

KEVIN C. HARVEY

Executive Vice President and Chief Scientist, EnerCrest, Inc.
President, KC Harvey, Inc., an EnerCrest Company
276 Gallatin Park Drive, Bozeman, Montana 59715
(406) 585-7402 kevin@kcharvey.com

Fields of Competence

- Environmental Soil Science
- Land Reclamation
- Surface Water Management
- NPDES Permitting
- Soil and Water Chemistry
- Environmental Impact Assessment
- Technical Litigation Support
- Technical Writing and Editing
- Multi-disciplinary Project Management
- Corporate Environmental Management

Education

- **M.S. in Land Rehabilitation** – Montana State University, Reclamation Research Unit, Bozeman, Montana. Emphasis in mine land reclamation, geochemistry of hard rock mine reclamation. Minor in soil science.
- **B.S. in Resource Conservation** – University of Montana, School of Forestry, Missoula, Montana. Emphasis in soil science. Thesis topic: Conifer revegetation of mine spoils.
- **Coursework towards Ph.D. in Soil Science completed** – Montana State University, Bozeman, MT.

Professional Summary

Kevin Harvey is a **board-certified professional soil scientist** (CPSSc No. 11076) with **27 years experience** providing environmental consulting services to the private and public sector throughout the U.S., Canada, Mexico, and Europe. He has held senior level management positions in the consulting industry and has directed professional staff and contractors on multi-million dollar environmental management, permitting and remediation projects. He has extensive international experience including establishing and managing the European operation for a major international environmental engineering and consulting firm (Roy F. Weston, Inc.). While in Europe, Mr. Harvey provided senior environmental management services to multi-national industries and served as special advisor to the government of Ireland on matters relating to environmental remediation. Mr. Harvey is currently Executive Vice President of EnerCrest, Inc. and President of KC Harvey, Inc., a wholly owned subsidiary of EnerCrest.

Mr. Harvey's technical strengths are in soil science, land reclamation, soil remediation, surface water resources, and general environmental problem solving. He has particular expertise in the management of surface water resources and land reclamation for the mining, and oil and gas industries. Mr. Harvey is recognized as an expert in the management of produced water and land reclamation associated with coalbed natural gas and conventional oil and gas operations in Wyoming, Montana and Colorado. He is credited with developing an innovative approach for beneficially using coalbed natural gas produced water to irrigate forage crops.

In addition to his permitting, compliance and closure expertise for the mining, oil and gas, and power industries, Mr. Harvey has directed and participated in CERCLA investigations and remediation (PA/SI, EE/CA, RI/FS, RD/RA), remediation technology development, watershed assessment, wetland delineation and mitigation, project water balance modeling, geochemical equilibrium modeling of waters, wastewater land application, storm water management, NEPA EIS/EA, technical litigation support, ecological risk assessment, pre-acquisition environmental due diligence, regulatory compliance audits, and hazardous waste management.

Mr. Harvey has direct experience with all environmental media, i.e., soil, surface water, groundwater, air, plants, livestock, wildlife, fish, aquatic macroinvertebrates, hazardous waste, solid waste and wastewater. He has also worked with a wide variety of regulated substances including metals, radionuclides, petroleum hydrocarbons, VOCs and SVOCs, pesticides and herbicides, PAHs, PCBs, and dioxins/furans. As a technical writer and editor, Mr. Harvey has participated in the preparation of several technical articles, EIS sections, permitting documents, book chapters, technical reports for the U.S. government, documents in support of litigation, and numerous technical project reports for public review.

