501 Lake Street
Barton, VT 05822
802-461-5553 (c)
donna@greenstatebiochar.com

VERMONT PHOSPHORUS INNOVATION CHALLENGE

STAGE ONE PROPOSAL

We are providing our Stage One Proposal for the Vermont Phosphorus Innovation Challenge per the RFP as follows:

- Contact Information For Principal Investigator:
  - John D. Forcier, P.E., President, Forcier Consulting Engineers, PC, 174 Browns River Road, Essex, Junction, VT 05452, p: (802) 657-3083, e: jforcier@fcevt.com
- Project Overview or Abstract:
  - We believe that our proposal clearly meets all of the criteria of the Vermont Phosphorus Innovation Challenge. We are a Vermont company that utilizes local renewable organic waste materials that are processed in an innovative machine that we developed in Vermont as a prototype pyrolysis machine that produces a sequestered carbon product called Biochar. We are passionate about cleaning the waters of the State of Vermont and our Phosphorus Capture System utilizes this Biochar to act as a filter that efficiently captures the majority of the phosphorus, while producing valuable soil amendment/ fertilizer products for local reuse.
- Description of Project Objectives:
  - Perform pilot studies to measure the effectiveness of:
    - Utilizing Biochar to capture and treat agricultural crop land run-off to significantly reduce nutrient pollution of nearby waterways.
    - Reusing the Biochar material (with captured nutrients) as a valuable soil amendment to improve the soil structure and to provide time-release fertilizer.
    - Providing an inexpensive local solution to reduce biomass waste.
  - Develop a larger version of the prototype pyrolysis machine in order support wider implementation of Biochar as a cost-effective local clean water solution.
- Narrative Describing the Proposed Process or Technology:
  - The Green State Biochar process involves a prototype pyrolysis system, which is a contained combustion oven which converts organic waste materials to sequestered carbon in the form of Biochar. This system was creatively designed and built with local salvage materials utilizing yankee ingenuity at its best. With its excellent adsorption properties, Biochar has been used for many years for various filtration systems including capturing contaminants (like PCB's) and to act as a soil amendment product. This amazing material is made from local renewable waste wood or other local organic waste materials and can capture at least 50% of its weight in nutrients.
  - Green State Biochar has also designed and built related custom filtration systems that currently filter tofu effluent, capture nutrients from manure pits and remove detergents from flushing waters at dairy farms.
  - Since the current pyrolysis system is being utilized to provide Biochar to service these current applications, a temporary pyrolysis system will be rented to service the current needs so that the current pyrolysis system can be utilized for this pilot project.
  - Our proposed Phosphorus Capture System will be installed as a pilot project on a one acre parcel on a local farm. It will consist of a 208' long by 3' deep ditch with a plastic liner with 12" thick of Biochar material (wrapped in filter fabric) and will be installed along the lower edge of the field per the attached Drawings No. 1 & 2. Over 90% of the phosphorus will be captured by the Biochar and

the filtered water will continue downstream. Phosphorus capture testing will be performed to document and confirm the phosphorus removal efficiencies. The Biochar materials will be replaced annually and the previous Biochar materials will be reused locally as a valuable soil amendment/fertilizer product to improve the soil structure and to provide time-released fertilizer.
    - Green State Biochar intends to develop a larger version of the prototype pyrolysis machine in order to support wider implementation of Biochar as a cost-effective local clean water solution.
- Description of the Team and its Qualifications (see attached Resumes):
    - Donna Pion is a founding partner and General Manager of Green State Biochar. Donna has over 24 years of diverse business experience as Business Manager, Registrar and Controller for several Vermont and Indiana Industrial Companies and Institutional Facilities.
    - Roger Pion is a founding partner and Owner/Operator of Green State Biochar and has more than 34 years of diverse business experience in Manufacturing and Construction (in Indiana) as a Consultant/Manager/Operator and in Trucking (in Vermont) as an Owner /Operator of a truck fleet. Roger helped to build and currently operates the pyrolysis system and the related filtration systems.
    - Luke Persons is a founding partner and Biochar Filtration Specialist of Green State Biochar and has over 40 years of experience as a truck driver, mechanic, welder and inventor. Luke designed, built and currently operates the pyrolysis system and the related filtration systems.
    - John Forcier, P.E., is President of Forcier Consulting Engineers and has over 46 years of experience in Construction and Engineering, including over 40 anaerobic digester projects and several biochar related projects with pyrolysis/gasification systems. He is a member of the International Biochar Initiative and of Lee Enterprises Consulting (which has several biochar and pyrolysis experts).
    - Hugh McLaughlin, Ph.D., P.E., is CTO of NextChar and has over 42 years of experience in Industry, Engineering and Research & Development and scale-up of new technologies in the U.S. and Canada. Dr. McLaughlin is a recognized expert in pyrolysis/gasification, biochar, and activated charcoal and has designed and commercialized patented technologies and has written several publications and authored three chapters in the book,"The Biochar Revolution".
- Budget for how award money will be used tofulfill project objectives:
    - Our proposed project budget is $49,236, with a breakdown as follows:
        - Phosphorus Capture System:
            - Furnish & Install Phosphorus Capture System: $21,137
            - Testing and Engineering: $ 6,100
            - Temporary Pyrolysis Machine Rental: $ 4,000
            - Subtotal: $31,236
        - Equity toward larger Pyrolysis System: $18,000
        - **Grand Total Budget Request: $49,236**
    - Based on a Phosphorus Capture System cost of $31,236 and the capture of 5,824 pounds of phosphorus, this works out to a cost of only $5.36/pound of phosphorus captured.
    - In subsequent years, with an annual cost of only $20,000, the unit price will be reduced to only $3.43/pound of phosphorus captured. This cost is reduced due to the elimination of the ditch excavation, the testing and engineering and the temporary pyrolysis machine rental. We have conservatively assumed that the revenue for the reused Biochar will balance the cost of its removal.
    - By developing a larger version of the prototype pyrolysis machine, we will be able to support wider implementation of Biochar as a cost-effective local clean water solution.
    - Budget comparison of other phosphorus capture technologies:
        - Commercial activated charcoal socks (with similar adsoption properties) would cost over 300% more than this Biochar material and the end product would not be readily available as a soil amendment/fertilizer product.
        - Erosion control socks with sawdust and/or compost fillers may cost less, but they capture

