Vermont Phosphorus Innovation Challenge
Stage 1 Proposal – DVO, Inc, Chilton, WI
July 2nd, 2018
Recovery of Phosphorus from Digested Dairy Manure

The principal investigator for this project will be Dr. Michael Curtis, a member of the DVO team (and Director of Project Development at Quantum Biopower, Southington, CT). Dr. Curtis has a long - standing relationship with DVO and has facilitated and managed the development of this proposal. Dr. Curtis's contact information is Michael D Curtis, Ph.D. P.E., 49 DePaolo Drive, Southington, CT 06489 (Tel: 860-539-2698).

Abstract

DVO of Chilton Wisconsin is proposing to lead the development of a phosphorus-rich plant food which has its basis in solids separation from DVO-developed digesters in the state of Vermont. DVO has placed 13 digester vessels state-wide -- and with enhancements to solids control, will develop a product that is high in phosphorus for potential nationwide resale. Working with Cenergy, development of this plant food / phosphorus-rich soil amendment will take place following the implementation of secondary solids separation at these DVO systems. With this new product – once it is developed and tested by University of Vermont researchers, – a soil amendment will be attained that will have a verified and significant value to agriculture. Notably, the installation of enhanced phosphorus removal at Vermont dairy facilities can be facilitated primarily with private investment dollars achieving a return on (soil amendment) sales.

Project Objectives

The project objectives of these efforts are as follows:

1. To create a nationally sold plant food / phosphorus-rich soil amendment from re-capture of 'fines' from DVO digester systems in the state of Vermont.
2. To perform testing of this soil amendment at UVM, including material characterization, greenhouse grow trials (plant bioassays), and crop disease suppression tests, to scientifically test and verify the validity of claims related to product development and sale.
3. With a sufficiently high-value solid being developed, to potentially enrich the 'topline' of Vermont dairies…giving these facilities a new value - added product not in place before.
4. To create a product that would entice external investors to develop and place these secondary solids removal systems on Vermont farms, after appropriate contract development, to capture the phosphorus-rich materials and bring them to market.
5. Lastly, but importantly, to allow for precision 'fertilization' at Vermont dairies using this captured phosphorus and to lessen phosphorus loads on Lake Champlain and other water bodies.

Introduction

DVO, Inc. (Chilton, WI) working with the University of Vermont, Quantum Biopower (Southington, CT), and Cenergy (Little Rock, AR) has developed this proposal for economical phosphorus removal (P-Removal) from digested (and potentially undigested) dairy manure solids in the State of Vermont. Applications of existent, highly successful P-Removal technology will be accomplished at a variety of sites which have DVO anaerobic digesters in place. Additionally, there is an opportunity for manure from smaller farms to be conveyed to a larger farm digester.

DVO, Inc. is the leading agricultural digester technology supplier in the United States. Over 100 systems have been installed nationally, primarily at dairy facilities. Through innovative engineering and experimentation, DVO has perfected two post-digestion solids recovery steps. The first is separation of a primary "fiber" solid which has been used nationwide in development of a sustainable bedding product. The second, with 6 full-scale "Phosphorus Recovery (PR)" installations in the US (and 2 more being installed currently), consists of the separation of 'fines' using a modified Dissolved Air Floatation (M-DAF) process. These digestate treatment steps **remove 85% (or more) of phosphorus from dairy manure slurry** (http://www.dvoinc.com/phosphorus-recovery.php)**.**

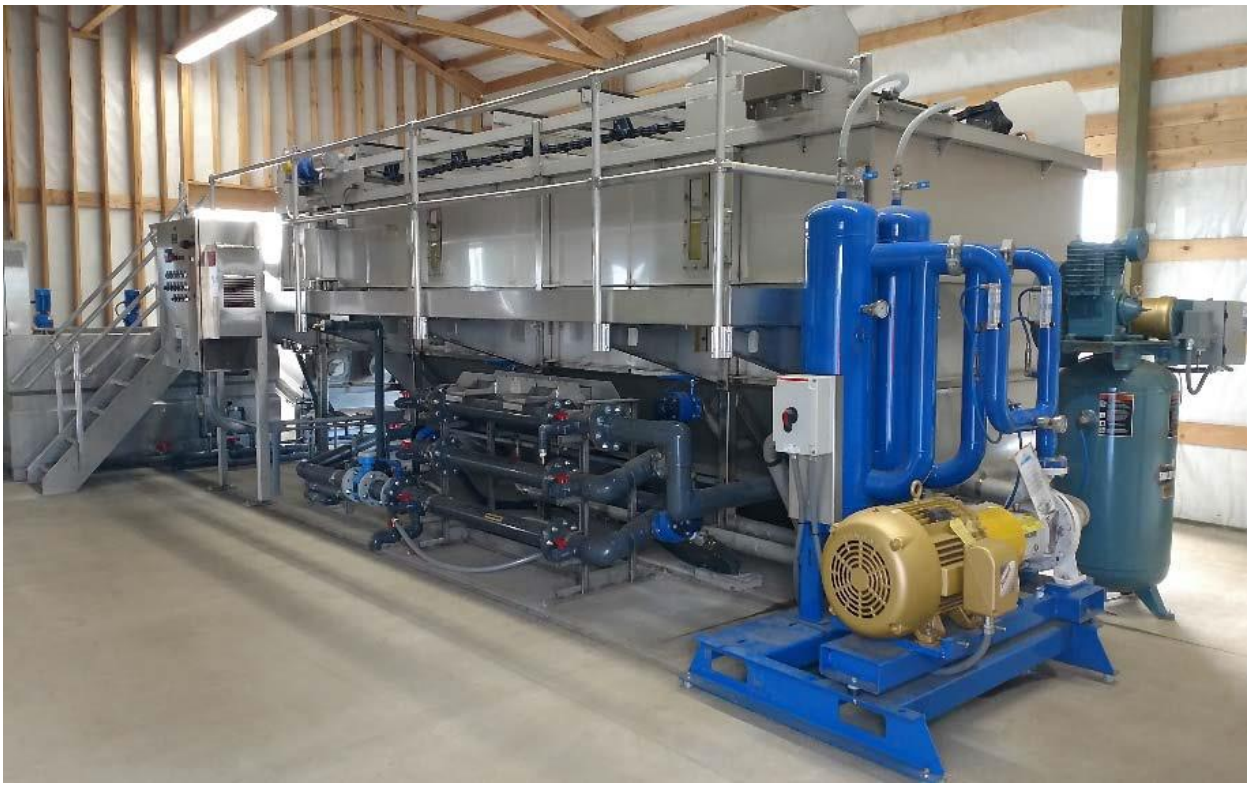


Figure 1 DVO Phosphorus Recovery System (PR)

Fiber recovery is already found at all VT digesters where DVO technology is in place. This typically results in a sustainable bedding product as well as solids for sale into commercial

markets. The principal market for these materials is with a company called Cenergy, owner of the Magic Dirt™ brand (https://www.magic-dirt.com/). Magic Dirt already sells nationwide and is a product in very high demand. The DVO "PR" system, will produce a plant food material. This material, a phosphorus cake, is being developed as a commercial product by Cenergy. Importantly, Blue Spruce Farms of Bridport, VT has begun the process of installing DVO's "PR" system **establishing the first site in VT for enhanced manure Phosphorus control**.

