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Engineering Technical Support Center

Innovative Science and Technical Support for Cost-Efficient Cleanups:
Five Year Summary Report for 2007–2012

Engineering Technical Support Center
Land Remediation and Pollution Control Division
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Abstract

The Engineering Technical Support Center (ETSC) was created in 1987 as one of four technical support centers to provide engineering expertise to U.S. EPA program offices and remediation teams working at cleanup sites across the United States. Based in Cincinnati, the ETSC's mission is to provide site-specific scientific and engineering support to remedial project managers (RPMs), on-scene coordinators, and other remediation personnel. The ETSC's mission allows the responsible local, regional, or national authorities to work more quickly, efficiently, and cost-effectively, while also increasing the technical experience of the remediation team. Since its inception, ETSC has supported countless projects across all EPA Regions in almost all 50 states.

This report summarizes a variety of significant projects that ETSC and its colleagues in the Land Remediation and Pollution Control Division (LRPCD) have supported during the last five years. Projects have addressed an array of environmental scenarios, including remote mining contamination, expansive landfill waste, sediment remediation by capping, and persistent threats from abandoned industrial sites. A major component of affecting meaningful remediation lies in the construction and testing of pilot projects and new technologies. As such, ETSC also organizes and reports significant developments in environmental engineering. In some cases, the team has gone into the field to spearhead projects that are at the cutting edge of remediation activities. ETSC has also taken on a selection of newer initiatives that focus on integrating sustainability into communities and land use plans. While ETSC's principal mission of bolstering technical expertise for site-specific remediation remains a central focus, the team is reaching out to support other efforts that will directly prevent the problems ETSC seeks to resolve. LRPCD and ETSC have evolved continually to meet the demands, as well as scientific and engineering needs, of the program offices and regional personnel.

Acknowledgements

John McKernan, Sc.D., CIH, Director of the Office of Research and Development (ORD) Engineering Technical Support Center (ETSC), and the Center's matrix-managed staff would like to acknowledge the exemplary contribution from ORD Land Remediation and Pollution Control Division leadership and scientists for their dedication to the Center and its mission. Additional assistance is also recognized from National Risk Management Research Laboratory (NRMRL) personnel, and individual scientists and experts from other ORD laboratories, Divisions, and EPA Offices. We extend our thanks to the Office of Science Policy and Office of Superfund Remediation and Technology Innovation, and the EPA Regions (particularly the STLs, RPMs, OSCs, and their management) for their technical and financial support. We would also like to recognize the exemplary support provided by our contractors, namely Battelle Memorial Institute and RTI International. Special thanks are also given to our recently retired ETSC Director, David Reisman, and those that provide document reviews, respond to technical request phone calls, and all manner of other assistance.

The ETSC is constantly evolving, and it re-configures its operations to better address the myriad of site needs and requirements from regional and site personnel. The Center is known for its punctuality, and the staff pride themselves on consistently responding quickly to submitted requests. The ETSC ensures quality support through its internal mechanisms and is continually adding customers and increasing the growing number of return requesters.

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List of Acronyms

ARRA	American Reinvestment and Recovery Act
ASARCO	American Smelting and Refining Company, Inc.
BCEE	bis(chloroethyl)ether
BCR	biochemical reactor
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
DCHD	Douglas County Health Department
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
ETSC	Engineering Technology Support Center
FAME	fatty acid methyl ester
FS	feasibility study
GI	gastrointestinal
GWTSC	Ground Water Technical Support Center
HAB	harmful algal bloom
HMC	Homestead Mining Company
LEED	Leadership in Energy and Environmental Design
LRPCD	Land Remediation and Pollution Control Division
MIW	mining-influenced water
NFCC	North Fork of Clear Creek
NPL	National Priorities List
NRMRL	National Risk Management Research Laboratory
OLS	Omaha Lead Site
ORD	Office of Research and Development
OSC	on-scene coordinator
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PLACES	Planning Land and Communities to be Environmentally Sustainable
PRP	potentially responsible party
RCTS	Rotating Cylinder Treatment System
RI	remedial investigation
RPM	remedial project manager
SMARTe	Sustainable Management Approaches and Revitalization Tools-electronic
STL	Superfund Technology Liaison
TSC	Technical Support Center
TSMD	Tri-State Mining District
TSP	Technical Support Project
WASP/META	Water Quality Analysis Simulation Program/ Water Quality Analysis Simulation Program with algorithm to incorporate metals contamination

Introduction

In 1987, the U.S. Environmental Protection Agency's (EPA's) Office of Research and Development (ORD), Office of Solid Waste and Emergency Response (OSWER), and regional waste management offices established the Technical Support Project (TSP). EPA designed the TSP to enable ORD personnel to provide effective technical assistance, and to ensure that ORD scientists and engineers were accessible to the Agency's Regional decision-makers, including RPMs, corrective action staff, and on-scene coordinators (OSCs). The TSP consists of a network of Regional forums and five major Technical Support Centers (TSCs) within ORD:

- Engineering Technical Support Center (ETSC) in Cincinnati, Ohio
- Ground Water Technical Support Center (GWTSC) in Ada, Oklahoma
- Site Characterization and Monitoring Technical Support Center (SCMTSC) in Atlanta, Georgia
- Superfund Health Risk Assessment Technical Support Center (SHRATSC) in Cincinnati, Ohio
- Ecological Risk Assessment Support Center (ERASC) in Cincinnati, Ohio

ETSC provides site-specific assistance, technical support, and conducts targeted research for EPA Regions and program offices. The center networks with EPA programs and other federal agencies to deliver the latest methods, approaches, and technologies needed to characterize, remediate, and manage risk at contaminated sites. ETSC's mission is to provide scientific and engineering knowledge and expertise in soil, sediment, and mine remediation and technology to Regional staff for risk management decisions. Services include field evaluation and demonstration of innovative technologies, verification of externally acquired data, development, and testing of remediation management techniques and disposal practices, and on-call technical assistance to RPMs and OSCs. In the past several years, the ETSC staff has also assisted in five-year Superfund site reviews and site and technology optimization studies, and has completed applied research projects that support site-specific technical assistance requests.

Although ETSC is primarily staffed with scientists and engineers from the LRPCD, additional assistance is provided by National Risk Management Research Laboratory (NRMRL) personnel from other laboratory divisions, as well as external contractors and consultants.

ETSC Involvement

ETSC joins a project or site effort at the request of existing regional project authorities. As a result, ETSC has become involved with projects at nearly every stage during the remediation process, from initial site characterization to the final steps of cleanup. ETSC matches its in-house expertise and extramural support from contractors to the specific needs of the project. The actual involvement of ETSC staff may consist of participating in or reviewing a remedial investigation (RI) and feasibility study (FS), as well as advising complex onsite application of remedial methods and different soil and sediment remediation technologies.

ETSC constantly reconfigures its operations to meet the myriad site needs of Regional and site personnel. ETSC is known for its punctuality, and staff members pride themselves on consistently responding within 48 hours of a request. ETSC ensures quality support through its internal mechanisms and is continually adding customers and increasing the number of return requesters.

Figure 1. ETSC staff, their collaborators and contractors conduct treatment technology research

As part of ORD, the ETSC staff also pursues research projects independent of site-specific needs. These efforts contribute to ORD's larger mission of improving and refining the broader understanding of land remediation strategies and developing new innovative technologies and techniques. Through field testing of equipment and procedures, laboratory analyses of samples, and data analyses from remediation sites, ETSC staff continues to evaluate the effectiveness of existing and new treatment technologies and methods. This larger scope of work builds on individual site successes and uses these experiences to contribute to the broader scientific body of knowledge. Some of the remediation strategies ETSC has explored include:

- Biochemical reactors (BCRs), a form of onsite passive treatment for mining-influenced water (MIW) by using bacteria to assist in the precipitation of metals.
- Lagoon lime treatment systems, used to treat heavy-metal contamination in water.
- Thermal technologies, a method that vaporizes and collects contaminants for disposal.
- Solidification and stabilization techniques affecting the mobility of chemicals of concern.
- New developments in sediment capping techniques and technologies.