significantly less phosphorus and require much more cost for maintenance and periodic replacements and the end product would also not be readily available as a soils amendment/fertilizer product.
- Upgrades to wastewater treatment facilities to capture similar amounts of phosphorus per year would likely cost millions of dollars initially, tens of thousands of dollars per year to operate and would not capture the phosphorus that is produced at agricultural crop lands.

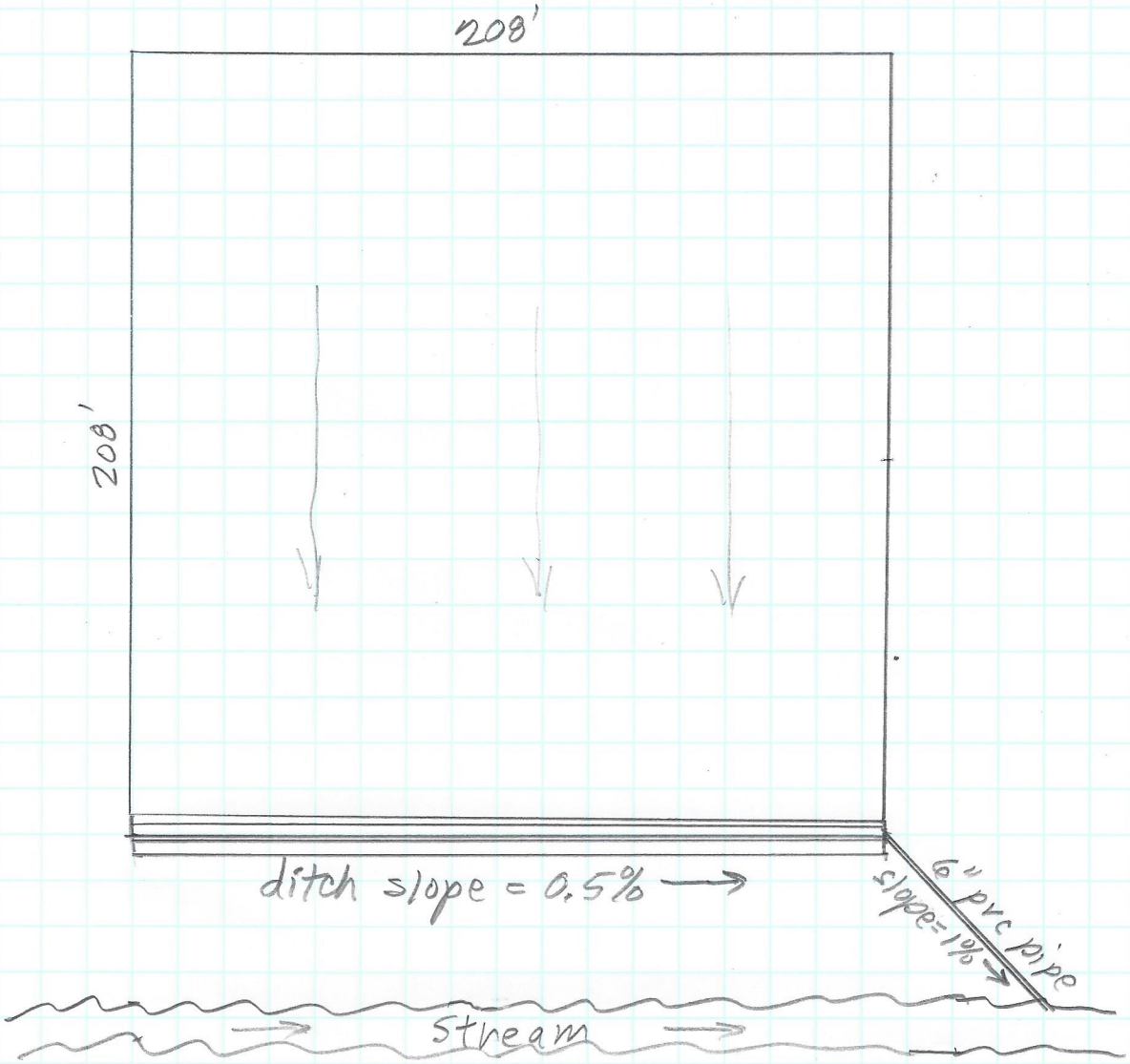
Here are our responses to the Primary & Secondary Criteria and Additional Information:

- **Primary Criteria:**
  - Projected ability to recover phosphorus:
    - Similar phosphorus capture systems in other States have succeeded in capturing over 90% of the phosphorus.
  - Cost effectiveness (estimated cost per pound of phosphorus recovered or reused):
    - As stated in the "Budget" portion of the proposal above:
      - The initial cost per pound of phosphorus captured is $5.36/pound.
      - The subsequent year cost per pound of phosphorus captured is $3.43/pound.
      - These numbers are conservatively based on assuming that the revenue for the reused Biochar will balance the cost of its removal.
      - Once a market has been established for the reused Biochar material (with captured nutrients) as a valuable soil amendment to improve the soil structure and to provide time-release fertilizer, then we expect a net profit on the sale of that product. This revenue would lower the cost per pound of phosphorus captured even more.
  - Strength of project team:
    - We believe that we have an excellent team (as listed above and on the attached Resumes) with a variety of expertise as follows:
      - Science of the approach:
        - John D. Forcier, P.E.:
          - Biochar, gasification/pyrolysis system experience.
          - Extensive erosion control and storm water experience.
          - Significant phosphorus removal experience at several VT wastewater treatment facilities.
        - Hugh McLaughlin, Ph.D., P.E.:
          - Recognized expert in pyrolysis/gasification, biochar, and activated charcoal.
          - Has designed and commercialized patented pyrolysis/gasification technologies, including the temporary pyrolysis system that we will rent from him.
          - He has written several publications and authored three chapters in the book,"The Biochar Revolution".
      - Entrepreneurial Talent:
        - Luke Persons:
          - He creatively designed and built the initial prototype pyrolysis system from scratch, utilizing his Yankee ingenuity and working with local scrap materials, motors, etc.
          - He continues to operate and modify the system to produce better and better Biochar materials.
          - When we contacted a vendor to consider purchasing a larger commercial pyrolysis system, they were so impressed with Luke's system, that they said that they would prefer to work with Luke to help him design a larger prototype pyrolysis system.
        - Roger Pion:
          - Works closely with Luke in building and operating:
            - The prototype pyrolysis system.

        - He also designed and built related filtrations systems that are currently being utilized to:
            - Filter nutrients and solids from tofu effluent.
            - Capture nutrients from manure pits.
            - Remove detergents from flushing waters at dairy farms.
    - Hugh McLaughlin, Ph.D., P.E.:
        - Has designed and commercialized patented pyrolysis/gasification technologies, including the temporary pyrolysis system that we will rent from him.
- Business Accumen:
    - Donna Pion:
        - Donna has over 24 years of diverse business experience as Business Manager, Registrar and Controller for several Vermont and Indiana Industrial Companies and Institutional Facilities.
    - Roger Pion:
        - Roger has more than 34 years of diverse business experience in Manufacturing and Construction (in Indiana) as a Consultant/Manager/Operator and in Trucking (in Vermont) as an Owner /Operator of a truck fleet and of four mail routes.

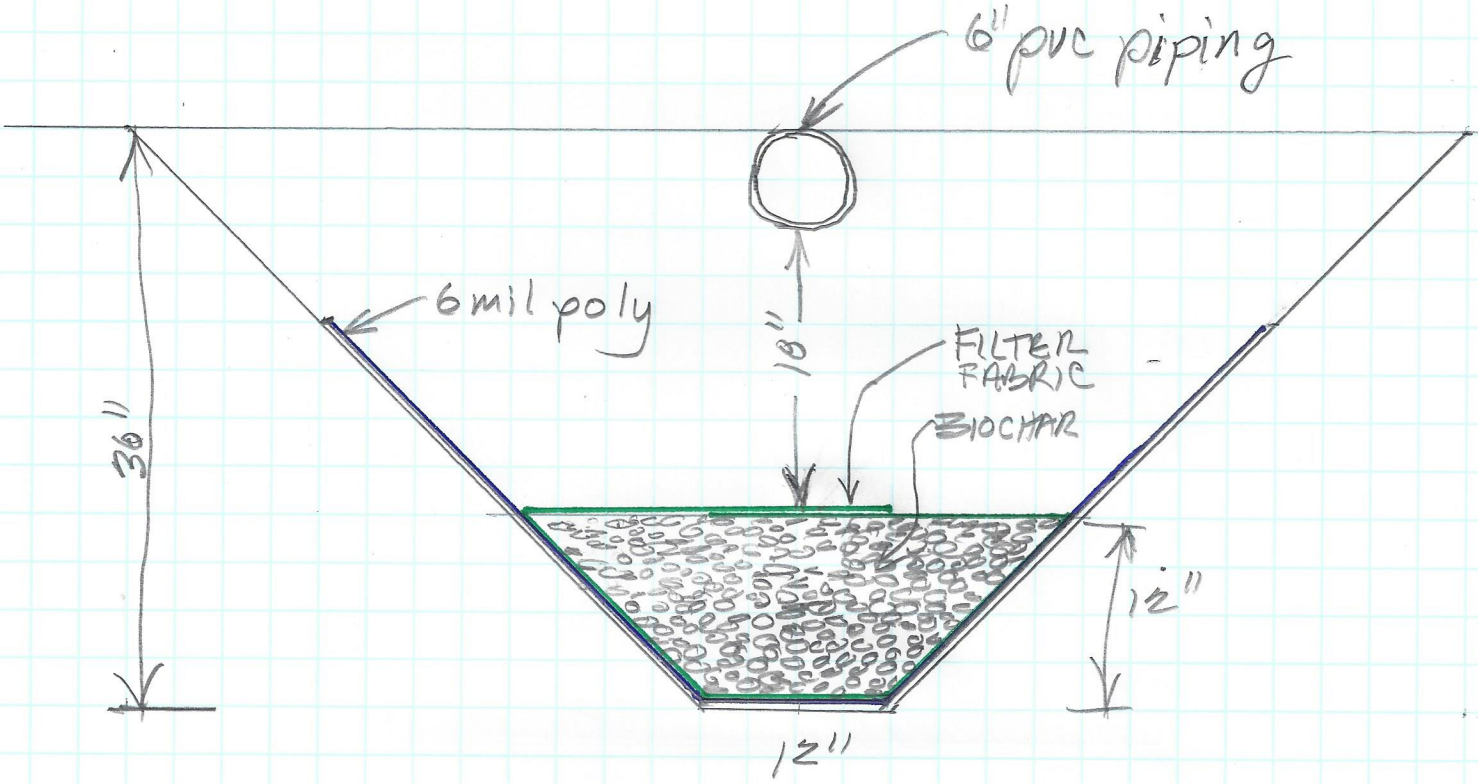
- **Secondary Criteria:**
    - Project feasibility and readiness:
        - Our prototype pyrolysis is ready to produce the Biochar materials now. However, since the current pyrolysis system is being utilized to provide Biochar to service other current filtration applications, a temporary pyrolysis system will be rented to service the current needs so that the current pyrolysis system can be utilized for this pilot project.
        - We intend to develop a larger version of the prototype pyrolysis machine in order to support wider implementation of Biochar as a cost-effective local clean water solution.
    - Constructability, Adaptability, and Deliverability:
        - We have already constructed, adapted and delivered the initial prototype pyrolysis system.
        - We have already constructed, adapted and delivered a custom nutrient capture system that captures nutrients from manure pits.
        - We will be developing a Phosphorus Capture System (Per Drawings No. 1 & 2) as a pilot project to capture the phosphorus that is produced at agricultural crop lands.
        - We intend to develop a larger version of the prototype pyrolysis machine in order to support wider implementation of Biochar as a cost-effective local clean water solution.
    - Sustainability, including opportunities for reuse of recovered phosphorus or other materials:
        - The reused Biochar material (with captured nutrients) is a valuable soil amendment which improves the soil structure and provides time-release fertilizer and can be given or sold to nearby farms. Once that market is fully developed, we expect a net profit on the sale of that product.
        - Cleaning the waters of VT by significantly reducing nutrient pollution of nearby waterways.
        - Reducing fertilizer costs by providing local soil amendment/fertilizer products.
        - Reducing the carbon footprint by reducing transportation of fertilizers.
    - Other possible sources of investment or financing:
        - Current:
            - Center for an Agricultural Economy (Farm Viability Program)
            - Northern Community Investment Corporation
            - USDA Rural Development
            - Local investors
        - Possible other sources:
            - USDA NRCS

