To: Illinois Pollution Control Board
Clerk of the Board
100 W. Randolph Street, Suite 11-500
Chicago, IL 60601

From: Charles H. Norris, PG,
On Behalf of Heart of Illinois Group Sierra Club and
Peoria Families Against Toxic Waste

PC 312

Date: September 24, 2008

Re: IPCB Case AS 08-10

Postmarked 9/25/08

On behalf of Heart of Illinois Group Sierra Club and Peoria Families Against Toxic Waste, I offer the following comments for the Board's consideration in the request by Peoria Disposal Company (PDC) to delist electric arc dust to allow the disposal of that waste in municipal landfills. I provide these comments as an Illinois Professional Geologist. I hold license number 196.001082, which expires March 31, 2009. For reference, I am attaching my resume to these comments.

Upon review of the application materials, transcript, Agency and Staff comments and questions, and Applicant responses, there are a few topics I believe warrant further or new comment. The first of these is the limitations of the TCLP test that is relied upon as the basic standard justifying the delisting and projecting impacts that would result from approving the delisting. The second topic is the concept of using coal combustion waste as a stabilizing agent for a metal-bearing waste stream in the light of its historic performance in the few places where that performance can be evaluated. The third topic is the practical and regulatory relevance of the first two topics to the anticipated disposal environment of municipal landfills and the natural environments that surround them.

The Limitations of the TCLP

The Toxicity Characteristics Leaching Procedure (TCLP) is the USEPA-prescribed laboratory

testing protocol that is used to rate certain solid wastes with respect to the potential toxicity of specific constituents. It replaced the original extraction procedure (EP-TOX) for that purpose. The TCLP results are compared to a regulatory gateway to determine if a non-listed, non-exempt solid waste can be managed under the rubric of Solid Waste (Subtitle D) or if it must be managed under the rubric of Hazardous Waste (Subtitle C). The TCLP is not, however, the USEPA-prescribed protocol for the converse purpose, of establishing that a listed hazardous waste is appropriately managed under Subtitle D.

A variety of additional regulatory uses for the TCLP have evolved through practice and time. Generally these uses are predicated upon the perception that TCLP results below the regulatory gateway can be scaled relative to that threshold to reflect potential real-world leachate composition or risks to human health and the environment. That perception, and the resulting uses, has been accepted without critical review or a scientific demonstration of efficacy.

The TCLP test was not designed to predict the concentration of any contaminant in the waste leachate that will form under disposal conditions. It was not represented as a protocol capable of doing so. And, the inadequacy of this and similar index tests to predict field compositions has been increasingly obvious for the last two decades as more and more regulatory programs have attempted to use them as surrogates for or predictors of field response of wastes.

The Science Advisory Board (SAB) for the USEPA has recognized and expressed the inadequacies of these tests since at least 1991 and in 1999 called for a review of agency procedures (USEPA, 1999). The USEPA funded research by the SAB to study the best methods for modeling the impacts of waste disposal on groundwater in terms of risks to human health and the environment. That report was issued in 2004. One of the elements of that study was yet more evaluation of why tests like the TCLP cannot be used for the purpose of predicting field leachates (Al-Abed, 2003). The SAB report (USEPA, 2004) documents that as long ago as the mid-1980s it was recognized that field observation and computer modeling were required to predict how leachates would evolve.

The National Research Council echoed the warning of the inadequacy of laboratory characterization tests as surrogates for determining field leachate composition in their investigation of coal combustion ash disposal in mined settings (NRC, 2006, pp 145-152). The USEPA, in its recently released-for-comment draft risk assessment of landfills and lagoons used for disposal of coal combustion wastes, ranked potential sources of data relative to their value as indicators of real-world leachate composition. TCLP and similar index tests ranked fourth among the four available data types (RTI, 2007).

On a more personal note, I was asked to serve on a Technical Review Committee for the Commonwealth of Virginia's Department of Environmental Quality to review regulations for the beneficial use of industrial solid wastes and specifically coal combustion waste. The committee is comprised of a broad spectrum of stakeholders; scientists, contractors, generators, users, environmentalists, and industry. It would be an understatement to observe that the meetings of this committee have been somewhat contentious. The only item before the committee upon which there was unanimity was the proposition that the TCLP and similar index laboratory tests were incapable of predicting the leachates that would form from the wastes and should not be used for that purpose.

The TCLP test is the protocol that determines if an unlisted, non-exempt solid waste will be regulated under Subtitle C. That is its only appropriate use, and it is appropriate because it is prescribed for that purpose by regulation. TCLP is not indicative of leachate compositions from a waste or their evolution in the disposal environment. The basis for the concern with the TCLP is not that it over-predicts concentrations of inorganic contaminants in the leachate, but that it will often under-predict their concentrations.

Coal Combustion Waste as a Stabilizing Material

Coal combustion waste (CCW) constitutes a group of high volume industrial wastes that are exempt by statute (Bevill Amendment) from regulation as Hazardous Waste. Were these wastes not exempt, some would need be managed under Subtitle C based upon TCLP toxicity and/or

corrosivity criteria. Inappropriate placement and use of CCW has resulted in groundwater contamination and ecological damage, some resulting in clean up or remedial actions under CERCLA.