KC HARVEY

Representative Oil and Gas Projects

- **Reclamation Science Program Leader. EnCana Oil & Gas (USA) Inc. Wyoming.** Leading a team of reclamation specialists and soil scientists in the planning and implementation of an unprecedented program to reclaim hundreds of conventional natural gas drill pad sites in the Jonah Field of western Wyoming.
- **Various Coalbed Methane Produced Water Land Application Projects. Pennaco Energy Inc. Wyoming.** Assisting a major coalbed methane producer with water management planning, permitting and operations in the Powder River Basin of Wyoming. Developed produced water managed irrigation systems for six separate CBM project areas. Services include screening of candidate sites, site/soil investigations, project water balance modeling, irrigation water quality suitability analyses, irrigation system design, development of soil amendment prescriptions, crop selection, irrigation scheduling/soil water balance modeling, preparation of permit applications, landowner negotiations, presentations to regulatory agencies, and soil and vegetation monitoring.
- **Reclamation of Produced Water Land Application Site. Marathon Oil Company. Wyoming.** Performed site/soil investigation of degraded and orphaned produced water land application site. Implemented an unprecedented reclamation prescription for rehabilitating extreme sodic soil conditions and re-establishing the plant community. First year monitoring indicates that all soil chemistry and plant establishment goals were met.
- **Development of Master Plan for Closure of CBM Reservoirs. Marathon Oil Company. Wyoming.** Prepared a master plan for evaluating and closing reservoirs/impoundments used to store coalbed methane produced water throughout the Powder River Basin of Wyoming.
- **Various Expert Consulting Tasks in Support of Litigation. Marathon Oil Company. Wyoming.** Successfully defended several complaints made regarding releases of coalbed methane produced water to stream channels and fields in the Powder River Basin of Wyoming.
- **Tongue River Agronomic Monitoring and Protection Program (AMPP). Montana.** Conceived a program for monitoring irrigated fields throughout the Tongue River Watershed in advance of coalbed methane production in Montana. This unprecedented multi-year program involves systematic monitoring of soil chemistry, soil infiltration, and crop yield.
- **Various Coalbed Methane Produced Water Land Application Projects. Williams RMT Production Company. Wyoming.** Assisting a major coalbed methane producer with water management planning, permitting and operations in the Powder River Basin of Wyoming. Developed produced water managed irrigation systems for 12 separate CBM project areas totaling over 1000 acres. Services include screening of candidate sites, site/soil investigations, project water balance modeling, irrigation water quality suitability analyses, irrigation system design, development of soil amendment prescriptions, crop selection, irrigation scheduling/soil water balance modeling, preparation of permit applications, landowner negotiations, presentations to regulatory agencies, and soil and vegetation monitoring.
- **Expert Consulting in Support of Litigation. Williams Production Company. Wyoming.** Providing expert soil science and water quality expertise in support of legal proceedings involving discharge of CBM produced water to an ephemeral stream system that is tributary to the Powder River.
- **NPDES Permitting/Section 20 Compliance Analysis. Williams RMT Production Company. Wyoming.** Conducted a "Section 20 Compliance Analysis" in support of NPDES permit applications to discharge CBM produced water to a major tributary of the Powder River.
- **Various Coalbed Methane Produced Water Land Application Projects. Fidelity Exploration & Production Company. Wyoming and Montana.** Assisting a major coalbed methane producer with water management planning, permitting and operations in the Tongue River watershed of Wyoming and Montana. Developed produced water managed irrigation systems for ten separate CBM project areas totaling over 850 acres. Services include screening of candidate sites, site/soil investigations, project water balance modeling, irrigation water quality suitability analyses, irrigation system design, development of soil amendment prescriptions, crop selection,

irrigation scheduling/soil water balance modeling, preparation of permit applications, landowner negotiations, presentations to regulatory agencies, and soil and vegetation monitoring.

- **Research and Development of Produced Water Managed Irrigation Systems. Fidelity Exploration & Production Company, and Barrett Resources. Wyoming.** Researched, developed, demonstrated and implemented an innovative approach for beneficially using CBM produced water to irrigate forage crops in the Powder River Basin.
- **Natural Gas Produced Water Land Application Design and Permitting. AntiCline Disposal, LLC. Wyoming.** Evaluated, designed and permitted land application system to beneficially use treated produced water from conventional natural gas fields to grow forage crops.
- **Various Coalbed Methane Produced Water Land Application Projects. PetroCanada. Wyoming.** Assisting a major coalbed methane producer with water management planning, permitting and operations in the Powder River Basin of Wyoming. Developed produced water managed irrigation systems for several CBM project areas. Services include screening of candidate sites, site/soil investigations, project water balance modeling, irrigation water quality suitability analyses, irrigation system design, development of soil amendment prescriptions, crop selection, irrigation scheduling/soil water balance modeling, preparation of permit applications, landowner negotiations, presentations to regulatory agencies, and soil and vegetation monitoring.
- **Various Expert Consulting Tasks in Support of Litigation. Gough Shanahan Johnson & Waterman. Montana.** Currently providing expert soil science and surface water quality technical support to the legal team representing defendants in several major lawsuit related to the management of CBM produced water in the Tongue River watershed of Montana. The plaintiffs allege non-compliance with water quality laws and impacts to soils, irrigation water quality and agricultural production.
- **Expert Witness and Consulting Support Associated with Coalbed Methane Water Management. Yates Petroleum Corporation. Wyoming.** Provided soil science and surface water quality technical support and expert witness services to the legal team representing defendants in an appeal to the Wyoming Board of Environmental Review related to the discharge of CBM produced water to the Little Powder River watershed in Wyoming. Successfully defended complaints alleging non-compliance with the Clean Water Act, the Wyoming water quality standards, NPDES permitting program, and impacts to soils, surface water, and agricultural production. Devised innovative permitting approach to satisfy all parties including Wyoming DEQ.
- **Evaluation and Design of Subsurface Drip Irrigation System for Produced Water. Yates Petroleum Corporation. Wyoming.** Conducted site assessment and design tasks for an innovative subsurface drip irrigation system to be used to deploy CBM produced water in accordance with a Class V Underground Injection Control permit.
- **Water Treatment and Land Application Feasibility Analyses. Oil Company of Australia. Australia.** Evaluated different produced water treatment and land application scenarios for managing coalbed methane produced water.
- **Preparation of Various NPDES Permit Applications. Yates Petroleum Corporation. Wyoming.** Provided soil and water chemistry support in the preparation of NPDES permit applications associated with the discharge of coalbed methane produced water. Analyses included evaluation of compliance with the Section 20 agricultural water quality standard.
- **Development of Policy for Implementing Agricultural Water Quality Standard. Wyoming Department of Environmental Quality. Wyoming.** Invited to assist the Wyoming DEQ in the revision of a policy to implement the Chapter 1, Section 20 agricultural water quality standards. The Section 20 narrative standard is the focal point of all CBM-related NPDES permitting in the state of Wyoming.
- **Evaluation of Sulfur Burners for Conditioning Produced Water. Williams Production RMT Company. Wyoming.** Evaluated the design, construction and operation of the first system designed to condition CBM produced water using sulfur burners and gypsum injection systems. This system is designed to lower the SAR of produced water by neutralization of bicarbonate alkalinity and the addition of calcium prior to land application.

