Sustainable & Healthy Communities Research Program

Project Plan for Project 3.63
Sustainable Materials Management

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Project Summary

This project will enable communities and the Agency to better protect and enhance human health, well-being and the environment for current and future generations, through the reduction in material consumption, reuse, and recycling of the materials to minimize the environmental impacts associated with products and materials. The projected integrated approach addresses the management of materials throughout their life-cycle in a cost-effective manner while minimizing negative environmental and socioeconomic impacts and incorporating community values. This Project consists of four major tasks that will result in the development of several products involving materials management resource tools to further advance the notion of integrative, sustainable materials management in cooperation with the

Office of Solid Waste and Emergency Response (OSWER)[1]. This project addresses 3 of the 5 Agency Goals: Goal 1 - addressing climate change and improving air quality; Goal 2 - protecting America's waters; Goal 3 - cleaning up communities and advancing sustainable development. This project addresses climate change aspects resulting from material flow, management, and handling by evaluating alternatives from both an energy and greenhouse gas emissions perspective. Furthermore, this project addresses the following cross-cutting Agency strategies: (1) Working Toward a Sustainable Future,(2) Working to Make a Visible Difference in Communities,(3) Launching a New Era of State, Tribal, Local and International Partnerships, and (4) Embracing EPA as a High-Performing Organization.

Project Description

Problem and Decision Context

To reduce the threat of and impact of materials to public health and the environment, a sustainable approach for materials management will encourage the minimization and extraction of raw materials, reducing pressure on the use of non-renewable materials, recycling materials for beneficial reuse, substituting more benign materials into commerce, and maximizing quality of life and prosperity, or in closed-loop manufacturing. The framework for Life Cycle Management of Materials (LCMM) developed in this project will catalyze a shift from end-of-life thinking (*waste* management) towards a more integrated life-cycle approach (*materials* management) by developing and demonstrating life cycle assessment paradigms and material, product, and process design strategies that lead to reduced environmental impacts while preserving natural capital.

Outputs

This project will directly contribute to three SHC Outputs:

- 3.63.1 Sustainable materials management options for industrial, construction / demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (FY17)
- 3.63.2 Strategy for sustainable materials management (FY18)
- 3.63.3 Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making (FY18)

Focus Areas

Three focus areas will support the key outputs of the project and address the stated needs of client program offices by conducting systems oriented research and delivering products:

[1] Office of Solid Waste & Emergency Response (OSWER) has changed its name to the Office of Land and Emergency Management (OLEM).

- Life Cycle Management of Materials (LCMM)
- Reuse of Organics and Other Materials
- Regulatory Support

Figure 1 shows the overall linkages between the three research focus areas to the OSWER Priority Areas and key products that will be produced.

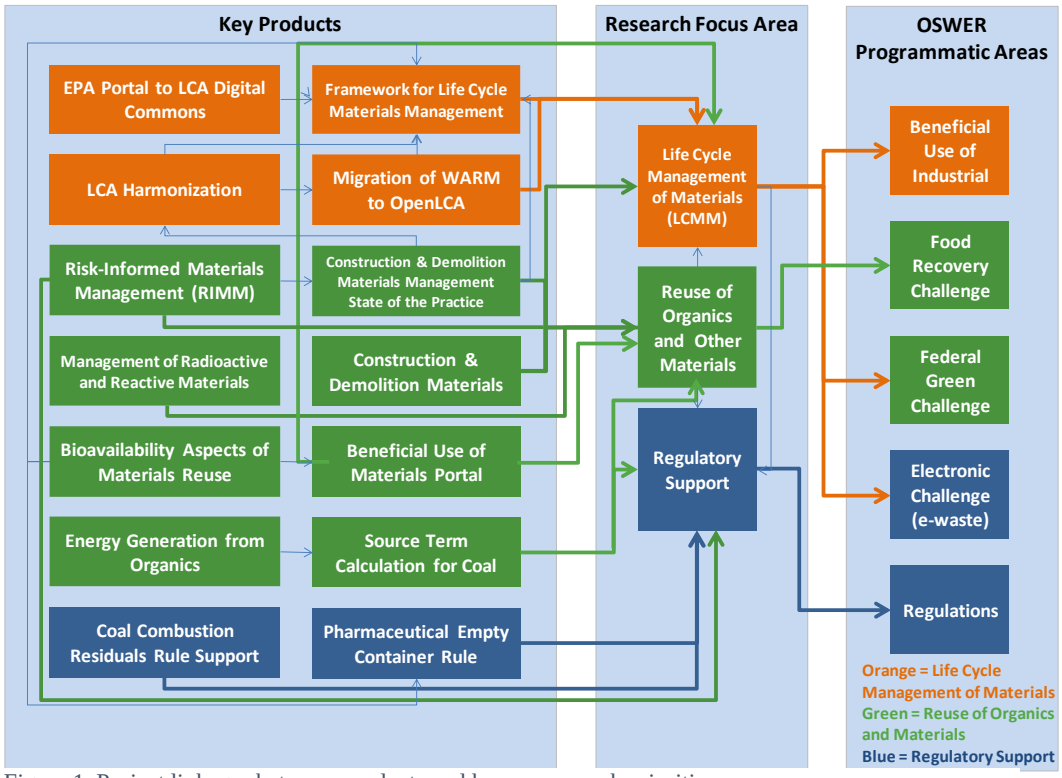

Figure 1. Project linkages between products and known research priorities

Focus Area 1: Life Cycle Management of Materials - As States and communities move towards sustainability, they must consider how to identify and reduce potential sources of environmental impact within their realm of influence, such as waste and water infrastructure, transportation systems, and industrial commerce. These decisions are made with the understanding that effective and sustainable environmental protection is linked to human health and quality-of-life, economic opportunity, and community vitality. In its 2009 report "Sustainable Materials Management: The Road Ahead" [2], EPA outlines its approach for sustainable materials management (SMM) as fulfilling human needs and prospering while using less materials, reducing toxics and recovering more of the materials used.

Life cycle assessment (LCA), as defined by the ISO 14000 series, has emerged as an invaluable tool for identifying the impacts associated with the environmental emissions and mass/energy

[2] U.S. Environmental Protection Agency "Sustainable Materials Management: The Road Ahead". Available at http://www.epa.gov/smm/sustainable-materials-management-road-ahead.

flows of products and services. While life cycle thinking is a key part of SMM, careful consideration of how best to apply a product-centric tool like LCA to answer material-centric questions is needed to maximize the effectiveness of this approach. These considerations include not only the effects of the numerous methodological choices for LCA, but understanding the various types of decision that can be involved with SMM and the information needed to support these decisions. Such decisions might include top-down management of materials based on policy or bottom-up approaches promoting sustainable material use through the development of viable material and process alternatives.

The LCMM focus area will develop a framework to support decision making within the nexus of LCA and SMM by integrating LCA methods being developed throughout ORD's national research programs (Air, Climate and Energy (ACE), Chemical Safety and Sustainability (CSS), Sustainable and Healthy Communities (SHC), Safe and Sustainable Water Resources (SSWR) and Homeland Security Research (HSR)) with approaches for the design of sustainable alternatives. Other methodologies for community material management will also be explored including urban metabolism. The intended outcome of the framework will be the identification of an optimum SMM strategy given the numerous options for impact reduction within a material life cycle. The initially proposed Framework for Life Cycle Materials Management (LCMM) envisions a 5-step process, including material prioritization, baseline assessment, alternatives development, alternatives assessment, and decision support that will enable users to identify materials of concerns and mitigate/eliminate associated impacts. The LCMM framework will provide process or product-oriented knowledge and will be complementary to community-level decision tools being developed within SHC.

In order to evaluate life cycle impacts, life cycle inventory (LCI) data that describe the manufacture, use, end-of-life management of high impact industrial and consumer materials is needed. LCI development within the context of this project will concentrate on end-of-life materials management processes (landfilling, recycling, etc.) because there are currently large data gaps for this life cycle stage for most materials. This work will also include development of a methodology to characterize the composition and volume of leachate from landfill processes. EPA has a unique capacity to provide these data and is already a leader as a data provider in the area of GHG emissions and characterization of MSW management through the WARM tool. Although the traditional use of landfilling for end-of-life is not the most desirable form of materials management in SMM, research on it is included in this project to provide more accurate models and data when establishing baseline scenarios in the framework. The data developed in this project should support not only in the tools developed by the Agency, but also the tools developed by other organizations. Therefore this project will include the design and implementation of an EPA portal to the Federal LCA data commons in collaboration with USDA, who has already launched a similar portal, and other federal agencies. The development of an EPA portal to the Federal LCA data commons is one of OSWER's top priorities.

Collaboration with state and local decision makers via stakeholder relationships established by OSWER and one or more Regional Offices will provide LCMM tools that can assist state and local governments in making effective materials management decisions. This will include

adapting the current national level material prioritization tool (OSWER's SMM IO Tool) for state (and possibly community) level analysis and migrating this tool, as well as the EPA Waste Reduction Model (WARM), to an open platform that can incorporate all of the LCI or materials information being generated in this Project. Non-expert user interfaces will be implemented in LCMM tools to help decision makers easily obtain results that answer their specific questions regarding materials of concern. During the process of tool development, stakeholder groups will provide feedback on the tools so that they are made more meaningful and useful to the various types of decision support in SMM.

Considering how national, state and local government policy makers might influence materials cycles, additional information is needed for tracking flows of high impact or high volume materials to aid in prioritization of SMM strategies. In particular construction and demolition debris (C&DD) is poorly characterized and tracked. Research in this focus area will include assistance for ORCR in developing a methodology to track C&DD at the national level. This research will support development of inventories for materials currently available in our nation's infrastructure, including old landfills and abandoned buildings. These inventories will assist stakeholders in devising local and national strategies to increase recycling and the potential "mining" of materials from landfills and brownfields.

The ultimate impact of the LCMM focus area will be the ability to assist stakeholders in decision making and implementation of effective and affordable materials management strategies at the product level to advance community sustainability, fostering improved public health, economic stewardship of resources and minimization of climate change impacts. As communities assess the future direction for SMM, they must also continue to evaluate the ramifications of legacy decisions. To that end the project will aim at addressing the issue of post closure care requirements for both subtitle C and D landfills.

The projected activities for the Lifecycle Management of Materials focus area are:

- National Generation Estimate of Construction and Demolition Debris following a bottom-up methodology
- Side By Side Evaluation of Life Cycle Tools for Waste Management
- Framework for Life Cycle Materials Management
- Life Cycle Inventory Databases of Materials Management
- Demonstrations of Life Cycle Materials Management
- Adaptation of Waste Reduction Model (WARM) to Open LCA
- Materials Management of Low Level Radiological Waste
- Life Cycle Materials Management Tools for Government and Industry Stakeholders.

Focus Area 2: Reuse of Organics and Other Materials - Beneficially using spent materials and waste streams as a feedstock, including those associated with organics for energy recovery options, provides an opportunity to reduce their life cycle impacts and improve the sustainability of the overall process. Reuse of materials (e.g. industrial, agricultural and organic and inorganic sources) may contribute to benefits including offsetting the use of virgin materials in products or processes and potentially lead to reducing their adverse effects on the

environment and human/ecosystem health. To address the key objectives of the SHC research program, this focus area will develop dynamic methods, data, strategies and tools to assist communities in framing sustainability goals to enhance energy generation and materials recovery from existing waste streams or underutilized material flows.

Thus, there is a need to optimize materials reuse and recycling while minimizing their environmental impacts and facilitating effective economic and social outcomes. Strategies to develop opportunities for materials reuse and valorization are based on our extensive knowledge of chemistry and engineering in designing more sustainable alternatives. It is the goal of this approach to demonstrate the opportunities that exist for producing useful and needed products from waste or spent material streams as well as ensuring these approaches have a minimal impact on the environment. It is also important to evaluate the utilization of biomass and food waste, especially the most abundant, natural and biodegradable biopolymers such as cellulose (from wood waste and agricultural residues) and chitin (from shrimp shells, crab and sea foods) for the synthesis of various mesoporous carbon materials. The biochar and magnetic versions of such carbonaceous materials could be used to make high-value products and in sustainable removal of contaminants from the environment. To extend on this focus area, another objective is to improve the effectiveness and efficiency of methods and guidance to address land and groundwater contamination sources (e.g. land application of specific outputs of anaerobic decomposition processes including digestate) and to encourage the use of innovative approaches to reduce new sources of contamination.

To assist society in fully utilizing these industrial and organic materials, this focus area involves the development and evaluation of technologies. In the case of organic materials, this research will provide reports and tools to make better use of currently available infrastructure at Waste Water Treatment Plants (WWTP) for organic materials management. A portion of this effort is to update a Region 9 tool (Co-EAT) and migrate it into open LCA platform to allow it better integration with other materials management models and approaches. This opportunity aims at tapping the currently unused capacity in the WWTP anaerobic digesters for processing non-wastewater organic material (pre- or post-consumer food waste). Furthermore, the focus area would assess innovation at local wastewater treatment plants related to beneficially using (and extracting energy from) organics, quantify the economic and environmental benefits of these practices, and determining the roadblocks to acceptance at non-innovating plants. There is a need for evaluation of methods to prepare collected gas for community use as well as targeting organic materials not traditionally evaluated for energy recovery. Part of this research may intersect with some biosolids work in SSWR.

Another example includes risk informed materials management models (RIMM). The RIMM collection of interoperable models, databases, and tools form the overall base RIMM system. RIMM includes the HE2RMES v1.0+ modeling domains in FRAMES v2.0 and a fully implemented D4EM-4-HE2RMES solution (as SDPProjectBuilder v1.0) that services all of HE2RMES science models, helping users easily gather needed model input data needed to run HE2RMES. Final software development work for RIMM in FY16 expands upon the suite of industrial source-release models offered in HE2RMES (e.g., adds Roadway line source model to study

contaminant releases in road-bed materials). The project is designed to be inclusive of OSWER technical staff who will provide ongoing consultation and design input on software development approaches, beta-testing efforts (as a future user), and demo uses of RIMM software technologies. Supporting OSWER directly and communities generally, the RIMM tool system is intended ultimately for public distribution.

This focus area supports all three identified key outputs for this project by providing data, reports and tools for communities and regulatory officials to evaluate options for sustainable materials management at the national and local level.

The projected activities for the Reuse of Organics and Other Materials focus area are:

- Utilization of Organics and Biomass – Demonstration and Evaluation
- RIMM module HE2RMES demonstrations, OSWER in-house desktop operations, OSWER parallel computing/clustering capabilities, ORD-OSWER software/results exchange capabilities. Final RIMM module HE2RMES v1.0 with documentation
- RIMM Module D4EM Complete Application Assistance and Hand-Off to OSWER
- RIMM Module Landfill and Roadway Components
- Beneficial Use of Materials Portal (BUMP)
- Evaluation of Beneficial Use Impact on Climate Change

Focus Area 3: Regulatory Support - This focus area will provide technical support regarding questions concerning regulatory aspects of SMM. This focus area will also benefit from associated research in the project, but is somewhat different in scope than the other two focus areas. For example, ORD's ongoing support for coal combustion residues (CCRs) and answering technical questions with regards to the use of the leaching environmental assessment framework (LEAF) is focused here as well as the evaluation of the empty container rule for pharmaceuticals.

E-waste is another high impact research for OSWER and an EPA commitment under the National Strategy for Electronics Stewardship. Although a variety of data sources are available to quantify used electronic waste, there is a lack of coherent sets of information on used electronics and their domestic movement. To address this need a multiyear research approach is being developed, building upon the inadequacies of existing systems. The outcome of the research would identify methods for domestic tracking of quantity of used electronics and their flows. Develop, publish, and implement tracking methods that containing electronics quantities and flows. Depending on the method developed, ultimately ORD would implement it online for communities use.

In the short term, ORD would conduct a detailed characterization of the sources and quantities of used electronics flows that would assist decision makers especially at the EPA. Furthermore, states have their own used electronics management and recycling programs that provide more complexity to any effort aimed at quantifying E-waste generated. ORD's research would identify and quantify the potential effects of the state-level electronics recycling requirements. The evaluation should also address the inherent benefits and drawbacks for the states

requirements. The evaluation should also address the economic effects of e-waste regulations and the impact of enacting similar regulations at the national level.

Depending on the type and quality of data currently available for electronic waste tracking (gap analysis), ORD researchers may be able to evaluate and summarize both top down and bottom up methods, using mass flow or process models, for quantifying and tracking used electronics. Based on those results, ORD would develop a method for the estimates of used electronic waste generation, recycling and disposal within the U.S.