Coal combustion wastes are highly variable in chemical composition, phase (*e.g.*, mineral and glass) composition, texture and grain size, and physical properties. Coal combustion fly- and/or bottom ash can be highly reactive with water, forming a variety of mineral suites depending upon things like water content, elemental composition, phase composition, and placement conditions. Sometimes, the reactions produce minerals that can set up the CCW analogous to cement, plaster of Paris, or wall plaster.

The set-up reactions can be created or enhanced by the addition of liming agents to a CCW that has insufficient lime for the reactions. A liming agent can be calcium oxide or hydrated calcium oxide. However, frequently the liming agent that is added is cement kiln dust and/or lime kiln dust. The two materials are industrial solid wastes that, like CCW, are exempt by statute (Bevill Amendment) from regulation as Hazardous Waste. Also like CCW, were these wastes not exempt, some would need be managed under Subtitle C based upon TCLP toxicity and/or corrosivity criteria.

The reactions of CCW, or CCW mixed with a liming agent, that cause the material to set up are often referred to as pozzuolanic reactions. Unless the result of these reactions for a specific mix is a suite of silica-cement minerals, this term is inappropriately used. Usually the minerals that initially form upon hydration are metal hydroxides, sulfate minerals, carbonate minerals, or more exotic minerals such as ettringite. Since only the silica-cement minerals have long-term physical and chemical stability, other hydration products will deteriorate by leaching, reaction, and/or recrystallization fairly soon after formation. This is typically the case.

Many power companies offer a CCW recycling product of lime-enhanced fly ash touted for its ability to set up like a low-grade cement with a low permeability. These materials are marketed or used for things such as low-permeability liners under lagoons or landfills, structural fill for

construction, and waste stabilization media. In each application, the treatment of the fly ash with a lime additive purportedly binds the inorganic contaminants, precluding their leaching. The evidence for this is the concentrations produced by the TCLP test. The premise behind such products is that the material initially formed and placed is permanent. That is, the product is non-reactive with the environment around it and that the mineral assemblage that initially forms is not intermediate phases that will react to a different assemblage with time.

Generally, landfills and lagoons that use these materials are not monitored. When they are monitored, they are shown to fail. I have over the course of the last ten years evaluated four such facilities across the country; Fern Valley in Pennsylvania, Petersburg in Indiana, Sunflower in Kansas and the Turris Mine in Illinois. In each case, the liner material deteriorated to the point that its hydraulic containment was compromised and contamination occurred.

Structural fills of lime-enhanced fly ash are even less frequently monitored than lagoons and landfills using these materials. For the two cases with which I am familiar, Bark Camp in Pennsylvania and Battleground Golf Course in Virginia, the placement of these materials as fill is resulting in groundwater contamination.

Waste stabilization is perhaps the most common use of alkaline fly ash or lime-enhanced fly ash. Mixing these materials with wastes that otherwise would fail the TCLP test will produce leachates with compositions that allow the wastes to be disposed as special wastes in municipal landfills. In these cases, there is no monitoring of the stabilized wastes to determine any time-dependent changes to the leachate they produce. There are three cases with which I am familiar, however, where the disposal occurred outside of landfills and the behavior of the materials after and beyond the initial TCLP characterization can be observed. Two of these are the structural fills mentioned above; Bark Camp and Battlefield Golf Course. In each case, the structural fill application was paired with waste stabilization. Stabilized wastes at Bark Camp were fly ash, cement kiln dust, lime kiln dust and harbor dredgings. At the golf course, the stabilized wastes were fly ash that was creating contamination at its landfill, and cement/lime kiln dusts. In both cases, although the stabilization process allowed the TCLP to be passed, the produced leachate

actively creates ground- and/or surface water contamination.

The third example of an inappropriate reliance on CCW-stabilized waste with which I am familiar is one from here in Denver. It is the best documented of those with which I am familiar. The USEPA used lime-enhanced CCW to stabilize waste uranium and heavy metals in a large mound of tailings within Denver itself. The tailings were excavated and processed with the lime-enhanced fly ash for stabilization. The TCLP results showed the metals and uranium were not mobile for the duration of that test environment, and the stabilized mix was returned to the site for disposal. Monitoring results from the disposal site after all the tailings were stabilized and replaced showed that contamination from the site quickly exceeded levels that predated the stabilization project. Now, instead of exhuming and transporting the mill tailings for disposal, the USEPA had to exhume and transport the substantially larger mass of mill tailings and CCW stabilizing material for disposal. This site is the Shattuck Superfund Site and can be reviewed at http://www.wateronline.com/article.mvc/Despite-Fix-Shattucks-Legacy-is-Reaching-the-0002?VNETCOOKIE=NO or with a Google search of USEPA+Shattuck+Denver.

At issue is not how the stabilized electric arc dust will respond to disposal in an unconfined environment, because it will be disposed in a municipal landfill. There are two relevant issues. The first is the inadequacy of the TCLP test itself with respect to how the stabilized waste itself will initially leach. As described above, the test will not and cannot predict the leachate that will form in the landfill environment. The second is the evolution of leachate from the waste with time. The leachate that forms in the landfill is a complex process that is waste, not water, dominated. Leachates forming in the disposal setting do not develop their composition within a one-day period; they evolve over months and years. The compositions of leachates that form in a disposal setting are not static. They evolve in space as they migrate through new waste or rocks and soil and as they mix with other waters and other leachate. They also evolve in time, as constituents are gained or lost in response to changing compositions of the waste which result from the leaching itself, as Eh or pH conditions change in the landfill with time, as the lime-enhanced fly ash evolves temporally, and as acted upon by biological agents.

