Suggested Research and Activities for the Superfund Hazardous Substance Research and Training Program Center Grants (P42)

This document contains suggested research topics and activities for the NIEHS Superfund Hazardous Substance Research and Training Program (P42) RFA-ES-23-001 (http://grants.nih.gov/grants/guide/rfa-files/RFA-ES-23-001.html) referred to as the Superfund Research Program (SRP) Center grant. Interdisciplinary SRP Center grants support problem-based, solution-oriented research Centers that consist of multiple, integrated projects representing both the biomedical and environmental science and engineering disciplines; as well as cores tasked with administrative (which includes research translation), community engagement, research experience and training coordination, data management and analysis, and research support functions. The research and activities from each Center are expected to address the SRP mandates:

1) Advanced techniques for the detection, assessment, and evaluation of the effect of hazardous substances on human health.

2) Methods to assess the risks to human health presented by hazardous substances.

3) Methods and technologies to detect hazardous substances in the environment.

4) Basic biological, chemical, and physical methods to reduce the amount and toxicity of hazardous substances.

Because of the complexity of the P42 application, applicants are highly encouraged to consult with SRP staff listed in the FOA to discuss the theme/focus of the proposed Center application prior to developing their P42 grant proposal.

How this document was developed: SRP seeks input for this document from key end-users such as the U.S. Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Registry (ATSDR), the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), U.S. Department of Defense (DOD), and the U.S. Department of Energy (DOE), and/or end-users of research and technology that assess, manage, and mitigate sites impacted by hazardous substances. SRP also considers important end-users to be state, local, and Tribal governments, and communities impacted by hazardous substances. Lastly, recent NIEHS Strategic Plans (SRP:https://www.niehs.nih.gov/research/supported/centers/srp/about/strat_plan and NIEHS: https://www.niehs.nih.gov/about/strategicplan/) serve as a basis for prioritizing research topics and activities.

- ***Section A*:** divides research topics by SRP's mandate areas to demonstrate how basic/fundamental and applied research can be directed to solve problems relevant to SRP's mandates. For any given topic, applicants are encouraged to integrate knowledge and results from multiple projects and cores to achieve a holistic solution (e.g., involving biomedical, environmental and engineering, research translation, and community engagement approaches) to solve complex environmental problems. Likewise, topics within one mandate area are likely to be synergistic with topics in other mandate areas. Applicants, therefore, should take into consideration the relationships between mandate area topics to develop an integrated, problem-solving SRP Center.
- ***Sections B – C*:** lists Hazardous Substances and Exposure Scenarios of interest to SRP end-users.
- ***Sections D – H*:** lists recommended Data Management and Analysis activities, Research Translation (including Project-Specific Research Translation), Community Engagement, and Research Experience and Training Coordination activities.
- ***Section I*:** lists resources, websites, and points of contact.

Section A) Suggested Research Needs

The following list consists of topics meant to direct P42 applicants to areas in need of research that would be responsive to SRP mandates and could be accomplished through interdisciplinary research. These examples are not intended to be exhaustive, and applicants may utilize these and many other topics to meet the objectives of the FOA.

1) Advanced techniques for the detection, assessment, and evaluation of the effect of hazardous substances on human health.

- Dissection of the roles that hazardous substances play in the disruption of biological responses (e.g., molecular, genetic, epigenetic, RNA biology, biochemical events, and/or progression of complex disease/dysfunction (e.g., cancer, neurocognitive decline, cardiovascular disease, metabolic syndrome, birth outcomes, etc.).
- Use and interpretation of high throughput cell-based assays utilizing novel cell types (e.g., iPSCs, physiologically-relevant in vitro models), "omics" techniques, organ-on-a-chip, tissue engineering (including organotypic tissues), and microfluidics to develop screening methods for rapid toxicity testing.
- Development of animal bioassays (e.g., humanized, knockout/knockin, etc.) to determine mechanisms of hazardous substances and to further develop mechanistic, toxicological, and epidemiological studies.
- Determination of the contribution of genetic and environmental variables in the development of disease (e.g., GxE interaction, genetic polymorphisms, epigenetic factors, sex, and age) and host factors (e.g., windows of susceptibility, nutrition, co-morbid disease/conditions, lifestyle habits, psychosocial stressors, allostatic load, timing of exposure, resilience).
- Employment of integrative or systems biology approaches to study the effects of environmentally relevant exposure routes/levels on the dynamic nature of biological systems and to identify biologically relevant events that lead to disease and dysfunction.
- Utilization, combination, and integration of various epidemiological data sets to determine relationship(s) between environmental exposures and phenotypic, or phenome functional read-outs, response(s).
- Development, validation, and interpretation of mathematical, computational, and/or machine learning approaches/models for analysis of high-density data and data used to predict toxicity (e.g., integration of various data types from high throughput assays and data *in silico* studies to uncover biological pathways leading to toxicity).
- Development of technologies to enhance the assessment of the Absorption, Distribution, Metabolism, and Elimination (ADME) of environmental toxicants, for singular, binary, and mixtures of compounds (e.g., toxicokinetic/toxicodynamic studies) and for toxicants with non-monotonic responses.
- Identifying and elucidating the interaction between environmental toxicants and the human microbiome including changes in ADME (including bioavailability/bioaccessibility), shifts in microbial community structure associated with a disease pathway, assessment of small molecule metabolites as biomarkers of microbiome interactions, and/or identification of patterns indicative of protective microbial communities/consortia.
- Identification and validation of sensitive and novel diagnostic or prognostic biomarkers of exposure and disease, that can be easily detected (in blood, urine, buccal swabs, saliva, sweat, and exhaled breath condensate, etc.) with a biological response anchored to a phenotypic characteristic, disease, and/or therapeutic efficacy.
- Evaluation of direct effects and biological responses resulting from hazardous substances on tissue compartments (e.g., brain/nervous system, eye, skin, lung, bone, lymph, kidney, liver, reproductive tract, and the gastrointestinal tract).
- Investigation of the internal and external exposome, which will require the development, validation, and implementation of characterization of exposure and biological response, exposure assessment for multiple analytes, utilization of computational tools and resources for analyzing, and conducting non-targeted analysis and screening analysis to identify connections between an exposure(s) and biological response(s).

- Investigation of disease/dysfunction related to environmentally relevant (low dose) exposures, using human biomonitoring data and/or other large databases to develop testable hypotheses (e.g., National Health and Nutrition Examination Survey (NHANES), ToxCast, disease registries, etc.).
- Incorporation of bioengineering and synthetic biology to study the regulation, control, and response to environmental chemicals (e.g., toxicity sensors that rapidly detect and quantify low concentrations of chemicals in cells or tissues).

2) Methods to assess the risks to human health presented by hazardous substances.