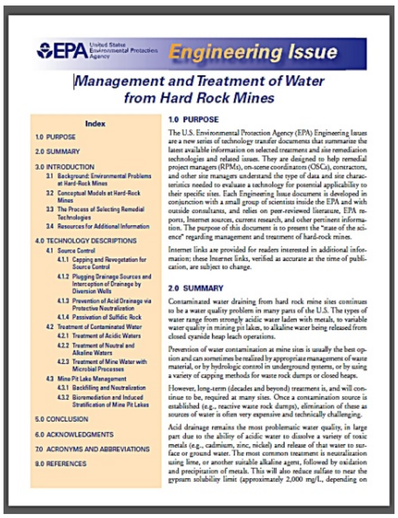
Distribution of Involvement

Since 1987, ETSC has supported sites within all 10 Regions across the United States (including our off-shore protectorates). Regions commonly seek ETSC to support Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Superfund sites that are results of mining waste impacts, chemical manufacturing, landfill, or other sediment and water restoration projects.

Engineering Issue Papers

As an integral part of their mission, ETSC works to make environmental engineers nationwide aware of the techniques and technologies being used by their colleagues elsewhere in the country. To fulfill this goal, ETSC publishes Engineering Issue Papers, a series of technology transfer documents that summarize key developments in the field. The documents address specific technical issues related to contaminants, their fate and transport, selected treatment and site remediation technologies, and other issues. Engineering Issue Papers are meant to equip RPMs with skills and background knowledge to help them tackle remediation projects more quickly and more independently. The topics addressed in these documents, which vary in length from 12 to nearly 50 pages, have included:

- In-situ chemical oxidation
- Treatment of water from hard rock mines
- In-situ treatment for contaminated soils
- Indoor air vapor intrusion mitigation approaches



EPA United States Environmental Protection Agency **Engineering Issue**

Management and Treatment of Water from Hard Rock Mines

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1.0 PURPOSE

The U.S. Environmental Protection Agency (EPA) Engineering Issues are a new series of technology transfer documents that summarize the latest available information on selected treatment and site remediation technologies and related issues. They are designed to help remedial project managers (RPMs), on-scene coordinators (OSCs), contractors, and other site managers understand the type of data and site characteristics needed to evaluate a technology for potential applicability to their specific sites. Each Engineering Issue document is developed in conjunction with a small group of scientists inside the EPA and with outside consultants, and relies on peer-reviewed literature, EPA reports, Internet sources, current research, and other pertinent information. The purpose of this document is to present the "state of the science" regarding management and treatment of hard-rock mines.

Internet links are provided for readers interested in additional information; these Internet links, verified as accurate at the time of publication, are subject to change.

2.0 SUMMARY

Contaminated water draining from hard rock mine sites continues to be a water quality problem in many parts of the U.S. The types of water range from strongly acidic water laden with metals, to variable water quality in mining pit lakes, to alkaline water being released from closed cyanide heap leach operations.

Prevention of water contamination at mine sites is usually the best option and can sometimes be realized by appropriate management of waste material, or by hydrologic control in underground systems, or by using a variety of capping methods for waste rock dumps or closed heaps.

However, long-term (decades and beyond) treatment is, and will continue to be, required at many sites. Once a contamination source is established (e.g., reactive waste rock dumps), elimination of these as sources of water is often very expensive and technically challenging.

Acid drainage remains the most problematic water quality, in large part due to the ability of acidic water to dissolve a variety of toxic metals (e.g., cadmium, zinc, nickel) and release of that water to surface or ground water. The most common treatment is neutralization using lime, or another suitable alkaline agent, followed by oxidation and precipitation of metals. This will also reduce sulfate to near the gypsum solubility limit (approximately 2,000 mg/L, depending on

Fig. 2. Example of an Engineering Issue Paper

Engineering Issue Papers provide a description of the technology or remedial issue, costs, feasibility, and other criteria. ETSC publishes these papers to assist RPMs through technology transfer.

ETSC Impacts

ETSC contributes an important layer of verification that only expert scientists regularly engaging in these types of remediation can provide, whereas the Regions may encounter specific cleanup techniques or field methodologies only a handful of times per decade. The flexibility of ETSC to work nationwide on Regional remediation projects fills the gaps, validates the planned methods and approaches, and eases the burden on RPMs.

RPMs rely on ETSC expertise to conduct field activities, recommend remedial action, and review ongoing activities and provide onsite advice. Through careful analyses of data and documents, site visits, and discussions with EPA site personnel, the ETSC staff provides technical, scientific, and site-specific engineering expertise in order to facilitate effective site cleanups.

This document highlights key projects over the last five years that show the breadth of ETSC's involvement with regional personnel and versatility in meeting requests for assistance. The report highlights more than one year of Center activity, because the higher-profile projects with greater impact that are presented here take more than one year to complete. Since 2007, ETSC has worked on more than 350 sites in all 10 Regions. In conjunction with state, local, and regional leads, ETSC has been the key component to cost-effective and time-efficient cleanups.

Materials Management

The by-products from former industrial sites can yield persistent environmental problems that linger for decades. Improperly secured industrial waste can impact local ecosystems through an array of transport mechanisms and media including soil, surface water, and groundwater. More mobile media may contaminate drinking water supplies and threaten local populations. When it comes to the origin of contamination, the causes of industrial waste are as varied as the impacts they cause. From former chemical plants and refineries to munitions depots and airports, ETSC has supported a large spectrum of industrial waste sites.

King of Prussia (Region 2)

The King of Prussia Superfund site is located in Winslow Township, New Jersey. Approximately 15 million gallons of wastewater containing toxic chemicals have been delivered to the site. The site had buried drums and plastic containers, 6 lagoons, and 2 rusting and compromised tankers. The site was fenced in 1988 to protect public health and to prevent further illegal dumping of waste on the site. The site is in a rural area within the Pinelands National Reserve and is adjacent to the Winslow Wildlife Management Area. The Great Egg Harbor River borders the property. Approximately 10,000 people live within 3 miles of the site, and 3,000 people depend on groundwater for drinking water supplies.

In 2011, ETSC was involved in the review of a document about a capture zone assessment, in-situ chemical reduction bench-scale testing, and the groundwater treatment plant optimization study that were conducted at the site to improve the effectiveness of the treatment plant to capture and treat the contaminated groundwater.

Mohawk Tannery Facility (Region 1)

Fig. 3. A waste lagoon at the Mohawk Tannery Facility

The Mohawk Tannery Facility is set on approximately 30 acres in Nashua, New Hampshire and produced tanned hides for leather for 60 years (1924 to 1984). Wastewater at the Superfund site contains chromium, zinc, and phenol, threatening the Nashua River. While in operation, the tannery deposited sludge containing chromium, pentachloro-phenol, phenol, and 2,4,6-trichloro-phenol into various unlined waste lagoons on site. The risks posed by the site's waste disposal practices affect the more than 5,000 people who get their drinking water from groundwater wells within a 4-mile radius of the site.

Originally, ETSC began working with the RPM by helping to review the Region's studies of the site. Over time, however, ETSC grew to play the lead role by developing the remediation plan and associated studies. The ETSC coordinated onsite efforts that included certifying a work plan and initiating both bench and pilot scale treatability studies. In short, ETSC has served as the critical technical direction and guidance under the work plan. The office's on-site involvement has accelerated the important planning stages that enabled successful remediation in a shorter than expected time frame and cost significantly less than the original estimates.

Tremont City Barrel Fill (Region 5)

Fig. 4. Buried drums at the Tremont City site

Set on an 8.5-acre section of a larger Tremont City property, the Tremont City Barrel Fill received approximately 51,500 drums and 300,000 gallons of industrial waste. After a quick stint of operations from 1976 through 1980, the operator placed soil covers over the site on a number of occasions. Inorganic and organic releases from the waste site have migrated into soils and groundwater, with some concentrations exceeding EPA maximum contaminant levels for groundwater. Two tests that were completed in 2006 also revealed volatile and semi-volatile organic compounds in the water.

ETSC advised Region 5 from 2008 until 2010 on various remedial options and technology combinations proposed by the potentially responsible party (PRP) group. In addition to reviewing existing plans, ETSC considered the short-term public health exposure associated with proposed remediation plans. As progress continued toward solidifying the remediation plans, the Region relied on ETSC as an experienced watchful eye to ensure that the remediation was completed in the best interest of local residents and the surrounding ecosystems. The final solution was to remove the waste from the site. ETSC's review and assistance was instrumental in informing the Region's action.

