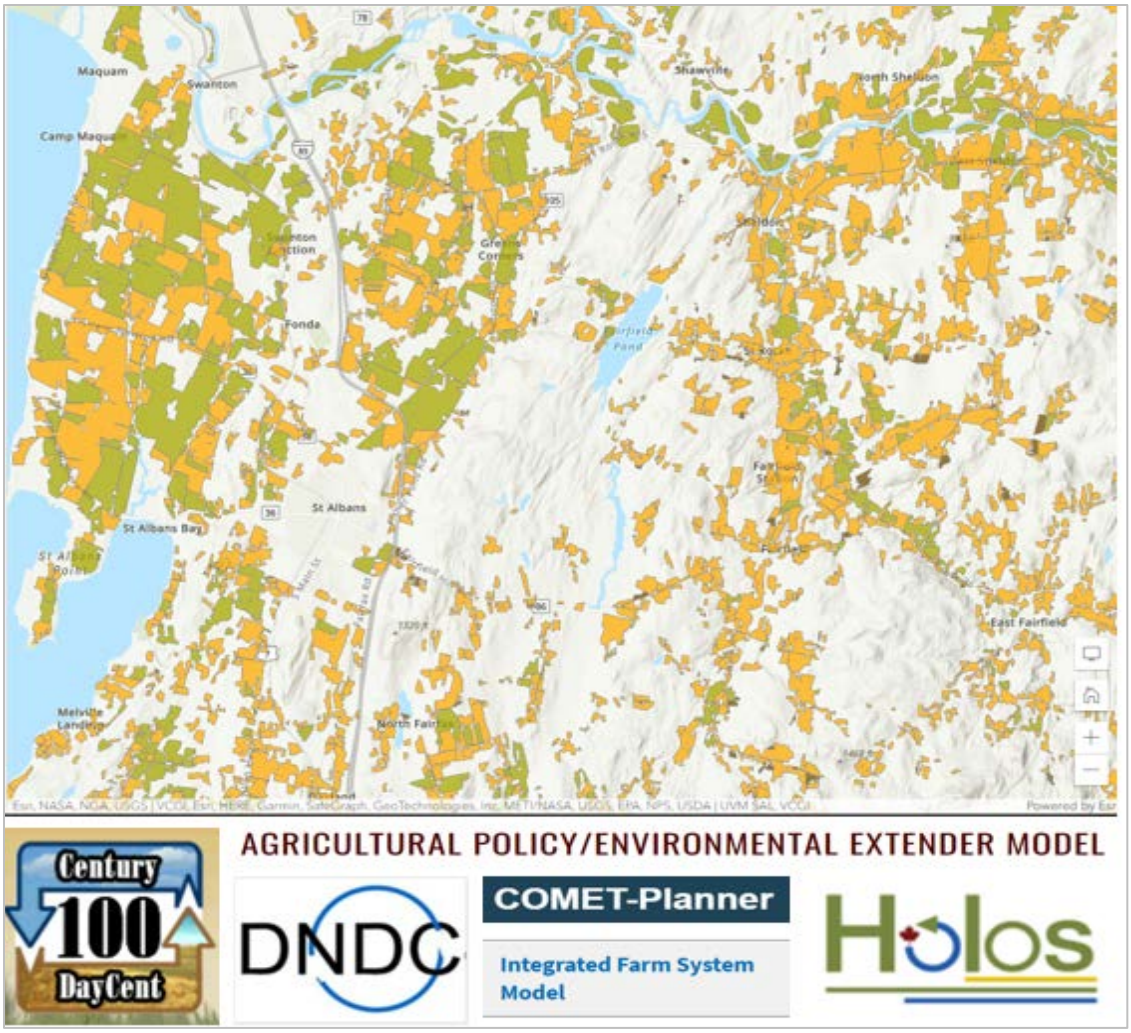
Proposal: Review of Agricultural Sector Greenhouse Gas Emissions and Sequestration in Vermont

STONE ENVIRONMENTAL



PROJECT NO.

20221263

REVIEWED BY:

MW

PREPARED FOR:

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October 21, 2022

Vermont Agency of Natural Resources
ATTN: Jane Lazorchak
One National Life Drive
Montpelier, Vermont 05633

Stone Project No. 20221255
Subject: Review of Agricultural Sector Greenhouse Gas Emissions and Sequestration in Vermont

Dear Jane and Members of the Selection Committee:

Stone Environmental, Inc. (Stone) is excited to respond to the Agency of Natural Resources' (ANR) Request for Proposals (RFP) to develop and recommend methodologies to accurately quantify the Agricultural component of an Agriculture, Forestry and Other Land Lase (AFOLU) sector estimate of greenhouse gas emissions and sequestration in Vermont. This will include a comparison and evaluation of a suite of models and data that could quantify greenhouse gas (GHG) emissions and sequestration from agricultural practices, recommend a methodology and tool most appropriate for Vermont, as well as implement a methodology to produce an analysis of Vermont's GHG's from the agricultural sector that can be published as a supplement to the next release of Vermont's GHG Emissions Inventory and Forecast.

We will work closely with the Vermont Climate Council and the ANR, the Global Warming Solutions Act (GWSA) Director, and other stakeholders to ensure that the project approach meets the needs outlined in this RFP. Stone is well qualified for this work based on a history of successfully completed modeling, database, and tool development projects for the State, considerable project experience related to the agricultural sector in Vermont, and significant expertise in model evaluation, development, and application to a range of relevant problems.

The following proposal includes a scope of work, an estimated budget, and additional information regarding our team's qualifications and experience. We appreciate this opportunity to submit our proposal and are available to answer any questions.

Sincerely,



Jody Stryker, Ph.D.
Project Manager, Senior Modeler
Direct Phone / 858.444.5790
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Proposal for Review of Agricultural Sector Greenhouse Gas Emissions and Sequestration in Vermont

Cover Photo:
Stone is currently working with VAAFM to customize Farm-PREP for the Pay-for-Phosphorus Program.

