Noncoal Mining and Abandoned Land Reclamation

CRUSHED STONE QUARRIES AND LAND RECLAMATION

F. A. RENNINGER
National Stone Association
Washington, D.C.

Nonpoint source pollution from aggregate mining operations is a natural phenomenon. Stone, sand, gravel, and clay are found beneath every stream and river on earth. It is the disturbance of the natural landscape to extract these minerals that creates a problem. The silt from surface runoff within the quarries and pits is carried into the natural system, decreasing water clarity and oversilting the receiving waters.

Federal legislative proposals in both the Senate and the House of Representatives would give the U.S. Environmental Protection Agency authority to require each State to conduct a nonpoint source pollution management program. This legislation defines for EPA what the programs should do, including requiring that the States set goals and a time schedule for attaining those goals.

To date, there is little data on noncoal mining stormwater runoff on which to base such goals. The EPA has announced that, beginning Dec. 31, it will require mining operations to file explanatory information, detailing their runoff situations, possible pollutants that the water may assimilate, and the conveyances used for directing runoff. In essence, mining operations will be filing for National Pollutant Discharge Elimination System (NPDES) permits.

In the past, EPA has considered any conveyance of stormwater to be a point source. This has caused problems for some quarries, particularly those where runoff from adjacent, undisturbed lands encroaches on their operations. Operators have attempted to redirect the runoff, preventing any possible pollution from the quarry and avoiding operating problems related to the excess water. The problem is in the logic.

If the mining operator directs the stormwater from the adjacent, undisturbed land away from his operation, then the mining operation itself is not contributing to the pollution of the water. Yet, the EPA defines the miner's conveyance—a nonpolluting entity—to be the point source, and the operator becomes liable for the quality of the water handled.

A second problem faced by quarry operators is posed by the ground water and runoff from the operation itself. Operating a quarry on a dry site is the ideal situation. Mining operators divert the ground water and runoff water to quarry sumps and, depending on its quality, pump the water to discharge or further treatment.

No system is 100 percent effective. But the systems do work, and the amount of water pollutants from a noncoal mining operation can be economically controlled within reasonable limits.

Abandoned quarries may be a problem. Most abandoned quarries—or sand and gravel pits—were either abandoned during the heyday of the interstate construction program or are slated for reclamation in the near future.

There is a real shift in how these lands are being managed, a shift caused not only by legislative and regulatory actions, but also by more responsible attitudes on the part of the operators. Admittedly, most operators were coerced into their first reclamation programs; but after one or two experiences where they see the ultimate benefit—not only to the ecosystem, but also to their pocketbook—many operators are planning for a more profitable end use prior to opening or expanding a site.

The National Crushed Stone Association (NCSA), now the National Stone Association, has taken a leading role in the effort to change operator attitudes toward reclamation and rehabilitation.

The first program initiated by NCSA helped operators handle their environmental problems. Committees within the association developed handbooks, offering solutions to air, water, and noise problems.

As a complement to that effort, a community relations awareness program was expanded in 1975 into a comprehensive industry awareness program called About Face. The first priority was to encourage operators to improve the general appearance of their sites. This was done, and continues to be done, through a recognition program in which operators provide a panel of judges with illustrations of their sites. The entries are evaluated and awarded in three categories, depending on the level of beautification achieved and the success of their efforts to reduce air, water, and noise pollution problems.

Another program instituted under the About Face umbrella was a competition for students in landscape architecture programs, cosponsored by NCSA and the American Society of Landscape Architects. This program addresses reclamation attitudes. Students work with operators, evaluating the existing site and the various environmental and community factors that affect the operation. From there, the students develop plans for the operator to improve the site's appearance, reduce its environmental impact, and begin the process of preparing the land for an end use. The students also provide a proposed end use that considers community plans and needs.

This cooperative program is widely accepted as having a direct impact on changing attitudes toward reclamation. Not only are operators becoming more amenable to reclamation, but there is an increasing pool of professionals in landscape architecture who have experienced and now understand the unique problems related to quarry reclamation. The program has been expanded to include the National Sand and Gravel Association as a cosponsor, further broadening its reach into the aggregate industry.

NCSA has also sponsored a number of programs to educate operators about the techniques and considerations of land reclamation.

Current trends in demographics have opened new doors to aggregate mining reclamation. The natural tendency toward reclaiming sites for recreation areas is now only one of a multitude of alternatives that include industrial parks, residential areas, and school campuses.

Water handling remains a primary obstacle to development. But preplanning has done much to resolve those problems. A good example is a closed quarry in New England, now being developed as an office/residential complex. Like many old quarries, this operation was in a rural area near a city when it opened and now is enveloped by a suburban environment.

More than 10 years prior to closing the operation, the owners realized that, at their location, land could yield prime rates—if it had not been a quarry. They hired a team of engineers to evaluate their site and define for them the best way to create salable land at closing. Using the plan, they continued to quarry stone for 10 more years—shaping the land to fit a design—then sold the property. The property became valuable to the operator and to the developer. The land shaping allowed the developers to use a series of ponds and fountains to handle the excess water on the site, thereby turning a potential liability into an asset.

Another example of a second land use for quarries that converts water liabilities into assets is in Fairfax County, Virginia. There, a mined-out quarry has been designated for water storage. In addition to clarifying the water before it goes into the neighboring river, the site stores the sediment, which reservoirs cannot do, and becomes a source for additional water, alleviating the once frequent water shortages in this fast-growing area.

Worked-out quarries have been converted into industrial/commercial sites, lakeside residential communities, water reservoirs, botanical gardens, recreational areas, wildlife habitats, and even college football stadiums.

There is a new view of reclamation in the industry today. It is a view that reclamation can eliminate many negative effects aggregates industries may have on communities or environments. Reclamation and reuse of quarried lands is an exciting and challenging undertaking. Quarrying need not be viewed as an undesirable, environmentally detrimental use of land, but rather a transitional use of land that enables man to build today while at the same time creating an environmental asset for the future. It is, in fact, an exercise in multiple land use planning.

