United States
Environmental Protection Agency

Land Research Program
Multi-Year Plan:
Fiscal Years 2007–2012

U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC 20460

Final Report, July 2007

Administrative Note

The Office of Research and Development's (ORD) Multi-Year Plans (MYPs) describe what research ORD proposes to accomplish over the next 5–10 years in a variety of areas. The MYPs serve three principal purposes: to describe where the research programs are going, to present the significant outputs of the research, and to communicate the research plans within ORD and with stakeholders and clients. Multi-year planning permits ORD to consider the strategic directions of the Agency and how research can evolve to best contribute to the Agency's mission of protecting health and the environment.

MYPs are intended to be "living documents." ORD will update MYPs on a regular basis to reflect the current state of the science, resource availability, and Agency priorities. This MYP was internally reviewed by ORD's Science Council in November 2005. The Land MYP was externally peer reviewed by the Board of Scientific Counselors (BOSC) Land Subcommittee in December 2005, and a formal response to comments was provided to the BOSC Executive Committee in 2006.

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Table of Contents

LIST OF FIGURES

LIST OF TABLE

Major Acronym List	
3MRA	Multimedia, Multireceptor, Multipathway Risk Assessment
APG	annual performance goal
APM	annual performance measure
ATSDR	Agency for Toxic Substance and Disease Registry
BAF	Bioaccumulation Factor
BDAT	best demonstrated available treatment
BIF	boiler and industrial furnace
BOSC	Board of Scientific Counselors
BSAF	Biota–Sediment Accumulation Factor
CA	corrective action
CCR	coal combustion residues
CEAM	Center for Exposure Assessment Modeling
CEM	continuous emissions monitoring
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
DNAPL	dense non-aqueous phase liquid
ECNIMS	electron capture negative-ion mass spectrometry
EFDC	Environmental Fluid Dynamic Code
ERO's	EPA Research Object-oriented-oil Spill Model
ESTCP	Environmental Security Technology Certification Program
FRAMES	Framework for Risk Analysis in Multimedia Environmental Systems
FTE	full-time equivalent
FY	fiscal year
GC/MS	gas chromatography/mass spectometry
GCL	geosynthetic glay liner
GPRA	Government Performance and Results Act
GSI	ground water-surface-water interaction
GW-SW	ground water-surface water
HHRA	Human Health Risk Assessment
HSWA	Hazardous and Solid Waste Amendments
HWC	hazardous waste combustors
HWIR	Hazardous Waste Identification Rule
ICERR	Interagency Collaboration on Environmental Remediation Research
ICP-MS	inductivity coupled plasma mass spectrometry
ITRC	Interstate Technical Regulatory Cooperation
LHS	Latin hypercube sampling
LNAPLs	light non-aqueous phase liquids
LRP	Land Research Program
LTG	long-term goal
LUST	leaking underground storage tanks
LUST CA	LUST corrective action
MACT	maximum achievable control technologies
MCL	maximum contaminant level
MNA	monitored natural attenuation
MNR	monitored natural remediation
MOU	memorandum of understanding
MS	mass spectrometry
MYP	multi-year plan

NAPLs	non-aqueous phase liquids
NAS	National Academy of Science
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NERL	National Exposure Research Laboratory
NIEHS	National Institute of Environmental Health Sciences
NPL	National Priority List
NRC	National Research Council
NRMRL	National Risk Management Research Laboratory
NSF	National Science Foundation
OAQPS	Office of Air Quality Planning and Standards
OEM	Office of Emergency Management
OMB	Office of Management and Budget
ORD	Office of Research and Development
OSRTI	Office of Superfund Remediation and Technology Innovation
OSW	Office of Solid Waste
OSWER	Office of Solid Waste and Emergency Response
OUST	Office of Underground Storage Tanks
PAH	polyaromatic hydrocarbons
PART	Program Processing Rating Tool
PBT	persistent bioaccumulative toxic
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PM	particulate matter
PRB	permeable reactive barriers
QSAR	quantitative structure activity relationships
RCC	Resource Conservation Challenge
RCRA	Resource Conservation and Recovery Act
RCRA CA	RCRA corrective action
RCT	Research Coordination Team
RT/FS	Remedial investigatory/Feasibility Study
RDRD	Research Development and Demonstration Rule
REMPI	resonance enhanced multi-photon ionization
ROD	record of decision
RSA	regional sensitivity analysis
S&T	science and technology
SA/UA	sensitivity analysis/uncertainty analysis
SAB	Science Advisory Board
SARA	Superfund Amendments and Reauthorization Act
SERDP	Strategic Environmental Research and Development Program
SITE	superfund innovation technology evaluation program
SPI	submersible photographic instrumentation
SPMD	semi-permeable membrane device
STAR	Science to Achieve Results grants
SW	surface water
TACS	Tools for Analysis of Contaminated Sites
TCDD	trichlorinated Dibenzodioxins
TCLP	toxicity characteristic leaching procedure
TIO	Technology Innovation Office

TOE	total organic emissions
TSC	Technical Support Centers
TSDE	tree-structured density estimation
UA/SA/PE	uncertainty analysis, sensitivity analysis, and parameter estimation
USGS	U.S. Geological Survey
USS	undisturbed sediment sampler
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic contaminant
WDP	waste-derived product
WM	waste management
WMPC	Waste Minimization Priority Chemical
XRF	x-ray fluorescent spectometry

1.0 Introduction

The EPA Office of Research and Development (ORD) uses multi-year planning to chart the direction of our research program in selected topic areas over a period of approximately five to ten years. This approach promotes ORD's focus on the highest priority issues and provides a roadmap to achieving our long-term research goals. The purpose of the multi-year plans (MYPs) is to provide a framework integrating research across ORD's Laboratories and Centers and Government Performance and Results Act (GPRA) goals in support of the Agency's mission to protect human health and to safeguard the natural environment. MYPs are composed of three major components: (1) a narrative description of the plan; (2) a wiring diagram outlining the sequence and relationship of annual performance goals (APGs) needed to achieve each long-term goal (LTG); and (3) a matrix of goals and measures (APGs and associated annual performance measures [APMs]) needed to meet the LTGs identified in the plan. The MYP matrices align the outputs in a particular year with the APGs they support, even if the APG is in an out-year. These goals and measures are based on total annual resource levels for the topic area consistent with the resource level proposed in the most recent President's Budget.

By helping to identify the impact of potential planning decisions, MYPs aid in the evaluation of research options and foster the integration of strategic, risk-based environmental protection and anticipation of future environmental issues. They also allow for a more comprehensive understanding of changes needed to emphasize a new direction or accelerate an existing program. MYPs are updated periodically to reflect changes in Agency strategic thinking, the realities of available resources, and the current state-of-the-science. The MYPs provide a link between the strategic plans and annual plans, showing how we intend to meet our out-year goals. MYPs also link the research strategies and research plans to show how ORD conducts research in an integrated fashion to reach major milestones and end points.

The Land Research Program (LRP) MYP puts forward ORD's strategy for planning and conducting research in response to the following:

- Office of Solid Waste and Emergency Response (OSWER) and Regional priorities for the LRP, presented in Appendix A
- Authorizing legislation (e.g., Superfund Amendments and Reauthorization Act [SARA] 9660b; Resource Conservation and Recovery Act [RCRA]), discussed further in Appendix B
- Linkage to the EPA Strategic Plan, appropriate research areas under the Land Preservation and Restoration Goal (Appendix C)
- Board of Scientific Counselors (BOSC) and EPA Science Advisory Board (SAB) peer reviews (Appendix D)
- National Academy of Sciences (NAS) and other resource documents[1]

[1] Documents that contributed to the development or revision of this plan include the following:
- EPA Strategic Plan, http://+www.epa.gov/ocfo/
- SAB Review of Contaminated Sites and RCRA MYPs, June 2005.
- BOSC Review of Land Research Program, December 2005.
- NRC: A Risk Management Strategy for PCB-Contaminated Sediments, 2001, p. 5, Research Needs.

- Office of Management (OMB) Program Processing Rating Tool (PART) evaluations and measures (Appendix F)
- ORD strategic decisions and initiatives.

The LRP MYP is built upon two previous reports, the Contaminated Sites MYP and the RCRA MYP. The ORD Executive Council and the EPA SAB, in their review of these two plans, endorsed the combination of the plans and the development of an integrated research program.

Approximate total research funding (FY07 PB) for EPA's Goal 3 Land program is $34.1 million; this funding supports extramural projects and 143 full-time employees (FTEs). Within Goal 3 there are four components, resource conservation (science and technology [S&T] appropriation) and three trust fund accounts: Superfund, Oil Spills, and Leaking Underground Storage Tanks (LUST CA). The trust funds can be used only to support research within the specific trust fund (e.g., oil spills). Figure 1 presents the funding and FTE levels for each of the four components of Goal 3. This plan is written on the assumption that the resources within each funding source will remain constant each year.

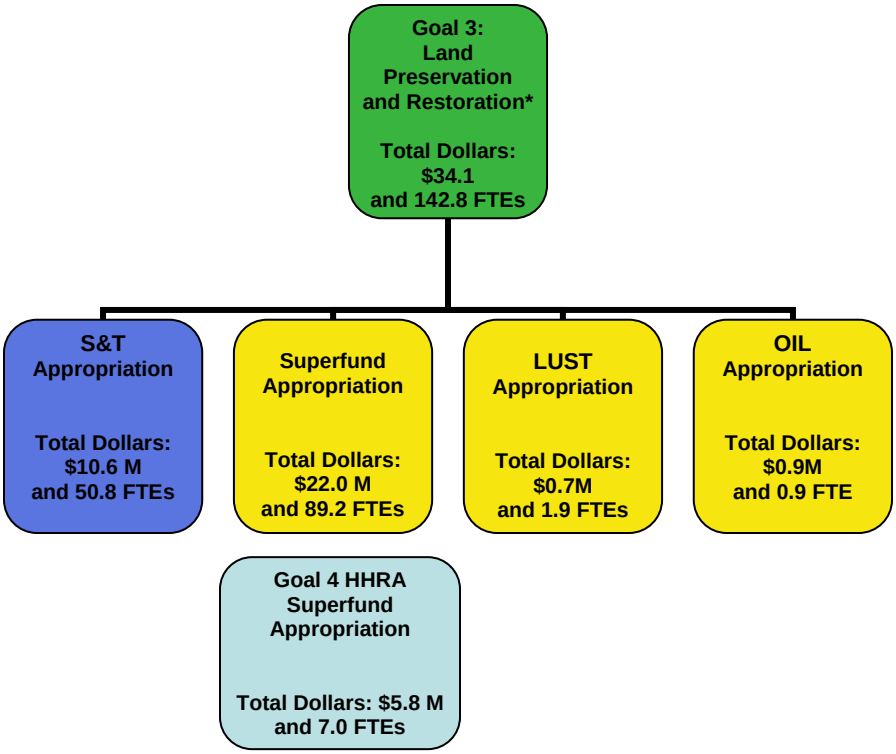

Figure 1. Land Program Resources and Funding Areas in 2007 President's Budget

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- Beyond RCRA: Prospects for Waste and Materials Management in the Year 2020 White Paper, August 2002.
- NRC: Superfund and Mining Megasites—Lessons from the Coeur d'Alene River Basin, July 2005.
- Superfund's Future: What Will It Cost? *Resources for the Future*, 2001, ISBN 1-891853-39-2.
- MYP guidance.
- Compilations of program office needs and formal and informal discussions with clients.

2.0 Background Overview of Land Multi-Year Plan (MYP)

Purpose: Land Research Program

***Restoration**:* The purpose of this research program is to provide improved scientific knowledge and develop and apply more cost-effective tools, models, and methods to inform decisions on land restoration.

***Preservation**:* The purpose of this research program is to provide improved scientific knowledge and develop and apply more cost-effective tools, models, and methods to manage material streams and inform land revitalization decisions.

The Land MYP describes ORD problem-driven research as defined by the National Academy of Sciences (NAS, 1997), supporting the Office of Solid Waste and Emergency Response (OSWER) research needs and three OSWER trust fund programs for which research is authorized: Superfund (SF), LUST, and the Oil Spills Program.

The Superfund research program is designed, in collaboration with OSWER and Regions, to address the most important science issues that affect policy development and program implementation. Because of limited resources, it is essential that our efforts are focused on the types of sites and problems that have higher risks, higher uncertainty, or higher impact in terms of number of sites, proximity to people, or value/size of ecological resources. The research program focuses on the important issues of contaminated sediments, ground water contaminant transport and remediation, and site characterization. The research program also provides site-specific technical support through topic-based centers and liaisons located in each region. Figure 2 outlines the variety of ways scientific support is provided by ORD to a site during site characterization and National Priorities Listing (NPL), remedial investigation/feasibility studies (RI/FS), communication to communities, and remedy selection.

Related risk assessment research activities and technical support for the Superfund program are an important part of ORD support to OSWER. The Integrated Risk Information System (IRIS) and Provisional Peer-Reviewed Toxicity Values (PPRTV), as well as the production of risk assessments on major chemicals of concern, are important for OSWER guidance and regional risk assessment activities. These are addressed in a Human Health Risk Assessment (HHRA) MYP, discussed in Appendix E along with other related research. The oil spill and LUST CA research are small programs focused on client needs for tools, models, and methods to address oil spill prevention and remediation, and underground storage tank issues concerning chemical fate and transport (F&T).

ORD Support Site Cleanup Process

Figure 2. Example of a Summary of ORD Support at a Superfund Site (Reed et al., 2007)

The preservation-oriented research program is transitioning to be responsive to program peer-review recommendations and broader OSWER strategic directions by addressing emerging issues in materials management and support of land revitalization decision processes. This change involves building on the foundation of the Multimedia, Multireceptor, Multipathway Risk Assessment (3MRA) program to support nanotechnology F&T research. We envision that EPA would be the Federal lead for nanomaterial environmental F&T research. Resources will support characterizing, modeling, and measuring the F&T of engineered nanomaterials in the environment, and analytical methods will be developed for detection and quantification of these nanomaterials. The exposure research will predict and evaluate unintended exposure pathways of engineered nanomaterials and evaluate and develop F&T mechanisms for nanomaterial release from intended pathways, such as zero-valent iron used for groundwater remediation. Additional material management research will support landfill bioreactors, landfill energy recovery, and technology transfer of cover/liner methods and debris management, which includes construction/demolition and disaster wastes. Reuse/Revitalization will focus on supporting Brownfields decision processes as well as bioavailability and leachability material reuse research.

Within OSWER, principal clients of the research program include the Office of Superfund Remediation and Technology Innovation (OSRTI), Office of Solid Waste (OSW), Office of Emergency Management (OEM), Office of Underground Storage Tanks (OUST), and Office of Brownfields Cleanup and Redevelopment. Additional research clients include

Regional and State staffs who implement these programs, regulated and responsible parties, and contractors who perform site-specific assessment and remediation.

Peer Reviews and Evaluations

In the past 3 years, the LRP has undergone two external peer reviews and an evaluation by the Office of Management and Budget (OMB). The EPA SAB conducted an advisory of the Contaminated Sites and RCRA MYPs in July 2004. The following quote is from the SAB letter to the Administrator on the findings of the panel:

> "In general, the Panel finds that the Contaminated Sites and RCRA Multi-Year Plans are programmatically and scientifically sound. We note in particular the remarkable coordination of the program's research with that of the relevant program offices and other institutions and are encouraged by the judicious use of leveraging opportunities to significantly stretch limited resources to meet more of the Agency's needs."

The LRP and the draft Land MYP were externally peer reviewed by the ORD BOSC in December 2005. The panel had positive comments on relevance, quality, and performance of program. In 2006, the LRP underwent an OMB Program Processing Rating Tool (PART) evaluation and received an adequate rating. Long-term, annual, and efficiency measures were established for the program under the PART process. The programmatic changes in response to peer-review and OMB comments are discussed in Section 5.1 and Appendices D and F.

This MYP incorporates peer-review recommendations and presents a transparent planning process that incorporates regional research needs and priorities, and program office research needs and priorities and utilizes that information in the Land Research Coordination Teams (RCT) evaluation and prioritization process. LTGs are focused on research products utilized by our clients that lead to outcomes in support of OSWER programs. The plan also addresses OMB relevance, quality, and performance criteria in focusing on the program goals and documented performance measures of the problem-driven research program.

Figure 3 shows a logic diagram[5] that summarizes the features of the research program. The OSWER statement of research needs indicates areas within this framework where ORD should direct its efforts, and the Activities and Outputs columns in the diagram reflect the research themes of the program. OSWER and the Regions are identified as the primary clients and the short-term outcomes for the research program are client use of our products to support their activities in cleanup, corrective action, and material management. The client use of our research products is specified in the two long-term goals for this MYP. The regions, states, and their contractors are identified in intermediate outcomes to which our products and technical support are further applied to address site-specific issues. The environmental and long-term outcomes support the objectives of Goal 3 in the EPA Strategic Plan.

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[5] McLaughlin, J.A., and G.B. Jordan, 1999, Logic Models: A Tool for Telling Your Program's Performance Story, *Evaluation and Program Planning*, 22, 65–72.

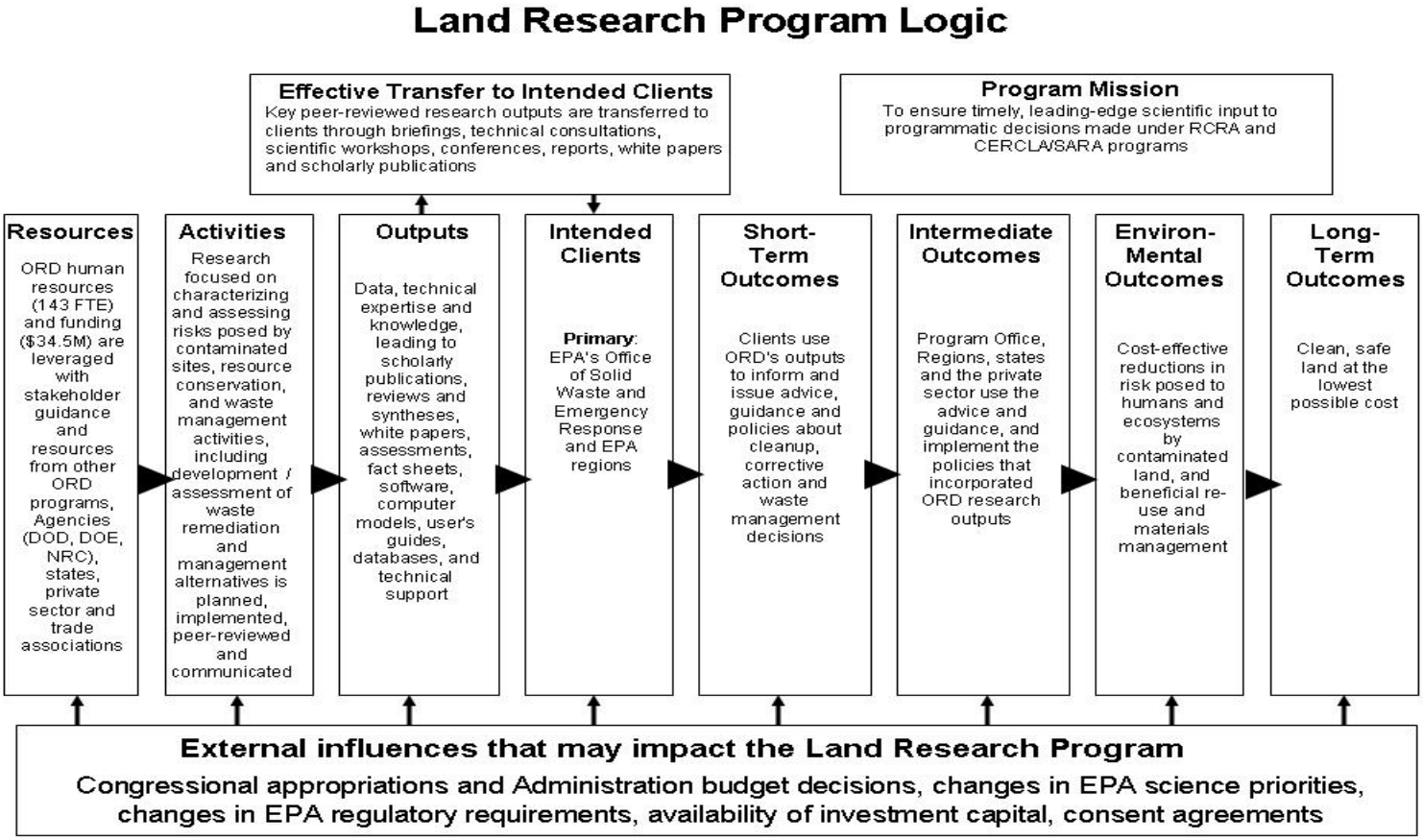


Figure 3. Logic Diagram of the Land Research Program

3.0 Progress to Date, 2002–2006

Key Accomplishments of the Land Program

Restoration Long-Term Goal

Contaminated Sediments

- Enhanced F&T modeling was incorporated at three major sediment sites.
- Evaluation of sediment resuspension models showed that they generally over-estimate the release and bioaccumulation of persistent organic contaminants from sediments after dredging operations. Key data were identified to improve the models.
- Combined use of field data and bioaccumulation models was demonstrated in a hybrid approach to extrapolate accumulation of persistent contaminants found in sediments. These findings improve ecological risk assessment of contaminated sediments.
- Bauxite has been found to be capable of sequestering a broad variety of heavy metals, including Hg, As, Cr, Cd, Pb, Zn, and Ni. Due to its unique surface properties, bauxite is

able to sequester both cationic and oxy-anionic forms of the metals through a combination of adsorption, absorption, ion exchange, and precipitation. Bauxite can be installed as a much thinner cap over the contaminated sediments, a critical parameter for remedy selection in navigable waters.
- Field evaluations of the performance of monitored natural remediation (MNR) and both sand and innovative caps will continue, with the aim of quantifying contaminant transport mechanisms to facilitate the prediction of remedy performance. Innovation in capping, both amendments and construction techniques (e.g., mats), will continue to be investigated.
- Boston Harbor/Eagle Harbor/Wyckoff Superfund Site. ORD is investigating the migration of contaminants through a sand cap and resuspension during cap placement to identify potential field methods for minimizing sediment resuspension during cap placement. The research indicated that resuspension can be minimized by using improved release techniques that result in fewer disturbances of the contaminated sediments.

Ground Water

- Results of the permeable reactive barriers (PRBs) long-term performance study were recently published in a synthesis of research findings, "Capstone Report on the Application, Monitoring, and Performance of Permeable Reactive Barriers for Ground Water Remediation" (EPA/600/R-03/045). This report represents a synthesis of 10 years of research and development on PRBs.
- PRB technology has expanded rapidly in its use and acceptance as a viable approach for achieving site cleanup and closure. Over 100 applications of the technology are documented in the U.S. and worldwide. The primary reason for this expansion is that technology results in cost savings over other alternative methods.
- For example, use of PRBs over traditional pump & treat methods results in an operation & maintenance savings at two sites of **$12 million**.
- Research products on monitored natural attenuation (MNA) of metals were applied to the Region 1 Industriplex site to treat arsenic contamination and resulted in a remedial decision that saved more than **$10 million** and earned a regional award in 2006.
- ORD developed and tested a patented technology for treating ground water contaminated with Chrome VI *in situ*. Region 4 estimates the technology saved them over **$1 million** in remediation costs relative to initial estimates for cleanup.

Multimedia

- *ORD oil spills research* supported the implementation of 40 CFR, Subchapter J, Part 300 –National Oil and Hazardous Substances Pollution Contingency Plan, Sub-Part J – Use of Dispersants and Other Chemicals.
- *Modeling tools to support oil spills*: http://www.epa.gov/athens/onsite/
- *Method 8261:* Method/instrument developed, patented, and commercialized by ORD to support Superfund's need for robust methods to address problematic matrices. Vacuum

distillation was pioneered as an analytical technique for determining volatile organic contaminants (VOCs) in environmental/biological samples (two patents awarded for the vacuum distillation apparatus). One of the first true performance-based methods developed for RCRA SW-846 was Method 8261: a vacuum distillation/gas chromatography & mass spectrometry (GC/MS) method, using optimized quality control, and used for the analysis of all environmental/hazardous waste matrices, except that for air.

- *Method 5032*: use of vacuum distillation as an extraction technique (FY04 APM 209); "Interlaboratory Study Evaluating Vacuum Distillation VOC Analysis Technology (SW-846 Method 8261) for Superfund Application."
- *Analytical support to OSRTI,* either through direct requests or via the Las Vegas Technical Support Center or other centers. This support includes analysis of extracts, data generated by various state-of-the-art analytical techniques (i.e., high-resolution mass spectrometry), and consultation on technical questions as requested from the Regions, States, Tribes, or Superfund Program Office.

Preservation Long-Term Goal

- The risk from arsenic-bearing water treatment sludge residuals leaching from municipal landfills was shown by 3MRA to be minimal, potentially saving several million dollars per landfill.
- Technology transfer: Eight evapotranspiration covers for landfills under construction in 2006 are expected to save more than **$30 million.**
- Research and technology transfer on evapotranspiration covers for landfills has resulted in construction of the innovative cover at more than 35 sites. For 13 of the sites that reported figures (FY06 data), cost savings ranged from $20,000 to $100,000 per acre, with a median savings of $40,000, compared to a conventional multi-layer cover. More than 2,500 people have attended classroom or internet training, much of it leveraged through the Interstate Technology & Regulatory Council, a state–federal partnership for state regulators.
- Bioreactor research won a Kentucky Governor's Award in 2003 and a SWANA Landfill Management award in 2005.
- Brownfields Tools: SMARTe contains four primary components:
  Screening Tool – leads users through the entire revitalization process
  eDocument – provides information, links, and resources regarding the revitalization process
  Search engine – allows users to search for information, tools, and best practices
  Toolbox – contains electronic tools (e.g., searchable databases, templates, calculators) to analyze and solve revitalization issues.
  http://www.epa.gov/brownfields/tools/tti_smarte.htm

4.0 Current Priorities of OSWER and Associated Research Issues

Four themes characterize OSWER's land program activities under Goal 3: The One Cleanup Program; Recycling, Waste Minimization, and Energy Recovery; Revitalization; and Homeland Security.

- ***One Cleanup Program:*** Through the One Cleanup Program, OSWER is looking across its programs to bring consistency and enhanced effectiveness to site cleanups. The Agency is working with its partners and stakeholders to enhance coordination, planning, and communication across the full range of Federal, State, Tribal, and local cleanup programs. This effort is intended to improve the pace, efficiency, and effectiveness of site cleanups as well as more fully integrating land reuse and continued use into cleanup programs. OSWER is developing environmental outcome performance measures that report progress among all cleanup programs.

- ***Recycling, Waste Minimization, and Energy Recovery (Objective 3.1 Preserve Land):*** OSWER's strategy for reducing waste generation and increasing recycling is based on the following: (1) establishing and expanding partnerships with businesses, industries, States, communities, and consumers; (2) stimulating infrastructure development, environmentally responsible behavior by product manufacturers, users, and disposers ("product stewardship"), and new technologies; and (3) helping businesses, government, institutions, and consumers by education, outreach, training, and technical assistance.

- ***Revitalization:*** OSWER and its partners are restoring contaminated land to make it economically productive or available as green space. Like the Brownfields program included under Goal 4, these revitalization efforts complement OSWER's traditional cleanup programs under Sub-objective 3.2.2 and enable affected communities to reuse contaminated lands in beneficial ways. OSWER is developing performance measures to assess its success in restoring and revitalizing sites under all its cleanup programs.

- ***Emergency Preparedness, Response, and Homeland Security (Sub-objective 3.2.1):*** OSWER has a major role in reducing the risk to human health and the environment posed by accidental or intentional releases of harmful substances and oil. OSWER is working to improve its capability to effectively respond to these incidents, working closely with other federal agencies within the National Response System.

OSWER relies upon its 10 Regions, in partnership with States and Tribes, to implement these program priorities nationally. Through their work, the Regions and their partners enable communities to reuse contaminated land, effectively clean up contaminated sites, reduce waste generation and increase recycling, and reduce risk by responding to releases of harmful substances and oil.