As discussed in the following section, these changes materially impact the performance of and risks from the municipal landfill. The performance of and risks from the landfill are beyond what was considered when the landfill was sited by the community. The performance of and risks from the landfill are also beyond what was considered by the IEPA in granting the construction and operating permits.

The Disposal Environment

The processed mixture of electric arc dusts, CCW, liming agent(s), and whatever proprietary ingredients are involved are to be placed in municipal landfills. The electric arc dust does not have a defined composition or range of compositions, because the proposed delisting is not for a single source. The composition and character of the disposal environment cannot be determined because the proposed delisting will allow placement in any number of different municipal landfills. Such concerns are dismissed on assurances from PDC. First, whatever the composition of the electric arc dust, the processed and stabilized wastes will pass the TCLP test. Second, the proprietary stabilization process will initially and perpetually render the contaminants bound and immobile.

The basis for the first assurance is hollow. The TCLP test does not and cannot predict the composition of the leachate and departures from the test results are typically greater than predicted, not less. Rhetoric describing the TCLP as unfairly aggressive and therefore conservative is inaccurate. The TCLP test is a short duration, water-dominated protocol with no limitations or control of Eh, gas pressures, or biological influences. Leachate compositions are also limited by simple solute availability in the dilute protocol environment. For example, metals concentrations in leachate are strongly dependent upon waste:water ratios (Al-Abed 2003), and in a landfill that ratio will be 10-fold or more that of the TCLP test.

Passing the TCLP test does not provide information about the leachate from these wastes in the landfill. The USEPA knows this through the research of its Science Advisory Board. The National Academy of Science knows this. The Commonwealth of Pennsylvania knows this as it

tries to develop a meaningful testing protocol for CCW-related waste streams. Representatives for all stakeholders in negotiations of a Technical Review Committee in Virginia all know this.

The basis for the second assurance is absurd. If there were only one electric arc waste stream that always had constant composition, if there were but a single source of CCW that had constant composition, if there were but a single composition for each other ingredient of the proprietary mixture, and if the waste were only going to be placed in a single landfill, the assertion that the stabilization process will initially and perpetually render the contaminants bound and immobile would still be indefensible. It is indefensible, even if all of those elements are held absolutely constant, because the landfill environment changes continually.

At time of disposal, the waste mix is bathed with precipitation, directly or through daily cover. At some point, the landfill environment begins to lose oxygen and become reducing. CCW wastes are typically strongly oxidized. They are a source of oxygen to both abiotic and biotic reactions. Minerals and mineral assemblages that are stable at the waste face are no longer in chemical equilibrium. Landfills typically have acidic environments and lime-enhanced CCW wastes are alkaline. Minerals, like ettringite that is stable at very high pH, become unstable at more neutral pH. As the mineral composition moves to a new equilibrium, the mobility of the contaminants change. The strongly reduced environment is not constant or permanent, however. Air can penetrate locally or generally. Waste deep within landfills can catch fire, spontaneously; another environment, and another temporary equilibrium, and more changes to the waste and the contaminant mobility.

One cannot maintain a perfectly and perpetually stable waste in an ever changing environment; it defies the laws of thermodynamics. What one can do, and what appears to have been done, is a waste processing recipe has been developed that allows the electric arc dust and CCW to suppress the metal mobility in the environment of the TCLP test for the 18-hour duration of that test. As a reward for that skill in laboratory chemistry, the applicant requests the right to so process that waste from any sources and place it in any of its landfills.

Does any of this make any difference to public health, safety, and welfare (local siting criteria) or human health and the environment (IEPA performance criteria)? Yes, it does.

The local siting authority was not presented with and did not accept an operating plan that proposed to bring in a delisted hazardous waste stream in unknown quantities that will react at unknown rates to produce leachates of unknown compositions. It is not an eventuality that might have been reasonably anticipated by the authority in its considerations, since this proposal is unprecedented in its scope and flexibility.

The IEPA's construction and operating permits become ineffective, as well. The requested delisting, in and of itself, will provide a new source of metals from both the electric arc dusts and the CCWs to the composition of the landfill. That new source of metals would be expected to increase the concentration of metals in the landfill leachate by an unknown and unknowable amount.

It is the practicing position of the IEPA that concentration of a contaminant outside and downgradient of a landfill is linearly proportional to the concentration inside the landfill. That assumption is the premise behind the accepted use of a unit concentration as the source term for fate and transport modeling done for the Groundwater Impact Assessment (GIA), whether the model is POLLUTE, MIGRATE, or MODFLOW/MT3D. Since the leachate composition from this new waste is unknown, the incremental change to the landfill leachate is unknown. Generally, concentrations in a municipal landfill leachate can be approximated by consideration of leachates observed from other municipal landfills. But, in this case, there is no other municipal landfill that accepts these wastes, let alone in this quantity or this form. Since the source term concentration isn't known, the downgradient plume concentration cannot be simulated and compliance with the performance standard cannot be demonstrated. Some of the landfills for which the right to dispose is sought are directly over major regional aquifers, including the Mahomet Aquifer. Such resources deserve fully defendable demonstrations of probable compliance, at a minimum. That cannot be done with what is proposed in this application.