- Development of multi-dimensional models that incorporate exposure data, fate and transport, transformation of contaminants in the environment, contaminant bioavailability in the environment and in biological systems to determine individual and population-based biological responses (i.e., populations with varying characteristics).
- Development of novel methods/approaches/statistical models/machine learning/artificial intelligence approaches to integrate exposures over time, determine windows of susceptibility, and to characterize the attributable risk from multiple exposures experienced over one's lifetime.
- Development of cumulative risk models to synthesize findings from health effects research, susceptible life stages, the influence of co-exposures and non-chemical stressors (e.g., infectious disease, psychosocial), indirect effects, and MOA to support more complex exposure assessments in susceptible populations (e.g., medically and economically disadvantaged).
- Development of models for integrating connections and interdependence between environmental risk and psychosocial health determinants (e.g., stress, mental health, etc.) within the environmental decision-making process.
- Development of sophisticated and appropriate statistical and computational methodologies and improved mathematical algorithms for predictive and computational toxicology to characterize low dose-response effects and disease latency.
- Provide innovative strategies to address uncertainty in risk associated with:
    - Extrapolation from *in vitro* to *in vivo* data, differences in species, extrapolation from virtual tissue/systems biology studies, individual susceptibility and predisposition, sex, age, extrapolation of high to low dose, and acute to chronic exposure.
    - Combined exposures or cumulative risk (e.g., component and whole mixture approaches, extrapolation from single chemical(s) to multiple exposures or mixtures; inclusion of non-chemical stressors).
    - Development, characterization, and validation of biomarkers of exposure and/or disease that can be applied to gain additional mechanistic insight(s) into disease pathogenesis
    - Non-monotonic dose response relationships.
    - High throughput screening tests (e.g., in silico, model systems) relevant to human toxicity, pathways, and endpoints (e.g., AOPs, network/systems biology, and knowledge graphs).
    - Mode(s) of action of hazardous substances.
    - Predisposition based on current or past disease states (e.g., immune-related diseases, cardiovascular disease, cancer, endocrine disruption, etc.).
    - Bioavailability factors of metals/metalloids using bench chemistry and animal studies.
- Determination of how exposome methodologies (e.g., capacity for untargeted analysis of biomarkers of exposure and response including and not limited to metabolomics, proteomics, lipidomics, transcriptomics metagenomics, and epigenomics) can be utilized to assess risk of disease.
- Development of methods to assess risk to hazardous substances that include alterations of the microbiome, effects of single polynucleotide polymorphisms (SNPs) and their effect on biological function, and consideration of epigenetic changes.
- Utilization of structure/function relationships (e.g., QSAR) in response to exposure(s) to hazardous substances to reduce uncertainty in risk.
- Utilization of geospatial tools to identify trends in exposure, disease, sociodemographic factors, etc. to better understand potential risk and susceptibility.

- Development of methods to determine exposure rates and different routes of exposure (e.g., tracer methods to identify the amount of soil ingested by children; exposure metrics of toxicants from fish consumption; contribution of soil to indoor and dust due to human activities (e.g., tracking soil indoors and areal radius of the "outdoor" source available for transport).

- Assessment of community vulnerability/resilience and understanding how vulnerabilities are exacerbated by current conditions (e.g., health status, poor health service, availability of food services, etc.) in communities threatened by contaminant exposure (e.g., urban centers prone to flooding within active and/or historical industrial facilities); developing a prioritization scheme for rating the importance of their vulnerabilities; and identifying actions that can increase their resilience.

3) Methods and technologies to detect hazardous substances in the environment.

- Development of fast, accurate, robust, low-cost, minimally invasive, and advanced detection technologies and assays to optimize regulatory sampling that allow for portable real-time, on-site monitoring and characterization of hazardous substances and their breakdown products.
- Development of advanced sensors and probes such as biosensors, molecular diagnostics tools, new imaging modalities (e.g., geophysical imaging), self-contained miniaturized toxicity-screening kits, miniaturized analytical probes, and *ce* devices that are capable of multi-analyte readings.
- Development of tools with data analysis and collection capabilities such those with field data exchange capabilities for real time remote monitoring of conditions, technologies that automatically geo-reference collected data, solar powered sensors embedded with wireless transmitters, and data collection via smart phones.
- Development of tool/assay designs that improve device reuse, waste generation, and utilization of non-toxic components (particularly for *in situ* devices).
- Development of detection technologies that are easily deployable for environmental disaster response and can be used at sites complicated by multiple contaminant streams or complex environmental media (e.g., soil, sediments, and groundwater).
- Integration of environmental data within a contextual framework of how contaminants affect nearby populations (human or wildlife) through modeling approaches, such as:
    - Utilization of bioassays or ecological indicators as measures of disturbance due to hazardous substances in the environment as well as recovery of ecosystems and ecosystem services following remediation (e.g., natural succession, changes in food web uptake, etc.).
    - Development of innovative generalizable methods to assess impacts of hazardous substances based on sentinel species.
    - Utilization of GIS-based environmental databases for understanding impacts of hazardous substances on ecosystem functioning (e.g., ecosystem services and natural succession).
    - Molecular and genetic endpoints in invertebrates, fish, birds, and wildlife that can serve as early predictors of toxicity and diminished reproduction/fecundity, that may impact normal wildlife population levels and/or ecological restoration/succession.
- Improvement of methods to assess physical characteristics of the environmental matrix (e.g., hydraulic conductivity, bedrock fractures, etc.) especially for understanding large, complex sites.
- Utilization of subsurface visualization and molecular diagnostic tools to characterize the physical, hydrogeochemical, or biogeochemical properties of complex sites (e.g., sites containing dense non-aqueous phase liquid (DNAPLs) and sites that are typically characterized by extensive, heterogeneous, and persistent source zones of entrapped and pooled organic liquids).
- Improved approaches for predicting/anticipating time-periods for occurrence of reasonable maximum indoor exposure(s) from soil vapor in impacted buildings, during which sampling is recommended; innovative methods and tools for analyzing specific vapor-phase chemicals (e.g., PFAS) in indoor air and gas samples.

- Development of techniques to improve analytical detection limits, particularly where current methodology detection limits exceed action levels for site cleanup, risk action, or screening benchmarks, or where it is unclear what is the background level of the contaminant.
- Development cost-effective techniques and approaches for identifying contamination in fractured rock including understanding the mechanisms of contaminant diffusion in/out of rock matrices; the fate of certain contaminants within rock matrices (i.e., sorption onto the rock matrix, influence of biodegradation/chemical transformation; role of rock type in influencing these factors); and other factors that may inhibit remedy effectiveness.
- Development of tools to support rapid assessment of bioavailable fractions of hazardous substances in the environment including relevant exposure times and locations in complex environments (e.g., groundwater/surface water interaction zones, etc.). In particular, there is a need for the development and validation of inexpensive, laboratory-based, *in vitro* tests of bioaccessibility for common contaminants of concern (such as PAHs, lead in soil, arsenic in mine tailings, etc.).
- Development and standardization of passive sampling methods, particularly for assessing bioavailability of hazardous substances including passive sampling methods for bioavailability of metals in sediments and water.
- Application of innovative sensors or passive sampling devices that can be used to validate remediation performance and/or conduct post-remedial monitoring, comparing these innovative approaches with conventional biomonitoring organisms or analytical methods.