4.1 OSWER and Regional Research Needs

OSWER identified its research needs through an iterative process, beginning with a review by Office of Science Policy staff of previously developed needs lists. During this review, needs that had already been met by ORD or other offices were deleted, and new needs were added. To this revised list were added OSWER-related needs suggested by the EPA Regional Science Council and EPA Regional staff in both the Superfund and RCRA Corrective Action programs.

OSWER added to its master list additional needs relayed from Regional Division Directors, Branch Chiefs, Technical Support Section Chiefs, and Technical Support Project members during a review of potential research projects being considered for funding under a proposed FY06 research project program. This compiled list of research needs was then combined and cross referenced with the ORD current research program for further prioritization and evaluation. The resulting tables are presented in Appendix A.

In 2005, OSWER formed five Regional Research Advisory Workgroups (RRAWG) to help develop and prioritize research needs as well as perform other coordinating functions between ORD and the Regions related to site cleanup. These workgroups consist of Regional and OSRTI staff, with liaisons from ORD's Hazardous Substance Technical Liaisons in the Regions and ORD staff from the Laboratories and Centers. The workgroups are discussed in the following section.

4.2 Description of Process to Prioritize and Address Research Needs

Needs for Superfund-Oriented Research

As part of the process in combining the RCRA and Contaminated Sites MYPs, the Land RCT wanted an improved method to incorporate Regional scientists into the research planning process and to document responsiveness in the research program to Regional input.

The Regional and OSWER representatives on the RCT identified research planning workgroup topics and recruited experts from various regional technical groups, such as the Engineering Forum, the Ground Water Forum, members of the Risk Assessment Teleconference for Superfund, Ecological Risk Assessment Forum, and Sediments workgroups to serve in these research planning workgroups. The workgroups were asked to become

The general duties for these advisory workgroups:

- Form a basic understanding of current ORD research in the above areas (from summary presentations from ORD via conference call, lab visits, etc.).
- Advise Land RCT of regional needs in their area and priorities in OSWER's list of research needs.
- Provide feedback on ORD products in the above areas.
- Advise Land RCT about specific projects that they see as high and low priorities among items in the MYP.
- Read quarterly reports from the ORD Technical Support Center in the above areas and provide feedback on their functioning when needed.

The time commitment for these advisory teams will be 1–2 years, with an approximate time commitment of 4–8 hours per month.

familiar with the current research program and the associated research products, and to evaluate the research program activities and the list of research needs that have been identified by the Program Office and the Regions.

The workgroup utilized a set of criteria and rankings so that a documented process was produced.

The primary task for the advisory workgroups was to review the research needs and current research program (Appendix A) under their topic (e.g., contaminated sediments) and rank them (*high*, *medium*, or *low*).

Ranking criteria for each activity/need:

- Feasibility and timeliness:
  Is investing in this now likely to meet the need?
- Applicability across sites/assessments:
  Would meeting the need impact a large number of sites or a high-priority risk pathway, or reduce cost/response time?
- Importance to several regions or programs:
  Is the need important to multiple Superfund Regions and/or RCRA, Water, Air, or Toxics?

There are five advisory workgroups:

1. ***Sediment:*** ecological effects, modeling, sampling, monitoring, and remedy-specific research; Superfund Sediment Resource Center; Ecological Risk Assessment Center.

2. ***Ground Water:*** MNA, dense non-aqueous phase liquid (DNAPL), and vapor intrusion (VI) research; Ground Water Technical Support Center.

3. ***Engineering, Containment, and Soil Treatment:*** soil containment and treatment; landfill covers, gas, and liners; Engineering Technical Support Center.

4. ***Site Characterization and Methods:*** sampling techniques, analysis methods, and statistics; Monitoring and Site Characterization Technical Support Center; Environmental Photographic Interpretation Center.

5. ***Human Health Risk Assessment:*** all research conducted through the National Center for Environmental Assessment (NCEA).

The RCT criteria:

- Feasibility and timeliness:
  Is investing in this now likely to meet the need?
- Importance to Regions
- Importance to OSRTI
- Responsiveness to BOSC and SAB recommendations
- Ability and expertise of ORD to do the research
- Is it a strategic direction for ORD and the research program?
- Are any shifts in resources or FTE strategic?

For this task, the output for each workgroup was a prioritized list of research activities of importance to the Regions. The results of these workgroup reviews were then used by the OSW and Superfund representatives to the Land Research Coordination Team to better represent program views to ORD during research planning. The Land RCT is committed to communicating to Regional managers, the workgroups, and other regional groups any shifts in the research program that reflect Regional and Program Office priorities.

Needs for Oil Program and Leaking Underground Storage Tank (LUST) Research

The Oil Program research needs are presented in Appendix A. They are based on discussions with OEM Oil Program staff and support the National Contingency Plan Product Schedule or are related to recent statutory requirements. OUST research needs are included in Appendix A under LTG 1. They are based on discussions with office staff and regulatory requirements.

4.3 Need for Identification Process in Land Preservation Research

Whereas OSRTI operations and programs tend to be addressed at the regional level, RCRA programs tend to be coordinated at the national level and implemented by the states. Therefore, a higher percentage of RCRA research needs assessment and prioritization took place at the headquarters level.

Prioritization Criteria:

- ***Resource Conservation Challenge (RCC)****:* RCC-related projects should be a priority.
- ***Cost****:* Something that costs less is more likely to be funded than something that costs more.
- ***Leveraging****:* Opportunities to leverage our needs with those of other Offices.
- ***Duration****:* Preferably a year or two.
- ***Quantifiable outcomes directly related to RCRA's strategic goals****:* Can we relate project outcomes (preferably quantitatively) to the Agency's strategic goals?
- ***Clear, narrowly defined scope****:* A clearer, more narrowly defined project with quantifiable outcomes.

Regional priority: Support from (preferably multiple) Regional Offices.

A request was made across RCRA regional and headquarters personnel for research needs in addition to those already listed in the previous MYP. Additional needs were added to the culled list of pre-existing needs. Representatives from all RCRA divisions met and prioritized the list into the following categories:

- *Category 1*: RCC-related, with a specific product deliverable within 2 years
- *Category 2*: important, but less confident it can be accomplished in 2 years
- *Category 3*: important, requiring research duration longer than 2 years.

RCRA management had the opportunity to further review the prioritized list. The research needs for the RCRA program and associated ORD research are presented in Appendix A.

4.4 Research Shifts in Program Related to OSWER and Regional Priorities

The Land RCT received the prioritizations of the regional workgroups and evaluated the higher priority topics. The workgroups evaluated research needs along with the current research program. The higher priority research from each workgroup (typically 4–6 research needs) were evaluated by the RCT, and ORD wrote a response for each of these, which was (a) a shift in the research program, (b) confirmation that current research addressed the need, or (c) the RCT was unable to address the need. For most of the higher research needs, the RCT was able to shift the research program or the current program addressed the need. Examples of research shifts:

- ***Ground water research:*** increased research effort for ground water–surface water (GW-SW) and VI by redirection of the Soil VOC's sampling guide to "Sampling Protocol for Subsurface Vapors" (VI support). Geophysics work was redirected to include a geophysics tool box to monitor natural attenuation for site managers.
- ***Contaminated sediments research:*** the highest and higher research needs were being addressed by the current research program.
- ***Site characterization research:*** real-time monitoring methods for ground water, and a shift of bioanalytical work from soil to ground water matrix to support rapid field-screening techniques. Bioavailability of arsenic in soil was also a high-priority need.
- ***Engineering research:*** The metal speciation need was discussed above and will be an ongoing issue. A short-term project on mining issues was also initiated.

5.0 Development of the Research Program

This version of the ORD Land MYP was developed using a process designed to focus on client priorities (OSWER and the EPA Regions), coordinate with other Agencies and organizations engaged in research on related topics, consider scientific advice from independent bodies (e.g., EPA SAB and BOSC), incorporate PART measures in the accountability of the program, acknowledge ongoing research activities, build upon previous planning efforts, and be consistent with ORD mission and capabilities.

The core planning/writing team for the Land MYP consists of the ORD Land National Program Director, Assistant Directors of ORD Labs and Centers, and liaisons from the client offices (OSRTI, OSW, and the regions). The team met regularly, either face-to-face or by telephone, and proceeded through the following tasks:

- identifying desired program outcomes (LTGs)
- reviewing BOSC and SAB peer review recommendations
- reviewing ORD strategic decisions
- identifying scientific questions and research needs that must be answered and addressed to achieve the desired outcomes
- identifying ongoing and previously planned research projects and outputs responsive to the scientific questions and research needs
- determining program and regional priorities for the research needs and ongoing/planned research projects and outputs
- proposing and prioritizing additional or alternative projects and outputs.

As practicable, prioritization criteria were developed and applied, but programmatic decisions were made ultimately by the National Program Directors (NPDs) considering all of the above inputs. Major goals, which must be achieved in order to successfully address the research needs, were developed for each year (called annual performance goals, or APGs). These APGs were developed through dialogue between the Labs/Centers, the clients, and the planning team.

Once the research needs to be pursued were identified, and the APGs were agreed upon in terms of nature and Lab/Center responsibility, the process of determining how to meet those research needs and APGs was a bottom-up process. Each ORD Lab and Center accomplished this task using a process consistent with their mission and culture. The result of these Lab/Center-specific deliberations consisted of lists of proposed APMs that the organizations expect to produce as milestones toward fulfilling their commitment to achieve the APG and resolve the critical research need. The proposed APMs were reviewed by the planning team to ensure understanding and agreement that their delivery would fulfill the Lab/Center's commitment.

5.1 Changes in the Research Program

Addressing Customer Priorities

Section 4 presented the process used to identify and address program office and regional research needs. A table, organized by research themes, presented client research needs and the current and planned research addressing the research need (Appendix A). This table was useful for the RCT to visualize areas where we were meeting research needs, partially meeting needs, or not addressing a research need. Both the prioritization process that the RRAWG performed and the categories that the OSW generated helped to focus the RCT on addressing the higher priority needs.

Addressing Peer-Review Recommendations

In developing the research program, recommendations from the 2004 SAB review of the MYPs were incorporated into the revised MYP. The SAB supported merging the two OSWER-oriented MYPs and wanted a stronger connection of the research to the EPA Strategic Plan. The panel stressed rewriting the LTGs to move toward "outcomes" and to address emerging issues, and they suggested that more information be presented on how research is prioritized. The LRP incorporated the majority of SAB's suggestions (Appendix D).

A BOSC external peer review of the research program and draft MYP was conducted in December 2005. The panel also made recommendations for improvements in the MYP, such as readability of the document, performance metrics and outcomes, use of research questions, and other aspects on the progression of research. Emerging needs were also stressed for areas such as nanotechnology and mining wastes. This document is responsive to the panel's recommendations. The BOSC comments and the EPA responses are in Appendix D.

In combining the MYPs, the number of LTGs was reduced from six to two. This reflected PART Guidance that a program should have a limited number of specific long-term performance measures that focus on outcomes and reflect the purpose of the program. The OMB Research & Development (R&D) Investment Criteria, Appendix A (http://www.whitehouse.gov/omb/part/), stress relevance, quality, and performance of research

programs. The LRP was evaluated by the OMB PART in 2006 and received an adequate rating. Long-term and annual measures to track performance were negotiated with OMB and reflect additional measures of program efficiency and effectiveness (Appendix F).

ORD Strategic Directions

An additional factor was responding to strategic priorities within the ORD research program. Responding to support initiatives and shifting staff to focus on higher priority research resulted in shifts in the research program.

5.2 Changes in the MYP Programs

Significant programmatic changes were made in the LRP in response to BOSC and SAB recommendations, particularly addressing emerging issues. The RCT decided to make a strategic shift in the research program to conduct nanomaterial F&T research and establish the program as the leader across the Federal government in this research theme. This work will complement funded Science-to-Achieve-Results (STAR) grants. The Agency's efforts are coordinated with other federal agencies through the National Nanotechnology Initiative (NNI),[2] which the Administration has identified as a FY 2008 research and development budget priority.[3] The RCT also decided to more broadly support the Brownfields program research needs in the land revitalization area through an enhanced research effort. Mining waste treatment and monitoring efforts will also be increased. Of decreased emphasis will be combustion research, multimedia modeling, and analytical method development.

The Hazardous Substance Research Centers (HSRCs) were universities funded with 5-year grants to conduct basic research, with each center focusing on a specific topic such as contaminated sediments, mining or urban issues. The HSRCs provided research, technology transfer, and community outreach that addressed hazardous substance problems of concern to the ten EPA regions. Funding for the HSRCs was eliminated in FY05, and ORD has attempted to mitigate their loss through an MOU with NIEHS and through other collaboration activities with Federal agencies that provide grants to universities in the remediation area. Funding for the Superfund Innovative Technology Evaluation (SITE) Program was eliminated in FY06. The program was judged to be mature and had accomplished many of its goals. The purpose of the program was to accelerate acceptance of newly developed tools and technologies, largely arising from the private sector. The SITE program evaluated characterization, monitoring, and remediation approaches and produced reports that project managers use to gain confidence in selecting innovative tools and technologies for their sites. ORD is working with the Department

[2] For more information, see http://www.nano.gov/.

[3] Executive Office of the President, Office of Management and Budget and Office of Science and Technology Policy, *FY 2008 Administration Research and Development Budget Priorities* (Washington: OMB, 2006), p. 5. See http://www.whitehouse.gov/omb/memoranda/fy2006/m06-17.pdf.

of Defense (DOD) Environmental Security Technology Certification Program (ESTCP), a technology demonstration program, to meet the needs previously met by the SITE program.

Table 1. Level of Emphasis for Research Themes

Research Theme	Emphasis	Mitigation
Long-Term Goal 1		
Contaminated Sediments	Level	
Ground Water	Level	
Multimedia	Increased for mining; decreased for analytical methods	
Hazardous Substance Research Centers	Eliminated in FY05 budget development	MOU with NIEHS Superfund grants
Superfund Innovative Technology Evaluation	Eliminated in FY06 budget development	Increased interaction with DOD ESTCP technology program
Long-Term Goal 2		
Materials Management	Combustion eliminated in FY07	
Nanomaterial F&T	Initiated leveraging from 3MRA to nanomaterials	
Multimedia Modeling	Focused on nanotechnology; decreased model development	
Revitalization	Brownfields increased	
Resource Conservation	Decreased level of effort	

5.3 Program Description

The purpose of the restoration research is to provide improved scientific knowledge and develop and apply more cost-effective tools, models, and methods to inform decisions on land restoration. The purpose of the preservation research is to provide improved scientific knowledge and develop and apply more cost-effective tools, models, and methods to manage material streams and inform land revitalization decisions.

ORD is in a unique position to link applied research to effective technical support at the site-specific level. This linkage is enhanced through eight ORD Technical Support Centers (see Appendix H), which exist to address inquiries from site managers and regional risk assessors and

engineers. ORD also has a liaison stationed in each region to facilitate the application of ORD science to address site-specific issues. ORD researchers partner with OSWER and Regional scientists and engineers to produce OSWER guidance documents, OSWER Directives, and fact sheets. They serve with regional staff on advisory groups and work with them to conduct technology demonstrations.

Collaboration Across Federal Agencies

EPA expends substantial effort coordinating with other agencies, including work with the (DOD in its Strategic Environmental Research and Development Program (SERDP) and the ESTCP, the Department of Energy (DOE), National Institute of Environmental Health Sciences (NIEHS), Agency for Toxic Substances and Disease Registry (ATSDR), Department of the Interior (DOI), and state groups to communicate results, leverage expertise, and collaborate on complex issues. Summary information on EPA collaboration with federal agencies and state groups is presented in Appendix H by topic area. The research topics and associated collaborative activities and products show the degree of collaboration and leveraging of technical expertise across the federal government on restoration and preservation issues.

In addition to the above activities in 2006, we established an Interagency Collaboration on Environmental Remediation Research (ICERR) Workgroup to develop increased understanding of federal environmental remediation research programs among the EPA, DOE, NIEHS, National Science Foundation (NSF), and DOD SERDP through the following:

- Program manager-level research program reviews

- Identification of research areas among the agencies to enhance collaboration, encourage leveraging of research, and minimization of duplicative research.

Long-Term Goal (LTG) Development

In the RCT, there were discussions about how to combine the two previous MYPs, and converting the six LTGs into two LTGs. In addition, the RCT had facilitated meetings to develop client oriented goals and outcomes. LTG 1 was primarily directed at ORD research that supported remediation activities of OSWER and the regions. This included Superfund, Oil Spills, and LUST research. The process to determine what research to conduct was presented in Sections 4.2–4.4. Three research themes are contained in LTG 1: contaminated sediments, ground water contamination, and multimedia and analytical methods. LTG 2 supports the prevention research needs of OSW and emerging issues. Research themes are resource conservation and management of material streams, which will include emerging material streams, specifically, nanomaterial fate and transport.

Each LTG includes the following:

a. *Definition and key research questions* within the LTG research themes
b. *Research theme:* Responses to key research questions and a description of the research program
c. *Performance measures:* Wiring diagram of research theme APGs leading to the LTG.

Land Research Program Long-Term Goals (LTGs)

LTG 1: Clients request and apply ORD research products and services needed for mitigation, management, and long-term stewardship of contaminated sites.

LTG 2: Clients request and apply ORD research products and services needed to manage material streams, address emerging material streams, and conserve resources.

5.4 Long-Term Goal 1: Research Questions, Description of Research Program, and Performance Measures

LTG 1: **Clients request and apply ORD research products and services needed for mitigation, management, and long-term stewardship of contaminated sites.**

To achieve this goal, ORD must identify accurately the scientific uncertainties which, when addressed, make the clients' mandated responsibilities and actions most cost-effective and scientifically defensible. From the clients' perspective, activities related to mitigation, management, and long-term stewardship at contaminated sites are dependent on the environmental medium of concern, and the needs for research vary accordingly. For that reason, this LTG is organized according to the following themes: contaminated sediments, ground water contamination, and multimedia and analytical methods. Each theme is described separately below, guided by key research questions and producing performance measures addressing the LTG.

5.4.1 Theme: Contaminated Sediments

Key research questions addressed:

- How can we build consensus in application of F&T models of contaminants and improve modeling use in site decisions?

- What is the most appropriate framework for modeling F&T of contaminants under different remedial alternatives?
- When dredging is used to remediate a sediment site, what are the (a) effects on biota, (b) F&T of resuspended contaminants, (c) measurement tools, and (d) management options?
- How effective are alternative technologies vs. sediment dredging?
- What are the critical tissue residues to use as screening levels for aquatic organisms exposed to persistent bioaccumulative toxins (PBTs)?
- How can we use field data and bioaccumulation models to extrapolate bioaccumulation of PBTs across ecosystems?
- What are monitoring and measurement tools to improve the characterization of sediments and their biota?
- How do we identify sediment remediation options that minimize contaminant accumulation in fish and impacts on benthic communities?

At contaminated sediment sites, the Superfund program must decide whether to leave the site alone or select a remedial option. These decisions are based in part on the relative risks to the environment and health posed by each alternative. Whatever decision is made at a site, the Superfund program must have an understanding of the potential risks posed by the remedial action itself, and an understanding of how best to monitor effectiveness of the action over time. The research questions, when addressed adequately, will provide an improved scientific basis for these decisions.

Because risk posed by a given contaminant concentration in sediment is likely to be related to the depth at which that contamination is found, the ability to sample selectively the top layers of sediment is important. Traditional approaches to sampling disturb the sediment surface, rendering assessment of distribution within layers inaccurate. This research addresses measurement tools to characterize sediments, specifically, how can the sediment surface be sampled without disturbing it? Based on determination of the best principles of existing commercially available devices, work was initiated on a sampling device. A prototype undisturbed sediment sampler (USS) has been developed and has undergone initial testing, resulting in technical improvements and modifications. Currently, field testing in different sedimentary environments is being planned to test the robustness of the sampler, along with technology transfer activities.

Decision makers must forecast changes in nature and extent of contamination under various management, temporal, and hydrodynamic scenarios. This research is therefore addressing F&T questions such as: What is the most appropriate framework for modeling F&T of contaminants under different remedial alternatives? Existing contaminated sediment transport models and bioaccumulation models were evaluated to determine their capabilities and limitations and to identify capabilities that should be added to these models. A three-step plan was developed:

1. Capability of the public domain F&T model that ranked highest in the model evaluation (Environmental Fluid Dynamic Code, or EFDC) was augmented to include:
    a. a sediment consolidation–contaminant transport model to simulate consolidation due to sediment self-weight and cap overburden, and the resulting contaminant flux.
    b. a model to simulate wave-induced resuspension of highly organic sediments and associated contaminants.

The sediment transport, eutrophication, and diagenesis modules in EFDC will be linked to account for resuspension of inorganic sediment and organic carbon, and for the settling and deposition of both inorganic sediment and organic matter.

2. The upgraded EFDC was tested in several types of water bodies, including:
    a. a salt-wedge estuary (Lower Duwamish Waterway)
    b. a reservoir (Lake Hartwell)
    c. a partially stratified estuary (St. Johns River)
    d. a river (Housatonic River).

EFDC will also be applied to Mobile Bay to test its ability to simulate formation and movement of fluid mud. The application of this research tool directly to these sites has improved the capability of the site-specific models to support management decisions.

3. The final step will be to develop the framework for modeling remedial alternatives. The framework will include:
    a. a watershed loading model
    b. the enhanced EFDC model
    c. a bioaccumulation model
    d. protocols for applying the component models
    e. software for evaluating uncertainties in a modeling study.

Understanding the toxic properties of contaminants is essential to understanding the risks associated with contamination. To a large extent, this is a general problem in toxicology, not restricted to contaminated sediments. The ORD Land Research Program is focused on those contaminants that tend to be persistent and bioaccumulate within organisms, since they pose the most evident long-term risk. Furthermore, since the risk to humans is primarily through exposure to other organisms within whom contaminants may have accumulated, the future ORD focus of this program is largely on ecological receptors. More specifically, ORD research is directed to provide the site-specific risk assessor with tools to make risk predictions based on extrapolation from an understanding of food web and bioavailability / bioaccumulation relationships and on the impact of remediation alternatives on these variables and their relationships. ORD's research will establish and improve understanding of causal relationships between sediment contamination and chemical residues and exposure to aquatic organisms. This

research will also provide tools for use in defining critical sediment and tissue residue thresholds between acceptable and unacceptable effects for aquatic and aquatic dependent organisms. Key research foci include the following:

- Determining the critical tissue residues to use as screening levels for aquatic organisms exposed to PBTs. Research consists of assembling and evaluating a residue–effects database for polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) for aquatic and aquatic-dependent organisms. The evaluation is identifying (a) major gaps in PCB residue–effect data; (2) the extent to which risk estimates are altered significantly by the manner in which PCB is expressed (e.g., total PCB, Aroclors, congeners, and dioxin-like congeners); and (3) methods, tools, and techniques for screening and evaluating the toxicity data as well as for deriving residue–effect relationships with varying amounts and types of laboratory-derived toxicological data.
- Determining how to extrapolate field-measured bioaccumulation data across species, ecosystem, and/or time through development of a hybrid empirical/modeling approach.
- Determining the impact of incomplete removal or resuspension of contaminated sediments on the aquatic organisms.
- Determining the conditions under which different approaches to measuring the integrity of benthic organism communities at sites are most suited.

Current remediation approaches to addressing contaminated sediments, include dredging, capping, and MNA. OSRTI must decide which of these options best suits a particular site. In addition, considering the costs, strengths, and limitations of these approaches in the context of the wide variety of sites to which they must be applied, development of new treatment approaches is desirable. ORD's research program is designed to provide a better understanding of the traditional risk management options and to investigate alternative options.

To improve understanding of existing risk management options, ORD will continue to evaluate post-dredging residuals models through case study and field evaluation. Field studies will be conducted to evaluate post-dredging residuals and implement innovative monitoring tools, such as core profiling techniques, semi-permeable membrane devices, volatilization chambers, and innovative techniques for evaluating capping technologies yet to be applied for monitoring dredging operations.

ORD is investigating several alternative sediment remedies with the potential to be more cost-effective than conventional dredging or capping remedies. An emphasis will be placed on bioremediation of organics, electrochemical degradation, and conventional and reactive caps. In coordination with the U.S. Army Corps of Engineers, and in association with the Strategic Environmental Research and Development Program (SERDP), ORD will complete a number of research projects to evaluate the field performance of dredging and capping and to improve understanding of the best management practices.

ORD will develop or test the applicability of a number of tools for monitoring contaminated sediment and associated risks, which can then be applied to monitoring remedy performance. The tools include sampling devices suitable to investigate contaminant migration into natural or constructed sediment caps and migration from the sediment into the overlying water column and atmosphere as well as monitoring techniques used in developing and evaluating potential remedies. The models of sediment transport and uptake by organisms will provide insight into the time scale appropriate for implementing the monitoring techniques to measure progress toward the cleanup goal. We expect the program office to work with ORD to provide this information to remedial project managers through fact sheets, guidance, or other technology transfer mechanisms.

5.4.2 Theme: Ground Water

Contaminated ground water is a problem at most Superfund sites and at virtually all LUST corrective action sites as well as many RCRA Corrective Action and Brownfield sites. We now know that remedies are taking much longer than originally anticipated. Operation and maintenance costs are substantial and conventional remedies may not be able to achieve cleanup objectives in reasonable time frames or at all, particularly for contaminants that are newly found to pose risks at concentrations once deemed acceptable.

The research is driven by science and technology questions related to characterizing the contamination and developing cost-effective and efficient remedial options. These questions are addressed differently for three classes of problematic yet pervasive ground water contaminants—DNAPLs, inorganic species, and fuel components, including oxygenates—and for hydrogeologic regimes that challenge existing characterization and remediation options.

Key research questions addressed:

- What are alternatives to pump and treat methods?
- What characterization, sampling, and analytical methods will reduce the uncertainty in F&T models and will improve exposure estimates supporting risk assessments?
- For DNAPL research: (1) How much DNAPL must be removed to be protective of human health and the environment, and (2) Are current technologies adequate to achieve this level of removal?
- What long-term performance tools are needed to evaluate the effectiveness of MNA?
- Can PRBs be applied to treat inorganic GW contamination?
- How can modeling and sampling methods be improved to reduce uncertainty in analysis of vapor intrusion into homes?
- What are strategic approaches to assess ground water–surface water interactions?
- How can F&T models of fuel components be improved to reduce uncertainty?
- What are cost-effective approaches for characterization and remediation of fractured rock settings?

- What are the factors and improvements that could be applied to natural or commercial processes to reduce the impact of mining sites on surface and ground waters?
- To what extent are the scientific advances in ground water research impacting the long-term stewardship of hazardous waste sites?

The remediation of subsurface formations contaminated by non-aqueous phase liquids (NAPLs) is a major impediment to the restoration of many hazardous waste sites. NAPLs are classified as those lighter than water (LNAPL) or denser than water (DNAPL) and can serve as long-term sources of contamination impacting both ground water and surface water. The remediation of DNAPL-contaminated sites is particularly challenging because DNAPLs can migrate deep through the saturated zone, leaving a trail of hydraulically trapped organic liquid. The rates and extent of migration are dependent on physical and chemical properties of the DNAPL and hydrodynamic properties of the subsurface. The resultant spatial distribution of DNAPLs can be very complex and difficult to locate and characterize. The region of the subsurface containing DNAPL, either as randomly distributed pools of organic liquid or sub-zones at residual saturations, is termed the *DNAPL source zone*.

Constituents from trapped DNAPL slowly partition into ground water to create and sustain dissolved contaminant plumes that may extend significant distances from the source zone. The extent of the dissolved plume will be determined by contaminant flux from the source and the capacity of the subsurface to attenuate the migrating dissolved contaminant (Figure 4). The most prevalent DNAPLs (halogenated organic solvents, e.g., trichloroethylene and tetrachloroethylene) are not readily degraded and relatively large dissolved plumes of these chemicals are frequently observed.