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1. Qualifications of the Project Team

Stone Environmental, Inc. (Stone) is a 100% employee-owned environmental science, engineering, and field services firm located in Montpelier, Vermont. Founded in 1992, our mission is to provide tools, information, and analyses to help clients solve environmental challenges with integrity, expertise, and innovation. We bring together over 50 scientists, engineers, and foundation staff with diverse backgrounds and skills and a shared commitment to excellence, creativity, and accountability through employee ownership. Our areas of expertise include development and application of a broad range of models in multiple areas relevant to agriculture including water quality, soil health, nutrient fluxes, crop growth, and conservation practices. In addition, we have experience in environmental planning and policy development, stormwater and watershed assessment, developed lands stormwater retrofit practice design and implementation, environmental monitoring, geographic information systems (GIS) spatial analysis, and application development.

Over the past three decades, Stone has worked with local, regional, and federal partners including Vermont Agency of Agriculture Food & Markets (VAAFM), Vermont Department of Environmental Conservation (DEC) Agency of Natural Resources (ANR), USDA Natural Resources Conservation Service (NRCS), Lake Champlain Basin Program (LCBP), and the Vermont Agency of Transportation (VTrans) to advance innovative strategies and tools for addressing sustainability and resiliency challenges. We have developed several web-based tools to support state programs aimed at meeting water quality, reconnection/restoration, and resiliency goals, including the Farm-P Reduction Planner (Farm-PREP), the Functioning Floodplain Initiative web application, Vermont Transportation Resilience Planning Tool (TRPT), and the Vermont Partners Database. We specialize in development and implementation of model-based environmental analysis approaches using a range of models at multiple scales to address complex environmental management challenges. Stone is currently working with multiple agencies and organizations across the Lake Champlain Basin to evaluate, site, design, and implement agricultural water quality improvement projects, as well as guide decision-making, nutrient management program planning, and policy development to address the water quality impacts associated with agriculture. We are eager to expand the suite of tools available for Vermont to reach climate change mitigation goals by developing a model-based approach to quantify emissions and sequestration of greenhouse gases (GHGs) in the agricultural sector and feel we are highly qualified to do so.

1.1. Relevant Experience: Modeling and Decision Support Tools

Stone's environmental modeling team is known for finding innovative solutions to the most challenging problems. We strive to discover new and better ways to evaluate and integrate data to improve the parameterization and application of environmental models. Our team has the modeling expertise to understand why a model produces a certain result and readily challenge results that don't meet the conceptual understanding of the physical processes. Our skills in computer programming and knowledge of environmental processes allow us to improve efficiency in parameterizing, executing, and evaluating model outputs and create new tools to automate activities. Our team specializes in guiding clients to the best modeling solutions for their use cases, customizing environmental models for improved fit to purpose, efficiently simulating large ensembles of model scenarios, and communicating results to diverse decision-

makers using interactive web applications and visualizations. Past projects have addressed challenges in the areas of climate change, agricultural conservation practices, and watershed water quality management. We also provide expertise in spatial analysis and have developed innovative approaches for integrating national-scale datasets in our modeling applications, as well as database development and management. Our proficiency in both web-based and desktop application development enables us to build decision support systems that allow stakeholders to leverage the sophistication and power of many agricultural, hydrologic, and water quality models. Stone's environmental modeling approach generally involves:

- Understanding our client's perspective and working together to define the goals and outcomes of the project.
- Building an inventory of existing datasets, resources, and models with the client.
- Incorporating state-of-the-art geographical information system (GIS) analysis, database tools, and both established and customized modeling tools.
- Rigorous quality control throughout the model development, application, and analysis process.
- Providing project deliverables including technical reports, publications in peer-reviewed journals, presentations, and web and desktop tools that clearly communicate project outcomes to both technical and non-technical stakeholders.

1.2. Key Staff Roles and Bios

We have assembled a project team that combines expertise spanning a variety of models and modeling approaches with the scientific knowledge to apply those skills to new areas of modeling. The training, abilities, and experience our team members bring to this project enable us to successfully evaluate the modeling tools, available datasets, and collaboratively develop a methodology for quantifying greenhouse gases emitted and sequestered from the agriculture sector in Vermont. Resumes are provided in Appendix A.

JODY STRYKER, PH.D. Senior Environmental Modeler

Project Manager, Model Development and Application

Jody will serve as Project Manager, responsible for the project schedule, coordination with the State, invoicing, contract requirements, and ensuring all deliverables are met. She will be the primary point of contact for the Global Warming Solutions Act (GWSA) director. Jody has an interdisciplinary background in environmental sciences and engineering. Her expertise includes model and methodology development, model application, lead report, proposal, and publication writing, data visualization and presentation, and project management. As part of her doctoral research, she made critical contributions to building an integrated assessment model for understanding the role of climate change on nutrient and sediment fluxes in the Lake Champlain Basin. At Stone, Jody has been involved in a range of model-based efforts including field and watershed scale modeling to evaluate nutrient and pesticide losses as well as evaluate effectiveness of conservation practices, air dispersion modeling for evaluating off-target movement of semi-volatile compounds, vegetation filter strop modeling for reduction of nutrient and pesticides, and others. Jody has considerable project experience modeling processes critical to understanding the impacts of agriculture on water quality and soil health, including evaluation of tools for simulating fluxes in phosphorus, nitrogen, and carbon, as well as incorporating different agronomic management and conservation practices. She manages Stone's role in the Vermont Functioning Floodplain Initiative (FFI) Phase 2 effort, which is to develop an application for accessing connectivity data, identify, and prioritize project opportunities, and track floodplain restoration and protection in the Lake Champlain Basin. She also leads ongoing development of the Farm Phosphorus Reduction Planner (Farm-PREP), which supports the Vermont Agency of Food, Agriculture, and Markets (VAAFM) Pay for Phosphorus Program by providing model-driven field and farm-specific estimates of phosphorus reduction based on simulated implementation of agricultural conservation practices. Jody earned

her Ph.D. and M.S. in Civil and Environmental Engineering from the University of Vermont, and a B.S. in Environmental Science from the University of Miami.