Eastern Michaud Flats (Region 10)

Eastern Michaud Flats extends over 2,530 acres near Pocatello in southern Idaho. Two adjacent phosphate ore processing facilities are located on the Superfund site. The J.R. Simplot Company has remained in continuous operation since the 1940s. Meanwhile, the now defunct FMC Corporation site produced approximately 250 million pounds of elemental phosphorus each year. Starting as early as the 1970s, regional groundwater monitoring has suggested contamination has been coming from the site. In 2006, five years after the FMC Corporation plant closure, gas was seen escaping from temperature monitoring ports of a capped waste pond. Further testing in June of that year revealed that phosphine gas was being released from one of the hazardous waste ponds.

Fig. 5. A view of the Eastern Michaud Flats capped site

Region 10 officials requested technical support from ETSC to assist in monitoring and remediating the phosphine gas releases. Since their initial involvement, ETSC staff has helped characterize the gas emissions, reviewed the gas extraction system, and advised on modeling. Site visits by ETSC staff have ensured that not only remediation plans are in order, but also that data collection and analysis are appropriate. The ETSC continued to provide support for this site into 2012 by reviewing over 30 deliverables from FMC Corporation to the Region. Most importantly, ETSC involvement has added a key layer of topical knowledge by experts to ensure that the monitoring and remediation proceeds in the most efficient and effective method possible.

Corrosive Drywall

Beginning in 2008, some homeowners, particularly in the southeastern United States, started reporting problems such as repeated failure of copper air conditioner coils, extreme tarnishing of exposed metal surfaces, and failure of electrical appliances. Some homeowners noted unpleasant odors, and in some cases, health impacts were reported. The occurrence of these problems was ultimately attributed to gas emissions from drywall imported into the United States from China and used in new home construction. Thus, the term “Chinese drywall,” motivated by reports of off-gassing from drywall products in residential homes in the United States, has commonly been used to describe the problematic products. In recognition that not all drywall products display the same off-gassing potential, the terms “corrosive drywall” or “defective drywall” have also frequently been applied.

ETSC staff investigated implications of various end-of-life management options for imported corrosive drywall. Gypsum drywall products manufactured in China and imported into the United States have been documented to cause metal corrosion and tarnishing in some homes. In a number of cases, this corrosive drywall is being stripped from homes and disposed of as part of the solid waste stream. As a result, ETSC conducted research to assess the potential implications of imported corrosive drywall being land-filled or recycled. This research does not address issues regarding emissions associated with corrosive drywall in homes or other structures.

The ETSC team collected five samples of corrosive imported drywall from homes in Florida and purchased three samples of domestically produced drywall from home supply retail outlets. ETSC processed the samples as needed to test for possible impacts if the drywall were recycled by land application or disposed of in a landfill. In a few cases, ETSC included testing results from other samples (beyond the eight samples collected as part of this project) to complement the analysis.

The results of this study have broad national implications as to the disposal of the drywall in many communities, as well as potential drywall hazards. The results may be used by many parties within and outside the Agency to determine future disposal alternatives.

GM Sioux City (Region 7)

The General Motors Corporation (GM) plant in Sioux City, Iowa closed in 1993. The site was used by Zenith and GM over a period of 28 years for manufacturing goods such as parts for electronics and automobiles. An assessment of the GM plant site after its closure showed that the groundwater extracted near the site and used as a drinking water source for Sioux City, Iowa, was contaminated by industrial solvents.

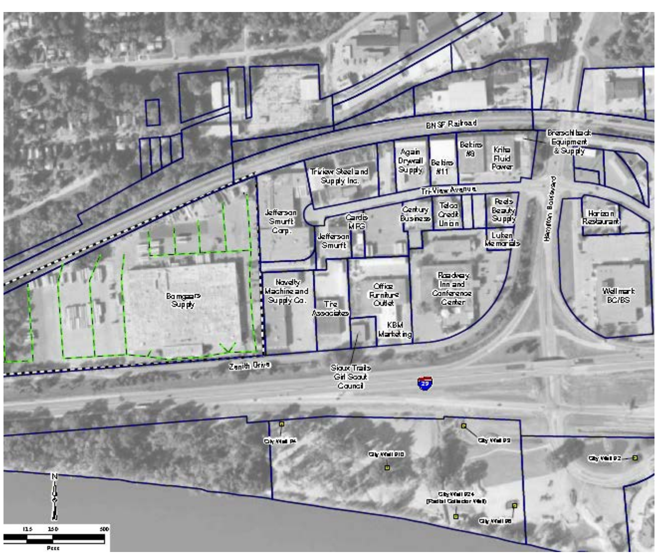

Fig. 6. A view of the GM Sioux City site indicating its proximity to the Missouri River and city drinking well sites on the bank of the river

ETSC staff reviewed work plans, became directly involved in the examination of the city wells, and discussed mapping, remediation and removal. The ETSC is supporting the Regional On-Scene Coordinator and RPM in conducting a removal action. The Center is providing groundwater modeling support to assess the effectiveness of the proposed removal action on industrial solvent concentrations in the groundwater. Modeling and decision support for this site will continue into 2013.

Mining Remediation

Contaminants from an abandoned mine are less varied than landfills or generic industrial waste, but their impacts on local ecosystems and residents can be just as harmful. Heavy metals from remaining slag heaps or tailings can contaminate local water. Once mobile, these toxic metals may impact groundwater, surface water, and soils, and contaminate the water supply for any nearby homes or businesses. The size of mining sites can often be daunting, particularly when mining sites are in remote locations. However, ETSC works with the Regions to explore easily deployed and cost-effective approaches that can tackle the challenges of a specific site.

Basin Mine (Region 8)

The Basin mining area is located in the town of Basin, Montana. The site was placed on the Superfund National Priorities List (NPL) on October 22, 1999, due to mining-waste problems in the watershed. Mine wastes impact Basin and Cataract Creeks and sediments, along with the surrounding soils. Contaminants include arsenic, cadmium, copper, lead, and other metals.

In 2011 and 2012, ETSC scientists provided expert advice to reduce the leaching of metals into the water, suggesting the potential use of a technology to coat surfaces of waste rock and tailing piles with encapsulating foam to keep them from oxidizing, thereby reducing subsequent leaching of metals and metalloids into surface water in the area.

Central City/Clear Creek (Region 8)

Gold and silver mining in Central City and Black Hawk, Colorado was profitable and supported economic development until the early 1900s. Once mining operations in this area ceased, it was noticed that waste rock and mine tailings were contaminating the Clear Creek watershed. EPA became involved in 1983, and in 2009 the site received $2.16 million in American Reinvestment and Recovery Act (ARRA) funding to consolidate and cap waste rock and mine tailing piles, implement sediment and drainage controls, and treat water to mitigate heavy metal impacts to the Clear Creek watershed. The goal of the site's cleanup is to continue to protect the Clear Creek watershed and the surrounding community.

Fig. 7. The mining industry in Black Hawk before its crash in the early 1900s

In 2011, ETSC provided technical support by applying multiple water models to envision the impact of applying different management techniques to the Clear Creek watershed. For example, one of the models (WASP/META) was used successfully to determine ion concentrations downstream of the proposed water treatment plant on the North Fork of Clear Creek (NFCC).

Black Butte (Region 10)

The Black Butte Mine Superfund Site is located near Cottage Grove, Oregon. Mercury and other contaminants from an abandoned cinnabar mine affect creeks that flow into Cottage Grove Reservoir and the Coast Fork Willamette River. Black Butte was one of the largest mercury mines in Oregon, and it was in operation from the 1890's to the late 1960's.

Beginning in 2011 and continuing into 2013, ETSC is involved with discussion of several small mercury bioaccumulation projects. In 2011, decision flow diagrams were developed to help manage the project. Groundwater to surface water interactions and geochemistry research are also being supported by the ETSC. One of the major issues is to determine the production and environmental 'cycling' of mercury to methylmercury (and back again) in the Cottage Grove Reservoir. The issue of mercury methylation is not unique to this reservoir; therefore, the ETSC has funded this research to better understand the mercury cycling issue and apply this knowledge to better remediate and control mercury at this and other sites in Regions 8, 9, and 10 with similar mercury issues. This research could potentially reduce mercury-related water issues in the 14 states that compose Regions 8, 9 and 10.

Back 40 Mine (Region 5)

A mine has been proposed for the upper peninsula of Michigan in an area called the Back 40. In response to the proposal, citizens of the area have inquired about the mine and the EPA's involvement with the process.