- **Design and Monitoring of Coalbed Methane Produced Water Irrigation System. Wolverine Energy, LLC. Wyoming.** Conducted site and soil investigations, site suitability characterization, project water balance analysis, irrigation system design, geochemical analyses associated with soil and water conditioning system design, cropping plans, and site/soil/water monitoring program for several full-scale irrigation systems for managing CBM produced water.
- **Preparation of NPDES Permit Application, Antelope Creek Water System. ConocoPhillips. Wyoming.** Provided lead soil science and water quality support to engineering team preparing contentious NPDES permit application for the discharge of coalbed methane produced water collected in the Powder River Basin and transferred by pipeline to the Cheyenne River watershed.
- **Hydrological Assessment and Water Management Study for Coalbed Methane Operations. Consortium of CBM Producers. Wyoming.** Directed a multidisciplinary team of consulting scientists and engineers for a consortium of eight coal bed methane producers in the Powder River Basin in the conduct of an unprecedented watershed scale analysis on the potential impacts associated with the discharge of produced water.
- **Technical Litigation Support Associated with Coalbed Methane Development. Confidential Client, Wyoming.** Performed a soil and water investigation for legal counsel regarding alleged impacts associated with the discharge of produced water on downstream flood irrigated hay fields in a tributary to the Powder River in Wyoming.
- **Preparation of NPDES Permit Applications for Discharge of Produced Water Associated with Coalbed Methane Production. Various Coal Bed Methane Producers, Wyoming.** Assisted several coalbed methane producers in Wyoming with the development of NPDES permitting strategies, water management plans, NPDES permit applications, monitoring programs, water quality assessments, beneficial use studies, and soil and water sodicity and salinity evaluations.

Representative Mining Projects

- **Development of Mine Reclamation and Closure Plan. Coeur Alaska, Inc. Alaska.** Prepared a comprehensive mine reclamation and closure plan included in the Plan of Operations for the proposed Kensington Mine north of Juneau, Alaska.
- **Preparation of Stormwater Pollution Prevention Plan. Coeur Alaska, Inc. Alaska.** Prepared permit application and stormwater pollution prevention plan for the proposed Kensington Mine.
- **Development of Integrated Surface Water Quality Monitoring Plan. Coeur Alaska, Inc. Alaska.** Integrated NPDES permit monitoring requirements and US Forest Service operational monitoring requirements into a single, cost-effective monitoring plan.
- **Land-Application Feasibility Analysis. Agrium. Idaho.** Managed an evaluation of land application (irrigation) disposal coupled with phytoextraction to remediate mine drainage contaminated with high levels of selenium. Conducted soil and vegetation surveys, fate and transport analyses, field-scale demonstration, and preliminary design of a full-scale land-based treatment system.
- **Mixing Zone Dye Study. Meridian Beartrack Mine, Idaho.** Designed and conducted an empirical mixing zone evaluation utilizing a fluorescent tracer dye solution. The objective of the study was to measure the length and width of the receiving water mixing zone in support of NPDES permit requirements.
- **Mixing Zone Analysis. Meridian Beartrack Mine, Idaho.** Performed mixing zone analyses using the EPA CORMIX hydrodynamic model to demonstrate compliance with toxic dilution zone requirements and State of Idaho fish avoidance criteria. The model results are being used to support an NPDES renewal application including a request for utilizing 100% of the receiving water flow to maximize dilution ratios used to derive effluent limits. Prepared comprehensive mixing zone analysis report for use by Region 10 EPA and Idaho DEQ.

