2010 – 2011 Annual Report

USF Polytechnic Florida Industrial and Phosphate Research Institute

January 2012

Index **Page**

Phosphate Research and Activities Board Members

Michael Daigle, The Mosaic Company

David Touchton, University of South Florida Polytechnic

***Herschel Morris**, CF Industries, Inc.

***Ann Paul**, Audubon of Florida

Michelle Sims, Florida Department of Environmental Protection,
Bureau of Mining and Minerals Regulation

* Reappointment currently under consideration.

Florida Industrial and Phosphate Research Institute

Directorial Staff

Brian K. Birky, Ph.D., Interim Executive Director, and
Research Director, Public and Environmental Health

Mike Lloyd, Director–Research Programs and Research Director, Chemical Processing

Patrick Zhang, Ph.D., Research Director, Mining and Beneficiation

Steven G. Richardson, Ph.D., Research Director, Reclamation

Gary Albarelli, Director of Information Programs

Karen J. Stewart, MLS, Library Director

Interim Executive Director's Message

Brian Birky, Ph.D. – Interim Executive Director

The phosphate industry plays an important role in ensuring a plentiful, low-cost food supply in the United States and helps ensure that there is sufficient food to feed a burgeoning world population. The industry also plays an important role in the economies of central and northern Florida. However, the industry's mining and chemical processing operations raise public concerns about the environment and public health. Some of these concerns are perceived but lack scientific grounding, while some have a basis in fact.

The people in the phosphate regions worry that the industry may contaminate the public water supply, spill acidic water or clay into the environment, and may not leave land in a useable form after mining.

The Florida Institute of Phosphate Research (FIPR) was established by the Florida Legislature in 1978 to study these issues, to help the public understand the extent and scope of any problems, and to find solutions. In 2010, the Legislature re-established The Florida Industrial and Phosphate Research Institute (FIPR Institute) within the University of South Florida Polytechnic.

The Institute's role is to conduct scientific investigations that will give lawmakers, regulators, members of the industry, environmentalists and the general public the information they need to make decisions relating to issues of industrial influence or origin. The Institute's mission was expanded in the new legislation to include industries other than the phosphate industry and to encourage commercialization of our research products and intellectual property.

Through science, we at the Institute try to make sure the people of Florida understand the facts. We then try to provide solutions for any problems that may exist. Some of the real issues the Institute's research currently addresses include:

Process Water - Process water is used in the chemical plant that converts mined phosphate rock into the phosphoric acid that is used to make fertilizer. There are billions of gallons of this acidic water generated in phosphate processing. Process water is stored on top of phosphogypsum stacks that rise 200 feet into the air and can cover 400 or more acres of land. Our research is looking at ways to reduce the quantity and improve the quality of the water. We also study ways to clean the water so it can be safely released into the environment.

Clay Settling Areas - Phosphate rock in Florida is found in association with clay. The clay must be removed before the rock can be processed and converted into products. The clay is separated as slurry and is stored in ponds where the solid clay particles settle out over many years. The Institute's research is helping to understand how the clay settling areas impact the surface and groundwater flow in the watershed around them and how they can be reclaimed and put to environmentally sound and economically viable use. Research into techniques to rapidly dewater the clay is the key component to clay pond reclamation.

Resource Recovery – Mining has environmental and economic consequences. In order to optimize both, we should recover as much of the useful material as practical. In addition to phosphate rock, which is essential to our food security, uranium and rare earths are also present in the mined matrix and may be economically extracted to enhance our energy security.

In this report you will also see the Institute studying water quality and quantity questions, new technologies to separate phosphate rock from clay and sand, techniques to rapidly settle clays and recover water, ways to determine what rock should be left in the ground and what should be mined, alternatives to the wet-acid process, reclamation techniques including stream design and nuisance plant control, uses for phosphogypsum including sulfur recovery and carbon sequestration, recovery of uranium and rare earths, workplace exposures to chemicals, natural radioactivity, and stewardship of global phosphate resources.

The Institute's mission includes sharing the information it generates and collects. Toward this end the Institute hosts technical conferences, workshops and meetings, operates a library that is open to the public, and conducts a kindergarten-Grade 12 education program. As our information program expands we are always looking for new ways to share the wealth of information we house. This report is part of that effort and is available through our web page (www.fipr.poly.usf.edu).

Financial Report

FIPR Institute's research and operation are funded through the Phosphate Research Trust Fund. This trust fund receives its income from a portion of the severance tax paid to the state for each ton of phosphate that is mined.

Since the Institute's inception, the severance tax rates, distribution, and associated fees have varied greatly, as has the rate of mining. This has, in turn, resulted in widely variable rates of income for the Phosphate Research Trust Fund.

Since 1978, the distribution to the Institute's trust fund has varied from 5% to 12.5% of the collected tax, and was 5.8% in fiscal year (FY) 2010-2011. The tax rate for FY 2010-2011 was $1.71 per ton severed and will drop to $1.61 next year. Mining capacity has decreased in recent years and mine permitting has been a contentious issue between the industry and environmental groups. All of these factors create uncertainty for planning and management of the research and operational budgets. However, the Institute strives to provide scientifically sound information to all of its stakeholders with the resources it is given.

The FIPR Institute's Executive Director provides a summary of expenditures and the trust fund balance at public meetings of the Institute's Phosphate Research and Activities Board. A more detailed summary is included herein.

Fiscal Year 2010-2011

Trust Fund Balance

July 1, 2010	$9,598,557
June 30, 2011	$8,967,833

Fiscal Year 2010-2011 (continued)

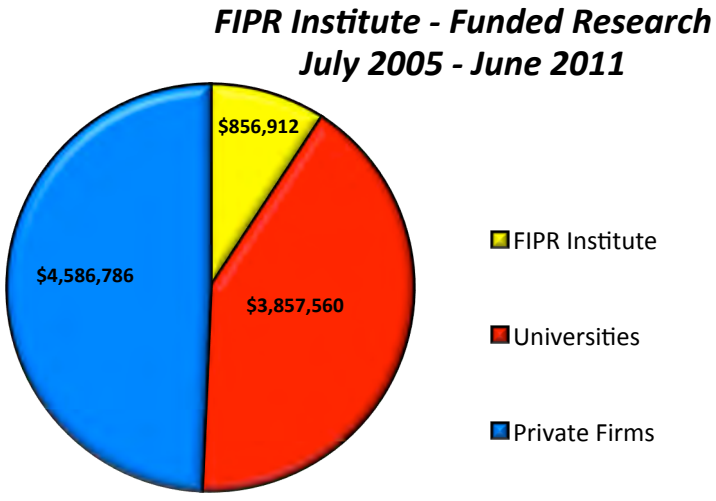
Operations

Income	
Gross Severance Tax[1]	$1,904,902.72
LESS Fees to Dept. of Revenue	($241,442.14)
Net Income	$1,663,460.58
PLUS Interest	$23,217.18
Total Income	$1,686,677.76
Expenses	
Research	$527,721.65
Internal Operations[2]	$1,672,392.45
Education	$7,907.57
Library	$38,184.63
Laboratory	$70,356.98
Total Expenses	$2,316,563.28
Change in Trust Fund	($629,885.52)

[1]Per Section 211.3103, F.S. as amended by section 3, Chapter 2010-166 the severance tax rate was $1.71 per ton of rock severed from the earth. The FIPR Institute received 5.8% of the proceeds from the severance tax.