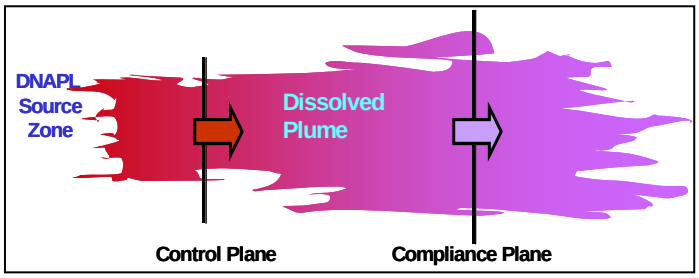


Figure 4. DNAPL Source Zone and Dissolved Plume

Characterization of ground water contamination is a critical issue, particularly for DNAPLs, which do not behave like dissolved contaminants, and for vapor intrusion into buildings which has parameter uncertainty issues for modeling exposure and migration of ground water contaminants into buildings. Research will produce characterization, sampling, and analytical methods to reduce the uncertainty in F&T models, which will improve exposure estimates supporting risk assessments. Improved understanding of the nature and extent of contamination will also influence selection and implementation of remedial actions and will result in more accurate cost estimates.

Research on releases from leaking underground fuel storage tanks will include oxygenates that represent a characterization and remediation challenge in themselves as well as affecting the behavior and treatment of hydrocarbon fuel components. F&T studies will lead to

improved modeling capability that predicts plume behavior and the effectiveness of remedial alternatives. Development will continue on a set of on-line calculators and a modeling system intended to be used by states in assessing the large number of LUST corrective action sites.

Development or enhancement of remediation technologies on challenging ground water contamination issues is a significant segment of the research effort. Recent research and demonstration projects have led to new alternatives to conventional pump-and-treat technologies that are being adopted in the field. Recommendations from an international external panel, addressing the effectiveness of DNAPL source elimination and the options for dealing with inevitable residual contamination, have helped shape the research goals that are being addressed in the research program.

Conventional remediation techniques designed for dissolved contaminant removal have proven inadequate for achieving acceptable environmental cleanup goals within reasonable time frames for DNAPL source zones. However, field-scale research conducted by ORD has demonstrated that a high percentage of DNAPL mass can be rapidly depleted from source zones by using aggressive *in situ* thermal or chemical flushing technologies. Even with these aggressive technologies, the efficiency of DNAPL removal often decays exponentially with increasing mass removed, and complete DNAPL removal may not be technically or economically feasible. For such sites, the key questions are as follows: (1) How much DNAPL must be removed to be protective of human health and the environment, and (2) Are current technologies adequate to achieve this level of removal? To answer these questions we must understand the relationships between DNAPL mass depletion, contaminant mass flux from the source zone, and dissolved plume properties. The ORD DNAPL source remediation research is focused on three critical issues: (1) Demonstration, evaluation, and optimization of DNAPL remediation technologies; (2) Assessment and prediction of the benefits of partial DNAPL depletion; and (3) Development and assessment of integrated DNAPL source remediation approaches.

Increasingly, inorganic contamination of ground water resources from arsenic, chromium, perchlorate, and radionuclides is recognized as a significant issue. Sources include large DOE and mining megasites as well as industrial and naturally occurring sources (e.g., arsenic). Remediation of inorganic plumes in ground water follows a dual track of assessing the potential effectiveness of MNA and PRBs, building on successful development of these approaches for organic contaminants. Because metals can't be destroyed, the mechanisms of immobilization are critical to the long-term performance of these approaches. MNA research focuses on identifying the attenuation mechanisms and the anticipated stability of the immobilized metals under anticipated geochemical conditions. One of the field studies will test the accuracy of the recently completed, cross-office framework for how to evaluate the applicability of an MNA remedy for a specific site. Research on PRBs will provide two cases of PRB performance in the near-term. Additional research will evaluate the long-term performance and efficiency of PRBs and extend the range of metals that can be addressed with this technology.

Complex hydrogeology impedes the evaluation and remediation of contaminants at sites; additional guidance on effective options for these sites will be provided. Regional experience and research are increasingly identifying the zone of ground water discharge to surface water to be the site of complex interactions. While past research addressed this as it was encountered in field studies, planned research will address the ground water–surface water interaction (GSI) zone more systematically.

A summary of the research for PRBs, MNA, and remediation of DNAPL source zones will be documented to determine the impact of each research area with respect to the long-term stewardship of hazardous waste sites. An evaluation of the state of the science is needed for each research area to determine the actual impact of the research on the stewardship of the sites.

5.4.3 Theme: Multimedia and Technical Support Program

Key research questions addressed:

- What cost-effective analytical and statistical methods are needed to support site characterization issues?
- What improvement will reduce uncertainty in modeling of oil spill fate and effects?
- What are the impacts of new or improved oil spill countermeasure approaches on fresh and saline water environments?
- What are the factors and improvements that can be applied to natural or commercial processes to reduce the impact of mining sites on surface and ground waters?

The Office of Solid Waste and Emergency Response (OSWER) and its Regional Offices require innovative methods and techniques to solve the difficult site characterization, contaminant containment, and risk management problems found at numerous contaminated sites throughout the United States. The research under the Multimedia and Technical Support theme includes development of analytical methods, field sampling guidance, statistical software, oils spills dispersal modeling and remediation, monitoring and remediation technologies for mining sites (specifically bioreactors), and the technical support infrastructure needed to move the products of these R&D activities from the lab and into the hands of site managers and other decision makers.

Site Characterization, Analytical Methods, and Statistical Analysis

This topic is an integral step in site characterization. Before predictions of contaminant F&T can be made, risk assessments performed, or remediation options evaluated, an understanding of the types of contaminants present and the extent of their dispersal in the environment must be acquired. Analytical methods research supports this understanding by improving cost, accuracy, portability, and speed of analysis for the most common or most difficult to analyze inorganic and organic contaminants. Immunochemical and other bioanalytical methods can allow rapid on-site characterization and monitoring of remediation

and cleanup activities at Superfund sites. Immunoassay detection, immunoaffinity chromatography sample preparations, electrochemical immunosensors, and coupled immunoassay detection/chromatography/mass spectrometry methods will be developed that allow for rapid, accurate, and precise quantification of various contaminants in the field. The use of these field methods will allow real time decisions to be made on additional sampling needs, delineating contaminant distributions, and determining the effectiveness of remedial actions. Future bioanalytical work will include development of dioxin assays for soil and sediments and a shift in focus to real-time and more cost-effective ground water analytical methods in response to Regional Research Advisory Groups client requests for additional analytical methods development for the ground water medium.

Additional analytical method development will include methyl mercury analyses in liver and muscle tissues for fish taken from Superfund mercury-impacted areas and the use of semi-permeable membranes and isotope dilution mass spectrometry for PCB analyses.

The assessment and cleanup of sites contaminated with multiple contaminants in multiple media is a complex process in which many factors can influence the validity and confidence in the final data used to decide on future actions at the site. Research in statistical sampling and data analysis is aimed at improving or developing statistical methods to reduce data uncertainty in the experiment or measurement process for environmental decision making. Peer-reviewed journal publications, book chapters, and guidance documents on robust data analysis, including multivariate outlier testing, causal outlier variable methods, principal component analysis, discriminant analysis, censored data analysis, multivariate geostatistical methods, and methods in parallel space, will be some of the outputs of this work. For site managers, the SCOUT statistical software package will be upgraded with new robust statistical procedures and a geostatistical model that allow for more advanced statistical techniques to be used in the assessment of the validity of analytical data. A field-sampling guidance document to identify methods and techniques to eliminate bias that occurs during field sampling will also be developed. This research will help site managers understand the driving factors and tradeoffs affecting environmental sampling design and to assess the validity (with increased confidence) of the data used during decision making on site characterization and remediation efforts.

Oil Spills Research

The ORD oil spills research program supports the preparedness and response functions of the Oil Spills Program within OSRTI, funded by a separate trust fund. Research is focused in three areas: developing a better understanding of fate and effects of spilled oil; development of testing protocols for spill control; and development of response options.

Developing modeling methodologies to assess the fate and effects of oil spills in fresh and saline waters will provide important tools, methods, models, data, guidance, and technical support to site managers and other decision makers and stakeholders to use in assessing and cleaning up spills of petroleum and non-petroleum oils. This work will provide essential information on dispersion and effects of dispersant treatments on spilled petroleum, non-

petroleum oils, and their constituents. Some of the major outputs of this work will be a report on linkage of the EPA research object-oriented-oil spill model (ERO^3S) oil spill model to surface water transport and quality models, assessments of optimal parameters for nutrient application for oil spill bioremediation on beaches, and assessments of optimal conditions for the bioremediation of wetlands. A major goal of this research effort is to develop a multicomponent mass-balance-based model for simulating transport of spilled oils with and without dispersant treatments.

Selection of appropriate risk management options in oil spill scenarios is supported through the development of protocols to evaluate spill response products and through development of new risk management strategies for petroleum and non-petroleum oil spills in fresh and saline environments. By FY07, the first phase of laboratory and field studies will be completed on the risk management and fate and effects of oil in fresh and saline environments. This will include work on petroleum and fuel emulsions, chemical and biological treatment, climatic effects on oil spills, dispersant modeling, and ecosystem exposure as a function of various response scenarios. By FY08, risk management strategies will be developed for non-petroleum oil spills. ORD, in collaboration with Fisheries and Oceans Canada, has funded the construction of a wave tank in Halifax, Nova Scotia, which generates breaking waves reproducibly. The wave tank will allow quantification of dispersant efficacy as a function of sea turbulence and the development of correlations between laboratory and wave tank data. In collaboration with Canada, work is also underway to develop a surface-washing agent to remove oil from coated surfaces, followed by round-robin validation testing.

Mining

One of the highest priorities and needs of many of the EPA Regions has been mine water remediation. It is estimated that there are over 400,000 abandoned mine sites in the western United States, and almost all of these sites contain contaminated waste and water. In the past 5 years, technical assistance for active and passive treatment of mine water has accounted for upwards of 25 % of the engineering assistance requests. While active treatment has been utilized at the larger mining mega-sites, there is a need for treatment systems that can be located in remote areas and at higher elevations. In these areas, there is no power source, access is restrictive, and the treatment season is very short because of winter weather. ORD has been actively supporting the research and acceptance of passive systems that require little power, have an acceptable operational life, and rely on chemical precipitation and adsorption as well as biological processes (sulfate-reducing bacteria and other microorganisms) to treat the water. The science is still in its infancy and has to be proven effective to meet effluent criteria and sustainable over longer periods of time.

Providing Technical Support to the Regions and States

Providing technical support to the Regions and states is an important part of the ORD LRP. Through the technical support program, the products of ORD's R&D activities move from the laboratories and field studies into the hands of site managers and other decision makers. In

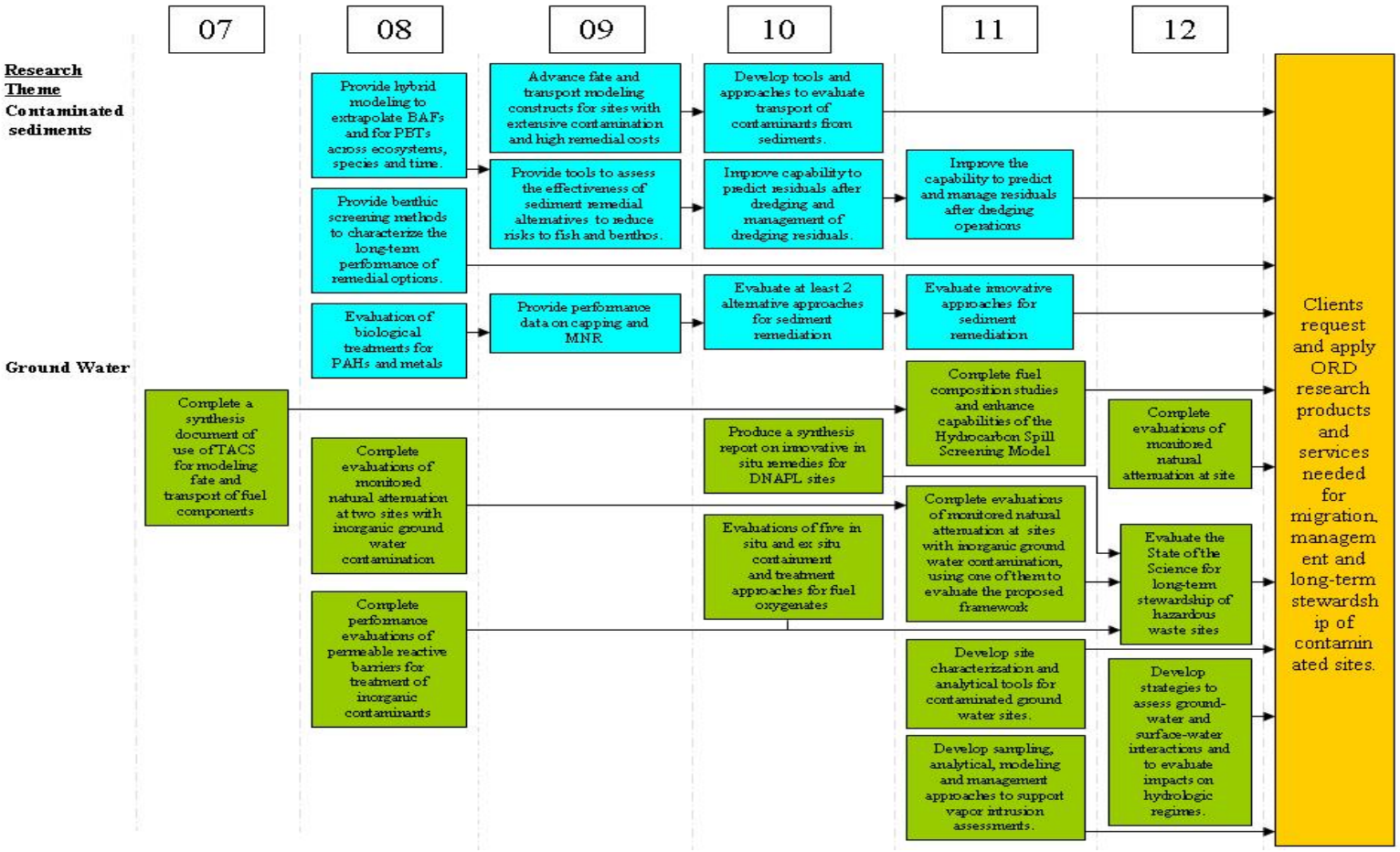
addition to this technology transfer function, the technical support program provides site-specific assistance in response to regional site manager requests. Other aspects of the technical support program include technology transfer via hotlines, websites, workshops, and client-oriented publications. OSWER and the regions have consistently cited technical support, and particularly site-specific assistance, as their top priority for ORD. In addition to ORD resources of FTE and extramural funds, OSWER and the regions provide Superfund extramural funds directly to several of the centers. Except where restricted by trust fund limitations, the centers provide support for Superfund, including Sediments, Ground Water/Surface Water, Multimedia, Mine Waste and Water, Modeling, RCRA, and Brownfields, to project managers. In most years, more than 500 assistance activities are completed for more than 100 sites. In Appendix H, the eight ORD Technical Support Centers are described. Because technical support activities are request driven, outputs and products are not listed in Table 4. Instead, the Centers provide annual reports to the Program Office, and issues are discussed at the annual progress review.

5.4.4 Performance Measures: Wiring Diagram of Research Theme APGs Leading to LTG

Figure 5 presents the path of contaminated sediments, ground water, and multimedia research, presenting the completed APGs as performance measures of progress toward the LTG. Contaminated sediment APGs address key issues in sediment remediation; improved F&T modeling; measures of risk reduction after remediation; estimates of residual contamination after dredging; methods to mitigate polyaromatic hydrocarbons (PAHs) and metals; and performance data on capping, MNR, and alternate remediation methods.

Ground water APGs include the following: completion of a geophysics-toolbox to monitor natural attenuation, and analytical method development and detection levels, applications for PRBs for inorganic contamination, risk management methods and performance measures for MNA and a synthesis document for DNAPL, and guidance on characterization and remediation approaches for fractured rock settings. APGs for emerging issues include assessment of ground water–surface water interactions and sampling methods for vapor intrusion into homes, and reducing uncertainty for vapor intrusion models. LUST accomplishments include enhanced screening models, F&T of fuel components, and evaluations *in situ* and *ex situ* containment and treatment approaches for fuel oxygenates.

Multimedia APGs will include improved methods for modeling the fate and effects of oil spills. Site characterization methods will be improved through additional sampling and analytical method development. Statistical methods will reduce uncertainty in measurement of contaminant distribution. Risk management APGs will include strategies to manage petroleum and non-petroleum oil spills as well as countermeasure methods. An APG will address monitoring and treatment methods for mining sites.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Research Theme
Contaminated sediments
Ground Water
Provide hybrid modeling to extrapolate BAFs and for PBTs across ecosystems, species and time.
Advance fate and transport modeling constructs for sites with extensive contamination and high remedial costs
Develop tools and approaches to evaluate transport of contaminants from sediments.
Provide tools to assess the effectiveness of sediment remedial alternatives to reduce risks to fish and benthos.
Improve capability to predict residuals after dredging and management of dredging residuals.
Improve the capability to predict and manage residuals after dredging operations
Provide benthic screening methods to characterize the long-term performance of remedial options.
Evaluation of biological treatments for PAHs and metals
Provide performance data on capping and MNR
Evaluate at least 2 alternative approaches for sediment remediation
Evaluate innovative approaches for sediment remediation
Complete a synthesis document of use of TACS for modeling fate and transport of fuel components
Complete fuel composition studies and enhance capabilities of the Hydrocarbon Spill Screening Model
Complete evaluations of monitored natural attenuation at site
Produce a synthesis report on innovative in situ remedies for DNAPL sites
Complete evaluations of monitored natural attenuation at two sites with inorganic ground water contamination
Complete evaluations of monitored natural attenuation at sites with inorganic ground water contamination, using one of them to evaluate the proposed framework
Evaluate the State of the Science for long-term stewardship of hazardous waste sites
Evaluations of five in situ and ex situ containment and treatment approaches for fuel oxygenates
Complete performance evaluations of permeable reactive barriers for treatment of inorganic contaminants
Develop site characterization and analytical tools for contaminated ground water sites.
Develop strategies to assess ground-water and surface-water interactions and to evaluate impacts on hydrologic regimes.
Develop sampling, analytical, modeling and management approaches to support vapor intrusion assessments.
Clients request and apply ORD research products and services needed for migration, management and long-term stewardship of contaminated sites.

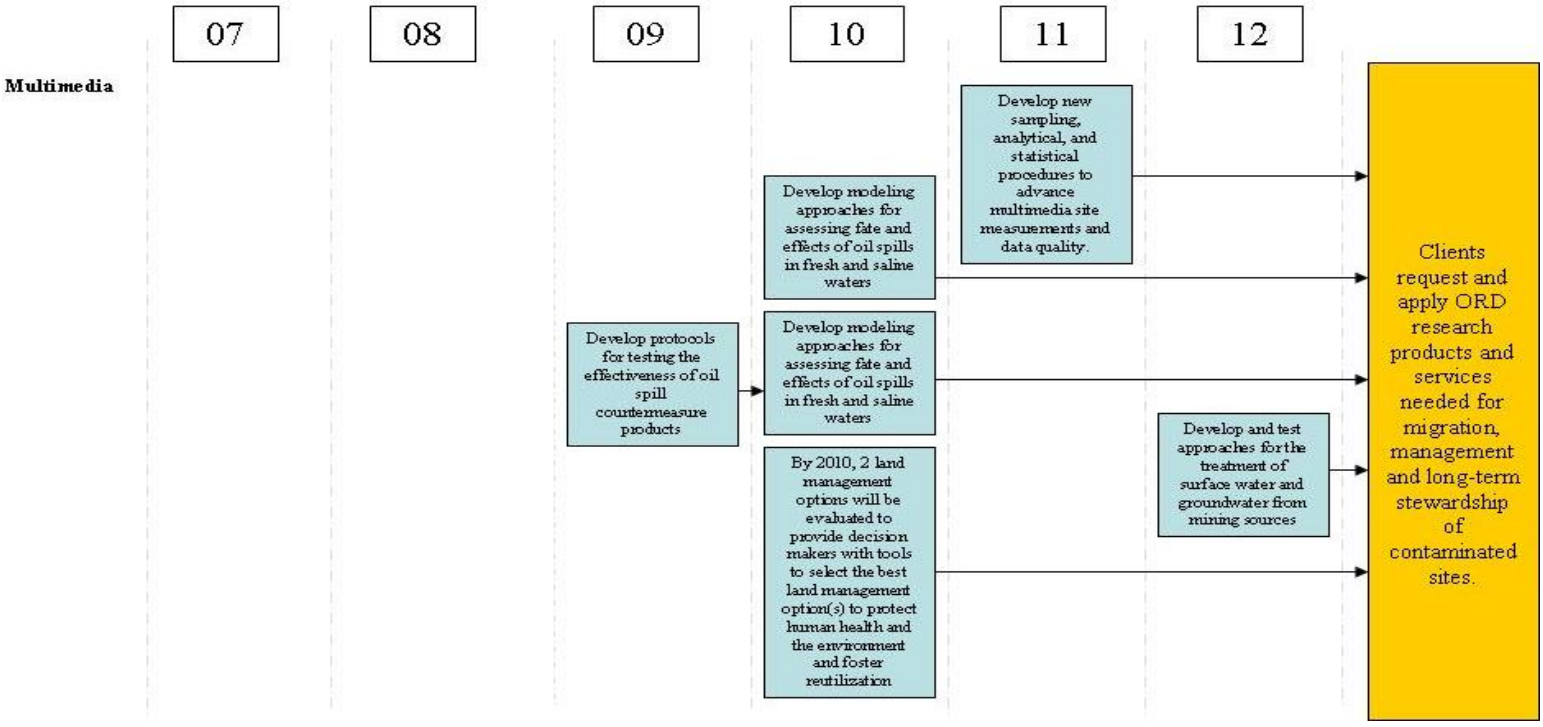

Figure 5. Performance Measures (APGs) Supporting the Long-Term Goal

5.4.5. Summary of Performance Measures Linking Research Activities, Outputs, and Short- Term Outcomes

Table 2 presents LTG 1 research activities and outputs by research theme. These are related to short-term outcomes or the utilization of research products by OSWER, the Regions, or their contractors. The topics in Table 2 are part of a logic model process leading to long-term outcomes.

Table 2. Research Activities, Outputs, and Short Term Outcomes to Support Long-Term Goal 1

ACTIVITIES	OUTPUTS	SHORT-TERM OUTCOMES
Sediments 1. Methods and models on extent of contamination 2. Application of hybrid models to assess PBTs; effects of remediation on biota; bioavailability 3. Technology development and evaluation of risk	**Sediments** 1. Advanced F&T models and tools for PBTs 2. Linkage of residues and effects to biota; effects of resuspension and long-term remediation options 3. Performance data on *in situ* methods, dredging residuals, and method development.	**Sediments** 1. Use in guidance and site-specific application to reduce uncertainty 2. Use in guidance and in site assessments to reduce uncertainty 3. Use in guidance, adoption, and use in site-specific decisions and records of decision (RODs).

management options. **Ground Water** 4. Characterization and analytical tools; VI methods; underground storage tank (UST) fuel transport 5. DNAPL and inorganics: methods on innovative treatments; performance evaluations, GW-SW interactions; treatment of fuel oxygenates. **Multimedia** 6. Analytical and statistical methods development 7. Technical Support Centers (TSCs) use ORD staff and tools to address site-specific issues 8. Develop improved methods to mitigate oil spills.	**Ground Water** 4. Analytical methods; VI enhanced models & methods; synthesis of fuel F&T models 5. Synthesis report on *in situ* methods; PRB uses, treatment methods for fuel oxygenates. **Multimedia** 6. Standard sampling and analysis methods 7. Answer site-specific questions from regional staff 8. Improved management strategies for oil spills.	**Ground Water** 4. Use at site characterization; VI model reduces uncertainty; UST F&T of fuels used in guidance 5. Remediation guidance, adoption, and use at sites and in RODs. **Multimedia** 6. Use in guidance, standard methods, and site-specific application 7. Regions use improved tools to characterize, assess, and remediate specific sites to reduce uncertainty, time, or expense 8. Use in guidance, regulation, and site- specific application.

5.5. Long-Term Goal 2: Research Questions, Description of Research Program, and Performance Measures

LTG 2: Clients request and apply ORD research products and services needed to manage material streams, address emerging material streams, and conserve resources.

The Office of Solid Waste, state agencies, and local governments make decisions about materials use, management, and ultimate disposition. Over the past several years, conservation of resources and reuse of materials formerly considered waste has received considerable attention. The research program has been evolving to consider not only appropriate waste disposal but also beneficial use, avoidance of more toxic materials, and operation of waste management to conserve capacity and produce energy. To address emerging material management issues, a strategic shift in the research program was made to conduct nanomaterial F&T research and establish the program as the leader across the federal government in this research area.

To achieve this goal, ORD must identify accurately the scientific uncertainties which, when addressed, make the clients' mandated responsibilities and actions most cost-effective and scientifically defensible. From the clients' perspective, activities related to the nature of material streams, mitigation and management of materials, conservation of resources and long-term

stewardship are important. Because the program office, regions, and states are still evaluating the highest priority material streams, we anticipate that the specific materials covered in the research program described below may change over the implementation period. The annual program review and budget refinement cycle provide the forum for ORD and clients to concur on changes in emphasis.

5.5.1 Theme: Resource Conservation

Key research questions addressed:

- What are the risk reductions from waste minimization programs?
- What models and tools can be developed and applied to support community decisions on Brownfields?
- What information on sustainable waste management practices can be integrated to support the Resource Conservation Challenge?
- What are the metrics for sustainability in Land Revitalization/Brownfields efforts, and how can they be applied in urban planning?

ORD has conducted extensive development of a modeling framework, originally intended to evaluate relative risks on a national basis, of various waste disposal options for use in regulatory decision making. Because OSW has now completed the majority of its mandated regulations, the need for modeling alternative risks has evolved to addressing questions related to regional or site-specific assessments, newer waste streams (e.g., electronic waste, nanomaterials), and the new emphasis on resource conservation and reuse through largely voluntary programs. In addition to modeling, material evaluation by speciation and leach testing is needed to understand what hazardous constituents might be released in various disposal and use scenarios.

OSW has targeted specific materials for volume reduction to minimize generation of hazardous waste and other materials for beneficial use to demonstrate one facet of resource conservation. Research is planned to support these efforts with case studies. A modeling study has already begun to evaluate the risk reduction achieved by reducing waste minimization priority chemicals (WMPCs). The 3MRA model is being used to develop comparative assessments of ecological and human populations risk reduction resulting from achievement of current and future waste reduction goals for up to 9 of 31 WMPCs (e.g., Pb, Hg, trichlorinated dibenzodioxins [TCDD]). An outcome of this work will be an ability to quantify, on a national scale, the reduction in risk to human and ecological receptors resulting from the reduction of selected WMPCs found within waste streams reaching industrial solid waste management facilities. Another case study will evaluate alternatives for lead in industrial usage. Emphasis will be placed on comparing the risks from lead use and release with risks from potential substitute materials.

Multimedia risk assessment methodologies for the Resource Conservation Challenge will be built on prior collaborative work between ORD and OSW that developed the Multimedia,

Multipathway, and Multi-receptor Risk Assessment (3MRA) modeling system in support of the Hazardous Waste Identification Rule (HWIR). The 3MRA modeling system is composed of 17 science sub-models that simulate source contaminant releases to the environment, F&T of contaminants through soil, air, and water media; and evaluation of exposure and risk for both human and ecological (terrestrial and aquatic) receptor populations. A critical feature of the 3MRA is the software system design. The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) is a software infrastructure designed to facilitate the development, testing, application, and maintenance of science-based modeling systems such as the 17 modules of 3MRA. The 3MRA modeling system received a very positive review by the SAB in 2005. Given the application of multimedia media modeling techniques to varying problems, a collaborative relationship was formalized in a Memorandum of Understanding (MOU), initiated in June 2001, and involves nine federal agencies. The purpose of the MOU is to establish a framework for facilitating cooperation and coordination among the signatory agencies in their R&D of multimedia environmental models.