Figure 2 Dried Solids from DVO's "PR" treatment step (dried)

Cenergy, working with DVO to develop the Magic Dirt™ brand, has enjoyed immense success at a multinational retail company (Walmart). Magic Dirt™, all of which comes from primary dairy solids separation at DVO digesters, is sold at over 2,000 Walmart's nationally and has consistently increased in sales in the 3 years since product introduction. Cenergy is now developing new soils/soil amendments for introduction into what will be a 'suite' of products. This suite of products will include Secondary solids from DVO systems (Plant Food) as well as other products. While still in development, it is believed that this product incorporating recovered phosphorus from dairy wastes will be quite valuable in both consumer and commercial fertilizer spaces. Cenergy is working with Walmart to attempt to bring these new products to its retail establishments. **They have already achieved success in bringing digester solids to the marketplace**. We look to leverage this success in Vermont.

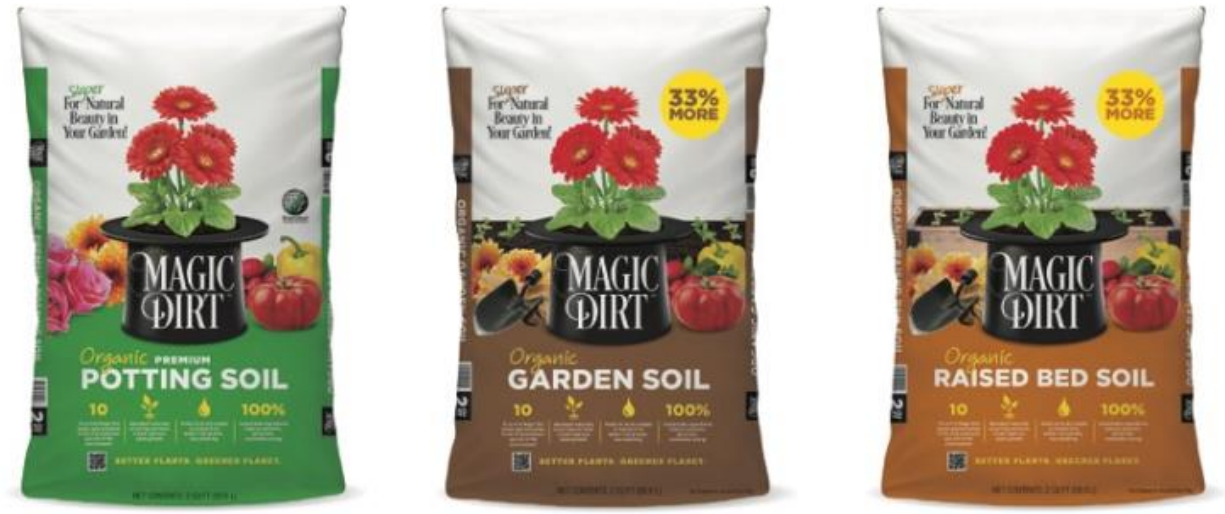


Figure 3 Sample products by Magic-Dirt

UVM scientists will work closely with this development group to verify and validate the 'grow-effectiveness' of this material in use in testing over the time period associated with prototype development. This combination of expanding manure phosphorus-rich solids separation and proving its effectiveness as a plant food will result in unique offering to the State of Vermont Agency of Natural Resources in pursuit of the Vermont Phosphorus Innovation Challenge.

As a basis of product development, we are proposing to work with Dr. Deborah Neher, Dr. Eric Roy and Dr. Joshua Faulkner, UVM scientists in soil nutrition and agricultural extension to perform grow-testing of our proposed product and to achieve certain milestones and certifications for the Plant Food product. These individuals will undertake/oversee greenhouse testing of these materials in the allotted time frame for prototype development detailed under the VPIC timelines in previously received documents.

Lastly, Quantum Biopower is the capital group for the project. After successful product development results, Quantum could capitalize 100% of Secondary Solids removal systems. Complete success would mean that State of Vermont/taxpayer expenditures, beyond initial stages of this effort, could be **zero** in their pursuit and development of phosphorus removal goals.

