataset, presentation for EPA Technical Review Workgroup Bioavailability Committee.
Interdependencies: Research also essential to/supports: Research Area 2: Reduce Lead and Other Metal Contamination and Exposure at Former Mining, Smelter, and Mineral Processing Sites
Partners: Decision support tools for Regional offices (EPA TRW Bioavailability Committee), and OLEM, OPPT. Supports actions under the December 2018 Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts.
Start Date: 07/2019
Delivery Date: 09/2021

**Product 5.2.2: Human small intestine soil lead bioavailability model and evaluation of lead minerals: Evaluate use of alternative in vitro models using human intestinal cells for bioavailability**
Brief Description and Research Use: The critical data gap addressed in this work is the lack of an in vitro cellular system of measurement of soil lead bioavailability that has been fully validated by comparison with other in vitro and in vivo models. Current cell-based models used to evaluate the bioavailability of metals and metalloids lack the structural and functional complexity of the gastrointestinal barrier. Alternative in vitro models using human intestinal cells will reduce costs associated with in vivo assays and allow high throughput testing for lead bioavailability. A three-dimensional in vitro model of the human small intestine will be evaluated for estimating soil lead bioavailability. This in vitro model system comprises highly differentiated epithelium consisting of villi structures, brush borders and columnar epithelium as a model of in vivo animal systems to measure biological uptake of lead in soil by humans. This research will

evaluate this in vitro system against previously evaluated in vitro artificial digestive fluid media and in vivo animal models. A variety of lead minerals commonly found at Superfund and Brownfield sites and in urban soils due to historical and concurrent air deposition, paint, and windblown mine and smelter deposits will be evaluated in this in vitro system and compared with in vitro artificial digestive fluid media and in vivo animal model. This will provide the Agency and others with a better understanding of using a low-cost in vitro system that can be used to rapidly assess multiple samples from a single contaminated site for use in determining clean up levels; evaluate efficacy of clean up at specific sites; determine the efficacy of new remediation or lead sequestration methods; and parameterize site-specific estimates of elevated blood lead using models such as the IEUBK or AALM. Data, draft standard operating procedure, and journal articles will be developed with and provided to Regional and Program office partners on lead bioavailability and the use of alternate in vitro intestinal models. Data will be provided for lead models and EPA Technical Review Workgroup Bioavailability Committee.

Product Form: Bioavailability model information will be conveyed in peer reviewed publications, dataset, presentation for EPA Technical Review Workgroup Bioavailability Committee.
Interdependencies: Research also essential to/supports: Research Area 2: Reduce Lead and Other Metal Contamination and Exposure at Former Mining, Smelter, and Mineral Processing Sites
Partners: Decision support tools for Regional offices (EPA TRW Bioavailability Committee) and OLEM, data to support lead modeling efforts at the OPPT. Supports actions under the December 2018 Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts.
Start Date: 03/2020
Delivery Date: 09/2022

**Product 5.2.3: American Healthy Homes Study II – evaluate lead concentrations in drinking water, soils, and indoor house dusts and lead bioavailability in paired soil and indoor house dusts**
Brief Description and Research Use: Product will be 1) quantified lead concentrations in drinking water, soils, and indoor house dusts from the American Healthy Home Survey II and 2) lead bioavailability in a subset of paired (from the same home) soils and indoor house dusts from the American Healthy Home Survey II. Analyze lead concentrations in drinking water, soils, and indoor house dusts from the American Healthy Home Survey II. Analyze lead bioavailability in a subset of paired (from the same home) soils and indoor house dusts from the American Healthy Home Survey II. Data and journal articles will be developed and provided to Regional and Program office partners on lead concentrations to aid in OLEM's TRW model refinement and data needed for model refinement by OPPT, OW, ORD. Distributional and summary data will be provided for lead models and EPA Technical Review Workgroup Bioavailability Committee. Future work may include analysis of questionnaire responses with housing and occupant information.

Product Form: Peer reviewed publications, dataset, presentation for EPA Technical Review Workgroup Bioavailability Committee.
Interdependencies: Research also essential to/supports: SHC Research Area 2: Reduce Lead and Other Metal Contamination and Exposure at Former Mining, Smelter, and Mineral Processing Sites, and the EPA Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts.
https://www.epa.gov/sites/production/files/2019-04/documents/leadimplementationbooklet_april2019.pdf

Partners: Decision support tools for Regional offices(EPA TRW Bioavailability Committee) and OLEM data to support lead modeling efforts at the OPPT, HUD
Start Date: 10/2018
Delivery Date: 09/2023

**Product 5.2.4: Health Effects of Changing Lead Exposures and Community Factors Which May Alter Potential Health Benefits**