Due to the shift in modeling focus to nanomaterials, the development of 3MRA will be slowed. However, the transfer of the sophisticated model to address other program office and regional needs will be conducted. There are increasing quality assurance requirements being placed on regulators to address uncertainty analysis, sensitivity analysis, and parameter estimation (UA/SA/PE) in model-supported, risk-based decision making. In addition, understanding and quantifying the uncertainty associated with exposure assessments is requisite for developing risk estimates with scientifically defensible confidence limits. Specific components of this research effort include development of UA/SA/PE tools that can serve multiple Program Office needs in meeting new quality assurance standards (e.g., EPA's Council on Regulatory Environmental Modeling, Data Quality Guidelines) and model simulation demands for national, regional, and site-specific studies.

Brownfields and Land Revitalization

Use of greenspace contributes to urban sprawl, reduction of natural resources, and destruction of natural systems. Revitalization of previously used land (e.g., brownfields) does not always occur because of obstacles related to real and/or perceived contamination (e.g., fear of uncertainty and potential liability, lack of financial resources to remove contamination, lack of vision, lack of communication, fear of time commitment, etc.). It is important to encourage the revitalization of previously used lands such that existing social and environmental systems are maintained and even enhanced in an economically advantageous manner.

Through the development of tools, approaches, methods, and technologies, we can facilitate revitalization of potentially contaminated sites while encouraging stakeholders to incorporate a balance of social, economic, and environmental interests and objectives into growth and development that will not negatively impact current or future generations. For example, a decision support tool called SMARTe will inform revitalization stakeholders about the entire revitalization process, help them overcome obstacles to revitalization, and assist them in the complex selection of reuse options. A standardized method for soil gas measurements will

reduce the error associated with soil-gas sampling and the movement of vapors (i.e., vapor intrusion) into buildings/homes. ORD will continue to develop GIS and Remote Sensing Tools to inventory Brownfield sites. Sustainability Planning Criteria will be developed, implemented, and evaluated for land use planning so communities and towns can develop to meet citizen needs and expectations while leaving the essential attributes of economic, social, and ecological systems intact and able to sustain future generations. Training and technical support to OSWER, regions, states, and local governments will continue to support the remediation of Brownfield sites.

The Brownfields efforts have been carried out through an ORD FTE and an intra-agency funding transfer from OSWER to ORD; these products are reflected in this plan.

5.5.2 Theme: Materials Management—Emerging Research

Nanomaterial Fate and Transport (F&T)

Key research questions addressed:

- Which engineered nanomaterials have a high potential for release and exposure from a life-cycle perspective?
- What technologies exist, can be modified, or need to be developed to detect and monitor releases of and exposures to engineered materials?
- What physical and chemical properties *and processes* determine the environmental release, fate, and transport of engineered nanomaterials?
- What are the exposure routes for human and ecological receptors to engineered nanomaterials? What are the forms of the engineered nanomaterials to which these receptors will be exposed?
- What properties of engineered materials are associated with potential hazard?
- What techniques and tools exist, can be modified, or need to be developed for detecting and predicting hazards of engineered nanomaterials?
- What are the prioritized information gaps that need to be addressed to support comprehensive assessments of ecological and human health risks of nanomaterials?
- How will EPA's risk assessment approaches need to be modified to accommodate the special properties of nanomaterials?

For nanotechnology F&T research, the primary objectives will be to determine the physicochemical properties and processes controlling nanomaterial movement through soil and aquatic ecosystems. The research will also focus on the engineering factors to understand the transformation, transport, and longevity of the engineered nanomaterials. Specific research will also investigate the life-cycle assessment of nanomaterials, particularly to understand their fate for emissions and releases. Research questions include the identification of system parameters that alter the surface characteristics of nanomaterials through aggregation (e.g., pH effects), complexation (e.g., surface complexation by dissolved organic carbon), or changes in oxidation state (e.g., chemically or biologically mediated electron transfer). This work will provide the

basis for prioritizing potential ecological exposure pathways that warrant further exploration. This work will complement funded STAR grants. The Agency's efforts are coordinated with other federal agencies through the National Nanotechnology Initiative (NNI), which the Administration has identified as a FY 2008 R&D budget priority. EPA's nanotechnology research is also guided by a draft research needs document being prepared by the Nanotechnology Environmental and Health Implications Working Group.[4] EPA will develop into the federal lead for environmental F&T research outlined in the NNI draft research needs document.

5.5.3 Theme: Materials Management—Disposal, Reuse, and Containment

Key research questions addressed:

- What is the mobility of metals in reuse of coal combustion products?
- What are the appropriate leaching methods to determine chemical mobility in material reuse scenarios?
- How can landfills be managed to conserve resources?
- How can the service life of a landfill be extended?
- How can landfill bioreactors be optimized for performance?
- What emerging waste materials issues require scoping?

Leach Testing for Material Reuse

The modeling approach to risk assessment will be supplemented with a modest program to evaluate wastes for their capacity to release hazardous constituents into the environment, either in a disposal setting or in reuse. Leach testing is a normal component of evaluating waste materials for compatibility with the local environment. As the range of potential environments expands (e.g., road bed, use in drywall and concrete, mine filling, land application, etc.), it becomes more critical to be able to simulate the release of hazardous constituents. Over the last several years, ORD has been investigating a range of leaching tests that consider pH, redox state, liquid:solid ratio and other parameters recognized as factors in determining the release of hazardous constituents. These studies will continue, with the aim of validating the predictive capability of a set of tests. This program is complemented and supplemented by an evaluation, under Goal 1–Air, of the application of a particular testing protocol to coal combustion residues (CCRs) and comparison of the results to leachate data from CCR monofills. ORD also plans to evaluate risks from beneficial use of CCRs or other materials that are normally disposed of in landfills.

[4] For more information, see http://www.nano.gov/html/society/NEHI.htm.

Landfill Research

Before varied risk management options can be evaluated and informed selection of the appropriate option made, research is needed to evaluate the existing risk management options and to develop new options when existing management options are insufficient to meet site management goals. Recent accomplishments include completing a multi-site study of alternative covers for landfills, which has resulted in selection of the new technology at both Superfund and RCRA sites and development of an *in situ* stabilization method for lead that renders it less mobile and less bioavailable.

Research in the next 5 years will focus on exploiting the chemical properties of contaminants and their host environment and inherent biological activity to develop new approaches for risk management. Our experience with MNA and recovery, alternative covers, and lead stabilization indicates that more complete understanding of the biogeochemistry of a system can lead to simpler technology and lower cost approaches for mitigation of risk. X-ray analysis tools will be applied to contaminants of concern to elucidate their speciation and interaction with surrounding environmental media and interaction with micro- and macro-organisms to develop approaches to alter the speciation in ways that promote degradation, removal, immobilization, or conversion to biologically less active forms.

With respect to traditional landfills, the remaining research needs relate to construction testing and long-term performance of materials used in composite covers and liners. Recent data suggest some performance problems associated with clay and geosynthetic clay liners (GCLs) when used as cover components. Additional work will address fugitive emissions, seismic stability, and development on closed landfills. The National Academy of Sciences will be providing ORD with a report on long-term protectiveness issues in FY08 that will further refine future research needs.

Ongoing research on the operation of landfills as bioreactors will continue. Bioreactors can contribute to resource conservation in two ways: (1) Accelerated waste decomposition results in volume recovery, reducing the need to site new landfills, and (2) Accelerated methane production may make energy recovery more economical. ORD has supported OSW in developing the Research Development and Demonstration (RD&D) rule for landfills, which provides flexibility to the states to allow innovative approaches to management of municipal landfills. As a result of this rule, ORD and OSW are working with the states to assist them in evaluating the effectiveness of landfill bioreactors. The research is addressing operation and monitoring parameters as well as evaluating risks such as increased fugitive emissions. Results to date have been incorporated in training and technology transfer materials used by state permitting officials.

Combustion has been an ongoing research area and will be eliminated in FY08. In-house work focused on monitoring devices to detect chlorinated dioxins and furans or surrogates and mercury. ORD provided technical support as OSW completed development of maximum achievable control technologies (MACT) regulations for combustion facilities under the Clean

Air Act. Emissions monitoring is important to ensure that waste combustors are operated in compliance. The loss of the modest resources in LRP is mitigated by more significant resources in other goals that address air toxics and mercury.

5.5.4. Performance Measures: Wiring Diagram of Research Theme APGs Leading to LTG 2

The diagram below (Figure 6) is the research path for resource conservation research supporting LTG 2. The APGs supporting the determination of risks associated with materials include assessing outcomes for reductions in priority chemical streams and leaching methods. Leach testing methods will contribute to assessments of material reuse. Brownfields products will expand the tools and methods to support community decisions on land reuse and urban revitalization. Emerging material management issues addressing nanomaterial F&T APGs will produce products to lay the foundation for understanding key nanomaterial characteristics in the mobility and fate of these materials. Multimedia modeling will address science improvements and support nanomaterial modeling issues. In material management, landfill and bioreactor goals will include research to improve liner performance and service life. The increased utilization of bioreactors at landfills will be promoted through completion of guidance documents on the design, operation, and maintenance of the systems. Management methods for emerging wastes materials will also be addressed.

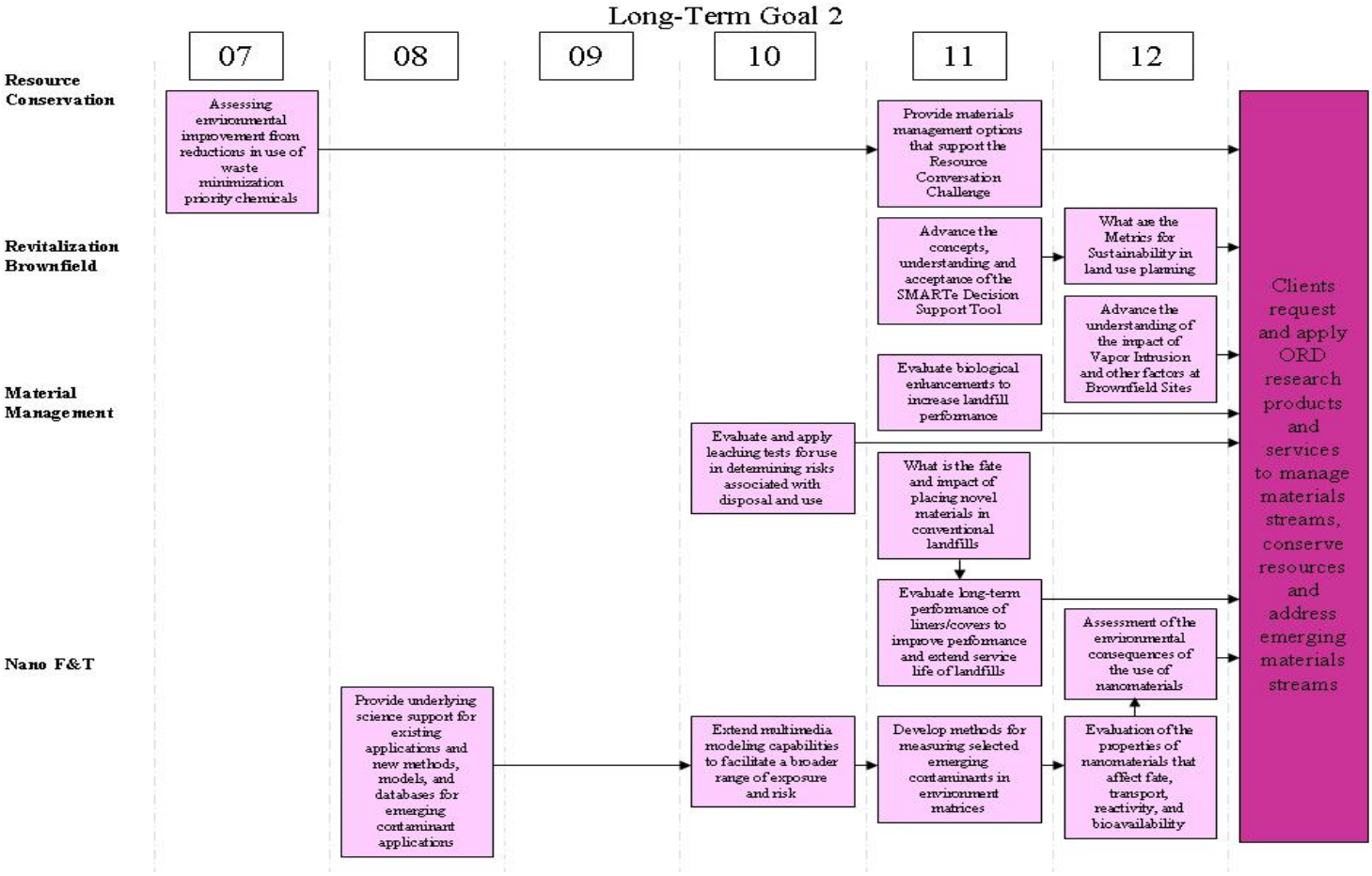

Figure 6. Performance Measures (APGs) Supporting Long-Term Goal 2

5.5.5. Summary of Research Activities, Outputs, and Short-Term Outcomes

Table 3 presents LTG 2 research activities and outputs by research theme. These are related to short-term outcomes or the utilization of research products by OSWER, the regions, or their contractors. The topics in Table 3 are part of a logic model process leading to long-term outcomes.

Table 3. Research Activities, Outputs, and Short-Term Outcomes for Long-Term Goal 2

ACTIVITIES	OUTPUTS	SHORT-TERM OUTCOMES
Resource Conservation 1. Develop methods to sample and assess risks from waste-derived products	**Resource Conservation** 1. Methods and assessments of risk of material reuse 2. National assessment of waste minimization	**Resource Conservation** 1. Supports regulatory and risk management decisions on material reuse 2. Report will focus waste

2. Assess benefits from waste minimization 3. Enhanced multimedia modeling applications 4. Brownfields: research to enhance methods and models for decision support tools.	3. Synthesis report on 3MRA and site-specific demonstrations of its use 4. Publish SMARTE reports and update Web site to tech transfer information to regions, states, and communities.	minimization efforts on major waste streams 3. Use in guidance and site-specific application to reduce uncertainty 4. Provides a decision support tool so communities can make decisions on development of Brownfields sites.
Materials Management 5. Evaluation of performance alternative caps for landfills 6. Research on bioreactor design, operation, and monitoring 7. Research on leaching from material streams and reuse of materials 8. Research on nanomaterial F&T.	**Materials Management** 5. Tech transfer of long-term performance evaluations to regions and states 6. Design manual and synthesis report on landfill bioreactor performance 7. Synthesis report on leachates and reports on material reuse 8. Reports F&T of nanomaterials in media, and key nanomaterial characteristics that affect fate and mobility.	**Materials Management** 5. Significant cost savings at multiple sites per year 6. Supports guidance and regulations on use of landfill bioreactors 7. Supports guidance and regulations on leachates and material reuse 8. Provides scientific leadership in this research area for federal government.

6.0 Annual Performance Goals and Measures

The following tables present APGs and APMs for the Land Research Program. The information is organized in the following manor: Long-Term Goal, Research Theme, Supporting APGs, Supporting APMs. The APGs and APMs are for FY06–FY12 and, unless indicated, are not official GPRA commitments.

Table 4. Annual Performance Goals and Measures for Long-Term Goals 1 and 2

Long-Term Goal 1: Clients request and apply ORD research products and services needed for mitigation, management, and long-term stewardship of contaminated sites.		
1.1 Sediments		
By 2009, provide critical assessment techniques and advanced fate and transport modeling constructs for bioaccumulative chemicals for sites with extensive contamination, high remedial costs, or other complex issues.	**FY09**	**NERL**

	Report on the evaluation of long-term (i.e., 1–10 years) accuracy of the upgraded contaminated sediment F&T models by modeling the transport and fate of sediments in a demonstration site (05-256)	FY06	NERL
	Development of new modules for selected F&T model(s) for certain types of water bodies to address the identified sediment-related needs of OERR and the regions	FY08	NERL
	Provide state-of-the-art contaminated sediment transport modeling system for modeling remedial alternatives at contaminated sediment Superfund sites.	FY09	NERL
By 2010, develop tools and approaches to evaluate transport of contaminants from sediments.		**FY10**	**NRMRL**
	Report on innovative techniques for measuring advective flux (06-208)	FY06	NRMRL
	Flux meter field data sets for advective transport	FY08	NRMRL
	Report on overall flux meter results	FY10	NRMRL
	Case study of semi-permeable membrane devices (SPMDs) on the Anacostia River	FY07	NRMRL
	Application of SPMDs to monitor contaminant migration in dynamic stream environment (milestone)	FY08	NRMRL
	Case study of using SPMDs to evaluate impact of dredging (milestone)	FY09	NRMRL
	Case study of SPMDs to evaluate performance of carbon sequestration	FY10	NRMRL
	Summary report on SPMD applicability for assessing risks and risk management	FY10	NRMRL
	Report on volatilization of contaminants and pathogens from sediments	FY07	NRMRL
By 2008, provide hybrid modeling approaches using empirical field data and bioaccumulation models to extrapolate BAFs and BSAFs for PBTs across ecosystems, species, and time. (08-222)		**FY08**	**NHEERL**

	Provide report on the evaluation of the PCB residue–effects database (06-487)	FY06 **completed**	NHEERL -MED
	Provide the methods and data necessary to parameterize and apply the hybrid modeling/ empirical approach to support ecological risk assessment of bioaccumulative sediment contaminants (BAFs, BSAFs) (06-214)	FY06 **completed**	NHEERL -MED
	Provide a fully field-validated hybrid modeling/ empirical approach for extrapolating BAFs & BSAFs and predicting the ecological effects of mixtures of PBTs with different rates of metabolism on a site-specific basis (08-111)	FY08	NHEERL -MED
By 2008, provide monitoring, measurement, and benthic screening methods and tools to characterize, assess, and communicate current conditions and the long-term performance of remedial options associated with cleanup of contaminated sediments. (10-161)		**FY08**	**NHEERL**
	Report to OSRTI on direct comparison of sediment profile imagery (SPI)/sieving methods at a sediment Superfund site (06-485)	FY06 **completed**	NHEERL -AED
	Report to OSRTI on relationship between SPI and other environmental variables, specifically, dissolved oxygen (07-486)	FY07	NHEERL -AED
By 2009, provide measurements, models, and monitoring data to assess the effectiveness of sediment remedial alternatives to reduce risks to fish and benthos.		**FY 09**	**NERL**
	Evaluation of F&T models for predicting dissolved concentrations of organic and inorganic contaminants in Superfund site sediments following resuspension events (06-483)	FY06 **completed**	NHEERL -AED

	Provide report assessing significance of changes in bioavailability of organic contaminants in Superfund site sediments following resuspension into the water column and resettlement to sediment bed (07-317)	FY07	NHEERL -AED
	Determination of the influence of newly deposited sediments on contaminant concentrations in collected samples (report) (06-212)	FY06	NERL
	Development of sensitive, reliable, and cost-effective elemental speciation methods to measure the toxic and mobile forms of inorganic contaminants (e.g., As, Se, Sn, Hg) in sediments (06-210)	FY06	NERL
	Report on detection of newly deposited sediments via frequency response measurements	FY09	NERL
	Report on application of geophysical methods to measure and verify cap integrity at contaminated sites	FY09	NERL
By 2008, evaluate biological treatments for PAHs and metals.		**FY08**	**NRMRL**
	Interim report on biodegradation of polyaromatic hydrocarbons (PAHs) in sediments (07-216)	FY07	NRMRL
	Two journal articles on biodegradation of PAHs in sediments (08-115)	FY08	NRMRL
By 2009, provide performance data on capping and MNR from at least three sites.		**FY10**	**NRMRL**
	Report on trials of *in situ* treatment cap (06-215)	FY06	NRMRL
	Report on medium-term performance of emplaced caps relative to predictions (07-137)	FY07	NRMRL
	White paper on carbon sequestration caps	FY07	NRMRL
	Report on cap integrity after field placement (SERDP)	FY08	NRMRL
	Report on AquaBlok cap after 3 years	FY08	NRMRL

	Report on field study of carbon sequestration cap	FY09	NRMRL
	Report on MNR performance at Lake Hartwell, SC, at the modeled compliance time (06-213)	FY06	NRMRL
	Long-term data report on MNR at Lake Hartwell, SC	FY09	NRMRL
	Summary of overall MNR performance over time	FY10	NRMRL
By 2011, improve the capability to predict and manage residuals after dredging operations.		**FY11**	**NRMRL**
	Evaluation of case studies and models for predicting dredging residuals	FY08	NRMRL
	Report on land disposal options for management of dredged sediments	FY08	NRMRL
	Evaluation of resuspended sediments and dredging residuals at Superfund sites	FY09	NRMRL
	Report of field study of dredging residuals	FY10	NRMRL
By 2011, evaluate innovative approaches for sediment remediation.		**FY11**	**NRMRL**
	Speciation of arsenic and lead in sediment	FY06	NRMRL
	Manuscript on design of innovative electrochemical destruction (ECD) pilot unit	FY06	NRMRL
	Report of pilot evaluations of electrochemical treatment in a metal/organic environment. (07-136)	FY07	NRMRL
	ECD field test results	FY09	NRMRL
	Summary report on ECD approach	FY10	NRMRL
	Impact of metals speciation on ecological receptors (07-355)	FY07	NRMRL
	Case study of metal speciation	FY08	NRMRL
	Evaluation of perturbation on metal speciation and ecological receptors (08-112)	FY08	NRMRL
	Evaluation of pathogen management alternatives	FY09	NRMRL

1.2	**Ground Water**		
By FY11, develop site characterization and analytical tools for contaminated ground water sites.		**FY11**	**NERL**
	Monitoring of a controlled DNAPL spill using a prototype dielectric tool (report) (06-590)	FY06	NERL
	Geoelectrical detection of surfactant-enhanced aquifer remediation of PCE (report)	FY08	NERL
	A geophysical tool box for site managers: using geophysical methods effectively to monitor natural attenuation	FY10	NERL
	Rapid screening techniques for toxicity testing and the analysis of high-priority ground water contaminants	FY08	NERL
	Bioanalysis of high-priority contaminants in ground water	FY10	NERL
By FY11, develop sampling, analytical, modeling, and management approaches to support vapor intrusion assessments.		**FY11**	**NERL**
	Report on macro- and micro-purge soil-gas sampling methods for the collection of contaminant vapors	FY08	NERL
	Assess bias associated with soil-gas sampling to support assessment of vapor intrusion (06-439)	FY06	NRMRL
	Report on the vertical distribution of VOCs from ground water to soil or subslab interface	FY09	NERL
	Report on effects of seasonal/moisture fluxes on subslab vapor F&T.	FY10	NERL
By FY07, complete a synthesis document of use of TACS for modeling fate and transport of fuel components. (07-141)		**FY07**	**NERL**
	Version 2 of Tools for Analysis of Contaminated Sites (TACS), revised with Version 1 user input (07-315)	FY07	NERL
By FY11, complete fuel composition studies and enhance capabilities of the Hydrocarbon Spill Screening Model.		**FY11**	**NERL**

	Report on 30-year retrospective of U.S. gasoline composition.	FY08	NERL
	Report on research summarizing fuel composition studies.	FY11	NERL
By FY10, produce a synthesis report on innovative *in situ* remedies for DNAPL sites. (10-35)		**FY10**	**NRMRL**
	Report on pilot scale evaluation of adsorption/ oxidation technology for ground water remediation (06-437)	FY06	NRMRL
	Effects of thermal treatment on the chemical reactivity of trichloroethylene (07-141)	FY07	NRMRL
	Journal article on mass flux response to DNAPL source zone treatment	FY09	NRMRL
	Identification and characterization methods for reactive minerals responsible for natural attenuation of DNAPL compounds in ground water	FY09	NRMRL
	Research brief on biological methods to characterize effectiveness of ground water remediation technologies at metals and DNAPL sites (08-116)	FY09	NRMRL
	Synthesis document on DNAPL remediation technologies (10-21)	FY10	NRMRL
Complete evaluations of monitored natural attenuation at sites with inorganic ground water contamination, using one of them to evaluate the proposed framework.		**FY11**	**NRMRL**
	Special issue of *Chemical Geology* on arsenic	FY06	NRMRL
	Issue of paper on metal attenuation processes at mining mega-sites (07-145)	FY07	NRMRL
	Evaluation of trends in site characterization to support use of MNA for remediation of inorganic contaminants in ground water (08-351)	FY08	NRMRL
	Report on the use of decision support framework for MNA+ for inorganic contaminants	FY11	NRMRL

Complete performance evaluations of permeable reactive barriers for treatment of inorganic contaminants. (08-350)		**FY08**	**NRMRL**
	Metal attenuation in acid mine water by sulfate reduction (06-222)	FY06	NRMRL
	Issue paper on mineralogical preservation of solid samples collected from anoxic subsurface environments (06-438)	FY06	NRMRL
	Field application of PRBs for arsenic (08-346)	FY08	NRMRL
	Performance evaluation of organic-based PRB systems for treatment of arsenic and metals (08-352)	FY08	NRMRL
Develop strategies to assess ground water and surface water interactions and to evaluate impacts on contaminant fate and transport between these hydrologic regimes.		**FY12**	**NRMRL**
	Characterizing and modeling water flow and solute transport in ground and surface water mixing zones	FY11	NRMRL
	Evaluation of methods to characterize ground water–surface water interactions at hazardous waste sites	FY12	NRMRL
Evaluate the State of the Science for long-term stewardship of hazardous waste sites.		FY12	NRMRL
	Summary report on the use and assessment of PRBs at hazardous waste sites	FY10	NRMRL
	Summary report on the use and assessment of MNA at hazardous waste sites	FY11	NRMRL
	Summary report on the remediation of DNAPL source zones	FY12	NRMRL
Evaluations of five *in situ* and *ex situ* containment and treatment approaches for fuel oxygenates.		**FY10**	**NRMRL**
	Report on treatability of alkylates as fuel oxygenates (06-225)	FY06	NRMRL
	Report on treatment of TBA, TAME, DIPE, and ETBE (07-146)	FY07	NRMRL
	Report on evaluation of treatment options for alternative oxygenates (08-147)	FY08	NRMRL

	Capstone report on ex situ biological treatment of fuel oxygenates (07-148)	FY07	NRMRL
	Report on monitored natural attenuation of TAME, DIPE, and EDBE Report on monitored natural attenuation of EDB (08-119)	FY08	NRMRL Wilson
1.3 Multimedia			
By 2011, develop new sampling, analytical, and statistical procedures to advance multimedia site measurements and data quality.		**FY11**	**NERL**
	Report on the use of immunoaffinity chromatography to streamline sample preparations for analysis of common environmental contaminants (07-391)	FY07	NERL
	SCOUT statistical software package upgrade to contain new statistical procedures.	FY08	NERL
	Unambiguous identification of PCB congeners in a complex matrix using GCxGC time-of-flight mass spectrometer sequentially in 1-D and 2-D modes	FY09	NERL
	Guidance document on robust statistical methods with an emphasis on environmental applications	FY10	NERL
	Analytical Protocol (GC/ECNIMS) for OSWER's Response to OIG Report (2005-P-00022) on Toxaphene Analysis.	FY09	NERL

Develop modeling approaches for assessing fate and effects of oil spills in fresh and saline waters.		**FY10**	**NERL**
	Report on linkage of the ERO^{3}S model with existing EPA water quality and hydrodynamic models	FY09	NERL
By 2010, two land management options will be evaluated to provide decision makers with tools to select the best land management option(s) to protect human health and the environment and foster reutilization. (10-45)		**FY10**	**NRMRL**
	Journal article summarizing results of research on air pathways at Brownfield and Superfund sites, using tiered approach (06-506)	FY06	NRMRL
	Journal article on Metals Risk Assessment Framework	FY08	ORD
Develop Oil Spill Countermeasure approaches applicable to multiple fresh water and saline environments.		**FY010**	**NRMRL**
	Report on clay–oil flocculation and nutrient effects on treating petroleum and vegetable oil slicks on lake surfaces (06-568)	FY07	NRMRL
	Journal article on sedimentation and nutrient effects of vegetable oil from the surface to lake sediments: lake mesocosm study	FY08	NRMRL
	Journal article on the effectiveness of dispersant formulation in treating oil spills in freshwater environments	FY07	NRMRL
	Journal article on dispersant effectiveness as a function of wave energy in batch and continuous-flow conditions	FY08	NRMRL
	Report on dispersant effectiveness for oil spills in icy environments	FY10	NRMRL
	Journal article on innovative ways to biodegrade non-petroleum oils in freshwater environments	FY06	NRMRL
	Journal article on the effect of mixing regime on oxygen depletion and toxicity in a receiving water body impacted by a vegetable oil spill	FY10	NRMRL
	Journal article on optimization of nutrient application for oil bioremediation on beaches and wetlands	FY07	NRMRL