Personal Comment

The above comments represent my opinions as a professional geologist. Beyond those comments, I would like to offer the following personal observation.

In the past few years of my career, I have observed a trend in waste management and regulation that very much concerns me. Waste generators and waste receivers/processors are increasingly exploiting the limitations of the TCLP test and some of its regulatory uses to circumvent responsible management of their wastes. Elsewhere, this approach has even been used to justify and approve the open placement of wastes in the environment with no pre-placement site characterization, no post-placement monitoring, and no regulatory oversight. This proposed delisting is part of that trend; benignness by TCLP.

The decision on this delisting proposal will have future impacts far beyond this electric arc dust. Because of its breadth, flexibility, and the reliance upon the TCLP, I believe there will be more such applications, each pushing the envelope further. If this application is successful, it will be but the first of a new type of delisting applications. Each will use parallel logic and a parallel approach. Each will rely upon laboratory bench chemistry to produce a waste or multi-waste "product" that can constrain contaminant mobility under the conditions and for the duration of the TCLP test, with no consideration of how the waste will actually behave upon disposal. One waste at a time, using this application as a template and its approval as a precedent, the fundamental concept and historical practice of handling the most dangerous wastes, the Listed Wastes, more carefully than household waste, will be undone. I think that would be a mistake.

I thank you for your attention to and consideration of my comments, both professional and personal.

References Cited

Al-Abed, Souhail, 2003, *Roadmap for Current and Long-tem Research on Waste Leaching,*

Office of Research and Development, National Risk Management Research Laboratory, United States Environmental Protection Agency, Cincinnati OH, presentation to USEPA Science Advisory Board, June 17, 2003, 23 pp.

NRC, 2006, Managing Coal Combustion Residues in Mines, Committee on Mine Placement of Coal Combustion Wastes, National Research Council of the National Academy of Sciences, The National Academies Press, Washington, D.C., March, 2006.

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USEPA, 1999, Waste Leachability: The Need for Review of Current Agency Procedures, EPA-SAB-EEC-COM-99-002, EPA Science Advisory Board, U. S. Environmental Protection Agency, Washington DC, 1999.

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SUMMARY OF QUALIFICATIONS

Thirty plus years of professional experience in geology, hydrogeology and management in the applied and theoretical geosciences. Experience includes performance, oversight review, or management of site assessment; RI/FS; computer modeling of fluid flow, contaminant transport, and geochemistry (applications and code development); policy and rule making procedures; aquifer evaluation; resource development; and litigation support; nationwide and internationally.

PROFESSIONAL EXPERIENCE

GEO-HYDRO, INC., Denver, Colorado, (1996-present), Principle, CEO, Vice-President
HYDRO-SEARCH, INC., Golden, Colorado, (1992-1996), Director of Hydrogeology
UNIVERSITY OF ILLINOIS, Urbana, Illinois, (1987-1992), Research Associate; Manager, Industrial Consortium for Research and Education for the Laboratory for Supercomputing in Hydrogeology
Consulting Hydrogeologist/Geologist, Champaign, Illinois and Denver, Colorado, (1980-1992)
MGF OIL CORPORATION, Denver, Colorado, (1985 - 1986), Manager Geological Engineering
EMERALD GAS AND OIL, Denver, Colorado, (1980 - 1986), President and Owner
PETRO-LEWIS CORPORATION, Denver, Colorado (1980), Districts Geologist
TENNECO OIL COMPANY, Denver, Colorado and Houston, Texas, (1977-1980), Senior Geological Engineer
AMOCO INTERNATIONAL OIL COMPANY, Chicago, Illinois, (1975-1977), Senior Geologist
SHELL OIL COMPANY, Houston and Midland, Texas, (1972-1975), Exploration Geologist

PROFESSIONAL REGISTRATIONS, MEMBERSHIPS, AND AFFILIATIONS

Professional Geologist: Illinois (# 196-001082), Indiana (# 2100), Pennsylvania (PG003994), Utah (#5532631-2250), Wisconsin (# 924), Wyoming (#2989)
Registered Environmental Professional (#5350), State of Colorado, Petroleum Storage Tank Fund

National Ground Water Association
Colorado Groundwater Association (Vice President 1999, President 2000, Past-President 2001)
Professional Geologists of Indiana (past)
The Colorado Mining Association (past)
Illinois Groundwater Association (past)
American Association of Petroleum Geologists (past)

Phi Beta Kappa, Phi Kappa Phi, Sigma Xi

EDUCATION

B.S., Geology, University of Illinois, High Honors and Distinction in Geology, 1969
M.S., Geology, University of Washington, National Science Foundation Fellow, 1970
University of Illinois, all but dissertation completed for Ph. D., Hydrogeology, 1992

PROJECT EXPERIENCE

RI/FS & GENERAL SITE INVESTIGATIONS

- Manager for technical assistance through a Technical Assistance Program (TAP) grant from PRPs to local citizens' group. Assistance through grant to provide assessment and feedback on site work products as they are developed and implemented, explain the remediation processes and activities to the citizens, and serve as technical liaison between citizens and remediation team.

- Modeler and hydrogeologic consultant at industrial tank farm adjacent to the Chicago Sanitary and Ship Canal in northeastern Illinois. Assess hydrogeologic data, interpret aquifer testing, and model groundwater flow in soil and fractured carbonate bedrock in area of DNAPL accumulation as part of site characterization and voluntary remediation design.

