49 Coal Combustion Products – Environmental Issues

Program Overview

Program Description
This program provides scientific data, engineering knowledge, restoration methods, and other tools for cost-effective soil and groundwater protection associated with fossil fuel–fired power plants and coal combustion product (CCP) storage, disposal, and use. Research currently focuses on the effects of new control technologies for mercury, sulfur oxides, and nitrogen oxides on CCP management options; disposal guidelines being developed by the U.S. Environmental Protection Agency (EPA); groundwater remediation associated with older management sites; large-volume land application uses; and byproducts associated with the new generation of power plants.

Industry Needs and Issues Addressed
- EPA risk assessment on CCP storage and disposal
- Likely proposal in 2008 or 2009 of Resource Conservation and Recovery Act, Subtitle D Guidelines for combustion product disposal
- Changes in the composition and leaching characteristics of CCPs with new air emissions controls and fuel blends
- Large increases in flue gas desulfurization (FGD) gypsum production over the next ten years
- Increased groundwater compliance monitoring and remediation, focused on inorganic constituents such as arsenic, selenium, and boron
- Information on byproducts from new generation technologies, such as integrated gasification combined-cycle (IGCC) technology
- Retirement of old power plants, coal storage areas, and ancillary facilities
- Effluent limitations that are increasing injection of ash/FGD wastewater and solids in deep aquifers

Impact
- Collaboration among the Electric Power Research Institute (EPRI), EPA, and the U.S. Department of Agriculture to provide fundamental data on environmental management of combustion products
- Pivotal studies on prediction and mitigation of the release of CCP constituents to groundwater
- Annual management costs exceed $1 billion; products now managed as nonhazardous, due largely to EPRI research on leachability and groundwater transport, help to reduce these costs
- Cost-effective and environmentally protective landfill/pond designs and closures
- Increased options for beneficial use applications

Key Accomplishments
- Documented savings of more than $3 billion associated with nonhazardous classification for CCPs under Bevill Phase I and II determinations
- Assessment of mercury emissions and leaching from fly ash from enhanced control demonstrations
- Coordination with EPA on leaching protocol for CCPs
- Determination of arsenic, selenium, chromium, and mercury speciation in leachate and groundwater transport
- Screening evaluation of groundwater remediation options for CCP sites
- Compilation of chemical profiles for several key constituents (boron, arsenic, thallium, beryllium)
- Development of network of sites for evaluation of FGD gypsum use in agriculture

Current Year Objectives

- Develop data and tools for assessing changes in CCP characteristics and impacts on disposal and use, focused on sulfur trioxide controls (e.g., trona, lime)
- Evaluate and develop effective groundwater remediation and treatment methods for key constituents at CCP disposal and use sites and coal piles
- Preserve and enhance opportunities for large-volume land application uses of CCPs, such as ash in roadways and structural fills, and FGD gypsum in agricultural applications
- Reassess the issues surrounding radioactivity in CCPs
- Investigate byproducts generated by emerging advanced generation technologies, such as IGCC

Industry Involvement

- Estimated 2009 funding: $2.0M

Program Technical Lead

Kenneth Ladwig, 262-754-2744, keladwig@epri.com

Summary of Projects

Project Number	Project Title	Value
P49.001	Characterization of Coal Combustion Products	Laboratory, field, and modeling information on coal ash and FGD solids, including chemical composition and leaching characteristics; focus on changes to CCP characteristics as a result of new air emission control technologies, coal blending, and use of nondomestic coals
P49.002	Management of Coal Combustion Products	Primarily field-scale studies to assess and control environmental impacts at CCP management facilities, including landfills, impoundments, mine fills, and beneficial use sites; development of tools and information to help utilities manage and analyze groundwater data
P49.003	Groundwater Assessment and Remediation	Information on transport and fate in groundwater of inorganic constituents commonly found at CCP sites and power plant facilities; development of groundwater investigation and risk assessment tools; development of cost-effective groundwater remediation technologies using laboratory and field studies

Project Descriptions

P49.001 Characterization of Coal Combustion Products (Q55327)