BETTINA MIGUEZ Environmental Modeler

Model Development and Application

Bettina will provide model development and application support, including review and evaluation of a suite of models for this effort. Bettina has over ten years' experience in environmental modeling, risk assessment, and natural resources management. Her work has spanned North and South America, in the private and public sectors. At Stone, she has supported SWAT and SWAT+ models of agricultural watersheds, APEX crop and field models, and the use of the SEAWAVE-QEX statistical model to create daily time series from sparse monitoring data. Prior to joining Stone, Bettina worked in public policy related to dairy nutrient management and irrigation at the Agricultural Ministry of Uruguay. Bettina holds a M.Sc. in Soil Science from UW Madison and a B.Sc.E. in Environmental Engineering from Princeton University.

MICHAEL WINCHELL Senior Environmental Modeler

Project Oversight, Technical Advisor, Modeling (Principal/Program Manager)

Mike Winchell will provide oversight of project execution as well as provide technical guidance and review of task completion. Mike has been a part of Stone for the last 21 years and serves as both the Vice President and Environmental Systems Modeling Service Line Leader. Over the course of his tenure at Stone, Mike has led technical geospatial analysis and modeling efforts, as well as managed projects across nearly all of Stone's areas of expertise. Mike's specific areas of expertise include chemical/nutrient fate and transport in soil and water, watershed scale water quality assessments, simulation and analysis of agricultural best management practices, integration of GIS with environmental models, and model interface development. Mike has worked directly with the APEX model since 2007. This work has included model interface development for ArcGIS and web-based interfaces, developing databases to support APEX modeling and automation, APEX model development support and review, calibration, and validation of the model in tile-drained and un-drained cropping systems, and application of APEX to assess the effectiveness of conservation practices and impacts on soil carbon storage. Mike holds an M.S. degree in Hydrology and Water Resources from the University of Arizona and a B.S. degree in Environmental Systems from Cornell University's Department of Agricultural and Biological Engineering.

MARY HALEY GIS Specialist

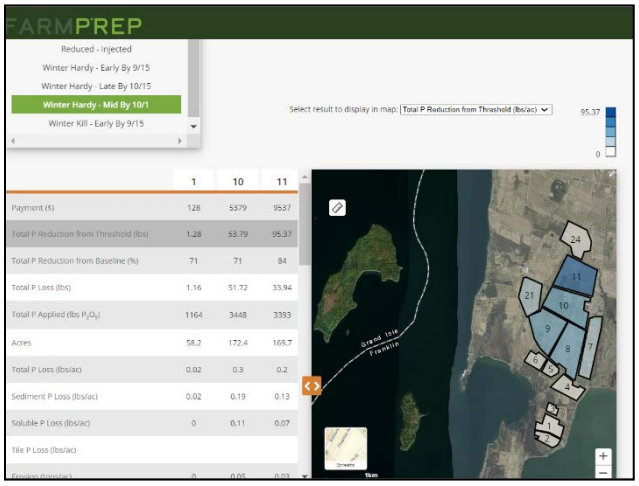
Spatial Analysis and Data Preparation

Mary will provide support for GIS data preparation and management as well as spatial analysis as needed. Mary is a GIS specialist with four years of experience leveraging advanced level GIS services to a range of technical projects. Prior to joining Stone, she applied her skills to the Vermont Agency of Transportation, where she administered geodatabases and mapping services with python automation, developed ArcGIS Online web maps and tools, and led field work for the terrestrial LiDAR scanning program. At Stone, she draws on her diverse design and field experience to support application development and geospatial analysis projects. Mary's recent project experience includes developing Python automation scripts to track and manage data services displayed in the ArcGIS Hub site developed for the Vermont Community Broadband Board, assisting with migrating data from existing servers and geodatabases into the platform developed for the New York Geographic Information Gateway, and developing an automated phosphorus reduction tracking system to identify current infrastructure condition changes over time for Vermont swales and culverts. Mary has a Professional GIS Certificate from Michigan State University and a B.S. degree in Environmental Science from Endicott College.

1.3. Related Project Experience

1.3.1. Farm-PREP Modifications to Support the VAAFM Pay for Phosphorus Program (2021–Present)

Stone supports the ongoing development of a version of the Farm Phosphorus Reduction Planner (Farm-PREP) for the Vermont Agency of Agriculture, Food, and Markets' (VAAFM) Pay for Phosphorus Program (VPFP). This program provides farmers with performance-based payments for reducing phosphorus loss based on the outcome of implementing conservation practices. Stone has developed historic base management assumptions (HBMA) for all of Vermont, to represent recent EPA modeling done to recalculate Lake Champlain's total maximum daily loads (TMDLs). When a farmer creates a field, Farm-PREP automatically assigns the appropriate HMBA scenario and when assessments run, each field is simulated with both the current management and its HBMA management assumptions. Features have been added to support programmatic verification processes, identification of NRCS practices, and streamlined creation of assessments. New functionality has also been developed such as mapping results and a new type of alternative assessment where all fields are automatically assigned a specific conservation practice to allow evaluation of the field-specific impacts of those practices on phosphorus losses. This expansion of the APEX-based Farm-PREP tool has required substantial model testing and evaluation which has included critical review of physical process linkages between soil carbon and nutrient dynamics, crop growth, water quality, and agronomic management decisions.