RURAL ISSUES: NONCOAL MINING AND ABANDONED LAND RECLAMATION

GARY UEBELHOER

AMAX Chemical Corporation
Lakeland, Florida

Whenever someone from the phosphate mining industry in Florida attends a national conference, he must first define the type of mining we perform in Florida and describe the differences between surface mining of phosphate rock and surface coal mining. While both minerals are recovered using surface mining techniques, the differences are significant. Therefore, I would like to describe our mining and mineral recovery processes in Florida so our perspective on nonpoint source issues can be appreciated.

In the heart of central Florida, about midway between Disneyworld and the Gulf Beaches, lies the largest concentrated deposit of phosphate rock in the world. It is called the Bone Valley Formation. This deposit is of marine origin, formed during the Miocene and Pleistocene ages some 15 million years ago. It lies within 30.48 m (100 feet) of the land surface and has supplied approximately 85 percent of America's, and approximately 33 percent of the world's, requirements for phosphate fertilizers since the deposit was located in 1881. Currently, 23 mines operating within the Bone Valley area produce 42 to 45 million tons of phosphate rock per year. Estimates by the industry as well as by the U.S. Bureau of Mines suggest that this deposit could continue to be mined for another 100 to 200 years, pending economic, political, and environmental conditions.

This massive orebody is located at the approximate midpoint between Disneyworld and the Gulf of Mexico beaches. Some people equate this to strip mining the Garden of Eden, and with 4 of the 10 fastest growing cities in America located within an hour's drive of the deposit, one can begin to understand public expectations of this industry. Although our history is deep and our future geologically far-reaching, the political pressures placed upon us on environmental issues are as stringent as those placed upon any other industry in America. After all, someone who spent 30 years working in the heart of Cleveland does not want to move to Florida to live next door to a strip mine, nor to live 48 km, (30 miles) downstream and see the nearby river clouded with mining effluent, whether it is discharged through a point source or comes in the form of runoff in a nonpoint source incident.

Florida's climate magnifies the need to control nonpoint sources of pollution because the average annual rainfall is 135 cm (53 in.) per year. In 1984, our mine experienced 180 cm (71 in.) of rainfall. If the precipitation was spread statistically throughout the calendar year, management of surface water issues would be much easier; however, average monthly precipitation can range from 5 cm (2 in.) in what we term the dry season in April and May to 33 cm (13 in.) during our summer rainy season in August and September.

The environmental characteristics of the land prior to mining include citrus groves, pine/palmetto scrub land, pastures, small isolated wet/dry marshes, hardwood bottomland, and wetland forested areas. To produce the 40-plus million tons of phosphate rock necessary to satisfy agriculture's demand for phosphate fertilizers, our industry mines approximately 2,600 ha (6,500 acres) of this land per year.

Phosphate rock ore is recovered using a dragline surface mining technique similar in appearance to what you see in surface coal mining operations. Medium size draglines carrying 15 to 57 m^3 (20 to 75 yd^3) buckets first strip the overburden or barren sand/soil off the phosphate matrix, then excavate the phosphate matrix and place it into slurry pit wells. From there the phosphate is slurried into a 65-percent water and 35-percent solids slurry for hydraulic pipeline transport to a central beneficiation plant or mill. During mining, the total depth of the excavation can range from 6 to 30 m (20 to 100 ft). The average is 9 to 10.5 m (30 to 35 feet) total depth from land surface to the bottom of the mined area. Because the water table is encountered anywhere from land surface to 3 m (10 feet) below land surface, water management in phosphate mines is a primary function. Large pumps dewater the mining areas and transport this pit water to large recirculation holding ponds wherein the water will be recycled for process water use. Recirculation of process water provides 95 percent of the total water requirements to produce a ton of phosphate rock.

Recovery of the phosphate rock from the ore, or matrix as we call it, is conducted in a central beneficiation plant where two types of product and two types of waste are produced. The volume of these two waste products typically exceeds the void created by removal of the ore and adds a waste disposal step between mining and reclamation. These waste products consist of silica sand separated from the phosphatic sands in a flotation process. The silica sand is traditionally 99.9 percent silica, dewaters very rapidly, is very permeable when compared to the other waste product, approximates the overburden permeability, and does not possess favorable agronomic potential. The other waste product is a mixture of clays usually consisting of montmorillonite, attapulgite, and some kaolinite. The clays dewater very slowly, are very impermeable, but possess very favorable agronomic characteristics when compared to the virgin or unmined overburden or the sand waste product. The ratio of products to waste is about equal. That is, an average phosphate mine produces 3 million tons of recoverable product per year; the mine will have to dispose of about 3 million tons of clay on a dry weight basis and 3 million tons of sand to recover that quantity of phosphate rock.

Waste disposal practices within the industry vary, however; disposal of the sand and clay waste is integrated into the reclamation process and is planned in advance of the mining. Disposal of the sand tailings falls into five general categories. First, the sand can be used as a construction material for building dams for the clay waste disposal and water recirculation. It also can be used to cap the consolidated clay waste settling areas, or it can be admixed with the clay to produce a sand/clay mix fill material. However, the most typical use for the sand is to pump this material from the beneficiation plant to mined areas where the sand is used to backfill between the spoil piles to desired post-reclamation elevations.

The waste clay produced at phosphate mines has been used for various things from kitty litter to soil amendments to increase the nutrient and moisture holding characteristics. Some mines also admix clay to the sand tailings to improve its dewatering characteristics and the pumping characteristics of the sand tailings. However, the typical sand/clay disposal process consists of pumping a 3-percent solids clay slurry to large clay settling areas, allowing the clays to settle through gravity from 3-percent solids to approximately 30-percent solids, and then revegetating the surface after dewatering is complete.

Land reclamation became mandatory in Florida in 1975. Voluntary reclamation began long before that and, today, two types of regulatory programs in Florida relate to phosphate-mined land reclamation. Lands mined prior to 1975 and not reclaimed either naturally or by man are covered under the nonmandatory program, which is similar to the abandoned lands program in coal mining States. Approximately 6,400 ha (160,000 acres) fall into this broad eligibility category. Reclamation of these "old lands" is financed by the severance tax now paid by phosphate producers on each ton produced. All other lands, those mined since 1975, fall into the mandatory reclamation liability program also administered by the Florida Department of Natural Resources. The mandatory program requires timing, postmining land use, revegetation, and other health and safety measures similar to those imposed by coal mining states.