[2]"Internal Operations" includes staff salaries and benefits. The Institute's Research Directors and technicians (44% of the staff) spend most of their time directing or conducting research. Of the remaining staff, 28% deliver information and education services to the public and schools, and another 28% provide office and IT support within the Institute.

Since "Internal Operations" also includes research done by the FIPR Institute staff, the portion of the annual income expended on research is substantial. Of the amount that is approved by our Board for specific research projects ("Research" in the summary table), the largest shares go to universities and private firms. Their research is conducted under the direction of the Institute.



FIPR Institute funded research by entity type, July 2005 to June 2011.

Information Program

During May 2010 a reorganization of the Institute's Information Program was put in place whereby the three principal Information work areas of its K-12 Education Program, Communications and Marketing, and Library were placed under the direction of Gary Albarelli, the Institute's former Library Director. Kate Himel continues to serve as the Institute's Communications and Marketing Officer, and is involved with the K-12 Education Program. Karen Stewart, the Institute's former Assistant Librarian, has been promoted to Director of the FIPR Institute Library, while Malysavanh Birky continues to serve as Library Assistant. In October 2010, the Institute hired Indira Sukhraj, a high school biology and environmental science teacher from the Polk County School System, to be its new K-12 Education Program Coordinator.

In keeping with the Institute's new relationship with USF Polytechnic, all program areas have made strides in integrating with their counterparts at the University. In addition to providing circulation and delivery of materials to all University students, faculty and staff, new acquisitions are now being incorporated into USF Polytechnic's Library announcements. News releases of Institute events of note are also being distributed on USF Polytechnic's distribution list and website. FIPR Institute publications are now being published under the USF Polytechnic brand and all communications from the Institute follow USF Polytechnic marketing guidelines with a newly developed and approved logo. Along with these developments, a new road sign appears at the Institute entrance on State Highway 60 and prominently features the new FIPR Institute logo.

Updated entrance sign for the FIPR Institute.

Along with becoming a part of USF Polytechnic, the expansion of research topics beyond phosphate into related areas will become incorporated into the Information Program work areas to support and reflect research activities.

The K-12 Education Program has undergone great change under the new coordinating leadership of Indira Sukhraj. While the Summer Teacher Workshop remains the cornerstone of the program, the Education Program has expanded its focus to not only train teachers, but now delivers resources and content directly to classrooms in the state. In the past year, Institute educational resources have been brought to hundreds of classrooms, reaching thousands of Florida students directly. In addition, the variety of curriculum offered has been greatly expanded to include dozens of newly developed lesson plans and activities, and several new teaching units. The great demand for these offerings has led to the recent hiring of another former Polk County science teacher, Barry Jacobs, to assist in their delivery and further curriculum development. Barry's background in teaching of the physical sciences will be an excellent complement to Indira's educational focus on the life sciences.

The format of the Summer Teacher workshop, which has been conducted at the Institute since 1998, has also been changed to meet the needs of more Florida teachers. In the past, many teachers have had difficulty scheduling a two-week workshop into their busy summers, so the summer session has been compressed into one week filled with presentation of core topics and field trips. For more in-depth investigation into topics, four one-day modules will be offered on Saturdays throughout the year, the first being offered on December 3, 2011. Teachers will be able to attend any or all of the modules as their needs and schedule dictate.

The FIPR Institute Education program has also entered into a consulting partnership with the Polk County School System to utilize the Institute's expertise in helping the County implement new Science, Technology, Engineering and Math (STEM) programs into four elementary schools and one middle school as part of a federal STEM education grant to pilot STEM programs. It is anticipated that additional activities and lessons will be developed by the Institute to enhance the STEM initiative in the State.

Technical Exchange

"Beneficiation of Phosphates VI" Conference

Beginning in 1993, a series of international conferences on phosphate beneficiation organized by the FIPR Institute has become the world's most prestigious and prominent conference on phosphate mineral processing. The sixth of this conference series, Beneficiation of Phosphates VI, was held early this year in Kunming, China with a record number of 55 presentations, 16 sessions and over 300 participants.

Dr. Patrick Zhang delivering the closing remarks at the Beneficiation of Phosphates VI conference.

Web-Based Training Course on Slurry Pumping

The first FIPR Institute web-based training course has been developed on slurry pumping, a widely used materials transportation method for various mining industries all over the world. The six module course, based primarily on FIPR Institute research findings, provides pumping basics, modeling techniques for improving pumping efficiency, troubleshooting tools, and operation and maintenance skills to reduce overall pumping costs.

MiLo Project and Derivative Projects

Have you ever wondered what would happen if the knowledge and wisdom of our elders was never recorded and was lost when we lost them? That is exactly what happens in many industries in spite of all of the scientific publishing that is done. The specialized knowledge of industry experts is termed “at risk knowledge” because it isn’t always written down and could be lost at any moment.

MiLo started as a research project to obtain comprehensive knowledge from a phosphate and fertilizer expert, the FIPR Institute’s Director of Research Programs, Mike Lloyd, and assemble that information into a meaningful computer-access program. MiLo is designed to be understandable to a variety of users, with the information arranged so that it can be extracted satisfactorily and easily. Through accounts of Mr. Lloyd’s life, the formulation of “Mike’s Rules of Order” (his approach to problem-solving), inclusion in the program of important information identified by Mike, and contributions from other experts recommended by Mike, the project passed proof of concept. With that milestone achieved, the project advanced from a research effort to an internal operational process.

Several derivative programs, called modules, have also been developed. For example, MiLoEdu is an educational derivative that can assist teachers and parents in achieving education standards through the integration of technology and content. MiLoEdu is a multi-media online program designed to provide standard-based, integrated curricula, activities and resources to make learning relevant to students, build content confidence for those teaching subjects out of their area of expertise and reenergize expert teachers who feel inhibited by one-size-fits-all performance measures. MiLoEdu was originally constructed as a K-12 teacher training module that connects phosphate information to standards in math, science, language arts and social studies. It is now intended not only for the classroom, but also to be used as a general knowledge tool about phosphate fertilizers and food production and a resource for parents to enhance the education of their children.

The Institute worked closely with Florida’s phosphate mining area educators to develop the curricula, training and other resources available through MiLoEdu and its K-12 Education Program. This collection of lesson plans and units, multi-media resources, virtual learning and professional development options is unique because the content stems from, and connects to, the Institute’s research, expertise and knowledge.

Another module, MiLoRad, is a multimedia tool developed to explain the physics behind naturally occurring radioactive materials that occur in the phosphate matrix.

In Florida, the main cause of concern arises from radon gas, a by-product of the decay of uranium. Radon decays into solid “daughter” products that can pose health risks if taken inside the body in great quantities. MiLoRad is intended to correct misconceptions that exist about nuclear science and provide information about radiation related to phosphate mining and fertilizer processing..

The multimedia aspect of MiLoRad makes it an ideal tool for delivering information. MiLoRad contains much traditional text, but text that is supported with images, animations and videos. It is expected that MiLoRad will be a useful reference tool as it includes a comprehensive glossary of frequently encountered terms associated with the phosphate industry in Florida and the nuclear industry.

Other MiLo modules are in various stages of development. The MiLo initiative is a co-development partnership with AleffGroup, Inc. As such, the products are proprietary in nature and will be available only by subscription.