Brief Description and Research Use:
Lead exposures remain a primary concern for many communities around the United States, and while all communities are working to reduce lead exposures the achieved benefits in health outcomes from reducing lead exposures have not always been quantified. As states and community leaders implement lead exposure reduction plans, a primary consideration is the health benefit to be obtained by communities from the reductions in lead exposure. However, there are often few retrospective studies that work to examine the observed health benefits from reductions in lead exposure in these communities, and consideration of community factors (housing quality, poverty, access to medical care, etc.) which may prevent communities from receiving the full health benefits expected from reductions in lead exposure. Therefore, research is needed to create a database of observed health benefits in combination with those factors which may prevent subsets of the community from receiving the full health benefits of reduced lead exposure. By combining data on communities with changing lead exposures (e.g. Superfund cleanups and models of airborne lead exposure) with data on observed lead exposure in children and data on health outcomes for children in those communities we can map changes in community lead exposure to health outcomes. As we will use electronic health records to examine health outcomes, we will have a near unprecedented insight into the complete health spectrum measured at high frequency and with deep clinical phenotyping. This will also allow us to examine health effects which may not develop for years and may persist even after exposures have been reduced. We can also understand novel health effects such as cardiovascular effects which have been suggested but not conclusively shown. Even at younger ages these may manifest as subclinical effects on blood pressure, heart rate, and other cardiovascular traits. Novel databases of community social, economic, and demographic factors, such as those developed by the University of North Carolina – Charlotte Urban Institute and the Institute for Social Capital will be employed to understand if any inequities in the distribution of health benefits from reducing lead exposure are due to the socioeconomic environment of the communities.

Product Form: Database of lead exposure health benefits and community factors which may modify the achievement of such benefits by a community. The database is to be built upon novel research undertaken using novel exposure maps, children's blood lead levels, and electronic health records. The database will be augmented with results from peer-reviewed research.
Interdependencies: UNC Charlotte Urban Institute, Institute for Social Capital
Product Lead: Lauren Wyatt, NHEERL/EPHD
Partners: TBD (Regional Offices, OP)
Start Date: 12/2019
Delivery Date: 10/2022

**Product 5.2.5: Pilot study on communities with elevated children's BLLs to examine key drivers of exposure**

Brief Description and Research Use:
This research will provide data on media (soil, dust, water, air, food, blood) and exposure factors (bioavailability, soil/dust ingestion rate, housing variables, chemical form, premise plumbing, sociodemographic facts, etc.) to help identify the key drivers of lead risk in communities. Results will allow EPA to address critical data gaps for Pb modeling and mapping to support decision making, improve the identification of high exposure locations in focus communities, identify the key drivers in the community which will inform mitigation efforts, and allow the ability to assess the effectiveness of actions taken. The identification of lead focus communities and the key factors driving high BLLs (Output 1, Product 1) can be challenging because of the use of data from disparate studies. This could potentially make it difficult to answer critical questions for effectively reducing lead exposure and assess the impacts of actions taken in the community. This product will focus on a coordinated interagency multimedia field study focused in U.S. locations with children at elevated risk to lead exposure (starting with early demonstration, e.g. R5). Based on the research results from Output 1 in SHC RA5, we will identify communities where elevated children's BLLs are not readily explained by existing lead indices (i.e., old paint). We will build partnerships with one or two communities to conduct field sampling in the summer months to comprehensively characterize children's exposure to Pb and factors that may contribute to greater exposure potential. This research will also be an opportunity to closely collaborate with our Federal Partners to conduct a targeted field study that could be expanded to more communities or a national-scale study in the long-term to support the Federal Lead Action Plan.

Product Form: Peer reviewed manuscript, data, publications, and presentations

Interdependencies : Federal partners as collaborators and active participants in the field sampling and analysis (i.e., HUD, CDC, FDA); community partners that are supportive of this study and desire to understand more about children's exposure to lead; SSWR RA7, output 20 for lead in premise plumbing
Partners: (OCHP), Others (Regions, states, communities)
Start Date: 10/2019
Delivery Date: 09/2023

**Product 5.2.6: Methods and approaches to improve accuracy, reliability and confidence of children's soil and dust ingestion rates**

Brief Description and Research Use: This product will provide proofs of concept for methods and approaches necessary for generating a robust dataset. These will be applied to further data collection to provide distributional estimates of age-, location-, and seasonally-specific soil and dust ingestion rates for children aged 6 months through 6 years. For children, soil and dust ingestion are important pathways of exposure to certain environmental contaminants found in their everyday environments. Children, in particular, may be especially vulnerable due to their developing biological systems and activities and behaviors that bring them into close contact with their environment. Getting better data on soil and dust ingestion rates for children will assist in reducing uncertainty in risk management actions and costs associated with soil remediation at contaminated sites and in other risk assessment decisions. Available soil and dust ingestion data are reviewed in detail in EPA's *Exposure Factors Handbook,* but the data are limited and ingestion rates are not available for all child-specific lifestages.

EPA's Program (OLEM, OCHP) and Regional Offices have consistently asked for better estimates of soil and dust ingestion rates for use in risk associated decisions, e.g., clean-up levels, regulatory risk assessments. Fulfilling this request requires the development of feasible, evaluated methods and approaches for collecting the data. Research is proposed to be produced by ORD scientists and through grantees selected through the STAR grant process. The current timeline projects the draft RFA to be complete by the end of FY19, approved and announced for solicitations in early FY20, with grantees selected by late FY20. Publications from grantees may start as early as FY22, with much of the data and information appearing in FY23 and beyond.

Product Form: Summary of grant progress, including presentations and peer reviewed publications
Interdependencies: The bulk of this work will be done through STAR grantees.
Partners: (OLEM (Region 5); (OCHP); (Region 9)
Start Date: 07/2019
Delivery Date: 09/2022