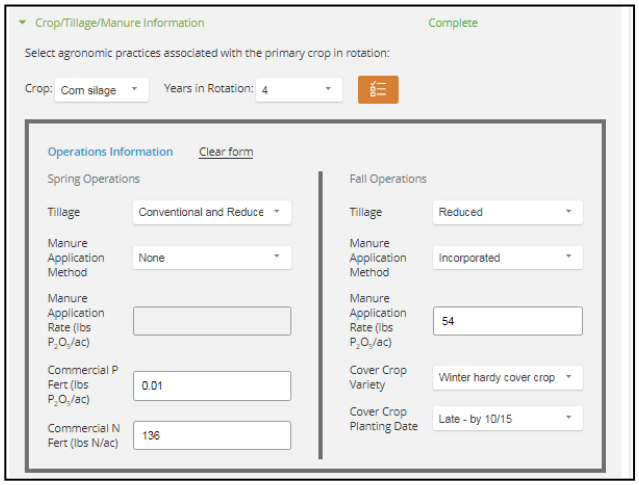


New features including mapping of field-scale APEX results, and calculation of new fields to support implementation of the Pay for Phosphorus Program.

1.3.2. Farm-PREP Web Interface for Optimizing Farm-Scale Phosphorus Loss Reduction, Lake Champlain Basin Program (2017–Present)

Stone has led the development of the Farm Phosphorus Reduction Planner (Farm-PREP), an integrated web-based application that helps farmers, technical crop consultants, and stakeholders easily evaluate the impacts of field-level best management practices on farm scale P loss reductions. Farm-PREP brings the power of the USDA's farm-scale water quality model, APEX, to a much broader audience through a streamlined and user-friendly interface that evaluates thousands of farm management scenarios. The tool integrates agronomic and hydrologic science, numerical modeling, and web-based application development into a high-powered scientific modeling tool operated with an elegant and intuitive user-facing front end.

Numerical modeling and optimization methods were developed to enable the execution of thousands of APEX model simulations for each farm to identify management solutions that meet a target for reducing P losses. The modeling and optimization approach utilized distributed cloud computing in a dynamic framework that could accommodate increasingly complex analyses associated with increasing farm size and number of concurrent users. Farm-PREP's web-based user interface, with a logical work-flow design, allows efficient inputs of critical farm information to conduct the modeling analysis. The information provided by the tool offers farmers multiple options for field-level practices that meet water quality objectives and allows the farmer to make decisions that also meet their farm's operational needs and preferences.



Users provide current crop rotations and agronomic practices, and Farm-PREP generates model simulations of multiple combinations of field practices to arrive at a farm-level plan that meets pre-determined farm phosphorous reduction targets.

The APEX model calibration and validation effort required an assessment and understanding of the complex biogeochemical processes that impact P loss from agricultural lands. APEX is a physically based model that simulates climate and management impacts on soil health, crop growth, GHG emissions, and water quality metrics. The integration of hydrologic and biogeochemical processes directly affects nutrient and carbon mass balances, both above and below ground. As part of the Farm-PREP development effort, a Vermont-specific regional calibration and validation of APEX based on 12 edge-of-field and tile drain monitoring sites was conducted. This effort accounted for hydrologic, sediment transport, nutrient cycling, and crop growth components of the model, which ultimately influence carbon storage and GHG emissions.

1.3.3. Comparison of Stewardship Evaluation Tools for the Vermont Environmental Stewardship Program, VAAFM (2019–2021)

Through the Vermont Environmental Stewardship Program (VESP), VAAFM aims to accelerate water quality improvements by encouraging local agricultural producers to achieve environmental and agricultural excellence through voluntary implementation efforts. The goal of this project was to compare output from two potential tools for use in the VESP program: USDA's Agricultural Policy / Environmental eXtender model (APEX) and the USDA's Resource Stewardship Evaluation Tool (RSET). Field level outputs for phosphorus losses, nitrogen losses, soil erosion, soil carbon, and organic matter outputs were compared for a number of fields that represent a wide range of agricultural practices and field conditions.

Data describing field conditions and agronomic practices were compiled for several VESP pilot farms, as well as additional acreage, and provided to Stone by VAAFM. APEX models were initially set up for each field using Farm-PREP, which facilitated development of input files. Farm-PREP aided in determining spatial inputs (e.g. soil, slope, weather) as well as for determining initial operations schedules and parameterizing conservation practices such as buffers and filter strips. Where necessary, models were subsequently customized outside Farm-PREP, such as for grazing practices or agronomic practices not provided as options in Farm-PREP (such as certain crop rotations). For each field, a current practices scenario was simulated, as well as a TMDL scenario that represented standard agronomic practices assumed in the Lake Champlain TMDL SWAT modeling (Tetra Tech, 2015).

Initial comparison of results indicated substantial agreement between the tools in their evaluation of whether fields met specific threshold values (for RSET, these were site specific and based on inherent risk while for APEX these were based on NRCS national thresholds). In addition, there was general agreement in the directional behavior of outputs when the current and TMDL scenarios were compared. The two tools differ significantly in their design and nature of outputs so no direct comparison of output values could be made. For example, APEX is a process-based model that outputs quantitative predictions of soil carbon storage (as well as several other quantitative outputs), while RSET is designed to indicate whether management is sufficient to meet a site's inherent risk and outputs index-based scores for several key indicator areas.

The second phase of this project included building the capacity to simulate grazing with the APEX model into Farm-PREP. Based on the previous phase of work, it was determined that a quantitative model could offer a more robust analysis as well as more opportunity for adaption and flexibility to support evaluation of multiple components of land stewardship under a broad range of conditions. We determined key user inputs for parameterizing grazing simulations (e.g., number of animals on a field, rest and consecutive grazing periods, etc.) and conducted a model sensitivity analysis to ensure model response to those inputs followed known trends and resulting phosphorus losses were within a reasonable range across a range of field conditions. Working with VAAFM, we established ranges for user inputs represent a range of typical grazing management in Vermont and successfully configured the Farm-PREP tool to simulate grazing with APEX.