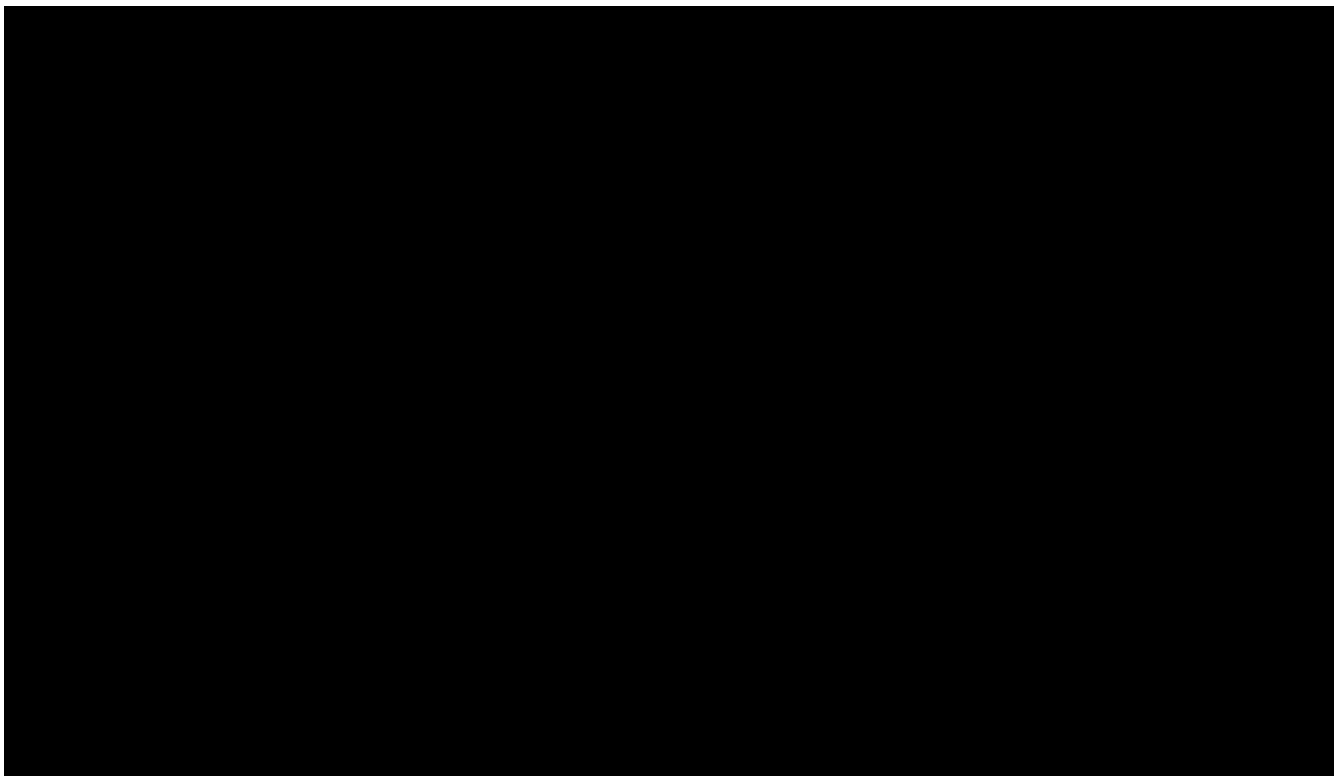
Existent Technology

DVO is an international leader in dairy/agricultural manure digestion, nutrient control and recapture. They have developed and refined, through award-winning innovation, the ability to capture nutrients from a variety of agricultural-based manures. In the dairy field, they have long practiced primary solids separation which has resulted in a bedding product. This product can immediately replace a purchased bedding with a sustainable fiber-based bedding system.

Their new secondary solids removal technology, with a growing number of installations (six systems in place, & several more in development nationwide) has been shown to capture, on average, 85-90% of the phosphorus from a dairy manure digestate. This results in the **segregation and re-capture** of phosphorus into a 'cake' product, which, when pressed, is the subject matter of the proposed product development. The following is a table showing the effectiveness of the DVO primary and secondary solids control related to nutrient reduction. As shown, from scrape and flushed systems, 85 to 90% (plus) phosphorus removal is accomplished on average at DVO digestate/solids removal system:

DVO, Inc Technology
Nutrient Reductions Accomplished with Solids Management

CONFIDENTIAL - PHOSPHORUS RECOVERY (PR)
DVO - SECONDARY SOLIDS PROCESS



For dairy waste the NPK ratio is approximately 3 – 1.5 - 1.7, representing a soil amendment/ plant food with the ability to supply an organic, sustainable, slow-release nutrient to crops.

There are 12 DVO digester sites with 13 total vessels in the state of Vermont. With installation of DVO's secondary solids removal system at these sites – made possible by a "grow study" that preconfirms the value of these solids to 3rd-party investors – these dairy's collective *treated* fiber + fine/secondary solids output (combined) would be in excess 200,000 TONS annually. And Vermont will then have the rapid ability to *capture and precisely manage well over a million pounds of elemental phosphorus every year.**

Cenergy, Inc., the creator of Magic Dirt™ has worked with DVO for a number of years in the exclusive development of the Magic Dirt™ product line. Through trial and error, a highly innovative organic 'peat replacement' was developed from primary fiber separation from DVO technology digesters. Cenergy is currently working with the DVO and on its own to develop a suite of new products including a Plant Food, consisting primarily of phosphorus recovery cake from DVO secondary solids separation systems.

* Dry weight basis (DWB). P as P_2O_5

Magic Dirt is a commercial product sold at over 2,000 Walmart stores throughout the United States. The popularity of the product is such that it typically sells out in early season and awaits the development of new inputs to replenish shelves. Cenergy is working with Walmart to create a Plant Food product, as detailed prior, consisting primarily of phosphorus recovery cake from phosphorus DVO secondary solids separation systems. The projected value of this Plant Food is appreciable.

Prototype Development through Grow-Testing

As amply detailed, highly-effective manure P-control technology has been developed by DVO. It has been perfected and is being deployed nationally to capture and better manage phosphorus from digested dairy manure. The basis of the VPIC proposal is to perform Product Grow-testing at UVM, assessing the effectiveness of the Phosphorus-rich Plant Food materials in supplying sustainable / re-captured nutrients and micronutrients to separate plant crops. **Prototype development** for the VPIC proposal consists of proving that the developed Plant Food enhances plant growth and can be developed into a Vermont-based product. Initial testing detailed below will be expanded in scope in 2019 but will consist of the following.

Material Characterization

The M-DAF P-cake granules, two novel plant foods containing these granules, and a suitable popular market alternative will undergo standard soil amendment testing for bulk density, pH, conductivity, TS, TVS, NO_3-N, NH_4-N, total C, total N, TKN, total P, K, Mg, Ca, B, Cu, Fe, Mn, and Zn at the University of Maine Soil Testing Lab. Further testing of the granules and soil amendments at UVM will be performed in the lab of Dr. Eric Roy to determine inorganic P, organic P, water extractable P, 2% citric acid extractable P, and Olsen-P. The latter three phosphorus tests collectively indicate phosphorus solubility over shorter and longer time scales in soils across a range of soil pH levels (Brod et al. 2015).

Plant Bioassays

Plant bioassays will be performed to compare the two novel plant foods as sole fertilizer sources with a suitable popular market alternative (e.g., Nature's Care). All tests will be conducted in the UVM Greenhouse Facility on Main Campus at 95 Carrigan Drive in Burlington, Vermont (https://www.uvm.edu/~grnhouse/?Page=facilities.html&SM=facilitiesmenu.html). A 75:25 peat:perlite base substrate will be used with soil amendments added to displace peat at 0, 2, 4, 6, 8, 10, and 12% v/v. Seedlings of Tomato ('Celebrity'), Pepper ('Lady Bell'), Petunia ('Bravo White'), and Marigold ('Janie') will be grown in 50 plug tray cells per plant-recipe combination. Cells will be misted up to four times per day to ensure adequate moisture until seedlings have established. After germination plants will be watered as needed. After 4 weeks, seedlings will be harvested and weighed to determine fresh weight. In addition to biomass, germination rate, days to emergence, plant height, and root:shoot ratios will be measured. The experiment will also be documented with photos.