In 2011, ETSC addressed questions posed by citizens concerned about the Back 40 mine. The Back 40 mine may be used to produce ore for copper, gold, silver, and zinc. The ETSC provided technical support as well as written materials for citizens to better understand the issues related to mine site development and operations. These materials included information on the management of potential cyanide release from gold mining and ore refinement processes.

Bristol Bay Watershed (Region 10)

The Bristol Bay watershed is located in southwestern Alaska and is being considered for large-scale mining activities due to its abundant supply of minerals, including gold and copper. The watershed is also home to the largest sockeye salmon fishery in the Pacific Northwest and native tribes who have maintained a salmon-based culture for thousands of years.

Fig. 8. Aerial view of Bristol Bay, Alaska (from U.S. EPA report: "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska")

In 2011 and 2012, ETSC provided technical support for the Bristol Bay quantitative risk assessment being developed and led by the National Center for Environmental Assessment. Many of the mining scenarios in the risk assessment were addressed by an ETSC team. A specific example of a topic that was discussed is the size of analogous mines that should be used for comparison. Additional discussion topics on mining included mining life cycles and potential mining footprints.

Homestake Mine (Region 6)

Located in Cibola County, New Mexico, this Superfund site was a uranium mill owned and operated by the Homestake Mining Company (HMC). HMC operated the mill between 1958 and 1990, until it was decommissioned and demolished between 1993 and 1995. Two tailings piles, remnants of the previous operations, remain on site. The first stands at 100 feet high over an area of 200 acres, totaling approximately 21 million tons of mill tailings. The second tailing pile is a small impoundment covering 40 acres at 25 feet high, containing approximately 1.2 million tons of mill tailings. The tailings piles sit atop alluvium that overlies the Chinle and San Andres aquifers. The primary contaminant of concern (COC) is uranium, along with other radionuclides and metals. Although the nearest residence and drinking well are 3,000 feet away from the site, the aquifer was used primarily for domestic water supply, affecting the 200 people who live within a mile of the tailings piles.

Since they first became involved in 2008, the ETSC staff has coordinated with the Region 6 RPM and onsite management. Working with partners in the Office of Superfund Remediation and Technology Innovation, ETSC developed a scope of work, issued a contractual work order, and approved a work plan for conducting a remediation optimization study for the closed mine. The first draft was considered incomplete during Agency and peer review, so an additional scope of work was issued, contractual work was completed, and a final report was issued in 2009. The current remediation plan consists of an injection of water into the tailings combined with an extraction system, a reverse osmosis treatment facility, and onsite disposal and evaporation ponds. ETSC staff were integrally involved in the planning, conducting a site visit and thorough site tour. In addition, ETSC staff helped coordinate a public meeting with stakeholders. Through this active, local involvement, ETSC helped accelerate and organize the plans for remediation, as well as provide engineering expertise.

Gladstone, Colorado Mines (Region 8)

ETSC involvement at the Gladstone, Colorado mines is a collaboration between ETSC, Region 8, the Bureau of Land Management (BLM), and Golder Associates, Inc. Together, they prepared a technology demonstration to evaluate the performance, effectiveness, and operating parameters of the Ionic Water Technologies Rotating Cylinder Treatment System (RCTS) in treating two distinctly different types of MIW. Approximately 1,500 inactive mines have MIW that directly impacts surface waters surrounding Gladstone. The concentrations of metals (e.g., aluminum, cadmium, copper, and zinc) from MIWs have affected some receiving streams to the extent that the habitat is no longer able to support aquatic life.

Together, the team authored a report that is now undergoing final review before publication. The application of this technology successfully handled variable flow rates and reduced concentrations of a variety of metals in the MIW at high altitudes (above 10,000 feet). The unique aeration system of the RCTS technology appears to offer several benefits, including (1) lower lime consumption due to the utilization of the available alkalinity from the introduced lime, (2) less sludge production resulting from less lime usage per unit of alkalinity, and (3) a less costly solution to treat MIW of varying chemistries and flow rates at high altitudes.

Fig. 9. Abandoned mine structures at the Gladstone site

This technical assistance effort involved a joint collaboration to evaluate a promising technology that can be extended to other EPA regions. Of the four partners in this demonstration, ETSC is uniquely positioned to take the technology elsewhere around the country for remediation purposes. With a firm grasp of the performance data, ETSC can determine whether this treatment technique can be applied at other sites. In turn, thanks to this document and future ETSC involvement, other Regions will become well versed in the development of preliminary plant designs, system footprint requirements, and projected capital and operating costs. As an example, ETSC is already working with Region 3 to evaluate the efficacy of this technology in treating MIW from mountaintop mining. In this way, the flexibility of ETSC to work with partners nationwide enables EPA to take one-of-a-kind technical experience and quickly apply it again halfway across the country.

Standard Mine (Region 8)

Sitting on 10 acres in the Ruby Mining District of the Gunnison National Forest, Colorado, Standard Mine was in operation for a 100-year period (1874-1974). The Colorado Geological Survey identified the mine as the most environmentally degraded mine site in the entire Ruby Mining District. At the time of its National Priorities List (NPL) designation in 2005, the site contained approximately 53,000 cubic yards of waste rock and 29,000 cubic yards of mill tailings, respectively, and a non-engineered surface impoundment constructed of highly mineralized waste rock. Overflows from this impoundment, along with water from open mine entrances, released metal-laden acid mine drainage directly into nearby Elk Creek. The contaminants of concern at the mine site consisted primarily of heavy metals, with elevated levels of manganese, lead, zinc, cadmium, and copper, in particular. Depending on the season, Standard Mine releases 70 gallons per minute (gpm) during high flow and 5 to 20 gpm (low flow) of mine-influenced water into Elk Creek. This contamination presents a potential threat downstream at Coal Creek, which is used as a city water supply. The severe contamination, remote location without easy vehicular access, and high elevation (11,000 feet) combine to make the Standard Mine a particularly problematic remediation site.

Fig. 10. BCR materials at Standard Mine

In 2006, ETSC initiated the remediation process by moving the tailings to a new impoundment. The site has such limited seasonal accessibility that ETSC sought a low-maintenance and self-sustaining treatment mechanism. In 2007, ETSC designed, built, and monitored a low flow (1.2 gpm) passive treatment pilot study for the area. The pilot-scale BCR conducts automated water sampling, transmits data daily via satellite, and relies solely on photovoltaic power throughout the year. Impressively, ETSC constructed the entire system for under $10,000. This unique pilot is a test prototype, indicating a possibility of building future systems at many of the mine sites in the Region.

Although the BCR has contributed to a reduction in effluent metals, the work at Standard Mine is not finished. ETSC continues to monitor BCR effluent quality, improve the oxygenation of the effluent, and conduct other remedial tasks. However, the one-of-a kind installation of an inexpensive and independently functioning BCR in such a challenging location shows the promise of future remediation efforts. ETSC continues to lead the way in alerting local and regional managers to these options and encouraging their deployment where appropriate.

Anaconda Copper (Region 9)

Located about 65 miles from Reno, the Anaconda Copper Mine extends over an enormous 3,400 acres in central Nevada. The site lies in an area featuring a mixture of private lands (including agricultural fields) and public lands managed by BLM. Operations at the mine site began in 1918 and continued under several different owners until its closure in 1978. Primarily a site for mining, milling, and related operations, the open-pit Anaconda Copper processed both copper oxide and copper sulfide ores at the facility. The operator of the mine processed copper oxide ore, which involved manufacturing and using large quantities of sulfuric acid on site. The storage of the by-products has resulted in 400 acres of waste rock placed south of the pit, 900 acres of contaminated tailings, and 300 acres of disposal ponds. Since the closure of the mining operations, varied industrial activity contributed 250 acres of heap leach piles and 12 acres of heap leach solution collection ponds until the site was abandoned for good in 2000.

Fig. 11. Aerial view of Pit Lake at the Anaconda Copper site. A large neighborhood with homes can be seen just off the west side of the pit *Source: Google Maps*

As mining operations ceased, so did groundwater pumping, which has resulted in the formation of the 180-acre Pit Lake in the former open pit. It is now about one mile long and 800 feet deep, and increasing in size each year. Leftover contaminants from industrial activities threaten groundwater, surface water, air, and soils. Both uranium and arsenic are the biggest concerns, but the fact that these metals are also naturally occurring in the region adds another layer of complexity.