1.3.4. Development of a Soil Health Calculator Tool to Quantify Impacts of Agricultural Management Practices on Soil Health in the Lake Champlain Basin

The soil health calculator tool is currently being developed to provide quantitative and field-specific information about the impact of agricultural management on key soil health indicators. The tool outputs will be based on the United States Department of Agriculture (USDA) Agricultural Policy Environmental eXtender model (APEX). The Soil Health Calculator will incentivize best management practices adoption by providing a better understanding of the relative impact of those practices and evaluating management options tailored to specific farm/field conditions. The tool will be designed for a broad range of stakeholders, including VAAFM, farmers, crop consultants, and researchers. The proposed Soil Health Calculator module could be an additional component of a State system (e.g., VAAFM programs) for quantifying the benefits of environmental stewardship on agricultural lands and supporting state programs. Using APEX to simulate key soil health indicators is a consistent and scalable approach that could advance environmental stewardship goals and support an ecosystem services framework in the agricultural sector of Vermont. In future projects, this tool could be further developed and/or integrated with other models (e.g., DayCent, economics models) to create a systems modeling tool and provide information on additional indicators and a larger suite of ecosystem services. The Soil Health Calculator Tool will be easily accessible and developed such that it can be used as an independent component of Farm-PREP, or as part of an assessment that includes nutrient loss, erosion, and runoff results (current outputs of Farm-PREP).

Table 1. Additional Project Experience

Project	Description
Agronomic and Water Quality Modeling and Model Interface Development	
Rangeland Modeling of Natural Resources Inventory (NRI) Data with the APEX Model Texas A&M University, 2018-Present	Stone has been working with Texas A&M University to automate the modeling of NRI point data for rangeland sites using the APEX model. A steward ship tool is being developed to allow the evaluation of impact of different grazing scenarios on erosion and plant productivity. To this end, the tool extracts data from the NRCS National Resources Inventory (NRI) database to parameterize APEX simulations for valid points within a selected Major Land Resources Area

Project	Description
	(MLRA) for multiple grazing scenarios. The tool generates all APEX run input files, efficiently executes and post processes APEX simulation output for analysis. The pre-defined scenarios account for different herd rotations, stocking rates, grazing timing, and grazing durations. A comparison across different NRI data points allows making informed decisions about best grazing practices across various climates, soil types, and landscapes.
Development of an APEX Model Interface for Precision Farming *USDA/Texas A&M, 2017 - 2018*	Stone developed an ArcGIS interface to the APEX model that allows for a grid-based field delineation strategy to help support precision farming practices. Spatial measurements of yield and environmental parameters such as erosion have clearly shown large within-field variability, suggesting that management practices could be improved by varying management at a sub-field scale. Thus, a grid-based field delineation tool was developed for APEX. The tool can account for inner field heterogeneities (e.g., variation in slope or soil types) and provide any APEX output at sub-field level in a geospatial raster format, which can be visualized using GIS. In addition, the output is summarized at the field scale allowing the user to quickly identify problematic fields. In a next step, the user can zoom into the field to identify if there are sub-field level hot spots and use the information to adjust management practices at the sub-field level.
Comparison of RZWQM and SWAT for Simulation of Pesticide Transport in Tile Drained Fields *Confidential Industry Client, 2017-2018*	Pesticide concentrations and flows through tile drainage on Midwest field sites were modeled using the Root Zone Water Quality Model (RZWQM) and the Soil and Water Assessment Tool (SWAT). Both models were calibrated to monitor data and were then used in long-term (30-year) simulations of pesticide transport from tile drains to receiving water bodies. Overall, the RZWQM model was found to better predict tile drainage pesticide fluxes. The modeling results were used as part of an ecological risk assessment
Development STAR, a Web-Based Tool for APEX Analysis of Farm Management *Vermont NRCS & Lake Champlain Basin Program, 2013-2015*	In 2013-15, Stone developed the Systematic Tool for Analyzing Resources (STAR), a web-based modeling tool for simulating the impacts of alternative conservation practices applied across individual farm fields to help scientists and technicians conduct more efficient resource assessments. STAR incorporates the APEX model to help scientists and technicians determine the applicability and effectiveness of a range of farm-scale nutrient management and conservation plans. As part of this effort, Stone worked with NRCS to develop standard agronomic management schedules for crop rotations typical of Vermont agriculture. These agronomic management schedules formed the foundation for scenarios that could then be customized by users to most accurately reflect their specific management practices. The development of the STAR agronomic management scenarios included comparisons with edge-of-field monitoring data and relative comparisons across scenarios in order to improve the confidence in the model predictions.
Improvement of Vegetative Filter Strip Model (VFSMOD) to Allow Continuous Simulations in Large Batch Runs *Confidential Industry Client, 2014-2015*	The Vegetative Filter Strip Model (VFSMOD) is used to estimate the efficiency of filter strips in capturing off-site transport of runoff, sediment, and nutrients. The standard model is executed on a storm event basis. In order to run 30-year simulations to assess long term reductions of offsite pollutant transport, Stone modified the VFSMOD code to allow integration with long term Pesticide Root Zone Model (PRZM) simulation. The VFSMOD code was also improved to monitor numerical instability during simulation and to adjust numerical modeling parameters dynamically to achieve solution convergence.
Application of SWAT to Assess Phosphorus	A review of watershed scale models capable of simulating the Lake Prespa watershed (Macedonia) and evaluating phosphorus (P) critical source areas was