Disease Suppression Potential

The novel plant foods can potentially also provide value in the form of pathogen/disease suppression. To test this, a plate competition assay method employed previously by UVM project collaborator, Dr. Deb Neher (Neher et al. 2017), will be used to examine suppression of *Rhizoctonia solani*, one of the most important pathogens on crop plants (Strange and Scott 2005). A half gram of each soil amendment (the two test plant foods and a suitable popular market alternative) will be added to 50 mL of sterile water and shaken overnight. The following day, 1.5 g agar will be added to 50 mL deionized water and autoclaved for 30 minutes, then cooled to 55°C, mixed in with the soil amendment water extract, swirled gently to mix, and poured into 100 mm x 15 mm plastic petri plates. Twenty-four hours later, plugs of *Rhizoctonia solani* growing on potato dextrose agar will be transferred onto the soil amendment water extract plates, and pure water agar plates will be used as a control. Plates will be incubated for 24 h at room temperature. Afterwards, the mycelium radius will be measured to the nearest 1 mm using a microscope. Three of the longest radii will be recorded, and the mean will be used as a representative measure to compare suppressive potential among different soil amendment samples (each tested 5 times in replicate). All measurements will be standardized against the control of mean mycelium radial growth on water agar (also tested 5 times in replicate).

Budget

It is anticipated that the vast majority of the budget will be spent at UVM for testing of the plant food / phosphorus-rich soil amendment product. A series of bioassays will be performed looking at critical concentration of these materials in a matrix testing approach. This testing scope detailed above is shown in the budget line item following.

Proposed budget VPIC Grant Proposal DVO, Inc	
UVM Testing: (grow testing consistent with above scope)	**$40,500**
Travel: Steve Dvorak, Bob Joblin (Cenergy), Michael Curtis (Quantum Biopower)	**$8,500**
Shipping: (phosphorus cake, other)	**$1,000**
Total	**$50,000.00**

Project team

The proposed project team for this effort is uniquely qualified to develop a commercial product and which results in precise application of phosphorus in Vermont agricultural soils as well as the potential export of phosphorus from the state given its capture in dairy digester

systems. The project lead will be DVO, Inc of Chilton Wisconsin. Mr. Steve Dvorak will lead the effort and work with Dr. Michael Curtis, the project manager working at Quantum Biopower to facilitate and develop the testing related to this proposal. UVM professionals, consisting of nationally renowned soil and agricultural scientists will develop and perform the testing protocol for this and future efforts. Lastly, Mr. Robert Joblin of Cenergy / Magic Dirt™ will be the commercial advisor related to the development of these soils as a commercial product. As detailed prior, Mr. Joblin has developed the highly innovative product Magic Dirt™ and is working to develop a suite of new products, all developed from agricultural dairy origins. Bios for key individuals follow and resumes are attached following this proposal.

Stephen Dvorak, P.E. – President, DVO, Inc. – Project Director

Stephen Dvorak, P.E., obtained a degree in Industrial/Mechanical Engineering from the University of Wisconsin-Madison. Upon graduation, Stephen joined the MBA program at Madison. He earned his Professional Engineer designation in 1977.

In 1989, Stephen founded an environmental engineering firm, known today as DVO, Inc (formerly known as GHD, Inc.). Since 2001, DVO has designed and built its market-leading, patented Two-Stage Linear Vortex^{TM} anaerobic digester systems across the nation, processing a wide array of feedstocks including dairy, swine and poultry manure, as well as food, food processing and slaughterhouse waste. DVO has 13 anaerobic vessels operating in VT and is the largest anaerobic digester developer in the United States, having designed and installed roughly 120 digesters in 19 states. In addition, DVO has expanded abroad, with international projects in Australia, Canada, Chile, China, Serbia and South Korea.

Michael D. Curtis, Ph.D., P.E. – Project Manager

Dr. Curtis is the Director of Project Development at Quantum Biopower, an Anaerobic Digester development company located in Southington, CT. Prior to Quantum, he spent 26 years at Fuss & O'Neill Consulting Engineers of Manchester, CT. At Quantum, Dr. Curtis has and is developing numerous AD systems, ranging from AG-based co-digestion systems to others co-digesting biosolids and SSO's. At F&O, Dr. Curtis was the Executive Vice President of Strategic Development and he led a staff of 100 professionals in 8 different business units. His background includes five years with the Connecticut DEP Bureau of Water Management's Planning Section followed by two years at the University of Connecticut Civil Engineering Department. His work touches nearly all aspects of the AD field, ranging from process efforts to optimizing energy and solids offtake and sales.

As a graduate from the University of Connecticut, he holds a BS in Biology, an MS in Civil Engineering and a Ph.D. in Environmental Engineering.

Dr. Eric Roy – UVM Lead Researcher

Dr. Eric Roy is an Assistant Professor in the Rubenstein School of Environment & Natural Resources, a Fellow in the Gund Institute for Environment, and Co-founder of the Recycling

Organics and Resources (ROAR) Research Group at the University of Vermont. He leads the Nutrient Cycling and Ecological Design Lab at UVM, focusing on three important themes in nutrient stewardship: nutrient use efficiency in food systems, nutrient recovery and reuse, and nature-based solutions/green infrastructure. Dr. Roy is a biogeochemist and ecological engineer by training, with extensive experience studying phosphorus dynamics in water, soils, waste management systems, and agriculture. He holds a B.S. in Mechanical Engineering from Old Dominion University, an M.S. in Food, Agricultural and Biological Engineering from The Ohio State University, and a Ph.D. in Coastal Sciences (nutrient biogeochemistry focus).

Dr. Deborah Neher

Dr. Deborah Neher is a Professor in the Department of Plant and Soil Science, an affiliate in Food Systems and the Gund Institute for Environment, and Co-founder of the Recycling Organics and Resources (ROAR) Research Group at the University of Vermont. Dr. Neher brings over 25 years of experience as a researcher, educator, and graduate student mentor. She leads the Soil Ecology and Biological Indicators Laboratory at UVM, with research interests in developing biological indicators for environmental monitoring of soils. Her recent focus is on the microbiology of composts with the goal of developing value-added products that foster a beneficial microbiome to suppress disease on plants and animals. Dr. Neher is a soil ecologist with formal education in plant pathology, plant population ecology, and environmental science. Her publications span topics of biological indicators of soil, ecotoxicology and biotechnology risk assessment, plant pathology and sustainable agriculture.