- **Land Application of Mine Waters. Stillwater Mining Company, East Boulder Mine, Montana.** Served as project manager and technical lead in the design of a full-scale land application disposal system at a major underground platinum-palladium mine in Montana.
- **Land Application Trouble-shooting. Beal Mountain Mine, Montana.** Participated in the analysis of land application problems involving acute phytotoxicity of neutralized process water. Through a progressive program of literature review, laboratory analyses and greenhouse trials the specific chemical responsible for phytotoxicity was isolated and an applicable water treatment technology was identified.
- **Preparation of NPDES Permit Application. Meridian Beartrack Mine, Idaho.** Responsible for the development of a comprehensive application for renewal of an NPDES permit for closure of an open pit/cyanide heap leach gold mine. The application documents include the rationale for new outfalls and proposed effluent limits calculated in accordance with U.S. EPA guidance.
- **Preparation of Mine Closure Plan. Meridian Beartrack Mine, Idaho.** Currently serving as coordinator for the development of a comprehensive mine closure plan that integrates facility decommissioning and reclamation with long-term water management and treatment objectives.
- **Preparation of Mine Closure Plan. Cerro San Pedro Mine, San Luis Potosi, Mexico.** Integrated closure concepts are being developed to address reclamation, water management, and socioeconomic issues associated with open pits, waste rock repositories, and a large heap leach pad. A key element of the plan is the closure of the 70,000,000 tonne heap leach pad by way of a risk-based direct discharge to subsurface soils. In accordance with Mexican policy, the plan is required prior to final mine construction approval.
- **Mine Water Land Application Permitting. Meridian Beartrack Mine, Idaho.** Served as lead soil scientist in the siting, design and permitting of a large land application system for final treatment of process water during closure of a 125-acre heap leach pad. Conducted extensive soil chemical, physical and hydraulic investigations to support the development of a land application management plan and design.
- **Preliminary Analysis of Land Application Potential. Hecla Grouse Creek Mine, Idaho.** Performed a preliminary analysis regarding the potential for land application of process water to native and reclaimed mine facilities. The primary water management objective is to reduce the volume of process water in the tailings pond so that the pond can be reclaimed and the site closed. The analysis involved a comprehensive review of the mine water management system, water quality data, climate records, and reclamation designs.
- **Analysis of Pre-Mine Baseline Water Quality - NPDES Support. Red Dog Mine, Alaska.** Compiled and analyzed reference stream and pre-mine baseline surface water quality data for a major open pit lead-zinc mine in northwest Alaska. Assisted in the development NPDES permitting strategies based on current discharge water quality and receiving water quality. Prepared databases and conducted statistical analyses of all available surface water quality data collected at the site for 15 years.
- **Environmental Permitting Review. Coeur d'Alene Mines Corporation, Montana.** Prepared a comprehensive overview of environmental permitting requirements and key issues related to hard rock mine operations in Montana for a multi-national mining company. The process involved: research of current law, regulation, policy, and agency guidance; interviews with key industry, legal, policy analysts, technical experts, and regulatory agency personnel; and analysis and synthesis of information into a document to be used as a decision-making tool by the board of directors and senior corporate personnel.
- **Calculation and Analysis of Probable NPDES Effluent Limits. Homestake Mine, South Dakota.** Calculated probable NPDES effluent limits for an underground/open pit gold mine in South Dakota in accordance with EPA methods. A sensitivity analysis of maximum daily limits (MDLs) and average monthly limits (AMLs) was performed based on different waste load allocations, receiving stream chemistry, hardness and other variables.
- **Review of Passive ARD Treatment Systems. Pegasus Zortman and Landusky Mines, Montana.** Performed a review of passive wastewater treatment systems for managing acid rock drainage in a remote drainage at an

open-pit heap leach gold mine in Montana. This involved a comprehensive review of potentially suitable technologies against site-specific water quality, flow and topographical criteria.