The Nevada Department of Environmental Protection and EPA have taken several emergency removal actions at the site to address immediate concerns. ETSC activities at the Anaconda facility have been ongoing since 2005, when ETSC first got involved with pre-RI. Since then, regional and state authorities have taken a number of remedial steps, including dust mitigation, radiological removal assessment, investigation of fluid migration, and soil removal.

In conjunction with the Ground Water and Ecosystems Restoration Division, ETSC supports the decision-making process for data collection and analysis. Agency work has led to a clearer understanding of groundwater dynamics and the extent of contamination. Of particular concern is groundwater that has moved beyond the site boundary. As an interim remedy for the spread of contamination at the site, the PRP has installed a series of extraction wells. ETSC and the PRP continue to characterize the breadth of the problem, as the large area of contamination at Anaconda Copper means high technical demands. ETSC's assistance with this project provides essential quality assurance for the remedial project managers and ensures that the decision-making process is robust and well-informed.

Formosa Mine (Region 10)

Fig. 12. Activities in progress at Formosa Mine

The Formosa Mine Superfund Site is located on Silver Butte in Douglas County in southwest Oregon. The mine is near the top of Silver Butte at about 3,600 feet above sea level. The only access for motorized vehicles is along a network of unpaved BLM roads. The major features of the site include sealed adits (mine entries), piles of waste rock, a former mill site, and a large tailings encapsulation mound. Four creeks, all tributaries of Cow Creek (source of public water supply for the town of Riddle), have headwaters near the mine, including Middle Creek, South Fork Middle Creek, Russell Creek, and West Fork Canyon Creek. Environmental sampling data from BLM indicated that metal-rich acid drainage emanating from the mine is currently discharging into Middle Creek and South Fork Middle Creek, but not into Russell Creek or West Fork Canyon Creek.
This copper and zinc mine was first operated from 1927 to 1933. No documented cleanup took place following this first operating period. In 1990, Formosa Explorations, Inc. reopened and significantly expanded the underground workings of the mine. This period of operation lasted until 1994 when the mine workings (shafts and tunnels) were backfilled with sulfide-rich tailings that included concentrated zinc, mill tailings, and ore. The mine owners sealed the portals with limestone rock and concrete and installed drains, but the drains soon failed. These conditions set the stage for the production of metal-rich (especially copper and zinc) acid mine drainage.

Formosa filled in the former tailings pond with the remaining ore and waste rock, and capped it with a bentonite/geotextile composite and drainage layer. Formosa mixed sulfide-rich soil with limestone and placed surface soil on top of the bentonite cap. This area is now known as the encapsulation mound. Formosa constructed the capping to prevent oxygen and water from reaching the fill material in the pond.

ETSC became involved with the site after a request from the region and the state of Oregon. ETSC staff met with Region 10 EPA, BLM, and other parties for several years. Region 10 took over the federal role in concert with BLM. ETSC staff suggested dividing the site into two operable units (OUs) by separating surface and encapsulation mound material and other mine piles into OU #1, and surface and groundwater into OU #2. ETSC provided continual advice to Region 10 RPMs and their contractors, and in 2011, the first RI was issued for Formosa Mine. A technical working group is now looking into all aspects of the mine and related areas.

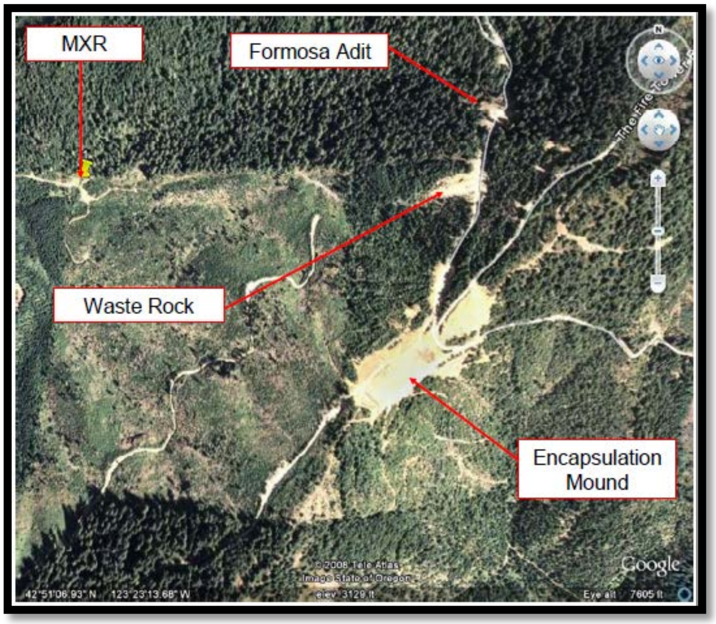

Fig. 13. An aerial view of Formosa Mine with key locations marked in red. "MXR" is a water sampling location about 3,000 feet west of the mine in Upper Middle Creek.

On June 10, 2008, representatives from federal and state agencies visited the mining site. The mine portals have been plugged with limestone and concrete, though water still drains from the adits. ETSC staff and personnel from the GWTSC provided expert Geoprobe Systems® support to the Formosa team and drilled many groundwater wells to collect important data for OU # 2. The drilling was difficult because of the rocky and steep slope conditions – an area where other drillers may not have achieved success. ETSC will collect data for the next several years. The drilling personnel at Ada, Oklahoma and Cincinnati, Ohio have many years of experience with contaminated sites.

In 2012, the ETSC continued to provide support to Region 10 in their efforts to remediate the mine site. A treatability study for the MIW escaping the adit is currently being conducted. Additionally, the ETSC is contributing expertise on how to treat ground and surface water that will emanate from the mine once the adit is reopened in late fall, 2013.

Other Mining Demonstration and Applied Research (Region 8)

Beyond the central role that ETSC played in the construction of Standard Mine's BCR, the team has contributed to a number of other BCR pilots. Anaerobic BCRs process mining-impacted water by using sulfate-reducing bacteria to convert sulfate to sulfide with comparatively little maintenance involved.

Fig. 14. Constructed biochemical reactor (BCR)

This advantage of low maintenance is largely due to the system's reliance on biological processes to treat the water. As an added bonus, BCRs do not depend on external power and can be installed with lower set-up costs. Individual BCR designs cater to a specific site by varying the flow of impacted water and the amount of oxygen available during treatment. However, despite the advantages of BCR, some concern remains over the toxicity of water treated by the process. Laboratory studies reveal that the BCR process significantly reduces the toxicity of impacted water, but does not consistently decrease toxicity to a level always safe for aquatic life.

To better understand the assets and shortcomings of BCR methodology, ETSC members collaborated with outside parties to assess the effects of BCR treatment at 4 selected sites in Region 8. ETSC's study produced the first results of successful BCR treatment in the field. Included in the analysis were two mining impacted sites in Montana, another site in Utah, and the Standard Mine in Colorado.

In the study, ETSC used treated effluent from the BCRs to evaluate the toxicological effect on fleas and minnows. As the BCR operated under different conditions at each site, ETSC hoped to glean insight on the best conditions for site treatment.

Results of the tests confirmed that some sites reduced the toxicity to safe levels, while others corroborated previous laboratory results showing lingering toxicity for aquatic life. The variability of the results will help determine the best design for other real-world BCR installations.

In particular, the ETSC study indicated that the sites using an in-field aeration step had a larger decrease in the toxicity of the BCR effluent. ETSC scientists are optimistic that aeration will lead to a reliable, cost-effective design for BCR site remediation. The entire study was published in the online version of *Environmental Toxicology and Chemistry* in November 2010.

Landfills

As disposal sites for consumer and industrial waste, landfills have a broader range of contaminants than other cleanup sites. In addition, many retired landfills were constructed when few containment measures were built into the landfill structure. As a result, these landfills are beginning to see contamination migrate to their surroundings, particularly via groundwater and surface water. These mobile contaminants can then threaten local aquatic life, as well as drinking water supplies.

Fort Devens Landfill (Region 1)

The 84-acre Fort Devens Landfill operated for 75 years until its closure in 1992. Located on the U.S. Army Base by the same name, the Fort Devens Landfill is located 20 miles northeast of Worcester, Massachusetts on Shepley's Hill. Nearby Red Cove is a shallow-water cove off Plow Shop Pond that abuts the landfill. The name "Red Cove" is derived from the red sediments, which are dyed by the high-iron groundwater discharging to the cove from the landfill.

