

Agrilab Technologies Inc.

Vermont Phosphorus Innovation Challenge (VPIC)

Reverse Pitch Response July 2018

Title: Integrating Technologies to Achieve Economical Phosphorus Removal and Redistribution

Contact information for Principal Investigator:

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Project overview or abstract: (100 word count);

Agrilab Technologies Inc. (AGT) proposes to use the combination of existing phosphorus (P) recovery technologies, composting and drying equipment, and associated best management practices to demonstrate the technical feasibility of stabilizing and adding value to recovered P cake and similar materials. Concurrently the project team will conduct market research and develop a business model for multiple P-products, including a sales and distribution plan. Identifying facility infrastructure needs and geographical distribution requirements will be a key piece of determining implementation costs and the related cost per pound of P captured and measurably redistributed from surface water pollution loading.

Description of project objectives:

AGT intends to accomplish several important objectives through selected demonstrations and development of economic assessments and a refined business model. These include physical demonstrations/prototypes of composting, drying and blending practices to stabilize and add value to phosphorus concentrates from multiple sources. The key objective is to identify the most promising set of renewable P-based products from Vermont dairy manure, biomass and other residuals.

The project objectives in this VPIC Stage II ultimately are focused on answering both technical and economic feasibility questions. They are intended to inform the implementation of efficient P redistribution strategies and how to proceed on a phased development of on-farm and centralized facilities in Vermont. Stage III implementation efforts in 2019 are in conceptual form and will be refined

based on outcomes from Stage II. The conceptual vision is a series of facilities to stabilize, dry and add-value to P-cake and other biomass residuals containing P. It would likely involve early phases of development to be focused in Franklin and Addison counties, the largest sources of dairy manure P and also home to several of the most impaired tributaries to Lake Champlain.

The AGT project team believes that multiple P-based products will need to be developed in order to find long-term reliable and economical solutions to redistributing P in impaired watersheds. Specifically, there is likely a mix of products targeted for agricultural, municipal and residential end-uses. Each end-use market has particular specifications, timeframes for application, price-points and requirements for consumer education to build confidence and interest in the end products.

There are multiple technologies in use and others in development that can efficiently remove significant fractions of P from liquid dairy manure and other residual streams. The resulting P cake, concentrate or other end product comes in various forms and in some cases includes polymers, flocculants and other thickening agents as additives. These P- materials have not found immediate markets in Vermont in other locations as they are often semi-processed, dense, wet and/or otherwise not attractive to end-users as a source of fertility. Prototyping and demonstrating cost-effective practical processes to add value to these materials is an important objective of this Stage II proposal.

The final and perhaps most important objective is identifying the economics for the suite of technologies needed at both on-farm and centralized facilities, and the cost of new product demonstrations, sales and distribution efforts for multiple P containing products. Different product demonstrations and trials will be needed for bulk agricultural products, bagged products targeted to residential consumers and other products targeted for horticultural and landscape use. Working to move materials through both existing and new distribution channels will be necessary to affect the redistribution of P at a meaningful scale.

Narrative describing the proposed process or technology;

The process to be applied in the prototyping tasks for Stage II include using a combination of practices to stabilize, dry, blend and generally add value to P-cake and other P biomass residuals. One part of this process includes forcing heated air through wet and dense materials, such as P-cake. The ambient air is heated using thermal energy from composting, a co-product of the decomposition process when managed appropriately. This approach has already been commercially implemented in Vermont using AGT equipment. Please see the table below with the project timeline (AGT VPIC Proposed Timeline) for an itemized lists of tasks and anticipated dates of activities.