        - Yankee Farm Credit
        - Other local investors
    - Co-Benefits:
        - Capture of other excess nutrients to assist with the farm nutrient management plans.
        - Beneficial reuse of biomass waste.
        - Provide more local jobs for:
            - Constructing the Phosphorus Capture System.
            - Constructing the larger prototype pyrolysis system.
            - Operating the larger prototype pyrolysis system.
            - Distributing the reused Biochar materials.
- **Additional Information:**
    - Pre-Identified Vermont Partners:
        - The Phosphorus Capture System will be constructed by local VT contractors.
        - The Biochar for this system will be produced in Vermont.
        - The larger prototype pyrolysis system will be constructed in Vermont, by Vermont personnel.
        - All of the members of our team are Vermonters, except for Hugh McLaughlin, PhD., P.E., (a very specialized expert) who is from Massachusetts.
    - 120 days to develop a prototype system:
        - Initial prototype pyrolysis system:
            - Our initial prototype pyrolysis system is currently available.
        - Temporary Pyrolysis System:
            - Since our initial prototype pyrolysis system is too small to service our current filtration commitments and the Phosphorus Capture System pilot study, we will rent a temporary pyrolysis system to supply Biochar for our current filtration commitments. Then we will have time (within the 120 day period) for us to utilize our current pyrolysis system to produce the Biochar needed and construct the Phosphorus Capture System for the pilot study within that time period.
    - Develop Business Case:
        - A major portion of our proposal is to develop a Phosphorus Capture System for the pilot study to:
            - Utilize Biochar to capture and treat agricultural crop land run-off to significantly reduce nutrient pollution of nearby waterways.
            - Reuse the Biochar material (with captured nutrients) as a valuable soil amendment to improve the soil structure and to provide time-release fertilizer.
        - We want to take this opportunity to develop a larger prototype pyrolysis system in order to support wider implementation of Biochar as a cost-effective local clean water solution.



PLAN VIEW
SCALE 1"=50'

GREEN STATE BIOCHAR	PHOSPHORUS CAPTURE SYSTEM	DWG. NO. 1
FCE Forcier Consulting Engineers, P.C. 174 Browns River Rd., Essex Jct., VT 05452	VERMONT PHOSPHORUS INNOVATION CHALLENGE	



SECTION

SCALE 1" = 1'

GREEN STATE BIOCHAR

FCE Forcier Consulting Engineers, P.C.