	Journal article on the use of sorbents to wick subsurface oil from wetland ecosystems to stimulate aerobic biodegradation	FY09	NRMRL
	Report on the effectiveness of surface washing agents to remove oil to surfaces at freshwater lakes (ELA study in Canada)	FY10	NRMRL
Develop protocols for testing the effectiveness of oil spill countermeasure products.		**FY09**	**NRMRL**
	Journal article on surface washing agent effectiveness protocol	FY08	NRMRL
	Journal article on a protocol for testing the effectiveness of solidifiers for treating on-water oil spills	FY09	NRMRL
Develop and test approaches for the treatment of surface water and ground water from mining sources.		FY12	NRMRL
	Develop a passive treatment process to replace active treatment from a mine waste repository	FY09	NRMRL
	Demonstrate the long-term performance of passive treatment of mine waste contaminants of surface water	FY11	NRMRL
	Investigate alternative substrates for use in biochemical bioreactors at mining sites	FY11	NRMRL
	Study the effectiveness of former operations and potential natural and commercially developed remedial approaches for the treatment of ground water and surface water from mining sources.	FY12	NRMRL

Long-Term Goal 2: Clients request and apply ORD research products and services needed to manage materials streams, conserve resources, and address emerging material streams.			
2.1 Material Management, including Managing of Emerging Material Streams			
2.1.1 Materials Assessment for Disposal, Reuse, and Containment			
Evaluate and apply leaching tests for use in determining risks associated with disposal and use.		**FY10**	**NRMRL**
	Report on application of leach testing protocol to coal combustion residues	FY07	NRMRL
	Application of life cycle assessment techniques to evaluate the fate of Pb	FY09	NRMRL

	extraction from steel		
	Synthesis report on evaluation of leaching procedures and limitations	FY10	NRMRL
Evaluate long-term performance and impact factors in order to measure the performance of landfills.		**FY11**	**NRMRL**
	Journal article summarizing results of research on air pathways at Brownfields and Superfund sites, using tiered approach (06-506)	FY06	NRMRL
	Report of nondestructive landfill liner and cover seam integrity testing technique (06-242)	FY06	NRMRL
	Report of performance of landfill covers, utilizing geosynthetic clay liners (GCLs)	FY07	NRMRL
	Report of long-term performance of existing waste containment systems (NAS study)	FY08	NRMRL
	Evaluation of the performance of evapotranspiration covers	FY10	NRMRL
	Report on environmental issues after post-closure monitoring and landfill redevelopment	FY11	NRMRL
Evaluate biological enhancements to increase landfill performance.		FY11	NRMRL
	Interim report on a landfill bioreactor design manual, characterizing the optimum operating and monitoring approaches (06-241)	FY06	NRMRL
	Synthesis report on landfill bioreactor design, operation, and performance	FY11	NRMRL
Determine the fate and impact of placing novel materials in conventional landfills		FY11	NRMRL
	Workshop report on wastes from natural and anthropogenic disasters	FY09	NRMRL
	New materials in construction and demolition wastes	FY11	NRMRL
2.1.2 Material Management of Nanomaterial Defining the Fate and Transport Factors			
Provide underlying science support for existing applications and new methods, models, and databases for emerging contaminant applications.		**FY12**	**NERL**
	Synthesis product: Develop extended	FY08	NERL

	abstract on existing capabilities, ongoing science needs, and future application areas identified with multimedia modeling		
	Report on nanomaterial-induced oxidative stress-related biomarkers of exposure.	2010	NERL
	Report on relation of surface chemistry factors to transport and fate of nanomaterials in soils and sediments.	2010	NERL
Develop methods for measuring selected emerging contaminants in environmental matrixes.		**FY11**	**NERL**
	Nanomaterials: Report on the state-of-the-science for sampling and measurement in environmental media.	FY09	NERL
	Methods for measuring selected emerging contaminants in environmental matrixes, for validating F&T models	FY10	NERL
	Nanomaterials: methods for measurement in environmental media (report)	FY11	**NERL**
	Nanomaterials-based analytical test methods for environmental matrixes.	FY11	NERL
Extend multimedia modeling capabilities to facilitate a broader range of exposure and risk assessment problems and new applications.		**FY10**	**NERL**
	Develop expanded capability within the multimedia modeling system to evaluate contaminant F&T	FY10	NERL
	Expand multimedia modeling capability to evaluate and characterize ecological exposure to emerging contaminants	FY10	NERL
Assessment of the environmental consequences of the use of nanomaterials.		**FY12**	**NRMRL**
	Fact sheet on the use of emulsified zero-valent iron nanoparticles to treat a chlorinated solvent source zone at a field site	FY09	NRMRL
	EPA report on reductive dechlorination of source zone chlorinated solvents, using emulsified zero-valent iron nanoparticles	FY10	NRMRL
	Journal article on the fate and mobility of silver nanoparticles in anaerobic environments	FY10	NRMRL
	Research brief on the transformation, transport, and longevity of nano-scale, zero-valent iron in subsurface environment	FY11	NRMRL

	Report on the evaluation of physical, chemical, and surface changes of added engineered nanomaterials in a ground water system	FY12	NRMRL
	Journal article on the fate of engineered nanomaterials in sediments	FY12	NRMRL
	Research brief to compare the life-cycle environmental tradeoffs of different disposal options for engineered nanomaterials (update municipal waste decision support tool)	FY11	NRMRL
	Report to evaluate the impacts of engineered nanomaterials on emissions/releases, including incineration to support life cycle analyses	FY12	NRMRL
Evaluation of the properties of nanomaterials that affect fate, transport, reactivity, and bioavailability.		**FY12**	**NRMRL**
	Journal article on the aging effects of nanoparticle stability and speciation in controlled sediment systems	FY09	NRMRL
	Journal article on the atomic-level characterization of nanomaterials to identify properties that drive behavior	FY10	NRMRL
	Journal article on the role of nanomaterial structure on the sorption/chemisorption of environmental contaminants	FY11	NRMRL
2.2 Resource Conservation, including Land Revitalization and Brownfields			
2.2.1 Resource Conservation			
Develop and apply an approach to assessing environmental improvement from reductions in use of waste minimization priority chemicals (WMPCs) by providing at least one report. (07-150)		**FY07**	**NERL**
	Conduct a national risk assessment of current waste loading rates and projected reduction in use of selected WMPCs (07-156)	FY07	NERL
Provide technical information on materials management options that support the Resource Conservation Challenge.		**FY11**	**NRMRL**
	Energy production from engineered MSW landfills		NRMRL
	Report on site reuse options, including light	FY08	NRMRL

	commercial development on closed landfills		
	Beneficial reuse of coal combustion products (CCP)	FY08	NRMRL
	Industrial alternatives for Pb (FY06 pilot project)	FY07	NRMRL
	Integration of more sustainable waste management practices for environmental protection	FY11	NRMRL
2.2.2 Land and Ecosystem Revitalization, including Brownfields			
Advance the concepts, understanding, and acceptance of the SMARTe Decision Support Tool.		**FY11**	**NRMRL**
	SMARTe 2007 edition published	FY07	NRMRL
	SMARTe book chapter: "Decision Support Systems for Risk-Based Management of Contaminated Sites"	FY08	NRMRL
	SMARTe 2009 edition published	FY09	NRMRL
	SMARTe 2011 edition published	FY11	NRMRL
Determine the metrics for sustainability in land use planning?		**FY12**	**NRMRL**
	Book chapter on the field trial of tools and techniques from Stella, Missouri	FY08	NRMRL
	Report on the development and evaluation of sustainability criteria at Sand Dunes, Nevada	FY09	NRMRL
	Final report on baseline evaluation of Stella, Missouri, using sustainability indicators	FY10	NRMRL
	U.S./German bilateral report on regional approaches to sustainable revitalization	FY11	NRMRL
	Journal article on concepts and proposed sustainability metrics for land revitalization	FY12	NRMRL
Advance the understanding of the impact of vapor intrusion and other factors at Brownfield sites.		**FY12**	**NRMRL**
	Internal report on vapor intrusion method development for exterior monitoring	FY10	NRMRL
	Journal article on vapor intrusion and engineering factors to determine approaches for remediation of gas stations and dry cleaners	FY10	NRMRL
	Report on vapor intrusion F&T process evaluation	FY12	NRMRL

7.0 References

National Research Council (NRC), Committee on Research Opportunities and Priorities for EPA. *Building a Foundation for Sound Environmental Decisions.* Washington, DC, National Academy Press, 1997. http://www.nap.edu/books/0309057/html/

APPENDICES

Appendix A: Client Needs and Current and Planned Research (generated in September 2005, update in progress) for Long-Term Goals (LTGs) 1 and 2

LTG 1: Clients request and apply ORD research products and services needed for mitigation, management, and long-term stewardship of contaminated sites in order to reduce risk to human health and the environment		
	Client Needs	**Current and Planned ORD Work**
Ground Water	Economical detection methods for emerging contaminants such as perchlorate and 1,4-dioxane	Office of Water (OW), with assistance from ORD, has published four methods for analyzing perchlorate in drinking water (Methods 314.0, 314.1, 331.0, and 332.0). Alpha Analytical has adapted one method for soils; others are making additional adaptations.
	Final analytical method for determination of perchlorate	
	Additional real-time and more cost-effective field characterization and monitoring methods for ground water contaminants	Report on the effectiveness of using geophysical methods to monitor natural attenuation: a geophysical toolbox approach for project managers. (NERL09) Report on geoelectrical detection of surfactant-enhanced aquifer remediation of PCE (NERL08) Report on geophysical methods applied to cap integrity at contaminated sediment sites (NERL09) Develop methods for screening for polar contaminants in ground water using HPLC/DAD, and identifying them using GC/MS with derivatization (NERL08)

	FRAMES internet-based tool for benchmarking ground water models	
	Ground Water–Surface Water: Transition zone sampling methods and screening approaches/criteria for evaluation of whether GW discharge is causing unacceptable SW or sediment impacts (OSW, Region 10)	Report on innovative techniques for measuring advective flux. Project includes developing a flux chamber for direct field measurement (NRMRL 06-208). Work continues through FY10. Report on field study of contaminant metal species transformations at the GW/SW interface (NRMRL 05-272) Report on MNR performance at Lake Hartwell at the modeled compliance time (NRMRL 06-213). Project includes measuring GW discharge via piezometers. Sediment capping projects are also evaluating advection with piezometers and flux chambers.
	Vapor intrusion: • Compile and analyze existing vapor intrusion data and evaluation methods (regional science priority) • Validate the indoor air vapor intrusion model (OSW) • Guidance on available engineering controls and remediation technologies for residential and commercial buildings (Region 9) • Better characterization tools for risk evaluation of VI pathway (Region 9) • Sampling protocol for subsurface vapor and screening criteria applicable to defining soil vapor contaminant concentrations that are protective for the indoor air exposure pathway • Innovative characterization technologies that	VI model with uncertainty analysis with LNAPL and flowing ground water source functions (NERL06) Internet training materials for VI modeling (NERL07-RCRA) Extended field data for temporal trend analysis (NERL FY10) Sampling at VI sites to determine vertical distribution of VOCs from GW to buildings (NERL09) Relationship of subslab and angular drilling sampling on VOC concentrations (NERL FY10) The influence of diurnal variation on the VOC concentrations in the home and soil (NERL FY10) Implement new VI model and user testing (NERL09-RCRA) Incorporate evolved VI model into multimedia modeling framework (NERL10-RCRA).

	allow for quicker and more accurate assessment of vapor intrusion pathway (OSW) • Methodology for States to assess vapor intrusion (OUST pilot priority)	Seasonal variation of soil VOCs concentration and role in indoor air VOC concentrations (NERL11) NRMRL is working on sub-slab sampling and other aspects of assessing vapor intrusion for Superfund and RCRA contaminants (NRMRL 06-439) and for petroleum compounds for USTs. Participating in EPA workgroup for assessing guidance and ITRC for training States. NRMRL has capability for VI mitigation research but no funding.
	Client Needs	**Current and Planned ORD Work**
Ground Water	MCLs or other national standards for 1,4-dioxane, perchlorate, and NDMA and national guidance for calculating risk (Region 10)	ORD does not develop national standards such as MCLs or AWQC or AQC. These are developed by Program Offices using RfDs or RfC as a health goal. MCLs and other criteria often take into account such things as relative source contribution or best available technology and are therefore contaminant specific. ORD has developed and continues to update Agency-wide guidance on developing risk estimates for cancer and non-cancer endpoints as well as mixtures and exposure assessment. In addition, ORD has developed and is revising specific software for calculating risks (i.e., dose–response assessment)
Client Needs		**Current and Planned ORD Work**

Technical assistance to sites through the Ground Water Technical Support Center (multi-region priority)	GW TSC Dave Burden (580-436-8606) and Center for Subsurface Modeling http://www.epa.gov/ada/csmos.htmlhttp://www.epa.gov/ada/csmos.html (NRMRL)

Innovative treatment technologies for NAPL, chlorinated solvents, chlorinated pesticides, dioxins, and metals (regional science priority) Treatment training to address PCE in ground water and soils at dry cleaners (Region 7)	***NAPL/chlorinated solvents/PCE in GW:*** • Report on pilot scale evaluation of adsorption/oxidation technology for ground water remediation (06-437) • Report on impacts of DNAPL source treatment (08-xxx). Pilot project on use of mass flux to assess treatment performance • Effects of thermal treatment on the chemical reactivity of trichloroethylene (07-141) • Identification of, and characterization methods for, reactive minerals responsible for natural attenuation of DNAPL compounds in ground water • Research brief on biological methods to characterize effectiveness of ground water remediation technologies at metals and DNAPL sites (08-116) • Synthesis document on DNAPL remediation technologies (10-21) • Summary report for characterization and remediation of recalcitrant organic compounds in fractured rock (09-18) ***Metals in GW:*** • Issue paper on metal attenuation processes at mining mega-sites (07-145) • Evaluation of trends in site characterization to support use of MNA for remediation of inorganic contaminants in ground water (08-351) • Report evaluation: use of decision support framework for MNA of inorganics: Evaluation of the use of EPA/ORD Technical Resource Document for MNA of inorganic contaminants in ground water (09-xxx) • Report on long term performance of inorganics MNA (synthesis report) (09-17) • Metal attenuation in acid mine water by sulfate reduction (06-222) • Field application of PRBs for arsenic (08-xxx) • Performance evaluation of a mixed compost/zero-valent iron PRB for treatment of arsenic and heavy metals associated with acid rock drainage (08-xxx)

Combined source remediation technologies to achieve greater overall effectiveness and accelerate site closure (OSRTI/Regions 2 & 9 pilot priority)	
Optimization of PRB designs for remediation of common organic and inorganic contaminants (Region 5)	Report on field application of PRBs to remediate arsenic contamination in ground water (NRMRL 06) Report on microbial processes in acid mine drainage (NRMRL 06-222) State-of-the-art monitoring methods for long-term performance of PRBs (NRMRL 07-143) Report on field evaluation of PRBs for acid mine drainage (NRMRL 07-144)
Economical treatment methods for emerging contaminants such as perchlorate and 1,4-dioxane (OSRTI/Region 7); treatment method for perchlorate reduction which makes use of a catalyst (Region 3)	Perchlorate treatment research is conducted under Goal 2: • Evaluate small-system, innovative treatment options for controlling perchlorate in drinking water (NRMRL DW 05-476) • Conduct pilot scale evaluations (cost and performance) of the most promising treatment processes to control perchlorate (NRMRL DW 06-358)
Review of butane biostimulation pilot study at GM Sioux City (Region 7; refer to Technical Support Center)	
MNA: • Decision support documents for MNA processes for inorganics and radionuclides • To better understand the processes associated with MNA of selected contaminants and appropriate circumstances for its use as a remedy	MNA framework for inorganics and radionuclides (NRMRL) Ongoing MNA research (NRMRL)

	Client Needs	Current and Planned ORD Work
Ground Water	Permeable reactive barriers: • Optimized design of PRBs for remediation of common organic and inorganic contaminants of concern in ground water (Region 5) • Recommendations on ways to increase lifetimes of PRBs (Region 10)	NRMRL's PRB research, described in CQ1.3, is addressing organic and inorganic contaminants and includes various treatment agents and designs to optimize performance and longevity. Collaboration via the RTDF PRB team is ensuring that lessons are learned from both ORD research and other organizations researching or implementing PRBs.
	Electronic toolboxes for the design and analysis of ground water capture zones to assist in evaluating and defining technically defensible capture zones and remedy optimization (Region 9)	CZAEM (Capture Zone Analytic Element Model), a single-layer model for simulating steady flow in homogeneous aquifers, using the analytic element method, is available via http://www.epa.gov/ada/csmos.html (NRMRL)

	Client Needs	Current and Planned ORD Work
Ground Water	Improved methods for evaluating long-term remedy performance (capture zone analysis for P&T systems, MNA, PRBs, and subsurface containment barriers) (OSRTI)	Version 2 of TACS, revised with Version 1 user input (NERL07) See previous entries for MNA, PRBs, and capture zone analysis

	Client Needs	Current and Planned ORD Work
Sediments	Surface sediment sampler that can sample the nephloid layer and determine the ecological significance of COCs in this layer	Site demonstration of sampler for collection of undisturbed surface sediments in 2007 Determination of the influence of newly deposited sediments on contaminant concentrations in collected samples (NERL06)

	Validation of surface water/sediment F&T and food chain models (OSRTI)	Report on the evaluation of long-term (i.e., 1–10 years) accuracy of the upgraded contaminated state-of-the-art sediment F&T models by modeling the F&T of sediments and PCBs at a demonstration site (NERL06) Development of new modules for selected F&T model(s) for certain types of water bodies to address the identified sediment-related needs of OERR and the Regions (NERL06) Provide consensus framework for modeling remedial alternatives in large water bodies and estuaries (NERL07)
	Client Needs	**Current and Planned ORD Work**
Sediments	Improved understanding of marine and freshwater contaminated sediments ecological risk issues (regional science priority)	NCEA's Ecological Risk Assessment Support Center can develop peer-reviewed white papers on ecological risk issues of concern to the regions as represented by ERAF.

	Understanding the relationship between PBT concentrations in sediment and residues in impacted species (OSRTI)	**NHEERL Project**: Linking chemical concentrations in water and sediment with residues in aquatic and aquatic-dependent wildlife ***FY06 APM:*** *Provide the methods and data necessary to parameterize and apply the hybrid modeling/empirical approach to support ecological risk assessment of bioaccumulative sediment contaminants.* ***FY08 APM:*** *Provide a fully field-validated hybrid modeling/empirical approach for extrapolating BAFs, BSAFs, and predicting the ecological effects of mixtures of PBTs with different rates of metabolism on a site-specific basis.* Use of the fathead minnow vitellogenin gene expression assay for PCBs in Lake Hartwell water and sediments (NERL06) Food web study for Lake Hartwell (NERL07)
	Critical tissue residue levels in warm water and cold water fish, which can be used as screening levels for PBTs (OSRTI)	**NHEERL Project**: Linking residues to effects in aquatic and aquatic-dependent wildlife ***FY06 APM:*** *Provide report on the evaluation of the PCB residue–effects database*
	Client Needs	**Current and Planned ORD Work**
Sediments	Technical assistance to sites through the Superfund Sediment Resource Center	ETSC and GWTSC are affiliated with the SSRC (NRMRL).

	Dredging releases and residuals: • Process for predicting residual contamination in sediment after dredging (OSRTI/Region 2 pilot priority) • Method to determine the impact of resuspension of sediment contaminants during dredging • Method for predicting and/or evaluating increase in ecological or human health risk from COC releases and sediment residuals from dredging.	NRMRL has research efforts underway to evaluate post-dredging residuals: • Evaluation of post-dredging residuals model through case study and field evaluation. Ashtabula field study in progress • Conduct field studies to evaluate post-dredging residuals and implement innovative monitoring tools such as core profiling techniques, semi-permeable membrane devices, volatilization chambers, and innovative techniques for evaluating capping technologies yet to be applied for monitoring dredging operations • Investigation of dredging performance at Lavaca Bay (Mercury) **NHEERL Project:** Research to evaluate the release and bioavailability of contaminants associated with resuspended sediments and post-dredging residuals at Superfund sites. ***FY06 APM:*** *Report evaluating F&T models for predicting dissolved concentrations of organic and inorganic contaminants in Superfund site sediments following resuspension events* ***FY07 APM:*** *Report assessing significance of changes in bioavailability of organic and inorganic contaminants in Superfund site sediments following resuspension into the water column and resettlement to sediment bed* ***FY08 APM:*** *Evaluate concordance between field measurements and fate and transport model predictions of dissolved concentrations of organic and inorganic contaminants in Superfund site sediments following resuspension events (in collaboration with NERL and AcoE).* ***FY09 APM:*** Report summarizing evaluation of approaches for measuring the transport of dissolved contaminants from the near to far field at selected Superfund sites.

	New *in situ* treatment and innovative containment technologies for contaminated sediment	NRMRL is investigating several alternative sediment remedies with the potential to be more cost-effective than conventional dredging or capping remedies. An emphasis is on bioremediation of organics, electrochemical degradation, and conventional and reactive caps. Some upcoming products include the following: • Report on trials of *in situ* treatment cap (NRMRL 06-215) • Three reports on tests of electrochemical degradation as a reactive barrier including bench and pilot scale results (NRMRL 05-251) • Report of field evaluations of electrochemical treatment in a metal/organic environment (NRMRL 07-136) • Report on experience with innovative biological treatment processes related to the destruction of PCBs and PAHs (08-113) • Capstone report on treatment of PCBs in sediments (08-114) • Interim report on biodegradation of PAHs in sediments (NRMRL 06-216) • Final report on biodegradation of PAHs in sediments (NRMRL 08-115) • Capstone report on treatment of PAHs in sediments (NRMRL 09-16) • Reported to Region 5 in September 2006 on application of raking, aeration, and thermal enhancement for removal of oils/PCBs/PAHS from contaminated sediments

	Determine how best to evaluate benthic recovery after dredging	**NHEERL Project:** Integrative assessment of benthic effects from remedial activities at Superfund sites. ***FY06 APM:*** *Report to OSRTI on direct comparison of Sediment Profile Imagery (SPI) and sieving methods at a sediment Superfund site.* ***FY06 & FY07 APM:*** *Report to OSRTI on relationship between SPI and other environmental variables, specifically dissolved oxygen.* ***FY08 APM:*** *Peer-reviewed paper on use of SPI to document benthic community effects and recovery from remedial dredging.*
	Method for treating oil-contaminated sediment (OEM pilot priority)	NRMRL has an ongoing project at Indiana Harbor; two pilot projects on oil cleanup on beaches and in wetlands.
	Development of permeable reactive mats for use in remediation of subaqueous contaminated sediments (Region 1)	NRMRL is conducting research on reactive caps for contaminated sediments (listed under "New *in situ* treatment and innovative containment technologies for contaminated sediment").

	Client Needs	Current and Planned ORD Work
Sediments	Understanding of best management practices for dredging and *in situ* capping (in coordination with USACE & NHSRC)	NRMRL has a number of research projects aimed at evaluating the field performance of the conventional remedies of dredging and capping: • Evaluation of post-dredging residuals model through case study and field evaluation, including the Ashtabula River project • Conduct field studies to evaluate post-dredging residuals and implement innovative monitoring tools such as core profiling techniques, semi-permeable membrane devices, volatilization chambers, and innovative techniques for evaluating capping technologies yet to be applied for monitoring dredging operations • Investigation of dredging performance at Lavaca Bay (Mercury) • Report on trials of *in situ* treatment cap (06-215) • Report on medium-term performance of emplaced caps relative to predictions (07-137) • In association with NHSRC, an investigation of permeable reactive mats for use in remediation of subaqueous contaminated sediments is underway at the Region 3 Anacostia site • In association with SERDP, develop improved engineering tools for more cost-effective and efficient cap designs by investigating contaminant transport processes through caps.

	Client Needs	Current and Planned ORD Work
Sediments		NRMRL has a number of projects evaluating the risk reduction and cost-effectiveness of various risk management remedies, including: • Investigation of dredging performance at Lavaca Bay (Mercury) • Report on medium-term performance of emplaced caps relative to predictions (07-137) • Report on MNR performance at Lake Hartwell at the modeled compliance time (06-213) NRMRL has developed tools for monitoring long-term remedy performance: • Use of semi-permeable membranes as tools to assess the effect of remediation strategies for contaminated sediments (05-248) • Assessment of ground water/surface water interaction • PCB volatilization from lake surfaces • Measurement of contaminant flux from sediment to water column

	Client Needs	Current and Planned ORD Work
Soil/Land	Best practices document for conducting three-dimensional site characterizations (OUST pilot priority)	FY06 pilot project awarded to address prevention and remediation strategies
	Final analytical method for determination of metals by ICP/mass spectrometry in soil matrices	

	Client Needs	Current and Planned ORD Work
Soil/Land	Metal speciation analytical methods and bioavailability of metal (National Regional Science Council priority)	FY06 pilot project awarded to evaluate the bioavailability and bioaccessibility of arsenic in soil
Soil/Land	Treatment approaches for arsenic and reactive wastes	Soil/Land research has been closed out by resource reductions
	Mining: • Innovative and cost-effective remediation technologies for mining wastes, including uranium • Site characterization tools for acid mine drainage • Methods for very long-term management (10s to 100s of years) of drainage from abandoned mines as well as water and air emissions from large mining waste disposal sites • Continuation of the AnchorHill C-redox Treatability Study and further development as a remediation system, using bacterial remediation (Region 8) • Enhancement of the Automated Web-based Monitoring System at Ruby Gulch (Region 8)	NRMRL is conducting research on remediation of mining sites via the Engineering Technical Support Center, the Mine Waste Technology Program and, more recently, through the Goal 3 Ground Water LTG. Remedies have included passive and semi-passive water treatment systems, innovative components for conventional water treatment, and PRBs. Additional research is addressing waste treatment and management to reduce the formation of acid rock drainage over the long term. A FY06 pilot project was funded for automated and remote data collection from mining sites F&T and remediation issues. ETSC is providing technical support for evaluating passive treatment at Gilt Edge mine.

	Effective alternative cleanup methods for lead in soils, e.g., phosphate treatment or other technologies (Region 7)	NRMRL has been conducting research on phosphate treatment for metals in soils, including assessing bioavailability before and after treatment.
Soil/Land	Landfill caps (OSRTI): • Methods and devices to monitor performance of landfill caps • Understanding of how contaminants affect long-term integrity of barrier materials • Understanding of seismic considerations for landfill caps and vertical barriers • Support for guidance development	NRMRL ongoing landfill/containment research has three components: cover/liner material performance, landfill bioreactors, and alternative covers. Current projects include a National Academy of Sciences study of long-term performance of materials. The alternative covers project has developed field lysimeters for side-by-side evaluation of cap performance applicable to multi-layer caps, geosynthetics, clay, and evapotranspiration covers. No further resources are available under LTG 1, and LTG 2 resources will be reduced. No funds have been available in recent years to revisit guidance for seismic considerations; construction quality assurance and non-destructive testing work has been deferred because of resource reductions (NRMRL).
	Landfill gas (OSRTI): • Methods to monitor and measure gas escaping from landfills • Technical assistance in developing guidance on when gas venting is acceptable in lieu of collection for beneficial use or treatment • Improved collection and treatment technologies • Understanding of gas movement under clay vs. phyto caps	Journal article of EPA report summarizing results of research on air pathways at Brownfields and Superfund landfills, using tiered approach (NRMRL 06-506) Update of landfill gas emission factors for MSW landfills (NRMRL AT 06-505)

	Alternative designs and materials for landfill caps and barrier walls, including information on performance, durability, and standards (OSRTI)	ACAP final report to present conclusions from the field study and to recommend monitoring and construction guidelines for alternative covers (synthesis report) (NRMRL 05-279) Protocol document for design and evaluation of alternative covers APMs (NRMRL 07-151); training (Internet and classroom) has been provided for decision officials and practitioners via ITRC. Synthesis report on covers and containment technologies (NRMRL 10-22) was deleted from MYP, owing to reduced resources.
	Landfill liners	See rows above
	Client Needs	**Current and Planned ORD Work**
Multimedia	Technical assistance to sites through the Monitoring and Site Characterization Technical Support Center	
	Technical assistance to sites through the Environmental Photographic Interpretation Center	
	Protocols for evaluation of chemical/biological warfare agents (Refer to Homeland Security)	
	Comprehensive catalog of petroleum constituents needs to be developed that reflects geographical and seasonal variability (OUST pilot priority)	FY06 pilot project awarded in bioremediation of wetland spills. Report on 30-year retrospective of US gasoline composition (NERL08). Report on research summarizing fuel composition studies (NERL11).