Issue

Management options and environmental assessments for coal combustion products (CCPs) are driven largely by CCP physical and chemical characteristics. New technologies for mercury (Hg) control, sulfur dioxide (SO_2) scrubbing, nitrogen oxides (NO_x) reduction, and sulfur trioxide (SO_3) mitigation will substantively change CCP characteristics. These new technologies also will impact future regulatory decisions, as well as selection of appropriate management alternatives. CCP radioactivity is under consideration again in light of technologically enhanced naturally occurring radioactive materials (TENORM) regulation. A new generation of byproducts will require management when advanced generation power plants, such as integrated gasification combined-cycle (IGCC) systems, begin operation

between 2015 and 2020. EPA is currently developing a new standard leaching protocol and revising previous risk assessments for CCP disposal.

Description
Provides laboratory and field information on CCP characteristics and how they behave in environmental settings. This ongoing project area provides core data touching all facets of CCP disposal and use. It evaluates changes to CCP characteristics from changes to air emission controls (Hg, SO_3) and fuels (blended coals, non-U.S. coals), develops laboratory leaching methods and geochemical models (with EPA), and characterizes and evaluates byproducts derived from IGCC. Research in this area contributes to maintaining the nonhazardous determination for CCPs and allows power companies to make informed decisions on the risks and benefits associated with various CCP management options.

Value
- Supports permitting, compliance, and groundwater assessment at CCP disposal sites and will facilitate risk-based decisionmaking considering the long-term behavior of CCPs in the environment
- Allows power companies to evaluate the impacts of fuel changes, changes in plant operation, flue gas additives, and other modifications
- Supports continued management of CCPs as nonhazardous materials, resulting in industrywide savings estimated at more than $1 billion per year
- Supports regulatory and public communication on power company efforts to control mercury releases into the environment

How to Apply Results
Engineers and scientists can use project data and tools to support a wide range of permitting and compliance activities at CCP management sites. A comprehensive database of CCP characteristics and a screening methodology can be used as part of an overall risk-based management approach for CCPs. Reports on various air emissions control technologies (mercury control, SO_3 mitigation, NO_x control) and their impacts on CCPs can be used by CCP managers to make decisions on new disposal and use control technologies. Summary brochures can be used to communicate those decisions to the public on sensitive issues. In addition, EPRI will facilitate broader use and awareness of the results by briefing key stakeholders, including EPA; developing materials for the trade press/media; and continuing service on various advisory panels.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
CCP Composition and Leaching: Laboratory characterization studies will investigate and document the impact of evolving air emissions controls, such as enhanced Hg capture, SO_3 mitigation, and ammonia injection for NO_x controls, on fly ash and FGD solids. The effect of coal blends and nondomestic coal sources on ash quality also will be considered. Emphasis will be on development of a robust database and assessment of how changes in characteristics affect CCP disposal and use options.	12/30/2009	Technical Report
Mercury in CCPs: Research on mercury releases from CCPs will continue, focused primarily on volatilization and FGD solids. Mercury release potential in sensitive CCP use settings will be assessed (e.g., wallboard and agriculture).	9/30/2009	Peer Literature

Product Title & Description	Planned Completion Date	Product Type
Radionuclides: Research on radioactivity in coal ash and FGD solids is driven by TENORM regulations, as well as regulatory and public perception of health risks. This project will update previous studies on radionuclides in CCPs and the potential risks in typical CCP management settings.	9/30/2009	Technical Report
IGCC and Advanced Generation Byproducts: IGCC and other advanced coal-fired power plants are likely to become a growing part of the new electric generation fleet over the next several decades. This project will describe and characterize the residues produced from these advanced generation technologies and provide the basis for environmental management and use.	6/30/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
CCP Composition and Leaching: Laboratory characterization studies will investigate and document the impact of evolving air emissions controls, such as enhanced Hg capture, SO_3 mitigation, and ammonia injection for NO_x controls, on fly ash and FGD solids. The effect of coal blends and nondomestic coal sources on ash quality also will be considered. Emphasis will be on development of a database and assessment of how changes in characteristics affect CCP disposal and use options.	2010	Technical Update
Metals Leaching Model: Detailed geochemical studies will be used to evaluate the long-term leaching characteristics of CCPs, using alternative laboratory leaching methods, field data, and geochemical modeling. The primary focus will be impacts of FGD solids, coal blends, and foreign coals.	2010	Technical Report
Mercury in CCPs: Research on mercury releases from CCPs will continue, focused primarily on volatilization and FGD solids. Mercury release potential in sensitive CCP use settings will be assessed (e.g., wallboard and agriculture).	2011	Technical Update
Metals Leaching Model: Research on a metals leaching model will focus on development of an advanced leachate characterization protocol and decision support tool for evaluating long-term leaching characteristics. Leachate modeling will be used as input to a framework for assessing disposal and use options. This work is being done cooperatively with EPA.	2011	Technical Update
IGCC and Advanced Generation Byproducts: IGCC and other advanced coal-fired power plants are likely to become a growing part of the new electric generation fleet over the next several decades. This project will describe and characterize the residues produced from these advanced generation technologies and provide the basis for environmental management and use. Sample characterization work will begin when the new generation of IGCCs begins to come on line.	2011	Technical Report