174 Browns River Rd., Essex Jct., VT 05452

PHOSPHORUS CAPTURE SYSTEM

VERMONT PHOSPHORUS INNOVATION CHALLENGE

DWG. NO. 2

Donna M. Pion
501 Lake Street
Barton, VT 05822
Pion501@msn.com
802-461-5553

EXPERIENCE

Green State Biochar, Greensboro, Vermont
General Manager, January 2016-Present

- Responsible for all financial transactions of startup, including administration of grants/awards
- Researches and collects all data on the Biochar industry and disseminates to partners and social media outlets
- Schedules all meetings of partners and various state and local officials and investors

Vermont Natural Coatings, Hardwick, Vermont
Business Manager, August 2014-Present

- Delivered an accurate trial balance for 2013 to accountants for tax return preparation, which included bringing the books current by taking physical inventories and adjusting the trial balance and cash reconciliations for the previous 12 months
- Prepares annual budget in conjunction with the President, General Manager, and Sales Team
- Reviews bill of materials for cost saving measures across expense line items

Versatile Fabrication/MFP, Elkhart, Indiana
Office Manager, July-August 2014

- Created the Office Manager Training Manual in addition to all accounts receivable and payable, sales orders, purchase orders, and payroll
- Was responsible for all month-end transactions and inventory control

EA Technologies/MFP, Elkhart, Indiana
Quality Management Team, December-August 2014

- Helped prepare company for ISO Certification
- Prepared work instructions, charts, manuals, training documents, and forms using Word, Power Point, and Excel
- Worked with department supervisors to determine new processes and procedures to increase efficiency and cut costs

Bonnie Doon Ice Cream/MFP, Elkhart, Indiana
Controller, March 2013- August 2014

- Prepared monthly financials, including monitoring and maintaining an annual budget, monthly sales reports, monthly inventory reconciliation, maintained asset management report, and an ongoing in-depth analysis of cost of goods sold
- Worked with new owner to determine business viability
- Delivered trial balance to accountants, which included all journal entries for preparation of tax return
- Monitored payroll, for restaurant and plant
- Collected rent and utilities from tenant utilizing a portion of the plant and responded to requests for necessary repairs and maintenance

Vermont Natural Coatings, Hardwick, Vermont
Bookkeeper, December 2011-February 2013

- Prepared all customer invoices, bank deposits, accounts payable, bank and credit card reconciliations, payroll entries

- Was responsible for accurate reporting of monthly profit and loss, sales reports, and cash flow statements

King George School, Sutton, Vermont
College Counselor and Registrar, January 2008–June 6, 2011

- Worked with therapists, parents, and educational consultants in the placement of students in colleges, technical schools, and gap year programs
- Produced a single, comprehensive transcript for each student representative of course credit received at previous institutions

Sterling College, Craftsbury Common, VT
Comptroller, September 1994-June 2007

- Provided payroll services for over 100 employees, administration and compliance for retirement plan, health insurance plan, short and long term disability plans, and workers compensation
- Prepared and was solely responsible for accuracy of actual figures as related to monthly, quarterly, and yearly budgets
- Reported profit and loss statements, and monthly cash flows to the President of the College and the Finance Committee of the Board of Trustees
- Worked independently each year with the auditors in preparation of year-end Financial Statements, A-133 Reports, and tax returns
- Responsible for all student invoicing and supervising various support staff as relating to Accounts Payable, Accounts Receivable, and Development

EDUCATION

University of Maine, Orono, Maine
Coursework in Environmental Science, 1990

Baruch University, New York City, New York
Coursework in furtherance of Accounting Major, 1985-1987

Queens College, Queens, New York
Coursework in furtherance of Accounting Major, 1982-1985

St. John's University, Queens, New York
Coursework in furtherance of Accounting Major, 1980-1982

COMMUNITY SERVICE

- Tax Return Preparer for IRS and NEKCA for 2008
- Auditor for the Town of Craftsbury, 2002-2004
- Treasurer of The Highfields Institute, 1999-2001

Roger R. Pion

501 Lake Street, Barton, Vermont 05822 ● (802) 793-2066 ● Rog@GreenStateBiochar.com

EXPERIENCE

Green State Biochar, Greensboro, Vermont
Owner/Operator, January 2016-Present

- Built a pyrolysis unit from scratch which produces over 300# of biochar per day
- Built and designed filtration unit that removes 62% of BOD's from tofu effluent
- Built and designed filtration units to capture runoff from manure pits and remove detergents from cleaning waters on dairy farms

MFP, Elkhart, Indiana
Consultant/Manager/Operator, August 2006-Present

- Supervise and maintain facilities at several large manufacturing businesses in the Midwest
- Oversaw construction of a multi-million-dollar estate in Wytheville, Virginia
- Oversaw construction and maintenance of a horse farm in Bristol, Indiana

Roger Pion Trucking, Inc., Barton, Vermont
Owner/Operator, June 1982-Present

- Maintain a truck fleet
- Employ 4 drivers for hauling mail for USPS for 30 years
- Negotiated contracts with USPS for 30 years

EDUCATION

Sacred Heart High School, Newport, Vermont
High School Diploma, 1984

REFERENCES

Available upon request

RESUME

John D. Forcier, P.E. 174 Browns River Road Essex Junction, VT 05452 (802) 657-3083

Mr. Forcier has more than 45 years of experience in the planning, design, permitting and construction of small through multi-million dollar municipal and private renewable energy, biogas, water, wastewater, stormwater, solid waste, utility, commercial, industrial and institutional projects throughout the eastern U.S.A. His unique experience includes design/competitive bid, design/build and construction management projects, both as the design project manager/ project principal and as the construction project manager/ estimator/ scheduler/ construction manager.