	Rapid field screening techniques and real-time field detection equipment, e.g., mobile or portable lab capabilities provided by EPA	Use of bioassays and chemical sensor arrays for the rapid, *in situ* determination of toxic soil VOCs (NERL07) Report on the use of immunoaffinity chromatography to streamline sample preparation for analysis of common waste constituents (NERL06) Comparison of bioanalytical methods for dioxins in soil and sediments to reduce the time and high cost of conventional analysis (NERL08) Semi-permeable membrane devices (SPMDs) for forensic environmental investigation of congener-specific polychlorinated biphenyls, using an isotope dilution / mass spectrometry method (NERL08)
	Standard analytic procedure for determining the soil/water partitioning coefficient (Kd) for PCBs, using soil and PCB samples from a site and an appropriate "column leaching" method	
	User-friendly guidance for non-statisticians, to assist regional review of statistically based sampling methods submitted to EPA by responsible parties	Field-sampling guidance document to identify methods and techniques to eliminate bias that occurs during field sampling can be produced by NERL if funding becomes available to support the research Guidance document on robust statistics with environmental applications, to provide OERR/Regions with a compendium of statistical methods that are available to assess the validity of analytical data (NERL10)

Multimedia –General	Technical assistance to RCRA sites in review of site-specific human health and ecological risk assessments submitted by owners/operators (OSW)	NCEA provides assistance on request but not through the HSTSC. These requests are generally sent directly to NCEA or filtered through OSP.
	Technical assistance to ecological risk assessors through the Ecological Risk Assessment Support Center (OSRTI) and increased access for RCRA (OSW)	ERASC (NCEA) has in place mechanisms for addressing both Superfund and non-Superfund requests. NCEA Director of the ERASC will contact RCRA folks and discuss access and ways of increasing awareness of process and funding.
	Metals: • Standard analytical methods to determine speciation of arsenic, chromium, and mercury in soils, sediments, water, and biota (regional science priority) • Finalize analytical method for determination of metals by ICP/mass spectrometry in soil matrices • Understanding of bioavailability and bioaccessibility of arsenic in soil and development of arsenic speciation methods (OSRTI/Regions 1, 4, 5, 8 pilot priority) • Anodic stripping voltametry (ASV) method for arsenic analysis of solid matrices (Region 4) • Standardized, laboratory (*in vitro*) EPA analytical test method for the determination of lead bioavailability (Region 7)	FY06 Pilot: Develop enhanced in vitro techniques for assessing arsenic bioavailability (NERL/NHEERL08) FY06 Pilot: Develop improved arsenic speciation method(s) (NERL/NHEERL08) Impact of metals speciation on ecological receptors (NRMRL 07-355). Evaluation of perturbation on metal speciation and ecological receptors (NRMRL 08-112); high-tech speciation would not become standard method Report on evaluation and optimization of sampling techniques for collection and preservation of solids from saturated or suboxic zones (NRMRL 06-438) NRMRL has conducted extensive study of speciation and bioavailability as part of developing a chemical stabilization remedy for metals in soil.

	TEQ: • Viable field analysis method for determining total toxicity equivalence (TEQ) strictly from dioxins/furans/dioxin-like PCBs (OSRTI/Regions 1, 4, 6 pilot priority) • Understanding of the applicability and limitations of bioassay or other direct assay methods for measuring TEQ for decision-making purposes (Region 5)	FY06 pilot proposals to meet this need were not selected.
	Validation of analysis method for toxaphene congeners and their degradation products (Region 4)	
	Field study to determine whether environmental weathering increases dioxin-like PCBs in surface or subsurface (OSRTI)	NRMRL sediment research at Lake Hartwell includes congener-specific analysis. The report on 2000–2001 data has an extensive analysis of weathering patterns. These results could be compared to Aroclor compositional data.
	Standard analytic procedure for determining the soil/water partitioning coefficient (Kd) for PCBs, using soil and PCB samples from a site and an appropriate "column leaching" method (OSRTI)	
	Protocols for evaluation of chemical/biological warfare agents (refer to Homeland Security)	
	Metabolism factors for phthalates, PAHs, and other organic contaminants	

Multimedia	Optimized nutrient application for oil bioremediation (OEM pilot priority)	Report on the linkage of the oil spill model with multimedia modeling frameworks and their uncertainty analysis (NERL07) Report on linkage of oil spill model with existing EPA water quality and hydrodynamic models (NERL 09) Extended abstract on existing capabilities, ongoing science needs, and future application areas identified with multimedia modeling. (NERL08) FY06 pilot projects were funded for oiled beaches and wetlands.
	Remedial applications for nanotechnologies that can be applied to soil, ground water, and sediment contamination (Region 5)	NRMRL ground water research on PRBs includes a nanoZVI PRB field study. Sediment research on reactive caps may also evaluate nanoZVI. Remediation applications of nanotechnologies is currently barred from ORD's nanotechnology initiative. The Land Program's LTG 2 is being revised to address engineered nanotechnology materials.
	Develop energy-efficient waste and contaminated site remediation/treatment technologies (OSW)	NRMRL's ground water and sediments research include treatment/management options that are energy efficient compared to conventional alternatives. For example, capping and *in situ* treatment (including MNR) of contaminated sediments are low-energy alternatives to dredging and transport to a disposal facility. Similarly, some *in situ* treatments for ground water are more energy-efficient than pump & treat.
	Technical support, continued and expanded where necessary, provided to Regions through the Corrective Action Technical Support Center (OSW)	ETSC and GWTSC provide site-specific assistance for RCRA Corrective Action sites (NRMRL). Revision of LTG 2 may reduce resources available for CA sites.

	Effective long-term containment remedies for sites that are technically impracticable to clean up	See **CQ1.3 Soil/Land** and **CQ1.5 Soil/Land** for relevant NRMRL research on mine wastes and containment, respectively.
Multimedia	Technical assistance to sites through the Engineering Technical Support Center (multi-region priority)	Assistance is available by contacting David Reisman at Reisman.David@epa.gov
	Client Needs	**Current and Planned ORD Research**
Risk Assessment in HHRA	More rapid and additional development of provisional peer-reviewed toxicity data and other technical support from the Superfund Technical Support Center (OSRTI/Regions 1–6, 9 pilot priority)	Ongoing effort; NCEA has developed improved SOPs for developing and distributing PPRTVs; 25 new assessments will be provided as well as review of at least 25 existing assessments each year under the Risk Assessment Program Project MYP
	Asbestos (OSRTI/Regions 1, 2, 4, 6, 8, 9 pilot priority): • Understand carcinogenicity of asbestos fibers • Understand releasability of the asbestos fiber from soils and solid matrices • Interim toxicity values for asbestos based on amphibole type • Assessment of sub-chronic inhalation exposure to Libby amphibole asbestos • Sampling protocol/methods for asbestos, especially soil matrices • Review of method development and further analytical development for use of scanning electron microscopy for counting asbestos fiber concentrations (Region 8)	NCEA is planning to conduct a cancer risk assessment for asbestos fibers, to be completed in FY07. FY06 pilot proposal awarded on asbestos releasability (NRMRL) to continue work initiated under Goal 4. NHEERL is initiating toxicity studies in 2007 to support Libby, MT, issues.

	Additional children's cancer and non-cancer risk methods	ORD has published (March 2005) Agency-wide supplement guidance on children's cancer risk assessment. A workgroup has been developed to provide guidance on implementing the guidelines, and training is being provided by Risk Assessment Forum and IRIS staff (NCEA).
	Integrated methodology for assessing dermal exposure to water, soil, and/or sediment (OSRTI)	Research and exposure and risk assessment activities are ongoing to develop comprehensive guidance for assessing dermal exposures in water, soil, and sediment. Work includes evaluation of absorption factors and parameters, dose–response modeling, and development of methods to predict risks using chemical structure and physical characteristics (NCEA).
	Test methods and standards for wipe-and-chip samples, to assess dermal and ingestion exposures to indoor surfaces (Region 7)	
	Further understanding of exposure pathways: • Exposure to multiple contaminants and potential for synergistic or antagonistic interactions • Refinements in consideration of timing of exposure • Further incorporation of natural attenuation in risk assessment	Risk assessment research is ongoing for developing tools, case studies, and guidance to address aggregate and cumulative risks. These efforts look at multiple routes of exposure, durations, and contaminants. Specific guidelines are planned for mixtures exposure assessments as well as development of a report on approaches for assessing interactions of multi-chemical, multi-effects, and multi-pathway exposures (NCEA).
	Additional and expedited IRIS updates, especially to develop toxicity information for polybrominated diphenyl ethers and to finish MTBE (OSW)	Ongoing; IRIS process has undergone a number of revisions to expedite assessment development. A tracking database has been established to provide regular updates of all assessments currently under development (NCEA). http://www.epa.gov/iris/index.html

	Nationally consistent set of acute toxicity benchmarks, beginning with a nationally consistent methodology for selecting acute toxicity benchmarks from currently available databases (OSW)	Ongoing risk assessment research and activities include development of tools, models, and case studies for performing acute risk assessments, development of guidance/methods for less than lifetime exposures, and development of acute information database; current effort focuses primarily on air exposures and HAPs (NCEA).
	Upgrades to all-ages metal model (IEUBK) (OSRTI)	Ongoing research includes updating lead model for all ages; SAB review schedule for late summer FY05; finalization of parameters and input for lead early in FY06; development of parameters for Cd FY06–07 (NCEA).
	Continued development of exposure factors handbook (OSRTI)	Ongoing research, revised/updated handbook in FY07; ongoing research also includes development of guidance on soil ingestion, for use in assessing exposures (NCEA).
	Toxicity information for toxaphene congeners and their degradation products, and associated information for human health and ecological risk assessment (Region 4)	Report on mutagenicity of toxaphene congeners is ongoing (NCEA).

Long-Term Goal 2 (LTG 2) Client Needs and Current and Planned Research Program

LTG 2: Customers of ORD waste and materials research request and apply ORD products and services in order to conserve resources and control risk to human health and the environment through materials and waste management (Reduce waste generation and increase recycling, and make better decisions on beneficial reuse of waste)		
	Client Needs	**Current and Planned ORD Research**
MFA/LCA	Develop prototype material flow accounting system (from pilot)	SAB subcommittee recommended research on MFA during review of FY06 science & technology budget request.
MSW	Better characterize the toxic constituents of RFIDs and biodegradable polymers in beverage containers (from pilot)	
E-waste	• Characterize the toxic constituents of electronics (from pilot) • Electronic wastes: Needs include developing technologies for reducing barriers to recycling, and evaluating worker exposures associated with shredding of electronic wastes • Methods and sampling strategies to characterize electronic wastes	NERL/NHEERL were awarded a FY06 pilot proposal to evaluate toxic constituents in electronic waste.
Sampling/ Analytical	• Method development to identify "free" cyanide and to support OSW policy efforts concerning cyanide reactivity guidance • Provide analytical method for determining cyanide and sulfide waste reactivity • Development/validation of test methods for evaluating waste for pyrophoric properties and ignitability of solids • Sampling strategies to characterize demolition debris • Methods and sampling strategies to characterize electronic wastes	Preliminary assessment of research needs for electronics wastes sampling (NERL05)

	• Perchlorate methods for soil, sediment, sludge and waste water • Develop laboratory X-ray fluorescent spectrometry (XRF) technique to analyze for four heavy metals in electronic products. • Method development/validation on speciation of mercury, arsenic, and selenium	OSW has this underway.
Leaching	• For wastes and waste-derived products (e.g., concrete blocks made with coal ash), research to more fully understand issues related to waste matrices, constituents of concern, and management unit environment, such as pH, L/S ratio, redox, ionic strength, chelators, flow rate, and aging/degradation • Understanding the chemistry of waste leaching more fully. Improving our ability to accurately predict waste constituent leaching, for a variety of waste types in a variety of waste management unit environments, is a critical RCRA and CERCLA program need. • Tailored leach-testing field validation of Kosson protocol (from pilot)	Report of field data comparisons with laboratory leach tests (NRMRL 07-165); synthesis report on evaluation of leaching procedures and limitations (NRMRL 08-132). The ongoing work isn't specific to waste-derived products but would be applicable for contaminant aqueous mobility. NRMRL awarded a FY06 pilot proposal for leach testing and modeling to assess beneficial use (leaching pathway only). NRMRL's ongoing research on applying the Kosson protocol to coal combustion residues is being funded from the Hg MYP: • Capstone report on fate of Hg and other metals from management of coal combustion residues (HG 06-91) • Report on the potential formation of organo-mercury from anaerobic decomposition of CCRs (HG 07-62) • Report on fate of toxic metals from land disposal and commercial use of CCRs from plants equipped with multipollutant control technologies (HG 08-42).

Sustainability	• Research to better understand "green chemistry" approaches to identify environmentally friendly substitutes, especially for the 30 highest priority chemicals (from a listing of persistent, toxic, and bio-accumulative chemicals) • Research into design of environmentally friendly products • Development of source reduction opportunities for other hazardous wastes (e.g., combusted wastes, metals finishing) • Industrial alternatives to/for priority chemicals (from pilot)	NRMRL conducts green chemistry research under Goal 5. The MYP is currently being revised. NRMRL was awarded a pilot project for lead to identify which priority chemicals should be targeted for reduction.
Beneficial Use	• Evaluating the stability, expected releases, and bioavailability of constituents in waste-derived products. Such products contribute to consumer exposures as well as to non-point source pollution of air and watersheds. OSW repeatedly receives queries on waste-derived products, and research and tests on these uses would help with the evaluation of any risks associated with them. Predictive analysis of expected releases could be verified through field monitoring (in a manner analogous to NERL's current research on the environmental fate of personal care products and pesticides). Major examples of waste derived products, a.k.a. "beneficial reuses" include road bed materials (asphalt), cement additives, frit, and CCA-treated wood. Aspects of leaching research are related to this, particularly the leaching research on materials that are applied to land (e.g., roadbed, fill). • Research into health impacts of use of hazardous wastes as products in manufacturing • Modify multimedia models to conduct national-level assessment of beneficial reuse of coal ash in road construction (from pilot)	
Multimedia Modeling	• Continue evaluation of techniques and approaches to verify and validate the multimedia and indirect exposure portions of F&T models, with a greater emphasis on identifying	Address SAB review comments and key recommendations (NERL05)

	specific sites with multimedia data sources • Develop air deposition models, especially the components dealing with vapor transport to surfaces, vapor/particle partitioning of semi-volatile compounds, wet vs. dry deposition properties, and deposition of semi-volatiles. Finalize TOE test and dry gas models. Better understanding of mercury speciation at stack and F&T transformation. • Continue efforts to understand the transfer of constituent mass within the multimedia concept and to improve, where necessary, how the modeling system addresses mass balance in the context of intermedia F&T • Continue evaluation of the sensitivity and uncertainty in the modeling system, to better inform users and decision makers of the areas of greatest uncertainty • Provide tools to facilitate user interactions with the system that will allow the modeling system to be used for other risk assessments at the national, regional, and site scales; provide the capability to add science modules or pathways (for example, vapor intrusion); and provide capabilities for advanced uncertainty/sensitivity analyses • Incorporate into the modeling system the capability for addressing more comprehensive ecological population- and system-level analyses as well as cumulative risk for humans • Continue development of subsurface F&T model and data by incorporating fracture flow and heterogeneous porous media • Continue efforts to enhance process information on hazardous chemical contaminant transformation, including half-lives and physicochemical characteristics of transformation products • Incorporate enhancements of the MINTEQA2 thermodynamic database into the modeling system • Continue evaluation of techniques and approaches to verify	Incorporate capabilities for regression/ correlation-based sensitivity analyses within multimedia modeling system (NERL06) Conduct an application workshop for 3MRA Version 2.0 stakeholders and develop proceedings (NERL06) Provide enhanced soil column model function for 3MRA (NERL07) Conduct an extended analysis of select WMPC chemicals, using an integrated sensitivity analysis methodology to identify key data gaps and greatest sources of uncertainty for land-based disposal of WMPC waste streams (NERL07) Develop capability to evaluate contaminant mass balance, downstream of sources (NERL08) Assess bias associated with soil-gas sampling to support assessment of vapor intrusion (NRMRL 06-439)

	and validate the multimedia and indirect exposure portions of F&T models, with a greater emphasis on identifying specific sites with multimedia data sources • Give 3MRA GIS ability (from pilot) • Evaluate alternative air dispersion models to ISC3 that take into account physicochemical and fate properties for volatile and semi-volatile compounds • Develop data appropriate for addressing the uncertainty in the toxicological dose–response relationship • Incorporate the dermal and vapor intrusion pathways • Develop algorithms to replace the Travis & Arms equations for estimating biotransfer of pollutants (from pilot). • Biotransfer factors from soils to plants,; from plants to pork, from plants to chicken, and from soil to chicken (from pilot) • Incorporate ingestion of chicken and pork products • Establish and incorporate correlation measures among exposure factors • Evaluate feed-forward calculation for multimedia modeling with respect to conservation of mass and secondary sources of contamination • Develop capability to assess simultaneous exposure from multiple chemicals and multiple sources • Parameterize the model • Improve the visualization and analytical tools for the modeled intermediate outputs and final results	
Sampling/ Analytical	o Develop analytical methods to achieve detection limits low enough to use in environmental decisions, for example, PBT detection limits below water quality criteria o Develop tandem procedure for discrimination of coeluting peaks	
Permitted Thermal Units	• Dioxin/furan emissions from boilers and from halogen acid furnaces. Continue work to identify significant D/F formation factors in boilers, ranging from operating	Publish paper on use of CEMs to measure organic surrogates for dioxin, and the application of those CEMs to assure compliance and

	parameters to design features, and identify key control mechanisms that are appropriate and cost-effective • Document that PM CEMS can meet SP-11 under HWC operating environments • Promulgate performance specs for multimetals CEMS and documentation that the CEMS can meet the specs under HWC operating environments. • Develop and demonstrate CEMS for D/F or surrogates • Promulgate performance specs for such CEMS and document that the CEMS can meet the specs under HWC operating environments • Determine if current MACT compliance monitoring requirements reasonably ensure compliance with the emission standards • Determine if new hazardous waste emission control techniques would provide a cost-effective reduction in emissions, and what health benefits would be realized • Develop improved surrogates and CEMs for organic HAP/ dioxin/furan/mercury emissions and post-combustion formulation. The surrogate approach is important for organic HAPs because current control mechanisms are limited in direct effectiveness (DRE, CO/HC limits) and because they do not supply the public with a sufficiently definite organic HAP profile. • Technical support to permit writers and OSW, on stack sampling analysis, CEM and risk assessment, metals emissions, dioxin and other PICs, particulate emissions, and operations parameters. Ongoing needs for support (site- specific risk assessments) and for access to in-house expertise on implementing ORD emissions control methodologies • Develop improved speciation methods for distinguishing among and measuring the products of incomplete combustion (PICs), including coplanar PCBs. Full-scale PIC testing to better understand formation dynamics,	optimize system operation (NRMRL 06-579) Develop draft report on the use of Jet-REMPI for measurement of trace organics from incinerators (NRMRL 07-167) NRMRL research in the Hg MYP, Air Toxics MYP and ETV is relevant to combustion sources: • Journal article on speciation and adsorption of Hg in coal-fired boilers to improve the ability of OAR to develop and implement effective Hg control strategies. (HG 06-88) • State-of-the-art report on CEMs for coal-fired boilers, to provide understanding of mercury emission monitoring options (HG 06-89) • ETV has completed verifications of Hg and multimetal CEMs; reports are posted at http://www.epa.gov/etv/verifications/verification-index.html Evaluate metal speciation of arsenic, nickel, and chromium in selected combustion systems to improve data used by OAR to develop emission factors assessments (AT 07-384) NRMRL published Evaluation of Total Organic Emissions Analysis Methods, EPA/600/R-04/144, September 2004; no further work is planned Develop data on the size distribution and detailed chemical composition of fresh and aged combustion-generated particles produced from

	particularly post- combustion PICs, including work on coplanar PCBs • Develop air deposition models, especially the components dealing with vapor transport to surfaces, vapor/particle partitioning of semi-volatile compounds, wet versus dry deposition properties, and deposition of semi-volatiles. • Finalize dry gas models. • Better understand mercury speciation at stack and F&T transformation • Assess how emissions from Subpart X high-temperature treatment units can be better characterized and controlled • Assess how reliable are laboratory procedures and data results from stack gas emissions characterization in relation to EPA methods currently being used. Specifically, • (1) How are laboratories across the country actually implementing EPA stack gas methods, e.g., with or without method modifications? and • (2) If labs are modifying EPA methods on a routine basis, or even only in certain case-driven instances, what are the impacts of these method modifications on data usability, specifically for risk assessment, permitting, and compliance evaluations? • Finalize TOE guidance • Develop surrogate particle-size distribution data sets or a methodology to generate them for different types of units that emit particles	full- and pilot-scale systems for use in real-time inhalation toxicology studies (PM NRMRL 08-215) Transfer to OAR technical information to guide the development of SO_2 and NO_x control technology requirements for coal-fired boilers to prevent formation of visible acid aerosol plumes (PM NRMRL 05-201) ***Technology Assessment—Energy Sector:*** Examine changes/improvements in fossil fuel energy generation, alternative energy technologies, and market penetration of these technologies (GLB NRMRL 06-126)
WtE	• Waste gasification (from pilot) • Analytical methodologies to better characterize the fate of hazardous constituents during gasification • Further development of energy-recovery technologies from wastes, and technologies for production of bio-fuels from biomass waste (renewable energy) • Research on the content and environmental durability of gasification frit	Decision support tool for holistic approach to solid waste management (PP NRMRL 06-511)

Beneficial Use	Evaluate beneficial use of industrial waste-derived products (coal combustion wastes, foundry sands, C&D debris, and slag) including safety	See pilot project under CQ 2.1, proposing a combination of leach testing and modeling to evaluate environmental compatibility of beneficial use
Sustainability	Development of source reduction and recycling opportunities for processes that generate hazardous wastes containing persistent, bioaccumulative, and toxic chemicals (PBTs)	
Landfills	• Research into long-term stability of landfills • Durability/failure of hazardous waste liners to better understand their life span and long-term effectiveness in protecting the environment • Identify likely failure mechanisms, for use both in near-term installation requirements and in modeling long-term probabilities of failure • Develop probabilistic modeling approaches to help identify long-term probabilities of failure under various regional environmental conditions • *Bioreactors:* Work with OSW and SWANA to identify recent developments in research on "landfills as bioreactors," which is being conducted in a number of municipalities and states • Conduct research to identify optimal operating condition and parameters, for use in national regulatory revisions and guidance, and ultimately in state programs • Develop an enhanced liquid delivery/gas extraction system • Characterize an optimal liquids feed composition for microbial degradation • Cover strategy/materials for improved methane collection and greenhouse gas minimization	Evaluation of the performance of liners/covers including phyto-technologies (NRMRL 10-22) Interim report on landfill bioreactor design manual, characterizing the optimum operating and monitoring approaches (NRMRL 06-241); synthesis report on landfill bioreactor performance (NRMRL 09-xxx) Develop and transfer to OAR and the States the ability to identify and quantify fugitive source particle emissions, using open path FTIR spectroscopy (PM NRMRL 08-233)
MSW	• Technological assessment of single-stream collection of recyclables and related processing systems; new uses for such difficult-to-market recyclables as certain plastic resins; feasibility of widespread commercial use of reusable containers. Research data would be used in conjunction with economic assessments to determine feasibility of	Decision support tool for holistic approach to solid waste management (PP NRMRL 06-511)

	single-stream collection systems. • *Technologies for municipal waste management programs:* Possibilities for technical evaluation include evaluation of ash aggregates for use in cement and non-cement applications; evaluation of compost products as a filtering medium; evaluation of specified recycled products for the Comprehensive Procurement Guidelines; durability of synthetic liner systems; and evaluation of innovative recycling, treatment, and disposal approaches being considered by local governments • Conduct pilot study to evaluate or supplement theoretical modeled analyses of human health and environmental impacts associated with the consequences of a change in a system	
MFA/LCA	• Life cycle assessment • Development and peer review of national-level life cycle inventory databases for selected industrial sectors	
Future Waste	Management of wastes associated with future technologies (e.g., nanotechnologies, fuel-cell technologies, technologies for harnessing various renewable and non-renewable energy sources, new battery technologies)	ORD is initiating a research theme on nanomaterial fate and transport
Hard-to-Treat Wastes	Management approaches for hard-to-treat wastes	A report evaluating the effectiveness of current waste stabilization processes for mercury, arsenic, and lead (NRMRL 06-243) (Hg work is a component of ORD Hg MYP.)
	Technical assistance to review site-specific risk assessments submitted by owners/operators	
Sampling/ Analytical	Real-time field detection equipment (mobile/portable labs) supplied by EPA to States	
Beneficial Use	Guidance materials on "beneficial reuse," performance of waste containment systems, liner design, waste-to-energy opportunities, calculating natural resource damages, and innovative technologies	See individual topics for products that can be incorporated into guidance materials.
Sustainability	Technical support to develop objective criteria for "environmentally preferable products"	

Appendix B: Legislative History

Legislation under the Resource Conservation and Recovery Act (RCRA), and the Superfund Amendments and Reauthorization Act (SARA) in 1986, authorized research programs to support scientific needs. The Solid Waste Disposal Act of 1965 was the first law to require safeguards and encourage environmentally sound disposal methods for household, municipal, commercial, and industrial refuse. Congress amended this law in 1970, the Resource Recovery Act, and again in 1976, with the Resource Conservation and Recovery Act. Congress revised RCRA in 1980 and 1984. The 1984 amendments, the Hazardous and Solid Waste Amendments (HSWA), significantly expanded the scope of RCRA. The major subtitles are as follows:

1. *Subtitle C* establishes a program for managing hazardous waste from generation to ultimate disposal, including the cleanup of sites contaminated by hazardous waste spills and other releases to the environment.
2. *Subtitle D* establishes a program for managing solid (primarily nonhazardous) waste, such as household waste.

Section 6902 of RCRA (42 USC 82 Subchapter I, Sec. 6902 (a)) describes the intent of Congress to promote the protection of health and the environment and the role of research by:

3. "Promoting a national research and development program for improved solid waste management and resource conservation techniques, more effective organizational arrangements, and new and improved methods of collection, separation, and recovery, and recycling of solid wastes and environmentally safe disposal of non-recoverable residues; and
4. "Promoting the demonstration, construction, and application of solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of air, water, and land resources.

RCRA as amended by HSWA has led to significant regulatory programs for the safe management of hazardous and non-hazardous wastes. The Agency is increasingly focusing on improvements to the regulatory framework based on the most current science and greater emphasis on resource recovery. In addition, legislation mandates that EPA require the investigation and cleanup, or remediation, of these hazardous releases at RCRA facilities. This program is known as RCRA Corrective Action (CA). EPA enforces RCRA CA primarily through statutory authorities established by HSWA.