- Manager and hydrogeologist of groundwater investigation at an industrial dump site adjacent to the Illinois River in north Central Illinois. Investigated fate and transport of 3-4 decades of disposal of mixed, hazardous industrial wastes at a non-engineered floodplain dump site. Expert testimony and legal support. Pre-trial settlement provided for installation of monitoring system in lieu of site characterization.

- Manager of groundwater flow modeling performed as part of the groundwater characterization effort and as part of the preliminary remedial designs. The site is a Superfund site involving both organic and metals contaminants at a wood treating facility in an urban area in Alabama adjacent to a major commercial waterway.

- Manager of groundwater flow modeling performed as part of the groundwater characterization effort and as part of the 90% and Final remedial designs. The site is a high profile Superfund site involving both organic and metals contaminants at a wood treating facility in Northern California.

- Technical advisor assisting in the evaluation of aquifer properties and well performances for an extraction well field near Sacramento CA. A high volume pump and treat system for chlorinated solvents showed strong and anomalous decline in productivity. Detailed evaluation identified both possible causes and recommended operations changes to alleviate the problems.

- Technical advisor assisting in the evaluation of aquifer properties and well performances for initial installation of a high volume extraction well field in Southern California. The chlorinated solvent plume associated with a Superfund site impacted a large area in a layered, heterogeneous groundwater basin managed intensively for public water supplies.

- Senior oversight and review in the evaluation of aquifer and soil properties, and the remediation of the soils contamination and groundwater impacts associated with compressor facilities of interstate gas transmission companies. Various projects and sites in western Colorado, Wyoming, and the Texas panhandle.

- Technical advisor for the Remedial Investigation/Feasibility Study (RI/FS) of the Landfill Solids and Gases Operable Units at the Lowry Landfill CERCLA site located near Denver, Colorado. This project involved the characterization of the extent of potential contamination within the unsaturated zone adjacent to this high profile site. Work involved extensive coordination and interaction with multiple PRP groups as well as various regulatory agencies.

- Project manager for independent oversight of a proposed low-level radioactive waste disposal site. Task was to develop technical and legal program for governmentally funded intervener's case as part of adjudicatory hearings on a high-profile, proposed disposal facility and involved identifying, retaining and educating legal staff, retaining a team of technical experts, negotiating fees, coordinating work product and presentations,

providing liaison with citizen's groups, responding to press and integrating personal testimony on hydrogeology and modeling. Expert testimony and legal support.

LANDFILL SERVICES

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment of existing water quality and off-site migration from existing licensed landfill near Joliet IL. Work includes groundwater flow modeling of remedial alternatives and groundwater impact assessments of various alternatives for submittal to IEPA.

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed expansion for a hazardous waste landfill in Peoria County, Illinois. Expert testimony and legal support. Review identified errors in application, unaddressed contamination on facility property, and inappropriate modeling design and implementation.

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed regional landfill by expansion of local landfill in Ogle County, Illinois. Expert testimony and legal support. Review identified in errors application, unaddressed existing leakage, and potential risk to public water supply. (Three hearings)

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed regional landfill by expansion of local landfill in Kankakee County, Illinois. Expert testimony and legal support. Review identified errors in application, unaddressed existing off-site leakage, and inappropriate modeling design and implementation. (Two hearings)

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill in Will County, Illinois. Expert testimony and legal support. Research documented numerous errors in application which resulted in underestimation of infiltration rates and potential migration rates. Identified evidence of sub-karstic migration pathway from site to nearby stream. Assisted with the design of the facility monitoring system submitted and accepted by IEPA.

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill expansion at East Peoria, Illinois. Research documented current leakage from the existing landfill into the regional unconfined aquifer within the cone of depression of the municipal water supply wells. In part as a result of the evaluation, the proposed expansion has been abandoned. Expert testimony and legal support.

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill at Ottawa, Illinois. Provided testimony at county hearings identifying and documenting site-specific conditions that invalidated part of the ground water evaluation testing, necessitating the need to re-evaluate the groundwater flow system and redesign the monitoring system. Expert testimony and legal support.

- Project manager and hydrogeologist for a geologic and hydrogeologic assessment of existing municipal landfills and a proposed landfill redesign and expansion at Salem, Illinois. Provided testimony at city hearings documenting existing landfill leakage and identifying site-specific conditions that complicate the design of a reliable monitoring system. Expert testimony and legal support.

- Project manager and hydrogeologist for site evaluations of the geology and hydrogeology of several proposed municipal landfills and a landfill expansion in Bartholomew County, Indiana. The review of the expansion demonstrated inadequate monitoring of the existing facility. One proposed site showed possible, current ground water usage from under the proposed facility and conditions that may preclude state-level site approval.

- Project manager and hydrogeologist serving in consultation to the Board of Wayne County, Illinois, regarding a proposed expansion to a regional landfill. Investigation and oversight established viability of the physical site and improvements that were needed in operating procedures and monitoring efforts. Expert testimony and legal support.

- Project manager and hydrogeologist for an assessment of an existing regional municipal landfill at Urbana, Illinois. Principle problems included ground water contamination, unplugged well(s) within the facility boundary that penetrated the aquifer serving public water supplies and a monitoring system inadequate to evaluate the contaminant migration. Results of the evaluation include an expanded system of monitoring wells, improved protocols for ground water sampling and revised statistical procedures to determine background water chemistries.