- **Delineation of Jurisdictional Wetlands - Mine Permitting Support. Meridian Beartrack Mine, Idaho.** Wetland delineations were required in support of proposed mine expansion. Also supported conceptual design of wetland mitigation plans.
- **Background Water Quality Assessment - NPDES Support. Pegasus Zortman and Landusky Mines, Montana.** Performed an assessment of background surface water quality for the Zortman and Landusky open pit heap leach gold mines in Montana in support of NPDES permitting. Background surface water quality was assessed for seven drainage basins by (1) monitoring reference streams, (2) researching historic pre-mine baseline data, and (3) assessing water quality in other geologically analogous mountain ranges in northcentral Montana. The data were compiled into a comprehensive database for statistical analysis.
- **Watershed Analysis. Meridian Beartrack Mine, Idaho. Collected field data to be utilized in the development of a Watershed Analysis for the Napias Creek drainage in central Idaho.** A comprehensive survey of the drainage basin was performed to collect data for stream channel classification (entrenchment, width/depth ratio, sinuosity, gradient and stream substrate), streambank stability, and hillslope sediment sources.
- **Passive Biochemical Treatment System Testing. Zortman and Landusky Mines, Montana.** Provided design and management oversight of a treatability study for a passive biochemical treatment system for managing mine drainage at a major open-pit heap leach gold mine in Montana. The objective of the study was to demonstrate the effectiveness of this technology in treating acidity, metals, and nitrate.
- **Preparation of NPDES Permit Applications. Hecla Grouse Creek Mine, Idaho.** Prepared complete NPDES permit applications for renewing existing and establishing new discharge points at this open pit gold mine in central Idaho. Participated in the development of strategies for discharging mine drainage, storm water and process water to headwaters of the Salmon River including the Yankee Fork.
- **Assessment of Mine Water Management Facilities and Practices. Echo Bay Kettle River, Lamefoot and K2 Mines, Washington.** Reviewed existing site water management information and conducted site inspections. Prepared recommendations for managing and discharging mine drainage, storm water and process water. Revised a site water balance for use in projecting the capacity of the tailings impoundment.
- **Expert Consulting in Support of Litigation. Pegasus Gold Corporation, Montana.** Pegasus and its subsidiary, Zortman Mining, Inc. were sued by the federal government, state government, and private citizen groups over alleged violations of the federal Clean Water Act and the Montana Water Quality Act at the Zortman and Landusky open pit heap leach mines in Montana. Provided technical support to the company's legal counsel in the preparation of settlement documents and the negotiation of a consent decree. Represented the company at settlement meetings and assisted in overall compliance management.
- **Preparation of NPDES Permit Applications. Pegasus Zortman and Landusky Mines, Montana.** These applications involve 47 mine drainage and storm water discharge points including the outfalls from two wastewater treatment plants. Analyses of data regarding historical water quality, in-stream aquatic biology, beneficial uses, and treatment performance were performed to support the derivation of effluent limitations.
- **Preparation of a Storm Water Management Plan. Pegasus Zortman and Landusky Mines, Montana.** Developed a storm water management plan for this major open-pit heap leach gold mine in the northern Rocky Mountains. This plan specifies procedures for managing storm water discharges and compliance with Clean Water Act, NPDES and state discharge permit requirements. The plan also specifies best management practices (BMPs) to be implemented concurrent with mining and reclamation operations to control storm water and reduce erosion and sedimentation.
- **Abandoned Mine Reclamation. U.S. Forest Service, Oregon and Washington.** Served as a technical advisor to the U.S. Forest Service for remediation of abandoned mine sites in Oregon and Washington. The objectives were to remediate soils, waste rock, process waste and sediment enriched with metals resulting from mining and processing over the last 100 years. These projects were conducted under the CERCLA Non Time Critical

Removal program. Directed the development of work plans, sampling and analysis plans, quality assurance project plans, data analyses, risk assessments, remedial action plans and final reports.