Legislative History Superfund, Oil Spills, UST

The assessment and cleanup of sites contaminated with hazardous substances, fuels, or oils are often complex processes, with both the variety and number of sites making cleanup costly and time-consuming. For Superfund, the National Priorities List (NPL) presently lists 1,232 sites and an estimated 40 new sites will be added annually through at least 2010. There are more than 300,000 LUST CA sites, and States spend nearly $2 billion annually to clean up these sites. Additionally, it is estimated there are potentially hundreds of thousands of old gas stations that may require remediation. Annually, 18,000 to 24,000 oil spills are reported, and 10–25 million gallons of oil are spilled, impacting coastal and inland waterways.

Contaminated sites under Superfund authority are addressed under provisions of the National Contingency Plan (NCP) (http://www.epa.gov/superfund/contacts/ntlcplan.htm) and related guidance documents (http://www.epa.gov/superfund/action/guidance/index.htm). Remedial actions follow a stepwise process from site discovery, through site assessment, through cleanup, to operation and maintenance and 5-year review. Removal actions are used when risks warrant near-term action.

Through ORD, EPA has been conducting research to support the needs of the Superfund Program since the inception of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), also referred to as Superfund. ORD's Superfund research program was not formalized, however, until 1986 with the passage of the Superfund Amendments and Reauthorization Act (SARA). SARA established an alternative or innovative treatment technology research and demonstration program at EPA and authorized EPA to conduct and support hazardous substance research with respect to the detection, assessment, and evaluation of the effects on and risks to human health of hazardous substances and detection of hazardous substances in the environment.

Oil spills are also addressed under provisions of the National Contingency Plan via a 3-pronged approach of prevention, preparedness, and response (http://www.epa.gov/oilspill/overview.htm). Research addresses the latter two aspects of the program.

Corrective action for LUST sites is largely delegated to States and implemented by regulations with related guidance. In general, the process for leak response is to stop the release, report it, manage immediate risks, and then determine short- and long-term responses needed for cleanup.

Brownfields redevelopment, part of EPA Strategic Goal 4, benefits from the characterization and remediation research described in this MYP. Research is authorized under the Small Business Liability Relief and Brownfields Revitalization Act, but an appropriation for research has not been requested. Instead, the Office of Brownfields Cleanup and Redevelopment works directly with ORD staff to identify high-priority research for funding via intra-agency funding transfer. This process is conducted by Goal 3 research staff to ensure coordination and prevent duplication of effort.

Appendix C. EPA Strategic Plan and Land MYP Linkages

EPA's Strategic Plan sets overall goals and specific targets for programs to achieve. The Land Goal within the strategic plan identifies the targets for the research programs that this MYP supports. The targets help us determine the appropriate sub-objectives where ORD can contribute to supporting the goals.

Three objectives within Goal 3 address the OSWER programs. The goal states:[5]

Objective 3.1: Preserve Land. By 2008, reduce adverse effects to land by reducing waste generation, increasing recycling, and ensuring proper management of waste and petroleum products at facilities in ways that prevent releases.

Sub-objective 3.1.1: Reduce Waste Generation and Increase Recycling. By 2008, reduce materials use through product and process redesign, and increase materials and energy recovery from wastes otherwise requiring disposal.

Sub-objective 3.1.2: Manage Hazardous Wastes and Petroleum Products Properly. By 2008, reduce releases to the environment by managing hazardous wastes and petroleum products properly.

Objective 3.2: Restore Land. By 2008, control the risks to human health and the environment by mitigating the impact of accidental or intentional releases and by cleaning up and restoring contaminated sites or properties to appropriate levels

Sub-objective 3.2.1: Prepare for and Respond to Accidental and Intentional Releases. By 2008, reduce and control the risks posed by accidental and intentional releases of harmful substances by improving our Nation's capability to prepare for and respond more effectively to these emergencies.

Sub-objective 3.2.2: Clean Up and Reuse Contaminated Land. By 2008, control the risks to human health and the environment at contaminated properties or sites through cleanup, stabilization, or other action, and make land available for reuse.

Objective 3.3: Enhance Science and Research. [The purpose of this objective is to meet the science and research needs of OSWER. Specifically, the objective is as follows:] Through 2008, provide and apply sound science for protecting and restoring land by conducting leading-edge research and developing a better understanding and characterization of environmental outcomes under Goal 3. Two sub-objectives further differentiate between science and research:

Sub-objective 3.3.1: Provide Science to Preserve and Remediate Land. Through 2008, provide sound science and constantly integrate smarter technical solutions and protection strategies that enhance our ability to preserve land quality and remediate contaminated land for beneficial reuse.

Sub-objective 3.3.2: Conduct Research to Support Land Activities. Through 2008, conduct sound, leading-edge scientific research to provide a foundation for preserving land quality and remediating contaminated land. Research will result in documented methods, models, assessments, and risk management options for program and regional offices, facilitating their accurate evaluation of effects on human health and the environment, understanding of exposure pathways, and implementation of effective risk-management options. Conduct research affecting Indian country in partnership with tribes.

[5] 2003–2008 EPA Strategic Plan, September 2003, EPA-190-R-03-003, http://www.epa.gov/ocfo/plan/2003sp.pdf

Table C-1 shows where ORD research activities conducted under Objective 3.3 support sub-objectives under **Objectives 3.1 Preserve Land** and **3.2 Restore Land**. It is not the intent of the research program to support each Goal 3 sub-objective. However, the program is leveraged with research conducted under other goals. Sub-objective 3.1.1 is primarily OSW resource conservation and waste reduction activities. The research activities supporting 3.1.1 are resource conservation and, under Goal 4, sustainability research, which addresses various areas of reuse, green chemistry, and life cycle assessment. The activities of OSW and OUST on management of hazardous waste, Sub-objective 3.1.2, is supported by research on waste management, multimedia modeling, and leaking underground storage tanks (LUST) fate and transport (F&T) studies and research on effectiveness of remedial alternatives. OSWER emergency response activities for oil and chemical spills and homeland security, under sub-objective 3.2.1, are supported by research on preparedness and response responsibilities with respect to risk assessment, F&T, site remediation, and risk management strategies for petroleum and non-petroleum oil spills. Homeland security research, conducted under Goal 4, also supports response activities through research on rapid risk assessment, water security, and decontamination of buildings. The Superfund program is addressed in Sub-objective 3.2.2. ORD research to support Superfund is primarily focused on contaminated sediments, ground water, site characterization, and site-specific technical support. Within EPA's Goal 4, ORD's human health risk assessment research produces exposure factors, toxicity values (IRIS), site-specific technical support, and conducts major risk assessments to support OSWER.

Table C-1. ORD Research Conducted in Objective 3.3 and Goal 4 That Support OSWER Activities in Objectives 3.1 and 3.2

Goal 3 Land	3.3 Science and Research
Objective 3.1 Preserve Land	
3.1.1 Reduce Waste Generation and Increase Recycling	Goal 3: Resource Conservation Goal 4: Sustainability Research
3.1.2 Manage Hazardous Waste and Petroleum Products Properly	Goal 3: Materials Management Goal 3: Underground Storage Tank Research
Objective 3.2 Restore Land	
3.2.1 Prepare for and Respond to Accidental and Intentional Releases	Goal 3: Oil Spill Research Goal 4: Homeland Security
3.2.2 Clean up and Reuse Contaminated Land	Goal 3: Contaminated Sediments, Ground Water, Multimedia and Analytical Methods, and Technical Support Goal 4: Risk Assessment
3.2.3 Maximize Potentially Responsible Party Participation at Superfund Sites	N/A

To better communicate the types of research conducted under this research plan and to demonstrate how leveraging occurs among ORD MYPs, the matrix in Figure C-1 presents Land MYP and other ORD MYP research areas versus media (e.g., soil, surface water) to highlight the focus of the Land MYP and present leveraging and collaboration with other MYPs.

Land MYP Matrix

MEDIA	EXPOSURE-SITE CHAR	ECOLOGICAL EFFECTS	HUMAN HEALTH EFFECTS	HUMAN HEALTH RISK ASSESS	REMEDIATION TECHNOLOGY	RISK MANAGEMENT
SEDIMENT	**LAND MYP**	**LAND MYP**	Human Health MYP	Human Health Risk Assess. MYP	**LAND MYP**	**LAND MYP**
GROUND WATER	**LAND MYP**		Drinking Water and Human Health MYPs	Human Health Risk Assess. MYP	**LAND MYP**	**LAND MYP**
SURFACE WATER	Water Quality and Drinking Water MYPs	Water Quality and Ecosystems Protection MYPs	Drinking Water and Human Health MYPs	Human Health Risk Assess. MYP	Water Quality and Drinking Water MYPs	Water Quality and Drinking Water MYPs
SOIL	**LAND MYP**	Ecosystems Protection MYP	Human Health MYP	Human Health Risk Assess. MYP	**LAND MYP**	**LAND MYP**
TECHNICAL SUPPORT CENTERS	**Site Characterization, Env. Photo. Interp., Subsurface Modeling, Exposure Assess. Modeling**	**Ecological Risk Assessment**	**Superfund Health Risk**	**Superfund Health Risk**	**Engineering, Groundwater**	**Engineering, Groundwater**

Figure C-1. Matrix of Land MYP and Other MYP Research Areas Versus Media

Appendix D. EPA Science Advisory Board Reviews

EPA Science Advisory Board Review of Contaminated Sites and RCRA Multi-Year Plans

Specific panel recommendations and the EPA response are presented below.

SAB Recommendation	EPA Response
The Panel supports ORD's plan to merge the documents into a single plan that clearly relates the research to the Agency's strategic goals and targets. By clearly linking research priorities and the Agency's strategic objectives with defined long-term goals, themes, and work products, the Agency will be able to demonstrate the relevance, quality, and contribution of the individual research activities to meeting the Agency's mission within resource constraints.	The Multi-Year Plan (MYP) merges the two former MYPs on contaminated sites and RCRA. Linkages to client outcomes are described in the logic diagram (Figure 3) and in the development of client-oriented long-term goals (LTGs).
The Panel recommends that the revised, integrated plan address the difficult question of how short-term research, long-term research, core research, and problem-driven research will be integrated to support the *Strategic Plan's* Goal 3 strategic targets.	A matrix (Appendix C, Figure C-1) in the MYP presents risk assessment/risk management categories versus media (e.g., soil, surface water) to highlight the focus of the Land MYP and leveraging and collaboration with other MYPs, which include core and problem-driven research.
The Panel also recommends that the revised plan show how the various research activities connect to the Strategic Plan's Goal 3 targets. The Panel believes that a specific and transparent mapping of the elements of the Multi-Year Plan to the substantive goals of the Strategic Plan will improve the Multi-Year Plans and will optimize the use of scarce research dollars.	Table C-1 in the MYP shows the relationship of Strategic Plan Objective 3.3 Science and Research activities with activities in Objective 3.1 and 3.2 and their sub-objectives. Leveraging and coordination with research in other goals is important to address issues under Goal 3 in the Strategic Plan.
These LTGs should be rewritten to be outcomes oriented rather than output oriented. The distribution of science and technical research activities by media, which is useful to OSWER, could be accomplished at the annual performance goal level.	The six LTGs in the previous MYPs were condensed into two client-oriented LTGs in the revised MYP. Research activities by media are presented as research themes under each LTG.
The Panel also recommends that the Agency implement a clearly defined institutional process of continuous re-scoping to regularly identify and prioritize emerging research topics, as discussed in the response to Charge Questions 1e and 2a.	The MYP instituted an enhanced process to incorporate regional and program office research needs.
Within the portfolio of projects identified in the RCRA and Contaminated Sites MYPs, the Panel believed there were clear opportunities for	Table 1 in Section 5.2 lists research areas that are enhanced, decreased, or eliminated. Collaboration activities continue to be very

efficiencies by combining some programs, reducing expectations in other programs, and reducing or eliminating other programs where clear leveraging opportunities with other government or private agencies could be identified.	important to the research program and are presented in Appendix H of the MYP. Of note are an MOU with NIEHS and contaminated sediments collaboration activities with the Navy, Army Corps of Engineers, and EPA.
The Panel recommends that the Agency continue to improve the annual performance measures to better reflect the intended/expected outcomes of ORD's efforts in supporting the Agency's strategic targets.	This is an ongoing process in which annual performance goals (APGs) are being focused on the intended use of the supporting research.
The Panel recommends that ORD establish a line item in its annual research budget that specifically supports research that looks far ahead (10+ years) on emerging needs, ideally through new resources but by re-programming if necessary.	The Land MYP discusses leveraging its research program with other MYPs to evaluate emerging issues. In FY08, ORD re-directed research to initiate enhanced research efforts in nanotechnology. Mining will have an increased emphasis.
The Panel recommends that the flow diagrams more clearly and succinctly illustrate the connections between the Strategic Plan, long-term goals, annual performance goals, and annual performance measures.	We are addressing an effective way to diagram the connection of research products to support goals stated in the Strategic Plan. Wiring diagrams for each LTG show APGs supporting each LTG.

Table D-2. Land Research Program: Summary of BOSC Recommendations from March 2006 Final Report and Proposed ORD Actions Timelines (March 2007)
(includes entries only for those recommendations that require ORD action)

Recommendation	ORD Action	Timeline for Action
(1a) How the MYP could communicate information more clearly	Addressed in revised MYP; Sections 1 and 2 were streamlined, and the removed text was added to the Appendices.	Final MYP
(1b) How future conditions can be better anticipated	We will continue to use Regional Advisory Workgroups, Technical Support Centers, and communication with OSWER management to assist us in being aware of future issues that require research activity.	Report progress at BOSC mid-point review
(1c) How collaborative efforts can be pursued with greater effectiveness, and how certain historical program needs are	In 2006, we formed a group of federal agency program directors from NIEHS, DOE,	Ongoing

addressed as programs sunset or are terminated	NSF, SERDP, and EPA to further document collaboration and limitation of the duplication of research.	
(2a) Improve the readability of the report by highlighting the essential features of the Land MYP and minimizing jargon and acronyms. Consider rephrasing the two LTGs to reflect technical or scientific themes inherent in ORD efforts to enhance the success of OSWER programs in Land Preservation and Restoration.	Disagree on rephrasing LTGs. LTGs were rewritten in the draft in response to SAB and OMB recommendations to have them be outcome-oriented LTGs. Research questions, with scientific themes, will be stated when research themes (e.g., ground water) are discussed.	Final MYP
(3a) Consider including periodic forecasting of emerging problems that could be examined in a preliminary way to judge their import.	The RCT, regional groups, Technical Support Centers, and OSWER management bring forward emerging issues (e.g., vapor intrusion into homes, ground water–surface water contamination, Brownfields, and animal carcass disposal. ORD shifts the research program to address the issues. In addition, the MYP will attempt to highlight emerging issues that are part of the research program.	Final MYP
(4a) Consider opportunities for collaboration and leveraging at the national and international levels. Enhance the use of Web-based support systems for facilitating multifacility research efforts. Look for opportunities to collaborate with EPA research efforts in Homeland Security and in risk communication.	See answer to 1(c). ORD is developing Web pages for each NPD, and we will have further discussion with the Superfund office on linking into their Web and communication systems.	Report progress at BOSC mid-point review
(5a) The MYP should address the current and future processes for replacing retiring expertise and developing new scientists with emphasis on emerging areas. Increase support of university-based research to involve these stakeholders and train future generations of environmental researchers.	This is not the purpose of a MYP. The ORD grants and fellowships programs in NCER address this issue by helping to develop the next generation of environmental scientists and engineers. ORD workforce planning is	Done

	conducted principally by the labs and centers.	
(6a) If there are recognized gaps associated with sunsetting or terminating programs, these could be prioritized for collaborative research efforts.	Text was added to the MYP in Sections 5.0 and 5.2 to address this comment.	Final MYP
(7a) The Subcommittee acknowledges the interplay of forces regarding performance metrics but endorses their continued use and suggests that the need for balance be borne in mind.	Agree. The PART for this program was completed in 2006, and the negotiated measures will be incorporated into the management of the program.	Done
(8a) Outcomes. Consider how the linkages could be made more clear or enhanced in the Land MYP.	Wording will be edited in the logic diagram, and PART measures will be added to the MYP. Section 3 was added on recent outcomes, and performance measures are stressed in the MYP.	Final MYP
(9a) Consider how to characterize and communicate uncertainties inherent in assessment methods and models. Explore collaborations with ORD efforts that focus on the analysis and communication of uncertainty. Integrate this information into Agency guidance and rules.	Characterization and communication of uncertainties in risk assessment is a research area that cuts across many ORD research programs in addition to the Land program. For this reason, research aimed at characterizing and representing uncertainty in risk assessment is currently included under the Human Health Risk Assessment Research Plan. This happens to be a topic of substantial interest to the Assistant Administrator for ORD, Dr. George Gray, who has personally conducted significant research in this area in his previous career. There are thus several efforts currently underway within the HHRA Research program that will address this topic in a manner suitable for integration into Agency guidance and rules.	Ongoing; primarily in HHRA MYP

(A1) State the goals and objectives of the Program in terms of their short-term or long-term nature.	Long-term and annual measures from the PART will be incorporated in the MYP. APGs in the MYP vary on the basis of the long-term or short-term nature of the science being addressed.	Final MYP
(A2) Articulate the benefits of the Land Research Program within the Land MYP by mapping the goals and activities within the Land MYP to the customer's performance measures.	Recent benefits of the program are listed in Section 3. The MYP will link research activities to program office research needs, EPA Strategic Plan Goal 3 strategic targets, and Land Research Program PART measures.	Final MYP
(A3) Clarify within the Land MYP who is meant by stakeholders and clients.	This comment is addressed in the final MYP.	Final MYP
(A4) Identify gaps not being covered by existing projects and the intersections among the projects. Such a gap analysis will position the Program to respond rapidly to circumstances where additional resources or leveraging opportunities present themselves.	To better communicate the types of research conducted under this research plan and to demonstrate how leveraging occurs among ORD MYPs, a matrix was placed in the MYP (Appendix Figure C-1) to present Land MYP and other ORD MYP research areas (e.g., human health effects, remediation technology) versus media (e.g., soil, ground water) to highlight the focus of the Land MYP and collaboration with other MYPs. Also, a gap analysis is embedded in Appendices A and B of the MYP.	Done
(A5) Emphasize to a greater degree within the Land MYP how and by what means the outputs and products generated from the Land Research Program will be transferred to the field. This includes placing greater emphasis on transferring technologies to the private sector so that they can come into more common use and have greater impact.	This may be beyond the purpose of a MYP. Additional efforts to enhance communication of research products involving linkage of line management to wider communication mechanisms are underway.	Report progress at BOSC mid-point review
(B1) Provide greater description of how	A high degree of detail was	Final MYP

criteria were used to prioritize needs and projects for both LTGs, but specifically for LTG 2.	provided on regional criteria and the process of utilizing regional workgroups for LTG 1. For LTG 2, OSW, the customer, utilized a category 1, 2, and 3 process that was described in the MYP. We'll look at this comment in the revised MYP, but it is likely that readability and flow issues will prohibit us from adding more detail.	
(B2) Incorporate input from outside groups (other government agencies, academia, industry, and other stakeholders), especially for future Land MYPs, and ensure that all valid scientific advice is heard and considered apart from policy issues.	The EPA conducts more peer review of their research programs than any other federal agency. When the MYP is final, it will be publicly available on the Web. The subcommittee was provided with the various levels of peer review that are already incorporated into the program.	Done
(B3) Articulate the mechanisms for ensuring periodic quality reviews during the conduct of projects. Such periodic (e.g., quarterly or annual) review and feedback are important for both ensuring that research is on track technically and for feedback from the customer. Where relevant, it may be appropriate to include the customer (e.g., regional staff, state agencies) in the process of obtaining periodic feedback.	A formal annual review with clients has been in place since the inception of the research coordination team. Since the BOSC review, we have committed to semiannual topical progress reviews with clients, using the regional research advisory workgroups.	Report progress at BOSC mid-point review
(C1) State the Program goals more clearly in terms of their scientific research focus. The goals could be recast in terms of the two major environmental challenges with problems, and the scientific advancements needed to aid their resolution then described as subgoals. Projects and outputs could be organized by major problems (e.g., assessment and cleanup of DNAPLs in ground water, design and operation of landfill bioreactors) along with the planned workflow.	In working to prepare for the PART, most of the MYPs shifted to customer-focused LTGs instead of a scientific research focus. For each research theme (e.g., ground water contamination), we will state the scientific research focus for that theme in the MYP.	Final MYP
(C2) Review potential needs related to	Cross-cutting issues are	Done

current issues that cross-cut multiple programs (e.g., biosolids and animal waste application to land, mining and megasites, oil and gas operations, infectious disease agents, beneficial reuse of waste materials, uncertainty in risk assessments, and communication of risk results.	typically assigned to a particular MYP with an understanding of which other MYPs include related work. For example, land application of waste is conducted under the Water Quality MYP but is of interest to OSWER. Beneficial use of wastes is in the Land MYP, but the sustainability program contributes results as well. In the 2003 editions of the MYPs, we attempted to cross-reference outputs that addressed multiple programs. It proved impractical to maintain the cross-references as the programs evolved because of changing priorities and resources. Within the labs and centers, Assistant Directors routinely consult each other and relevant staff and management on synergies between various research programs and bring that information back to the various research coordination teams.	
(C3) Clarify in the Land MYP the sequence of research questions along a timeline and the activities that are to be conducted.	The text in Section 5 of the document has been edited to clarify the progression of research. Wiring diagrams are updated. The reorganization of the Land APMs and APGs will also assist in presenting the timeline of research (see the response to C1).	Final MYP
(C4) Identify, to the extent they exist, the opportunities for staff scientists or engineers to initiate ideas, for example, through a seed funding program.	Most of the laboratories have an independent research program in which P.I.s compete for seed funding.	Done
(D1) Consider leveraging and collaborating with others so as to ensure	The transition of half of the LTG 2 program to	Final MYP

timely progress for LTG 2.	nanomaterials will be leveraged with other federal programs. The MYP will present a smaller focused materials management program.	
(D2) Improve the process for updating Integrated Risk Information System (IRIS) values for chemicals currently in the database and for developing values for potentially important chemicals not in the IRIS database. The Subcommittee recognizes that this falls only partially within the domain of the Land Research Program.	The IRIS is guided under LTG 1 of the Human Health Risk Assessment (HHRA) Research Program and is not a part of the Land Research Program. It is recognized that IRIS is a cross-cutting Agency database of interest and relevance to many ORD research programs. The IRIS program is currently undergoing a period of significant revision, with the aim of increasing the transparency and inclusiveness of the IRIS chemical evaluation process, including formal, quantitative uncertainty analysis in IRIS assessments, and developing guidance for incorporating uncertainty analysis into decision making. There is a tradeoff to be made in that more transparency and consideration of uncertainty inevitably results in more time needed to complete assessments and, hence, delays the development of values for potentially important chemicals not within the IRIS database. However, ORD is committed to increasing the availability of current, scientifically rigorous chemical toxicity information within the IRIS database.	Addressed in HHRA MYP
(D3) Articulate how planned and future research programs support decision	Brownfields research activities will address	Final MYP

making on sustainability issues and on life cycle assessment determinations related to solid and hazardous waste management.	sustainability issues; however, the shift to nanotechnology will reduce the research program activities in hazardous waste management.	
(D4) Update key technology documents related to landfill design. ORD could collaborate with the geosynthetic industry to help fund such work.		Final MYP
(D5) Identify within the Land MYP the mechanisms for tracking progress for specific projects with respect to the LTGs.	The ORD management has quarterly reporting for progress toward completing APMs and APGs which lead to addressing LTGs. These reports are forwarded to NPDs and the DAA for Management. Management is held accountable for completing scheduled milestones.	Ongoing
(E1) Identify a process for acquiring or developing key leaders for those programs where clear leadership may be lacking. Such leadership should be reflected in personnel as well as programs. Particular emphasis should be given to leadership in emerging fields.	ORD has a hiring process in place to add senior scientists to lead emerging or high priority research areas.	Done
(E2): Describe or develop mechanisms for identifying mature research fields, emerging issues, and/or ensuring that the ORD-planned research is not duplicating efforts being conducted by other government or state agencies or by private industry. This could be guided by external peer review by experts drawn from universities, nongovernmental organizations, state agencies, and private industries.	This is an ongoing issue that we will continue to address. Addressing customer research needs, collaboration of research efforts, and limiting duplication of research are always of concern in this research area (see responses to 1c and 3a). ORD, in its response to the BOSC subcommittee, provided examples from regional site managers on the specific benefits of applied research.	Final MYP
(E3) Enhance ORD's position as a global leader by encouraging continued participation in international panels and meetings.	Agree.	Done
(E4) Ensure that funding is directed	Agree. The shift to	Final MYP

toward areas in which large gains in understanding can be made through research. This involves favoring research areas that are new or emerging over mature areas of research. The Subcommittee recognizes the balance that must be struck between new research and technical assistance.	nanomaterials, in part, addresses this comment. This is a problem-driven research program in which importance is placed on addressing customer research needs. Every year, new issues are brought forward (e.g., vapor intrusion into homes, ground water–surface water contamination, Brownfields, animal carcass disposal), for which we shift the research program and partner with OSWER to address the issue.	

Appendix E: Research Conducted Under the Human Health Risk Assessment MYP and Related Research

Risk assessment is a process in which information is analyzed to determine if an environmental hazard might cause harm to exposed persons or ecosystems (NAS, 1983). It is the essential intermediary means by which primary data and published literature are compiled, analyzed, and summarized for application to decision making in real-world situations. This science-based framework for decision making is central to EPA's implementation of its statutory responsibilities and to its mission to protect human health and the environment.

The National Center for Environmental Assessment (NCEA) conducts a variety of risk assessments and risk assessment research in support of OSWER. Much of this research is described in the Human Health Risk Assessment (HHRA) Multi-Year Plan (MYP). This plan serves as a primary EPA mechanism to implement this process, linking laboratory and field science with the use of this information by EPA programs, regions and the broader community. To achieve this goal, the HHRA MYP directs efforts toward the following:

- Providing qualitative and quantitative health hazard assessments of priority environmental contaminants for incorporation in applied risk assessments, exemplified by the Integrated Risk Information System (IRIS) Toxicological Reviews and Summaries, reference doses (RfDs), reference concentrations (RfCs), oral cancer slope factors and inhalation cancer unit risks;

- Preparing Air Quality Criteria Documents (AQCDs) for criteria air pollutants as a mandated pre-requisite to EPA's review of National Ambient Air Quality Standards (NAAQS);

- Conducting environmental risk assessments of national importance, such as potential health impacts in the aftermath of the attack on the World Trade Center and the reassessment of the health risks posed by dioxin;

- Developing models, methods and guidance to incorporate the latest scientific advances into EPA risk assessment practice, thereby maintaining the scientific quality and objectivity of EPA assessments consistent with the state-of-the-science;

- Identifying, evaluating, and conveying to the scientific community any key uncertainties and research needed to improve health risk assessments through laboratory, field, and methods research; and

- Supporting the Risk Assessment Forum (Forum), through which risk assessors across the Agency can communicate and harmonize risk assessment practices to facilitate a consistent and predictable framework for EPA activities.

The core of the HHRA activities is the IRIS, which began two decades ago as an internal EPA activity to facilitate communication among ORD programs and regions to harmonize the otherwise disparate reference values prepared for hazardous substances in different parts of the Agency. IRIS has since grown to be the premier national and international source for quantitative risk values and environmental pollutant health hazard information. A typical IRIS

Toxicological Review and Summary provides a qualitative discussion and documentation of environmental health hazards posed by a substance to humans, accompanied by a reference dose (RfD), reference concentration (RfC), oral cancer slope factor (CSF), and/or cancer inhalation unit risk (IUR). OSWER risk assessors and policy makers apply these quantitative risk values to measured or estimated human dose levels to inform their decision making on environmental issues.

Although nonregulatory, quantitative IRIS values influence many environmental decisions and may serve as a basis for additional regulatory consideration. The increased visibility accorded IRIS values has been accompanied by additional government and stakeholder scrutiny, leading to increased time required for document review and finalization. To facilitate more rapid responses to urgent programmatic needs on less controversial substances, the HHRA MYP also guides the production of Provisional Peer-Reviewed Toxicity Values (PPRTVs) for internal used by OSWER and the regions when IRIS values are not available.