Direct FIPR Institute Staff Tech Transfer

FIPR Institute staff members have been actively involved in technical exchange at various forums during the last several years, as highlighted below:

- Participated as an invited expert in discussing phosphorus sustainability at a seminar sponsored by the European Commission, Brussels, Belgium
- Provided technical input at a workshop for The Global TraPs (Transdisciplinary Processes for Sustainable Phosphorus Management) Project organized by the International Fertilizer Development Center and Swiss Federal Institute of Technology, Zurich, Switzerland
- Delivered a keynote speech at the Arab Fertilizer Association's 23rd International Technical Conference & Exhibition, Tunis, Tunisia
- Delivered a keynote speech at the 1st International Symposium on Innovation and Technology in the Phosphate Industry, Marrakech, Morocco
- Edited and published the book, *Beneficiation of Phosphates: Technology Advance and Adoption*, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colorado, January 2010
- Attended committee meetings of the Society for Mining, Metallurgy, and Exploration in Denver, Colorado
- Served as President and Past-President of the Florida Chapter of the Health Physics Society
- Presented *"Inhalation Dose Assessments in NORM Industries"* at the International Radiation Protection Association's (IRPA) 12th Congress in Buenos Aires, Argentina
- Presented numerous talks and two papers at meetings of the International Atomic Energy Agency, Vienna
- Attended and presented talks at the annual meeting of the Florida Association of Water Quality Control (FAWQC) and at the Florida Farm to Fuel Summit
- Served as a board member of the Fertilizer Industry Round Table
- Organized, chaired, and presented at a two-day Restoration Workshop held at University of South Florida Polytechnic in Lakeland, Florida
- Served as member of the Peace River Basin Management Advisory Committee
- Served as a member of the Focus Group for the Polk County Planning Department's Selected Area Study for Southwestern Polk County

- Presented multiple technical session talks at the Annual Regional Phosphate Conference, held each October in Lakeland, Florida
- Presented research papers at the Florida Exotic Pest Plant Council Symposium in Jacksonville, Florida; the Florida Aquatic Plant Management Society meeting in Daytona Beach, Florida; the Southern Weed Science Society meeting in Jacksonville, Florida; and the Florida Vegetation Management Association conference in Daytona Beach, Florida
- Presented two sessions at the National Agriculture in the Classroom conference in Fort Lauderdale, Florida
- Attended and displayed program materials at the Florida Association of Science Teachers conference in Orlando, Florida
- Presented at the AIChE Clearwater Phosphate Conference
- Made a presentation to the Manatee County citizen's advisory group

Recent FIPR Institute Publications (available at: http://www1.fipr.state.fl.us/Publications)

01-148-226 *Field Application of Phosphate Rock for Remediation of Metal-Contaminated Soils*. Lena Q. Ma, Jorge Santos, Xinde Cao, Uttam Saha, and Willie Harris - University of Florida; May 2008.

01-190-237 *Effectiveness of Secondary Liners in Reducing Phosphogypsum Stack Post-Closure Liabilities*. Nadim F. Fuleihan with Reinaldo Rolo and Rajendra K. Shrestha - ARDAMAN & ASSOCIATES, INC; December 2006.

01-197-235 *Preparation of an Application for Approval to Use Stabilized Phosphogypsum as a Fill Material for Coastal Protection Devices*. Kelly A. Rusch and Roger K. Seals with Maria Teresa Gutierrez-Wing - Louisiana State University; April 2010.

02-158-227 *An Investigation of Flotation Reagents*. FIPR; June 2008.

02-160-222 *Commercial Products from Phosphatic Clays: A Pre-Feasibility Study*. University of Florida; August 2007.

02-162-229 *Development and Pilot-Scale Demonstration of Deep Cone™ Paste Thickening Process for Phosphatic Clay Disposal*. University of Kentucky; August 2008.

02-164-223 *Utilization of Phosphatic Clay Waste in Concrete*. University of Florida; September 2007.

02-168-232 *Field Demonstration/Evaluation of a Rapid Clay Dewatering and Consolidation Process Using Other Wastes (FIPR/DIPR Process) to Minimize Clay Settling Ponds*.University of Florida; March 2009.

02-172-240 *Pilot-Scale Testing and Demonstration of Picobubble-Enhanced Flotation of Phosphate for Increased Recovery and Reduced Reagent Consumption.* Daniel Tao with Rick Honaker and Maoming Fan - University of Kentucky; Mosaic Phosphates and Jacobs Engineering Group; April 2011.

02-173-236 *Effect of Particle Characteristics on Fatty Acid Flotation of Florida Phosphate Rock. Volume I: Project Summary*. Hassan El-Shall - University of Florida; J.D. Miller - University of Utah; P. Somasundaran - Somasundaran, Inc; R. Stana - R Squared S, Lakeland, FL; G. Wang - ArrMaz Custom Chemicals; April 2010.

02-173-236 *Effect of Particle Characteristics on Fatty Acid Flotation of Florida Phosphate Rock. Volume II: Sample Collection, Flotation Results, and Diagnostic/Remediation Protocol.* Hassan El-Shall - University of Florida; J.D. Miller - University of Utah; P. Somasundaran - Somasundaran, Inc; R. Stana - R Squared S, Lakeland, FL; G. Wang - ArrMaz Custom Chemicals; April 2010.

02-173-236 *Effect of Particle Characteristics on Fatty Acid Flotation of Florida Phosphate Rock. Volume III: Phosphate Encapsulation/Liberation Studies*. Hassan El-Shall - University of Florida; Jan D. Miller with C.L. Lin, M. I. Al-Wakeel, J. Nalaskowski, L. Hupka, and O. Ozdemir - University of Utah; April 2010.

02-173-236 *Effect of Particle Characteristics on Fatty Acid Flotation of Florida Phosphate Rock. Volume IV: Fundamental Studies*. Hassan El-Shall - University of Florida; P. Somasundaran - Somasundaran, Inc; April 2010.

02-176-234 *Enhanced Removal of Dolomite Pebble Concentrate by CO_2 Generation*. Michigan Technological University; August 2009.

03-141-225 *Commercial Tree Crops for Phosphate Mined Lands.*University of Florida; May 2008.

03-142-231 *Successional Trajectories of Constructed Forested Wetlands.* University of Florida Center for Wetlands; April 2009.

03-147-230 *Wildlife Habitat and Wildlife Utilization of Phosphate-Mined Lands*. Biological Research Associates/University of South Florida; December 2008.

03-149-238 *Wetlands on Clay Settling Areas.* Mark T. Brown with Mary Boyd, Wesley Ingwersen, Sean King, and Daniel McLaughlin - University of Florida; November 2010.

03-153-239 *Wastewater Treatment with Wetland and Tailing Sands Filtration Prior to Confined Aquifer Recharge*. Peter J. Schreuder - Schreuder, Inc.; Thomas Pichler - University of South Florida; December 2010.

04-067-224 *LIBS Module for Dolomite Content Evaluation on a Conveyor*. Laser Detect Systems Ltd.; September 2007.

04-069-233 *Centrifugal Slurry Pump Concentration Limit Testing and Evaluation - Expansion of FIPR 04-069-215*. GIW Industries, Inc.; March 2009.

04-072-228 *Solids Composition Measurements of Phosphate Slurry Using Impedance Spectroscopy, Phase I: Feasibility Study*. The Mosaic Company; August 2008.

Other Publications and Presentations by FIPR Institute Staff

Birky, B. “Global Uranium Supply/Demand Projections and the Impact on Florida,” Florida Chapter of the Health Physics Society, Spring Meeting 2008.

Birky, B. “Inhalation Dose Assessments in NORM Industries,” Invited seminar for professional education credit, IRPA 12, Buenos Aires, Argentina, October 2008.