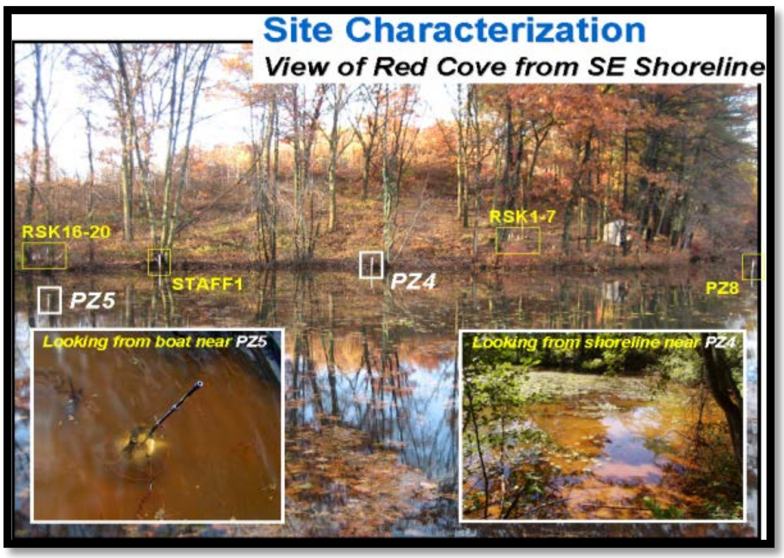

Fig.15. View of Red Cove from the southeast shoreline

Arsenic, the primary COC, displays similar transport characteristics from groundwater to discharge into Red Cove. Furthermore, two municipal drinking wells draw their supplies within one mile of the landfill.

ETSC first became involved with the site when Region 1 requested technical assistance on the fate, transport, stability, and extent of elevated arsenic in Red Cove. Region 1 was in search of scientific findings that would provide justifications to the Army Base for moving forward with an RI. ORD designed the field study to address initial findings presented in the Expanded Site Investigation prepared by Region 1.

Together with other members of ORD, ETSC staff investigated the migration of mobile forms of arsenic from the landfill to Red Cove. The study helped characterize the arsenic contamination, define the processes governing mobility, and determine the stability of the arsenic once in the Red Cove sediments. The investigation revealed that groundwater contaminated with arsenic was discharging into Red Cove, despite the fact that groundwater extraction and treatment was the landfill was undergoing as a preventive measure. The authors also provided a number of suggestions for remedial action that could better contain groundwater contamination from spreading to the surface water. With ETSC experts leading authorship, the team provided the technical experience that was largely responsible for characterizing the threats to surface water.

Lipari Landfill (Region 2)

The Lipari landfill in Pitman, New Jersey, occupies a 6-acre area of a larger 15-acre Superfund site. Operating between 1958 and 1971, the Lipari Landfill accepted 12,000 cubic yards and 3 million gallons of liquid municipal and industrial waste, including chemicals. Today, half of the landfill uses soil vapor extraction to address volatile organic compound contamination. ETSC, however, is focusing on the contamination of bis(chloroethyl)ether (BCEE) in a plume in an underground aquifer. The primary method for containing the problem involves treating contaminated leachate and physically separating the BCEE. The costs of this method average $5 million per year.

ETSC has teamed up with the RPM in Region 2 to explore the feasibility of cutting costs by using bioremediation technology. Over the course of a 16-month study, the team concluded that BCEE could degrade aerobically on site at a rate faster than current anaerobic degradation. Thanks to ETSC's assistance, Region 2 is implementing bioventing field pilots at the landfill. If results from the pilots confirm ETSC's applied research, then the approach can be considered and implemented as a cost-effective solution site-wide.

Puerto Rico Capping Project (Region 2)

Fig. 16. ETSC and Regional staff conduct site investigations of abandoned Puerto Rican landfills

Managing waste on a small island with over 4 million people can present a number of environmental and logistical challenges. Puerto Rico's high rainfall and dense population have made safely containing the waste for the foreseeable future a challenge. In February 2010, representatives from ETSC and its contractors organized a two-day workshop focusing on evapotranspiration (ET) covers for landfills, soil physics, water movement, and computer modeling. In particular, ET covers have been identified as potentially well suited in Puerto Rico for isolating capped waste from the percolation of rainfall, reducing the potential for the 'bathtub effect.'

In addition to conducting the panel discussions and technical outreach, the ETSC and contractor team visited seven landfill sites in Puerto Rico to make a qualitative assessment of the condition of existing closed sites. Although the quality of the landfill covers varied, the group came away with generally positive remarks about the environmental condition and regular maintenance of landfill sites.

Programs such as these workshops demonstrate ETSC's important role in raising awareness about issues. The workshops informed and empowered local authorities to address environmental challenges independently. Beyond the meeting discussions, ETSC created a decision tree outlining the various steps and considerations that landfill owners or Puerto Rico regulators could consider when evaluating the use of ET covers as part of a landfill closure process. This approach helps ensure that effective field methods are applied from the outset, thereby saving time and money while protecting environmental and public health.

Sustainability in the Community

While many of ETSC's efforts focus on remedial action, the team has also taken on projects that promote sustainable communities. Incorporating sustainability into planning helps create a balance between a community's economic, social, and environmental goals or objectives. The balance assures that no single element will be sacrificed for the benefit of the others. In a way, implementing a sustainability plan acts as a preventive measure to guard against the need for future remediation.

Stella, Missouri (Region 7)

Fig. 17. Community members/advocates for Stella, MO involved in planning to remove an abandoned hospital (previously a brownfields site) and revitalize the site

Razing its asbestos-laden hospital in 2006 marked an important change in the 200-person town of Stella, Missouri. Shortly after the EPA-supported demolition was complete, ETSC staff collaborated with community members, Region 7, the Missouri Department of Natural Resources, and the Office of Brownfields to develop a revitalization plan for the community. Using the essential attributes of economic, social, and environmental systems as planning criteria, ETSC staff developed the "Master Plan for a Sustainable Revitalization of Stella." By integrating sustainable air, water, and energy technologies along with methods to preserve current ecosystem services, the community's revitalization plan aims to meet current and future needs of the citizens. In addition, through a beta test of the Sustainable Management Approaches and Revitalization Tools-electronic (SMARTe) program, Stella residents and stakeholders had a new resource to help with funding, additional planning, and risk management. By using SMARTe, Stella was able to locate financial resources available through organizations such as the Department of Housing and Urban Development and the Department of Transportation.

ETSC's involvement with the community of Stella marks one of ETSC's first ventures outside of typical site-specific involvement. ETSC staff often advises and comments solely during the remediation phase and does not follow into the revitalization stage. The continued involvement at Stella will help inform ETSC's future work in supporting sustainability planning. ETSC aims to build on this opportunity to provide guidance on implementing sustainable practices into the growth and revitalization of other communities as well.

Planning Land and Communities to be Environmentally Sustainable

For a broader long-term pursuit toward sustainability, ETSC has created a certification program to assess land uses. The initiative, known by its acronym "PLACES," is a planned voluntary program geared towards local communities who want to certify their sustainability efforts. The program will evaluate a host of issues that a local municipality might take on to promote sustainability. These include land use policy, public initiatives, public-private partnerships, sponsorship of science, water management, local ecosystem health, and many other facets.

Fig. 18. A sample of design plans potentially certified by PLACES

PLACES is built in the mold of other voluntary certification programs, such as Leadership in Energy and Environmental Design (LEED). A well-publicized program with visible rewards can raise awareness of sustainability issues, increase efforts to pursue sustainability by communities, and realize the environmental benefits from such efforts. Therefore, like LEED, PLACES establishes criteria that award credit points to participants for every component they successfully address. ETSC hopes that those meeting certain threshold scores will be awarded "U.S. EPA Recognition of Sustainable Community." Depending on how high they score, communities would receive Green, Bronze, Silver, Gold, or Platinum recognition.

San Jacinto River Waste Pits (Region 6)

The San Jacinto River Waste Pits site is situated on a marshy 20-acre plot in the southeastern part of Texas. The site features two waste ponds, comprising three impoundments, which had been used to store refuse from the former pulp and paper mill. One waste pond totals more than 132,000 square feet, while the other contains impoundments of more than 46,000 and 188,000 square feet. Since use of the waste pits ended in the 1960s, 2 of the 3 impoundments have been fully submerged by the San Jacinto River. The third has been partially submerged by the river.