The projected activities for the Regulatory Support focus area are:

- Coal Combustion Residues Rule Regulatory Support
- Source Term Calculations for Coal Combustion Residues
- Electronic waste inventory and tracking system

Collaboration

Program office partners: OSWER (ORCR), OCSPP, OAR, OW (OGWDW), OP, OSC

Regions: Region 4 for developing an SMM approach applicable at the state level , Region 3 development of secondary applications for spent industrial solvents FY14 RARE Project), Region 5 application of EPA pollution prevention and sustainability software. Region 9 development of SMM approaches for communities.

State(s): The State of Georgia for conducting a pilot study of a state SMM tool

Other federal agencies: USDA ARS for developing and publishing materials life cycle data consistent with the federal LCA data commons

Other SHC projects:
SHC 1.61 – Guidance for model development and interoperability will inform development of stakeholder SMM tools
SHC 1.62 – Incorporate Enviro Atlas as possible into the SMM support tools regarding location-specific impacts to ecosystem services related to material production or disposal
SHC 2.62– Utilize C-FERST in SMM support tools to identify location-specific health concerns that may be effected by changes to material cycles
SHC 2.63: Assessing Environmental Health Disparities in Vulnerable Groups
SHC 2.64 Indicators, Indices and the Report on the Environment
SHC 3.61 – Will provide this project ground water modeling for the LCMM support
SHC 4.6.1 – Demonstrate how life cycle approaches can be used to supplement TRIO assessments
SHC 4.6.2 – Will provide this project examples of tools that use systems approaches and consider multiple sectors to address community decisions.

Other ORD research collaborations:

ACE Sustainable Energy Evaluation (SEE) 1 – Regionalized air impact models based on spatially-resolved emissions, community-ACE SEE 1 – Community focused energy models and underlying electricity life cycle inventory data;
CSS 11.01 Lifecycle and Human Exposure Modeling (LC-HEM)–LCA data structure and software platform, models incorporating human exposure into the life cycle approach, rapid LCI modeling methods, Use of SHC-developed LCI data in CSS LC-HEM project.
CSS 9.01 Sustainable Chemistry – application of developed strategies/guidance for sustainable molecular design which could potentially be used for designing products that are readily biodegradable, possess physical or chemical properties that allow the molecule to be "taken apart" when an action is place on it and the resulting "two pieces" can be used for secondary application and for use in identifying opportunities for design of alternative products or processes.
ACE - climate change and impacts on materials management operations, historical operations as well locations TBD
SSWR – location of MM operations and impacts on water supplies/water quality.

SHC Project 3.63 – Sustainable Materials Management - Tasks

SHC 3.61.1	Task 1 – Tools and Methods for SMM Decision Analytics
SHC 3.61.2	Task 2 – Beneficial Use of Materials
SHC 3.61.3	Task 3 – Materials Management Innovations and Long-Term Performance
SHC 3.61.4	Task 4 – Net Zero

Task 1 – Tools and Methods for SMM Decision Analytics

Project Title: SHC 3.63 - Sustainable Materials Management (SMM)
Task Title: Tools and Methods for SMM Decision Analytics (SMMDA)
Task Lead: David E. Meyer

Task Start Date: October 1, 2015 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESRIPTION:

The key objective of this research is to develop a sustainable materials management decision analytics (SMMDA) framework to inform stakeholders on how and when to apply environmental tools for sustainable materials management (SMM) and integrate the resulting knowledge with socioeconomic considerations to make the best-informed policy decisions for optimal SMM. The framework will be capable of addressing decisions from a community to national scale by incorporating stakeholder preference as part of the process. The framework will encompass the entire decision process, including material prioritization based on stakeholder needs, baseline assessment to identify areas for improvement of material use, design and assessment of practical SMM strategies, and multi-attribute decision making within a stakeholder environment. As opposed to other projects in SHC addressing community decision making, this task will address the challenge of applying product and/or chemical-centric tools like life cycle assessment (LCA) and risk assessment (RA) to the material-centric questions associated with SMM. The creation of this framework will directly satisfy the task output to the project to provide sustainable materials management options for industrial, construction/demolition, and municipal materials, as well as the project output to SHC: enhance sustainable materials management to support community public health and development, revitalization and better management of materials. Four research sub-tasks have been created to organize the research necessary to support development of the framework: data generation, tool development, SMM strategy design, and demonstration case studies. The framework will require a broad range of knowledge and draw primarily on LCA methods, exposure and RA within a life cycle perspective, economic analysis (e.g., life cycle costing (LCC)), social impact assessment, sustainable chemistry and engineering design theory, and multi-criteria decision theory. The emphasis on data acquisition and tool development for this task will focus on LCA, RA, and LCC, with a high priority being placed on developing open access tools and data that can be disseminated publically through the Federal LCA Commons. Data and

methods for inclusion of social indicators will depend on outputs from other projects in SHC. Methods for multi-attribute decision making will be developed in collaboration with SHC 1.61.

RESEARCH APPROACH

The research in this task has been organized to support development of a framework for SMM decision analytics (SMMDA) (Figure 1). The purpose of the framework is to provide a logical understanding of how the various tools needed to support SMM decisions fit together to design and implement SMM strategies that best meet the needs of stakeholders.

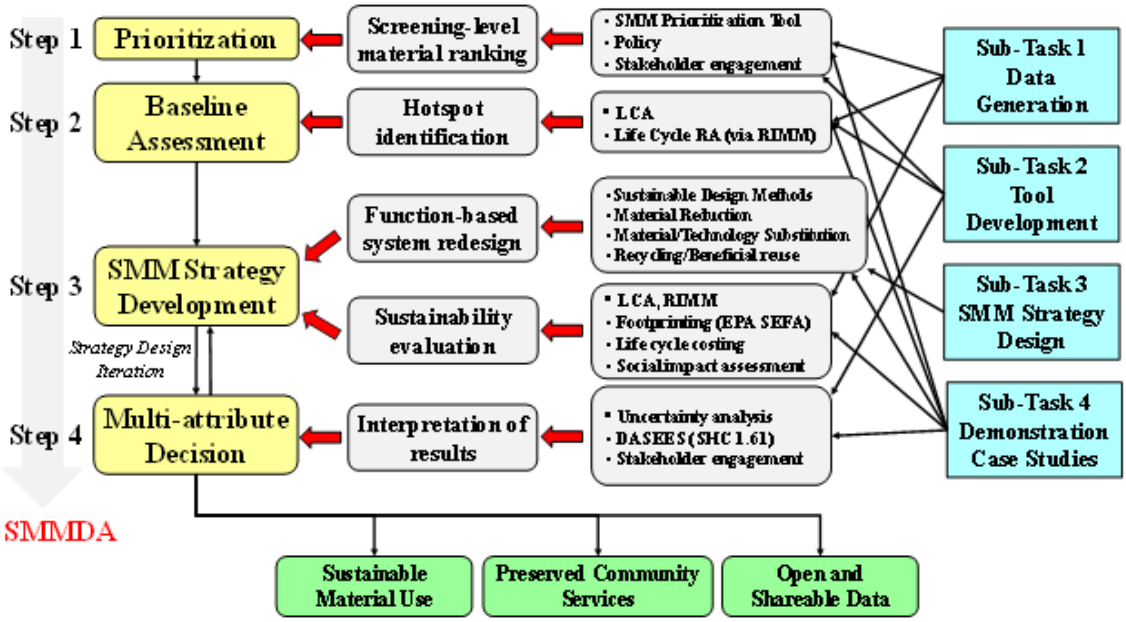

Figure 1. A Conceptual Framework for SMM Decision Analytics with Supporting Research

The first step of the proposed framework involves prioritization of materials of concern for assessment and alternatives design. Prioritization can begin with screening-level Agency resources such as the SMM Prioritization Tool being developed by the Office of Resource Conservation and Recovery (ORCR) and ORD, or it can simply be defined by immediate regulatory, policy, or community needs. Examples of the latter include materials generated by a natural disaster, a new material proposed by industry, or an alternate use of an existing material. For such special cases, the community still needs to assess the safety of the implied management paradigm. The research needs for this step include: (1) establishing a protocol to identify an appropriate stakeholder group for SMM and adequately capturing the group's preferences during prioritization, (2) extending national-scale prioritization tools to be applicable for community-scale decisions, and (3) acquiring the necessary data to support community-scale prioritization.

Once a priority material is identified, key product system(s) using this material are identified (based on the material market share) and the baseline environmental impacts are scored to establish hot spots for the material application (Step 2) using LCA. During this step, the life cycle impact assessment results can be strengthened by adding the benefits of enhanced RA to better address the hazardous health aspects of the baseline material profile by incorporating

more site-specific knowledge. The research needs for this step include determining how best to integrate life cycle and risk-based knowledge to identify material hotspots within a product life cycle and developing an open and shareable database of life cycle inventory describing typical end-of-life treatment of common materials that will be needed for baseline product system modeling.

In Step 3, the hot spot information obtained in Step 2 is used to identify and develop potential SMM strategies that address the overarching goals of "dematerialization", "detoxification", and "design for value recovery", leading to reduced system-wide environmental impacts while preserving natural capital. Such strategies include the application of sustainable chemistry and engineering to promote material substitution, process substitution, cleaner technology options, product or process redesign, and material reclamation from process or waste streams for beneficial reuse. The key constraint when designing SMM strategies will be preserving a material's function and the good or service the resulting product provides a community. Once potential SMM strategies have been created, new product life cycles based on these alternatives are developed and compared with the original product life cycle to evaluate the ability of the proposed alternative to improve the sustainability of the incorporated materials. In addition to tools like LCA and RIMM, there is a need to evaluate and incorporate socioeconomic impact data during this step to support a sustainable outcome in Step 4. Life cycle tools like EPA's Spreadsheet for Environmental Footprint Analysis (SEFA) can be incorporated into the alternatives assessment for special applications like clean-up of contaminated sites. The development of a viable SMM strategy with a demonstrated ability to maintain the needed material function greatly enhances the value of this approach and represents an innovative contribution to the application of product-centric LCA to SMM questions. Given communities include industry and industry will ultimately be part of any SMM strategy, the essential research need for this task involves establishing a design knowledge base to provide guidance to users of the SMMDA framework for working with industry to develop viable SMM strategies.

The final step of the framework focuses on contextualizing the information for use by decision makers and stakeholders. The desire to make sustainable material decisions implies the need for multi-criteria decision theory, of which there are numerous approaches that can be used. For this task, the Decision Analysis for a Sustainable Environment, Economy & Society (DASEES) method (SHC 1.61) is used to facilitate multi-criteria decision making. Although the method is fully applied and finalized in Step 4, it must ultimately guide the entire SMMDA process by first helping to formulate the problem statement and stakeholder criteria in Step 1. This will identify which tools are needed in Steps 2 and 3 and establish how the outputs from these tools can be structured and integrated. DASEES, as with prioritization, incorporates stakeholder preferences and requires research in this task to understand how to solicit and incorporate stakeholder input for DASEES within an SMM decision context. Other challenges associated with this step of the framework include evaluating the uncertainty of the data, properly interpreting the limitations of the models and tools, and determining the most meaningful way to visualize and communicate this information to stakeholders as part of the results. Although uncertainty analysis is not specified as a specific research activity in this task, it is considered an implied activity for all research conducted in this task because uncertainty will be a key factor in making

sound and defensible decisions regarding material management. Achieving a decision using the SMMDA framework can be an iterative process that involves refining SMM strategies in Step 3 based on stakeholder interpretation of results in Step 4 until the stakeholder group arrives at a satisfactory solution. Successful application of the SMMDA framework will lead to sustainable material use, preserved community goods and services, and open and shareable data that can be used by others to support similar efforts to promote SMM.

By developing and demonstrating the application of life cycle tools to design SMM strategies, the SMMDA task will answer the following questions:

- What tools and methods provide the most timely and useful knowledge to stakeholders when considering SMM within a life cycle context?
- How can risk-based health considerations be integrated with life cycle thinking for community-based SMM decisions?
- How do uncertainty and data quality affect interpretation of results and how should they be communicated to decision makers and stakeholders?
- What are the significant environmental impacts associated with a selected material or product?
- Where in the life cycle do the impacts occur?
- What materials and processes drive these impacts?
- What opportunities and options exist to reduce these impacts?
- What are the effects of alternative SMM strategies on the socioeconomic impacts of the material life cycle?

The ultimate impact of the SMMDA task will be the ability to allow stakeholders to more easily decide on and implement effective and affordable materials management strategies that advance community sustainability while improving public health and economic stewardship of resources.

Successful implementation of the SMMDA framework will require data generation, tool development, and an understanding of sustainable design principles that can only be properly developed through case studies. These research activities provide a sub-task structure to capture the detailed research approach of this task as described below.

1) Data Generation and Partnerships

A critical need for any material assessment is the generation of material and energy flow data (i.e., inventories of resources used and pollutants emitted) for products and their alternatives. Life cycle inventory development within the context of this project will first concentrate on the end of life management of materials, as EPA is in a unique capacity to provide these data and is already a leading data provider in the area of characterization of municipal solid waste (MSW) and construction and demolition debris, for example providing an annual Sustainable Materials Management report (previously MSW Facts and Figures) with data on generation and emissions associated with these wastes. These data must be coupled with EPA product inventories that are existing or under development in other national research programs (ACE, CSS, SSWR) to produce robust data sets that support detailed life cycle material/product assessment. Although the traditional use of landfilling and incineration for end-of-life is not considered

SMM, development of these data sets is included in this project to provide more accurate models and data when establishing baseline scenarios in the framework. Data generation activities will begin with construction and demolition debris material given the large volume of these materials flowing through communities. This effort will be expanded to include compilation of EPA data sources for end-of-life treatment of MSW. Additional materials will be added based on both Program and Regional Office needs and case study activities in this task. The generated life cycle inventory should support not only the tools developed by EPA, but also be made available for external decision makers and stakeholders. Therefore, this project will include the design and implementation of an EPA portal to the Federal LCA data commons in collaboration with the United States Department of Agriculture (USDA) who has already launched a common portal that EPA will link to (lcacommons.gov). Working with other federal agencies the goal is to make federally compiled life cycle inventory publically available as machine readable data. In a corollary effort, EPA is working with other international government agencies to develop a Global Network of LCA databases through an international partnership launched in March 2015 where UNEP is secretariat. EPA OITA, OSWER and ORD have spearheaded this concept, with ORD serving in a technical leadership capacity with a seat on the technical advisory panel and serving on all three technical working groups.

2) Tool Development

A select number of tools and methods for environmental assessment have been identified for use in the SMMDA framework and encompass a range of concepts, including material flow analysis, life cycle assessment, and risk assessment. Research in this sub-task will focus on developing and refining these tools for application in Agency decision making as follows:

1. *SMM Prioritization Tool*. The Office of Solid Waste and Emergency Response (OSWER) has developed a prototype of the SMM Prioritization Tool using input-output LCA to prioritize materials of concern within an economy. The SMM IO Tool was originally developed using proprietary national level data that may not support decisions at the regional and state level because of the regional and state-level variations in the process technologies and supply chains of prominent industries across the U.S. Furthermore, the underlying data must be purchased to use the tool. Therefore, the application of this tool for state and regional level decisions will require refinement of the underlying input-output models to better capture impacts and concerns of interest to stakeholders within a state. OSWER has requested ORD support to further develop the SMM Tool by incorporating regional IO methods in an openly shareable platform that will allow it to be applied to state and regional economies. Reducing the scale of IO methods to state and regional economies is challenging because the interactions of industrial sectors within these micro economies are harder to discern and the data needed to accurately model these interactions are difficult to obtain. Research in this area will involve identifying efficient approaches to develop regionalized IO models and implementing the tool in the freeware openLCA software package (see the Life Cycle Assessment and openLCA description below). An evaluation of the refined tool will be performed as part of the Georgia Pilot Case Study (see Sub-task 4).

The underlying open IO model is based on economic data from the Bureau of Economic Analysis and environmental data from various other public sources, but reflects national conditions in 2002. This model needs to be updated in order to better reflect current conditions and data quality in the model needs to be more clearly articulated to aid in possible uses and interpretation. As other federal entities are also using IO models including NIST and DOD, collaboration on a common IO model would support multiple agencies and strengthen the underlying model. Like with electricity data in planned development, the IO model could become a cross-Agency model. IO models typically are useful for estimation of "cradle-to-gate" impacts and therefore do not include retailing, use stage, and end-of-life effects. Procedures for including retailing and end-of-life in IO models have been proposed for the openIO model, but not yet implemented in the SMM tool.