4) Basic biological, chemical, and physical methods to reduce the amount and toxicity of hazardous substances. (Please note: at least one ES&E project must address mandate 4):

- Optimization of sequential and compatible remediation strategies for different phases of a clean-up process (i.e., “combined remedies” or “treatment train”) to maximize the degradation/removal of hazardous substances, including mixtures, at complex sites.
- Optimizing cleanup technologies, components, and strategies to develop sustainable “green” and resilient remediation solutions that are effective, energy efficient, economically feasible, cost-effective, technologically sound, reduce ecosystem impacts, and acceptable to affected communities. (Applicants are encouraged to quantify the environmental footprint of remediation activities; http://cluin.org/greenremediation/subtab_b3.cfm)
- Development of innovative approaches to remediate complex contaminated sites (e.g., karst environments, fractured bedrock, rock matrix diffusion, heterogeneous sedimentary deposits, complex contaminant mixtures, groundwater/surface water interactions).
- Utilization of molecular, biochemical, cellular, and/or engineering tools to understand the basic structural and functional properties of microorganisms, microbial communities, or plants involved in the bioremediation of hazardous substances.
- Development of new technologies for source zone treatment and persistent back diffusion, including delivering agents *in situ* for remediation of contaminated sediments, soils, and groundwater.
- Determination of the long-term efficacy and sustainability of a remediation technology (e.g., the efficacy of using phosphates for long-term stabilization of lead in soil; use of colloidal activated carbon to sequester compounds such as PCBs, PFAS etc.).
- Development of robust remediation strategies resilient to extreme weather event impacts.
- Development of low cost and effective soil immobilization approaches to prevent transport of contaminants indoors (e.g., lead), translocation into plants, or re-entrainment.
- Development of automated systems for site cleanup and monitoring to overcome hazards associated with unknown contamination and lower risk of initial sampling for routine or emergency-related site assessment.

- Development of new innovative passive remediation technologies (particularly for in situ groundwater remediation and mining influence waters), with potential for reduced treatment costs, treatment waste volumes, and energy usage.
- Utilize existing data streams (high throughput or rapid small scale column testing) to understand replacement of target compounds through time (e.g., PFAS or any contaminant sediments).

Biomedical Approaches:

- Development of basic mechanistic/fundamental studies to assess how diet, nutrition, exercise, vitamin supplements, pharmacological, microbiome/probiotic, and behavioral intervention, etc. may reduce toxicity of hazardous substances.
- Development of nutrition or other prevention/intervention strategies (e.g., diet, exercise, vitamin supplements, pharmacological intervention, microbiome/probiotic, behavioral intervention) to reduce toxicity of hazardous substances.
- Development of biological monitoring studies to assess the effectiveness of remediation technologies in preventing exposures in humans.
- Determination of the benefits of ecosystem services on the impact of hazardous substance exposure (for more information see: https://www.epa.gov/eco-research/ecosystem-services-research).

Section B. Hazardous Substances of Interest

SRP Centers present a unique opportunity to address research needs of existing Superfund sites. **Applicants are highly encouraged to consult with SRP staff for specific questions about the relevancy of a hazardous substance** as the presence of a compound on one of the lists mentioned below does not automatically make it relevant to the SRP. ***Per SARA Mandates, hazardous substances do not include petroleum nor natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel.*** With regard to specific hazardous substances, please refer to the following areas of interest:

- **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Priority List**: these are hazardous substances that are relevant to the US Environmental Protection Agency (EPA) Superfund Program and to the Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/SPL/index.html). These hazardous substances are ranked based on frequency of occurrence at NPL sites, toxicity, and potential for human exposure.
- **EPA Superfund Website**: provides information about current and previously listed National Priorities List sites and their contaminants: https://www.epa.gov/superfund. In addition, EPA's Integrated Risk Information System (IRIS) develops Toxicological Reviews for many compounds relevant to Superfund and identifies hazard endpoints for which there is insufficient data to derive reference values. The list of IRIS chemicals can be found at: https://cfpub.epa.gov/ncea/iris2/atoz.cfm including assessments in development, can be found at: https://iris.epa.gov/AtoZ/?list_type=alpha.
- **EPA Sustainable and Healthy Communities Strategic Action Plan (SHC StRAP) 2023-2026:** The purpose of the SHC StRAP is to inform EPA's partners and external stakeholders of the program's strategic direction over the next four years. The current SHC StRAP includes a section on "Chemicals of Immediate Concern." This section identifies lead and PFAS as priority compounds and identifies several critical gaps in knowledge that may be useful for applicants: https://www.epa.gov/system/files/documents/2022-10/SHC%20FY23-26%20StRAP_EPA-ORD_October%202022_508.pdf
- **Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles:** By Congressional mandate, the Agency for Toxic Substances and Disease Registry (ATSDR) produces "toxicological profiles" for hazardous substances found at National Priorities List (NPL) sites (https://www.atsdr.cdc.gov/toxicological-profiles/about/index.html). Toxicological profiles are

developed from a priority list of 275 substances and include a "Data Needs" section, which is a useful resource to identify gaps/needs in toxicological testing.