Fig. 19. The San Jacinto waste pits and adjacent terrain

The polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans that contaminate the waste pits have been found entering the San Jacinto River. Continued submersion of the waste pits themselves have allowed contaminated sediment to come in direct contact with river water.

ETSC is providing ongoing support through a critical removal action and subsequent RI/FS. The Agency is also working with the Texas Commission on Environmental Quality and the U.S. Army Corps of Engineers to safeguard the health of the watershed. EPA is considering remedial options that range from various containment strategies to excavation, dredging, and treatment.

Fig. 20. Aerial view of the San Jacinto waste pit site and surrounding areas

ETSC has commented on all sampling and analytical plans and removal proposals and has expressed possible concern regarding colloidal transport through non-sealed sheet pile sections associated with a removal action option. ETSC has proposed and is evaluating various containment options, such as site capping or disposal in a Confined Disposal Facility, and dioxin treatment technologies, including the use of geosorbents.

In 2011 and 2012, ETSC continued its support for this site by evaluating several hydrodynamic and sediment transport models relating to the colloidal transport concern.

Chattanooga Creek Cap Monitoring Study (Region 4)

LRPCD researchers are working with EPA Region 4 and with the Department of Environmental Conservation in Tennessee to monitor an installed AquaBlak® cap, a clay polymer composite designed to swell and form a continuous and impermeable barrier. This section of Chattanooga Creek has seen decades of industrial pollution from coal tar and creosote, which contain around 10,000 chemicals. This work has been implemented to protect the local population and to further evaluate the usefulness (benefits and cost) of this technology.

Capping is a common strategy for decreasing the risk associated with contaminated sediments in lakes and streams. Caps have been designed to physically isolate contaminated sediments and prevent the transport of these contaminants from coming into contact with the water above, aquatic organisms, wildlife, and humans in and around the contamination.

Since 2004, ETSC sediment researchers have been evaluating how the performance of capping technology is affected by gas generation below cap. Copies of these studies from the Region 10 Wyckoff/Eagle Harbor Superfund site and the Region 1 capping activities in Boston Harbor are available on the EPA website. Considering that the magnitude of contaminated sediments sites on Superfund sites and in harbors is so large, this research and development of technologies to manage the risk are imperative.

Other Technical Assistance

Bioavailability Research

Researchers from ORD's NRMRL, LRPCD, National Environmental Research Laboratory (NERL), and National Health Environmental Effects Research Laboratory (NHEERL) have been actively collaborating with ETSC on a research program to understand the bioavailability and fate of metal contaminants (lead and arsenic) in soils. An understanding of the bioavailability and fate of metals is being accomplished through spectroscopic synchrotron speciation, *in vitro* (fertilization of an egg in a laboratory dish or test tube) extractions, and *in vivo* (in the living body of a plant or animal) mice feeding studies. A pitfall of previous research in this area is the lack of consensus on the experimental methods and the variability of soil samples examined. The objective of this integrated research project is to define the soil characteristics that influence bioavailability to develop a prognostic *in vitro* model validated against *in vivo* results. The identification of soil characteristics governing metal bioavailability, and developing a simple *in vitro* extraction test may replace the more resource intensive *in vivo* animal testing currently conducted to predict bioavailability.

Regulations on the fate and effects of metals in the environment based solely on total concentrations are no longer valid, state-of-the-art, or scientifically sound. While total metal content is a critical measure in assessing risk of a contaminated site, total metal content alone does not provide predictive insights on the bioavailability, mobility, and fate of the metal contaminants. Thus, a better understanding of the nature of the chemical and physical interactions of contaminants with soil constituents can increase the scientific, regulatory, and public confidence in the use of bioavailability for remedial actions. Predictions of long-term stability rely on a mechanistic understanding of how contaminants are stored or sequestered within the soil.

In its concern with direct ingestion of soil, EPA has defined bioavailability as the fraction of an ingested dose that crosses the gastrointestinal (GI) epithelium and becomes available for distribution to internal target tissues and organs. Bioavailability processes are defined as the individual physical, chemical, and biological interactions that determine the exposure of plants and animals to chemicals associated with soils. As the fraction of a soil element that can actually be absorbed by an organism to cause harm depends on the chemical forms present and physical/chemical properties of the soil, in both risk assessment and remediation evaluation, the fraction of a soil element that can actually cause harm must be identified. This fraction is ultimately defined as the bioavailable fraction. Because measurement of the bioavailable fraction is time-consuming and expensive via *in vivo* protocols, chemical extraction methods are being developed to estimate the bioavailable fraction. In the case of ingestion of soil, the *in vitro* or chemical estimation method has been labeled "bioaccessible" and is a measure of the amount of metal that can be liberated from the soil matrix, thus not a measure of the amount of metal that moves across the GI epithelium to harm internal target tissues and organs.

Working directly with RPMs, soil samples from various project sites have been obtained to determine a site specific bioavailability value. The research project involves careful preparation and characterization of bulk soil properties followed by advanced spectroscopic analysis to determine the speciation of the metals via synchrotron X-ray absorption spectroscopy at the Advanced Photon Source of Argonne National Laboratory. Once the soil samples that contain bioavailable metals are characterized, they are sent for *in vitro* analysis. *In vitro* chemical extractions generally only require knowledge of the total metal content so that a percent bioaccessible number can be generated from *in vitro* extractions that simulate digestive systems or mimic responses to sensitive ecoreceptors. In addition to an array of traditional one- and multi-step *in vitro* extractions, efforts are underway to explore new method development involving the use of historic soil extractions for nutrients.

To validate results from *in vitro* and soil characterization, *in vivo* mice feeding studies are conducted to confirm the bioavailability of soil metals. The *in vivo* mouse method utilized has many advantages over other *in vivo* protocols (swine or primate) in that the costs are significantly less and a larger number of animals can be tested to improve the statistical analysis of the data. The *in vivo* results are compared to the *in vitro* results to identify a correlation and the *in vitro* results are measured against the speciation and soil characterization data to find positive relationships. For example, factors such as metal speciation and iron oxide content in soils have been shown to be influential in metal bioavailability. Identification of a robust, validated *in vitro* procedure is vital to this research project through carefully planned *in vivo* support studies and soil characterization research.

Grand Lake St. Marys (Region 5)

Fig. 21. Grand Lake St. Marys

Grand Lake St. Marys is a very shallow, man-made lake in northern Ohio, the largest inland lake in the state. The lake and 19 other nearby lakes, including Lake Erie, have experienced increasing levels of harmful algal blooms (HABs) along with high concentrations of cyanotoxins. Microcystin, a toxic peptide produced by some species of blue-green algae, is of particular concern. Potential sources of nutrient pollution contributing to these blooms include nonpoint source runoff from the more than 300 agricultural operations in the watershed, as well as failing septic systems. HABs in Grand Lake St. Marys have led to the loss of recreational uses of the lake and a decline in tourism revenue.

The state, EPA Region 5, and a contractor have been evaluating chemical treatment methods, such as addition of silica or buffered aluminum sulfate (alum), to reduce nutrient (phosphate) levels and thereby reduce the growth of HABs. To determine whether the treatments were successful, the algal community composition was measured and the dominant species determined. Traditionally, species identification has been done using cell count methods, which are laborious and time-consuming. In the past, EPA has successfully used an alternative, chemical method, fatty acid methyl ester (FAME) analysis, to measure bacterial species composition. ETSC recognized an opportunity to apply FAME analysis to algae to help determine whether the treatment methods being tested were successful. The ETSC rapidly assembled a team and equipment and took measurements inside and outside the test area throughout September 2010. To conduct the FAME analysis, EPA's Cincinnati laboratory identified markers for blue-green algae, green algae, and diatoms and measured the concentration of these markers extracted from the samples. These measurements were comparable to the cell count data for the samples.

This work demonstrated that FAME analysis, compared to traditional methods, may be a faster and more reliable method to determine the dominant species in a system. Thus, this method has the potential to become a useful tool for states and Regions to help address the problem of HABs in the numerous man-made lakes that have become eutrophic throughout the country.

ETSC was continuing onsite work during 2011, with ETSC members assisting the Ohio EPA with monitoring efforts directed at reducing or eliminating cyanobacterial blooms and their effects. EPA and ETSC also provided technical support and assistance to the Ohio EPA Division of Surface Water in deploying and maintaining a data sonde Econet to monitor general water quality variables in the lake during 2011 and 2012. Ohio EPA and ETSC installed four networked data sondes at points in the lake that provide real-time measurements of critical variables including temperature, dissolved oxygen, pH, turbidity, conductivity, and chlorophyll-*a* during a proposed 45-day, lake-wide alum application process.