Project	Description
Critical Source Areas in Lake Prespa *United Nations Development Programme, 2013-2015*	conducted. SWAT was identified as the most appropriate model, and was coupled with the BATHTUB lake water quality model to evaluate the impacts of alternative management practices on in-lake P concentrations.
Identification of Phosphorus Critical Source Areas (CSAs) in the Missisquoi Basin of Vermont *Lake Champlain Basin Program/EPA, 2010-2012*	To identify locations of CSAs and prioritize areas for implementation of BMPs, Stone developed a high-resolution SWAT model that incorporated parcel boundary data and was able to generate results in a manner meaningful to individual landowners. The analysis determined that just 10% of the land area contributes nearly 60% of the P load and showed that using a targeted implementation strategy for technical and financial assistance programs offers clear benefits.
Agricultural and Environmental Database and Analysis Application Development	
The Vermont Partners Database *VAAFM (2014—Present)*	The Vermont Partners Database is a web-based mapping, database, and reporting platform designed to help improve long-range planning across and within agencies to maximize resources and improve agronomic impacts to water quality. Stone has been working with VAAFM and the Vermont Agriculture Water Quality Partnership since 2014 to design, develop, implement, and enhance the Partners Database to include up-to-date, farm field data that can be used by field staff plan, coordinate, and track farm BMP implementation statewide. Using ArcGIS Server and PostGres, Stone developed a robust relational database to manage both spatial and non-spatial information associated with agricultural best management practice implementation. The application helps reduce redundancy and improve communication among farm conservation planners by allowing authorized users to view and edit farm information including farm fields, practices, visits & interactions, and farm contacts. Access to the application is available only with a secure username and password. Vermont conservation districts are provided access and farm data is restricted based on the user's county. The relational database also allows for flexible reporting capabilities to list details of practices or a summary based on county or watershed.
Vermont Transportation Flood Resilience Planning Tool *Vermont Agency of Transportation, 2015-2018*	Stone developed a web-based planning tool for visualization of flood risk to Vermont transportation infrastructure. Stakeholders can quickly identify high-risk assets to prioritize upgrades and make decisions about mitigation strategies based on supporting information that includes factors determining vulnerability and criticality of an asset, project scale and duration, unit cost, and initial river and network impacts. https://roadfloodresilience.vermont.gov
Field Monitoring Data Collection, Study Design, and Analysis	
Monitoring and Evaluating the Impacts of Tile Drainage Systems on Water Quality in the Lake Champlain Basin, Vermont *Lake Champlain Basin Program, 2016—Present*	Stone is conducting a multi-year study focused on evaluating nutrient outputs from agricultural tile drains in the Lake Champlain Basin and assessing the significance of these loadings to Lake Champlain. In 2016-2017, Stone installed monitoring systems at 12 tile drain outfalls in the Jewett Brook watershed in Vermont, where flow rates are continuously measured, and flow-paced composite samples are collected, processed, and analyzed to calculate phosphorus, nitrogen, and sediment concentrations and loading. The annual phosphorus loading observed at these stations was compared with tributary phosphorus loading in this watershed to estimate the proportion of phosphorus

Project	Description
	loading attributable to tile drainage systems, approximately 25%. In 2018, the program was expanded to five new tile drains in Addison County, Vermont. Stone has observed extremely high variability in phosphorus concentrations among the monitored sites over time, ranging from 11–4,000+ µg/L.
Monitoring Farm Runoff to Evaluate Agricultural Conservation Practice Performance *Vermont Agency of Agriculture and the Lake Champlain Basin Program, 2012—2019*	In 2012, Stone began an edge-of-field runoff monitoring program for the Vermont Agency of Agriculture. The study generated critical data on the effectiveness of several practices currently promoted by the Agency of Agriculture and NRCS in Vermont to reduce nutrient and sediment pollution in farm runoff. At its peak, 16 stations were continuously monitored on seven farms in the Lake Champlain Basin. The practices Stone evaluated were soil aeration on hay land prior to manure applications; cover cropping; reduced tillage and manure injection on cornland; a water and sediment control basin treating runoff from a cornfield; and a grassed waterway. Monitoring concluded in 2019 and Stone delivered a final report evaluating the performance of specific BMPS. The results from these studies are being considered and incorporated into efforts to meet the requirements of the Lake Champlain Phosphorus TMDL.
Assessment of Dairy Manure Management Practices to Reduce Pathogen Runoff Losses from Agricultural Watersheds *USDA CSREES, 2007—2011*	Stone conducted an edge-of-field, paired-watershed study for USDA-CSREES to investigate the effects of several management practices on runoff of microbial pathogens and indicator bacteria (E. coli, Salmonella, Giardia, and Cryptosporidium) from fields in corn and hay production. The management practices tested had been identified in an earlier plot study Stone conducted using simulated rainfall. High E. coli counts were observed in runoff events that closely followed manure applications; bacteria counts tended to decline with increasing elapsed time between manure application and the runoff event. Manure incorporation on corn land had no significant effect on concentrations of E. coli observed in runoff, but bacteria export was reduced because incorporation reduced runoff volumes. Prompt incorporation of manure on tilled land was recommended because it may protect against microorganism wash-out in immediate major rainfall events, and because incorporation reduces microorganism export in the long run.

2. Approach to Completing the Work

Through engaged collaboration, strong project management, and regular communication, Stone will successfully accomplish the scope of work set forth in this proposal. In the following section, we outline our proposed approach for this project, but will work collaboratively with the GWSA Director, ANR staff, the Vermont Climate Council, and other stakeholders. We are open to adapting the approach described here to ensure meeting the specified objectives and accomplishing the desired outcomes.

Task 1: Project Management

This project will receive a trained and qualified project manager (PM)who will serve as the primary point of contact with the GWSA Director. The Stone PM will ensure high quality, on-time deliverables and will maintain open, regular communication with the GWSA Director and other contacts specified during the kickoff meeting. The PM will also be responsible for conveying any issues that may arise in a timely matter and coordinating a solution that meets the client's needs.