Birky, B. “Inhalation Doses and Regulatory Policy in Wet-acid Processing of Sedimentary Phosphate Rock.” Proceedings of the NORM V Symposium. March 19-22, 2007. Seville, Spain. Published by the IAEA.

Birky, B. “Phosphate Mining and Natural Radioactivity,” Manatee County Citizens Advisory Panel. March 2009.

Birky, B. “Phosphogypsum Use in Road Construction in the USA,” Phosphate Industry Group on Use of NORM Residues, IAEA, Vienna, 14 July 2008.

Birky, B. “Phosphogypsum Use in Roads, Construction, and Landfills,” Institute of Process Engineering, Beijing, China, 21 October 2009.

Birky, B. “Towards a Consistent and Coherent, “Three Layer” Evidence-based PG Regulatory Model,” Phosphate Industry Group on Use of NORM Residues, IAEA, Vienna, July 2008.

Birky, B. and Hilton, J. “You Have to Admit, It’s Getting Bigger, Getting Bigger All the Time…,” “Stack Free by ’53? Safe, Beneficial Uses of Phosphogypsum: Project Update,” Lakeland Regional Phosphate Conference, October, 10, 2007.

Birky, B. Phosphate “Summit” Meeting: Sustainable Management of the Global Phosphate Resource, Farmer’s Club, London, UK, February 16, 2010.

Birky, B., “Natural Radioactivity and Public Health in the Florida Phosphate Mining Region,” EPA State of the Science on Phosphate Mining and the Environment, Charlotte Harbor Event Center, Punta Gorda FL, March 29, 2011.

Birky, B., “Natural Radioactivity in the Phosphate Industry,” Florida Association for Water Quality Control, Naples, FL, USA, June 9, 2010.

Birky, B., “Phosphogypsum Use in Road Construction and Environmental Monitoring,” IAEA Technical Meeting, Vienna, Austria, September 27 – October 1, 2010.

Birky, B., “Phosphogypsum use in road construction,” Phosphogypsum Working Group (PGWG), and co-contributor to “Progress Report (1) from the Steering Committee, November 2009, Including Conclusions from the PG Consultation Meeting,” IAEA, Vienna, Austria, November 16-20, 2009.

Birky, B., “Phosphogypsum Use in Road Construction,” 6th International Symposium on Naturally Occurring Radioactive Material (NORM VI), Workshop on Phosphogypsum Management & Uses, Marrakech, Morocco, March 25, 2010.

Birky, B., “Radiation in the Phosphate Mining Environment,” US Army Corps of Engineers Phosphate Mining Workshop, Lakeland, FL, USA, October 6-7, 2010.

Birky, B., Hilton, J., “Safety, Radiation Protection and Management of Radioactive Wastes in the Phosphate Industry, the Three Layer Conceptual Model,” 6th International Symposium on Naturally Occurring Radioactive Material (NORM VI), Workshop on Phosphogypsum Management & Uses, Marrakech, Morocco, March 25, 2010.

Birky, B., Hilton, J., Bouabdelaoui, Y., Johnston, J., Moussaid, M. and Stana R., “Towards an Evidence-based Score-card for Aligning Risk Management and Sustainability Goals for Essential NORM Industries: Case Study - Phosphates,” 6th International Symposium on Naturally Occurring Radioactive Material (NORM VI), Marrakech, Morocco, March 22-26, 2010.

Birky, B., Hilton, J., Moussaid, M. and Warren, B., “A NORM-Specific Approach to Education and Training Needs in NORM Industries,” 6th International Symposium on Naturally Occurring Radioactive Material (NORM VI), Marrakech, Morocco, March 22-26, 2010.

Birky, B., Hilton, J., Moussaid, M., and Stana, R. “Uranium and Phosphorus: A Cooperative Game for Critical Elements in Energy and Food Security,” Technical Meeting on Uranium from Unconventional Resources, IAEA, Vienna, 4-6 November 2009.

Birky, B., International Atomic Energy Agency Technical Meeting: Uranium Production from Phosphate Rocks. “Radiation Safety: considerations and good practices.” September 26-30, 2011.

El-Shall, H., J. Hazen, P. Zhang, M.F. Raslan, L. Bromwell, and L. Seale, “A Novel Technique for Water Recovery and Land Reclamation Using Phosphatic Clay and Sand Tailings,” in *Beneficiation of Phosphates: Technology Advance and Adoption*. P. Zhang, et al, editors, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colorado, pp. 67-79, 2010.

Hilton, J. and Birky, B., “Legacy or Liability? The Future of Phosphogypsum,” presented at the IBC NORM Waste Conference, London UK, February 26, 2008.

Hilton, J., Birky, B. and Johnston, J., “The Constructive Regulation of Phosphates and Phosphogypsum – A New, Evidence-based Approach to Regulating a NORM Industry Vital to the Global Community,” IRPA 12, Buenos Aires, Argentina, October 2008.

Hilton, J., Moussaid, M. and Birky, B. A Twelve Point Consultation Paper for Strengthening and Sustaining the Professional Radiation Protection Community in Africa. “Capacity-building for the radiation protection dividend,” AFRIRPA2010, Nairobi, Kenya, September 13-17, 2010.

Hsu, Y. M., Kolett, J., Wysocki, K., Wu, C. Y., Lundgren, D. A. and Birky, B. K., “Sources of Artifacts in Sulfuric Acid Mist Measurement Using NIOSH Method 7903,” *Environ. Sci. Technol.*, doi: 10.1021/es070265e, **41(17)**, 6205 -6209, 2007.

Hsu, Y. M., Wu, C. Y., Lundgren, D. A. and Birky, B. K., “Size Distribution, Chemical Composition and Acidity of Mist Aerosols in Fertilizer Manufacturing Facilities in Florida,” *J. Aerosol Sci.*, doi: 10.1016/j.jaerosci.2007.10.008, **39**, 127-140, 2007.

Hsu, Y. M., Wu, C. Y., Lundgren, D. and Birky, B. K., “Size-resolved Sulfuric Acid Mist Concentrations at Phosphate Fertilizer Manufacturing Facilities in Florida,” *Annals of Occupational Hygiene*, doi: 10.1093/annhyg/mel066, **51(1)**, 81-89, 2007.

Hsu, Y. M., Wu, C. Y., Lundgren, D. and Birky, B., “Minimization of Artifacts in Sulfuric Acid Mist Measurement Using NIOSH Method 7903,” submitted to *Environ. Sci. Technol.*, February 2008.

Kim, K., Wu, C. Y., Birky, B. and Bolch, W., “TENORM Aerosols in the Florida Phosphate Industry - Assessment of Lung Fluid Solubility and Annual Effective Dose to Workers,” *Radiation Protection Dosimetry*, doi: 10.1093/rpd/ncl083, **123(1)**, 41-55, 2007.

Li, H.W., Afshar-Mohajer, N., Wu, C.Y., and Birky, B. “Impact of Hazardous Air Pollutions Emitted from Phosphate Fertilizer Production Plants on their Ambient Concentration Levels in Tampa Bay Area,” AAAR 30th Annual Conference, Orlando, FL, October 3-7, 2011.

Richardson, S.G. Selective Herbicidal Control of Weeds in Restored Native Plant Communities. Florida Vegetation Management Association Conference, April 19-20, Daytona Beach, Florida, 2007.

Richardson, S.G. Control of Exotic Grasses in Uplands and Wetlands. Ecosystem Restoration Workshop, April 2-3, University of South Florida, Lakeland, Florida, 2008.