The results of this collaborative work between the ETSC and the state include protocols for use in monitoring cyanobacteria, and alum application techniques to reduce bacterial growth. The alum application appeared to be effective over the time the lake was treated. Research conducted at the lake is also being used to develop a correlation between sonde monitoring data and satellite spectral analysis data (light reflection/absorption from freshwater). The ETSC is pursuing applications of this correlation data, including the development of an algorithm for NASA, EPA, and USGS to jointly identify freshwater lakes in the U.S. that are candidates for harmful algal blooms. If successful, this work will lead to the development of a national monitoring network that will help states and other environmental and public health decision makers in identifying impaired freshwater bodies.

Omaha Lead Site (Region 7)

The Omaha Lead Site (OLS) includes surface soils present at residential properties, child-care centers, and other residential-type properties in the city of Omaha, Nebraska, that have been contaminated as a result of deposition of air emissions from historic lead smelting and refining operations. The OLS encompasses the eastern portion of the greater metropolitan area in Douglas County. The site is located around Omaha, where two former lead-processing facilities once operated. American Smelting and Refining Company, Inc. (ASARCO) operated a lead refinery for over 125 years. Aaron Ferer & Sons Company (Aaron Ferer), and later the Gould Electronics, Inc., (Gould) lead battery recycling plant were also located nearby. Both the ASARCO and Aaron Ferer/Gould facilities released lead-containing particulates to the atmosphere from their smokestacks, which were deposited on surrounding residential properties.

The ASARCO facility operated from the early 1870s until 1997 and was located on approximately 23 acres on the west bank of the Missouri River in downtown Omaha. Aaron Ferer constructed and operated a secondary lead smelter and lead battery recycling plant from the early 1950s until 1963. In 1963, the facility was purchased by Gould, who operated it until closure in 1982. During the operational period of these facilities, lead-contaminated particulates were transported downwind in various directions and deposited on the ground surface. The Douglas County Health Department (DCHD) performed monitoring of the ambient air quality around the ASARCO facility beginning in 1984. This air monitoring routinely measured ambient lead concentrations exceeding the ambient standard for lead at that time of 1.5 micrograms per cubic meter ($\mu g/m^3$). The highest recorded quarterly average measured in air was 6.57 $\mu g/m^3$.

The DCHD has compiled statistics on the results of blood lead screening of children less than 7 years old for more than 25 years. Screening of young children living in several zip codes in close proximity to the former lead refinery indicates a high occurrence of blood lead levels exceeding 10 micrograms per deciliter (µg/dl). Lead is classified by EPA as a probable human carcinogen and is a cumulative toxicant.

ETSC is performing two main studies with Region 7 personnel. In the first study, ETSC's primary objective is to provide technical support to EPA Region 7 and EPA NRMRL by coordinating and/or conducting the identification, compilation, and analysis of educational, social, and analytical data for the Omaha Lead Site area. These data will be compared to lead reduction activities in the community over time including (but not limited to) the EPA Superfund removal and remedial activities. Activities include the following phases:

> **Phase 1** – Determine and access current available data sources and inputs to evaluate the educational and social outcomes in aggregate data sets. This information may be acquired through local government organizations, academia, criminal data and standardized educational tests. Data gaps and source acquisition for individual subjects and other specified cohorts shall be identified.
>
> **Phase 2** – Gather and analyze additional data based on Phase 1 recommendations, to evaluate lead reductions and human health impacts over time, then to compile and synthesize all collected data and information to be incorporated into a final summary report to be delivered to EPA and collaborators.

An external technical expert in the area of lead toxicology will utilize data from multiple sources to identify links that may exist between changes in environmental lead exposures and the quality of human life. These sources may include historical information about lead refining in the Omaha area, historical information about EPA activity at the Omaha Lead site, educational achievement tests, juvenile delinquency data, and crime statistics data. A third party expert will work with ETSC's contractor and other parties to look for any other available sources of data. The team is working with numerous agencies and stakeholders and applying statistical analysis and epidemiological methodology to gain insight and understanding pertaining to the corrective action measures.

In the second ETSC study at the OLS during the summer of 2011, ETSC collected soil samples from residential yards before and after excavation to elucidate the extent of soil mixing as a function of depth and excavation technique. In a specially-designed methodological approach, ETSC staff performed laborious sampling on approximately 30 sites. The results of this study will help determine if the remedial and removal actions undertaken 10 years ago still offer the same protection as originally designed.

Remediation and Restoration Planning of Watersheds (Regions 6 and 7)

The Tri-State Mining District (TSMD) encompasses the Spring and Neosho River watersheds in Missouri, Kansas, Oklahoma, and tribal lands where mined ores containing lead, zinc, and other metals were processed for a over a century. After processing, the remaining waste material or chat was left on the land surface, often in large uncovered piles. Decades of exposure to wind and water erosive processes has led to widespread contamination of sediments in streams, rivers, reservoirs, and lakes throughout the TSMD. Several of these areas with chat piles are on the NPL as known sources of hazardous waste contamination. As such, cleanup of these sites and the watersheds they are in falls under CERCLA.

Ecological risk assessment studies identified cadmium, lead, and zinc as the primary contaminants of concern and chromium, copper, and mercury also likely contributors to ecological receptor toxicity. Benthic invertebrate site specific toxicity thresholds for cadmium, lead, and zinc were found to be reliable indicators and thus serve as preliminary remediation goals for environmental risk managers tasked with developing remediation and restoration plans for the Spring and Neosho River watersheds. The general approach is to collect and organize relevant watershed data in a spatially explicit geographical information systems framework. The effect of proposed remedial and risk management actions can then be simulated via integrated hydrological, contaminant transport, and biological response models, as well as interpreted and displayed geospatially, facilitating the comparison of alternatives. These models, combined with multi-criteria decision analysis methods will assist the TSMD stakeholders in making informed decisions about mine waste risk management and remediation actions. The approach is a powerful, transparent way of organizing and communicating complex scientific information to a diverse group of stakeholders, as well as providing a basis for improving communication among the stakeholders themselves. The project approach has potential for application in watershed planning and watershed risk management decision making in other states or regions.

Restoring Degraded Industrial Waterways (Region 5)

The team at ETSC has explored remedial support for environmental concerns that are not well defined as being a single "site," including ETSC's work in remedial action for rivers and streams impacted by industrial and community waste. The team has made a significant effort with the Grand Calumet River, outside of Chicago. Because of its proximity to a major industrial hub, terminus at Lake Michigan, and diverse wildlife population, the Grand Calumet River was considered a particularly important waterway to examine.

Fig. 22. Floating booms on the Grand Calumet River

The Grand Calumet River, which flows through the man-made Indiana Harbor Ship Canal into lower Lake Michigan, has been the site of industrial development since the 1870s. Over the years, wastes from steel mills, foundries, refineries, meat packing plants, and glue factories have left Calumet River sediments highly polluted. Other significant impacts on the hydrology of this coastal area include the deliberate reduction of sand ridges, once a notable feature of this location in northern Indiana. Additionally, when EPA examines waterways to determine impairment, 14 categories are considered, including restrictions on fish consumption. The Grand Calumet is the only site in this area to be identified as impaired in all 14 categories.

A primary goal of the ETSC staff was to investigate management technologies that would be suitable for the river. These technologies could include dredging, sediment capping, phytoremediation, or other methods that address contaminated sediments in the waterway. One principal study by ETSC scientists involved conducting research on sorbents and sorption capacity in the Grand Calumet River. Additional research has examined the physical stability of various types of sediment capping in the waterway. This method would help prevent contaminated sediments from moving vertically back up into the water channel. ETSC has also explored another alternative for the Grand Calumet River that involves reusing contaminated sediments. For example, ongoing research is evaluating the reuse of petroleum compounds in the sediments for use as a fuel supplement in asphalt plants.

Summary

Although these investigations have yet to yield substantial results, they represent the unique role that ETSC plays as a bridge between environmental remediation and innovative engineering.

Through its interdisciplinary background, the ETSC staff brings creative thinking to life by testing these ideas in real-world scenarios. In addition to the promise they inspire, these technologies have the potential to produce long-lasting dividends and, ultimately, a cleaner environment.