- **Co-Exposures and Mixtures:** Commonly-occurring mixtures of contaminants found at Superfund sites and relevant to human exposure are of high interest to the SRP and its end-users. Examples include but are not limited to: methylmercury and PCBs (potential co-exposures due to fish/shellfish consumption); polycyclic aromatic compounds and metals; co-occurrences of endocrine disrupting chemicals; metal/metalloid mixtures associated with mining operations, etc.); apparent co-exposures/mixtures identified in national databases (e.g., NHANES, National Center for Environmental Health); databases from state biomonitoring programs, and community biomonitoring programs. Applicants are encouraged to visit the following website for interaction profiles that have been developed by the ATSDR: https://www.atsdr.cdc.gov/interaction-profiles/about/index.html.
- **Emerging Contaminants (ECs)**: There are many contaminants that are of emerging concern to Superfund for reasons such as increased prevalence of a compound on Superfund sites or in human biomonitoring studies together with a lack of data about the hazards of the compound. These compounds may not be on the CERCLA Priority List; however, there is uncertainty about the safety of these compounds in the environment. ***Applicants considering a focus on emerging contaminants are strongly encouraged to contact SRP staff early in the application development process to discuss the programmatic relevancy of the proposed hazardous substance.*** As a general framework, the characteristics that would make ECs candidates for consideration within the SRP Centers include:
    - **Chemicals of Unknown Hazard Found at Superfund Sites**: A Provisional Peer-Reviewed Toxicity Value (PPRTV) is a toxicity value derived for use in the Superfund Program when such a value is not available in EPA's Integrated Risk Information System (IRIS, the first tier in the Superfund hierarchy of human health toxicity values). PPRTVs can be found at: http://hhpprtv.ornl.gov/.
    - **Federal Facilities Restoration and Reuse Office (FFRRO) Emerging Contaminants** FFRRO is a resource for many ECs. For a full list of FFRRO emerging contaminants and for additional EC resources, please see the following: https://www.epa.gov/fedfac/restoration-and-reuse-federal-facilities.
    - **Other EC Characteristics:** Typically, the EPA recognizes that chemicals with a High Production Volume (HPV) – i.e., chemicals are produced at quantities greater than 1 million pounds or 500 tons per year – could become problematic if there is a potential for exposure together with human health and environmental hazard potential. In addition, it is generally recognized that compounds with structurally similar chemicals to CERCLA Priority List of hazardous substances may confer similar toxicity/fate & transport issues as those on the CERCLA list. In general, these types of compounds (HPV and structural similarity) would make these emerging compounds a "high priority" for risk-based priority decisions.

Section C. Exposure Scenarios of Interest

The following examples have been identified as scenarios that require further research efforts.

- **Susceptible Populations and Predisposition:** research on susceptible populations (e.g., pregnant women, children, elderly, ethnicity, disease states) in order to develop strategies to reduce their burden of environmentally-influenced diseases; investigation of windows of susceptibility including pre-pregnancy, development, infancy, early childhood, puberty, and aging; determination of specific windows of susceptibility that are most sensitive to environmental exposures and may lead to disease; identification of *in vitro* and *in vivo* models to accurately predict disease from exposure during critical life stages in human populations; development of biomarkers of exposure and disease to predict disease later in life; determination of the role of genetics and the mechanism(s) responsible for the latency of effect; determination of how exposure to environmental contaminants during windows of susceptibility

can be used to support risk assessment and predict risk of disease; identification of other potentially susceptible populations.

- **Vapor Intrusion (VI):** development of sustainable remediation strategies to mitigate exposure; development of alternative method(s) for assessing effectiveness of vapor intrusion mitigation systems; evaluation and optimization of site investigation methods to improve the conceptual site model and assess the vapor intrusion pathway including source forensics and sitewide preferential pathways; development of cost-effective, real-time, and validated methods to detect vapor intrusion and/or assessment of exposures; innovative methods to assess spatial/temporal/seasonal fluctuations in soil VI and strategies to apply to risk assessment modeling; development of non- invasive sampling techniques; development of hand-held or remote-capable air monitoring tools to detect volatile PFAS and VOCs in air at low (relevant) risk-based detection limits; development of studies to understand mechanisms and health consequences of chronic, low level exposure of chemicals associated with vapor intrusion.
- **Combined Exposures and Cumulative Risk Assessment:** investigation of effects of combined exposures/mixtures which include any combination of chemical and/or nonchemical stressors that act jointly to elicit a measurable adverse effect; examples include: whole mixtures; mixtures of multiple environmental toxicants (where the individual toxicants are well-defined), combinations of environmental toxicants and nonchemical stressors (e.g. physiological stressors psychosocial stress; social determinants of health), or the interactions between diet, or infectious agents, with environmental toxicants; development of computational toxicology approaches to understand the interactions among combined exposures, which may include mathematical and statistical models/approaches, to predict human health effects associated with combined exposures and to support cumulative risk assessments (for more information about cumulative risk assessment, see https://www.epa.gov/risk/framework-cumulative-risk-assessment); development of innovative detection and/or remediation technologies for combined exposures in the environment; assessment of strengths/weaknesses of various approaches used to determine cumulative impacts including understanding the advantages/disadvantages of including certain data sources, geographic scales, and methods of statistical analysis; determination of environmental exposures that may be unique to particular communities, including mitigation approaches for those communities. (In addition, applicants may wish to visit the EPA's Community-Focused Exposure and Risk Screening Tool (C-FERST) webpage for ongoing efforts to integrate information about community exposure to multiple stressors. Combined exposures selected for study should have relevance to Superfund and human exposure, with an emphasis on investigating relevant contaminant exposure and dose concentrations.)
- **Emerging Exposure Pathways:** Examples include: new exposure pathways from legacy contaminants; the emerging concern posed by arsenic (and other metals/metalloids) inhalation from mining sites; multiple contributions to body burden of heavy metals such as lead; volatile PFAS, and the human and environmental health effects associated with e-waste and reclamation activities.
- **Exposome:** investigation of the exposome, which describes the totality of human exposures in an integrated temporal, spatial, and biological framework (see Vermeulen, 2020, Science 2020, Volume 367, Issue 6497, p. 392-396; https://www.science.org/doi/10.1126/science.aay3164 and Wild, 2012, International Journal of Epidemiology, Volume 41, Issue 1, p. 24-32; http://ije.oxfordjournals.org/content/41/1/24.long); exposome research requires the development, validation, and implementation of characterization of exposure and biological response. Exposome research topics include: comprehensive assessment of external exposure, internal dose, and biological response; assessment of multiple analytes in biological samples; computational//artificial intelligence/machine learning tools and resources for analyzing and providing centralized access to information on the associations between exposure and disease; development of objective measures of historical exposures to inform investigations of latent effects of exposures or diseases arising from exposures during windows of susceptibility; assessment of exposure before, during, and after remediation; development and validation of exposure

assessment tools to determine the incorporation of bioavailability of contaminants in the environment; use and refinement of environmental monitoring and geographic information system (GIS) for spatial exposure assessment.