- **Mine Drainage Source Assessment. Pegasus Zortman and Landusky Mines, Montana.** Assessed mine drainage sources from surface water runoff and seepage at a major open-pit heap leach gold mine in the northern Rocky Mountains. The primary objective of this project was to develop estimates of runoff and seepage volumes that would be managed under a Clean Water Act compliance plan and NPDES permits.
- **Preparation of Waste Rock and ARD Management Plan. Florida Canyon Mine, Nevada.** Prepared a comprehensive waste rock management plan including geochemical characterization of waste rock materials, assessing the acid generating potential of waste rock materials, review of potentially applicable ARD control measures, development of a materials handling plan, conceptual design of waste rock repositories, surface water management measures, reclamation and closure plans, repository monitoring plans and contingency strategies.
- **Preparation of a Water Quality Management Plan - Mine Permitting Support. Zortman and Landusky Mines, Montana.** This document was incorporated into an Environmental Impact Statement regarding mine expansion and final reclamation. Developed water quality improvement concepts, facilities and practices to be implemented pursuant to receiving permits for mine expansion.
- **Preparation of Mine Closure Plan. Zortman and Landusky Mines, Montana.** Prepared a comprehensive financial closure plan for a major open-pit heap leach gold mine in the northern Rocky Mountains. The purpose of this plan was to develop an estimate of the costs associated with closing the mine and meeting all environmental requirements. The components of this plan included water quality compliance, reclamation, employment, maintenance, decommissioning, salvage, and taxes.
- **Mine Revegetation Plan. Piegan Creek Mine, Montana.** Conducted a vegetation inventory of reference areas and prepared a revegetation plan for an abandoned gold mine site in western Montana. The purpose of this study was to assess the existing vegetation community in the disturbed reference areas to determine whether or not revegetation was necessary and to develop native seed mixes based on the performance of colonized species.
- **Miscellaneous Environmental Management Tasks. Pegasus Gold Corporation, Montana.** These ongoing tasks include the development of a comprehensive environmental management program for the Zortman and Landusky mines, review of NEPA documents, development of innovative reclamation cover designs, preparation of miscellaneous soil and water quality reports and liaison with regulatory agencies.
- **Water Quality Improvement Feasibility Study. Zortman and Landusky Mines, Montana.** Performed a comprehensive water quality improvement feasibility study for a major open-pit heap leach gold mine in the northern Rocky Mountains. This study, in response to Clean Water Act compliance litigation, was conducted to identify effective water quality improvement technologies, screen them, and assemble them into appropriate alternatives for protecting and improving surface water and groundwater resources associated with the mine. Various alternatives were developed for source control (ARD, metals, cyanide and nitrates), stormwater management, mine drainage capture and treatment, and erosion and sediment control.
- **Pre-mine Biological Studies. Stillwater Mining Company, Montana.** Prepared baseline permit application report for a proposed platinum/palladium mine in south central Montana. Coordinated studies of aquatic biology, fish, wildlife, vegetation, and threatened and endangered species (grizzly bear and bald eagle).
- **Mine-soil Reconstruction and Overburden Handling Plan. Diamond Alaska Coal Mine, Alaska.** Assisted in the development of a mine-soil reconstruction and overburden handling plan included in a permit application for a proposed surface coal mine in Alaska. Interpreted drill hole physicochemical data as part of the overburden characterization program and developed a computer database system.
- **Pre-mine Soil Survey and Reclamation Planning. Confidential Client.** Assessed soil resources to be used for reclamation of a proposed gold mine in the Elkhorn Mountains of Montana. This information was incorporated into the mine permit application and reclamation plan. Assessed depth and volume of suitable soil materials to be salvaged during mining operations.

- **Mine Reclamation Demonstration. Champion Mine, Montana.** Managed a reclamation demonstration for an abandoned mine tailings site in western Montana. Succeeded in permanently neutralizing acidic mine tailings and establishing a grass community on tailings that had been barren for over 80 years.