Robert Joblin

Robert Joblin is the President of Cenergy USA and Co-Manager of Magic Dirt Horticultural Products, LLC. Cenergy is a fee developer and financial advisor for energy efficient and renewable energy projects, including geothermal HVAC, fuel cell and biomass. Cenergy's first anaerobic digester project on a dairy has been in constant operation since January 2009.

At Magic Dirt, Mr. Joblin is an inventor and patent holder for two products. Magic Dirt is five-year-old company that repurposes digester waste into sustainable and organic horticultural products. Its first product, a patented organic premium potting soil, has been named Innovation of the Year in international competition at the World BioProducts Conference and by the American Biogas Council. In 2018, Magic Dirt received a National Sustainability Award for its work with dairies across the U.S. and Walmart from the Innovation Center for U.S. Dairy.

Throughout Mr. Joblin's career, he has owned and operated a development and management company; co-founded a hospitality chain and taught at a historical black college. Mr. Joblin has also served as a consultant to various lending institutions such as, the Federal Deposit Insurance Corporation, the Resolution Trust and the Tourism Ministry of Spain.

Bob Joblin is a writer and Fellow of the National Endowment for the Arts. He is a graduate of the University of Arkansas and was commissioned in the U.S. Army.

Conclusion

In conclusion, the project team does not have a ***projected ability*** to recover phosphorus (primary criteria one). It has a ***proven ability*** to recover 85 – 90% of phosphorus from digested dairy manure. We offer the following, addressing additional judging criteria.

1. When the value of the plant food / phosphorus-rich soil amendment is developed, consistent with current professional judgment, the cost effectiveness of phosphorus removal will be quite high. It is envisioned that **No Public Monies** will be required if projected soil value numbers are achieved. Private investment will drive the removal of phosphorus from dairy systems with **no cost seen** to the state of Vermont.
2. The strength of the project team is unmatched. The combination of entrepreneurs, scientists and proven technologist is likely unmatched by any other proposal developed in response to the VPIC.
3. Project feasibility has been proven at multiple full-scale sites throughout the nation. The phosphorus removal effectiveness of the technology is not in question and has received numerous national awards for innovation and environmental control. The feasibility to develop this material as a high-value product is notable. Cenergy has developed a comparable product, Magic Dirt™ as a nationwide best-seller. It is our true belief that the Plant Food product derived from secondary solids at dairy systems will follow suit with Magic Dirt.
4. The constructability of these systems has been demonstrated nationwide. Cost-effectiveness of the M-DAF system has been proven. The first of such systems in VT will be delivered in 2018. Current solids pickup routes are already in place in the state of Vermont as a few Vermont farms supply primary solids to Magic Dirt. Bagging facilities located nearby will work with Cenergy to enhance the brand of the product and deliver of product in a regional roll-out at regional Walmart stores.
5. The maintenance requirement of these systems are known to be low. In the full-scale systems placed to date, **none** have external or dedicated operators. Instead, **all** are operated by farm personnel who also have other important duties to attend to.
6. The project defines a sustainable approach for phosphorus capture and reuse. And, lastly, it is believed that with successful product development, external sources of funding will be abundant to provide secondary solid removal systems at existing sites in Vermont.

As an aside and in conclusion, it has been projected, in systems being developed in the southern New England, that the value of soils will complement the value of dairy products produced at an individual farm.

Appendix

Resumes

STEPHEN W. DVORAK, P.E.

Education:

B.S. Industrial Engineering, University of Wisconsin- Madison, 1972
M.B.A. Program, University of Wisconsin-Madison, attended 1972

Certifications & Qualifications:

Registered Professional Engineer (#E-16461), State of Wisconsin, 1977 NRCS Technical Service Provider

Employment History:

DVO, Inc. (formerly GHD, Inc.), Chilton, WI
President / Senior Engineer, 1989 to Present D&D Equipment Co., Inc., Chilton, WI
President/General Manager, 1978 to Present Packerland Packing Co., Green Bay, WI
Corporate Engineer, 1975 to 1978 Packerland Packing Co., Chippewa Falls, WI
President, 1973 to 1975

Affiliations:

National Society of Professional Engineers (NSPE)
Wisconsin Society of Professional Engineers (WSPE)
American Biogas Council (ABC)

Experience:

Mr. Dvorak, a Professional Engineer, established the environmental engineering firm DVO, Inc. (formerly GHD, Inc.) in 1989. Initially, DVO's operations involved underground storage tank (UST) integrity testing, UST removal, site investigations, and soil and groundwater remediation activities. Mr. Dvorak provided the Professional Engineering expertise for the evaluation and design of remedial options, as well as project costs.

Mr. Dvorak has also consulted to the food industry, and more specifically to the food wastewater treatment industry, since his experience at Packerland Packing Co. In 1985, Mr.

Dvorak consulted on the design of Packerland Packing's anaerobic digester, the first digester in the state of Wisconsin and one that is still in operation today.

In the late 1990's, Mr. Dvorak became actively involved in the study and design research of the application of anaerobic digestion for animal waste manure. He began researching and developing his patented Two-Stage Linear Vortex™ anaerobic digester system. His first digester system was built in 2001 at Gordondale Farms in Nelsonville, Wisconsin. Since then, DVO has grown to become the largest anaerobic digester developer in the US, having installed Dvorak's patented anaerobic digester system at over 80 sites nationwide, handling the waste of more than 250,000 cows. Since 2003, DVO has also helped more than 70 farmers across the country obtain a USDA REAP/Rural Development Renewable Energy Grant.

DVO is also doing business internationally, with operating digesters in Canada, Chile, China, Serbia, and South Korea, along with digester projects under construction in Australia and elsewhere.

MICHAEL D. CURTIS, Ph.D., P.E.
Director – Project Development
Quantum Biopower – Southington, CT

Education

B.S. Biology – University of Connecticut – 1976
M.S Environmental Engineering – University of Connecticut – 1980
Ph.D. Environmental Engineering – University of Connecticut - 1987

Quantum Biopower – Southington, CT

Dr. Michael Curtis is the Director of Project Development at Quantum Biopower, a merchant Anaerobic Digester development company located in Southington, CT. His work has and still includes several projects, research and business startups in energy-related technologies. At Quantum, Dr. Curtis has and is developing numerous AD systems, ranging from AG-based co-digestion systems to others co-digesting biosolids and SSO's. His work touches nearly all aspects of the AD field, ranging from process efforts to optimizing energy and solids offtake and sales.