Section D. Suggestions for Data Management and Analysis Core activities

The RFA-ES-23-001 details the requirement for applicants to include a Data Management and Analysis Core (DMAC) to support the management and integration of data assets across the Center to foster and enable the interoperability of data between biomedical and environmental science and engineering projects, accelerating the impact of the Center's research. Depending on the research goals of the center, the following activities may be useful activities to demonstrate how the DMAC can support effective data management and analysis across the center through:

Coordination with Project and Cores leaders:

- Developing and refining project/core specific data management and sharing plan templates that align with the Center's overall Data Management and Sharing Plan. Applicants are encouraged to refer to the following resources for tips and templates (Elements to Include in a Data Management and Sharing Plan: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-21-014.html and the NIH Scientific Data Sharing: https://sharing.nih.gov/; DMPTool: https://dmptool.org/).
- Helping to ensure data management and sharing aligns with the FAIR (Findable, Accessible, Interoperable, and Reusable) principles and, as applicable follows the CARE (Collective Benefit, Authority to Control, Responsibility, and Ethics) Principles for Indigenous Data Governance.
- Development of schema that collects sufficient metadata Developing, supporting and encouraging the use descriptors (e.g., through development of a checklist for data including methodologies, definitions of variables, vocabularies, and ontologies (or semantic relationships) and their relationships to other data generated in the Center, type of data and file formats, data analysis and any scripts (i.e., metadata) that incorporate the concepts of Findable, Accessible, Interoperable, and Reusable (FAIR) (see Wilkinson MD et al. Sci Data. 2016; 3:160018), to enable interoperability and compatibility across the Center, creating the potential to advance the understanding of relationships between multiple datasets to advance the research goals of the Center.
- Developing tools that enable the collection of metadata (e.g., metadata packages) during the research process so that it is consistent with community standards to support rigor and reproducibility and facilitate interoperability and reuse of data.
- Identifying appropriate data sharing platforms (within and outside the Center and to SRP staff) or strategies for sharing prioritized data sets outside the Center and reporting to SRP staff (e.g., via DCT) and establishing timelines for deposition.
- Facilitating the creation of a data sharing platform to enable access of data combined with analytical tools to allow multiple data sets to be queried together (e.g., Data Commons).
- Providing support for research projects so that handling of sensitive and restricted data (e.g., human population studies) is described and appropriately anonymized with formal consent agreements in place.
- Facilitating the creation of a controlled and secured data sharing platform to enable access of data combined with analytical tools for sensitive and restricted data (e.g., Data Enclave).
- Providing data analytical/statistical support for research projects/core leaders.
- Providing support to enhance data integration and interpretation through visualization approaches (e.g., computational modeling support combined with GIS mapping to reveal geographic patterns to characterize exposure) and through graphical approaches to understand relationships between data (e.g., knowledge graphs).
- Working closely with project/core leaders to ensure high data quality throughout the entire lifecycle of the data and describing how this will be ensured.

- Encouraging and providing strategies to foster and enable project and core leaders/trainees to analyze shared datasets creating opportunities for exploring new linkages between data and the formation of new hypotheses.
- Working with the Research Experience and Training Coordination Core to support training and education on data management practices.

- **Fostering Data Sharing and Interoperability.** Examples include:
  - Developing visualization and other application tools to facilitate data sharing and integration (e.g., graphical interfaces and dashboards).
  - Developing ontologies/semantic relationships, standardized data documentation (metadata), and/or analysis tools to enable interoperability and compatibility across the Center (e.g., knowledge graphs) creating the potential to advance the understanding of relationships between multiple datasets to advance the research goals of the Center.
  - Developing strategies to foster and enable the interoperability of data between biomedical and environmental science and engineering projects.

- **Data Quality Assurance and Quality Control**. Examples include:
  - Developing a strategy for how quality control and assurance measures will be implemented and monitored for each data type across the Center.
  - Assessing these measures for effectiveness by reviewing internally and externally to ensure and evaluate quality using peer or other reviews of the study design or analytical methods prior to data collection and how recommended changes will be implemented.
  - Training project/core staff and trainees on best practices for and how to implement quality assurance.
  - For an example of a data assurance and quality control plan, refer to DataONE: https://www.dataone.org/best-practices/develop-quality-assurance-and-quality-control-plan

Section E. Suggestions for the Administrative Core's Research Translation Activities

The RFA-ES-23-001 details the requirement for research translation as part of the Administrative Core for each SRP Center. Research translation has a critical role in assisting project/core leaders in translating research emanating from the Center to appropriate audiences, thereby encouraging the accurate and timely use of these research products. Research Translation refers to moving project outcomes to end-users. These activities are not meant to be a pilot project/activity program. The following are examples that would demonstrate some of the various tools and activities that can be used for effective research translation:

- Communicating within SRP: Per the RFA, this includes Project-Specific Research Translation; SRP communication (i.e., communication with SRP staff at NIEHS headquarters); and Cross-Center communication. Examples include:
  - Coordinating with Project leaders to develop plain language description(s) of research project(s) for dissemination to broad audiences (e.g., elevator pitch, lightening talk, website summaries).
  - Developing materials for multi-media outlets (e.g., YouTube videos, webinars, social media).
  - Coordinating with Project Leaders in identifying potential end-users for project research to assist in developing Project-Specific Research Translation Plans (see ***Section F***).
  - Communicating to SRP the results of research translation activities through utilization of the NIEHS SRP research translation activity data collection tool to provide information about various activities (e.g., investigator awards, meetings, workshops) – visit SRP Data Collection Tool (https://tools.niehs.nih.gov/srp/rtc/).
  - Participating in SRP research translation teleconferences, webinars, and working groups as appropriate to the Center.
  - Proactively disseminating timely information to SRP and other Centers (e.g., high impact publications, press releases).

- Developing workshops, networking groups, and/or meetings among the various SRP Centers to advance scientific themes of the Center.
- Participating in networking groups between SRP Center investigators and end-users to advance translation of new scientific research.
- Utilizing the NIEHS's Translational Framework initiative: https://www.niehs.nih.gov/research/programs/translational/framework-details
- Helping to identify opportunities for trainees to interface with research translation activities relevant to their research.

- Partnerships with Government Agencies. Examples include:
  - Identifying appropriate Center expertise for serving on External Advisory Panels (e.g., EPA or ATSDR panels).
  - Participating (reviewing documents, submitting public comments when appropriate) during Public Comment periods on Superfund relevant environmental health related documents at local, regional, state, and federal government levels. A few examples of regularly posted documents include:
    - ATSDR:
      - Public Health Assessments available for comment requests
      - Draft for Public Comment Toxicological Profiles https://www.atsdr.cdc.gov/toxicological-profiles/about/index.html
    - EPA: EPA's Integrated Risk Information System (IRIS https://www.epa.gov/iris)
    - State products (e.g. CalEPA)
    - Other Federal Agencies: There are many important documents routinely announced. To find other public comment opportunities related to hazardous waste, Centers may find it helpful to monitor the Federal Register https://www.federalregister.gov/, the NIH Guide for Requests for Information (RFI; https://grants.nih.gov/searchguide/) and/or Regulations.gov https://www.regulations.gov/.
  - Establishing connections with Regional EPA offices and ATSDR offices (EPA Superfund and Technical Liaisons (STLs); ATSDR Regional staff) and Headquarter Offices (https://www.epa.gov/aboutepa/about-office-land-and-emergency-management).
  - Communicating scientific findings to and establishing working relationships with local/state/Tribal health and environmental departments (e.g., participating together in meetings, workshops, conferences, webinars).
  - Identifying opportunities to work with or leverage resources from other end-user agencies such as, but not limited to: National Oceanic and Atmospheric Administration (https://www.noaa.gov), U.S. Geological Survey (https://www.usgs.gov), U.S. Department of Defense (https://www.defense.gov), and the U.S. Department of Energy (https://www.energy.gov), National Science Foundation (https://www.nsf.gov), and other NIH Institutes and Centers (https://www.nih.gov/institutes-nih/list-institutes-centers).
- Technology Transfer. Examples include:
  - Assisting in Project-Specific Research Translation (PSRT) opportunities such as identifying appropriate sites for piloting remediation technologies and sharing/testing of environmental/biological samples (see Section F).
  - Partnering with implementation science experts to integrate evidence-based practices and interventions into public health settings.
  - Coordinating with formal technology transfer mechanisms (patents, licenses, Small Business Innovation Research/Small Business Technology Transfer Research grants).
  - Using research findings to improve current risk assessments and communication.
  - Advancing biomarker, remediation, detection, etc. research into application with consultation from technology transfer offices and/or end-users such as EPA and ATSDR.
  - Creating open- source data sharing repositories.