The waste disposal process results in a postmining elevation and lithological profile and reduces the reclamation process to grading and revegetation. Reclamation programs consisting of land and lakes involve regrading spoil piles without adding waste products. The resulting lakes with undulating shorelines and a variety of depths are surrounded by shorelines and uplands used for pasture, silviculture, citrus and intensive agricultural uses, and residential and commercial uses.

Overburden fill reclamation consists of regrading overburden without adding sand or clay wastes, resulting in a land form similar to that which existed prior to mining, albeit at a different elevation. Because of the amount of overburden combined with the depth to the water table, no lakes are developed in these areas. We have already discussed the sand backfilling technique whereby sand is pumped into the rows between the spoil piles. This reclamation process results in final land uses that require well-drained soils. The sand/clay admixture backfilled areas are a newer development yet to be proven in the form of the final land use. Agricultural crops requiring well-drained soils will likely not be used in these areas. The nutrient and moisture-holding capacity increased by the admixing of clay sand will result in high yield forage and pasture uses. Lastly, reclamation of clay settling areas is a process which consists of drying and developing a clay crust on the reclaimed surface followed by agriculture and in some case natural systems. Forage yields from these clay soils are so far superior to virgin land that the use of clay settling areas for these purposes is considered highly desirable by the agricultural industry.

Reclamation timing in phosphate mining varies depending upon whether the acre just mined is scheduled to receive waste products or not. If wastes are not to be added to a mined area and reclamation is limited to grading overburden and revegetation, reclamation is typically completed, including a growing season to certify successful revegetation, within 2 years of the date of excavation. If sand tailings are admixed, the 2-year figure increases to approximately 3 years. Clay disposal sites are typically used for 10 to 15 years for filling; once filling is completed, dewatering, drying, crusting, and revegetation can be completed within 5 years.

With respect to overall progress, reclamation lags behind mining during the first half of a given mine's life as sites are set aside for waste disposal purposes. Once waste disposal sites have been set aside, the rate of mining equals the rate of reclamation. Thus, when a given mine is fully depleted, usually 75 percent of the mined area has been reclaimed and released from reclamation liability. Reclamation of the remaining 25 percent usually is completed within 5 years after the mine-out date.

Because the reclamation of old lands or nonmandatory lands is limited by severance tax revenues versus the intent of landowners to reclaim the land, the cash flow from the trust fund dictates the rate of reclamation. At the current severance tax production rate and trust fund interest generation rate, it appears as if all eligible old lands where the owner of the property wishes to participate will be reclaimed no later than 1995. This equals a reclamation rate of approximately 2,000 ha/yr (5,000 acres/yr).

Postreclamation land uses have been mentioned; however, it might be useful to go through the reclamation revegetation land-use options. The first option is surprising. Environmental groups and regulators are all beginning to recognize the need to leave certain lands unreclaimed because of the success of natural reclamation processes in some places. As a matter of fact, some of the old lands have been deemed ineligible for the nonmandatory reclamation refund program because their environmental characteristics are so high from wildlife habitat and recreational perspectives that the Agency refuses to pay to convert them to houses or citrus groves.

Citrus is a very profitable crop and is, of course, Florida's best known ag crop. Citrus groves are being planted and cultivated on the overburden fill type reclamation and on the sand backfill areas. These two waste disposal options are the only logical sources for citrus groves because the groves must be very, very well drained, thereby precluding the use of any sand/clay or clay fill areas. Extremely rich soil is not necessary for citrus planting. Planting citrus trees between alternating rows of land and lakes in the land-and-lakes process is gaining popularity because the heat released by the lakes during cold winter nights prevents freezes. Groves on reclaimed lands lying southeast of lakes created by the mining process have never frozen.

Pasture land was the first and most logical choice for much of the reclaimed land because that was the premining land use. Florida is the largest cattle State east of the Mississippi and ranks third behind Texas and Colorado in beef production.

Row crops also present a postmining land use option in that they produce high land returns and can capitalize on Florida's climate. The row crops we speak of are lettuce, carrots, radishes, cucumbers, strawberries,and other garden vegetables. Admixing some waste clay with regraded overburden or sand tailings produces a superior soil for these types of vegetables because of the water and nutrient holding capacity of the clay as compared with the native soil.

Residential and commercial development has occurred near surrounding communities typically on sand fill and land-and-lake areas. A number of lakefront properties have been created by the mining industry and, as most of you know, lakefront property draws a premium over a standard building lot.

Finally, during the past 10 years, the mining industry has made significant progress and great strides in reclaiming natural systems, both uplands and wetlands. The industry has agreed to acre-for-acre reclamation of wetlands in regulatory proceedings both in terms of total acreage as well as "type for type," meaning marsh or herbaceous wetlands versus hardwood swamp forest. Two companies have received the U.S. Fish and Wildlife Service award for outstanding citizenship because of wetland reclamation projects. These projects have moved from the experimental research stage because reclamation of wetlands is no longer disputed. By allowing wetland reclamation to progress, more acres of phosphate should be recovered in the future than in the past. Historically, mining companies have had to mine around wetlands of any significance, thereby leaving that ore in the ground forever as it is not cost efficient to mine a parcel of less than 200 ha (500 acres). Further, the industry takes great pride in a survey environmental groups conducted in Florida over the past decade in which phosphate mine reclamation of wetlands was considered perhaps the greatest environmental improvement of the decade. In fact, reclamation of mined lands allows one of the few opportunities to recreate natural systems, whether they are uplands or wetlands, of any development option for raw undeveloped lands. In only a very few places in Florida are developers creating wetlands, let alone at the rate the Florida phosphate industry is.

Obviously, without some steps to mitigate the potential for water quality degradation, phosphate mining in Florida could become a significant nonpoint source of pollution. This would principally be in the form of suspended solids or turbidity, since the mineral we mine does not dissolve in water. Data collected from our process water streams indicate that, with the exception of turbidity, a phosphate mine's process water stream meets Federal drinking water standards and can comply with applicable stream water quality standards. Therefore, the question that needs to be addressed with respect to nonpoint sources of pollution is to describe the steps necessary to control nonpoint sources and to minimize the potential for such releases.