- Project manager and hydrogeologist for a site assessment of a proposed municipal landfill expansion in west central Indiana. Established feasibility of using the engineering and design features of the expansion to prevent contamination from the pre-existing non-engineered facility.

- Project hydrogeologist for a site assessment of a proposed saturated-zone, regional balefill in central Illinois. Principal problems involved the evaluation of the hydrogeologic characteristics of the strip mine spoils within which excavation would occur, the blasted mine bottom upon which the liners would be built and the materials available for liner construction. Expert testimony and legal support.

- Project manager and hydrogeologist for a site assessment of a proposed municipal landfill expansion in Livingston County, Illinois. Principal problems involved the evaluation of the impact of shallow coal tunnel mining beneath the site and reaction of waste leachate with unusual clay mineralogy important to waste isolation at the site. Expert testimony.

- Technical reviewer of site assessment and re-assessment of a proposed inter-governmental regional landfill in central Illinois. Verified unanticipated, politically unacceptable risks to major aquifer system serving public water supplies. Assisted in drafting of technical policy statement that permitted new siting efforts to proceed in the jurisdiction. Expert testimony.

WATER RESOURCE EVALUATION & DEVELOPMENT

- Manager for ground water modeling effort associated with the development of a high-volume ground-water supply and delivery project in Colorado. The effort included investigating and evaluating a previously used, court-accepted model, adapting and updating the model, and applying the model to assess the impacts of a proposed private ground-water diversion project that would be the largest in the United States. Ongoing effort includes subsequent review of alternative proposed model and further litigation support.

- Manager for review of an application for an expansion of a large long-wall mine in southeastern Ohio. The review identified extensive unrecognized mining-related impacts to water supplies from historic mining and identified hydrologic risks to a unique old-growth forest adjacent to the proposed expansion, and resulted in an appeal of the application. Expert testimony and legal support.

- Manager for ground water modeling effort associated with the development of a surface reservoir designed for conjunctive use of ground and surface water to reduce peak ground water pumping demands in Denver metro area. The effort included investigating and evaluating a previously used, model, adapting and updating the model, and applying the model to assess the impacts of project on other water rights. Study is a component of the EIS.

- Project Manager for multi-company effort to model thermal loading of northern Nevada surface waters as a

result of mine dewatering project. Successful liaison among technical staffs and regulators and modeling work for a high profile EIS resulted in approval of discharge permit.

- Project Hydrogeologist for the feasibility study of a small lake for a northern Illinois nursery, to be used for recreation, fishing and irrigation. Evaluated shallow and intermediate ground water and surface run-off, reviewed engineering design and directed ground and surface water sampling program to determine nutrient levels.

HYDROCHEMISTRY

- Principal investigator for grant to research the geochemical implications of using alkaline addition as one means for preventing and/or remediating inorganic contamination resulting from acid mine/rock drainage. Empirical and modeling evidence showed conditions under which alkaline addition can cause or exacerbate contamination of some constituents of concern.

- Project manager, hydrogeologist, geochemist for ongoing investigation of metals contamination of a trout stream in West Virginia. Impacts from natural and industrial sources , present and past, evaluated to segregate relative significance of various sources. Includes expert testimony and legal support.

- Project geochemist and hydrogeologist for evaluation and critique of modeling protocols used by USEPA for risk assessments performed as part of regulatory determinations for various solid wastes. Identified errors in methodology and input that had caused previous modeling to mischaracterize risks for settings with observed damage cases. Computer modeling.

- Geochemist and hydrogeologist for evaluations of inorganic groundwater chemistry at an industrial RCRA site near Joplin MO. Federal lawsuit filed pursuant to PRP contribution and sources and timing of contamination. Was able to use geochemical interpretations to establish significant elements of aquifer characteristics and implications for contamination routes. Expert testimony.

- Project hydrogeologist and geochemist for evaluations of proposed coal combustion waste disposal as part of reclamation activities at surface coal mines in Southwestern Indiana. Efforts were targeted toward refining regulatory framework for disposal efforts, establishing effective characterization and monitoring programs and determining appropriate operation and engineering practices. Project involved extensive interdisciplinary effort and expert testimony.

- Project geochemist for the investigation of the impacts of remediating acid mine drainage by installing bulkheads to flood exhausted mine working. Predictively modeled water chemistries in situ, within flooded mine, along flow paths and upon surface discharge. Assisted in preparation of testimony that resulted in permit approval for the San Juan County, Colorado project.

- Project manager and project geochemist/hydrogeologist for investigation of potential environmental impacts of disposal of coal combustion wastes (CCW) as part of a reclamation plan at a surface coal mine in northern New Mexico. Performed or directed geochemical, infiltration and flow modeling of the proposed project to identify optimum disposal methods and worst case impacts. Presentation to State resulted in approval of this precedent-setting project.

- Project manager, geochemist/hydrogeologist Investigating a proposed disposal/construction project for a central Illinois ski mountain from co-generation fly ash from a major food products manufacturer. Involved overseeing an engineering review of project plans, site investigation and evaluation, geochemical modeling of initial and final mineralogical composition of the mass and of the leachate chemistry and evolution and the impact on the hydrogeologic and structural integrity of the project. Expert testimony and legal support.