    - Creating and sharing open-source data analytic resources in coordination with DMAC.
    - Refining technologies/demonstration research to make more applicable to end-users.
- Information Dissemination to other End-users. Examples include:
    - Developing website(s), informational videos, brochures, utilizing media (e.g., newspapers, magazines, social media, video) and/or factsheets about the SRP Center to be readily available to a broader audience.
    - Coordinate writing of editorials, commentaries, and review papers, and opinion papers.
    - Developing audience appropriate educational courses/curricula/learning material.
    - Developing meetings/symposia/conferences/workshops based on the focus of the Center.
    - Participating in local community or health events (e.g., health fairs, school-based programs, etc.).
    - Hosting webinars, symposia, and science cafes.

Section F. Suggestions for Project-Specific Research Translation activities

The SRP Strategic Plan encourages interaction between project leaders and end-users throughout the proposal development, the project duration, and conclusion of research activities to increase project and Center relevancy (end-users may include federal government agencies, state/local/tribal government agencies, non-government organizations (NGOs), medical/clinical settings, commercial sector, affected communities, etc.). To address this, RFA-ES-23-001 details the Project-Specific Research Translation (PSRT) as part of the Project Resource Sharing Plan section.

The following activities have been identified by SRP and its end-users as potential ways to use research findings in the manner most appropriate for their application and the advancement of the research objectives. This list is not meant to be exhaustive. Investigators should be in communication with their research translation coordinator (within the Administrative Core) to identify PSRT opportunities most appropriate for a given research project. When work is proposed for Superfund Sites, the site Remedial Project Manager as well as appropriate EPA and ATSDR regional staff, should be contacted and incorporated into the PSRTs. As appropriate, the CEC's impacted community may be an appropriate end-user for project discoveries and could, therefore, be considered as part of PSRT plans.

PSRT plans may include the following:

- Coordinating between with the project leader and the research translation coordinator to develop plain language description(s) of research project(s) for dissemination to broad audiences (e.g., elevator pitch, lightening talk, website summaries).
- Sharing of anticipated project-generated resources: e.g., specimen sharing, field sample sharing, development and distribution of analytical protocols/methodologies, data generated from toxicological (e.g., dose-response studies) and epidemiological studies (e.g., adding data to NIEHS and/or EPA data repositories).
- Identifying contaminated sites that may be appropriate for piloting project technologies and assisting field practitioners in site monitoring and remediation technologies when developing these technologies, partnering with engineering firms for testing technologies (either bench or pilot) on real sites or with site materials.
- Providing comments during open public comment periods for EPA's Integrated Risk Information System (IRIS) draft toxicological reviews and/or ATSDR's Toxicological Profiles and Public Health Assessments. Applicants may wish to consider monitoring public comment periods for federal documents from a variety of government agencies: EPA, ATSDR, NIH, NIEHS, NIEHS NTP, CDC, FDA, USDA, NOAA, USGS, DoE, DoD, etc., (see "Partnerships with Government Agencies" section above for details).
- Coordinating with federal and/or state research laboratories undergoing similar/complementary research studies (i.e., EPA Office of Research and Development) especially where toxicological data is missing from the scientific literature.

- Planning visits to EPA, ATSDR, and/or other end-users to give seminars and participate in conferences/workshops to meet agency staff to learn first-hand about programs and potential data gaps, as well as identify future collaborations.
- Coordinating validation processes of biomarkers and/or sensors with end-users regarding high throughput screening methods and coordination with technology transfer offices for validation of these platforms.
- Participating in scientific advisory boards (e.g., EPA Science Advisory Board: https://yosemite.epa.gov/sab/sabpeople.nsf/WebCommittees/BOARD; National Research Council https://www.nationalacademies.org/home)
- Participating in NIEHS's Translational Research Framework initiative: https://www.niehs.nih.gov/research/programs/translational
- Translating research discoveries into public health interventions or risk communication tools.
- Utilizing field data to assist/aid in determining background concentrations for specific chemicals; determining the most appropriate way to identify background concentrations (i.e., state-wide, county-wide, based on geologic formation).
- Utilizing ecological data for use in develop ecological toxicity reference values (TRVs) for contaminants for which data are lacking; assessment of many chemicals for numerous feeding guilds or particular classes of organisms (e.g., amphibians and reptiles).
- Translating and quantifying health, well-being, environmental, and economic benefits resulting from application of a relevant remediation technology.
- Coordinating data and knowledge management to integrate complex information systems (e.g., development of data integration tools to facilitate data sharing among research projects and cores and to broaden the interdisciplinary research potential for environmental health sciences; or development of publicly available resources and computational tools for integrating and analyzing environmental health data).
- Participating in sample and data-sharing with other SRP grantees, (e.g., exchange of data/samples/resources in complementary studies; sharing of sediments to compare the effectiveness of remediation amendments).
- Developing communication strategies to address uncertainty in risk associated with differences in species, sex, extrapolation of high to low dose, acute to chronic exposure, *in vitro* to *in vivo* data, epigenetic changes, microbiome, exposome, SNPs, etc.
- Coordinating with the CEC and the CEC's impacted community to develop appropriate activities/education materials based on the community's needs.

Section G. Suggestions for Community Engagement Core activities

The SRP considers the individuals and communities living near impacted sites as key end-users and recognizes the opportunity for SRP Center research and activities to achieve positive public health benefits through bidirectional interactions between the Center and impacted communities. The purpose of the SRP Community Engagement Core (CEC) is to direct best practices in community engagement for exposure prevention and intervention. For the purposes of this RFA, the SRP refers to prevention and intervention as "basic biological, chemical, and physical methods to reduce the amount and toxicity of hazardous substances." Through exposure prevention and intervention, the CEC empowers impacted communities to be full participants in decisions to reduce the amount and toxicity of hazardous substances whether in their homes, their schools, their community, and/or their environment.