Richardson, S.G. Primrose Willow (*Ludwigia peruviana*) Management in Restored Forested Wetlands. Florida Exotic Pest Plant Council Symposium, April 21-24, Jacksonville, Florida, 2008.

Richardson, S.G. Primrose Willow and Cattail Management in Forested Wetlands. Ecosystem Restoration Workshop, April 2-3, University of South Florida, Lakeland, Florida, 2008.

Richardson, S.G. Selective Control of Cogongrass and Natalgrass. Florida Exotic Pest Plant Council Symposium, April 21-24, Jacksonville, Florida, 2008.

Richardson, S.G. Selective Control of Cogongrass and other Weeds When Restoring Native Plant Communities on Phosphate Mined Lands. Proceedings Southern Weed Science Society. Jacksonville, Florida, 2008.

Richardson, S.G. Selective Control of Cogongrass and Torpedograss. Florida Aquatic Plant Management Society Symposium, October 15-16, Daytona Beach, Florida, 2008.

Richardson, S.G. Integrated Management of Cogongrass and Other Weeds. Regional Phosphate Conference, October 13-14, 2010, Lakeland, Florida, 2010.

Shou, L., Theodore, A., Wu, C.Y., Hsu, Y.M. and Birky, B. "Development and Laboratory Evaluation of a Novel Porous Membrane Denuder," AAAR 30th Annual Conference, Orlando, FL, October 3-7, 2011.

Simmons, C., presented by Birky, B., "Legal Aspects of NORM/TENORM Regulation in the United States," Invited Presentation, 6th International Symposium on Naturally Occurring Radioactive Material (NORM VI), Marrakech, Morocco, March 22-26, 2010.

Tao, D., G. Chen, B.K. Parekh, R. Honaker, and P. Zhang, "Laboratory Studies on Flocculation of Phosphatic Clay/Sand as a Forerunner to Phosphate Tailings Disposal Using the Deep Cone™ Paste Technology – Part I. Screening of Anionic and Cationic Polymers," in *Beneficiation of Phosphates: Technology Advance and Adoption.* P. Zhang, et al, editors, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colorado, pp. 95-116, 2010.

Tao, D., G. Chen, B.K. Parekh, R. Honaker, and P. Zhang, "Laboratory Studies on Flocculation of Phosphatic Clay/Sand as a Forerunner to Phosphate Tailings Disposal Using the Deep Cone™ Paste Technology – Part II. Rheological Characterization," in *Beneficiation of Phosphates: Technology Advance and Adoption.* P. Zhang, et al, editors, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colorado, pp. 117-132, 2010.

Tao, D., M. Fan, B.K. Parekh, R. Honaker, and P. Zhang, "Pilot-Scale Demonstration of Deep Cone™ Paste Thickening Process for Phosphatic Clay/Sand Disposal," in *Beneficiation of Phosphates: Technology Advance and Adoption*. P. Zhang, et al, editors, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colorado, pp. 81-94, 2010.

Research Areas:

Beneficiation and Mining

Deep Cone™ Paste Technology for Waste Disposal

The Florida phosphate matrix (ore) is composed of roughly one-third each of phosphate, clay and sand. The clay must be removed before the upgrading of phosphate using flotation. Therefore, approximately one ton of clay waste (phosphatic clay) is generated for each ton of phosphate rock product. This translates to nearly 100,000 tons/day of waste clay in Florida. Under the current practice, phosphate clay slurry, with an average solids content of about 3%, is pumped to clay storage ponds where the clay slowly settles. These ponds occupy many acres of lands and generally have limited use after reclamation.

The FIPR Institute just concluded Phase II of a pilot testing project to develop and demonstrate the Deep Cone™ paste technology for dewatering phosphatic clay and/or sand-clay mix. This is perhaps the most successful project on phosphatic clay dewatering ever undertaken by the FIPR Institute or any other organization. It offers the best hope for phosphatic waste disposal without impounding. The process involves treating phosphatic clay with an anionic polymer, mixing the treated clay with sand, pumping the sand/clay mix into the feed box of the Deep Cone™ thickener where a cationic polymer is added, and thickening the sand/clay mix in the thickener unit to achieve a high-solids paste.

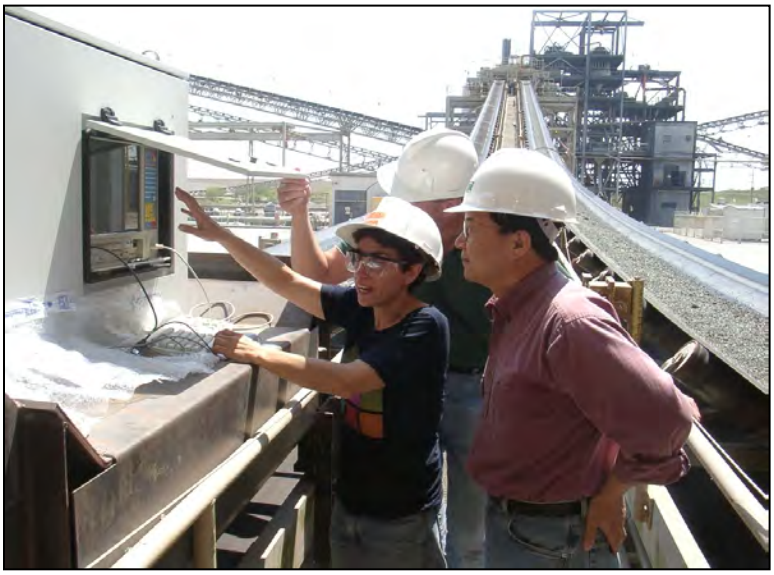
Pilot plant for the FIPR Institute's Deep Cone™ paste technology.

Following a successful lab test program to evaluate numerous flocculants of varying properties, extensive pilot testing was conducted using a two-ton-per-hour pilot-scale Deep Cone™ thickener at two plants. The pilot-scale field testing successfully demonstrated the simultaneous production of an underflow paste product and a clear overflow water stream, achieving a paste of sand/clay mix that does not segregate. This technology has the potential to save the phosphate industry tens of millions of dollars annually, to make it easier for the industry to obtain new mining permits, and to leave more lands available for high-value uses.

Online LIBS (Laser-induced Breakdown Spectroscopy) Analyzer

Online analysis and process automation are powerful tools for achieving optimal industry efficiency. Since its inception, the FIPR Institute has sponsored five major projects for evaluating online analytical systems.

The breakthrough came when the FIPR Institute started collaborative research with Dr. Michael Gaft of Laser Detect Systems in Israel. This effort has resulted in the development and commercialization of the world's first online analyzer for wet minerals using the LIBS technology. One phosphate company recently purchased a new analyzer, and some other phosphate and coal mining companies are in the process of acquiring this analyzer. According to industry estimates, one installation of the LIBS analyzer could bring an annual economic benefit of about $3 million.



Online LIBS analyzer control station.

Remote LIBS

The FIPR Institute has pioneered research to develop a LIBS analyzer for remote, real-time analysis of phosphate mine minerals before they are transported to the beneficiation plant. Field testing of a remote LIBS prototype has been conducted successfully, demonstrating its capability to analyze phosphate mine minerals from a 5-

25 meter distance. The device could be used to analyze the mine face and minerals in a dragline bucket or hauling truck. It provides the following useful information: differentiation between overburden, matrix and bottom; analysis of the P_2O_5 content; and analysis of MgO content in matrix samples. This technology has great potential for improving both mining and beneficiation efficiency.