Part of the SMM framework is to transition from the large-scale but course picture of material impacts currently provided by the SMM tool to a more refined analysis of alternatives. Consistency across scales and models is key to the integrity of this approach. Therefore research needs to be done into using IO-based data together with more refined process based data to understanding the extent to which hybridization can provide reliable results and how to interpret results from these models with their inherent uncertainties.

A long term goal of this research is to explore the integration of community-scale material flow data to further extend the applicability of the SMM Prioritization Tool to municipal and community-scale analyses.

2. *WARM in openLCA*. WARM is a life cycle GHG and energy calculator for MSW materials originally developed and maintained by OSWER. It is used primarily by community solid waste managers for estimating GHG emissions associated with various community waste management scenarios. Because WARM is a life cycle based tool, discussions began between OSWER and ORD on making the tool consistent with the ORD NRMRL LCA Center and furthermore Federal LCA Commons standards, as well as taking advantage of US public life cycle data generated by US federal agencies and others. In FY 14 OSWER and ORD agreed that the first step would be to move WARM into openLCA platform. WARM was successfully ported to the openLCA platform in FY15. Additional LCA expertise from ORD will be used to maintain WARM in the openLCA platform in FY16. Future work on WARM will depend upon research needs identified by OSWER that can be addressed by ORD.
3. *Risk-Informed Materials Management (RIMM)*. EPA has responsibility under RCRA for regulating the management of solid wastes, a portion of which are designated as hazardous. As part of EPA's transition towards sustainability, we recognize that some kinds of 'waste' materials can in fact be reused as input materials for making safe products that benefit society. RIMM provides an integrated data gathering, modeling, and decision analysis tool system to enable scientifically rigorous assessment of risks, benefits, and evaluation of opportunities for the safe, beneficial reuse of a wide variety of materials that may in the past have been considered to be 'waste'. RIMM is

envisioned as a core capability needed by communities supporting exposure and risk assessment aspects of SMM decision analytics. The Human and Ecological Exposure and Risk in Multimedia Environmental Systems (HE2RMES) model represents one of the complementary RIMM components needed to foster sustainability in communities supporting materials management decision-making by facilitating "Anywhere, USA" auto-parameterization of exposure and risk models. The RIMM Tool System is an open and shareable platform for decision-making at site-to-community-to-regional-to-national spatial scales.

To provide a mechanistic, first-principles-based exposure and risk assessment solution rooted in a mass balance approach, a science and technology tool box has been developed to support RIMM assessments. The tool box positions the USEPA to be able to strategically adapt to expanding science and data over time. To enhance analysis for sustainable materials management solutions, a base platform of RIMM tools has been designed to integrally expand upon USEPA's iemTechnologies prototype system of systems approach. With completion of the tool system development in FY 16, out year research engages in specific demonstration applications of RIMM via two case studies.

4. *Spreadsheet for Environmental Footprint Analysis*. As a subset of community applications, sustainable materials management can play an important part in conserving natural resources, reducing waste, and minimizing the environmental footprint of cleanup actions (e.g. Superfund, Resource Conservation and Recovery Act (RCRA), underground storage tank, and brownfields cleanup). To minimize the environmental footprint of remediation and site clean-up activities, EPA staff and contractors developed the Spreadsheet for Environmental Footprint Analysis (SEFA), a software/spreadsheet tool to estimate energy usage, greenhouse gas emissions, air pollutants, and hazardous air pollutants (HAPs). The SEFA footprint tool contains inventory datasets based on life cycle thinking throughout the supply chain. Automated calculations within SEFA generate knowledge of emissions and resource use that help the user to determine which cleanup activities are driving the project's environmental footprint, and to adjust project parameters to reduce the footprint. The application of SMM should be a key piece of remediation planning because this implies managing all aspects of the environmental impacts associated with remediation materials (e.g., climate change, resource use including land and water, human and ecological health) and supports the development of efficient remediation technologies.

   EPA’s Office of Solid Waste and Emergency Response (OSWER) and EPA regional staff have requested ORD to review the data underlying the SEFA tool and revised and update the emission factors, as well develop data for additional materials and processes. The initial plan includes at least twelve construction and treatment materials commonly used at cleanup sites, as well us updated models and data for energy production and transportation in the US. For the materials, publically available life cycle inventory datasets will be developed to generate emission factors describing greenhouse gas emissions, criteria air pollutants, and energy and water use that can be added to the SEFA database to account for emerging treatment technologies. Datasets will be developed using secondary data sources (e.g. EPA databases such as NEI and TRI,

government reports, journal articles, etc.) and material and energy balancing principles. Similarly, inventories will be developed for renewable energies (i.e. solar cell arrays, wind turbines) and will be based on collaborative research with the National Energy Technologies Laboratory (NETL) and National Renewable Energy Laboratory (NREL) through the ACE program. New transportation inventories will be developed by combining recent data for the production of various fuels with data describing the use phase consumption of fuels based on simulation outputs from EPA's Motor Vehicle Emission Simulator (MOVES) model. ORD scientists have been working to establish a collaborative relationship with the MOVES team in OAR/OTAQ to ensure MOVES simulations are correctly modeled with respect to EPA policies for vehicle classifications and typical operating parameters. Final SEFA research will focus on modeling off-site environmental sample analysis to create a life cycle inventory and emission factors to enable inclusion of this service in the treatment footprint. Unlike other inventory work for SEFA, this effort will attempt to use primary data for energy use, material use, waste generation and facility emissions obtained directly from environmental labs. This is an often overlooked aspect of remediation services that represents a major activity. During this research activity, ORD will work with OSWER and Region 9 to identify an efficient method for ORD to provide future data updates as needed. This may include preliminary evaluation of what benefits transitioning SEFA to a platform based on openLCA would provide in terms of tool performance and maintenance.

3) SMM Strategy Design

Opportunities to advance and implement SMM strategies can exist at any stage of the life cycle for a product, process or service. The SMMDA framework identifies the hot spots within a life cycle creating the greatest environmental and human health impacts. Once hotspots are identified, stakeholders must implement an alternative technology or initiate recycle, remediation or sequestration efforts to address and solve a community's environmental and human health challenges associated with the use of a material. The research in this sub-task investigates how sustainable design methods rooted in the philosophies of the green chemistry and green engineering principles can be used to develop SMM strategies that address the overarching topics of "dematerialization", "detoxification", and "design for value recovery". SMM strategies can be classified into four types: (1) material substitution, (2) process substitution and cleaner technology options, (3) technology substitution (product or process redesign), and (4) material reclamation (recycling and beneficial reuse) from process or waste streams. The anticipated outcome of this research is guidance on how best to interpret and translate the results for hotspot analysis from baseline assessments in Step 2 of the SMMDA framework into viable SMM strategies in Step 3. The key research challenge will be learning to balance the hierarchical preferences of policy makers for the various SMM strategies (for example, material substitution before recycling) with the need for technological and economic viability, all while minimizing the impacts of environmental hotspots and preserving the intended function of the product or service in question.

Specific research activities that will be used to investigate and understand practical development of the four types of SMM strategies include:

1. Ascertaining the current state of sustainable design methods. Before performing applied research to better understand SMM strategies, it is important to first understand the current state of the science. For this purpose, an academic book examining the sustainable design of materials, products, and processes will be compiled. The book will be outlined and edited by ORD scientists. Submissions of material will come from both EPA experts in the field as well as leading academics from the international research community. The content of the book will be used to refine and enhance the research approach for the other activities in this sub-task.
2. The use of process intensification approaches as a means to implement process substitution. Process intensification minimizes the environmental footprint (resource and energy consumption) of processes and greatly reduces the time, costs, and operational needs when compared with standard chemical production processes by minimizing the required processing steps for material synthesis through the use of next-generation equipment configurations that support simultaneous material synthesis and separation. In addition to mitigating environmental impacts, these changes can reduce safety risks to workers and have the potential to impact insurance rates, zoning requirements, and transportation needs. All these benefits have the potential to immediately and drastically affect the presence of a chemical facility in a community.
3. Evaluating the impact of new hazardous waste rulings and regulations to promote the use of material substitution and/or reclamation in the chemical industry. Through a RARE collaboration with Region 3 and OCSPP, ORD is utilizing and updating OCSPP's Green Engineering Materials Management (GEMM) tool to develop a new evaluation technique for quantifying the environmental, economic and material benefits gained with the implementation of new rules and regulations that lead to alternative material life cycles.
4. Continued development of EPA's GREENSCOPE model for application by framework users to the design of processes for viable SMM strategies. The newly designed processes can encompass any of the four types of SMM strategies. GREENSCOPE utilizes 139 indicators to assess chemical manufacturing processes on a "sustainability scale" from 0 to 100 percent sustainable. The indicators are categorized and measured in the areas of environment, efficiency (material), energy, and economics, also known as the "Four E's." GREENSCOPE determines how well a chemical process makes use of mass and energy to manufacture a valuable product, how well it meets social and environmental needs, and how it maximizes economic benefits. This can provide more comprehensive information for developing candidate SMM strategies in Step 3 of the SMMDA framework. In addition to strategy design, the data outputs from GREENSCOPE can be used to develop process and geographically specific life cycle inventory to support assessment tools within SMMDA framework.

The above tools and approaches will be applied to product life cycles associated with the sub-task case studies (see below). The knowledge from these efforts will be supplemented with outcomes from planned research in other areas of SHC 3.63, such as beneficial re-use, to develop a knowledge base to provide guidance to framework users for designing viable SMM

strategies. These methods will be evaluated as part of the Georgia Pilot Study (see below) and refined as needed. The inclusion of viable SMM strategies that maintain the desired material function within a community is key to successful implementation of the SMMDA framework.

4) Demonstration Case Studies

Practical application of the SMMDA framework is ultimately needed to understand how factors like tool selection, uncertainty, and stakeholder management should be incorporated into an SMM decision process. Case studies will be used for this purpose and have been designed to explore all parts of the framework. A total of three case studies are proposed initially with the potential to add more based on the needs of Program and Regional Offices.

1. *OSWER/Region 4 Georgia SMM Pilot*. The case involves a pilot-scale project with the state of Georgia to develop state-level IO models and data for the SMM IO Tool and evaluate its use within a user-friendly interface based on the OpenLCA software platform (see LCA and openLCA research description under Sub-task 2) using a Georgia stakeholder group. EPA will elicit feedback from the stakeholders on how the SMM IO methodology can be improved to better capture the needs for state-level decision-making. This will build on existing partnerships between the Georgia DNR, Region 4, industry groups and NGOs. The knowledge gained from the pilot study will then be used to refine and optimize methods for generating state-level IO data that are applicable to all states as they develop strategies for SMM (See MFA research description under Sub-task 2). The feedback on the SMM IO Tool will be used to improve the user-interface and operation of the tool for non-expert users. This research will inform key parts of the SMMDA framework by addressing such issues as data source selection, stakeholder selection, and prioritization of materials. Significant synergies/efficiencies will be achieved in this work through close coordination with ongoing ORD research in connection with the SHC SMM, CSS Life Cycle Human Exposure Modeling, ACE SEE-1 Regionalized Impact Modeling, and SSWR Green Infrastructure efforts. The knowledge being generated by these projects can be applied as needed to improve the ability of the SMM IO methodology to meet the assessment needs of stakeholders. Furthermore, this work is coordinated with the U.S. Federal LCA Digital Commons (see Sub-task 1) and a related IO-LCA effort underway in connection with the General Services Administration's efforts to facilitate sustainable procurement. Although initial work will focus on the prioritization step, the long-term goal for this case study is to build a strong stakeholder group and work with Programmatic and Regional partners to apply the entire SMMDA framework. This will involve selecting a key hotspot material(s), developing potential SMM strategies, and implementing DASEES to assist the Georgia Stakeholder group with implementing the most viable SMM strategy. The outcomes of this case study will then be used to further refine the SMMDA framework for application at a truly community-scale. Additional Regions and States have indicated to OSWER they are interested in pursuing this type of project after conclusion of the Georgia Pilot to continue implementation of the ORCR's SMM vision. Extension of this exercise to these other stakeholders will be at the discretion of ORCR.

2. *Beneficial Reuse Assessments*. OSWER decision-making will be better supported by sufficient modeling tools in-house that can meet its assessment needs related to reused or disposed materials. To conduct exposure and risk assessments to support analysis of options and management approaches, OSWER often must hire contractors to develop and run computer models, as well as collect much of the input data required by the models. After completing development of the RIMM Tool System as part of FY16 work, two case study applications are pursued in subsequent years that focus on an overall outcome of interactive deployment and training in RIMM's use by ORD's key Partner, OSWER/ORCR. The application phase promotes RIMM's proper uses and communicates its capabilities further in "applied" demonstrations. The two planned RIMM case studies ensure Partners touch and use the tool to meet the primary design objective of RIMM development -- to allow OSWER staff the ability to conduct in-house assessments needed to support policy/analysis and decision-making in its solid and hazardous waste management programs. The overall effort proposed includes:

    - Pursuing two RIMM assessments in out years covering high profile focus applications of immediate interest to OSWER/ORCR. The two case studies are based on meeting OSWER priorities in conducting beneficial reuse assessments desired for certain industrial by-product materials. These include

        - **RIMM-based Beneficial Reuse Assessment of FGD Gypsum Application to U.S. Farmland**: The first ORD-ORCR case study will assess FGD Gypsum derived from coal combustion power plants and its direct application on farmland; contaminants of concern include, selenium, arsenic, and mercury. The base decision-context is determining safe-application rates of FDG Gypsum that protect human health and ecological populations. The case study will demonstrate multi-scale application and utility of the tool system (e.g., showing how spatially-explicit safe concentrations can be derived supporting site, state, and national decision-making contexts).

        - **RIMM-based Beneficial Reuse Assessment of an Industrial Material: A Case Study with Partner-Driven Problem Formulation**: The second case study will engage an initial ORCR-driven "material assessment prioritization process" managed by the OSWER/ORCR-ORD modeling team (i.e., during FY16). This leads to a client-driven problem statement, a collaborative OSWER/ORCR-ORD technical approach, RIMM models/tools selection, site-sample data collection (via D4EM-4-HE2RMES), simulation experiments, and the desired analysis/study. The 1st step is intended to identify specifics on: (i) material of interest and contaminants of concern; (ii) decision context for material reuse; and (iii) application/decision-scale (inclusive of one site to the nation). The study design purposefully uses a "listening stage" to formulate the problem of interest from the user's perspective. It also demonstrates flexibility of the RIMM tool system to address a wide class of problems. Key assumptions include: (a) one of HE2RMES' nine available "industrial source-release"

models will be suitable; and (b) "contaminants of concern" are already parameterized within the existing RIMM chemical properties database.

3. *Decision Analysis of Electronic Enclosures*. The application of DASEES for decision analysis to support sustainable materials management (SMM) will provide a powerful approach for helping stakeholders identify optimal sustainable materials management strategies based on knowledge obtained from life cycle tools and preferences regarding socioeconomic indicators such as life cycle cost. DASEES incorporates Bayesian networks to evaluate the probabilistic outcomes of stakeholder decisions for a defined problem set in relation to the stakeholders' established values. It can be applied to a wide range of questions and problems and accepts a variety of input information based on stakeholder needs. The methodology for integrating tool outputs and modeling SMM problems within DASEES will be developed in SHC 1.61 while research in this task will focus on developing a methodology to engage stakeholders for the purposes of SMM. Stakeholder interests for SMM are often focused on addressing material-centric questions, whereas the underlying assessment tools like LCA are product and chemical-oriented. There is a need to research how these perspectives can be reconciled within the decision making process of the SMMDA framework. To address these research needs, a case study will be performed regarding the use of materials in electronics enclosures. ORD, through its Chemical Safety and Sustainability (CSS) national research program, has performed an LCA of laptop enclosures made from fossil plastics, renewable materials, or metals to support efforts by EPA's Sustainable Electronics Group to provide recommendations to the ongoing development of the EPEAT Standards for consumer electronics. This study will be revisited to evaluate how DASEES could be used to improve the outcomes from the study. The existing LCA results will be modeled in DASEES along with stakeholder preferences identified by the members of the Sustainable Electronics Group. These preferences will include both environmental and socioeconomic factors to elicit a better understanding of how DASEES can be used to incorporate environmental impact assessment results into a broader decision for sustainability. Life cycle costing (LCC) will be evaluated in SHC 1.61 as a tool to capture the economic impacts and/or benefits of the various material options. Consideration of social indicators will incorporate outputs from other projects in SHC. The lessons learned from this case study will be used to formulate a methodology to assist framework users with engaging stakeholders for SMM issues.