Community Engagement Core activities build from the research and expertise of the Center's projects and cores. Although each community is likely to have specific needs, the following activities are suggestions to enable and promote community engagement and informed participation in the Center's Community Engagement Core activities and any community engagement projects (if applicable).

Community Engagement Core Activities may include:

- Coordinating with local, state, tribal, and Federal end-users to conduct community-based needs and exposure assessments to identify culturally appropriate prevention and intervention strategies to reduce exposures.
- Partnering with tribal communities in determining exposure pathways relevant to their traditional and cultural practices and using these findings to develop culturally appropriate exposure prevention strategies.
- Developing ways to improve the community's resilience to natural disasters or extreme events, especially related to contaminated sites including improved methods for assessing cumulative impacts of these events.
- Supporting prevention and intervention strategies such as:
    - Training and education for community organizers and individuals in best practices for data collection and sampling methodologies (e.g., teaching community members how to use personal sensors or exposure assessment devices).
    - Assisting a community in accessing pertinent information regarding the scientific aims of the research, the meaning of the research findings, and the public health or policy implications of the research (e.g., helping individuals make choices about their own exposures/avoiding exposures; or helping communities with decision-making related to site management, remediation, or redevelopment).
    - Working with the community to understand the behaviors that increase the risk of exposure to hazardous chemicals and develop culturally acceptable ways to change those behaviors to reduce exposure or avoid exposure.
    - Partnering with implementation science experts to integrate evidence-based practices and interventions into public health settings.
- Coordinating with Center's research translation efforts to address community needs in outreach and engagement which may include:
    - Providing scientific expertise in response to a community's questions.
    - Training for community members in how to translate materials into the community's native language or in a language that is understandable and relevant to that local community.
    - Developing and validating risk communication tools/methods tailored to the community partner.
    - Providing "train-the-trainer" workshops for risk communication or information dissemination within the community group.
- Developing guidance to contribute knowledge of appropriate risk communication practices, etc.
- Developing tools for data collection such as crowdsourcing, use of phone applications, texting, or social networking media.
- Attending EPA or ATSDR community involvement meetings related to the community of interest; coordinating with the Research Translation Coordinator and the Research Experience and Training Coordination Core/trainees for opportunities to participate in community meetings and/ or opportunities for other Center-community interactions.
- Establishing a plan for training opportunities for Center researchers/staff/trainees working with the community including, for example, training on cultural competency, bioethics, and on the basic principles and practices of Community-Based Participatory Research.
- Applying lessons learned from prevention and intervention activities specific for one community to other communities. Note: because SRP is not a site-specific program, it is expected that community engagement core and/or research activities, though targeting one community, would be generalizable to other communities living around or near sites affected by hazardous substances.
- Establishing a plan for unanticipated opportunities for community engagement relevant to the Center's activities – including notifying local networks, the SRP Program Staff, and leveraging strengths among the SRP network.
- Incorporating Tribal Ecological Knowledge (TEK) and Tribal Knowledge (TK) into the environmental monitoring and decision-making process for exposure prevention. TEK and TK involve systems of knowledge and investigation may not conform to mainstream "scientific

method," but could be valuable for determining health impacts and improve environmental decision making for tribal communities.

- Conducting an inventory of community-level environmental and health resources/needs to help prioritize prevention actions, taking into account community preservation and economic development in communities impacted by hazardous substances.
- Developing improved risk communication strategies in the event of natural or manmade disasters to enhance effectiveness of prevention/interventions such as presentation of data in new and more effective ways (e.g., the use of indices and color illustration schemes).
- Developing methodologies for communities to effectively generate data to provide input for developing effective prevention/intervention strategies.
- Developing activities to increase community resilience by reducing potential risks, promoting health, and revitalizing communities

Community Engagement vs. Community Outreach: The RFA-ES-23-001 details the expectation that the Community Engagement Core develops a substantive bidirectional interaction with an impacted community (or communities). This is distinct from what is sometimes referred to as "community outreach," which would generally fall under research translation of "Information Dissemination to other End-users." For example, participating in informal education outreach opportunities with high school students may be more appropriate as an Administrative Core's research translation activity; however, if the students are from the impacted community and involved in a prevention and intervention activity, this could be an appropriate activity for the Community Engagement Core. **Please consult with SRP Program staff for assistance in distinguishing between "Community Engagement" and "Community Outreach."**

Section H. Suggestions for Research Experience and Training Coordination Core activities

The RFA-ES-23-001 details the requirement for applicants to include a Research Experience and Training Coordination Core (RETCC) to support graduate and postdoctoral level cross-disciplinary training in fields related to environmental health and environmental science/engineering. The SRP defines "trainees" within the core as graduate students and post-doctoral researchers that perform research/activities that are supported by the Center.

The following are recommended RETCC activities:

- Conducting and promoting interdisciplinary research/activities among the trainees within the Center, and as appropriate, with other trainees from outside the Center.
- Promoting trainees to participate in RETCC activities and in the Center's overall research program, projects, and cores.
- Providing trainees with opportunities to enhance their professional career development and mentoring of SRP and non-SRP trainees (e.g., undergraduates, high school students, elementary students, and trainees).
- Participating in activities which may include: serving in leadership/mentoring roles, presenting their research or activities to the Center's institution and/or outside organizations, and participating in workshops/conferences that promote professional development (e.g., resume or scientific writing, interviewing skills, and oral/poster presentation skills).
- Facilitating practical opportunities for coordination or collaboration among other SRP grantees and for communicating research outcomes to various audiences (e.g., the public, their peers, and experts in the field) so that the trainees learn how to explain their work in a manner easily understood by the intended audience – whether the audience be the public or professionals in other areas of science.
- Facilitating opportunities for recruitment of Center trainees for fellowship/externship/award opportunities (e.g. KC Donnelly Externship; other educational exchange opportunities, SRP Karen Wetterhahn Memorial Award, and other opportunities.
- Hosting events within their Center and among Centers to promote collaboration among the trainees (e.g., workshops, conferences, seminars, or field days).

- Providing training in professional development. entrepreneurship, and/or development of small businesses.
- Providing training and education on data management practices and data sharing opportunities with the Center's Data Management and Analysis Core (DMAC).
- Coordinating trainee participation in the Community Engagement and Administrative Core's research translation activities.
- Participating in the SRP's Student/Post-Doc/Alumni Network (SPAN) Leadership committee (i.e. quarterly conference calls/webinars) and SRP-hosted trainee webinars (e.g., professional development webinars).
- Coordinating with the Center's Administrative Core to ensure that the Center's trainees are followed in the NIEHS CareerTrac database and providing metrics of trainee successes in publications, newsletters, and other outlets.