Representative Remediation Projects

- **CERCLA Remedial Investigation/Feasibility Study. Asarco East Helena Smelter, Montana.** Managed investigation tasks associated with soil, water, range, crops and livestock resources at the East Helena Smelter Superfund site in western Montana. The scope included the characterization of metal contamination throughout the 100 square mile Helena Valley Study Area. On-site treatability studies were implemented to evaluate innovative reclamation technologies aimed at revegetating soils impacted by toxic metals.
- **CERCLA Remedial Investigation/Feasibility Study. Silver Bow Creek Superfund Site, Montana.** Managed site investigation tasks and on-site remediation pilot tests at the Silver Bow Creek CERCLA site in western Montana. This site involves 100 years of mining and smelting waste deposited within the flood plain of Silver Bow Creek and the Upper Clark Fork River. Conducted vadose zone investigations to determine the contribution of mine tailings to groundwater contamination. Developed innovative remedial action technologies involving leachate reduction, chemical neutralization, and revegetation capping of acidic/metalliferous mine waste and tailings.
- **Researched Metal Toxicity in Soil and Plant Receptors. Western U.S., U.S. EPA.** Co-authored an in-depth literature review of heavy metal toxicity for the U.S. EPA. The metals and associated receptors included arsenic, cadmium, lead, and zinc in soils, plants, livestock and water, and copper, mercury, selenium, silver and thallium in soils and plants. Included in the review were assessments of toxicology mechanisms for arsenic, cadmium, lead and zinc in plants and animals and the establishment of selected hazard levels for these elements in soils, animal tissue and plant tissue. This work was completed to assess potential risks to plants and livestock resulting from smelter emissions at a CERCLA site in Montana, however, it is applicable to a wide range of sites contaminated with heavy metals. These documents are the most comprehensive reports of this type completed to date.
- **Mine Waste Reclamation Demonstration. Silver Bow Creek CERCLA Site, Montana.** Directed the implementation of a full-scale reclamation demonstration on former farmlands contaminated with flood deposited mine wastes and metals. Responsible for planning, implementation and monitoring of soil neutralization and revegetation plots. A series of plant species differing in metal tolerance were seeded into soils amended to alleviate metal toxicity. Forage produced was suitable for livestock consumption.
- **Bioremediation Land Treatment Review. Confidential Client.** Provided technical review of a large bioremediation land treatment unit for a railroad client in Montana. Contaminants of concern include diesel fuel, lube oils and other petroleum hydrocarbons. The objectives of the project were to troubleshoot operations to optimize biodegradation rate and extent. Developed plan for maintaining optimum soil moisture, oxygen and nutrient conditions for bioremediation.
- **Soil Bioremediation - Refinery. Confidential Client. Wyoming.** Developed a work plan for ex-situ soil bioremediation of heavy petroleum hydrocarbons in soil as part of an overall site remediation plan at a refinery in Wyoming. Provided technical guidelines for designing, operating and monitoring an aboveground biopile.
- **Soil Bioremediation - Wood Treating Plant. Environment Canada, Manitoba, Canada.** Managed a full-scale ex-situ soil bioremediation demonstration in northern Manitoba. Directed pre-remediation treatability studies, biopile design, soil processing, construction, and operation and monitoring of a 1000 cubic yard biopile as part of a Canadian remedial action demonstration program. Contaminants include Bunker C fuel, PAHs and other petroleum hydrocarbons.
- **Soil Bioremediation. Confidential Client.** Managed ex-situ bioremediation of petroleum hydrocarbon contaminated soil at a rail-yard site in Great Falls, Montana. This was the first on-site test of a prototype computerized automated biopile control system designed to optimize soil conditions for microbial growth and aerobic biodegradation. Bioremediation was successfully carried out during extreme cold weather.

- **Soil Bioremediation Treatability Testing. Various Petroleum Clients.** Managed 15 different soil bioremediation treatability tests performed for major companies and government agencies throughout North America. The work involved site characterization, bench-scale tests, on-site pilot-scale tests and full-scale bioremediation demonstrations. Soil contaminants ranged from PCP, PAHs, creosote, PCBs, petroleum hydrocarbons, pesticides, and explosives.
- **Soil Bioremediation System Design and Testing. Mycotech, Inc., Montana.** Managed the design and testing of a computerized automated biopile control system for enhanced bioremediation. This system is designed to optimize soil environmental conditions for exogenous and indigenous microbial growth and aerobic biodegradation. This system is capable of maintaining optimum biopile soil temperatures independent of ambient temperatures thus extending the bioremediation treatment season into the cold winter months. A patent application has been filed.
- **Hazardous Waste Landfill Investigation and Remediation. Dublin, Ireland.** Managed investigation and remediation of an uncontrolled hazardous waste landfill located outside Dublin, Ireland. Directed the pre-remedial investigations of contaminated soils, surface water and groundwater and assessed risk to adjacent human and ecological receptors. Conducted feasibility study to select the optimum remedial approach, which involved slurry walls, capping and groundwater control to isolate the buried wastes. Contaminants of concern include metals, and numerous SVOCs and VOCs.
- **Contaminated Site Investigation and Remediation. Historic Dublin Gas Works, Dublin, Ireland.** Served as special technical consultant to the Irish government for the investigation, remediation and redevelopment of the historic Dublin Gas Works in Ireland. Developed and reviewed remedial investigation work plans. Analyzed results of soil, water and waste sampling efforts. Developed site remedial approach. Contaminants of concern are coal tars, PAHs and other organic compounds.
- **CERCLA Remedial Design/Remedial Action Oversight. BN-Somers CERCLA Site, Montana.** Provided technical oversight of remedial design and remedial action activities at this former timber-treating site in northwestern Montana. Oversight involved review and approval of all technical design documents and field activities at the site including bioremediation pilot study implementation and ground water testing. Also assisted in the development of community relation activities and documents.
- **CERCLA Preliminary Assessments and Site Inspections. USDA Agricultural Research Service, Montana and Idaho.** Managed CERCLA preliminary assessments and site inspections as a contractor to the USDA. Activities included planning and implementing site assessments, calculation of HRS ranking scores, developing preliminary assessment reports and remedial recommendations, and conducting removal actions.
- **UST Site Assessment and Closure. Triangle Pacific Corporation, Tennessee.** Responsibilities included planning, meeting with state regulatory officials, oversight of environmental assessment activities, data interpretation and report preparation. This project included soil and ground water characterization (karst geology), plume delineation and corrective action planning and implementation.
- **Pre-acquisition Environmental Assessment. Former Glasgow Air Force Base, Montana.** Planned and implemented a comprehensive assessment involving sampling and analysis of soils, ground water, surface water, and waste associated with numerous landfills, underground storage tanks, sewage lagoons, waste pits, transformers and ponds. This work was performed under contract to the Boeing Company.
- **Soil and Groundwater Assessment and Remediation. Whirlpool Corporation, Utah.** This site exhibited contamination of vadose zone and ground water with volatile and semi-volatile organic compounds. Responsibilities included project planning, client consultation, regulatory agency liaison, subcontract management, development of a groundwater monitoring program, data interpretation, and report preparation.
- **CERCLA Interim Remedial Action Plan. DOE Rocky Flats Plant, Colorado.** Developed an engineering evaluation/cost analysis (EE/CA) for evaluation of remedial technologies and alternatives aimed at the remediation of contaminated alluvial ground water systems for three solid waste management units. Groundwater collection and treatment systems were designed to remediate volatile, semi-volatile, inorganic, and radioactive contaminant plumes.