TASK OUTPUTS/PRODUCTS

Product Title: **SMMDA Framework to support materials management decisions**

- Product Contact (email): David E. Meyer (meyer.david@epa.gov)
- Product's Delivery Date: FY19
- Product Description: The SMMDA Framework is approach to allow stakeholders to more easily decide on and implement effective and affordable materials management strategies that account for stakeholder preferences to advance community sustainability while improving public health and economic stewardship of resources.

- Product's Contribution to Project Outputs: The SMMDA framework is an SMM approach (3.63.2) that provides options for industrial, construction/demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (3.63.1) through the development and use of tools for evaluating temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3).
- Product's Timeline (with milestones):
    - FY16 – FY19 – Products delivered under sub-tasks are milestones to the development of the framework
    - FY19 – Journal article describing the development of the SMMDA framework and its evaluation and refinement based on case studies
- Product's intended user/customer/audience: ORCR and their clients (Government – Regional Offices and States, Industry, and NGOs), as well as anyone else interested in applying SMM to identify the best use of materials in communities, regions, states, and countries

Data Generation

Product Title: **Parameterized material life cycle inventories**

- Product Contact (email): Wes Ingwersen (ingwersen.wesley@epa.gov)
- Product's Delivery Date: FY19
- Product Description: The parameterized material life cycle inventories are a collection of data describing various material life cycles that will enable users to quantify life cycle impacts of changes in material management. The parameterized models will be developed based on a combination of primary (manufacturer-supplied), secondary (academic and patent literature, federal data) and experimental data. Once existing conditions for materials management have been modelled,
- Product's Contribution to Output: This product supplies data to support SMM options for industrial, construction/demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (3.63.1) and a strategy for SMM (3.63.2).
- Product's Timeline (with milestones):
    - FY16 – Life Cycle Inventories describing baseline life cycles for construction and demolition debris (C&D) materials
    - FY17 – Life Cycle Inventories of municipal solid waste (MSW) materials
    - FY17 – Baseline life cycle impact study of current US C&D management demonstrating use of the C&D LCI (milestone)
    - FY18 – Life Cycle Inventories describing alternative treatment and management scenarios of select municipal solid waste and C&D materials (product)
    - FY19 - Journal article describing benefits of alternative management scenarios for large volume and high impact materials in the US (product)
- Product's intended user/customer/audience: Any decision makers seeking to apply LCA for SMM within communities, states, and industry.

Product Title: **EPA portals to the Federal LCA Commons and Global Network of LCA Databases**

- Product Contact (email): Wes Ingwersen (ingwersen.wesley@epa.gov)
- Product's Delivery Date: FY18
- Product Description: The EPA portal to the Federal LCA Commons is a public data repository for life cycle and sustainability data where EPA scientists can share life cycle inventory developed during research activities, with emphasis on end-of-life treatment of materials, products, and services. EPA will lead development of some of the foundational pieces to be created for the Federal LCA Commons including data quality guidelines and the list of elementary flows (1000s of possible resources and emissions used and emitted in material life cycles). The portal will connect to a Federal network of LCI data established through collaboration with various Federal agencies, as well as to the Global Network of LCA databases.
- Product's Contribution to Output: This product supplies data to support SMM options for industrial, construction/demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (3.63.1) and a strategy for SMM (3.63.2).
- Product's Timeline (with milestones):
    - FY16 – A Memorandum of Understanding between the EPA and other Federal Agencies to support collaboration on the Federal LCA Commons (milestone)
    - FY16 – A white paper co-authored with other federal agency partners describing the concept and benefits of a Federal LCA Commons (product)
    - FY16 – Guidelines for data quality for the Federal Commons (milestone)
    - FY16 – A critical review of existing nomenclature for LCA elementary flows. This product is a deliverable for the Nomenclature Working Group of the Global Network of LCA databases (milestone)
    - FY17 – A common elementary flow list for the Federal LCA Commons (milestone)
    - FY18 – Publically accessible EPA portal to the LCA commons and Global Network of LCA Databases (key product)
- Product's intended user/customer/audience: Any decision makers seeking to apply LCA for SMM within communities, states, and industry.

Product Title: **State of the Practice for Construction Demolition and Recycling**

- Product Contact (email): Thabet Tolaymat (tolaymat.thabet@epa.gov)
- Product's Delivery Date: FY16 Q4
- Product Description: Construction and demolition debris (CDD) consists of the materials generated during the construction, renovation, and demolition of buildings, roads, and bridges. Broadly, the CDD stream is comprised of concrete, wood, metals, asphalt, drywall, masonry products, and land-clearing debris (LCD). CDD represents a substantial fraction of the overall materials and discards generated as a result of human activities, at amounts similar to the magnitude of municipal solid waste (MSW). CDD may be recovered for direct reuse, utilized in other beneficial ways, or disposed of in landfills (and to a lesser extent in combustion facilities. However, there still are large amounts of material that are not being recycled. This report will research the current state of

CDD recycling in the US. The report will also describe CDD generation, disposal and recycling estimates and the types of systems and technology used to facilitate CDD recycling and processing. Finally the impacts of green building practices and economics on CDD recycling will be explored to provide a top level assessment of national trends and implications on advanced recycling.

- Product's Contribution to Output: The report will provide data for the development of an effective approach for addressing materials management across media (output 3.63.2) and could be used to generate tools for evaluating temporal and spatial impacts of materials management on public health and the environment (output 3.63.3)
- Product's Timeline (with milestones)
    - Complete site visits and data collections March 2016
    - Data Synthesis and processing August 2016
    - First draft of final report March 2017
    - Review and comments June 2017
    - Final draft July 2017
    - Submittal August 2017
- Product's intended user/customer/audience: OSWER, EPA Regions and States

Product Title: **Inventories and flows of wood in the U.S. economy**

- Product Contact (email): Thabet Tolaymat (tolaymat.thabet@epa.gov)
- Product's Delivery Date: Q4 FY17
- Product Description: Wood waste is one of the largest component of waste, yet there is a lack of understanding of the amount of wood that is generated, used and disposed in the U.S. economy today. Because of the increased interest in using life cycle thinking for materials management, the question remains as to how much of the wood waste is used and what is the ultimate disposition of that materials. Understanding these variables would allow stakeholders to understand and evaluate the impact that wood could have on the environment and climate change. The flow data generated through this effort will be incorporated into the parameterized material life cycle inventories delivered for this task.
- Product's Contribution to Output: The report will provide data for the development of an effective approach for addressing materials management across media (output 3.63.2) and could be used to generate tools for evaluating temporal and spatial impacts of materials management on public health and the environment (output 3.63.3)
- Product's Timeline (with milestones):
    - Data Synthesis and processing Q4 2016
    - First draft of final report Q3 2017
- Product's intended user/customer/audience: OSWER, EPA Regions and States

Product Title: **Generating Experimental Emissions Inventory for construction and demolition materials**

- Product Contact (email): Thabet Tolaymat (tolaymat.thabet@epa.gov)
- Product's Delivery Date: Q4 FY19

- Product Description: The generation of life cycle inventory describing end-of-life management of construction and demolition materials (C&D) relies heavily on secondary data and predictive models. This product generates emission inventory and processing data for selected C&D materials using experimental simulation of end-of-life processes and actual C&D material collected from the field. This data will be incorporated into the product parameterized material life cycle inventories delivered for this task.
- Product's Contribution to Output: The report will provide data for the development of an effective approach for addressing materials management across media (output 3.63.2) and could be used to generate tools for evaluating temporal and spatial impacts of materials management on public health and the environment (output 3.63.3)
- Product's Timeline (with milestones):
    - Drywall samples collection and laboratory setup Q1 FY16
    - Drywall data generation and synthesis Q1 FY17
    - Roofing shingles samples collection and laboratory setup Q1 FY17
    - Drywall Life cycle inventory Q4 FY17
    - Roofing shingles data generation and synthesis Q1 FY18
    - Concrete samples collection and laboratory setup Q1 FY18
    - Life cycle inventory for roofing shingles Q4 FY18
    - Concrete data generation and synthesis Q1 FY19
    - Life cycle inventory for concrete Q4 FY19
- Product's intended user/customer/audience: LCA practitioners, OSWER, EPA Regions and States

Tool Development

Product Title: **Full life cycle, hybridized and regionalized SMM Prioritization Tool**

- Product Contact (email): David E. Meyer (meyer.david@epa.gov)
- Product's Delivery Date: FY17
- Product Description: This product provides a tool to identify and prioritize materials, goods, and services that constitute the environmental hotspots within a national or state economy. The enhanced tool developed in LCA will add the ability to build hybrid life cycle inventory models by combining input-output data for material, product, and service flows with process-level data for end-of-life treatment options. The use of process-level data will provide more detail regarding areas to apply alternatives design and allow the introduction of scenario analysis with life cycling costing to better interpret results to make decision for SMM. Environmental indicators will be augmented with economic indicators to show value-added of sustainable materials management activities.
- Product's Contribution to Output: The regionalized SMM Prioritization Tool is a tool that enables evaluation of temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3) as part of an approach to SMM (3.63.2).
- Product's Timeline (with milestones):

    - FY16 – A journal article describing the environmentally-extended input output model underlying the SMM Prioritization Tool (milestone)
    - FY16 – BETA SMM Prioritization Tool in openLCA (key product)
    - FY17 - Full life cycle, hybridized and regionalized SMM Prioritization Tool with complimentary life cycle costing and economic indicator reporting features (key product)
- Product's intended user/customer/audience: ORCR and their clients (Government – Regional Offices and States, Industry, and NGOs), as well as anyone else interested in applying SMM to identify the best use of materials in communities, regions, states, and countries

Product title: **Updated SEFA Tool System**

- Product Contact (email): randall.paul@epa.gov
- Product's Delivery Date: FY16
- Product Description: The SEFA Tool system provides a method to evaluate the potential environmental impacts of remediation activities. The updated version delivered in this product will include the following: an expanded materials library with a minimum of twelve Construction and Treatment(C&T) materials (e.g. asphalt, Portland cement, concrete, in-situ oxidants such as potassium permanganate, hydrogen peroxide), updated emission factor sets for existing materials; an expanded energy library covering renewable energy sources (i.e., solar, wind, etc.), an updated transportation library providing future vehicle emissions factors based on EPA's MOVES model, and emission factors for analytical support services.
- Product's contribution to output: SEFA is a tool that enables evaluation of temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3) as part of an approach to SMM (3.63.2).
- Product's Timeline (with milestone):
    - FY16 – An updated life cycle inventory with an expanded library for new materials and transportation processes (product)
- Product's intended user/customer/audience: Programmatic and Regional partners involved in field remediation and site reclamation activities (for example, Superfund).

Product Title: **RIMM Tool System Technology Transfer and Demonstration**

- Product Contact (email): Justin Babendreier (babendreier.justin@epa.gov)
- Product's Delivery Date: FY16
- Product Description: This product is a tool to apply risk-informed materials management to key parts of the life cycle when considering material use. Delivery includes a completed, externally peer-reviewed RIMM Tool System with the following functionality:
    - Full source-to-outcome exposure and risk assessment function provided by new the HE2RMES Modeling System, offering 9 different material management source-release models to support a variety of material management scenarios,

including GEM-based land application unit, waste pile, and roadway models, OSWER's Rags & Wipes landfill model, and enhanced hydrogeologic fate and transport models.
    - HE2RMES modeling system application capability for Anywhere, USA site-based assessments provided by the complementary D4EM-4-HE2RMES tool which allows users to parameterize the HE2RMES modeling system for use at any site location;
    - The USEPA's iemTechnologies modeling platform which houses RIMM and further complements the system with a range of tools supporting evaluation and decision analysis - uncertainty analysis, sensitivity analysis, multi-scale roll-up functions for conducting regional and national RIMM assessment studies, etc.
- Product's Contribution to Output: The RIMM tool system enables evaluation of temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3) as part of an approach to SMM (3.63.2).
- Product's Timeline (with milestones):
    - FY16 - RIMM Tool System (Final): Externally peer reviewed RIMM Tool System;
    - With intended subsequent public distribution via EPA's website to serve the rest of the Agency and communities (e.g., CEAM website for model distribution).
- Product's intended user/customer/audience: OSWER/ORCR

SMM Strategy Design

Product Title: **Surveying the Existing Landscape: An Academic Book for Incorporating Sustainability in the Design of Products and Processes**

- Product Contact (email): Gerardo Ruiz-Mercado (ruiz-mercado.gerardo@epa.gov)
- Product's Delivery Date: FY 16
- Product Description: There are current interests (societal, economic, and environmental) in incorporating sustainability at the early stages of the life of an industrial project (with multiple system-level perspectives), and there also is strong interest in the educational aspects of protecting human health, communities, and the environment. The aim of this new book is to contribute to the engineering technical community by incorporating sustainability concepts such as social responsibility, pollution prevention, sustainable materials management, green chemistry and engineering, life cycle assessment, and industrial ecology into conventional engineering knowledge and foundations (chemical production, mass and energy transfer, reaction, separation, process design, control and optimization, Process/product health, safety and hazard, etc). The goal is to demonstrate the development of alternative products and processes that are more sustainable, easier to adopt, and less complex, making it easier to design for sustainability. The information compiled for this book will form the foundation of the knowledge base for SMM strategy development.
- Product's Contribution to Output: This product provides necessary knowledge to develop strategies for SMM (3.63.2).

- Product's Timeline (with milestones):
    - FY15 – Compilation of book chapters from invited authors (milestone)
    - FY16 – Published Book (product)
- Product's intended user/customer/audience: The target audience for this book is the broad engineering community. This includes academia, industry, and government. Also, professionals serving in the research and development areas and engineering practitioners who want to include sustainability in their work. In other words, diverse industry sectors such bulk manufacturing, chemical manufacturing, fine chemicals, oil and gas, pharmacy, food industry, etc, are the focused target. In addition, these approaches will provide valuable concepts and principles to the EPA on how and where sustainability is expected to be revealed during impact assessment, material and energy use, and material management studies of new and existing plants and products.

Product Title: **Development of a web-based tool for the application of Green Engineering Materials Managements (GEMM) for demonstrating technology substitution as a potential SMM strategy**

- Product Contact (email): gonzalez.michael@epa.gov
- Product's Delivery Date: FY17
- Product Description: The GEMM tool is designed to provide a new understanding of the significant life-cycle impact of creating solvents, using them only once, and then destroying them. Extending the life of these materials generates significant financial and environmental benefits and lowers risk. Another benefit is the reduction of short-lived climate pollutants (SLCPs), known as SUPER pollutants, such as ozone precursors. Due to their short lifetimes (compared to C02 which remains in the atmosphere for approximately a century), actions to reduce emissions of short-lived climate pollutants will quickly lower their atmospheric concentrations, yielding a relatively rapid climate response. In collaboration with Region 3 and OCSPP in this RARE project, the product developed will convert the current Excel® version of the GEMM tool into a web-based version. By providing this conversion, increased use, transparency of data and calculations and integration with other ORD life-cycle based tools will result. Case studies with Regional and Industrial partners will verify the tool and provide documented examples of application of sustainable materials management strategies.
- Product's Contribution to Output: This product provides necessary knowledge to develop strategies for SMM (3.63.2) and a tool to evaluate sustainable material management options for industrial materials, including reduction, reuse, and recycling to protect community public health and the environment (3.63.1).
- Product's Timeline (with milestones):
    - FY15 – Development of Quality Assurance Project Plan, Decipher and understanding of the Excel® version of GEMM, Development of mathematical equations underlying GEMM calculations (milestone)
    - FY16 – Development of the Web-based GEMM Tool, alpha version and beta versions, Case study development, Verification of tool (product)

    - FY17 - In collaboration with Regional and industrial partners, development and documentation of a case study materials. (product)
- Product's intended user/customer/audience: Office of Chemical Substances and Pollution Prevention, Office of Recovery and Resource Conservation, Office of Solid Waste and Emergency Response, Office of Air and Radiation, Regions and Industry

Product Title: **Perspectives on Design of SMM Strategies through Application**

- Product Contact (email): Michael Gonzalez (gonzalez.michael@epa.gov)
- Product's Delivery Date: FY18
- Product Description: Step 3 of the SMMDA framework requires development of SMM strategies that address the overarching topics of "dematerialization", "detoxification", and "design for value recovery". This product provides a knowledge base describing methods to develop SMM strategies by utilizing material substitution, process substitution and cleaner technology options, (3) technology substitution (product or process redesign), and (4) material reclamation (recycling and beneficial reuse) from process or waste streams.
- Product's Contribution to Output: This product provides necessary knowledge to develop strategies for SMM (3.63.2).
- Product's Timeline (with milestones):
    - FY15 – None
    - FY16 – Journal article on the development of a process intensified approach to demonstrate application of material and process substitution as part of an SMM strategy. (milestone)
    - FY17 - Journal article on the development of multiple alternative routes for a specified same product functionality by employing technology substitution and material reclamation. (milestone)
    - FY18 - Journal article detailing common approaches and recommended practices for developing SMM strategies (product)
- Product's intended user/customer/audience: Office of Chemical Substances and Pollution Prevention, Office of Recovery and Resource Conservation, Office of Solid Waste and Emergency Response, Office of Air and Radiation, Regions and Industry

Demonstration Case Studies

Product Title: **Demonstration of SMMDA Framework components in a Georgia Pilot Study**

- Product Contact (email): David E. Meyer (meyer.david@epa.gov)
- Product's Delivery Date: FY19
- Product Description: The Georgia Pilot Study is a collaborative effort between ORD, ORCR, Region 4, and the Georgia EPD to apply EPA's SMM vision to the state of Georgia. The SMMDA framework will be evaluated and refined based on knowledge gained from the Georgia Pilot.
- Product's Contribution to Output: This product demonstrates the SMMDA framework; an SMM approach (3.63.2) that provides options for industrial, construction/demolition,

and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (3.63.1) through the development and use of tools for evaluating temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3).