Picobubble-Enhanced Flotation

The efficient capture of hydrophobic particles by air bubbles is the key to effective flotation. It is generally recognized that small bubbles enhance flotation of small- and medium-sized particles, while some large air bubbles are required to lift coarse particles. However, the attachment of coarse particles to large bubbles is weak, resulting in detachment and eventually loss of coarse particles in flotation. Air bubbles of less than a micron in size, known as picobubbles, have been found to be effective in preventing detachment. These tiny bubbles also make particles floatable with significantly less surfactant coverage, thus reducing reagent use for flotation.

Encouraged by promising lab testing results, the FIPR Institute Board of Directors approved funding for a project to evaluate the picobubble-enhanced flotation technology on pilot scale for Florida phosphate. It was demonstrated both in the lab and on pilot scale that the introduction of picobubbles into flotation of phosphate could reduce fatty acid use by up to 50%, while maintaining or increasing recovery by 10% or higher.

Rare Earth Elements

As part of our effort to promote comprehensive uses and sustainable development of Florida phosphate resources, the FIPR Institute started exploring the recovery of rare earth elements (REE) from phosphate. These elements have very specific, critical uses in a multitude of markets. For example, lanthanum is used as a catalyst in breaking down crude oil to produce gasoline, diesel and jet fuel; neodymium is the core magnetic component in high-strength magnets for electric car batteries, wind turbines and hard disk drives; and cerium oxide is an important component of glass polishing powders. Rare earths are also essential for many military applications. Many of these applications have no substitute materials and the move to green technologies has dramatically increased their demand. The first phase of our effort is to characterize REE occurrence in the phosphate ore and various processing streams. The analytical method for REE adopted/developed by the FIPR Institute is reliable. Preliminary conclusions from the ongoing project include the following: (1) appreciable amounts of REE are present in the currently mined Florida phosphate; (2) the highest REE concentrations are found in a flotation concentrate analyzing over 900 ppm; and (3) REE are mainly associated with francolite (the phosphate mineral) and are concentrated in the fine particles. This project has enhanced the capabilities of the FIPR Institute analytical lab, laying a sound foundation for our future research on extraction of REE from phosphate.

Chemical Processing

Phosphogypsum Utilization

Phosphogypsum utilization is gaining attention with many countries finding uses for this co-product of phosphate fertilizer production in agriculture, as a chemical raw material, and for construction uses. Recently, the FIPR Institute has had discussions with phosphate producers from Brazil and Morocco relative to possible cooperative research to find practical uses for phosphogypsum. While circumstances in the two countries are very different, both groups are interested in recovering the sulfur values in phosphogypsum, due to higher sulfur prices. Based on market prices over the last five years, or so, sulfur recovery from phosphogypsum could be economically attractive. In Brazil, fertilizer producers will soon have access to natural gas that could be used to process phosphogypsum and generate sulfuric acid and cement, both materials that are now being imported. Utilization of phosphogypsum would also help reduce storage issues and possible environmental impacts. Morocco has somewhat different circumstances, compared to Brazil. Moroccan fertilizer producers would have to import all fuel required for phosphogypsum processing. At present, Moroccan processors are discharging phosphogypsum into the ocean. However, they have committed to eliminating ocean discharge and are extremely interested in utilizing phosphogypsum for road construction and for sulfur recovery. Producers in Morocco are also interested in fixing carbon dioxide (CO_2). Sulfur recovery schemes can be implemented to convert phosphogypsum to either cement or calcium oxide (CaO). The cement produced can be utilized in construction projects, while CaO produced could be converted to calcium carbonate ($CaCO_3$). The $CaCO_3$ could be discharges to the oceam to fix two moles of CO_2 for each mole of phosphogypsum processed.

The FIPR Institute will continue discussions with both groups and hopes to jointly develop environmentally sound methods to utilize phosphogypsum. It is expected that more phosphate producers worldwide will be showing interest in sulfur recovery in the near future.

Agricultural Uses of Phosphogypsum

The FIPR Institute is contacted, almost on a weekly basis, with inquiries about the use of phosphogypsum in agriculture. We advise them of the experimental results that the FIPR Institute and others reported in previous years, and refer them to the results reported by researchers in Brazil and Spain, where long-term agricultural use has been practiced. The results from studies in Brazil are particularly interesting; it has been reported that phosphogypsum applications on coffee and other crops have allowed the growing plants to root more deeply, reducing or even eliminating the need for irrigation.

A second benefit of phosphogypsum application on crops in Brazil is that it causes the soil surface to remain more open and allows rainfall to penetrate the soil more rapidly, while also reducing surface runoff and erosion. Additionally, improved crop yields have been noted, due to the sulfur and calcium in the phosphogypsum, adding back needed nutrients to the soil.

Phosphogypsum in Road Building and Dwelling Construction

The FIPR Institute has not been able to make progress in research or demonstration projects using phosphogypsum in road building, despite our desire to do so. We are still following such practices in other countries. It is possible that Morocco will be the next country to commonly use phosphogypsum for road building.

At this time, there are dwelling construction research activities in Brazil where experimental houses have been built using phosphogypsum. Data are being collected on multiple parameters that are of interest to public health concerns. In China, there are numerous building materials containing phosphogypsum currently in commercial production.

Phosphogypsum as Landfill Cover Material

The FIPR Institute has provided technical assistance to researchers in Brazil who are currently conducting a landfill cover demonstration project in that country. Preliminary results of the Brazilian study show that the use of phosphogypsum as a cover material would make it possible to reduce the need for landfill volume by as much as 50%.

CO_2 Sequestration

The FIPR Institute was contacted by U.S. Department of Energy (DOE) personnel who were visiting Florida and were concerned about CO_2 sequestration. DOE staff wondered if the stacks of phosphogypsum could be used in some way for this purpose. Phosphogypsum can be used quite readily for this purpose, since almost any chemical reaction of phosphogypsum results in the generation of $CaCO_3$. Despite their obvious interest in the possibility of utilizing phosphogypsum in this manner, the DOE staff have never followed up on this approach to CO_2 sequestration.

Sulfur Recovery from Phosphogypsum

The FIPR Institute has continued research on recovering sulfur from phosphogypsum with power generation. Initial results led to the development of a modified sulfuric acid process with a greater-than-normal energy generation and a power plant design that utilized sulfur as a fuel, which includes recycling the sulfur in the process. Efforts have been directed toward obtaining funding for a demonstration-size plant as a next step in the commercialization of these processes.

Process Water

Process water treatment continues as a high-priority research item, and the FIPR Institute is often contacted by organizations that feel that they have the answer to the problem. To date, none of these suggested solutions have improved the existing processing methods. Through the years, there have been advances in the knowledge base on process water treatment, but determination of the ultimate method(s) to eliminate the high conductivity of the conventionally treated process water continues to be elusive.

JDC Kiln Process

The FIPR Institute has been given the opportunity to evaluate the JDC Kiln Process that reacts silica with phosphate rock to produce P_2O_5 that dissolves in water to give phosphoric acid. The process offers a viable alternative to the wet process manufacturing route for phosphoric acid and is certain to find application in particular circumstances. The JDC Kiln Process has the ability to process low-grade rock that cannot be used in the traditional wet processing route.

Public & Environmental Health

Natural Radioactivity

Mining for phosphate rock brings up soil from about fifteen to fifty feet below the surface, where naturally occurring radioactive materials are more concentrated. The redistribution and concentration of natural radioactivity began to receive attention in the 1970s when pipes and filtration equipment in the processing plants were found to have radiation above typical background levels. As a result, the industry has worked with the FIPR Institute and other researchers to evaluate exposures in the workplace.