Nerac, Inc – Tolland, CT

Prior to Quantum, Dr. Curtis worked at Nerac, Inc. of Tolland, CT as a Sr. Consulting Engineer. Nerac is a research / information group and Dr. Curtis brings extensive, synergistic water and energy expertise to Nerac. At Nerac, he worked with clients in these fields and is supplying strategic information in technology development and regulatory strategy.

Startups and Entrepreneurial Pursuits

Dr. Curtis is the former CEO of the company, Simplified Energy Solutions (SES), an Engineering / Service Company located in Norwich CT. Prior to SES, he co-founded, with Joel Douglas, Engineered Carbon Solutions and Loon Medical, Inc, a product development and firms in the energy and medical arena where he was 'interim CEO' from February, 2015 to July, 2015.

In addition to these firms, Dr. Curtis is part of other technology start-ups in the energy field, ranging from an exciting new micro Combined Heat and Power company, Enviro Power to development of sophisticated, 'purposed' battery systems at SES. His role as an energy entrepreneur with extensive contacts in the northeast is well known and the basis of his strong relationships with Siemens, Schneider Electric, Fuel Cell Energy, (formerly) UTC Power, Hydro Holdings, Titan Energy and numerous municipal and industrial concerns.

Teaching

Dr. Curtis has maintained teaching positions at UConn – School of Engineering and Trinity College (Department of Economics). At UConn – he has participated / been a visiting professor in undergraduate, graduate and Senior Class Design efforts. At Trinity, he has taught courses in Entrepreneurship for the Department of Economics from Fall, 2012 through the present.

Fuss & O'Neill, Inc.

Before SES, Dr. Curtis was the Executive Vice President and Director of Strategic Initiatives at Fuss & O'Neill (F&O), a 300-person firm in Manchester, CT. His role evolved over the years from Project Manager in the Industrial Services Group to Director of Strategic Development, leading the firm in new ventures, startups and direction. While at F&O he grew a sizable, nationally-known industrial service group, starting as an Environmental Health and Safety (EH&S) compliance-oriented practice; driving growth in this market sector to a point where it is Fuss &'Neill's largest business practice.

Over 26 years at F&O, particularly the latter half, Dr. Curtis hired approximately 20% of current F&O employees and participated in the hiring of at least as many. Senior employees hired by Dr. Curtis currently manage approximately 60% of the total billings at the firm. He managed over $250M worth of engineering and construction projects and grew the industrial service group from 2 to 60 employees. Many construction efforts evolved from designs performed by F&O with very constrained end-points (i.e. environmental compliance and fire safety). His business and project management skills were publicly recognized with his induction to the UConn School of Engineering Distinguished Alumni Society, a prestigious honor shared by only a few dozen individuals.

Eric D. Roy

www.nced.weebly.com

Professional Preparation

Old Dominion University	Mechanical Engineering	B.S.	2006
Ohio State University	Food, Agricultural & Biological Engineering	M.S.	2008
Louisiana State University	Oceanography & Coastal Sciences	Ph.D.	2013
Brown University	Biogeochemistry	Post-doc	2014-15

Recent Appointments

2018-present, Fellow, Gund Institute for Environment, University of Vermont, Burlington, VT.
2016-present, Assistant Professor of Environmental Sciences, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT.
2014-2015, Voss Postdoctoral Fellow, Institute at Brown for Environment and Society, Brown University, Providence, RI.
2014, Environmental Scientist, Comite Resources, Inc., Baton Rouge, LA.

Synergistic Activities

Active research agenda examining phosphorus and nitrogen dynamics in ecosystems, food systems, and waste management systems, including ecological design approaches to nutrient management. Past research includes lab measurements and experimentation (nutrient characterization in soils, sediments, and organic residuals; grow trials; sorption isotherms; phosphorus fractionation; phosphatase enzyme activity; mineralization; nutrient fluxes at sediment-water interface; water quality measurements; and more), ecosystem field studies, watershed-scale modeling, & regional and national assessment using GIS. Co-founded UVM Recycling Organics and Resources (ROAR) research group with Drs. Deb Neher and Meredith Niles. Member of the Vermont Dairy and Water Collaborative. Teaching at UVM has included Ecological Design & Living Technologies, Advanced Ecological Design, & Ecological Design in an Urban Watershed.

Research Projects at UVM

2019-2020 **Roy, E.D. (PI)**, B. Bowden, J. Hecht. Quantifying phosphorus retention in restored riparian wetlands of the Lake Champlain Basin. $115,000. *Lake Champlain Basin Program*.

2018-2019 **Roy, E.D. (PI)**, C. Koliba. Resource recovery and reuse to support phosphorus management and sustainable development goals in Sri Lanka. REACH Award, *UVM Office of the Vice President for Research,* $29,999.

2018-2019 Niles, M.T. (Co-PI), and **E.D. Roy (Co-PI)**. Identifying nitrogen hotspots in the United States to improve nitrogen management through farmer incentive programs. Catalyst Award, *Gund Institute of Environment, University of Vermont*. $35,973.

2018-2020 Hurley, S. (PI), and **E.D. Roy (Co-PI)**. Application of Drinking Water Treatment Residuals in Green Stormwater Infrastructure for Enhanced Phosphorus Removal. *U.S. EPA RARE Program* (EPA ORD PI: Y. Yuan), $155,000.

2017-2018 Support for M.S. Student, Brendan O'Brien. Physicochemical properties of combined dairy manure and food waste digestates and their use for cultivation of *Pleurotus ostreatus*. Casella Resource Solutions, Inc., $15,000.

2016-2017 Neher, D.A. (PI), M.T. Niles (Co-PI), and **E.D. Roy (Co-PI)**. Innovations at the NEXUS of Food, Energy and Water Systems (INFEWS): An Interdisciplinary Incentive Competition. *UVM Office of the Vice President for Research*, $5,000.

Most Relevant Publications (out of 20 total publications)

Roy, E.D. 2017. Phosphorus recovery and recycling with ecological engineering: A review. *Ecological Engineering* 98: 213-227. ***Currently listed as one of the journal's Most Downloaded Articles.***

Roy, E.D., E. Willig, L.A. Martinelli, P.D. Richards, F. Ferraz Vazquez, L. Pegorini, S. Spera, & S. Porder. **2017.** Soil phosphorus sorption capacity after three decades of intensive fertilization in Mato Grosso, Brazil. *Agriculture, Ecosystems and Environment* 249: 206-214.

Roy, E. D., Nguyen, N. T., & White, J. R. **2017.** Changes in estuarine sediment phosphorus fractions during a large-scale Mississippi River diversion. *Science of the Total Environment* 609: 1248-1257.