PROFESSIONAL EXPERIENCE:

2010 - Present	FORCIER CONSULTING ENGINEERS, P.C., Essex Junction, Vermont President/Founder - Overall responsibility for Civil/Environmental Consulting Engineering firm specializing in Renewable Energy, Biogas, Anaerobic Digesters, Water, Wastewater, Stormwater, Solid Waste, Biosolids, Civil/Site and Professional Construction Management projects throughout the eastern U.S.A.
1995 - 2010	FORCIER ALDRICH & ASSOCIATES, INC., Essex Junction, Vermont 1995 - 2010: President/Co-Founder/Senior Associate - Overall responsibility for 25 person Civil/Environmental Consulting Engineering firm specializing in Municipal Water, Wastewater, Solid Waste, Biogas and Civil/Site projects.
1991 - 1995	THERMO CONSULTING ENGINEERS, INC., Williston, Vermont Project Manager/Department Manager - Civil & Environmental Engineering - Overall responsibility for 10 person Civil/Environmental Engineering Department specializing in Municipal Water, Wastewater, Solid Waste and Civil/Site projects throughout the northeastern U.S.A.
1986 - 1990	ENGELBERTH CONSTRUCTION, INC., Colchester, Vermont Project Manager/Chief Estimator
1985 - 1986	M.A. BONGIOVANNI, INC., Syracuse, New York Chief Estimator/Project Manager- Wastewater Treatment Plants in NY and Maryland.
1972 - 1985	PIZZAGALLI CONSTRUCTION COMPANY, INC., South Burlington, Vermont Project Manager (1980-1985); Senior Project Engineer (1976-1979); Assistant Chief Estimator (1974-1976); Safety Engineer (1972-1974)

EDUCATION:

- University of Vermont, 1972; BSCE
- Honors: Chi Epsilon (Civil Engineering Honor Society)

PROFESSIONAL ENGINEERING REGISTRATIONS: Vermont License #3995, Maine License #4119

PROFESSIONAL AFFILIATIONS:

- Lee Enterprises Consulting, Inc. (2016 – present; Biogas/Anaerobic Digestion Division Leader/Expert)
- American Council of Engineering Companies (ACEC)- Vermont Section (1998- present; President 2003 - 2005, National Director 2005 - present)
- American Council of Engineering Companies (1998 - present; Member)- National Board (2005 - present; Member, Board of Directors); Small Firm Council (2007 - present; Member)
- National Society of Professional Engineers (1981 - present; Member)
- Vermont Society of Professional Engineers (1981 - present, President 1991-1992 & 2005, MathCounts State Co-Coordinator 1998 -2010)
- Vermont Society of Engineers (1995 - present; Member)

AWARDS:

- **Vermont "Engineer of the Year" 2000**
- **Tau Beta Pi** (Engineering Honor Society)- Inducted as an Eminent Engineer in 1999.

Updated: January 17, 2018

FCE
Forcier Consulting Engineers, P.C.

174 Browns River Road
Essex Junction, VT 05452
802-657-3083 (p/f)
802-777-9601 (c)
info@fcevt.com

BIOCHAR OPPORTUNITIES

1/18/18

1. Biochar Background/Resources-
   a. Member of International Biochar Initiative.
   b. Member of Lee Enterprises Consulting (with over 100 International Experts, including several Biochar Experts).
   c. Collaboration with Kathleen Draper, Finger Lakes Biochar and U.S. Director of the Ithaca Institute for Carbon Intelligence.
   d. Collaboration with Hugh MacLaughlin, NextChar CTO and Pyrolysis/Gasification/Biochar Expert with Lee Enterprises Consulting.
   e. Limited collaboration with Karl Strahl from Oregon Biochar Solutions.
   f. Performed several studies in past 6 years with biochar and other bi-products of pyrolysis/gasification systems.
      i. See attached Resume Supplement.
      ii. Also see attached “Dual-Train Organics to Energy Solution”.
2. Biochar Properties/Applications-
   a. Biochar has excellent absorption properties and has been used for many years to successfully absorb contaminants like PCB’s.
   b. Biochar has been found to significantly increase biogas production in anaerobic digesters and to reduce detention times considerably.
   c. When combined with anaerobic digester effluent/digestate, it can improve the quality of the organic liquid fertilizer by acting as a time-release capsule for the nutrients and by absorbing contaminants.
   d. Kathleen Draper is currently working with companies utilizing biochar to:
      i. Filter Tofu effluent
      ii. Filter Yogurt effluent.
      iii. Filter brewery wastewater by-products (high strength and low strength liquid waste)
      iv. Adding biochar and wood chips to socks for erosion control.
3. Opportunities for Green State Biochar-
   a. Stormwater/Agricultural Run-Off-
      i. Biochar socks vs. compost socks for improved erosion control.
      ii. Add biochar to ditches/swales at lower edge of fields to capture/filter nutrients before the streams.
      iii. Add biochar to stormwater detention basins to improve removals of nutrients and suspended solids.
   b. Algae Control-
      i. Add biochar to critical bays to help control algae.
      ii. Add biochar to aerated laogoon wastewater treatment facilities to help control algae.
   c. Anaerobic Digesters-
      i. Add biochar to anaerobic digesters to significantly increase biogas production and to reduce detention times considerably.
      ii. Add biochar to organic liquid fertilizer (anaerobic digester effluent/digestate) to improve the quality of the organic liquid fertilizer by acting as a time-release capsule for the nutrients and by absorbing contaminants.

RELATED EXPERIENCE (PYROLYSIS/GASIFICATION/BIOCHAR):

BioWatts (Florida)- CO, FS, OR:

- Prepared feasibility studies for three Design/Build/Own/Operate collaborative facilities in Central Florida. These will include both Anaerobic Digester and Pyrolysis technologies, which will allow for multiple organic waste streams including pre-consumer and post-consumer food waste, animal waste, wastewater biosolids and yard waste. Outputs and by-products of each project will include 2MW equivalent of BioCNG or BioMethane, agricultural fertilizer and **1,300 tons/year of Biochar soil amendment**; FCE Project Manager.