Product Title & Description	Planned Completion Date	Product Type
CCP Composition and Leaching: Laboratory characterization studies will investigate and document the impact of evolving air emissions controls, such as enhanced Hg capture, SO_3 mitigation, and ammonia injection for NO_x controls, on fly ash and FGD solids. The effect of coal blends and nondomestic coal sources on ash quality also will be considered. Emphasis will be on development of a database and assessment of how changes in characteristics affect CCP disposal and use options.	2011	Technical Update

P49.002 Management of Coal Combustion Products (058342)

Issue
Disposal facilities are often subject to stringent design and management standards that do not recognize the unique characteristics and generally low toxicity of coal ash and flue gas desulfurization (FGD) byproducts, along with the limited mobility of their chemical constituents in groundwater. EPA issued a draft risk assessment related to coal combustion product (CCP) disposal in 2007. The agency will revise the risk assessment and possibly promulgate federal guidelines for CCP disposal in the 2008–2010 time frame. The Office of Surface Mining is making a similar determination on how placement of CCPs in mines will be regulated. FGD byproducts will increase substantially over the next ten years in response to the Clean Air Interstate Rule and mercury regulations. These actions have the potential to significantly increase CCP disposal costs and decrease alternatives for beneficial use, and they will certainly increase groundwater monitoring and compliance requirements at CCP management facilities.

Description
This project provides field-scale information to predict and control environmental impacts at management facilities. It explores options for fixation of trace metals in CCPs in disposal and use settings, conducts research on the use of FGD gypsum in agriculture, evaluates innovative liners and caps, updates disposal site design manuals, and develops risk-based assessment tools for structural fill and roadbed applications.

Value
- Reduces power company costs and improves risk-based decisionmaking associated with environmentally sound disposal and high-volume land applications of CCPs
- Informs EPA risk assessment and rulemakings on management standards for CCP sites and mine placement
- Provided EPA with data informing the agency's determination that comanagement of CCPs with low-volume waste would not be subject to hazardous waste regulations
- Helped individual power companies obtain documented savings of more than $70 million as a result of implementation of alternative closure methods