Roy, E.D., P.D. Richards, L.A. Martinelli, L. Della Coletta, S.R. Machado Lins, F. Ferraz Vazquez, E. Willig, S. Spera, L.K. VanWey, & S. Porder. **2016.** The phosphorus cost of agricultural intensification in the tropics. *Nature Plants* 2: 16043. ***Named an Editor's Pick for Crop Science & Agronomy.***

Roy, E.D., J.R. White, & M. Seibert. **2014.** Societal phosphorus metabolism in future coastal environments: insights from recent trends in Louisiana, USA. *Global Environmental Change* 28: 1-13.

Zurita, F., **E.D. Roy**, & J.R. White. **2012**. Municipal wastewater treatment in Mexico: current status and opportunities for employing ecological treatment systems. *Environmental Technology* 33: 1151-1158.

Roy, E. D., Nguyen, N. T., Bargu, S., & White, J. R. 2012. Internal loading of phosphorus from sediments of Lake Pontchartrain (Louisiana, USA) with implications for eutrophication. *Hydrobiologia* 684: 69-82.

Media Coverage:

2018 UVM Gund Institute Press Release
2018 Interview on UVM Food Feed
2018 Interview on Vermont Public Radio's Vermont Edition
2016 UVM Press Release

Coverage of my work has also appeared in The Washington Post, Newsweek, Guardian, CBS News, Science Daily, Phys.org, Futurity, AoBBlog, High Country News, Resilience.org, Union of Concerned Scientists, Cool Green Science Blog of the Nature Conservancy, Columbus Dispatch, Digital Journal, and more

DEBORAH A. NEHER
http://www.uvm.edu/~dneher/

PROFESSIONAL PREPARATION

McPherson College	McPherson, KS	Environmental Science	B.S. Summa cum laude, 1984
University of Illinois, Urbana-Champaign	Champaign, IL	Plant Biology	M.S. 1986
University of California, Davis	Davis, CA	Plant Pathology	Ph.D. 1990
North Carolina State University, Raleigh	Raleigh, NC	Postdoctoral Research Associate	1990 - 1992

APPOINTMENTS

University of Vermont	**Professor**, Department of Plant and Soil Science	2018 - Present
University of Vermont	**Professor and Chairperson**, Department of Plant and Soil Science	2008 - 2018
University of Vermont	**Associate Professor and Chairperson**, Department of Plant and Soil Science	2004 - 2008
University of Toledo	**Associate Professor**, Department of Earth, Ecological, and Environmental Sciences	2002 - 2004
University of Toledo	**Assistant Professor**, Department of Earth, Ecological, and Environmental Sciences	1996 - 2002
University of Toledo	**Assistant Professor**, Department of Biology	1996 - 2000
North Carolina State University, Raleigh	**Visiting Assistant Professor**, Department of Plant Pathology	1993 - 1996

SYNERGISTIC ACTIVITIES

- Co-founded UVM Recycling Organics and Resources (ROAR) research group with Drs. Eric Roy and Meredith Niles. PI on seed grants from *Northeastern Experiment Station Directors* Planning Grant, $10,000 and *UVM Office of the Vice President for Research* Innovations at the NEXUS of Food, Energy and Water Systems (INFEWS): An Interdisciplinary Incentive Competition, $5,000.
- As department chair, recruited and mentored 6 tenure-track faculty, served 6 years designing plant science building, provided leadership for development of curriculum and programs at undergraduate and graduate level in food systems and agroecology, advised majors in ecological agriculture and environmental science.

- Subject Editor for *Ecological Applications*, Associate Editor for *Agroecology and Sustainable Food Systems*, ad-hoc reviewer of an average of 35 articles for publication in peer-reviewed journals per year, and ad-hoc reviewer for NSF, USDA, and DOE grant panels.
- Conducted nematode community surveys for a wide range of ecosystems and quantified statistical rigor necessary to 'characterize' nematode communities in regional biodiversity surveys, which provided basis for inclusion of nematodes as a measure of farmland soil biological condition in *The State of the Nation's Ecosystems* report (2000-2008).
- Professional Leadership: *Organization of Nematologists for Tropical Americas*, President (2017-present), Vice President and Scientific Program Chair (2016-2017).

Extramural Research Grants within the past five years:

1. **Neher, D.A.** Soil Health Institute, Cooperative Agreement, Research landscape tool: multi-decadal annotated soil biology bibliography, 7/1/17-6/30/18, $55,440.
2. Barlow, J. and **Neher, D.A.** Dairy Center of Excellence, USDA HATCH Project VT-H02203 (Accession number 1006686), Integrated bedded pack management and fly control reduce mastitis risk by promoting a beneficial teat skin microbiome, 5/1/15-5/31/18, $149,971.
3. **Neher, D.A.** Vermont Agricultural Experiment Station Competitive Hatch Program VT-H02110MS, Designing compost for disease suppression on specialty crops, 10/1/14-9/30/19, $103,000.
4. **Neher, D.A.,** and Donnelly, C. United States Department of Agriculture, Agriculture Research Service, Specific Cooperative Agreement 58-1245-4-110, Persistence of enteric pathogens in manure-amended soils in northeast U.S. produce-growing environments, 9/29/14-8/30/18, $500,000.

Most Relevant Publications (out of 97 total publications, †: denotes advisee author)

1. Conrad, Z., Niles, M., **Neher, D. A.**, Roy, E. D., Tichenor, N. E., and Jahns, L. 2018. Relationship between diet quality, food waste, and environmental sustainability. ***PloS ONE*** 13(4):e0195405. doi.org/10.1371/journal.pone.0195405.
2. **Neher, D. A.**, Fang, L.†, and Weicht, T. R. 2017. Ecoenzymes as indicators of compost to suppress *Rhizoctonia solani.* ***Compost Science and Utilization*** 25(4): 251-261. DOI 10.1080/1065657X.2017.1300548.
3. **Neher, D. A.**, Williams, K. M.†, and Lovell, S. T. 2017. Environmental indicators reflective of road design in a forested landscape. ***Ecosphere*** 8(3):e01734. 10.1002/ecs2.1734.
4. Bakelaar, J.E.†, **Neher, D.A.,** and Gilker, R. 2016. Minimal soil impact by cold season pasture management in Vermont. ***Canadian Journal of Soil Science*** 97(2): 215-225. DOI 10.1139/CJSS-2014-0005.
5. **Neher, D.A.,** Weicht, T.R., and Dunseith, P.† 2015. Compost for management of weed seeds, pathogen, and early blight on brassicas in organic farmer fields. ***Agroecology and Sustainable Food Systems*** 39:3-18.