- Product's Timeline (with milestones):
    - FY16 – Completion of regionalized SMM IO model for Georgia through Georgia EPD (cross-product milestone)
    - FY17 – Preliminary BETA SMM IO Tool in openLCA (cross-product milestone)
    - FY17 – Prioritized list of hotspot materials in Georgia (milestone)
    - FY18 – Set of alternatives for hotspots based on sustainable chemistry and engineering (milestone)
    - FY18 – Completed assessment of alternatives (milestone)
    - FY19 - Application of DASEES to interpret assessment results (milestone)
    - FY19 – Journal article describing the Georgia Pilot study and its key findings (product)
- Product's intended user/customer/audience: ORCR, Region 4, Georgia Environmental Protection Division

Product Title: **Interpretation of life cycle impacts to identify sustainable materials for laptop enclosures using DASEES**

- Product Contact (email): David E. Meyer (meyer.david@epa.gov)
- Product's Delivery Date: FY17
- Product Description: This product is a case study exploring the use of decision theory to interpret life cycle impact results for SMM decisions. The product system selected for the case study is a laptop enclosure because of the importance of this topic to EPA's Sustainable Electronics Group that informs the EPEAT standards process.
- Product's Contribution to Output: This case study addresses the multi-criteria decision theory need for the SMMDA framework and will provide knowledge to enable an SMM approach (3.63.2) that provides options for industrial, construction/demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (3.63.1) through the development and use of tools for evaluating temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3).
- Product's Timeline (with milestones):
    - FY 16 – Finalized set of life cycle impact scores for specified laptop enclosure product systems. (milestone)
    - FY 16 – Completed models for laptop enclosure product systems in DASEES (milestone)
    - FY 17 - Journal article describing the application of DASEES to the interpretation of life cycle impact scores to identify optimal decisions to support SMM in consumer electronics. (product)

- Product's intended user/customer/audience: Programmatic and regional partners working in policy development for sustainable consumer electronics and sustainable consumer purchasing; industries and trade associations involved with the consumer electronics market

Product Title: **RIMM Tool System OSWER/ORCR-ORD Collaborative Case Studies**

- Product Contact (email): Justin Babendreier (babendreier.justin@epa.gov)
- Product's Delivery Date: FY19
- Product Description: Summary reporting on each of two case studies with key elements for each study described in an associated journal article submission.
- Product's Contribution to Output: Application of the RIMM tool system enables evaluation of temporal and spatial impacts of materials management on public health and the environment for use in restoration and revitalization decision making (3.63.3) as part of an approach to SMM (3.63.2).
- Product's Timeline (with milestones):
    - FY18 – RIMM Case Study 1: journal article describing outcomes of the beneficial reuse assessment of FGD Gypsum on U.S. farmlands.
    - FY19 – RIMM Case Study 2: journal article describing outcomes for the OSWER/ORCR-prioritized beneficial reuse assessment conducted *(the specific material and decision-context will be determined as part of the study approach)*.
- Product's intended user/customer/audience: OSWER/ORCR

Task 2 – Beneficial Use of Materials

Project Title: SHC 3.63 – Sustainable Materials Management
Task Title: 3.63.2 – Beneficial Use of Materials
Task Leads: Mark Johnson, NHEERL/WED

Task Start Date: October 1, 2015 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESCRIPTION
Task 2, "Beneficial Use of Materials" is designed to conduct research and analyses to characterize and quantify the risks and benefits of using or reusing waste materials. This Task will enable communities and the Agency to better protect and enhance human health, well-being and the environment for current and future generations, through the reduction in material consumption, reuse, and recycling of materials to minimize the environmental impacts associated with products and materials. There are three overarching research areas in Task 2 derived from the SHC Charter. The first is to demonstrate and evaluate the beneficial use of organics and other waste materials. This can be in the form of making useful and needed products, or using the waste from one process as a feedstock in another process. Attention is also given to identifying and tapping underutilized material flows. This can be as simple as reducing the need for virgin materials by using alternatives or capturing and reprocessing wastes into feedstocks or reusing similar materials. This reduces environmental impacts and possibly the dependence on fossil fuel feedstocks, which has environmental benefits. Success here helps to protect human health and the environment. In addition, this research considers the use of waste biomass and food wastes to achieve a Net Zero (i.e., no wastes are landfilled) outcome. A tremendous amount of food waste and waste biomass is land-filled, burned or dumped every year. Utilizing these wastes to produce other products, such as biochar, or to synthesize useful and needed chemical feedstocks, keeps these materials out of landfills and can help to meet societal needs for these products. One focus of this task is on the specific production of products for use in remediating contaminated soils or waters and also on the generation of energy from organics. Finally, the task considers ways to improve methods and guidance for land application of the products of anaerobic decomposition. This includes the use of biosolids from municipal wastewater treatment plants and water treatment residuals. Here too, consideration is given to using these materials to reduce land and water pollution.

There are 5 primary research activities planned for the Evaluating Beneficial Use Task with each addressing one or more of the research areas outlined above. The planned activities are diverse and cover a broad spectrum of topics germane to the beneficial use of waste materials and address Agency, Office, Region and other client needs.

1. *Materials Recovery Technology:* Developing separations approaches to facilitate organic solvent reuse/remanufacturing
2. *Novel Products:* Developing novel renewable biomass-based magnetic materials from biodegradable waste and production of platform chemicals derived from waste biomass

3. *Biosolids:* Land application of wastewater treatment residuals
4. *Soil Remediation Amendments:* Amending metals contaminated mine soil with biochar and other waste-derived materials to facilitate soil remediation and the establishment of a soil-stabilizing native plant cover
5. *Methods Development:* Using a comprehensive approach to develop methodologies that could be used to evaluate the beneficial use of materials

RESEARCH APPROACH

1) Solvent Recovery Technology: EPA recently finalized a new definition of Solid Waste rule promoting the reuse/re-processing of 18 industrial solvents in four industrial sectors. In the EPA report "Sustainable Materials Management: The Road Ahead", industrial inorganic and organic chemicals, including industrial solvents, were ranked 3rd highest for their direct impact/resource use/waste and intermediate consumption. The objectives of this research are to provide scientific support regarding efficient separation technology options to EPA program/regional offices, states, tribes, and the regulated industries seeking to implement the re-manufacturing exclusion and solvent reclamation in general. This research will focus on the review and development of advanced separation materials/technologies for energy-efficient solvent re-processing. It will foster collaboration between separations technology developers, university researchers, solvent end-users, and regulators to promote solvent and water recovery/reprocessing/reuse.

This research will involve in-house research in the areas of chemical process simulation and design, separation material development, and evaluation/demonstration of technology options for representative solvent systems. The in-house work will be supported by on-site cooperators and contractors and supplemented by the services of expert consultants in the field of solvent recovery.

2) Novel Products: A large amount of cellulosic (forest-based waste biomass, demolition materials) and chitin and chitosan-based materials (from shrimp shells, crab and sea foods) and protein-rich (poultry wastes) are discarded in landfill. A suitable and beneficial use for these waste would not only decrease the burden on solid waste handling and pressure on land fill space, but would create high value-added products that may find commercial marketable product(s) with multiple uses. One purpose of this research is to develop novel adsorbent materials or bio-renewable catalyst support for chemical processing and sustainable remediation of pollutants from water and soil. In addition, biorefinery plays the pivotal role in the conversion of waste biomass into industrial feedstocks (i.e., Platform Chemicals that are the basis for the production of other products). The biorefinery part of this research will characterize and evaluate the evolution of the biorefinery in terms of biomass input, transformation technology improvement, and novel value-added outputs.

3) Biosolids: The broad goal of this research is to continue an on-going study designed to evaluate the fate of chemical and microbial species when biosolids are land applied. In this study, Class B biosolids have been applied to land at agronomic levels in pilot scale units planted with fescue and rye grass. The study compares liquid and solid biosolids applications.

Following the land application of Class B Biosolids several species are monitored including: pathogenic surrogates such as fecal coliforms, nutrients such as nitrogen species and total phosphate, metals, and emerging chemicals such as alkylphenol ethoxylates (APEs) and polyfluorinated chemicals (PFCs).

4) Soil Remediation Amendments: Approximately 500,000 abandoned mines across the U.S. pose a considerable, pervasive risk to human health and the environment. While specific programs exist to remediate the most toxic of these sites, most sites receive little or no attention. Here we propose research to investigate the use of biochar, a waste biomass derived material, as a tool to provide both soil remediation (i.e., reducing toxic metal concentrations and availability in the plant root zone) and reestablishment of a soil-stabilizing native plant community at abandoned mine sites, particularly those not yet targeted with remedial actions. Biochar is a charcoal-like, carbon-rich, porous by-product of thermal pyrolysis or gasification of plant biomass often originating from agricultural or other waste streams. A benefit of using biochar is the ability to align its properties to correspond to specific soil remediation needs; it has properties that make it ideally suited for use in remediating mine soils and reestablishing vegetation. Biochar is not the only soil amendment being considered in this research. Other waste derived materials, such as biosolids, water treatment residuals, compost, and iron oxides will also be considered alone and in combination with biochar.

Our approach is to design and produce biochars to reduce or eliminate soil quality issues that prevent the establishment of native plant communities on metals-contaminated mine soils. Our goal is to use waste biomass as a biochar feedstock to make biochars that significantly reduce the bioavailability of toxic metals when used as a soil amendment. Biochar and other soil amendments will be used in field conditions to demonstrate their efficacy to reduce soil quality limitations, improve soil health, and for establishing a soil stabilizing native plant community at the abandoned Formosa Mine near Riddle, OR. The Formosa Mine is a former Cu and Zn that is now listed as a Superfund site. Soils from the Formosa Mine will be used in laboratory and greenhouse studies to develop innovative methods for amending metals contaminated soils. Ultimately, soil amendment test and demonstration plots will be established at the Formosa Mine. NHEERL/WED will lead the biochar components of this research effort and NRMRL/LRPCD will lead the research integrating other soil amendments. NRMRL/LRPCD will also lead the effort to use chemometrics to develop predictive mathematical relationships to link soil amendments and their remedial potential to contaminated soils. Together research will be conducted to determine the underlying mechanisms of toxicity reduction. Efforts in FY15 – FY17 will be directed towards the Formosa Mine. In the subsequent years (FY18 – FY19) other sites will be addressed building on the knowledge base developed in the initial years.

5) Methods Development, Implementation and Application: The beneficial use (BU) of industrial materials is one of the elements in sustainability because it allows reductions in the net waste generation, energy and water consumption, and raw materials use, climate change, and could potentially generate an economical benefit for the involved parties.

All four validated methods that comprise the leaching environmental assessment framework (LEAF) were available on EPA's SW-846 on Jan 2013. The focus now is on LEAF implementation and applications in support of CCR regulations and policies to support beneficial use and evaluation of remediation and treatment processes for both hazardous and non-hazardous waste and materials. Source terms can be evaluated at the different life-cycle stages from production, use, storage, and disposal at end of life. The objective of this research is to complete work on the implementation of LEAF for developing source terms for inorganics for use in OSWER's framework for beneficial use evaluation. This includes a decision support tool (i.e., LeachXS-Lite) for LEAF data management, analysis, visualization and derivation of source terms for use in fate and transport models.

TASK PRODUCTS

Product Title: **How to Guide for Use of leaching environmental assessment framework (LEAF) data & Source Term Derivation for use of LEAF data**

- Product Contact (email): Susan Thorneloe (thorneloe.Susan@epa.gov)
- Product's Delivery Date: Q4, FY16
- Product Description: This guide provides information for users to use LEAF for development of source terms for the assessment of beneficial use, waste remediation and treatment. The major focus of ORD's contribution to this How to Guide is the development of source terms through a set of case studies to illustrate how to select LEAF methods, identifying site-specific datasets for developing site- and material-specific source terms. Although OSWER is responsible for the review of the guidance, ORD has had a major role in its development.
- Product's Timeline (with milestones):
    - 3.63.1 Sustainable materials management options for materials including reuse to protect community public health and the environment (FY17) - This product will contribute to science based decisions about land application and beneficial use of materials by providing more accurate source terms for three examples (i.e., use of coal fly ash as embankment fill, evaluation of contaminated soils for remediation, and evaluation of solidified waste form for treatment).
    - 3.63.2 Strategy for sustainable materials management (FY18) – This product will contribute to the sustainable management of materials and is referred to in OSWER's "Reuse of Industrial Materials: A Compendium of Information and Tools for Risk-Based Decision" – Will provide input to this document from updates to the LEAF How to Guide on Source Term Development-
    - 3.63.3 Source term derivation for additional defining algorithms for other high-volume uses of CCRs and other industrial by-products where diffusion and percolation predominate. The source terms will be used in OSWER's IWEM model which provides fate and transport modeling for EPA's beneficial use program of industrial by-products. Each source term derivation will be documented through appendices within the LEAF How-to-Guide.

- Product's intended user/customer/audience: OSWER, OAR, OW, Regions, States, industry, academia, and others

Product Title: **Optimizing the Beneficial use of Waste Materials**

- Product Contact (email): Souhail Al-Abed (alabed.souhail@epa.gov)
- Product's Delivery Date: Q4, FY16
- Product Description: The report will include mathematical optimization algorithm that may assist the BU decision-making process by determining the optimal allocation of materials, among competing BU options not only to minimize the cumulative environmental impact across relevant media but to also take into account costs, and social impact.
- Product's Contribution to Output:
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment - This product will contribute to science based decisions about responsible beneficial use of materials.
    - 3.63.2 Strategy for sustainable materials management – This product may contribute to enhance the sustainability of beneficial use.
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – The algorithm for beneficial use could be used as a tool for evaluating the social and economic impacts of beneficial use.
- Product's Timeline (with milestones):
    - Draft report Q2, FY 16
    - Report review Q3, FY16
- Product's intended user/customer/audience: OSWER, Regions, states, industry work

Product Title: **Land application of biosolids: field test 2**

- Product Contact (email): Carolyn Acheson (Acheson.Carolyn@epa.gov), Ron Herrmann (Herrmann.Ronald@epa.gov)
- Product's Delivery Date: Q4, FY17
- Product Description: In the US, about 60% of municipal biosolids are land applied as an agricultural amendment. The remainder are incinerated or landfilled. The National Research Council (NRC) expressed concern about the persistence of organic compounds in land applied biosolids and the potential for transport within soils. Furthermore, the NRC has recommended additional data collection to determine if additional chemicals should be regulated and to examine management practices. Changes in chemicals regulated in biosolids or in management practices would likely decrease the percentage of biosolids disposed through land application and increase the amount that are landfilled or incinerated. This product will evaluate the fate of chemical and microbial species when Class B biosolids are land applied at an agronomic level.
- Product's Contribution to Output:
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment - This

product will contribute to science based decisions about responsible management of municipal wastewater residuals.
    - 3.63.2 Strategy for sustainable materials management – This product may contribute to life cycle assessments of specific chemicals or products.
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – This product will demonstrate a method for evaluating the attenuation of chemicals introduced into the environment when municipal wastewater residuals are land applied.
- Product's Timeline (with milestones):
    - Field application and sample collection Q2, FY16
    - Data generation and sample processing Q4, FY16
    - Draft report Q2, FY17
    - Report review Q3, FY17
- Product's intended user/customer/audience: OSWER, OW/OWM and OST, OCSPP/OPPT, Regions, states, industry work groups and outside organizations (such as WERF and industrial consultants)