How to Apply Results
EPRI will use the broad information generated in this project to help inform EPA's rulemaking process on management of CCPs. Utility engineers and scientists can use the manuals and research results to ensure environmentally protective and cost-effective design and maintenance of disposal facilities using proven methods. Environmental data can be used by CCP managers to support land applications, providing a high-volume beneficial use alternative to disposal. Groundwater data assessment tools can be used to establish efficient compliance programs for collecting, managing, and analyzing the large volumes of data that will accompany increased monitoring and compliance requirements at disposal sites.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Use of FGD Gypsum in Agriculture and Land Applications: Research will evaluate the environmental efficacy of using FGD gypsum and other FGD products for agricultural crops and related large-scale land applications, using a combination of laboratory tests and field plots in diverse geographic areas. Key environmental issues will be addressed, including the fate of mercury and other metals. This work is being closely coordinated with the U.S. Department of Agriculture and EPA.	12/30/2009	Workshop, Training, or Conference
Structural Fill and Road Base Applications: Structural fills and road base applications offer high-volume use opportunities for ash that does not meet specifications for use in concrete, as well as a sustainable alternative to virgin materials. This research will develop risk-based approaches to evaluating the long-term risks and benefits, including life-cycle societal benefits, associated with these applications.	12/30/2009	Technical Update
Coal Storage Areas: This research will establish mechanisms and rates of acid production from coal piles and trace metal release. Results will be used to develop methods for managing active coal piles and closing/restoring former coal storage areas, methods that neutralize acidity and reduce releases of contaminants to groundwater.	6/30/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Fixation of Metals in CCPs: CCP disposal and beneficial use options are often limited by leachable constituents determined from standard laboratory test data. This research will evaluate physical and chemical characteristics of CCP mixtures and CCPs with additives designed to control and minimize leaching.	2010	Technical Update
Coal Ash and FGD Disposal Manuals: EPRI's disposal manuals, last revised in the mid-1990s, will be updated to incorporate recent advances in engineering design and changes in regulatory requirements.	2010	Technical Report
Use of FGD Gypsum in Agriculture and Land Applications: Research will evaluate the environmental efficacy of using FGD gypsum and other FGD products for agricultural crops and related large-scale land applications, using a combination of laboratory tests and field plots in diverse geographic areas. Key environmental issues will be addressed, including the fate of mercury and other metals. This work is being closely coordinated with the U.S. Department of Agriculture and EPA.	2010	Technical Update
Use of FGD Gypsum in Agriculture and Land Applications: Research will evaluate the environmental efficacy of using FGD gypsum and other FGD products for agricultural crops and related large-scale land applications, using a combination of laboratory tests and field plots in diverse geographic areas. Key environmental issues will be addressed, including the fate of mercury and other metals. This work is being closely coordinated with the U.S. Department of Agriculture and EPA.	2011	Workshop, Training, or Conference

Product Title & Description	Planned Completion Date	Product Type
Structural Fill and Road Base Applications: Structural fills and road base applications offer high-volume use opportunities for ash that does not meet specifications for use in concrete, as well as a sustainable alternative to virgin materials. This research will develop risk-based approaches to evaluating the long-term risks and benefits, including life-cycle societal benefits, associated with these applications.	2011	Technical Report

P49.003 Groundwater Assessment and Remediation (058343)

Issue

The need for groundwater impact assessment and remediation at power company sites is expected to grow as monitoring requirements increase, old sites are retired, and EPA guidelines for new sites are enforced. Legacy groundwater impacts will be an issue of increasing importance over the next decade, as a result of more-stringent disposal regulations and water quality standards. Groundwater assessment costs can exceed $1 million per site, and remediation costs for large sites can easily exceed $10 million. Much of the groundwater remediation research in the United States centers on organic chemicals, while the suite of chemicals unique to the utility industry consists largely of inorganic chemicals such as boron, sulfate, arsenic, selenium, chromium, thallium, antimony, molybdenum, and vanadium. Retired power plant properties also provide potential liabilities that require soil and groundwater assessment and site restoration to ensure environmental integrity prior to property transactions or development.

Description

Research is focused on the specific inorganic constituents that are commonly found at power plant facilities. The project produces chemical profiles for inorganic constituents of interest at power plants, providing comprehensive information on occurrence, geochemistry, attenuation, potential health effects, and remediation and treatment. It also provides data and tools for assessing and managing long-term risks associated with groundwater releases, laboratory treatability tests and field tests to refine groundwater remediation technologies for use at power plant sites, and methods for ensuring the groundwater/aquifer integrity of programs for deep-well injection of wastewaters.

Value

- Tools and data are developed specifically for addressing groundwater issues unique to power plant facilities.
- Risk assessment methodologies facilitate assessment of potential liabilities and selection of cost-effective remediation strategies.
- Significant cost savings can be realized with expedited groundwater investigations, prescreening of available technologies, and targeted remediation.
- Chemical profiles bring together wide-ranging information from EPRI and literature sources on key constituents at CCP and coal pile sites.