Agrilab Technologies Inc. - Proposed Timeline				Vermont Phosphorus Innovation Challenge (VPIC)												
Jun-18																
				Months Starting 2018											2019	
Order	Subject	Activity	Plan Start	Plan Duration												
					Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan				
1.1.1	Stage 1 preparation/development	Submission	6/29/18	1	█											
1.1.2	Stage 1 preparation/development	Submission - supplemental letters of support	7/6/18	1		█										
1.2.1	Review	Responses to reviewer questions	7/7/18	1		█										
1.2.2	Review	In-person interview	8/6/18	1			█									
2.1.1	Agreement Details	Revisions to Scope of Work if Needed	8/20/18	1			█									
2.2.1	Project Kick-off Meeting	Conference call to coordinate project team	9/4/18	1				█								
2.3.1	Procure materials/equipment	Prototyping ductwork, sensors, controls	9/5/18	1				█								
2.3.2	Team, vendor, sub coordination	Feedstock logistics, scheduling technicians	9/5/18	3				█	█	█						
2.3.3	Physical Batch Testing	Conduct processing trials	9/26/18	3				█	█	█						
2.3.4	Analytical Testing	Sample feedstocks and product mixes	9/26/18	3				█	█	█						
2.4.1	Market Analysis	Initial product selection for prototyping	9/12/18	1				█								
2.4.2	Market Analysis	Retailer outreach/interview - bagged line	10/3/18	3					█	█	█					
2.4.3	Market Analysis	Farmer/grower outreach - bulk products	10/10/18	3					█	█	█					
2.5.1	Economic Modeling	Cost tracking - processing	9/26/18	3						█	█	█				
2.5.2	Economic Modeling	Price projections - market feedback	10/3/18	3						█	█	█				
2.5.3	Economic Modeling	P mass balance projections and cost/lb P	10/17/18	3						█	█	█				
2.5.4	Economic Modeling	Facility pro-formas for implementation at scale	11/7/18	2							█	█				
2.6.1	Reporting	Draft final report	12/17/18	1									█			
2.6.1	Reporting	Final report	1/12/18	1											█	

Projects both inside and outside of Vermont have demonstrated that the concentration and recovery of P from manure and other biomass is technically feasible. However the resulting end product is variable, often difficult to store and has limited or still unknown market demand. There are multiple composting, drying, pelletizing and other processes in existence intended to stabilize and add value to manure and other biomass residuals. These systems range widely in size, cost, energy consumption and operating demands.

AGT has worked with multiple systems and helped farms, businesses and institutions to select equipment, plan and design appropriate integration, support installation and commissioning, and provide on-going operating support and technical assistance. The relevant facilities, mobile and stationary equipment are sourced both from outside vendors as well as equipment developed and fabricated by AGT itself. The featured AGT products include compost aeration and heat recovery (CAHR) equipment. Their operating process involves using negative aeration to provide oxygen to multiple batches of decomposing feedstocks. Sensors and control systems with on-site and remote capabilities guide the optimization of the process to achieve the desired product quality and reduce the overall timeline to generate mature, consumer-ready products. The on-board heat recovery permits process acceleration as well as renewable thermal energy capture for use in drying compost and soil products prior to screening and bagging, as well as heating facilities such as buildings, greenhouses and other hot water demands.

Drying these P-cake and similar feedstocks and their end-products has multiple benefits. Reducing the weight of the materials facilitates more cost-effective trucking and transport to remote fields on the same farm, to regional farms for bulk applications or to centralized bagging and distribution facilities.

Presently some P-cake materials are so wet and dense that trucks hit their maximum over-the-road weights without completing filling the truck box.

Drying also stabilizes these P-products for seasonal storage. Both bulk and bagged markets have seasonal use patterns, with the largest consumption of fertilizers, composts and similar products in the spring to early summer, the start of the crop and gardening seasons. As the manure and other biomass sources for the concentrated P are typically generated year-round, stabilization through drying is beneficial for long-term storage. Without this step, unmanaged stacking of P-cake can degrade the end product resulting in odors, development of slimy texture and biofilms, and clumping that make the end product less pleasant to use and difficult to handle.

Most commercial drying processes for manure, crops and other biomass use propane, heating oil or other fossil fuels to rapidly heat and dry manure and other biomass, in chambers, along conveyors or other mechanisms. This practice is also applied to some compost and soil products prior to screening and bagging if materials are not sufficiently dry to be stable in a bag waiting for retail sale. Generally this approach is energy intensive and can be expensive for the return.

The AGT CAHR and stabilization process utilizes renewable thermal energy to drive the drying of materials. As it operates at a lower temperature, a longer residence time is required – a moderate temperature, slower drying approach. This is appropriate for bulk processing when there are months to prepare for distribution and use, and has a lower energy footprint and cost. Fortunately thermal energy from CAHR systems is available 24/7 and product drying can continue through overnight hours using timers and other controls. In addition, the aeration ductwork at Vermont Natural Products (VNAP) and other facilities is versatile and can be used for composting or drying as processing demands to manage inventory vary through the year. More precise assessments of the processing costs and added value will be completed for the different P-cake feedstocks and product blends in the prototyping tasks.

Using a lower, slower drying approach may also have additional end product benefits including the conservation of nitrogen (N) in the end-products. Rapid heating and drying of manure, compost and similar materials tend to volatilize N and drive off ammonia to the atmosphere. Beyond atmospheric loading and pollution potential when practiced at larger scale, this also represents a loss of fertility that could otherwise be applied to crop growth. P is not significantly affected through the composting or drying processes as it is physically attached (adsorbed) to particles and not as volatile as N.