Product Title: **The current Status of Platform Chemicals that Can be Derived from Using Biorefinery Methodology.**

- Product Contact (email): Tao Li (Li.Tao@epa.gov); Sudhakar Takkellapati (Takkellapati.Sudhakar@epa.gov)
- Product's Delivery Date: Q4, FY17
- Product Description: Platform chemicals serve as the basis for production of specific useful products. The biorefinery part of this Subtask will characterize and evaluate the evolution of the biorefinery in terms of biomass input, transformation technology improvement, and novel value-added outputs (i.e., Platform Chemicals).
- Product's Contribution to Output: This would not only decrease the burden on solid waste handling and pressure on land fill space, but would create high value-added products that may find commercial marketable product(s) with multiple uses.
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment - This product will contribute to science based decisions about responsible management of biorefinery byproducts.
    - 3.63.2 Strategy for sustainable materials management – This product may contribute to life cycle assessments and the enhance use of biorefinery by products
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – This product will allow communities to evaluate the impacts of biorefinery products.
- Product's Timeline (with milestones):
    - Literature review and data collection Q4, FY16
    - Development of first draft report Q1, FY17
- Product's intended user/customer/audience: OSWER, Regions, States, Tribes

Product Title: **Mesoporous Material Derived from Poultry and Fishery Wastes.**

- Product Contact (email): Rajender Varma (Varma.Rajender@epa.gov)
- Product's Delivery Date: Q4, FY17
- Product Description: A huge amount of chitin and chitosan-based materials (from shrimp shells, crab and sea foods) and protein-rich (poultry wastes) are discarded which essentially end up in landfill with no utility. In the proposed research, natural and bio-degradable waste material may be combined with an appropriate metal-based waste stream (mine or industrial), or used in conjunction with clay or aluminosilicates, to produce magnetic biochar (mesoporous carbon materials) that can be easily separated or reused and recycled. Alternate energy input systems such as mechanochemical mixing, ultrasound- or microwave-irradiation would be explored to generate high surface area porous materials. This report will document appropriate and valuable use for these waste materials which are renewable and biodegradable.
- Product's Contribution to Output:
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment - The proposed research will transform varied bio-renewable wastes to novel adsorbents and catalysts that may be used for soil augmentation and sustainable remediation.
    - 3.63.2 Strategy for sustainable materials management – The information would not only decrease the burden on solid waste handling, pressure on land fill space, but would create high value-added eco-friendly and benign products that may find commercial marketable product(s) with multiple uses.
- Product's Timeline (with milestones):
    - Literature review and data collection Q4,FY16
    - First draft report Q2, FY17
- Product's intended user/customer/audience: OSWER, Regions, States, Tribes

Product Title: **Designing Biochars for Remediating Metals Contaminated Soils.**

- Product Contact (email): Mark Johnson (johnson.markg@epa.gov)
- Product's Delivery Date: Q4, FY17
- Product Description: A technical report providing guidance for making specifically designed and engineered biochars to match mine soil quality limitations at mining affected sites for the purpose of improving mine soil quality and health to the point that it can sustainably support a native plant community. Because biochars are made from agricultural, forestry and biomass from other waste streams this is an example of a beneficial use for the purpose of site remediation and prevention of off-site movement of toxic metals. This product will utilized by Remedial Project Managers (Superfund) and others tasked with remediating metals contaminated soils.
- Product's Contribution to Output:
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment –

Would allow the better evaluation of biochar for the management of solid waste.
    - 3.63.2 Strategy for sustainable materials management – The information would not only decrease the burden on solid waste handling, pressure on land fill space, but would create high value-added eco-friendly and benign products that may find commercial marketable product(s) with multiple uses.
- Product's Timeline (with milestones):
    - Evaluation of biochar use Q4, FY16
    - First draft of report Q2, FY17
- Product's intended user/customer/audience: OSWER, Regions, States and Tribes

Product Title: **Methods Development for the Quantification of the Beneficial Use of Un-encapsulated Waste Materials**

- Product Contact (email): Souhail Al-Abed (alabed.souhail@epa.gov)
- Product's Delivery Date: Q4, FY18
- Product Description: To better understand the full impact of the beneficial use of waste there is a need to quantify the amount (tons) of materials used. While there is industry specific quantification for beneficial use (e.g., CCRs) there isn't a no peer-reviewed methodology that would quantify BU across the U.S. economy. This product aims at the development of the a method that would allow the Agency to conduct such quantification
- Product's Contribution to Output:
    - 3.63.2 Strategy for sustainable materials management – This product will allow more accurate lifecycle evaluation of the impacts of the beneficial use of materials
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – Data generated by this product would lead to the development of tools and models to track the beneficial use of materials.
- Product's Timeline (with milestones):
    - Initial method development Q4, FY16
    - Data collection and analysis Q3, FY17
    - Method validation and review Q1, FY18
    - First draft report, Q2, FY18
- Product's intended user/customer/audience: OSWER/ORCR; OCSPP; EPA Regions; Target States: Pennsylvania and New Jersey

Product Title: **Advances in Materials for the Separation of Solvent-Water Mixtures**

- Product Contact (email): Leland Vane (Vane.Leland@EPA.gov)
- Product's Delivery Date: Q4, FY18
- Product Description: This report will describe the state of the science in the types of materials required to separate solvent-water mixtures and will identify the material advancements needed (if any) to foster the reuse/reprocessing of industrial solvents, particularly those identified in the New Definition of Solid Waste Rule.

- Product's Contribution to Output:
    - 3.63.2 Strategy for sustainable materials management – allows for the better management of mixtures and understanding of the new definition of solid waste.
- Product's Timeline (with milestones):
    - Experimental design Q4, FY16
    - Develop and analyze separation materials and processes for water-methanol and solvent-methanol mixtures for recovery/reuse of methanol from industrial process streams Q4, FY17
    - First draft report, Q2, FY18
- Product's intended user/customer/audience: OSWER/ORCR; OCSPP; EPA Regions; Target States: Pennsylvania and New Jersey

Product Title: **Methodology to Create Novel Platform Chemicals from Waste Cellulosic or Lignin Biomass.**

- Product Contact (email): Tao Li (Li.Tao@epa.gov); Sudhakar Takkellapati (Takkellapati.Sudhakar@epa.gov)
- Product's Delivery Date: Q4, FY18
- Product Description: A large amount of cellulosic and lignin waste material (forest-based waste biomass, demolition materials, crop waste) are discarded in landfill with no beneficial use. When burnt for waste volume reduction and energy recovery, the practice can pollute the air by generating hazardous waste (small particles and toxic organics) emission. This report will describe suitable and beneficial use for these waste materials which are renewable and biodegradable. Cellulose, hemicellulose and lignin are the main components of waste woody biomass and these can be utilized in the conversion to various platform chemicals. This part of research will explore the opportunities for the development of sustainable and greener synthetic methodologies for the conversion of biomass or sugars (components of biomass) to various platform chemicals and also the conversion of these platform chemicals to other value added chemicals. This research will explore the chemistry and sustainable processes to convert these aromatic biopolymers to products with useful properties.
- Product's Contribution to Output:
    - 3.63.2 Strategy for sustainable materials management –biodegradable waste materials to novel catalysts that may be used for soil augmentation and sustainable environmental remediation applications
- Product's Timeline (with milestones):
    - Initial method development Q1 FY17
    - Methodology validation and evaluation Q4 FY17
    - Draft method submitted Q2 FY18
- Product's intended user/customer/audience: OSWER, Regions, States, Tribes

Product Title: **LeachXS-Lite – LEAF data management, visualization, and automation of LEAF data to develop source term**

- Product Contact (email): Susan Thorneloe (thorneloe.susan@epa.gov)
- Product's Delivery Date: Q4, FY19
- Product Description: LeachXS-Lite is freely-available software available through the leaching environmental assessment web-site that provides excel templates for individual LEAF test methods for data management, recording, and uploading. This product would update that tool and allow it to be used for Source-term characterization
- Product's Contribution to Output:
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – This report will provide data and information to assist in determining the temporal and spatial impacts of materials management on public health and the environment.
- Product's Timeline (with milestones):
    - Beta version of the tool Q4 FY17
    - Peer-review completed Q4FY18
- Product's intended user/customer/audience: OSWER, Regions, and States

Product Title: **Protein-based Mesoporous Material**

- Product Contact (email): Rajender Varma (Varma.Rajender@epa.gov)
- Product's Delivery Date: Q4, FY18
- Product Description: Nearly 2 million metric tons of poultry feathers are discarded as waste in the United States from poultry slaughter houses. These feathers, which are made of predominantly (~90%) proteins called keratins, are often disposed by landfilling or incineration. The biochar from protein matter and magnetic versions of such carbonaceous materials could be used to make high-value products and in sustainable removal of contaminants from the environment. The food material, especially rich in protein matter, would be investigated for conversion to useful amino acid building blocks. Keratin or food-derived waste will be combined with a suitable support material, such as a clay or silica, in an environmentally friendly medium. The clay/polymer composite-based highly porous structures, often termed aerogels of varying structural types could be obtained by changing the relative ration of clay to polymer (keratin/protein waste) ratio.
- Product's Contribution to Output: It is our hypothesis that these highly porous, high surface area keratin-based aerogels will be suitable as adsorbents for removing pollutants from water and air. The proposed research will transform such protein-based waste to novel adsorbents that can be used for air and water purification. This project may lead to novel filtration system created from a renewable resource.
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment – development of potentially usable materials from waste will contribute to sustainable materials management.
    - 3.63.2 Strategy for sustainable materials management – development of potentially usable materials from waste will contribute to sustainable materials management

- Product's Timeline (with milestones):
    - Literature review and data collection Q2, FY17
    - Draft report submission Q2, FY18
- Product's intended user/customer/audience: OSWER, Regions, States, Tribes

Product Title: **Separation Process Options for Solvent Recovery and Reuse**

- Product Contact (email): Leland Vane (Vane.Leland@EPA.gov)
- Product's Delivery Date: Q4, 2019
- Product Description: Replacing virgin solvents with reclaimed materials requires the application of separation technologies to recover those solvents from their mixtures with the other processing materials, such as water, and to purify the solvents to meet process specifications. This report will provide scientific support regarding efficient separation technology options to EPA program and regional offices, states, tribes, and the regulated industries seeking to implement the re-manufacturing exclusion in the new definition of Solid Waste. The report will focus on the review and development of advanced separation technologies for energy-efficient solvent re-processing.
- Product's Contribution to Output:
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment (FY17)
- Product's Timeline (with milestones):
    - Data collection and literature review Q4, FY17
    - Complete evaluation of solvent-water separation processes, especially for applications involving water-miscible solvents identified in the New Definition of Solid Waste Rule Q4, FY18
    - First report draft Q2, FY19
- Product's intended user/customer/audience: OSWER/ORCR; OCSPP; EPA Regions 2 and 3; Target States: Pennsylvania and New Jersey

Product Title: **Beneficial Use Calculator**

- Product Contact (email): Souhail al Abed (al-abed.souhail@epa.gov)
- Product's Delivery Date: Q4, 2019
- Product Description: Most of the evaluation for the beneficial use of materials concentrates around the environmental benefits in terms of minimization of waste and reduction of pollution. However, in an era where climate change is one of the major drivers for environmental protection there is a need also to develop a methodology that would calculate greenhouse gas offset as a result of beneficial use. This product will develop an easy to use calculator to calculate greenhouse gas offset for the beneficial use of materials.
- Product's Contribution to Output:
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – This calculator will provide a tool to assist communities in determining the impacts of materials management on public health and the environment.

- Product's Timeline (with milestones):
    - Scoping and understanding the algorithms needed Q4, FY16
    - Development of the algorithms Q4, FY17
    - Calculator beta version Q3, FY18
    - Internal calculator review Q4, FY18
    - External calculator review Q2, FY19
- Product's intended user/customer/audience: OSWER/ORCR, Regions, States, Tribes, local community and environmental offices, Materials Generators

Product Title: **Biochar and Other Soil Amendments for Remediating Metals Contaminated Soils**.

- Product Contact (email): Mark Johnson (johnson.markg@epa.gov)
- Product's Delivery Date: Q4, 2019
- Product Description: A technical report providing new and updated guidance for using a variety of soil amendments with a special focus on utilizing designer biochar at sites with metals contaminated soils. With the objective of using designer biochar and other soil amendments to improve soil quality and health to the point of that they can sustainably support a native plant community that sequesters carbon, reduces erosion and off-site movement of toxic metals. This product will utilized by Remedial Project Managers (Superfund) and others tasked with remediating metals contaminated soils.
- Product's Contribution to Output:
    - 3.63.1 Sustainable materials management options for municipal materials including reuse to protect community public health and the environment – This product will summarize the science of capturing and reusing waste materials to make soil amendment products for remediating metals contaminated soils to help Regional/Program offices and communities make better decisions that protect human health and the environment.
    - 3.63.2 Strategy for sustainable materials management – This product will provide guidance for the utilization of waste materials to make soil amendments to remediate metals contaminated soils thereby promoting sustainable materials management.
    - 3.63.3 Tools for evaluating temporal impacts of materials management on public health and the environment – This product will provide guidelines for optimizing designer biochar and soil amendment selection to best remediate specific soil limitations (e.g., specific metal contaminants) to protect human health and the environment.
- Product's Timeline (with milestones):
    - Scoping and literature review Q4, FY16
    - Data collection and summarization Q4, FY18
    - First draft of technical report Q2, FY19
- Product's intended user/customer/audience: Remedial Project Managers (Superfund) dealing with metals contaminated soils at mining sites. Specific customers are Region 10 (Chris Cora RPM for the Formosa Mine) and OSWER (Michele Mahoney at OSWER

covers soil amendments of contaminated soils for OSWER). Others include the other EPA Regions, States and Tribes dealing with metals contaminated mine soils.

Task 3 – Innovation and Long-Term Performance

Project Title: SHC 3.63 – Sustainable Materials Management
Task Title: 3.63.3 – Innovations and Long-term Performance
Task Leads: Teri Richardson/NRMRL/LRPCD

Task Start Date: October 1, 2015 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESCRIPTION

The research addressed in this task reflects the need immediate research needs for the EPA to evaluate sustainable materials management. This task evaluates the current practices for managing used electronics and long term performance of materials management systems. The resulting information and data will provide information that can be immediately used by the Agency to identify areas for the improvement of materials management.

RESEARCH APPROACH

1) Used Electronics Flow and Tracking
Current used electronics legislation will be evaluated at the states level for effectiveness and to identify gaps where significant lapses of proper disposal can exist. Information currently available on the stewardship of electronics products across their life cycle is incomplete, does not track the flow of materials at different stages of the life cycle, and documentation varies across the States. Initially, this effort will focus on the analysis of a selected cluster of states that are selected for their legislation, and philosophy of statute implementation. The collected information and data will later be used to develop methods or mechanism to enable interested parties to access information relative to flows of used electronics and best management practices. The data and its analysis will assist regulatory bodies and provide to the public information related to amounts of used electronics generated and their ultimate disposition within the U.S.

2) Containment System Performance
This research will focus on the Agency's identified that the long-term performance and adaptation to climate change of its materials management systems. The evaluation of containment performance will inform next generation management approaches for containment systems. Additional efforts will finalize design information on bioreactor landfill operational approach, study of the performance of hazardous facilities, develop approaches for materials management in climate change, and identify better practices for the demolition of buildings.
Long-term landfill performance also hinges on an understanding of the physicochemical dynamics within a landfill cell. These dynamics include parameters to indicate waste degradation, liner performance, and interactions between the waste and natural hydrogeologic processes. Degradation models incorporate these criteria; however, models are only as good as

their input data. Landfill field data include point source sampling from wells and perhaps well collection galleries. This research will augment the containment system performance effort through the development of geophysical tools, methods, and models to complement the well data as it will provide the spatial data coverage between well locations in three-dimension.