The Florida Department of Health was concerned that phosphate worker radiation doses from breathing dust in the workplace might exceed regulatory limits. The FIPR Institute and the University of Florida gathered information in the workplace to address that concern. A series of studies demonstrated that the inhalation doses were very low and that the total doses to phosphate industry employees are consistently below the regulatory limits. The results indicate that respiratory protection programs for naturally occurring radioactive materials are not necessary in this industry. Respirator use is physically stressful for workers and should be avoided when use is not justified.

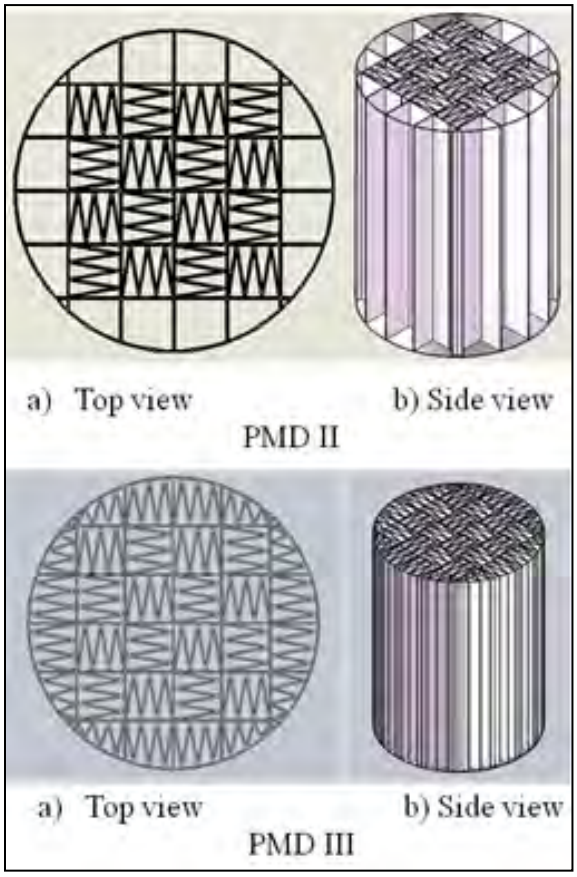
Residential Radiation Exposure

Everyone is constantly exposed to radiation from natural sources and some man-made sources. The average annual radiation dose to a member of the public has nearly doubled over the previous two decades due to advances in medical imaging and treatment using radiation sources. This increase in the dose is not necessarily desirable, but it is accepted because lives are saved by improved medical treatment. The natural background dose has remained the same, but is now a lower percentage of the total dose.

The U.S. Environmental Protection Agency (EPA) regulates practices that result in a radiation dose *in addition to* the baseline natural background dose. Although all of the increases in dose due to mining in the phosphate mining region of Florida are within the range of natural background, EPA considers them an *extra* dose because the natural rock was moved nearer to the surface. Radon is, by far, the most significant contributor to background radiation dose. Natural radiation doses to people in the phosphate mining region of Florida are similar to other areas of the nation. In fact, Florida is at the lower end of the natural background spectrum, even in the mining region. The FIPR Institute has provided information to the EPA through participation in a “State of the Science” conference and submissions to the U.S. Army Corps of Engineers (USACE) Areawide EIS.

Workplace Exposures to Sulfuric Acid Mist

This research was requested by the phosphate industry in response to new lower exposure limits that were proposed based on decades old measurements that are not representative of the modern facilities. A series of studies were conducted. The first study indicated that sulfuric acid mist exposures to Florida phosphate industry workers are below the new, more restrictive standards. However, the standard method used to measure sulfuric acid concentration overestimates those concentrations in sulfuric/phosphoric acid manufacturing plants and could result in reports of excessive exposure when they have not actually happened. Subsequent studies identified the physical sources of the errors and described methods to exclude them and correct the method. Finally, a porous membrane denuder (PMD) that excludes interfering aerosols from the sampling stream to give a more realistic measurement of the acid concentration in air was designed, constructed and patented.



Porous membrane denuder (PMD) designs II and III.

Chemicals and the Mining Environment

Concerns regarding the potential environmental impacts of flotation reagents used in the production of concentrated phosphate rock products have increased as new mining facilities are proposed in Hardee and DeSoto Counties in Florida. Previous research sponsored by the FIPR Institute and conducted by BCI Engineers & Scientists, Inc. (now AMEC) concluded that the fatty acid and amine components of flotation reagents were not detected in the surficial and intermediate aquifers near phosphate processing disposal areas (sand tailings disposal areas and clay settling areas). The results of the study indicated, however, that traces of fuel oil (another component of flotation reagents) were found in both the surficial aquifer, and at one site, in the intermediate aquifer, downgradient from disposal areas.

New research determined the fate and consequences to the environment of specific fuel oil components, known as polynuclear aromatic hydrocarbons (PAHs), some of which are known carcinogens and others suspected carcinogens. The PAHs serve as markers for spatial migration of fuel oil, as well as being an important component in the evaluation of potential impacts to consumers of shallow well waters. The project is important for landowners and residents adjacent to or near mining sites and for consideration in mine permitting. The results of the FIPR Institute-funded studies are in agreement with a Florida Department of Environmental Protection study conducted concurrently. In addition, PAHs were not detected in any clay settling areas or beyond mining site boundaries. PAHs were also not detected in intermediate groundwaters. Consequently, there is no reasonable threat to public health.

Groundwater sampling for PAH detection study.

Uranium Extraction

The FIPR Institute continues to investigate the economic feasibility of uranium extraction from phosphoric acid. Uranium is present in trace amounts in phosphoric acid, so it is not one of the major sources for this element. In the past, it has only been extracted with the support of government contracts or when the price of uranium was high enough to provide a good profit margin. However, the strategic needs for food and energy security as well as potentially favorable economics have generated renewed interest in uranium extraction around the world. The FIPR Institute is engaged in the international dialogue concerning competing extraction techniques and training in both extraction and safety.

Phosphogypsum (PG)

The FIPR Institute has funded research over multiple years to determine if phosphogypsum can be used safely and economically or if stacking it on land is the best option. This effort quickly developed global interest and co-funding. In 2009, the International Atomic Energy Agency (IAEA), following an evidence-based review and gap analysis, established an International Phosphogypsum Working Group (IPGWG) to evaluate phosphogypsum and its relative risks and benefits. Based on two Technical Meetings (2009 and 2010), the IPGWG set out its "Guide Principles for Safe, Sustainable Uses of Phosphogypsum." These principles in turn were developed against the background of the "IAEA Fundamental Safety Principles," IAEA Safety Standards Series, No. SF-1, Vienna, (2006):

- PG is a co-product with phosphoric acid of the so-called "wet process" manufacture of phosphatic fertilizers and related products, such as animal feeds.

- As a co-product, or residue, PG is not a *de facto* "waste," as currently defined in some jurisdictions, nor does it meet the legal definition of waste in that it has a history of safe use.

- Based on known published and peer-reviewed evidence, PG has a wide variety of safe, beneficial options for use, assuming that the instructions for use and known good practices are correctly followed.

Reclamation

The general purpose of the Reclamation Research Program is to increase our understanding of ecological and hydrological systems on mined lands and to develop improved reclamation methods. This includes consideration of native plant communities, weed control, wildlife habitat, streams, wetlands, lakes, forestry, agriculture, aquifer recharge and water supply (quantity and quality for ecological, agricultural, industrial and residential needs).