Adaptability of these practices is key to adding additional on-farm and centralized processing capacity for P-products. As these practices are already in use on VT and regional farms and composting facilities, it is already demonstrated that the equipment can be deployed and operated by many users. The bigger question is which subsets of practices and equipment are most-effective at which points of the overall supply chain. Available labor, geographic location, site suitability and net revenue potential are among the factors that will affect the ability to achieve meaningful scale.

The field work for prototyping involves conducting a series of composting and/or drying trials of several blends to be determined by the project team at the project start. VNAP has agreed to host these trials at their facility and support bulk material handling. AGT staff will provide additional mobile drying equipment, procure aeration piping and complete on-site electrical and water connections. AGT staff will install additional sensors, take photo and narrative observations for documentation, collect

feedstock and end-product samples for both field and lab analysis. AGT staff will also gather cost data on labor, equipment and other inputs.

The operating trials do not require daily on-site operation and are reasonable to complete within the proposed timeframe. Weekly site visits are sufficient to work with VNAP staff on material handling and placement, and complete documentation tasks. Remote monitoring of process temperatures, flow rates, oxygen levels that are already in place in VNAP will be extended in part to these prototype batches. Remote monitoring enables identification of anomalies or other process challenges, and permits a faster response to adjust the processing steps if necessary.

VNAP currently handles a wide range of feedstocks that contain P. These include manures from dairy, poultry and equine operations, source-separated food scraps from the Addison and Rutland Counties Solid Waste Management Districts and forest products from sawdust, shredded bark and wood chips. Food processing residuals are accepted on an intermittent basis based on spoilage events. VNAP has been approached by other vendors implementing P concentration/recovery technologies to handle and process P-cake. Depending on the systems in operation by this fall, several P-cake or filtrate materials will be available for incorporation into trial blends. The project team will be able to compare the processing economics and P mass balance for compost blends that consist primarily of separated dairy manure solids (from a screw-press) as a baseline or control.

The proposed tasks include using UVM assistance for feedstock and end product analyses to quantify nutrient concentrations and forms. This information will be used to project total mass balance of P that could be appropriately redistributed via the suite of products and blends. University of Maine, Penn State or Woods End Laboratories will be used for quality assurance and quality control by sending 10% of samples as replicates (The new VT State Testing Lab in Randolph may be used for QAQC in 2019). Samples will also be analyzed for % C/organic matter content as a number of the P-products under consideration should also have the benefit of adding organic matter in soils, along with nutrients for fertility, and can be marketed for that additional soil amendment value. Conducting these tests will facilitate the projection of total P that can be redistributed through various products and end-user segments.

The project team recognizes the mass balance of P possible for redistribution through this project and potential for bringing to scale is affected by numerous variables. Identifying the factors is helpful for both recognizing opportunities to maximize P export to appropriate end use markets, understanding that products may have seasonal changes and how this might affect fertilizer claims and requirements for labeling products for sale. A few of these factors include: 1) the level of P in dairy diets can change due to variable forage quality through a growing season and from year to year, as well as the proportion of feed supplements fed to cows changes manure P concentrations; 2) the performance of P recovery equipment is variable as evidenced by P-cake samples collected from the only centrifuge operating in VT. This is influenced by manure handling ahead of the centrifuge and settings of the unit itself. 3) P-cake and compost blend handling and storage. While nitrogen is of greater concern for loss to leaching or volatilization, some P can be lost to leaching if materials are exposed to precipitation when processed or stored outside. These and other factors will be considered when finalizing material handling plans, conducting nutrient analyses via UVM and other labs, and when developing labels for end products.

The process to evaluate market potential in greater detail involves conducting market research for several products to gauge market readiness, possible pricing and identify areas of uncertainty. AGT

staff, VNAP staff and outside marketing consultants will be used to assess multiple products in bulk agricultural, residential consumer, horticultural/landscape and other specialty markets. The project team assumes the distribution of bulk P-products may not have the same value-added potential on a per unit basis versus bagged products, but P redistribution at scale may be more rapidly achievable if appropriate regional end-use markets are developed.

A market assessment for the potential of bagged products will focus initially on adding P-fortified compost and similar products to the existing product lines bagged and distributed by VNAP in 11 northeastern states. The project team assumes that developing new product lines, establishing sales and marketing plans and full roll-out of product distribution may take 2 to 3 years based on past experience. This highlights the importance of a well-crafted sales and marketing strategy to avoid the need to abandon a new product line after years of development.