TASK PRODUCTS

Product Title: **Comprehensive assessment of the flow of used electronics for selected states**

- Product Contact (email): Teri Richardson (richardson.teri@epa.gov)
- Product's Delivery Date: Q4 FY16
- Product Description: Current legislation on the management of used electronics are in need to be evaluated for effectiveness and to identify gaps where significant lapses of sustainable management exist. Thus, this report will focus on the analysis of a selected cluster of states that are selected for their legislation, and philosophy of statute implementation. The collected information and data can assist in the development of a tracking mechanism that enables stakeholders evaluate the relative to flows of used electronics and best management practices. More importantly this analysis will provide the Office of Solid Waste and Emergency Response the ability to track quantities and final disposition of used electronics.
- Product's Contribution to Output:
    - 3.63.1 - Sustainable materials management options for industrial, construction / demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment. The product will evaluate methods for tracking used electronics at the State level and providing sustainable options for the management of used electronics.
    - 3.63.2 – Strategy for sustainable materials management. The product will also provide a strategy for the sustainable management of used electronics
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making. In the long term, the product will also lead to the development of tools to evaluate the impact of used electronics on public health and the environment.
- Product's Timeline (with milestones):
    - First draft December 2015
    - Review and comments March 2016
    - Final draft July 2016
    - Submittal August 2016
- Product's intended user/customer/audience: OSWER, EPA Regions, and States

Product Title: **Subsurface Exothermic Reactions in MSW Landfills**

- Product Contact: Thabet Tolaymat (tolaymat.thabet@epa.gov)
- Product's Delivery Date: Q4 FY16

- Product Description: This report investigates the occurrence of sustained subsurface heating (SSH) events at MSW landfills and summarizes the state of the science with regard to their detection, causes, effects, control, and long-term mitigation. While the number of SSH events is difficult to quantify, based on 2007-2011 data, it is estimated that about 185 SSH events may occur annually in the U.S., representing approximately 30% of all reported landfill "fires."
- Product's Contribution to Output:
    - 3.63.1 - Sustainable materials management options for industrial, construction / demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment. The product will provide the means for sustainable materials options for municipal solid waste landfills that may experience subsurface oxidation event.
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making. In the long term, the product will also lead to the development of tools to evaluate the impact of used electronics on public health and the environment. The product will lead to the development of tools or indicators that may be used to signal the start of subsurface oxidation event.
- Product's Timeline (with milestones):
    - First draft December 2015
    - Review and comments March 2016
    - Final draft July 2016
    - Submittal August 2016
- Product's intended user/customer/audience: OSWER, EPA Regions, and States

Product Title: **Modelling Heat Generation and Migration Profiles in Landfills**

- Product Contact: Thabet Tolaymat (tolaymat.thabet@epa.gov)
- Product's Delivery Date: Q4 FY16
- Product Description: The report develop herein will aim at numerically modelling heat generation in landfills to identify factors that impact temperature distribution in landfills and the magnitude of the impact of these factors. Elevated temperatures and surface or sub-surface fires can occur at municipal solid waste (MSW) landfills from external factors (e.g., smoldering loads delivered to the site) or from chemical or biological processes that occur after disposal. The resultant conditions when temperatures go beyond those which normally occur during anaerobic decomposition of organic wastes can pose a threat to worker health and safety (and the surrounding community) and damage critical protective infrastructure such as liner systems, stormwater management systems, and gas collection systems.
- Product's Contribution to Output:
    - 3.63.1 - Sustainable materials management options for industrial, construction / demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment. The product will provide a mechanism (a model) for the evaluation of landfill

heating events and leads to a more sustainable management options for wastes and materials.

- Product's Timeline (with milestones):
  - First draft December 2015
  - Review and comments March 2016
  - Final draft July 2016
  - Submittal August 2016
- Product's intended user/customer/audience: OSWER, EPA Regions, and States

Product Title: **Evaluation of Open Dumps in Remote Pacific Islands Communities**

- Product Contact: David Carson (carson.david@epa.gov)
- Product's Delivery Date: Q4 FY16
- Product Description: Developing sustainable materials management and complying with appropriate regulation for remote communities can be a challenge attributed to the geographical remoteness and the size of these communities. The report provides a survey of materials management practices at these remote areas and tries to present economically feasible approaches for the sustainable management of materials at these locations.
- Product's Contribution to Output:
  - 3.63.2 – Strategy for sustainable materials management. The product will also provide a strategy for the sustainable management of used electronics. The product will identify technics and approaches that would enhance sustainable materials management specifically for remote and tribal areas.
- Product's Timeline (with milestones)
  - First draft December 2015
  - Review and comments March 2016
  - Final draft July 2016
  - Submittal August 2016
- Product's intended user/customer/audience: OSWER, EPA Regions, and States

Product Title: Evaluation of performance of Hazardous Waste Containment Systems – 25 years Update

- Product Contact: David Carson (carson.david@epa.gov)
- Product's Delivery Date: Q4 FY17
- Product Description: This report aims at quantifying the field performance of engineered systems based on data from Subtitle C landfills that are nearing completion of 30 years of post-closure care (PCC) and to "ground truth" expected leachate generation rates and chemistry during PCC in relation to current industry norms and expectations. It is anticipated that this study will help the U.S. Environmental Protection Agency (EPA) assess and update field performance of Subtitle C landfills.
- Product's Contribution to Output:

    - 3.63.2 – Strategy for sustainable materials management. The product would provide data that will allow communities to more sustainably manage their hazardous materials
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . This product is specifically designed to determining the temporal and special impacts of hazardous waste materials management on public health and the environment
- Product's Timeline (with milestones):
    - Complete site visits and data collections from 10 subtitle C sites March 2016
    - Data Synthesis and processing August 2016
    - First draft December 2016
    - Review and comments March 2017
    - Final draft July 2017
    - Submittal August 2017
- Product's intended user/customer/audience: OSWER, Regions and States

Product Title: **Mapping Soil-Moisture using Electromagnetic Induction**

- Product Contact (email): Dale Werkema (werkema.dale@epa.gov)
- Product's Delivery Date: Q4 FY17
- Product Description: The proposed work plan includes the code development, documentation, publication, and field demonstration of Electromagnetic Induction technology at a landfill site. The field demonstration will showcase the use of other innovative geophysical technologies, including nuclear magnetic resonance (NMR) to help ground-truth soil-moisture, porosity, and hydraulic-conductivity variability.
- Product's Contribution to Output:
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making .The report will provide data that supports the development of tools for moisture evaluation in landfill settings.
- Product's Timeline (with milestones):
    - FY15: code development,
    - FY16: field testing;
    - FY17: publication of code and field demonstration
- Product's intended user/customer/audience: OSWER, RPMs, and landfill investigators

Product Title: **Evaluation of performance of Municipal Solid Waste Containment Systems – 30 years update**

- Product Contact: David Carson (carson.david@epa.gov)
- Product's Delivery Date: Q4 FY18
- Product Description: This report aims at quantifying the field performance of engineered systems based on data from Subtitle D landfills that are nearing completion of 30 years of post-closure care (PCC) and to "ground truth" expected leachate

generation rates and chemistry during PCC in relation to current industry norms and expectations. It is anticipated that this study will help the U.S. Environmental Protection Agency (EPA) assess and update field performance of Subtitle C landfills.

- Product's Contribution to Output:
    - 3.63.2 – Strategy for sustainable materials management. The product would provide data that will allow communities to more sustainably manage their materials
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . This product is specifically designed to determining the temporal and special impacts of solid waste and materials management on public health and the environment
- Product's Timeline (with milestones):
    - Complete site visits and data collections from 10 solid waste landfills 2016
    - Data Synthesis and processing August 2017
    - First draft report December 2017
    - Review and comments March 2018
    - Final draft July 2018
- Product's intended user/customer/audience: OSWER, Regions and States

Product Title: **Resiliency of Waste Containment System to Extreme Weather Events**

- Product Contact (email): David Carson (carson.david@epa.gov)
- Product's Delivery Date: Q4 FY18
- Product Description: Most waste materials in the U.S. are handled at landfill sites. Some of these sites are in areas that could easily be impacted by climate change. Thus, there is a need to evaluate the impact extreme weather event may have on the robustness of waste containment structures. The report will provide an overview of potential climate change vulnerabilities of waste containment and processing systems. The report will also provide information to community decision makers on future areas of concern that the community would have to address.
- Product's Contribution to Output:
    - 3.63.2 – Strategy for sustainable materials management. The product would provide data that will allow communities to evaluate the impact of climate change on their materials management systems and as a result provides a strategy for a more sustainable materials management systems.
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . The product will allow for the evaluation of the unintended consequences of the placement of our materials management systems.
- Product's Timeline (with milestones):
    - FY16: Data collection,
    - FY17: Data synthesis and analysis;

    - FY18: Final Report
- Product's intended user/customer/audience: OSWER, EPA Regions, and States

Product Title: **Methodology for tracking, quantifying and reporting used electronic in the U.S.**

- Product Contact (email): Teri Richardson (richardson.teri@epa.gov)
- Product's Delivery Date: Q4, 2018
- Product Description: Based on the evaluation of data collected by the states and stakeholders (e.g., recycling facilities) the research team will develop a methodology for the quantification and tracking of used electronics in the U.S. Data generated by the methodology will allow the EPA to also evaluate trends associated with the prevention, reuse, recycling, disposal, processing capacity of used electronics in the U.S.
- Product's Contribution to Output:
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making. Data generated by this product would assist in determining the temporal and special impacts of used electronics.
- Product's Timeline (with milestones):
    - FY16: Data Evaluation and collection
    - FY 17: Methodology development and testing
- Product's intended user/customer/audience: OSWER, states, region, general public

Product Title: **Software and Field Approaches for Landfill Moisture Characterization**

- Product Contact (email): Dale Werkema (werkema.d@epa.gov)
- Product's Delivery Date: Q4 FY19
- Product Description: The USGS/EPA code 1DTempPro will be extended for analysis of data collected in the unsaturated zone. Currently, 1DTempPro supports analysis of temperature time-series data collected along vertical profiles in streambeds or lakebeds. The code is a graphical user interface to the USGS numerical modeling code VS2DH, enabling streamlined data analysis to infer groundwater/surface-water exchange. 1DTempPro V2 (in review) allows for time-varying exchange and aquifer heterogeneity, and provides for both manual model calibration and parameter estimation. The graphical user interface (GUI) will be extended to capitalize on the capabilities of VS2DH for modeling flow and heat transport in the unsaturated zone, thus allowing for estimation of soil moisture dynamics based on temperature time series collected at different depths. The enhanced code, 1DTempProUnsat, will support estimation of time-varying infiltration rate and aquifer recharge. The proposed work plan includes code development, documentation, publication, and field demonstration at a landfill site. The field demonstration will showcase other innovative, geophysical technology (including nuclear magnetic resonance) to help ground-truth soil-moisture, porosity, and hydraulic-conductivity variability.
- Product's Contribution to Output:
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and

revitalization decision making. This product would develop tools for landfill moisture mapping that would be instrumental in assist in determining the temporal and special impacts of materials management on public health and the environment

- Product's Timeline (with milestones):
    - FY16: code development,
    - FY17: publication of software;
    - FY18: field demonstration/testing;
    - FY19: publication of field testing
- Product's intended user/customer/audience: OSWER, States, RPMs, landfill investigators.

Product Title**: A Landfill Module for the Geophysical Toolbox Decision Support System (GTDSS)**

- Product Contact (email): werkema.d@epa.gov
- Product's Delivery Date: Q4, FY19
- Product Description: The Geophysical Toolbox Decision Support System (GTDSS - under SHC 3.61) will provide an interface for quantitative modeling tools to support decisions for which geophysical methods can be used given the combination of intended targets and project goals, and the geologic and physical conditions present at a site. Pre-modeling functionality will allow the user to predict the likelihood that a given geophysical method will provide information to help answer relevant questions, such as: Can the method (a) detect DNAPL pools? (b) monitor amendment emplacement?, (c) verify biodegradation, (d) map permeability, or (e) image discrete fractures? A new module will be incorporated into the GTDSS with a series of targets/goals relevant to landfills including: (1) delineation of waste cells, (2) mapping of soil moisture, (3) discrimination of waste type, and (4) detection of liner breaks. The user will graphically specify the size/shape of the expected target and enter information about the site geology, water table depth, etc. The GTDSS will generate synthetic data, i.e., the data that a survey would produce; add random noise to the data for realism; analyze the data; and produce synthetic geophysical results, i.e., the images that would be estimated by data analysis. Comparison of the true target and estimated image provides a basis for go/no-go decisions for the method being considered, guides, field acquisition, and decision support.
- Product's Contribution to Output:
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making. This product would develop tools for landfill moisture mapping that would be instrumental in assist in determining the temporal and special impacts of materials management on public health and the environment
- Product's Timeline (with milestones):
    - FY18: code development

    - FY18: field demonstration/testing
    - FY19: publication of module to GTDSS
- Product's intended user/customer/audience: OSWER, States, Regions, Regional program managers (RPMs), and landfill investigators.

Product Title: **Adapting materials management approaches to climate change**

- Product Contact (email): Thabet Tolaymat (tolaymat.thabet@epa.gov)
- Product's Delivery Date: Q4 FY19
- Product Description: Most waste materials in the U.S. are handled at landfill sites. Some of these sites are in areas that could easily be impacted by climate change. Thus, there is a need not only to evaluate the impact extreme weather event on these sites but to present possible adaptation measures that may be considered to increase a waste site resilience to climate change impacts and provide a roadmap for decision makers.
- Product's Contribution to Output:
- This report will provide data and information to assist in determining the temporal and special impacts of materials management on public health and the environment (output 3.63.3). It would also assist managers to effectively evaluate and manage materials across media (output 3.63.2)
    - 3.63.2 – Strategy for sustainable materials management. The product would provide data that will allow communities to site their materials management facilities in areas that are less prone to climate change impacts.
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . The product will also provide a tool for communities to evaluate the long term impact of their materials management systems.
- Product's Timeline (with milestones):
    - FY17: Data collection,
    - FY18: Data synthesis and analysis;
    - FY19: Final Report
- Product's intended user/customer/audience: OSWER, States, Regions, landfill investigators

Product Title: **Recovery of Critical Elements and the Conversion from Electronic Waste**

- Product Contact (email): Endalkachew Sahle-Demessie (sahledemessie.endalkachew@epa.gov)
- Product's Delivery Date: Q4, FY19
- Product Description: The report will identify the various techniques used for the recovery of critical elements from used electronics including those that can be removed magnetically and with eddy current, and results of experimental studies for the proper recycling of cathode ray tube glass, and other elements that are regulated under RCRA.
- Product's Contribution to Output: Provide data and analysis for sustainable management of used electronics that results in the recovery, recycle and useful

application of used electronics. This will provide data and information to assist in determining the temporal and special impacts of materials management on public health and the environment (output 3.63.3).
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . The product will allow for the evaluation of the impact of used electronics on human health and the environment.
- Product's Timeline (with milestones):
    - Q4FY17: Progress report
    - Q4 Fy19: Final report
- Product's intended user/customer/audience: OSWER, State and Regional office policy makers and e-waste program managers

Product Title: **Scientific Review of Materials Management Requirements**

- Product Contact (email): Edwin Barth, barth.ed@epa.gov
- Product's Delivery Date: Q4 FY19
- Product Description: Science has advanced greatly since the introduction of some of the material management regulations in the 1980s and 90s. There is a scientific need to evaluate these requirements in-light of the new science. This report will provide the bases for the agency to evaluate the effectiveness of its policies and may help address some of the questions regarding improvement to our material management approach.
- Product's Contribution to Output: This report will provide data and information to assist in determining the temporal and spatial impacts of materials management on public health and the environment (output 3.63.3).
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . The product will provide data and lead to the development of more sustainable approaches for materials management and help in assessing the historical impacts of materials management systems.
- Product's Timeline (with milestones):
    - FY16: Field visits, gaining access to sites and data collection,
    - FY17: Data evaluation
    - FY18: Data synthesis and analysis;
    - FY19: Final Report
- Product's intended user/customer/audience: OSWER, Regions, and States

Product Title: **State of Bioreactor Landfills**

- Product Contact (email): Thabet Tolaymat, (tolaymat.thabet@epa.gov)
- Product's Delivery Date: Q4 FY19
- Product Description: The EPA has allowed for a new type of sustainable bioreactor landfill operations since 2004 as part of a research and development strategy. This report will try to summarize the data and findings of five bioreactor landfills the EPA has

been tracking since 2004. The findings of the report will allow the Agency to evaluate the performance of these landfills for future considerations into the regulations.

- Product's Contribution to Output:
    - 3.63.3 -- Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making . The product will provide a tool for the more sustainable and evaluation of the impact of bioreactor landfills on the environment.
- Product's Timeline (with milestones):
    - FY17: Filed visits, gaining access to sites and data collection,
    - FY17: Data evaluation
    - FY18: Data synthesis and analysis;
    - FY19: Final Report
- Product's intended user/customer/audience: OSWER, Regions, and States

Task 4 – Net Zero

Project Title: SHC 3.63 – Sustainable Materials Management
Task Title: 3.63.4 – Net Zero
Task Lead: Ardra Morgan, NERL/IO

Task Start Date: October 1, 2015 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESCRIPTION

Net Zero (and more recently, net positive) waste strategies are comprised of five interrelated steps: reduction, re-purpose, recycling and composting, energy recovery, and disposal – with each step linking towards achieving net zero. As such these approaches can provide a framework for the application of ORD science and innovative technologies. The Army defines Net Zero Waste as follows: a Net Zero waste installation reduces, reuses, and recovers waste streams, converting them to resource values with zero solid waste to landfill.