Wastewater Treatment with Wetlands and Sand Tailings Filtration

Research has been conducted to evaluate the use of wetlands plus a sand tailings filter basin on mined phosphate lands to treat industrial and municipal wastewater and surface runoff prior to recharge of the Floridan Aquifer. Treatment is necessary to meet the water quality standards for injection into the aquifer. The system was found to reduce nitrogen, phosphorus, sulfate, arsenic, dissolved oxygen (DO), and oxidation-reduction potential (ORP) levels of wastewater. The tailing sand filter basin greatly reduced coliform bacteria, but there were some exceedences of the drinking water standard, which were handled with UV treatment. Iron, manganese and fluoride levels in water from the system were similar to those in surficial aquifer waters in the region. There are many potential benefits in the concept of recharging the Floridan Aquifer and storing water there for later retrieval. Water stored underground is not subject to evaporation as in surface reservoirs, and the aquifer itself can serve as a conveyance "pipeline" when water is injected at one point and retrieved at a distant point (aquifer recharge and recovery program, or ARRP). However, injection of oxygen-rich surface waters into the Floridan Aquifer limestone has resulted in the water retrieved via the same well used for injection (aquifer storage and recovery or ASR) having higher arsenic concentrations due to dissolution of pyrite in the limestone and release of arsenic. It was hypothesized that the lower DO and ORP of the water from the wetland and sand tailing treatment system might reduce the dissolution of pyrite and release of arsenic from Floridan Aquifer limestone compared to surface waters with higher DO and ORP. However, laboratory column leaching tests did not support this idea; arsenic was also released from the limestone with the low-DO, low-ORP treated water. Further study of the complex geochemical reactions is needed. Another hypothesis that needs field testing is the possibility of re-precipitation of the arsenic as the water moves some distance through the limestone, as in the ARRP concept.

Wetlands on Clay Settling Areas

Clay settling areas (CSAs) have typically occupied 40 percent or more of the post-mining landscape; virtually all have wet areas. Questions arose concerning the wetlands on the CSAs. Can wetlands be established on CSAs that have some or all of the ecological functions and values of unmined wetlands? Can wetlands on CSAs serve as mitigation for wetlands disturbed or destroyed by mining? Studies were conducted to evaluate wetland development on CSAs, including hydrologic relationships, soils and vegetation, and to suggest methods for establishing or enhancing functional wetlands.

Studies of wetlands on CSAs indicated that substantial portions of these CSAs meet the hydrologic, soil and plant community definitions for wetlands. The naturally established wetlands are dominated by willow, saltbush, cattail and primrose willow. A few old sites had been planted with wetland trees, such as cypress, ash and water tupelo, and exhibited good growth and accumulation of organic matter in the soils beneath their canopies. The hydrology of several CSA wetlands was examined, and temporal and spatial models were developed to predict the depth, duration and spatial extent of flooding. Topography and upland soil type were important factors in CSA hydrology. CSAs with steeper gradients had deeper and more stable ponded areas fed by larger watersheds, compared to flatter CSAs, which had larger numbers of smaller watersheds and ponds with more "flashy" hydrology (rapid response to rainfall and drought). CSAs with sand tailings or overburden in their upland watersheds resulted in more buffered hydrologic regimes with less fluctuation in wetland hydroperiods compared to when all the watershed was clay. A wide variety of wetland plant species have recently been planted on a few CSAs, and most seem to have adapted to the clay soils under moist conditions. However, time is required to observe their long-term survival, growth and reproduction, and more generally, the further development of these wetlands and their acceptability as mitigation for other wetland losses.

Hydrology of Clay Settling Areas

There are more than 120,000 acres of clay settling areas (CSAs) in Florida. What effects are these areas having on the surface and ground water regimes in the basins where phosphate mining occurs? How do CSAs behave hydrologically, and how can this behavior be modeled and predicted? How should CSAs be designed and reclaimed to optimize their hydrologic functionality? It is important to understand and be able to predict internal and external hydrologic relationships. The internal CSA hydrology is related to supporting functional wetlands on a CSA, and the "external" hydrology is related to impacts on surrounding surface and ground water systems.

Previous research has shown the importance of water storage in depressions and surface desiccation cracks. In addition, the depressional storage increases with time following reclamation due to further clay consolidation and surface subsidence. Progress has been made in improving the ability to predict clay consolidation and to account for it in modeling CSA hydrology. However, there were still uncertainties in making accurate estimates of evapotranspiration and ground water seepage. This project is evaluating and

modeling the complete water balance of a CSA and includes methodology for more accurate determination of evapotranspiration and ground water seepage. One interesting finding has been that the vertical and horizontal permeability of the top meter of clay is much greater than previously thought due to cracks and old root channels.

Natural Channel Design of Headwater Streams at Florida Phosphate Mines

There is a great deal of public interest in protecting streams. To obtain permits to mine, companies must provide reasonable assurance that streams, including headwaters, can be restored and that downstream areas will not be degraded. A fundamental component of the restoration of stream function is that the channel shape and dimensions must be in dynamic equilibrium with the watershed. This research is providing much needed information to enable project designers to rapidly and accurately fit equilibrium channels to reclaimed basins. The hydrology and morphology of natural watersheds and headwater streams in Florida have been analyzed to provide the design parameters for restored streams. In addition, stream construction methods such as hydraulic channel carving have been, and are being, tested.

A reclaimed stream project.

Improving Weed Control for Native Plant Community Establishment and Restoration

There are many exotic, and a few native, weeds that greatly increase the difficulty and expense of reestablishing or maintaining native plant communities or other desirable vegetation on reclaimed mined lands. The FIPR Institute has been evaluating the degree of competition, or interference, that various weeds present to native plants, plus exploring methods for cost-effectively managing the weeds. In some cases, such as with primrose willow or cattail in forested wetlands, we have found that the trees will eventually shade out the weeds so that little or no additional weed control efforts are necessary as long as the trees become established in sufficient density to provide the needed canopy coverage. In other cases, such as with the notorious cogongrass, more extensive weed control measures are necessary.

Methods have been developed for selectively controlling cogongrass and several other weeds; that is, methods that kill the weeds without killing various native plants. This involved testing the tolerance or susceptibility of weeds and native plant species, or other desirable plants, to various herbicides in greenhouse and field studies. The differences in herbicide tolerance depend on several factors, including the rate and seasonal timing of application.

Spraying herbicide on weed control test plots.

The competitive interactions of weeds with native plants have also been studied and we have documented the ability of certain trees and large shrubs, such as wax myrtle, to control cogongrass. Integrated control methods, such as using selective herbicides applied at the optimum rates and season in combination with competitive native plants, have been tested. We are continuing to refine methods for more cost-effective weed control and establishment or restoration of native plant communities and other desirable vegetation.

Guidance Manual for Control of Nuisance and Exotic Vegetation on Reclaimed Land

The FIPR Institute and other university researchers have conducted extensive research on controlling many exotic and nuisance weeds, as well as methods for native plant establishment and for habitat management. In addition, land managers for various government agencies and non-profit organizations, plus mining industry reclamation personnel, have tried a number of approaches for controlling weeds and restoring native vegetation communities. This information is being compiled and distilled into a manual to guide practitioners toward successful management of nuisance and exotic plants and the reestablishment or restoration of native vegetation communities.

USF Polytechnic Florida Industrial and Phosphate Research Institute

1855 West Main Street

Bartow, FL 33830

(863) 534-7160

www.fipr.poly.usf.edu

Please contact us for more information on the research or programs of the FIPR Institute.