Green Mountain Power, Rutland, VT- CO, FS, PR:

- **Dual-Train Organics to Energy Solution Study:** Prepared a Conceptual Study of a Combined Anaerobic Digester & Pyrolysis System to handle animal waste, yard waste, wastewater sludge/septage, pre-consumer and post-consumer food waste and other organic waste products. Includes nutrient capture system to capture high solids phosphorus to be sold off-site while producing much lower phosphorus organic fertilizer to improve lake quality. Other by-products include **biochar (a valuable soil amendment)**, wood vinegar (a valuable AD substrate) and animal bedding. The pyrolysis system provides complete removal of contaminants, including emerging contaminants (prions, pharmaceuticals, etc.)

Town of Greenfield, MA/Massachusetts Clean Energy Center (Mass CEC) (As a subconsultant to BEAM Engineering, Brattleboro, VT)- CO, FS:

- Process design team member in preparing a Transfer Station Anaerobic Digester feasibility study to compare several anaerobic digester technologies utilizing nearby municipal wastewater sludge, food waste, fats-oils-grease (FOG) and source-separated organics feedstock to fuel a 300 kW CHP generator set and to provide process heat and excess heat for surrounding buildings. Another option was considered to provide 100 SCFM of BioCNG (Biogas cleaned to natural gas quality and compressed and distributed) for the entire municipal fleet. Includes processing of dewatered digestate to be composted at a nearby compost facility to produce Class A (PFRP) compost. Also considered a Pyrolysis option (including by-products of syngas, synthetic oil and **biochar**) in lieu of Anaerobic Digestion; FCE Project Manager.

Town of Plymouth, MA/Massachusetts Clean Energy Center (Mass CEC) (As subconsultant to BEAM Engineering, Brattleboro, VT)- CO, FS:

- Process design team member in preparing a Wastewater Treatment Facility Anaerobic Digester feasibility study to compare several anaerobic digester technologies utilizing on-site municipal wastewater sludge, off-site food waste, fats-oils-grease (FOG) and source-separated organics feedstock to fuel a 400 kW CHP generator set, to provide 50 SCFM of BioCNG (compressed biogas) to fuel the municipal fleet and to provide process heat and excess heat for surrounding buildings. Also includes an on-site compost facility to produce Class A (PFRP) compost from the digestate. Also considered a Pyrolysis option (including by-products of Syngas, Synthetic Oil and **Biochar**) in lieu of Anaerobic Digestion; FCE Project Manager.

INDEX:

CO: Cost Opinions
FS: Feasibility Study
OR: Owner's Representative
PR: Peer Review of Design

Dual-Train Organics to Energy Solution

Combined Anaerobic Digester & Pyrolysis System

1. **Background/Issues-**
   - a. Organics-
     - i. Act 148 requires that all organics be diverted from landfills by 2020.
     - ii. Typical organics reuse solutions include anaerobic digesters and composting.
       - (1) Compost facilities take significant amounts of land.
       - (2) Many existing anaerobic digester systems are not well suited for mixed substrates.
     - iii. There are few current organics collection/separation solutions.
     - iv. There are many small producers of organics that are wide-spread across the State.
   - b. Wastewater Sludge-
     - i. Current disposal methods include significant transportation costs and are expensive.
     - ii. Land application of stabilized sludge, including in Class A, is controversial due to concerns about emerging contaminants (prions, pharmaceuticals, etc.) which remain.
   - c. Water Quality-
     - i. Due to water quality issues, it is important to minimize phosphorus in many areas.
     - ii. Nutrient capture systems will be necessary to lower the amount of phosphorus discharged.
   - d. Renewable Energy-
     - i. More base-load solutions are needed.
     - ii. Higher efficiency renewable energy solutions are needed.
2. Dual-Train Organics to Energy Solution- Combined Anaerobic Digestion & Pyrolysis System
   - a. Complete Organics Solution-
     - i. Newer anaerobic digester technology:
       - (1) Accepts pre-consumer and post-consumer food waste.
       - (2) Accepts other source-separated semi-solid and solid organics.
     - ii. Provides regional organics collection/separation solution.
     - iii. Provides separated inorganics to be recycled at the MRF.
     - iv. Provides Act 148 organics diversion beneficial reuse solution.
   - b. Wastewater Sludge Solution-
     - i. Provides local beneficial reuse solution.
     - ii. Accepts wastewater sludge and septage.
     - iii. Provides complete removal of contaminants, including emerging contaminants (prions, pharmaceuticals, etc.).
     - iv. Converts waste products to valuable soil amendment (BioChar) and valuable AD substrate (Wood Vinegar).
     - v. Provides local solution to minimize transportation and overall disposal/reuse costs.
   - c. Water Quality Improvement-
     - i. Nutrient capture system produces lower phosphorus organic fertilizer to improve lake quality.
     - ii. Separated liquid from AD effluent has more readily available nutrients for better crop uptake and lower solids for ease of application and improved water quality.
     - iii. Produces valuable high solids phosphorus, which is sold for off-site use.
     - iv. Produces valuable animal bedding to replace purchased bedding and reduce trucking.
   - d. Renewable Energy Solution-
     - i. True base-load (24/7) renewable energy solution-
       - (1) Electrical energy for hundreds of homes.
       - (2) Thermal energy (hot water) for hundreds of homes.
     - ii. High efficiency renewable energy solution to reduce energy costs.
     - iii. Utilizes several waste products to produce cost-effective renewable energy.
     - iv. Produces several beneficial reuse products and by-products.