During the mining process, all runoff within disturbed areas is controlled through a series of perimeter ditches constructed with small construction draglines and designed to drain into the central clay settling/water recirculation system. As a result, runoff is captured and allowed to settle and clarify in the water recirculation system for reuse as process water or for ultimate discharge through a permitted NPDES discharge point. A perimeter ditch will be constructed by placing the spoil outside the collection system to act as a small .9- to 1.2-m (3- to 4-foot) dike encircling and containing all runoff, either process water spills or rainfall. However, when placing spoil outside the perimeter ditch, the spoil pile berm needs to be grassed so that erosion from the berm does not defeat the purpose of its construction.

A second important step is to reclaim land as quickly as possible and practical. This reduces the amount of process water and rainfall runoff diverted to the clay waste settling/water recirculation system and makes it more manageable. Reclamation timing is, however, important because of Florida's unique wet/dry climate cycle. Reclamation grading should take place during the fall and spring dry seasons to minimize erosion during the active earth-moving phase when barren land surfaces are present. Furthermore, the ideal time to finish grading on a reclamation project is around Thanksgiving; such timing allows revegetation to begin at the point when gentle winter weather increases the survivability of the planted species and decreases the need to irrigate and to use temporary erosion control measures.

Florida's reclamation rules require tree planting at a rate of 200 trees per acre with understory grassing to achieve a minimum of 80 percent cover at the end of one year. This further minimizes the nonpoint sources of reclaimed lands. In fact, with little difficulty, very lush vegetative covers return to reclaimed land within a matter of weeks of the seeding of those lands.

In fact, probably the largest, most effective means for long-term control of nonpoint sources of pollution is in the reclamation design of wetlands, lakes, and stream and creek channels. By properly designing the lakes, greenbelts, wetlands, and stream systems, phosphate mining creates additional off-stream storage capability, thereby increasing base flow during the dry season and reducing runoff during the wet season. As a result, the hydrologic cycle variation on an annual basis declines. Concurrent with that is a reduction in the sediment loading caused by runoff. Further, because the permeability of most reclaimed land is as high or higher than virgin land, ground water recharge rates increase, and runoff rates decrease.

Are all of these measures working? Yes they are. And to that end, the phosphate industry is spending more than $2 million per year researching and developing techniques to further improve their ability to reclaim land to more desirable uses, and to find better ways to minimize problems in the interim. In addition, the severance tax paid by the phosphate industry is used for two very important purposes related to nonpoint source pollution. First, the phosphate severance tax funds the Conservation and Recreation Lands Trust Fund, which is used to purchase environmentally sensitive lands and keep them from being developed by other sources.

Secondly, the phosphate severance tax pays for the operation of the Florida Institute of Phosphate Research designed to find solutions to public and environmental problems associated with phosphate mining and processing. The Institute is researching reclamation and mining, and to this end has committed over $4.6 million since it was formed in 1978. As a result of these efforts, combined with the private efforts of the industry's member companies, I am confident that our point source pollution problems have already peaked and probably will only decrease in the future.

NONCOAL MINERAL MINING AND RECLAMATION (CURRENT AND ABANDONED OPERATIONS) IN THE TENNESSEE RIVER BASIN

JACK A. MUNCY
Reclamation Specialist
Tennessee Valley Authority
Norris, Tennessee

Surface mining is one of the most complex, critical, and emotionally charged environmental issues of our day. Throughout the United States, surface mining is used to recover about 50 different materials essential to our industrial society. In the seven-State region of the Tennessee Valley, over 25 noncoal minerals, including mica, feldspar, kaolin, manganese, copper, phosphate, sand, and brown iron ore are obtained by surface mining.

Most Tennessee Valley States now have laws regulating surface mining for certain noncoal minerals. Georgia and Tennessee passed a noncoal minerals surface mining law in 1968, followed by Alabama and Virginia in 1969, North Carolina in 1971, and Kentucky in 1975. These laws primarily require that the environmental impacts from mining be minimized and that mined sites be stabilized through vegetative measures.

These environmental protection standards have been received by the mining industry with varying degrees of success. Tennessee's 1968 reclamation law was considered ineffective until around 1972, 4 years after it was enacted. In addition, the portion of the Tennessee law addressing sand mining was repealed in 1981, and it was also noted that limestone, dimension stone, marble, and chert were not regulated by the act.

It is interesting to compare the similarity of the history of State legislation of coal mining before passage of the Federal Surface Mining Control and Reclamation Act of 1977 to the current State legislation regarding noncoal mining. The Federal Act established the first national standards for surface coal mining and reclamation, including provisions for reclaiming abandoned coal mine lands on a priority system.

While abandoned noncoal mineral mine lands overall may not have the same magnitude of problems as coal mines, a pressing need still exists for their reclamation since they affect local environments just as severely. In the Tennessee Valley approximately 9,315 ha (23,000 acres) of these lands were created before State laws fixed responsibility for reclamation (Fig. 1). Furthermore, hundreds of hectares of abandoned sand mines are still being created annually in Tennessee.

These abandoned mine lands are society's legacy, and we all share in the responsibility for the problems they cause as well as the efforts necessary to return them to a productive part of the region's natural resource web.