Methods development work under the HHRA MYP is directed toward incorporating scientific advances into risk assessment practice, similar to equipment upgrades to maintain standards of practice. In order to achieve peer-review quality, these methods developments must respond to the increasing breadth and depth of available information across the diverse scientific disciplines contributing to risk assessment. To address this, the HHRA MYP has engaged in a process to determine the scientific foci most advantageous to advancing risk assessment science, based on projections of future Agency needs, scientific developments, and the availability of resources. These HHRA foci include mode of action, PBPK modeling, quantitative methods, inhalation methods, exposure measures, chemical mixtures assessment, and microbial risks. Many of these methods are applicable to risk assessment problems of interest to OSWER (e.g., assessment of risks associated with exposure to asbestos, and methods for quantifying dermal exposure).

Technical support to customer programs and regions is a key component of all these HHRA activities, whether assessment production, methods development, guidance, or other outputs. This support is provided through both formal and informal channels. Formal technical support is provided through such means as the IRIS Help Desk, the Superfund Health Risk Technical Support Center, and the Ecological Risk Assessment Support Center. Where necessary, these support centers can access additional expertise from HHRA and other EPA scientists. Direct technical assistance is also provided by HHRA scientists to programs and regions that request regulatory or site-specific support. These efforts are tracked internally through the Programmatic and Regulatory Support Tracking System. More informal channels are also widely used to expedite assistance on less complex issues, testifying to the widespread use of HHRA products across the Agency and beyond.

Within the purview of the HHRA Program Project, technical expertise is often transferred between projects in order to achieve program objectives. For example, Forum projects prepared under this MYP represent major Agency consensus documents requiring considerable technical and managerial input. A recent example of this is the “EPA Guidelines for Carcinogen Risk Assessment” document, developed through a cross-Agency effort including significant OSWER participation.

Related Research

Homeland Security Research Topics

The ORD Homeland Security research program conducts research in the following areas:

Safe Buildings:
Sampling and analysis methods, containment, decontamination technology, residue disposal, exposure modeling, agriculture biomass, and structures and outdoor decontamination

Water Infrastructure Protection:
Sampling and analysis methods, decontamination technology, surveillance systems, exposure modeling, and water/wastewater treatment

Threat and Consequence Assessment:
Risk assessment methods and data, rapid risk assessment tools, threat analysis, and technical support.

NCER-Related Research

Several programmatically relevant research programs have been supported through the NCER's Science to Achieve Results (STAR) competitive grants program and the Small Business Innovation Research (SBIR) program.

A new generation of cleaner industrial manufacturing and processing technologies is needed as it becomes increasingly clear that "end-of-pipe" pollution controls for industrial operations are not always a sufficient means of reaching avoidance/prevention goals. In collaboration with the National Science Foundation, NCER has provided funds for fundamental and applied research in the physical sciences and engineering to stimulate the discovery, development, and evaluation of advanced and novel environmentally benign methods for industrial processing and manufacturing.

Nanotechnology has the potential to (a) develop new processing technologies that minimize or eliminate the use of toxic materials and the generation of undesirable byproducts and effluents and (b) develop materials to replace current hazardous constituents, resulting in reductions in energy, materials, and waste generation. NCER has funded a nanotechnology and nanomaterials research program encouraging proposals in areas in which theoretical foundations are sufficiently well established to allow practical applications to be addressed. Because nanomaterials can have a potentially harmful effect on human health and the environment, NCER has also funded research to address these concerns, including the toxicology of manufactured nanomaterials, their environmental fate and transport, bioavailability, and exposure pathways for humans.

Small Business Innovative Research (SBIR) Successful Products

EPA is one of 11 federal agencies that participate in the SBIR program. The two-phase structured program seeks to document the feasibility of the proposed technological concept in Phase 1 and to commercialize the technology in Phase 2. NCER has issued a number of SBIR

solicitations, including research for Pollution Prevention, Nanomaterials, Waste Management and Site Remediation, Hazardous Waste Monitoring, and Solid Waste Recycling. A summary of SBIR program success stories is presented below:

	Company	***Product***
1.	Advanced Technology, Inc.	Solid scrubber for semiconductor industry
2.	Enertech Environmental, Inc.	Clean energy from solid waste
3.	eSpin Technology, Inc.	A novel approach to filtration
4.	Faraday Technology, Inc.	Functional trivalent chromium plating process to replace hexavalent chromium plating
5.	ionEdge Corporation	Zero-waste dry platting
6.	LSR Technology, Inc.	Control device for particulate emissions
7.	Nanomaterials Research Corporation	Hazardous solvent-free manufacturing of electroceramic powders
8.	National Recovery Technologies, Inc.	Sorting of post-consumers plastic resins
9.	Niton LLC	Dual-detector lead paint Analyzer
10.	Physical Sciences, Inc.	Spark-induced breakdown spectroscopy (SIBS) for metals in soil
11.	Precision Combustion, Inc	Microlith fast lightoff catalytic convertors
12.	Sea Sweep, Inc.	Environmentally benign oil absorbent

Appendix F: Performance Assessment Rating Tool (PART) Measures

<table>
<tr>
<td>1</td>
<td>Long-term</td>
<td>Output</td>
<td>Percentage of Land research publications rated as highly cited publications.
<table>
<tr><th>Year</th><th>Target</th><th>Actual</th></tr>
<tr><td>2005</td><td>Baseline</td><td>25.3</td></tr>
<tr><td>2008</td><td>26.8</td><td></td></tr>
<tr><td>2010</td><td>27.8</td><td></td></tr>
<tr><td>2012</td><td>28.8</td><td></td></tr>
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<tr>
<td>2</td>
<td>Long-term</td>
<td>Output</td>
<td>Percentage of Land publications in "high-impact" journals.
<table>
<tr><th>Year</th><th>Target</th><th>Actual</th></tr>
<tr><td>2005</td><td>Baseline</td><td>24.2</td></tr>
<tr><td>2008</td><td>25.7</td><td></td></tr>
<tr><td>2010</td><td>26.7</td><td></td></tr>
<tr><td>2012</td><td>27.7</td><td></td></tr>
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<tr>
<td>3</td>
<td>Annual</td>
<td>Output</td>
<td>Percentage of planned outputs delivered in support of the Mitigation, Management, and Long-Term Stewardship of Contaminated Sites LTG.
<table>
<tr><th>Year</th><th>Target</th><th>Actual</th></tr>
<tr><td>2003</td><td>100</td><td>87</td></tr>
<tr><td>2004</td><td>100</td><td>55</td></tr>
<tr><td>2005</td><td>100</td><td>70</td></tr>
<tr><td>2006</td><td>100</td><td>96</td></tr>
<tr><td>2007</td><td>100</td><td></td></tr>
<tr><td>2008</td><td>100</td><td></td></tr>
<tr><td>2009</td><td>100</td><td></td></tr>
<tr><td>2010</td><td>100</td><td></td></tr>
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<tr>
<td>4</td>
<td>Annual</td>
<td>Output</td>
<td>Percentage of planned outputs delivered in support of the Manage Material Streams, Conserve Resources, and Appropriately Manage Waste LTG.
<table>
<tr><th>Year</th><th>Target</th><th>Actual</th></tr>
<tr><td>2003</td><td>100</td><td>67</td></tr>
<tr><td>2004</td><td>100</td><td>80</td></tr>
<tr><td>2005</td><td>100</td><td>100</td></tr>
<tr><td>2006</td><td>100</td><td>100</td></tr>
<tr><td>2007</td><td>100</td><td></td></tr>
<tr><td>2008</td><td>100</td><td></td></tr>
<tr><td>2009</td><td>100</td><td></td></tr>
<tr><td>2010</td><td>100</td><td></td></tr>
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<table>
<tr>
<td>5</td>
<td>Annual</td>
<td>Efficiency</td>
<td>Average time (in days) for Technical Support Centers to process and respond to requests for technical document review, statistical analysis, and evaluation of characterization and treatability study plans.
<table>
<tr><th>Year</th><th>Target</th><th>Actual</th></tr>
<tr><td>2005</td><td>Baseline</td><td>35.3</td></tr>
<tr><td>2006</td><td>32.5</td><td>30.9</td></tr>
<tr><td>2007</td><td>30.5</td><td></td></tr>
<tr><td>2008</td><td>29.0</td><td></td></tr>
<tr><td>2009</td><td>28.0</td><td></td></tr>
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Appendix G: Coordination and Collaboration (Intra- and Inter-Agency)

EPA expends substantial effort coordinating with other agencies, including work with the DOD in its Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program, the Department of Energy (DOE), National Institute of Environmental Health Sciences (NIEHS), Agency for Toxic Substances and Disease Registry (ATSDR), Department of the Interior (DOI), and State groups to communicate results, leverage expertise, and collaborate on complex issues. Summary information on EPA collaboration with federal agencies and state groups is presented in Appendix C by topic area. The research topics and associated collaborative activities and products show the degree of collaboration and leveraging of technical expertise across the federal government on restoration and preservation issues.

Collaborative research efforts of note involve coordination of the unique controlled-spill field research facility, which was designed in cooperation with the U.S. Bureau of Reclamation. Geophysical research experiments and development of software for subsurface characterization and detection of contaminants are being conducted with the U.S. Geological Survey (USGS) and DOE's Lawrence Berkeley National Laboratory. USGS also has a number of programs, such as the Toxic Substances Hydrology Program, that support studies related to contamination of surface water and ground water by hazardous materials. EPA also conducts collaborative laboratory research with DOD, DOE, DOI, and the National Aeronautics and Space Administration (NASA) to improve characterization and risk management options for dealing with subsurface contamination.

The DOD SERDP supports research on various remediation topics (http://www.serdp.org). The EPA and DOE work with DOD on the SERDP Council, Executive Working Group, and various technical panels. The technical panels work together to identify research needs and evaluate proposals.

The Agency is also working with the NIEHS, which manages a large basic research program focusing on Superfund issues, to advance fundamental Superfund research. The ATSDR also provides critical health-based information to assist EPA in making effective cleanup decisions. EPA ORD has formal memoranda of understanding (MOUs) with each of these agencies on collaborative projects, information exchange, and identification of research issues.

The Interstate Technology Regulatory Council (ITRC) has proved an effective forum for coordinating federal and state activities and for defining continuing research needs through its teams on topics, including contaminated sediments, permeable reactive barriers, radionuclides, and Brownfields. EPA developed an MOU with several other agencies (DOE, DOD, Nuclear Regulatory Commission [NRC], DOI–USGS, National Oceanic and Atmospheric Administration [NOAA], and the Department of Agriculture [DOA]) for multimedia modeling research and development. For more information, please go to the Interagency Steering Committee on Multimedia Environmental Models MOU at http://www.iscmem.org/Memorandum.htm.

Topic	Partner	Title	Activity	Formal / Informal	Products
Human Health	NIEHS Superfund Basic Research Program	MOU	Roles and responsibilities; enhanced coordination and collaboration	Formal	Coordination and collaboration to increase site-specific support
Human Health	ATSDR	MOU	Collaborate on the development of toxicity values for use on IRIS and ATSDR toxicity profiles	Formal	Information and data sharing for development of Agency-specific toxicity values
Human Health	USAF/ ATSDR/ DOE/ DOD/ NIOSH	IAG with USAF	Conference and training workshops on toxicity	Formal	Annual Risk Assessment and Toxicology Conference and workshops
Human Health	Regions, States	Risk Assessment Guidance for Superfund	Monthly calls	Informal	Information sharing and guidance
Research on various remediation topics (http://www.serdp.org	DOD SERDP	SERDP Council, Executive Working Group, and various technical panels	Scheduled meetings	Formal	The technical panels work together to identify research needs and evaluate proposals.
Contaminated Sediments	USGS/NOAA	Technical Advisory Committee for National Sediment Inventory	Assessment	Informal	Planning and review of inventory
Contaminated Sediments	USGS / SCCWRP / NOAA / USACE / Environment Canada	Technical Advisory Committee for the Louisiana Harbor Contaminated Sediment Task Force	Assessment	Formal	Peer review of assessment
Contaminated Sediments	USACE / NOAA / USFW / States	Contaminated Aquatic Sediment Remedial Guidance Workgroup	Remediation	Informal	OSWER guidance
Contaminated Sediments	USN / USACE / NOAA / Academia / Industry	RTDF Contaminated Sediments Action Team	Remediation	Formal	Technical workshops
Contaminated Sediments	States / USN / USACE / Industry	ITRC Contaminated Sediments Team	Remediation	Formal	State guidance
Contaminated Sediments	Academia	South and Southwest Region Hazardous Substances Research Center	Remediation	Formal	Research advisory panel

Contaminated Sediments	USACE/NOAA/ State (MA)	New Bedford Harbor Team	Remediation	Informal	Monitoring plans, PCB research
Contaminated Sediments	USACE/ State (RI)	Centredale Manor Superfund site team	Remediation	Informal	Sampling assistance
Contaminated Sediments	USACE/NOAA/ State (SC) / Private/ SCCWRP	State of California Sediment Quality Steering Committee	Advisory (assessment)	Formal	Advise State in the development of sediment guidelines
Contaminated Sediments	USACE	Resuspension workgroup	Communication	Formal	Discuss results of resuspension research
Contaminated Sediments	EPA Region 4, USACE, Clemson University	Ecological assessment (Lake Hartwell)	Field support	Formal	Input to 5-year review; research reports
Contaminated Sediments	Industry, USACE, NERL	SERDP Project: Evaluation of In-Place Capping	Remediation	Formal	Publications
Contaminated Sediments	GLNPO, USACE	Grand Calumet	Remediation	Informal	Publications
Contaminated Sediments	Region 3, S/SW HSRC	Anacostia capping demonstration	Remediation	Informal	Publications
Contaminated Sediments	Region 5, GLNPO, USACE	Indiana Harbor	Remediation	Informal	Publications
Ground Water	DOD SERDP project	Enhanced Source Removal	Remediation	Formal	Research
Ground Water	NIEHS	2005 workshop on DNAPL dissolution; 2003 workshop on ground water research	Workshop/meeting	Informal	Presentations and collaboration
Ground Water	USACE	DNAPL Remediation Performance Assessment (Fort Lewis)	DNAPL Remediation	Formal	Technology demonstration
Ground Water	DOE	Performance Monitoring Workshop	Workshop/ meeting	Informal	Presentation
Ground Water	DOD/ Academia	Impacts of DNAPL source treatment	DNAPL Remediation	Formal	Technology demonstration
Ground Water	DOE / DOD / Local/State government / Seven academic institutions	RTDF Phytoremediation of Organics Action Team	Remediation	Formal	Technology collaboration
Ground Water	ASARCO, Inc. / EPA Region 8	CRADA	Remediation	Formal	Technology Evaluation Report
Ground Water	OSWER / OAR / Regions	MNA Framework Document for Inorganic Contaminants in Ground Water	Remediation	Formal	Framework Document

Ground Water	Federal Remediation Roundtable (DOD/DOE)	Tri-Agency Research Initiative for Long-term Performance of PRBs	Remediation	Informal	Report
Ground Water	States / Private sector / Academia	ITRC MTBE Team	Remediation/ Assessment	Informal	Training courses on MTBE site assessment and remediation
Ground Water	States / OUST	Internet LUST Training	Remediation/ Assessment	Informal	Develop Internet training for LUST site managers
Ground Water	States /Private sector / Regions	Vapor Intrusion Workgroup	Assessment	Informal	Develop guidance document for vapor intrusion problems
Ground Water	Regions / States / DOE	Ground Water Forum	General	Formal	Technology transfer
Ground Water	DOE / NASA / USN / USAF	Interagency DNAPL Consortium	DNAPLs	Formal	Technology collaboration
Ground Water	USN / state / private	RTDF NAPL Cleanup Alliance	DNAPLs	Formal	Technology collaboration
Ground Water	USAF / USACE / DOE / USGS / State / University	RTDF Permeable Reactive Barriers Action Team	Remediation	Formal	Technology collaboration
Ground Water	DOD / DOE / Industry, U.K. Environment Agency/ Academia	RTDF Bioremediation Consortium	Remediation	MOU being developed	Reports and input to training and guidance materials
Soil / Land and Ground Water	Academia / DOE / DOD	Western Regional Hazardous Substances Research Center	Remediation	Formal	Science advisory
Soil / Land	German Environmental Ministry / States	German Bilateral Agreement	Redevelopment	Formal	Workshop proceedings
Soil / Land	EREF; Regions 1, 3, 5, 8; OAQPS	CRADA with Environmental Research & Education Foundation on landfill emissions monitoring	Assessment and remediation	Formal	Reports; input to guidance documents
Soil/Land	EPA/ORD, Regions, Superfund	Arsenic Technical Workgroup	Review	Formal	Reviews applications of metals and asbestos risk assessment methodologies at hazardous waste sites
Soil / Land	OSW, DOE, MSE, States	Hardrock mining conferences	Assessment and remediation	Informal	Conference proceedings
Soil / Land	Program, Regions, States	Engineering forum	Remediation		Information sharing; issue papers for project managers

Soil / Land	Center for Hazardous Substances in Urban Environments	Academic research	Science advisory committee	Informal	Science advisory
Soil / Land	OSW	EPA National Electronics Team	Preparation of E-waste disposal white paper	Monthly calls	Risk assessment paper
Soil / Land	DOD SERDP / U.S. Army Program Manager, Chemical Demilitarization / DOE–MWFA	Development of Air Toxic (Dioxin) Monitor	Development and application testing of a fieldable real-time monitor for dioxins and other air toxics	Funding of project at EPA	Journal papers on monitor performance, emission factors, and field prototype
Soil / Land	States / Private sector / DOE / Academia	ITRC Brownfields Action Team	Redevelopment	Informal	Communication and technical review
Soil / Land	Kansas, Kansas State University	Technical assistance to Brownfields	Redevelopment	Informal	Communication and workshops
Site Characterization	DOE / Idaho National Laboratory	Support to the Technical Support Center for Monitoring and Site Characterization	Superfund Site-specific technical assistance on monitoring and site characterization issues	Formal via an IAG	Provide site-specific technical assistance to the Regions via letter report and issue papers
Site Characterization	DOI/USGS/DOE/ LBNL	Geophyscial Research Interagency Agreements	Site Characterization	Formal	Evaluation of geophysical methods for subsurface DNAPL detection and site characterization
Site Characterization	U.S. Navy	MOU (near completion)	Site characterization	Formal	U.S. EPA Characterization Test Cell to be constructed at the Naval Facilities Engineering Service Center, Port Hueneme, California
Oil Spills	NOAA	Annual proposal reviews for the Coastal Response Research Center	Workshop/ meeting	Formal	Proposal reviews
Oil Spills	USDI's Minerals Management Service (MMS)	Dispersant Effectiveness of Heavy Fuel Oils and Weathered Crude Oils	Interagency agreement	Formal	Publication
Oil Spills	State of Louisiana	Annual proposal reviews for the Oil Spill Research and	Meeting	Formal	Proposal reviews

		Development Program			
Oil Spills	Integrated Petroleum Environmental Consortium	Annual proposal reviews for funding under EPA cooperative agreement	Meeting	Formal	Proposal reviews
Oil Spills	Fisheries & Oceans Canada	Projects on bioremediation, chemical oxidation, and dispersants	Collaborative research projects	Formal	Publications
LUST	Rhode Island	Demonstration of *ex situ* bioreactor for MtBE degradation	Demonstration project	Formal	Publication
Environmental Modeling	DOE/NRC/DOD/ USGS/USDA	MOU	Advancing the science and technology of multimedia modeling	Formal	Collaborative reports on model advancements
Multimedia Environmental Modeling	Battelle/DOE	FRAMES	Development of modeling systems, modeling frameworks, and model evaluation software	Formal	Software systems, documentation
Multimedia Environmental Modeling	ACOE, NRC, EPA-ORIA	FRAMES	Co-development of modeling systems, modeling frameworks, and model evaluation software	Informal	Software systems, documentation
Model Evaluation	USGS	JUPITER	Software technology for local sensitivity analysis and calibration techniques	Informal; coordinated R&D efforts across agencies	JUPITER software system, applications
Integrated Human Health and Ecological Risk Assessment	OSW	Integrated Multimedia Modeling System Development	Development of Integrated 3MRA multimedia modeling system	Formal partnership	3MRA modeling system, ongoing science enhancement
Multimedia Environmental Modeling	Multiple workgroups; representing various research arms within DOE, NRC, USGS, DOI, DOC, ACOE, EPA	MOU: Inter-Agency Steering Committee on Multimedia Environmental Modeling (ISCMEM)	Broad-scope coordination across Agencies on research programs related to multimedia modeling, including	Monthly calls, workshops, conference	Various proceedings, Web site

			framework technology and model evaluation science		
Model Comparison /Evaluation	EPA Office of Air Quality and Planning	3MRA – TRIM.Fate Model Comparison	Effort to understand and explain differences between the two multimedia models and the resulting impacts on model predictions	Formal	Two reports produced; several more reports planned
Materials Management	Industry	CRADA Landfill Bioreactor	Waste management	Formal	Reports and input to training materials
Materials management	Academia, Industry	Landfill liner performance	Waste management	Formal	EPA technical report
Materials Management	Nuclear Regulatory Commission, NIST	NRC Examination of Containment System	Waste management	Formal	NRC report
Waste Management	DOE	Interagency agreement	Scavenging of Cs and Sr by Kaolinite during Thermal Processing of Radioactive Wastes	Formal	DOE report and peer-reviewed journal paper (ES&T)
Waste Management	DOD SERDP / U.S. Army Program Manager, Chemical Demilitarization / DOE-MWFA	Development of Air Toxic (Dioxin) Monitor	Development and application testing of a fieldable real-time monitor for dioxins and other air toxics	Funding of project at EPA	Journal papers on monitor performance, emission factors, and field prototype
Waste management	OSW – OSRTI / OAQPS / Chlorine Chemistry Council	ETV demonstration of Dioxin Emission Monitoring Systems	ETV tests at RTP, NC, on a hazardous waste firing industrial boiler	Formal ETV test through cooperation with Battelle	ETV verification reports

Appendix H: ORD Superfund and RCRA CA Technical Support (Revised May 2007)

Laboratory/Center Contacts for General Information:

National Center for Environmental Assessment (NCEA)	**Andrew Gillespie**	**513-569-7989**
National Center for Environmental Research (NCER) (Including Hazardous Substances Research Centers)	**Mitch Lasat**	**202-343-9705**
National Health and Environmental Effects Research Laboratory (NHEERL)	**Bill Russo**	**919-541-7869**
National Exposure Research Laboratory (NERL)	**Michele Aston**	**919-541-2766**
National Risk Management Research Laboratory (NRMRL)	**Tom Holdsworth**	**513-569-7675**
Office of Science Policy (OSP)/Hazardous Substance Technical Liaison Program	**Mimi Dannel**	**202-564-9944**

Contaminated Sites—Site-Specific Technical Support

This technical support area consolidates activities that provide site-specific technical support for characterization, modeling, monitoring, assessment, and remediation of contaminated sites under Superfund and, in some cases, under RCRA Corrective Actions. Specific technical support areas include the following:

Environmental Photographic Interpretation Center (EPIC)
Contact: Dan Heggem, 702-798-2278
http://lvord1.las.epa.gov:9876/epic/default.htm
This center provides site-specific information on the condition and activities occurring at hazardous waste disposal sites at a point in time or over a historical period; documents these conditions and changes; provides guides in the form of reports, maps, and photographs for assisting in the safe cleanup of hazardous waste materials; and assists in emergency response and enforcement efforts when requested by client offices. Remote-sensing technical support is provided to all EPA Regional Superfund Offices and OERR, and includes hazardous waste disposal site characterization and mapping, annotated aerial photo interpretation reports, topographic mapping of waste disposal sites, acquisition of aerial photographs, and enforcement support.

Monitoring and Site Characterization Technical Support Center
Contact: Brian Schumacher, 702-798-2101
http://www.epa.gov/nerlesd1/tsc/tsc.htm
This center provides scientific and technical assistance in the characterization of hazardous waste sites and associated site contaminants. State-of-the-science methods and technologies are

identified and applied to identify contaminants, determine their levels and concentrations, and identify their geographic extent and distribution for site characterization and remediation.

Center for Exposure Assessment Modeling (CEAM)
Contact: Candida West, 706-355-8023
http://www.epa.gov/ceampubl/
CEAM's goals are to develop, maintain, and apply state-of-the-science technical tools including multimedia exposure and ecosystem response simulation models, environmental databases, data analysis packages, tool application strategies, and advanced educational materials in the environmental sciences.

***Center for Subsurface Modeling Support (CSMoS*)**
Contact: David Burden, **580-436-8606**
http://www.epa.gov/ada/csmos.html
This center provides support for development, testing, application, and distribution of models on fate and transport of contaminants in the subsurface environment.

Engineering Technical Support Center (ETSC) and Superfund Technical Assistance Response Team (START)
Contact: Dave Reisman, 513-569-7588
This center provides site-specific assistance on engineering and treatment issues during any phase of a site cleanup. Focus areas include containment, thermal treatments, soil vapor extraction, bioremediation, and solidification/stabilization. Support is provided for incorporating technology-based data needs in the RI/FS phase and conducting/evaluating site-specific remedy options in the RD/RA and post-construction phases. The center publishes Engineering Bulletins on technologies and site types. The center supports Superfund, Brownfields, and RCRA Corrective Action sites.

Ground Water Technical Support Center (GWTSC)
Contact: David Burden, 580-436-8606
http://www.epa.gov/ada/tsc.html
This center provides site-specific assistance on ground water and subsurface contamination problems in site remediation. Focus areas include *in situ* water treatment, *in situ* thermal treatment, monitored natural attenuation, soil vapor extraction, and permeable reactive barriers. The center also publishes issue papers on subsurface remediation and ground water topics and provides project manager training upon request by the regions. The center supports Superfund, Brownfields, and RCRA Corrective Action sites.

Superfund Health Risk Technical Support Center
Contact: Jon Reid, 513-569-7375
The Superfund Health Risk Technical Support Center (STSC) supports regional and headquarters Superfund risk assessors by reviewing and developing exposure and toxicity factors that allow more accurate quantitative estimates of risk to be developed. Much of the activity is focused on developing new and updated peer-reviewed provisional toxicity values that describe dose–response toxicological relationships. External peer review of the provisional toxicity values was initiated in FY 1999. The Center also provides user support through the STSC Hotline as well as on-site expertise reviews. All assistance is provided on a rapid turnaround basis.

Ecological Risk Assessment Technical Support Center
Contact: Michael Kravitz, 513-569-7140
The Ecological Risk Assessment Support Center (ERASC) will provide technical and management support and arrange for scientific review and consistency on topics relevant to ecological risk assessment and ecological concerns. NCEA will manage the Center, but it is understood that it will routinely be necessary to access the expertise that is located in various ORD laboratories and centers. The Center Director will arrange for this access as appropriate. During the FY01 pilot program, an Implementation Committee consisting of members from the Office of Research and Development, the Office of Solid Waste and Emergency Response, and EPA regional offices will provide oversight and guidance for formation of the ERASC and its guiding principles.

Science and Technology Liaisons
Coordinator: Ken Sala, 202-564-1567
This program provides ORD representatives to regions to support regional integration of technology and coordination with ORD. STL's mission is to enhance interactions of the EPA regional offices with ORD and with other organizations involved in environmental research and technical support (including its funding, development, and application), with specific emphasis on OSWER Program (Superfund/RCRA/FF/UST/Solid Waste) issues, thereby facilitating the use of sound science and engineering in EPA decisions and actions.

Region 1	**Stephen Mangion**	**617-918-1452**
Region 2	**Jon Josephs**	**212-637-4317**
Region 3	**Vacant**	**215-814-**
Region 4	**Felicia Barnett**	**404-562-8659**
Region 5	**Charles Maurice**	**312-886-6635**
Region 6	**Terry Burton**	**214-665-7139**
Region 7	**Robert Mournighan**	**913-551-7913**
Region 8	**Vacant**	**303-312-**
Region 9	**Michael Gill**	**415-972-3054**
Region 10	**John Barich**	**206-553-8562**

RCRA Technical Support

***RCRA Program Support* — Contact: Lab/Center as above**.
Technical support to the OSWER RCRA program includes technical advice on implementation of combustion regulations, technology transfer documents, workshops, and pollution prevention to support RCRA programs, scientific advice, input, and review in support of regulations and guidance.