RELATED PETROLEUM INDUSTRY EXPERIENCE

- Project manager for the environmental assessment of 82 Texas producing properties targeted for acquisition. Evaluations included site walk-overs, surface soil and liquid sampling, radiological monitoring and geoprobe sampling of soils and ground water. The assessments documented a multitude of impacts from both exempt and non-exempt wastes that, unrecognized, could have resulted in substantial financial exposure to the client.

- Project geologist and petrophysicist for an investigation of resource potential of coal bed methane in San Juan Basin of New Mexico and Colorado. Study focused on innovative log analysis techniques; formation water chemistries, production rates and disposal problems; well drilling, completion and re-completion practices; and detailed subsurface facies and structural mapping and stratigraphic correlation in shallow coal beds of Kirtland/Fruitland/Pictured Cliffs shoreline complex and relationships to overlying Tertiary sandstones.

- Developed a successful play in the Hunton and Mississippi Lime formations of northwest Oklahoma. The play recognized the secondary porosity systems of both formations (dolomitization and fracturing, respectively) and the genetic significance to each of the buried topography at the intervening unconformity.

- Managed a detailed reservoir study of a Cotton Valley gas field in east Texas that resulted in RRC approval of non-standard spacing based upon the recognition of secondary porosity and a dual-conductivity system that resulted from drape-induced fractures. The revised spacing both protected resource ownership and conserved the costs of infill drilling. Expert testimony and legal support.

- Project geologist, petrophysicist and expert witness for various contested adjudicatory hearings apportioning oil and gas ownership. Cases involved primary recovery of oil/gas and secondary recovery of oil. Accepted as expert (geology, hydrogeology, and/or geological engineering) in Oklahoma, Texas, and Wyoming.

ADDITIONAL PROFESSIONAL EXPERIENCE

- Invited presenter to National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes.

- Appointed member of a Quality Assurance Committee under the West Virginia Department of Environmental Protection. The committee, comprised of representatives of state and federal regulators, industry , and interveners, was charged with a year-long review of state mining applications and approval practices relative to mining under the state and federal surface mining laws.

- Invited presenter to National Research Council of the National Academy of Sciences, Subcommittee on Alternatives, Study on Coal Waste Impoundments.

- Project manager and hydrogeologist for the review of Proposed and Revised Proposed Criteria for the Siting of a Low Level Radioactive Waste Disposal Facility in Illinois. Evaluation was targeted toward both technical content and processes of selection. Testimony and written comments led to significant improvements and flexibility in the Criteria as finally published.

- Project hydrogeologist testifying at hearings before the Illinois Pollution Control Board on regulatory language for the Illinois Ground Water Protection Act. Contributed major conceptual and specific language changes to the final promulgated rules for Ground Water Quality Standards and Regulations for Existing and New Activities with Setback Zones and Regulated Recharge Areas. Expert testimony and legal support.

- Project hydrogeologist and log analyst for three applications to U.S. EPA for permits to continue deep well

disposal of hazardous wastes in east central Illinois and southern Ohio. Project required evaluation of geophysical logging data to determine injection zone and confining layer properties, regional flow systems, chemical interactions of the waste stream with the native rock and the ability of the injection system to isolate the waste from the environment.

REPORTS, PRESENTATIONS, AND PUBLICATIONS

Norris, Charles H., 2005, "Water Quality Impacts from Remediation Acid Mine Drainage with Alkaline Addition", draft version released to National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes, Geo-Hydro, Inc., Denver CO, July 3, 2005

Norris, C. H., "notes from the front. . . Overview of three sites", invited paper before National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes, Evansville IN, March, 2005.

Norris, Charles H., 2004, "Environmental Concerns and Impacts of Power Plant Waste Placement in Mines", Presented at Harrisburg PA, May 4-6, 2004. Published in Proceedings of State Regulation of Coal Combustion By-Product Placement at Mine Sites: A Technical Interactive Forum, Kimery C Vories and Anna Harrington, eds, by U. S. Department of Interior, Office of Surface Mining, Alton IL, and Coal Research Center, Southern Illinois University, Carbondale IL.

Norris, C. H., "Developing Reasonable Rules for Coal Combustion Waste Placement in Mines. Why? When? Where? How?", USEPA Contract 68-W-02-007, IEI Subcontract 7060-304, Invited paper at USEPA MRAM meeting, Rosslyn VA, September, 2003.

Norris, C. H., "So, You think You're a Geologist? (F. Kafka to A. Liddell, In Wonderland)", Colorado Ground Waster Association Monthly Meeting,, Denver CO, September, 2002.

Norris, C. H., "Assessment of the Anker Energy Corporation proposal for mining and reclamation, Upshur County, West Virginia." Independent evaluation on behalf of Anker Energy Corporation and West Virginia Highlands Conservancy , July, 2002.

Norris, C. H., "Coal Combustion Waste: Coming soon to a neighborhood (and maybe a faucet) near you." Colorado Ground Waster Association Monthly Meeting,, Denver CO, May, 2001.

Norris, C. H., "Slurry-to-ashes, and ashes-to . . . A case of a coal company and citizens working together to evaluate alternatives." Invited paper before National Research Council of the National Academy of Sciences, Subcommittee on Alternatives, Study on Coal Waste Impoundments, St. Louis MO, June, 2001.