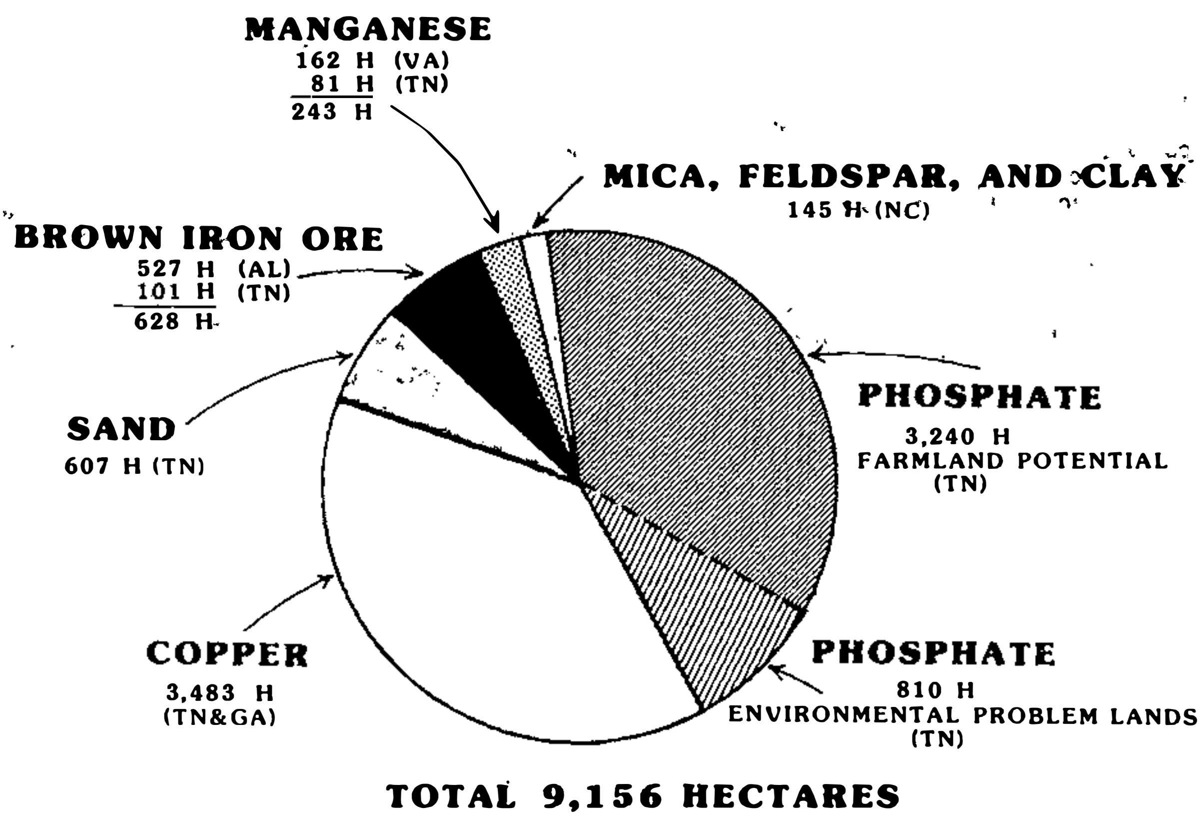

Figure 1.—Estimated hectares of abandoned noncoal mineral surface mine lands in the Tennessee Valley in need of reclamation.

Many environmental problems are caused by unregulated mining of minerals. A major problem is soil erosion and subsequent sedimentation. This can alter the chemical balance of the water, bury aquatic organisms, change feeding and spawning habitats, and suffocate fish by coating their gills. Sediment clogs streams, rivers, and reservoirs, reducing the flow-carrying capacity of streams and the flood detention capacity of reservoirs, which increases flood damage potential. In addition, sediment damages hydroelectric units, reduces recreational value of streams and reservoirs, and adversely affects water-supply systems by increasing treatment costs, causing excessive wear on equipment through abrasion, and clogging or covering intake pipes.

While certain noncoal mineral mining (reclamation) is covered under State laws, few provisions have been made to pay for corrective reclamation of earlier mining activities. Only Tennessee and Virginia have budgets for minimal, on-the-ground reclamation efforts. In recent years, the cooperative efforts of many participants have helped the Tennessee Valley Authority reclaim selective critical lands. A listing of these efforts follows:

Mica, feldspar, and kaolin. TVA, in cooperation with local, State, and Federal agencies, landowners, and the mining industry, has treated most (239 ha/590 acres) of the environmental problem mines in western North Carolina. North Carolina passed legislation in 1984 to provide financial support to complete the project.

Manganese. In 1983, the State of Tennessee, in cooperation with Johnson County Soil and Water Conservation District and the Soil Conservation Service, established a mine reclamation demonstration. Also in recent years, Virginia has reclaimed a few sites.

As part of TVA's rehabilitation efforts of the South Fork of the Holston River basin, the agency joined hands with the U.S. Forest Service to reclaim up to 41 ha (100 acres) of critically eroding abandoned mine lands on the Mount Rogers National Recreation Area. This work is now underway.

TVA is formalizing a plan to reclaim the remaining unvegetated private lands in upcoming years in a cooperative TVA/State/landowner project. The total hectares of abandoned lands in the Holston River watershed is estimated at 243 (600 acres). Virginia hopes to treat selective sites in 1986.

Copper Basin. TVA has been involved with the environmental problems of Copper Basin in the past; however, the mining companies have been the most consistent reclamationists. In 1984, TVA initiated new demonstrations in cooperation with SCS and the Tennessee Chemical Company. About 284 ha (700 acres) will be treated in 1985 by pooling resources. Of the original 12,960 ha (32,000 acres) denuded, 3,483 ha (8,600 acres) still need reclamation.

In recent years, the Tennessee and Georgia SCS have implemented resource conservation and development plans showing intensive and minimum degrees of reclamation. The local soil and water conservation districts sponsored the projects.

Phosphate. In 1979, the State of Tennessee initiated a cooperative program with SCS, local soil and water conservation districts, and landowners to reclaim abandoned phosphate mines. The program goal is to restore these unproductive lands to their premining land use—agriculture. Through 1984, 170 ha (420 acres) have been reclaimed, but no funding is available to continue this effort. Of the 4,050 ha (10,000 acres) judged to be in need of reclamation, about 810 ha (2,000 acres) are causing offsite problems.

As part of the comprehensive cooperative natural resource development plan for the upper Duck River basin in Tennessee, TVA reclaimed 59 ha (146 acres) of abandoned phosphate mines causing offsite environmental damage. TVA, SCS, and several other Federal and State agencies developed the plan to address several nonpoint sources of pollution.

Sand. In 1982, Tennessee and SCS established a small-scale reclamation demonstration in Benton County. There are about 607 ha (1,500 acres) of abandoned sand mines in Tennessee counties alone.

Brown iron ore. Abandoned brown iron ore mines exist in northwest Alabama (527 ha/1,300 acres) and southwest Tennessee (101 ha/250 acres). As yet no plans have been made by the States or others to systematically reclaim these lands.