- **CERCLA Remedial Action Plan. EPA Region 10, Washington.** Assisted in the development of a soil fixation/stabilization protocol for remediation of a CERCLA site in Washington state. This site involved soils and groundwater contaminated with inorganics and semi-volatile and volatile organics.

Representative Air Quality and Waste Management Projects

- **Air Emissions Characterization Study. Pfizer Pharmaceutical, County Cork, Ireland.** Directed a comprehensive air emissions characterization and pollution control engineering project for a multinational pharmaceutical manufacturer. The work included characterization of approximately 60 separate air streams emitted from a major batch process facility and the selection and design of a suitable pollution control facility.
- **Landfill Assessment and Environmental Design. County Cork Municipal Landfill, Cork, Ireland.** Directed site analysis and environmental impact assessment of a municipal solid waste landfill for a large European community. This was the community's first engineered municipal solid waste landfill. Designed systems for environmental protection including composite liner, leachate collection, landfill gas venting, capping, ground-water monitoring and closure plans.
- **Waste Management Assessment. Confidential Client.** Directed landfill assessment / waste toxicity evaluation for a European chemical manufacturer. The landfill was investigated with respect to groundwater, surface water, soils, geology, tidal influences, aquatic life, etc. Process waste streams were evaluated for toxicity to marine aquatic organisms.
- **Dioxin/Furan Soil Investigation. Eli Lilly Facility, County Cork, Ireland.** Directed a dioxin/furan investigation for a major European pharmaceutical company. The objective was to map the spatial distribution of these pollutants being deposited on the soil surface from on-site hazardous waste incinerator emissions. The scope of work included developing a statistically valid sampling design, soil sampling and analysis, statistical evaluation of the data, development of soil pollutant isopleth maps and research into the correlation of pollutants being emitted from hazardous waste incinerators.
- **Landfill Geophysical Survey. Bristol Myers Squibb, Dublin, Ireland.** Managed a geophysical survey of landfilled hazardous waste for a multinational pharmaceutical plant in Ireland. The client was concerned that hazardous wastes may have been landfilled on site over twenty years ago. The scope of the project included determining the presence or absence of waste and the extent of landfill and any associated contamination using non-intrusive geophysical techniques.
- **Environmental Audit. Confidential Client.** Managed an environmental audit and waste stream compliance management study for a multinational manufacturer in Ireland. The objective was to bring the plant into compliance with U.S., Irish and European Community regulations. Characterized waste streams, and developed treatment alternatives and recommendations.
- **Solid Waste Management Plan. Gallatin County, Montana.** Provided subcontractor project management for the development of a comprehensive solid waste management plan for Gallatin County, Montana. This plan incorporated all aspects of solid waste management including source reduction, recycling, composting, waste-to-energy, and land disposal. As part of this work, a new landfill needed to be located and developed in accordance with the new RCRA Subtitle D regulations and environmental impact guidelines.