Norris, C.H., and C. E. Hubbard, "Use of MINTEQA2 and EPACMTP to Estimate Groundwater Pathway Risks from the Land Disposal of Metal-Bearing Wastes", for Environmental Technology Council, submitted as public comment to USEPA on regulatory determination for Fossil Fuel Combustion Wastes, May, 1999.

Norris, C.H., "Report on the Determination of Intermittent Streams and the Potential Impacts of Valley Fill on Area Drainages, Southern West Virginia", expert report for litigation prepared for Mountain State Justice, Inc, Charleston WV, March, 1999.

Norris, C.H., "Report on the Geology and Hydrogeology of the Caterpillar Levee Site with an Evaluation of Potential Pathways on- and off-site for the Movement of Solid and Hazardous Wastes", expert report for litigation prepared for Citizens for a Better Environment, Chicago IL, March, 1998.

Norris, C.H., "Dr Pepper, Biorhythms, and the Eight-Hour Pumping Test ", Colorado Ground Waster Association

Annual Meeting, Golden CO, December, 1997.

Norris, C.H., "Characterizing Ash Composition and (vs.) Projecting Environmental Impact for Purposes of Permitting CCW Disposal ", Coal Combustion By-Products Associated with Coal Mining - Interactive Forum, Southern Illinois University at Carbondale, Carbondale IL, October, 1996.

Norris, C.H., "Geochemical Modeling". Co-instructor for Short Course on Hydrogeologic Issues Related to Mine Permitting, Reclamation and Closure, SME Annual Convention, Phoenix AZ; March, 1996.

Norris, C.H., An Improved Method for Middle Time Analysis of Slug and Bail Test. Unpublished. 1994.

Norris, C.H., "Evolution of the Landfill", presentation as part of a Telnet program, *Garbage Dilemma Educational Series*, sponsored by Illinois Farm Bureau and Cooperative Extension Service of the College of Agriculture, University of Illinois, Urbana, Illinois, April 20, 1992.

Norris, C.H., "Technical Analysis or Political Acceptability: The Domesticated Fowl or its Ovum", Solid Waste Management and Local Government Workshop, sponsored by Institute of Government and Public Affairs, University of Illinois, Urbana, Illinois, Jan-Apr, 1992.

Norris, C.H., Report on the Geology and Hydrogeology [of the] SWDA Proposed Landfill Site, Township 8 North, Range 6 East, Section 31, Bartholomew County, Indiana, for Central States Education Center, Champaign, Illinois, 1991.

Norris, C.H., Hydrogeology and Modeling of the Proposed Illinois Low Level Radioactive Waste Disposal Site at Martinsville, Illinois; testimony before the LLRW Siting Commission, October and November, 1991, Martinsville, Illinois.

Norris, C.H., Ground Water Quality Standards for the Illinois Ground Water Protection Act; testimony before Illinois Pollution Control Board, Chicago, Illinois; February, May, October and December, 1990; May, 1991.

Norris, C.H., Hearing on a Petition for a Special Use Permit for the Construction of a Ski Mountain in Oakley Township, Macon County, Illinois; testimony before the Macon County Zoning Board of Appeals; February 16, 1990.

Norris, C.H., Hearing on a Solid Waste Disposal Permit for the Siting of a Municipal Landfill for Streator, Illinois; testimony before the Livingston County Board; August 6, 1990.

Norris, C.H., In the matter of the Gallatin National Company Proposed Balefill, Fulton County, Illinois, written comments to the Illinois Environmental Protection Agency, Springfield, Illinois, 1990.

Norris, C.H., 1990, Log Analysis of the Allied Chemical Corporation Waste Injection Well, Danville, Illinois, for Alberto Nieto, Champaign, Illinois.

Norris, C.H., 1989, Log Analysis of the Cabot Corporation Waste Disposal Wells, Tuscola, Illinois, for Alberto Nieto, Champaign, Illinois.

Norris, C.H., Regulations for Existing and New Activities Within Setback Zones and Regulated Recharge Areas for the Illinois Ground Water Protection Act; testimony before Illinois Pollution Control Board, Chicago, Illinois, June, 1989.

Norris, C.H., and C.M. Bethke, (Abstract) "Mathematical Models of Subsurface Processes in Sedimentary Basins", Conference on Mathematical and Computational Issues in Geophysical Fluid and Solid Mechanics, Society

for Industrial and Applied Mathematics Annual Meeting, Houston, Texas, September 28 (invited paper), 1989.

Norris, C.H., "An Evaluation of the Geology and the Monitoring Well Data [at the] City of Urbana Regional Landfill", report submitted to the City of Urbana, Champaign County, Illinois, for Central States Education Center, Champaign, Illinois, 1989.

Norris, C.H., Gallatin National Proposed Balefill/Landfill [at] Fairview, Illinois; testimony before Fairview Town Council, Fairview, Illinois, November, 1988.

Norris, C.H., "Evaluation of the Hydrogeologic Factors Influencing Risk [at the] ISWDA Regional Landfill Site B", report submitted to the Inter-Governmental Solid Waste Disposal Association, Champaign County, Illinois, 1988.

Norris, C.H., and C.M. Bethke, "Status and Future Directions of Quantitative Flow Modeling in Sedimentary Basins", Workshop on Quantitative Dynamic Stratigraphy (QDS), Colorado School of Mines, Lost Valley Ranch, Colorado, February 14-18, 1988.