Stone will organize a project kickoff meeting by December 16, 2022, or within two weeks of contract initiation (should contracting be delayed). The Stone project team will prepare a draft project initiation workplan for review prior to the kickoff meeting, where the primary focus of the kickoff meeting will be the proposed approach and establishing any desired modifications to the workplan. Attendees will include Stone's project manager and key project team members, the GWSA Director, a task group comprised of members of the Agriculture and Ecosystems Subcommittee and the Science and Data Subcommittee of the Vermont Climate Council, and any other key members of the project team from ANR. Stone will present an overview of the workplan, as well as determine a schedule for prescribed meetings with ANR staff and the task group, confirm or adjust timelines for deliverables as needed, and establish communication channels. Stone will revise the workplan following the kickoff meeting and deliver a revised project initiation workplan by January 4, 2023 (or within 2 weeks of the project kickoff meeting).

Stone will finalize a project initiation workplan with the GWSA director, ANR, and the task group as quickly as possible after contract initiation, to minimize initial delays. However, we also recognize the development and implementation of an appropriate methodology will depend in part on the findings of the model evaluation and data review task, therefore we will remain open to modifying the workplan (specifically the scope of work for Task 3) as the work progresses. A meeting to review the findings of Task 2 will revisit the workplan and make any final decisions or adjustments in collaboration with the external team (GWSA director, ANR, Vermont Climate Council).

We will also establish a regular meeting schedule during the project kickoff meeting. While we value regular communication and check-ins, based on the aggressive timeline, scope of work, and size of budget, we suggest regular monthly meetings with Stone, ANR staff, and the task group. In addition, Stone's PM for this project will provide a bi-weekly status update to the GWSA director (in lieu of bi-weekly meetings). Stone or the GWSA director can request additional meetings at any time to discuss interim and/or administrative items. We foresee collaboratively deciding on the scope of work and requested deliverables for Task 2 during the project kick-off meeting. We believe that three meetings during execution of Task 2 (end of January, end of

February, and by March 17th) would sufficiently allow for feedback on progress and ensure collaboration on any key decision points. All meetings will include an agenda and documentation of action items and decisions. Email correspondence between meetings will be used for status updates and serve as an open channel for questions or idea exchanges.

Internally at Stone, we have a suite of project management tools that ensure team members are aware of tasks assigned to them and can report progress and alert other team members of key decision points. We use Ajera as project management and accounting software to provide resource planning, time recording, and invoicing. Project managers access real-time budget reports that include budgeted and actual and accrued costs, enabling them to monitor cost performance daily. Project-specific scope, schedule, and budget management protocols are in place to ensure we track project progress. We routinely use on-line collaboration tools such as Microsoft Teams, SharePoint, Asana, and Slack in our projects. Such tools are useful when project team members are in offices far apart, allowing for project communication under remote working conditions as well as providing access to information in a central location accessible to all members.

Task 1 Deliverables

- ✓ *1.00 Project Kickoff Meeting delivered by December 16, 2022*
- ✓ *1.01 Project initiation workplan delivered by January 4, 2023*
- ✓ *2.00 Ongoing project management tasks, including bi-weekly meetings and presentations delivered by March 17, 2023*
- ✓ *3.00. Ongoing project management tasks, including bi-weekly meetings and presentations delivered by June 16, 2023*

*Note: All project meetings associated with subsequent tasks have been budgeted for in this project management phase.

*Note: Dates provided are based on a contract initiation date of December 2 2022. If contracting is delayed, dates will be adjusted accordingly.

Task 2: Review Relevant Existing Materials and Develop Methodology Proposal for Review

This task will review a suite of existing models for simulating GHGs from agriculture with the goal of making a scientifically defensible recommendation on a practical tool or suite of tools and methodology for quantifying GHG emissions and sequestration from the agricultural sector in Vermont. This task will be broken into two components: 1) review of existing models and methodologies, and 2) recommendation of tool(s) and methodology appropriate for Vermont.

Task 2.1: Candidate Model Review

In order to efficiently review the large number of models that have been identified in the RFP (including DNDC, DayCent, APEX, COMET-Planner, Holos (Canada), and USDA IFSM), as well as ensure we have identified any other potentially suitable models or tools, we propose a tiered screening approach. As a first step, Stone will review existing datasets that are available for use in simulating GHG emissions and storage for agricultural land in Vermont. We will collaborate with ANR staff on this to ensure we leverage work already conducted by the State. The resulting list of datasets and relevant properties (e.g., resolution/scale, uncertainty, format) will be generated as a deliverable but will also serve as a basis for subsequently screening of GHG emissions/storage models for use in the work described here. Once we have a strong understanding of the available data, we will prepare a screening level review of all the specified models as well as others that we are aware of as potential options for quantifying agricultural GHGs. This will include compilation of information on model characteristics that would constitute criteria by which they could be eliminated as viable

options for meeting this work's objectives. These could be characteristics such as spatial scale at which they can be applied, temporal resolution, types of GHGs simulated (outputs), complexity of parameterization, data requirements (including whether required inputs are available), agricultural practices simulated, and more. An initial list of potential criteria will be proposed in the draft workplan, and a final list of criteria will be determined collaboratively with the ANR staff and the Vermont Climate Council task group during the project kick off meeting. Results of this screening level review will be presented and discussed during the first meeting occurrence for this task (mid/late January of 2023).

Based on this initial screening, a small number of models (2-3) will be identified as the best prospects. These models will be further evaluated to make a final recommendation for tool(s) and an implementation approach. The more in-depth evaluation will investigate sensitivity of the models to inputs, strengths and/or weaknesses in performance (based on a literature review), a more in-depth review of model processes and algorithms, and any additional model characteristics deemed essential through discussions with and feedback from the external project team. Results of this second tier of review will be presented and discussed during the second meeting occurrence for this task (mid/end February).