SUMMARY

Although progress is being made to reclaim these erosive abandoned mine lands through cooperative efforts, the circumstances that allow these lands to develop have not totally disappeared. Legislation regulating mining is a step in the right direction, but these regulations must be enforced to minimize the environmental problems of surface mining for resources other than coal. Also, mineral mines not presently covered by State laws should be periodically re-evaluated to ensure that their related mining activities do not cause future environmental problems. More funding sources are needed for action programs to deal with the abandoned mine lands that cause offsite environmental degradation.

PHOSPHATE AND PEAT MINING IN FLORIDA

CAROL J. FALL
St. Johns River Water Management District
Palatka, Florida

INTRODUCTION

Florida is often envisioned as a land of beaches, tourists, and orange groves. However, agriculture and mining are important components of the State's economy. Florida is first in the nation in production of nonmetallic minerals and sixth in production of all minerals (State Fla. 1982). Nearly 75 percent of the phosphate produced in the United States is mined in Florida. Nationally, Florida ranks second in peat production (Bond, 1984).

PHOSPHATE MINING

Florida's phosphate deposits are of sedimentary origin. Shallow deposits, such as central Florida's Bone Valley formation, are strip mined. Deeper deposits in eastern Florida have the greatest long-term potential but require specialized mining techniques, such as the borehold slurry process (Fla. Dep. Environ. 1984).

The strip-mining process generally consists of (1) site draining and dewatering, (2) logging of available timber, (3) land clearing by bulldozer, (4) removal of overburden, (5) mining of phosphate ore, (6) pumping of phosphate slurry through pipeline, and (7) washing and flotation in the beneficiation plant. This last step produces sand tailings and a clay slurry, also called phosphate slimes. These colloidal clays settle very slowly and are typically stored in aboveground, diked impoundments. Approximately 170,000 acres have been strip mined in Florida, producing 55,000 acres of slime ponds (State Fla. 1982).

Strip mining can substantially alter hydrologic conditions, disrupting wetlands and intersecting small streams. Ground water conditions are modified as dewatering lowers the shallow aquifer and mining pits intersect aquifers, sinkholes, or other karst features. Hydrologic alterations are particularly significant since about 15 percent of Florida's phosphate reserves are located in wetlands.

Strip mining affects surface water quality through discharge of wastewater and land disturbances. Land clearing and dewatering increase erosion and sedimentation of receiving waterbodies. Discharge of process water elevates levels of sulfate, fluoride, total phosphorus, nitrogen, and dissolved and suspended solids in streams (Miller et al. 1978). Processing plants contribute 65 percent of the phosphorus load to the Alafia River (Wright, 1980). Spills and dam breaks pose an infrequent threat to surface water quality (U.S. Environ. Prot. Agency, 1978). An additional concern is radiation potentially produced as uranium and its decay products brought to the land surface by the mining operation (Fla. Def. Environ. 1984).

Ground water quality is affected by seepage into underlying aquifers from slime ponds and ditches (Miller and Sutcliffe, 1984). Removal of the overburden during strip mining allows direct contamination of local or regional aquifers in some areas of Florida (Wright, 1980). The initiation of experimental borehole mining in north Florida has raised additional ground water quality concerns. In this technique, a series of large boreholes are drilled through the ore deposit and high pressure water jets cut and slurry the ore. The phosphate slurry is pumped to surface holding ponds for processing. When extraction is complete, the 10 m diameter cavity and borehole are sealed, using a variety of techniques. Ground water contamination may occur if the borehole penetrates the confining layer of the artesian aquifer or by vertical seepage along the casing of an improperly sealed borehole. In initial test results, water level and water quality changes were observed following collapse of the cavity roofs (Hampson, 1984).

Reclamation of strip-mined lands has progressed and is mandatory for lands mined after July 1, 1975. Florida statute requires reclamation of wetlands on an acre for acre basis. However, data on wetland reclamation are inconclusive (Dames and Moore, 1983), generating much opposition to proposed phosphate mining leases in the Osceola National Forest. The U.S. Department of the Interior (1983) concluded that sufficient technological capabilities do not exist to reclaim wetland hardwoods. Criteria suggested to evaluate the effectiveness of wetland reclamation include vegetation diversity, water quality and quantity, plant survival, and wildlife use (Dames and Moore, 1983). Many reclamation schemes use artificially regulated or augmented water levels, which may be unsatisfactory for long-term maintenance.

PEAT MINING

Peat deposits accumulate in a waterlogged environment. Therefore, peat mining almost always takes place in wetlands. Major deposits of peat in southern Florida are located in the Everglades and headwaters of the St. Johns River. In north and central Florida, there are thousands of small, scattered deposits.

Peat mining requires dewatering the site through drainage ditches or pumping. Overlying vegetation is logged or cleared, and the overburden removed. The peat is excavated and stockpiled for drying. As in phosphate mining, the major impacts are altered hydrology and loss of habitat. Mining alters flood water runoff response, ground water elevations, surface flow patterns, and minimum stream discharges (Bond, 1984).

Dewatering of peat mines produces discharges which have low pH and elevated biochemical oxygen demand (BOD), nutrient, organic, and solids concentrations. Peat soils accumulate heavy metals, which may be released during mining operations. A concomitant effect is the reduction in water quality improvements provided by the wetland, such as sedimentation and denitrification.

Reclamation of peat mines is more haphazard than phosphate mines. When dewatering ceases, the mined pit fills with water. Within the St. Johns River Water Management District, a reclamation plan is required based on the following guidelines: 20 percent of the site will be recreated as a littoral zone, a peat layer of .3 m or greater will remain at the bottom of the excavation, and the site will be mulched with a stockpiled or borrowed overburden with a viable seed bank.

CONCLUSION

The major impacts of phosphate and peat mining are altered surface and ground water hydrology and loss of habitat, particularly valuable and irreplaceable wetlands. Nonpoint source pollution problems result primarily from land disturbance during mining operations. Surface and ground water quality are affected by phosphate-processing plants. Some environmental impacts can be mitigated by applying best management practices and reclamation techniques.

REFERENCES

Bond, P. 1984. An Overview of Peat in Florida and Related Issues. Bur. Geol. Fla. Dep. Nat. Resour., Tallahassee.