Section I. Other Resources

- ***SRP, NIEHS, and NIH Resources***
  - Superfund Research Program Strategic Plan 2020-2025: https://www.niehs.nih.gov/research/supported/centers/srp/about/strat_plan/index.cfm.
  - NIEHS Strategic Plan 2018-2023: https://www.niehs.nih.gov/about/strategicplan/index.cfm.
  - *Superfund Research Program Webpage:* contains information about the NIEHS Superfund Research Program including currently supported research areas (e.g., Who We Fund, Research Briefs, Science Digest, e-Posted newsletter, etc.) https://www.niehs.nih.gov/research/supported/centers/srp/index.cfm.
  - *P42 Funding Opportunities Webpage:* contains details about how to assemble the SRP P42 application (page limits, sections to include, forms to use) and provides a link to a free informational SRP funding opportunities webinar on October 1, 2020 (https://www.niehs.nih.gov/research/supported/centers/srp/funding#multiproject_center)
  - *SRP Search Tool:* SRP maintains a searchable website that includes access to currently-funded SRP grants and topics being investigated by SRP Centers (http://tools.niehs.nih.gov/srp/search/index.cfm). Applicants are encouraged to identify unique topic areas that are not currently represented among SRP Centers.
  - *SRP Materials for Grantees:* although not all information found in this section is applicable to new applicants, applicants should review these materials which include the "SRP Data Collection Form", "How to Gain and Maintain Access to Superfund Sites" "CareerTrac" (https://www.niehs.nih.gov/research/supported/centers/srp/resources/), and other important resources.
  - *NIEHS Partners for Environmental Public Health (PEPH)*: a network that brings together scientists, community members, educators, health care providers, public health officials, and policy makers in the shared goal of advancing the impact of environmental public health research at local, regional, and national levels. Resources useful for applicants, such as information about best practices for establishing partnerships as well as suggestions for assessing efficacy of community engagement and translation activities, can be found on the following website: http://www.niehs.nih.gov/research/supported/translational/peph/index.cfm
  - *PEPH Evaluation Metrics Manual:* provides examples of tangible metrics that can be used for both planning and evaluation. For example, logic models are used to develop evaluation metrics for cross-cutting PEPH themes such as Partnerships, Leveraging, Products and Dissemination, Education and Training and Capacity Building. A link to the evaluation manual can be found here: http://www.niehs.nih.gov/research/supported/translational/peph/metrics/index.cfm
  - NIH Comparative Genomics Resource (CGR): https://www.ncbi.nlm.nih.gov/comparative-genomics-resource/

- ***USEPA and ATSDR Resources***
  - *Superfund Remedy Report* (SRR; formerly called "Annual Status Report"): The SRR follows trends in remedy selection using past data as far back as 1982. The SRR analyzes remedies selected or modified in 594 decision documents; includes brief project highlights related to green remediation, in situ bioremediation, and high-resolution site characterization; and includes downloadable appendices with data for several key tables and figures in the report and new appendices that summarize all the remedy components. A link to the most recent report can be found at this website: http://www.clu-in.org/asr/
  - Next Generation Compliance calls for detection technologies that are easy to use: see environmental data collection for compliance:https://www.epa.gov/compliance/article-next-generation-compliance-using-advanced-monitoring-technology-meet-todays
  - National Health and Nutrition Examination Survey (NHANES): NHANES is a survey that examines a nationally representative sample of about 5,000 persons each year. Participants complete a survey (includes demographic, socioeconomic, dietary, health-related questions), receive a medical examination, and provide biospecimens for laboratory tests including several environmental contaminants or contaminant metabolites: https://www.cdc.gov/nchs/nhanes/index.html. Results are reported in the National Report on Human Exposure to Environmental Chemicals: https://www.cdc.gov/exposurereport/. The report also includes laboratory methods for both preparative and analytic chemical methods currently used on NHANES samples.
  - End-user Points of Contact: SRP recognizes the value of coordinating with End-users during the application development process to maximize the relevancy of the proposed research. Although making contact with regional representatives is generally encouraged, it is particularly important that researchers proposing to work on Superfund Sites contact the site's EPA Remedial Project Manager as well as regional EPA and ATSDR contact persons as outlined in the Best Practice Tips for SRP Grantees: How to Gain and Maintain Access to Superfund Sites. The following websites may be useful in finding appropriate contacts for the EPA and ATSDR within your region:
    - EPA Community Involvement Offices in each region: https://www.epa.gov/superfund/epa-regional-superfund-community-involvement-contacts
    - EPA Superfund and Technology Liaisons facilitate the use of sound science and technology in decision making for hazardous waste programs: https://www.epa.gov/sites/default/files/2015-10/documents/stl_factsheet102015.pdf
    - The ATSDR Division of Community Health Investigations fulfills the Agency's directives at the regional level by staffing an ATSDR Regional Office within each of the 10 EPA Regional Offices. The ATSDR regional representatives provide the Agency a unique expertise that combines special technical and field experience from their assigned regions. Regional Directors may be found by accessing the appropriate link on this website: http://www.atsdr.cdc.gov/dro/index.html
  - EPA Office of Land and Emergency Management's map of cleanup sites, https://www.epa.gov/superfund/search-superfund-sites-where-you-live
  - Sustainability Initiatives: EPA's sustainability paradigm incorporates 3 pillars of environmental, social, and economic issues. See more here: http://www.epa.gov/sustainability/; this link has a description of the Agency's research programs with an emphasis on sustainability: https://www.epa.gov/sustainable-futures/about-sustainable-futures
  - EPA maintains a spreadsheet tool titled "Spreadsheet for Environmental Footprint Analysis (SEFA)" to quantify the environmental footprint of remediation activities. See: http://cluin.org/greenremediation/subtab_b3.cfm

- Principles of Community Engagement (Second Edition): report released by ATSDR provides guidance for best practices in community engaged research: https://www.atsdr.cdc.gov/community-stress-resource-center/php/resources/principles-of-community-engagement2.html
- EPA Superfund Technical Support and Resource Centers: include several centers that link latest methods/approaches/research to solve problems encountered in field (https://www.epa.gov/superfund/superfund-technical-support-and-resource-centers).
- EPA maintains a tool to understand differences in biological response between species and/or across similar compounds (SeqAPASS) https://www.epa.gov/chemical-research/sequence-alignment-predict-across-species-susceptibility
- The following websites provide recently developed laboratory methods for both preparative and analytic chemical methods used on NHANES samples: (http://www.cdc.gov/exposurereport/)
    - EnviroAtlas: https://www.epa.gov/enviroatlas/how-use-enviroatlas
    - About ORD: https://www.epa.gov/aboutepa/organization-chart-office-research-and-development-ord
- Also see SRP's "Additional Resources" webpage: htttps://www.niehs.nih.gov/research/supported/centers/srp/funding#multiproject_center

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