6. **Neher, D.A.,** Weicht, T.R., Bates, S.T., Leff, J.W., and Fierer, N. 2013. Changes in bacterial and fungal communities across compost recipes, preparation methods, and composting times. ***PLoS ONE*** 8(11):e79512, DOI: 10.1371/journal.pone.0079512.
7. **Neher, D.A.**, Asmussen, D. †, and Lovell, S.T. 2013. Roads in northern hardwood forests affect adjacent plant communities and soil chemistry in proportion to maintained roadside area. ***Science of the Total Environment***. 449: 320-327.
8. Lawhorn, C.N.†, **Neher, D.A.**, and Dively, G.P. 2009. Impact of coleopteran targeting toxin (Cry3Bb1) of Bt corn on microbially mediated decomposition. ***Applied Soil Ecology*** 41: 364-368.

Joshua W. Faulkner, Ph.D.
University of Vermont Extension Center for Sustainable Agriculture
105 Jeffords Hall, 63 Carrigan Dr., Burlington, VT 05405
802-656-3495, joshua.faulkner@uvm.edu

Education

PhD, Cornell University (2009), Biological & Environmental Engineering, Soil and Water Concentration

MS, Cornell University (2005), Agricultural & Biological Engineering, Soil and Water Concentration

BS, Virginia Tech (2003), Biological Systems Engineering, Land and Water Resources Option

Experience

2013-Present Farming and Climate Change Program Coordinator, University of Vermont Extension Center for Sustainable Agriculture
Adjunct Assistant Professor, University of Vermont Department of Plant and Soil Science

2009-2013 Extension Assistant Professor and Agricultural Engineering Specialist, West Virginia University, Agriculture and Natural Resources Extension Unit

2010-2013 Regular Graduate Faculty Member, West Virginia University, Davis College of Agriculture, Natural Resources & Design

Publications (peer-reviewed)

Christianson, L., D. DeVallance, J.W. Faulkner, T. Basden. 2017. Scientifically advanced woody media for improved water quality from livestock woodchip heavy-use areas. *Frontiers of Environmental Science and Engineering* 11(3):1-9.

Faulkner, J.W., J.L. Miller, T.J. Basden, D.B. DeVallance. 2015. Woodchip heavy-use area effluent quality, quantity, and hydrologic design considerations. *Applied Engineering in Agriculture.* 31(5):783-790.

Faulkner, J.W., W. Zhang, L.D. Geohring, T.S. Steenhuis. 2011. Tracer movement through paired vegetative treatment areas receiving silage bunker runoff. *Journal of Soil and Water Conservation.* 66(1):18-28.

Faulkner, J.W., W. Zhang, L.D. Geohring, T.S. Steenhuis. 2011. Nutrient transport within three vegetative treatment areas receiving silage bunker runoff. *J Env Mngmt.* 92(3):587-595.

Faulkner, J.W., Z.M. Easton, W. Zhang, L.D. Geohring, T.S. Steenhuis. 2010. Design and risk assessment tool for vegetative treatment areas receiving agricultural wastewater: Preliminary results. *Journal of Environmental Management.* 91(8):1794-1801.

Zhang, W, J.W. Faulkner, S.K. Giri, L.D. Geohring, T.S. Steenhuis. 2010. Effect of soil reduction on phosphorus sorption of an organic-rich silt loam. *Soil Sci Soc Am J.* 74(1):240-249.

Zhang, W, J.W. Faulkner, S.K. Giri, L.D. Geohring, T.S. Steenhuis. 2009. Evaluation of two Langmuir models for phosphorus sorption of P-enriched soils in New York for environmental applications. *Soil Science.* 174(10):523-530.

Funding Awarded

Development of an Approach and Tool to Optimize Farm-Scale Phosphorus Management and Achieve Watershed Scale Loading Targets, (Co-PI), Lake Champlain Basin Program, 2017-2018, ($189,945)

The Next Generation of Controlled Drainage for Preventing Tile Phosphorus Loss, (PI), Vermont Agency of Agriculture Clean Water Initiative Grant, 2017-2019 ($46,106)

The Climate Adaptation Fellowship: A Collaborative Design Project, (PD), USDA-NIFA Agriculture and Food Research Initiative, 2017-2018 ($248,959).

Revising and Implementing Phosphorus Indices to Protect Water Quality in the Northeastern US, (Co-PI), USDA-NRCS Conservation Innovation Grant, 2016-2019 ($45,000)

Revision of the Vermont Phosphorus Index for Improved Nutrient Management and Water Quality, (PI), USDA-NRCS Vermont Conservation Innovation Grant, 2016 ($74,996)

Increasing Ecosystem Services and Climate Change Resilience in Dominant Agroecosystems of the Northeast, (PI), USDA-NIFA Agriculture and Food Research Initiative Foundational Program, 2015-2019 ($499,810)

What Lurks Below: How Important are Subsurface Flows of Nitrogen and Phosphorus?, (Co-PI), Vermont EPSCoR Pilot Award, 2014-2015 ($9,999)

Linking bench-scale evaluation and field-scale application of thermally-treated biomass media in livestock heavy-use areas for reducing environmental impacts of agriculture, (PI), WVU Faculty Senate Research Grants, 2013-2014 ($31,495)

Refining and Harmonizing Phosphorus Indices in the Chesapeake Bay Region to Improve Critical Source Area Identification and to Address Nutrient Management Priorities, (Co-PI), USDA-NRCS Conservation Innovation Grant, 2012-2015 ($801,535)

Development of 21st Century Agriculture for Water Quality Protection, (Co-PI), USDA-NIFA Agriculture and Food Research Initiative (AFRI) Program, 2012-2015 ($466,000)

Revision and Update of West Virginia's Phosphorus Site Index, (Co-PI), US-EPA Chesapeake Bay Program Chesapeake Bay Implementation Grant, 2011-2012 ($83,000)

REFERENCES

Brod, E., Øgaard, A. F., Haraldsen, T. K., & Krogstad, T. (2015). Waste products as alternative phosphorus fertilisers part II: predicting P fertilisation effects by chemical extraction. Nutrient Cycling in Agroecosystems, 103(2), 187-199.

Neher, D. A., Fang, L., & Weicht, T. R. (2017). Ecoenzymes as Indicators of Compost to Suppress Rhizoctonia Solani. Compost Science & Utilization, 25(4), 251-261.

Strange, R. N., & Scott, P. R. (2005). Plant disease: a threat to global food security. Annual Review of Phytopathology, 43.