FCE Forcier Consulting Engineers, PC
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Dual-Train Organics to Energy Solution

Combined Anaerobic Digester & Pyrolysis System

Food Waste & Organics

Act 148 Organics Diversion Solution

Depackaging & Screening

Separated Solids

Plastic & Other Inorganics

Recycling Materials to MRF

Combined Anaerobic Digester & Pyrolysis System

Wastewater Treatment Facility

Separated Liquids

Wastewater Sludge

Sludge Dewatering

Filrtrate Back to WWTF

Pyrolysis/Gasifier System

BioChar Soil Amendment to Farm Fields

Pyrolysis System Eliminates Emerging Contaminants

Wood Vinegar back to AD

Pyrolysis System

Anaerobic Digester System

Clean Water With Improved Quality

Liquid Mesophilic Digester System

Animal Manure

Liquid & Solid Organic Waste

Biogas

Combined Heat & Power Unit

Thermal Energy- Heat for Hundreds of Homes

Electrical Energy- Electricity for Hundreds of Homes

Baseload (24/7) Renewable Energy

Digestate

Solid Separator

Separated Liquid

Separated Solids

Animal Bedding to Replace Purchased Bedding

Nutrient Capture System

Low-P Organic Fertilizer to Farm Fields

High Phosphorus Fertilizer For Sale Off-Site

Lower Phosphorus Fertilizer Improves Lake Quality

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Cv of HUGH McLAUGHLIN, Ph.D., P.E.

Mr. McLaughlin is an expert in the area of biochar properties, biocarbon processing, chemical manufacturing processes and chemical process safety. He has many years of experience developing new processing technologies and implementing those technologies on a commercial scale. Since 2009, he has served as Director of Biocarbon Research for Alterna Biocarbon, Inc., while maintaining his consulting practice at a reduced scope due to corporate obligations.

Qualifications:

* Registered Professional Engineer (Mass, NY)
* Extensive experience in Process and Technology Development
* Excellent written and verbal communication skills
* Solid understanding of environmental technologies and regulations
* Experience in Process Safety and Pollution Prevention programs

Education

Ph.D.	Rensselaer Polytechnic Institute	1988	Chemical Engineering
M.S.	University of Southern California	1978	Chemical Engineering
B.S.	Harvey Mudd College	1976	Chemistry

Professional History

1/00 to present	Hugh McLaughlin, P.E.	Consulting Professional Engineer
3/09 to 9/13	Alterna Biocarbon, Inc.	Director of Biocarbon Research
2/98 to 1/00	Camp Dresser & McKee	Senior Chemical Engineer
7/92 to 2/98	Waste Min inc.	Vice President
11/88 to 7/92	ENSR Consulting & Eng	Sr. Process Engineer/Division Leader
7/84 to 10/88	Hugh McLaughlin, P.E.	Consulting Engineer
11/78 to 7/83	Schenectady Int., Inc.	Process Engineer/Group Leader
7/76 to 7/78	United Controls	Development Engineer

Technical Specialties

30+ years of professional experience:

* Process Development, Design and Modification
* Waste Minimization/Pollution Prevention Programs
* Process Safety Management/Risk Management Programs
* Industrial Waste Treatment/Air Pollution Control

Specialized Expertise in Activated Carbon and Biochar

Dr. McLaughlin has over 25 years of experience with activated carbon and its applications. He has performed fundamental research on activation and regeneration of activated carbon, with particular insight into the extent of adsorption performance and impact on the activated carbon physical properties.

Dr. McLaughlin has in-house capabilities to produce laboratory scale high temperature steam-activated carbon samples from a wide variety of carbon precursors, including biomass-derived and polymeric raw materials. The activated carbon samples can be characterized by various analytical techniques or generated for application testing. Specifically, he has the ability to generate entire "activation series", based on any carbon-rich starting material, and characterize the evolution of the adsorption properties by GACS (Gravimetric Adsorption Capacity Scan). He has completed this development cycle for several proprietary chemical industry clients.

Dr. McLaughlin also has consulted extensively on industrial applications of granular activated carbon, including vapor phase emission control and product recovery, storm water applications and numerous applications of treatment of aqueous wastewater and contaminated groundwater. Consulting services include guidance in the selection and application of activated carbon products, modifying and optimizing current adsorption operations, and operational reviews of current high temperature reactivation operations (Multiple Hearth, Rotary Kiln and customized designs). All reviews include revision of operating setpoints for improved adsorbent performance and lower overall operating cost. He has provided this service multiple times, including Sugar Refining applications.

Dr. McLaughlin has emerged as a leading expert in the rapidly developing field of Biochar, principally because all activated carbon products are produced by first creating the precursor char, followed by activation. He has presented at National Conferences on Biochar and published extensively on the characterization of biochar based on measurable physical properties of the end products

Selected Papers and Publications

H. McLaughlin, Chapter 6 (What is Biochar), Chapter 7 (How Biochar helps the Soil – authored in conjunction with Julie Major, PhD) and Chapter 8 (Characterizing Biochars: Attributes, Indicators and At-Home Tests) of *The Biochar Revolution*, edited by Paul Taylor, Global Publishing Group, 2010.

H. McLaughlin, "Biochar and Energy Co-Products", appearing in the U.S. Focused Biochar Report: Assessment of Biochar's Benefits for the United States of America.

H. McLaughlin, P.S. Anderson, F.E. Shields, and T.B. Reed. "All Biochars are not Created Equal and How to Tell them Apart", presented at the North American Biochar Conference, Bolder, CO 2009 (http://www.biochar-international.org/node/1029).