The overall purpose of this task is, through application of ORD science and tools, demonstrate three case-studies towards achieving Net Zero waste to landfill through co-digestion and small-scale technologies. This task will not only focus on military installations, but surrounding non-military communities in order to catalyze public-private partnerships that embraces co-ownership and joint development and application of integrated solutions for sustainable outcomes. To the greatest extent possible, this task will strive to incorporate social and behavioral science, cost-benefit and other economic analyses through both internal expertise and external partnerships. Additionally, this task will aim to provide broadly-applicable tools and will disseminate lessons learned and best practices of Net Zero Waste approaches.

RESEARCH APPROACH

The approach for this task focuses on three case studies that will disseminate lessons learned and best practices of integrated solutions towards achieving Net Zero Waste:

1. **Case Study 1 – Integrated Waste Management in Region 4** - In the U.S., organic waste is the second highest component of landfills, which are the largest source of methane emissions. In addition, 30-40% of the food supply is wasted, equaling more than 20 pounds of food per person per month. The food recovery hierarchy provides a framework for organizations and decision-makers to develop and prioritize actions they can take to prevent and divert wasted food. However, patterns of waste generation, processing and management are complex in nature and reflect a range of spatial (local to regional) and temporal (now and into the future) dimensions. Decision-makers need to account for a variety of factors when considering actions under the hierarchy to minimize unintended consequences. For example, treating organic materials through anaerobic digesters at existing wastewater treatment plants may reduce materials from

going to landfill but the resulting production of biogas can have negative impacts to critical infrastructure, air quality and energy demands. Alternative management approaches such as transporting organic materials over long distances can remove these materials from the local waste stream but may have economic ramifications for existing processing facilities. Decisions that an entity may take under this framework have inherent trade-offs that must be considered. As such, information on these trade-offs need to be provided to decision-makers so that strategic choices can be made and integrated in order to achieve the best possible solution for a particular a region. The aim of this study is to investigate strategies and methods for developing practical organics diversion, collection and processing solutions. U.S. EPA Region 4 (specifically the greater Columbia, SC area) will serve as the study region.

a. **Phase 1 - Completion of Feasibility Study –** provide overview of regional organic waste generation, potential receptors, and potential markets.
b. **Phase 2 – Options Identification and Decision Support -** Identify options for better management of organic waste per food recovery hierarchy. To the greatest extent possible, leverage a suite of EPA decision support tools such as WARM, CoEAT to analyze proposed management options resulting from the feasibility study (accounting for environmental, social and economic trade-offs of such options). Rank options and provide recommendations to regional stakeholders.
c. **Phase 3 - Communicate** and make results broadly available.

2. **Case Study 2 – Co-Digestion at Fort Huachuca -** Wastewater treatment facilities with existing anaerobic digesters have the ability to co-digest a variety of organic waste materials, especially energy-rich carbohydrates, proteins, and lipid wastes. Co-digestion at WWTFs can help an installation manage waste more sustainably and provides a number of concomitant environmental, economic, and human health benefits. For example, co-digestion can reduce the carbon footprint of waste by diverting these materials from going to landfills, where methane may be generated and released into the atmosphere. In addition, co-digestion practices can minimize hauling distances for municipal solid waste, reducing truck traffic and associated air emissions. From an economic perspective, delivering water and wastewater services is an energy-intensive effort and can account for a large portion of a facility's total operating and maintenance costs. WWTFs and municipalities practicing co-digestion have the ability to generate renewable energy on-site in the form of biogas, which can be used as fuel for vehicles or be used to generate heat and power. However, there is a great need to assess and evaluate the benefits and limitations of anaerobically digesting wasted food in wastewater treatment facilities (WWTF) on Army installations towards (1) reducing the amount of organic materials going to landfills; (2) reducing greenhouse gas emissions; and (3) renewable energy production.

   This case study will evaluate the most effective organic waste diversion options for Fort Huachuca, with emphasis on co-digestion and biogas generation at their WWTP. The study will also quantify non-food organics that could serve as anaerobic digestion

feedstock. In addition, a guidance document will also be developed for installations and communities looking to explore organics diversion strategies and co-digestion opportunities. This guidance document will include broadly applicable steps and methodologies for conducting a practical organics diversion plan.

a. **Phase 1 – Complete Feasibility Study of Co-Digestion at Fort Huachuca -** gather base-line data and information such as food waste volume, characteristics, management options, disposal practices and associated costs; develop suitable indicators and performance measures; determine economic feasibility and capital investments needed.
b. **Phase 2 – Small-scale project demonstrations -** Contingent upon the results of the feasibility analysis and after consultation with stakeholders, explore small-scale demonstrations of technologies or approaches for food waste diversion on post.
c. **Phase 3 – Develop Guidance Document –** synthesize results and methodologies from existing case studies and reports.
d. **Phase 4 - Communicate** and make results broadly available.

3. **Case Study 3** – **Evaluation of Small-Scale Food Technologies towards Net Zero Waste** – There are growing interests in and/or government mandates in handling food waste – which can represent a substantial portion of an institutions MSW– in environmentally friendly ways. In addition, organics disposal bans or commitments to divert food waste from landfills has led to aggressive marketing and purchasing in a variety of on-site food waste processing systems. For institutions, these processing systems are often seen as relatively simple, low-maintenance options, particularly when materials are co-mingled with other MSW. In general, it can be difficult for facility managers to obtain objective information about on-site systems independent of marketing claims. In addition, there are relatively few independent and comparative studies to date that discuss the range of technological options applicable to site-specific considerations. As a result, there is a strong need to assess and evaluate food waste processing systems with respect to factors such as performance, capital costs, existing infrastructure, quantity and quality of the waste stream, and its overall potential to address organic waste reduction and diversion at an installation. This study will assess and evaluate the benefits and limitations of a variety of on-site food waste management devices that are currently being used at Army installations. The goal would be to provide an objective analysis of these technologies towards addressing challenges that facility managers have regarding space, cost and maintenance. In addition, this study will evaluate these on-site processing systems in terms of 1) how effective these technologies are towards certain goals and end-points (e.g. waste reduction, diversion, energy production, etc…), and in what contexts are these technologies most viable (e.g. capital costs, quality/quantity of materials, etc…). The results of this study will assess and validate these parameters so that other stakeholders will be able to compare across processing systems. While the focus of this evaluation will be on the waste issues of Army installations located within

the United States, the results (to the greatest extent possible) will be made broadly available to communities with similar MSW issues.

a. Phase 1 – **Army survey and stakeholder outreach**. Make a comprehensive list of bases that have purchased systems/devices
b. Phase 2 - **Develop a testing protocol.** We will also develop a standard waste mix that would be fed into the device. The food waste mix should be representative of a typical restaurant, cafeteria, or other food service institution. The same inputs would be metered. Having a standard food waste mix will allow comparison across devices and across bases.
c. Phase 3 - **Test each device** in place for approximately a week. The device will first be assessed in place while the base staff operates it as they normally prepare food. The staff will be observed and interviewed and the device inputs and outputs for energy, water, and organics will be measured and monitored.
d. Phase 4 – **Outreach** – synthesize and communicate results.

TASK PRODUCTS

Product Title: **Managing Food Waste in Columbia, South Carolina**

- Product Contact (email): Steve Rock (rock.steve@epa.gov); Alex Lan (lan.alexis@epa.gov)
- Product's Delivery Date: Q4, FY17
- Product Description: The product is a report that will detail integrated management strategies for the diversion of organic materials from landfill into valued uses, using Columbia, South Carolina as a case study region. A group of interested stakeholders have formed a partnership in the region to explore ways to regionally manage their organic materials. The stakeholders represented in this partnership include both sources and potential receptors of organic waste, and includes U.S. Army Fort Jackson – the largest and most active initial entry training center in the U.S. Army. This report will 1) provide objective base-line information on the current state of organic materials in the region (business-as-usual impacts, quantity, quality and magnitude) and will 2) provide a set of potential diversion options. Results of this study will be broadly available to other communities facing organic waste issues.
- Product's Contribution to Output: providing data and information that would lead to better management of organic waste and impact decisions at the community level
- Product's Timeline (with milestones):
    - [Deliverable 1] Complete Feasibility Study of Organic Waste Challenges and Opportunities in Columbia, South Carolina by January/February 2016
        - Options Identification and Analysis by November 2015
        - Present results of analysis to stakeholders by November 2015
        - Submittal of report to ORD Clearance by December 2015
        - Final draft by January 2016
        - Submit for publication January/February 2016
- Product's intended user/customer/audience: OSWER, EPA Regions, US Army and States

Product Title: **Towards Net Zero Waste: Co-Digestion at Fort Huachuca**

- Product Contact (email): Steve Rock (rock.steve@epa.gov); Alex Lan (lan.alexis@epa.gov)
- Product's Delivery Date: Q4, FY17
- Product Description: The product is a report that will assess and evaluate of the benefits and limitations of anaerobically digesting wasted food in wastewater treatment facilities (WWTF) on Army installations towards (1) reducing the amount of organic materials going to landfills; (2) reducing greenhouse gas emissions; and (3) renewable energy production.
- Product's Contribution to Output: providing data and information that would impact decisions at the community level
- Product's Timeline (with milestones):
    - [Deliverable 1] Final Feasibility Report by September 2016
        - Quantify organic waste streams at Fort Huachuca, estimate hardware upgrades, operational costs, and changes in installation practices required to operate the AD system at the WWTP using food waste as a feedstock – July 2016
        - Estimate the effectiveness and cost of alternative food waste diversion strategies and technologies and compare to AD effectiveness – August 2016
        - Develop final synthesis report - September 2016
- Product's intended user/customer/audience: OSWER, EPA Regions, US Army and States

Product Title: **White Paper – Steps in Conducting an Organics Diversion Plan**

- Product Contact (email): Steve Rock (rock.steve@epa.gov); Alex Lan (lan.alexis@epa.gov)
- Product's Delivery Date: Q3, FY19
- Product Description: The product is a guidance document that will be developed for installations and communities looking to explore organics diversion strategies and co-digestion opportunities. This guidance document will include broadly applicable steps and methodologies for conducting a practical organics diversion plan. It will include case studies and lessons learned from Fort Huachuca, South Carolina, etc…
- Product's Contribution to Output: providing data and information that would impact decisions at the community level
- Product's Timeline (with milestones):
    - Complete Small-scale demonstrations of technologies or approaches for food waste diversion on post – December 2018
        - Determine options for specific demonstration projects; scope technological and capital investments – December 2016
        - Stakeholder consultations – January – March 2017
        - Initiate demonstration projects on post – Summer 2017
        - Complete demonstration projects and assess results - December 2018
    - [Deliverable 1] – Complete Guidance Document – Summer 2019
        - Synthesize results of other case studies and reports – January 2019
        - Complete draft of guidance document – March 2019
        - Submittal of report to ORD Clearance - May 2019
        - Final draft - Summer 2019

- Product's intended user/customer/audience: OSWER, EPA Regions, US Army and States

Product Title: **Comparison and Evaluation of Small-Scale Food Technologies towards Net Zero Waste**

- Product Contact (email): Steve Rock (rock.steve@epa.gov); Alex Lan (lan.alexis@epa.gov)
- Product's Delivery Date: Q1, FY19
- Product Description: This study will assess and evaluate the benefits and limitations of a variety of on-site food waste management devices that are currently being used at Army installations. In addition, it will include broadly applicable strategies that communities and regions can use to better manage and divert organic waste.
- Product's Contribution to Output: the product will provide data and information for better life cycle evaluation of organics.
- Product's Timeline (with milestones):
    - Complete Army survey and stakeholder outreach by March 2017
        - Develop comprehensive list of bases that have purchased systems/devices by December 2016
        - Develop a testing protocol by March 2017
    - Test each device by Nov 2018
        - The staff will be observed and interviewed and the device inputs and outputs for energy, water, and organics will be measured and monitored from through Nov 2018
    - [Deliverable 1] - Complete Final Synthesis Report by October 2018
        - Submittal to ORD Clearance by August 2018
        - Final draft by September 2018
        - Submit for publication by October 2018
- Product's intended user/customer/audience: OSWER, EPA Regions, US Army and States.

List of Research Products for SHC Project 3.63 -- Sustainable Materials Management		
Task Title	**Product Title**	**Due Date**
Tools and Methods for SMM Decision Analytics		
	SMMDA Framework to support materials management decisions	FY 19
	Parameterized material life cycle inventories	FY 19
	EPA portals to the Federal LCA Commons and Global Network of LCA Databases	FY 18
	State of the Practice for Construction Demolition and Recycling	FY 16
	Inventories and flows of wood in the U.S. economy	FY 17
	Generating Experimental Emissions Inventory for construction and demolition materials	FY 19
	Full life cycle, hybridized and regionalized SMM Prioritization Tool	FY 17
	Updated SEFA Tool System	FY 16
	RIMM Tool System Technology Transfer and Demonstration	FY 16
	Surveying the Existing Landscape: An Academic Book for Incorporating Sustainability in the Design of Products and Processes	FY 16
	Development of a web-based tool for the application of Green Engineering Materials Managements (GEMM) for demonstrating technology substitution as a potential SMM strategy	FY 17
	Perspectives on Design of SMM Strategies through Application	FY 18
	Demonstration of SMMDA Framework components in a Georgia Pilot Study	FY 19
	Interpretation of life cycle impacts to identify sustainable materials for laptop enclosures using DASEES	FY 17
	RIMM Tool System OSWER/ORCR-ORD Collaborative Case Studies	FY 19
Beneficial Use of Materials		
	How to Guide for Use of leaching environmental assessment framework (LEAF) data & Source Term Derivation for use of LEAF data	FY 16
	Optimizing the Beneficial use of Waste Materials	FY 16
	Land application of biosolids: field test 2	FY 17
	The current Status of Platform Chemicals that Can be Derived from Using Biorefinery Methodology	FY 17
	Mesoporous Material Derived from Poultry and Fishery Wastes.	FY 17
	Designing Biochars for Remediating Metals Contaminated Soils	FY 17
	Methods Development for the Quantification of the Beneficial Use of Un-encapsulated Waste Materials	FY 18
	Advances in Materials for the Separation of Solvent-Water Mixtures	FY 18
	Methodology to Create Novel Platform Chemicals from Waste Cellulosic or Lignin Biomass	FY 18
	LeachXS-Lite – LEAF data management, visualization, and automation of LEAF data to develop source term	FY 19
	Protein-based Mesoporous Material	FY 18
	Separation Process Options for Solvent Recovery and Reuse	FY 19
	Beneficial Use Calculator	FY 19
	Biochar and Other Soil Amendments for Remediating Metals Contaminated Soils	FY 19

Innovation and Long-Term Performance		
	Comprehensive assessment of the flow of used electronics for selected states	FY 16
	Subsurface Exothermic Reactions in MSW Landfills	FY 16
	Modelling Heat Generation and Migration Profiles in Landfills	FY 16
	Evaluation of Open Dumps in Remote Pacific Islands Communities	FY 16
	Evaluation of performance of Hazardous Waste Containment Systems – 25 years Update	FY 17
	Mapping Soil-Moisture using Electromagnetic Induction	FY 17
	Evaluation of performance of Municipal Solid Waste Containment Systems – 30 years update	FY 18
	Resiliency of Waste Containment System to Extreme Weather Events	FY 18
	Methodology for tracking, quantifying and reporting used electronic in the U.S.	FY 18
	Software and Field Approaches for Landfill Moisture Characterization	FY 19
	A Landfill Module for the Geophysical Toolbox Decision Support System (GTDSS)	FY 19
	Adapting materials management approaches to climate change	FY 19
	Recovery of Critical Elements and the Conversion from Electronic Waste	FY 19
	Scientific Review of Materials Management Requirements	FY 19
	State of Bioreactor Landfills	FY 19
Net Zero		
	Managing Food Waste in Columbia, South Carolina	FY 17
	Towards Net Zero Waste: Co-Digestion at Fort Huachuca	FY 17
	White Paper – Steps in Conducting an Organics Diversion Plan	FY 19
	Comparison and Evaluation of Small-Scale Food Technologies towards Net Zero Waste	FY 19