Dames and Moore. 1983. A survey of wetland reclamation projects in the Florida phosphate industry. Sponsored by Florida Inst. Phosphate Res., Bartow.

Florida Defenders of the Environment. 1984. Phosphate Mining in Florida: A Source Book. Environ. Serv. Center, Tallahassee.

Hampson, P.S. 1984. Effects of hydraulic borehole mining on ground water at a test site in northeast St. Johns County, Florida. WRI Rep. 83-4149. U.S. Geo. Surv., Tallahassee.

Miller, J.A. 1978. Impact of potential phosphate mining on the hydrology of Osceola National Forest, Florida. WRI Rep. 78-6. U.S. Geo. Surv., Tallahassee.

Miller, R.L., and H. Sutcliffe, Jr. 1984. Effects of three phosphate industrial sites on ground water quality in central Florida, 1979 to 1980. WRI Rep. 83-4256. U.S. Geolog. Surv., Tallahassee.

State of Florida. 1982. Testimony by the State of Florida before the Subcommittee on Public Lands and reserved water of the Senate Committee on Energy and Natural Resources on legislation to prohibit issuance of phosphate mining leases in the Osceola National Forest. Office of the Governor, Tallahassee.

U.S. Department of the Interior. 1983. Environmental assessment on state of reclamation techniques on phosphate mined lands in Florida and their application to phosphate mining in the Osceola National Forest. Bur. Land Manage., Eastern States Off.

U.S. Environmental Protection Agency. 1978. Final Areawide Environmental Impact Statement for Central Florida Phosphate Industry. Vol. I. Atlanta, GA.

Wright, C.R. 1980. Water quality and mining. State Water Quality Management Plan. Dep. Environ. Reg., Tallahassee, FL.

WATER QUALITY PROBLEMS CAUSED BY ABANDONED METAL MINES AND TAILINGS

JOHN FORD

Missouri Department of Natural Resources
Jefferson City, Missouri

BACKGROUND

Missouri is a major producer of lead. One active and one inactive mining area are located completely within the State, and the State shares a second inactive mining area with Oklahoma and Kansas. Hundreds of small vertical shaft mines and hundreds of small to moderate-sized tailings piles characterize the last of these areas, the Tri-State lead–zinc area. The other inactive area, the Old Lead Belt, has fewer mines and much larger tailings piles. Both areas adversely affect streams, contributing both heavy sediment loads from eroding tailings piles and dissolved metals (primarily zinc) from both surface runoff and seepage from flooded mines. Occasional tailings dam failures result in deposition of huge amounts of sand and silt-sized tailings that smother all existing aquatic life and seriously degrade aquatic habitat for years. A total of 58 miles of classified stream is affected.

MINERALIZATION OF GROUND WATER AND SURFACE WATER

Barks (1977) documented the Tri-State area water quality problems in 1976. The ground water in flooded mines is highly mineralized and has high levels of some dissolved metals, particularly zinc and iron. Mineralization in the mines has affected shallow wells in the area to some degree but has not affected wells in the deep aquifer (Table 1). Considerable artesian flow and subsurface seepage from flooded mines enters receiving streams even during dry weather. The inflow of these ground waters is the primary source of zinc.

Most of the ground water flow recharges Center Creek, which maintains a dissolved zinc concentration of about 500 µg/L, a figure five times the State of Missouri standard for protection of aquatic life. Barks likewise found increased mineralization and dissolved metals concentrations in the surface runoff from the tailings (Table 2). This runoff not only could elevate instream levels of certain metals during a local rainfall but also could physically move metal-rich tailings into stream sediments.

The combined effect of resurfacing ground water flows and surface runoff has seriously undermined the ability of portions of Center Creek to support aquatic life. Surveys of aquatic macroinvertebrate benthos and of fish by the author and others in the Missouri Department of Natural Resources have found that much less density and diversity of aquatic life occurs in Center Creek than in other streams of similar size and substrate.

Table 1.—Ground water quality in the Tri-State lead–zinc area (Barks, 1977).

Constituents[1]	Mines	Shallow wells	Deep wells
Dissolved solids (mg/l)	1,030	327	207
Bicarbonate (mg/l)	140	214	195
Sulfate (mg/l)	580	72	28
Zinc (µg/l)	9,400	1,100	70
Iron (µg/l)	5,100	350	30
Nickel (µg/l)	46	7	0
Cadmium (µg/l)	25	4	0
Lead (µg/l)	10	10	6

[1]dissolved fraction only

Table 2.—Quality of runoff from tailings in the Tri-State lead–zinc area compared to quality of Center Creek above tailings area (Barks, 1977).

Constituents[1]	Runoff from tailings	Center Creek
Dissolved solids (mg/l)	414	134
Bicarbonate (mg/l)	62	136
Sulfate (mg/l)	230	8
Zinc (µg/l)	16,000	20
Aluminum (µg/l)	600	30
Lead (µg/l)	380	4
Copper (µg/l)	46	0
Cadmium (µg/l)	26	1
Nickel (µg/l)	16	2

[1]dissolved fraction only.

The Old Lead Belt and Fredericktown areas are located in east central Missouri. Fewer mines and fewer and larger tailings piles characterize these areas. Mineralization of water in flooded mines also occurs in this area but has not been serious enough to impair the water's use. Some communities withdraw water directly from the mines rather than incur the expense of drilling a well. Sulfate values average about 225 mg/L in the mine water and frequently exceed the secondary (aesthetic) drinking water standard of 250 mg/l. Sulfate concentrations in ground waters of the area average 10 to 15 mg/l.

Two independent studies conclude that dissolved metals have caused water quality problems in both the Old Lead Belt and Fredericktown areas. A chat pile (coarse sand-sized particles) in the Old Lead Belt contributed enough dissolved zinc to cause water quality standards violations in over 2 miles of Flat River Creek (Wixson, 1976). At Fredericktown, artesian flow from a flooded mine caused violations of water quality standards for nickel and cobalt in 2 miles of Saline Creek (Hufham, 1981).