Seeking both bulk and bagged product markets is intended to promote the adaptability of this approach to achieve the highest volumes of P redistribution at the highest values. Actual market acceptance will not be known until after products have been produced and in regular use. Certain products may have more rapid market acceptance and therefore not putting “all the eggs in one basket” will be beneficial to moving these products to markets and avoid accumulating an inventory that fails to generate revenue for farmers and P processors.

The market value for some of the developed products may recognize other attributes beyond the P fertility. Specifically N fertilizer value will be of interest to many growers as N is often a limiting resource for a range of forage crops and vegetables. Other macro and micro nutrients may be of interest to growers based on their crop types and soil test recommendations. While there is the potential for custom blending to fulfill these needs, this level of product development is beyond the scope of work proposed by this team in Stage II.

The market value for organic matter contained in these products is of particular interest to the project team. The products proposed for development will likely contain a range of organic matter content. Some of the higher level P concentrates may have less organic matter from the fine particulate fraction of manure if processed with limited or no blended feedstocks or amendments. Those products that are more of a blended or P-fortified compost will have more organic matter content from the coarse fibers in separated dairy manure solids, from various forest products and other biomass. This will be of interest to some end-users that seek benefits of improved soil moisture and nutrient retention. These products that improve soil quality by increasing soil organic matter content may have additional secondary P loading reduction benefits. It has been shown that soils with higher soil organic matter content and soil health attributes are more resistant to erosion, and therefore reduce the potential for P loss and transport to surface waters.

The process to evaluate the potential for business enterprises to accomplish P redistribution at scale will use a combination of research of historical installations, findings from Stage II prototyping and reasonable assumptions for filling gaps in actual data and making future projections. This includes developing business plans and pro forma projections of a business structure or structures that can be economically viable to deploy and operate. AGT staff and outside business and technical consultants will perform this task.

The project team will also identify sources of financing, cost-share funding, grants and point out gaps in achieving a profitable business model for P-product sales. Key in this is identifying models that provide sufficient incentive for dairy farmers to adopt P-reduction practices to achieve reductions in P loss. As VNAP already has a business model that pays farmers for their manure, there is a framework to build upon. This provides farmers some modest value for their materials and has the important benefit of encouraging cleaner feedstocks for inputs to the composting process.

Financing structures that will be explored include industrial revenue bonds and other tax-exempt, and tax-deferred instruments. This may be most relevant to commercial centralized facilities that may be needed to aggregate products from multiple sources – farms, food processors, source-separated food scraps and other biomass. Some of these financing tools are not available to agricultural properties, so establishing which steps of the supply chain are appropriate and eligible will be evaluated.

Description of the team and its qualifications (resumes may be attached, will not count toward the page limit);

The project team is led by Agrilab Technologies Inc. (AGT), based in Enosburg Falls, VT and acting as Stage II Principal Investigator (P.I.) will be Brian Jerose, AGT President. AGT internal staff and subcontractors are listed below with qualifications. Additional services may be obtained for analytical or other technical, mechanical or digital support, such as for laboratory analysis of feedstocks and products, or for plumbing/mechanical field support, networking and data support or other discrete consulting.

The listed project team represents a solid combination of skill sets to fulfill the objectives of Stage II and building towards Stage III solutions. AGT has researched, recommended and help install and implement equipment and other systems, both conventional and specialized, in order to reduce pollution, improve process efficiency and create products for a range of farms, institutions, municipal facilities and other businesses. Further, AGT has designed, fabricated and installed its own farm and composting equipment that is in use in five states and Wales, U.K. AGT has the capacity to develop and adapt new equipment if needed to dry, blend and otherwise add value to products if warranted to address discrete challenges in the supply chain for P-products. Collectively AGT and VNAP possess the business acumen to develop business plans for facility infrastructure and equipment, operating requirements, and the sales, marketing and distribution channels to economically redistribute P from surface water loading.

AGT has experience working on a range of watershed protection projects in Vermont and New York. Beyond composting and manure management projects, AGT has worked on riparian buffer plantings, cover cropping, erosion control and other conservation and pollution reduction initiatives. This experience working with local farmers, agencies on the local, state and federal levels, non-profits, businesses and other stakeholders will ensure project efforts are complimentary to the range of on-going activities related to P loading reduction.

Other project participants are anticipated to include generators of P-containing products, processors and end-users. Generators are primarily dairy farms but will also include composting facilities and possibly other commercial or institutional sources that will provide P-containing feedstocks. Processors will consist of a subset of generators that can effectively add value to materials via composting, drying,

blending and other practices. End-users are those forage, vegetable, horticultural/landscape, turf and other growers who will utilize any of the P-containing fertilizers, composts and other products to be tested in Stages II and III.