How to Apply Results

The information and tools developed under this project will assist power companies in responding to potential or actual groundwater compliance issues at CCP facilities. Compliance managers can use assessment techniques to identify and define issues and to evaluate the significance and long-term ramifications of impacts. Summary compilations for specific constituents will provide companies with wide-ranging information that will allow remediation and waste specialists to perform site-specific risk assessments and groundwater modeling. In cases where significant impacts have occurred, the

laboratory studies can be used by remediation teams to screen groundwater remediation technologies and select those most appropriate, and field studies can be used to refine remediation design.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Groundwater Remediation: This research will track innovative groundwater restoration technologies for inorganic chemicals, such as reactive walls and geochemical barriers. Treatability studies will be used to assess individual constituents and mixtures commonly encountered at power plant sites. Promising technologies will be further developed as appropriate for use at CCP management sites and coal piles.	9/30/2009	Technical Update
Groundwater Quality Signatures: Electric power companies are increasingly faced with monitoring multiple potential sources of groundwater contamination at power plant sites, including coal piles, ash ponds, ash landfills, and FGD management facilities. Distinguishing between on-site sources as well as potential off-site sources and background levels for compliance/remediation purposes can be difficult. This research will develop methodologies for establishing unique source signatures (e.g. isotopes) for groundwater quality monitoring programs.	6/30/2009	Technical Update
Natural Attenuation of Metals: Natural attenuation of metals in the subsurface can often significantly reduce the potential for groundwater impacts from releases from coal storage and CCP management facilities. Natural attenuation is an integral component of any groundwater remediation plan. This research will develop data on the attenuation characteristics associated with key inorganic constituents.	12/30/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Groundwater Remediation: This research will track innovative groundwater restoration technologies for inorganic chemicals, such as reactive walls and geochemical barriers. Treatability studies will be used to assess individual constituents and mixtures commonly encountered at power plant sites. Promising technologies will be further developed as appropriate for use at CCP management sites and coal piles.	2010	Workshop, Training, or Conference
Groundwater Quality Signatures: Electric power companies are increasingly faced with monitoring multiple potential sources of groundwater contamination at power plant sites, including coal piles, ash ponds, ash landfills, and FGD management facilities. Distinguishing between on-site sources as well as potential off-site sources and background levels for compliance/remediation purposes can be difficult. This research will develop methodologies for establishing unique signatures for groundwater quality monitoring program, including isotopes.	2010	Technical Update

Product Title & Description	Planned Completion Date	Product Type
Risk Assessment: The need for groundwater remediation at CCP and power plant facilities is a function of human health and ecologic risk posed by facility releases. This research will utilize information and tools generated within the program to develop an overarching framework that participants can use to evaluate risks to groundwater for their facilities under various management and release scenarios.	2010	Technical Update
Site Restoration: The research includes field studies associated with the restoration and development of former power plant properties. Projects are performed largely under collaborative agreements with utilities and include soil and groundwater assessment, coal removal and ash capping, and work with the community to arrive at suitable development plans.	2010	Technical Report
Chemical Profiles: Information for evaluating the transport and fate of key constituents at power plant sites will be assembled into individual reports, or chemical profiles. These data include power plant source concentrations, other potential sources, geochemistry, attenuation coefficients, treatment/remediation technologies, and health effects. Selenium, molybdenum, and antimony are under consideration for 2009–2011.	2010	Technical Report
Natural Attenuation of Metals: Natural attenuation of metals in the subsurface can often significantly reduce the potential for groundwater impacts from releases from coal storage and CCP management facilities. Natural attenuation is an integral component of any groundwater remediation plan. This research will develop data on the attenuation characteristics associated with key inorganic constituents.	2011	Technical Update
Groundwater Remediation: This research will track innovative groundwater restoration technologies for inorganic chemicals, such as reactive walls and geochemical barriers. Treatability studies will be used to assess individual constituents and mixtures commonly encountered at power plant sites. Promising technologies will be further developed as appropriate for use at CCP management sites and coal piles.	2011	Technical Report
Deep Well Injection of Wastewater: FGD wastewater systems are required to treat high-dissolved-solids-content blowdown, and EPA is developing revisions to the effluent guidelines for steam electric plants that are likely to require treatment of more constituents. One option being employed by utilities is deep-well injection of wastewater. This project will assess groundwater, aquifer, and well considerations for development of a successful injection program.	2011	Technical Update