EROSION OF TAILINGS

The erosion of tailings into area streams causes greater concern. These tailings contribute sand-and-silt-sized particles to streams at a much greater rate than surrounding lands. This constant rate of erosion occasionally is increased dramatically by the catastrophic failure of a tailings dam. Three such failures have occurred on dams in the Old Lead Belt and in Fredericktown. On such occasions sediment completely fills stream channels and either buries or displaces all aquatic life. At Fredericktown, sediment severely affected the aquatic benthos (Duchrow, 1983), and the benthic community remained abnormal for that locality throughout the 1-year study. Czarnezski (1981) noted similar effects on 5 miles of Big River with another 25 miles less severely affected.

Studies of the distribution of mussels on Big River and Flat River Creek (Buchanan, 1980) clearly show the degra-

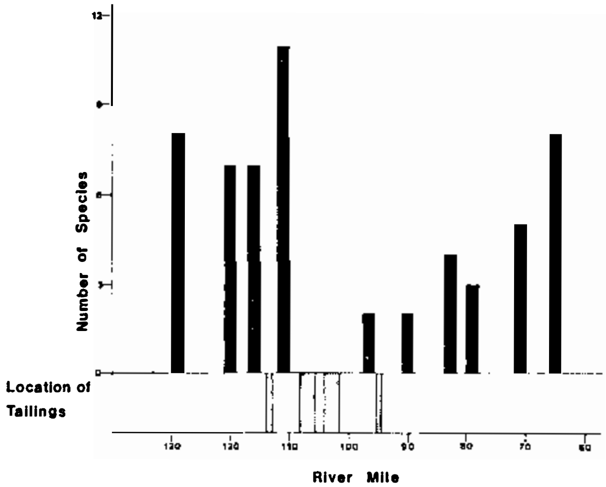

Figure 1.—Number of mussel species found in Big River, St. Francois County, MO.

dation in aquatic habitat (Fig. 1). While occasional dissolved zinc problems on Flat River Creek may also contribute to the lack of mussels there, no problems with any dissolved heavy metals exist on Big River. Researchers believe that deposition of tailings is the sole reason for the mussels' disappearance.

STRATEGIES FOR IMPROVEMENT

No concerted effort to address the problems presented by lead–zinc mines and their tailings has been made. However, the author has noted improvements in water quality in the Tri-State area. Time trend analysis of dissolved zinc levels in Center Creek show a statistically significant + ($P < .05$) decline in concentrations from 1972 to present. Two possible reasons suggest themselves. Barks (1981) has estimated that 80 percent of the tailings in the Tri-State area have been removed. The mineralization in this part of the State took place within a zone of very cherty material, and the tailings have been used both for road building material and for sand blasting. A second possibility is that the oxidation rates of the pyritic materials in the flooded mines are declining over time (Warner, 1977; Stewart, 1980).

By contrast, in the Old Lead Belt neither improvement nor the expectation of significant improvement exists. The lead–zinc ores in this part of the State were extracted from dolomites. Some tailings have been removed for agricultural lime, but the amounts are trivial compared to the tailings that remain. Recent work (Wixson et al. 1983) showed that using Old Lead Belt tailings as agricultural lime would result in greater levels of heavy metals in vegetation relative to other agricultural limes, but such levels would not exceed recommended dietary intake.

State and local officials have made two attempts to turn these large tailings piles from environmental liabilities into environmental assets. One county uses part of a large tailings area as a sanitary landfill. This has the advantage of not having to use other land as a landfill, but has the disadvantage of being almost impossible to vegetate. Thus, wind erosion is constantly uncovering and blowing litter and garbage from the site. In addition, the lure of hundreds of discarded tires at the landfill poised so near the top of a long, steep embankment has encouraged people to roll large numbers of tires down into Big River where it borders the tailings dam.

A second tailings area has been converted into a State park that promotes the use of outdoor recreational vehicles within the park. With a great deal of effort, this tailings area was the most successfully vegetated area in the Old Lead Belt prior to its conversion to a State park. Now, the recreational vehicle use appears to be causing some loss of vegetation.

CONCLUSION

Although removal or proper on-site use of tailings may yet be realized as viable alternatives, stabilization of tailings in place seems the best strategy at present for reducing nonpoint source problems from tailings in the Old Lead Belt and Fredericktown areas. Planting vegetation on the large flat areas of tailings can control wind erosion. Water erosion control requires good maintenance of the existing internal drains and protection of the dams which are made of sand-sized material. Sediment traps between the tailings and the area streams need to be constructed and periodically cleaned.

The water quality problems from abandoned lead–zinc mine areas in Missouri are well documented and well known to Federal, State and local government agencies and private organizations. No existing source of funding, however, provides for the implementation of realistic solutions.

REFERENCES

Barks, J.H. 1977. Effects of abandoned lead and zinc mines and tailings piles on water quality in the Joplin Area, Missouri. U.S. Geolog. Surv. Water Resour. Invest. 77-75.

Barks, J.H. 1981. Personal communication. U.S. Geolog. Surv., Rolla, Mo.

Buchanan, A.C. 1980. Mussels (*Naiades*) of the Meramec River Basin. Aquatic Ser. No. 17. MO Dep. Conserv. Columbia.

Czarnezski, J. 1981. Personal communication. MO. Dep. Conserv. Columbia.

Duchrow, R.M. 1983. Effects of lead tailings on benthos and water quality of three Ozark streams. Trans. Mo. Acad. Sci. 17: 5–17.

Hufham, J. 1981. A Baseline Study of the Heavy Metal Content of Open Waters of Fredericktown, Missouri. Univ. Missouri, Rolla.

Stewart, D.R. 1980. Water resources contamination from abandoned zinc–lead mining–milling operations and abatement activities. Ozark Gateway Counc. Gov., Joplin, MO.

Warner, D.C. 1977. Alternatives for control of drainage from inactive mines and mine waste sites. Joplin Area, Missouri. Ozark Gateway Counc. Gov., Joplin, MO.

Wixson, B.G. 1976. Missouri Lead Study. Univ. Missouri, Rolla.

Wixson, B.G., N.L. Gale, and B.E. Davies. 1983. A Study of the Possible Use of Chat and Tailings from the Old Lead Belt of Missouri for Agricultural Limestone. Univ. Missouri, Rolla.