Letters of support have been sought and obtained for some generators, processors and end-users. The intent is to demonstrate the network of farms and businesses willing to work collaboratively towards addressing the challenge around P-pollution. Please note some letters of support may not be attached to this document and submitted separately.

Details for key project personnel for Stage II project tasks are listed by company, name, title, phone/email contact, and summary of project roles. Full resumes/bios/CVs are attached separately to this proposal narrative.

Agrilab Technologies Inc. (www.agrilabtech.com)

Brian Jerose, President and co-founder, Principal Investigator; (802) 370-4774, brian@agrilabtech.com. Brian will manage the project and work with all technical and business team members to select most promising products for the prototyping and future stages, and coordinate project tasks from planning, through prototyping, market and economic assessments and reporting.

Jason McCune-Sanders, VP Engineering; (802) 578-5193, jason@agrilabtech.com. Jason will lead equipment and drying system layout final design, coordinate fabrication tasks and process technical data captured during prototyping. Jason will also contribute to the economic reporting to prepare infrastructure, equipment and operating cost projections.

Todd White, COO; (603) 715-4413, todd@agrilabtech.com. Todd will support collection of relevant economic data and build pro forma business plans for on-farm and centralized processing operations, including identifying the most attractive options for financing subsequent stages of scaling up operations.

Jaime Tibbits, Conservation Services Leader; (802) 393-5239, jaime@agrilabtech.com. Jaime will provide operational support for deploying and conducting prototyping product drying and blends.

Ryan Koloski, Drafting Engineer, (802) 249-3639, rkoloski@agrilabtech.com. Ryan will provide operational support as well as 3-D AutoCAD or other drawings where needed.

Vermont Natural Ag Products (www.vermontnaturalagproducts.com)

Robert Foster, President; (802) 989-2771, rfmoodoovt@sover.net. Robert will be engaged with identifying and selecting product blends with the best market potential, coordinating use of trademarked names and work on the sales and marketing planning.

Heather Foster-Provencher, VP Finance and Administration; (802) 989-2770, hfmoodoovt@sover.net. Heather will review cost of production, marketing and distribution as part of market assessment and testing economic viability.

Wes Kimball, lead site operator, (802) 377-9988. Wes will support material handling for composting, drying and blending activities.

Budget for how award money will be used to fulfill project objective(s).

The AGT proposal has a budget of \$50,151. Stage II budgeting is divided into two broad categories, 1) Field Prototyping and 2) Market Assessment, Economic Analysis and Reporting. Please see the attached budget worksheet at the end of this proposal document (VPIC Stage II budget) that summarizes itemized cost projections for labor, materials and other expenses.

Field prototyping expenses include labor for AGT and VNAP staff, acquisition of aeration and drying pipe/ductwork, rental of facility space and thermal energy, rental of mobile aeration equipment with sensor and control package, lab analysis and feedstock acquisition/trucking. These tasks and related costs are intended to build on similar prior efforts to dry, stabilize and add value to manure and compost products. The number of batch trials conducted during the prototyping phase will be determined in part after observing the duration and labor intensity of composting, drying and other stabilization practices for particular feedstocks and blends. Certain blends may be processed more rapidly and permit time for additional batch trials. The current assumption is batch trials will be conducted through November 2018 and then the project team's focus will be on the market and economic assessments and reporting.

The number and type of feedstock and end product nutrient analyses are intended to capture the range of P and other nutrient concentrations. Field testing of moisture content will be conducted by project team to track the drying of blends during the prototyping work and verified via the laboratory analyses.

The market assessment work will focus on the potential size of bulk and bagged markets, along with price points that affect the size of the market. That information feeds into the economic assessment as the revenue potential from sales will be modeled against the infrastructure, equipment, operating, sales, marketing, and distribution costs of new products. While the project team would ultimately like to develop 8 or 10 bulk and bagged products, due to limiting the scope and expense of this task, 3 or 4 products will be assessed in some detail. The budget items are intended to reflect the level of effort and rates of the individuals and subcontractors engaged in these tasks.

The listed budget items are intended to provide sufficient staff support and prototyping capacity to fulfill the objectives of this Stage II work. The project team recognizes additional development work will be needed beyond the 120-day prototyping phase envisioned by the State of Vermont in crafting the "Reverse Pitch". This proposal is focused on the questions that can be addressed in that timeline for both technical feasibility, economic feasibility and the opportunity to redistribute P through new supply chain models.

Closing Summary

Agrilab Technologies Inc. is available to provide additional information on this proposal for any sections that we could not provide sufficient detail in the allotted space. We look forward to the review and working on developing solutions to address the phosphorus challenge in Vermont and beyond.