Task 2.2: Agricultural GHG Emissions/Storage Model Recommendation

Based on the findings of both tiers of model review (Task 2.1) and consultation with ANR and the task group, we will develop recommendations for the selection of model(s) and an appropriate methodology for quantifying Vermont's GHGs from the agricultural sector. Based on the budget and timeline of this scope of work, the methodology will need to be readily implementable while still providing an improved estimate of GHG emissions and sequestration from the agricultural sector in Vermont, suitable for inclusion in the Vermont GHG Emissions Inventory. We will also incorporate ANR's practical requirements in developing this methodology, such as how frequently they will want to execute it, who will need to implement the methodology after this project is complete, and what level of complexity/effort is acceptable.

We envision that based on the model(s) recommended, there will be multiple approaches for their application to generate a state-wide agricultural GHG emissions/sequestration inventory. The approaches will be largely dictated by the both the spatial resolution and availability of input datasets. On one extreme, field level information regarding climate, soils, topography, crop rotations, manure/fertilizer application rates, animal densities, and agronomic management practices would provide the highest resolution and most arcuate accounting of GHGs across the state. However, acquiring this resolution is infeasible and impractical. On the other extreme, agricultural land across the state could be simplified to represent the most "typical" or "representative" climate, landscape, and crop management conditions. There are then a wide range of possible spatial resolutions in between field-level and state-level which would strike an appropriate balance between complexity and feasibility.

Our approach will be to engage with ANR and the Vermont Climate Council task group to derive two approaches for quantifying GHG's from the agricultural sector in Vermont: a deterministic methodology will be developed that is an higher resolution improvement upon current estimation methods and that uses the tool/s identified in Task 2.1 but that can be feasibly executed in this scope of work, and a more spatially refined probabilistic GHG emissions/sequestration modeling methodology will also be recommended that could be implemented in the future based on further data collection if needed and time/budget to execute. The higher resolution approach would need to be readily applicable to the entire state's agricultural land with readily available datasets. This would include multiple spatial datasets describing climate, land use/crops, soils, and topography. Crop rotations and agricultural management practices (including conservation practices) would be required at a more aggregated spatial resolution, such as the county level. Depending on the GHG emissions/sequestration model chosen, some combination of inputs from these datasets will be

required. Based on the primary attributes associated with these model inputs, such as annual precipitation and temperature, land use, soil texture, soil organic matter, slope, and crop rotation, we would create unique combinations of similar spatial units, GHG Response Units (GHGRUs), across the entire state. More generalized agronomic management practices associated with each agricultural land use and county would add another management factor to each GHGRU. By categorizing each major input (e.g., binning organic matter into <1%, 2%-3%, 3%-5%, and >5%), a practical number of GHGRUs are constructed, each requiring its own model simulation. This semi-distributed deterministic modeling approach will account for a significant amount of variability in landscape-level GHG emissions/sequestration processes, be computationally efficient, and represent a substantial improvement over past approaches.

The refined probabilistic statewide modeling approach would likely build upon the deterministic approach by further discretizing the primary inputs (e.g., more variability in soil properties and/or climate) and also integrating finer resolution and more heterogeneity in agronomic practices across each agricultural land use class (e.g., row crops, orchards, hay, pasture). The inputs to the GHG emissions/sequestration models that have the highest uncertainty on a state-wide basis would be field-specific agronomic practices, which have a substantial impact on the carbon budget and GHG missions. A refined modeling approach would improve the representation of agronomic practices in two ways. First, it would incorporate sub-county level practice information explicitly where available. For example, a specific study conducted in a sub-watershed within VT such as the Missisquoi Bay watershed, may have more intensely compiled practice information suitable for public use. Another opportunity for incorporating higher resolution agronomic practice information into the GHG modeling framework would be to mine the VAAFM Partners Database. The Partners Database contains farm and field specific practice information. While this data is confidential, it could be mined and aggregated, such as to a HUC12 watershed scale, to provide more geographically relevant inputs to support higher resolution GHG model predictions. The second way that the refined modeling approach would improve upon the representation of agronomic practices in the GHG emissions/sequestration modeling would be through explicitly accounting for the uncertainty and heterogeneity of practices. This would entail applying a probabilistic modeling approach that requires distributions of practices associated with each agricultural land use within a specified region. Implementing such an approach would require compiling information on practices such as a matrix of the probabilities associated with different combinations of practices within a given region within VT. The probabilities of these practice combinations would then be cross-tabulated with the combinations of climate/landscape conditions associated with the same region. A hypothetical agronomic practice probability matrix is provided in Table 2 below. Stone would work closely with ANR and the task group to define the input data specifications, modeling approach, and output specifications required for implementation of this refined probabilistic GHG emissions/sequestration modeling framework.

Table 2. Hypothetical Agronomic Practice Probability Matrix, Corn Rotations, Franklin County

Tillage Practice	Cover Cropping	Manure Rate (gal/ac-year)	Probability
Reduced Till	Yes	4000 - 6000	0.13
Reduced Till	Yes	6000 - 8000	0.18
Reduced Till	No	4000 - 6000	0.09
Reduced Till	No	6000 - 8000	0.14
No Till	Yes	4000 - 6000	0.1
No Till	Yes	6000 - 8000	0.15
No Till	No	4000 - 6000	0.08
No Till	No	6000 - 8000	0.13

The recommended GHG emissions/sequestration modeling methodology will be documented in report form, including suggested tool(s) and required datasets for both the deterministic and refined probabilistic approaches, and submitted for review by ANR and the task group. The final methodology report will incorporate feedback and be redelivered within two weeks of receiving comments. This final methodology will also be presented at a joint meeting of the Science and Data Subcommittee and the Agriculture and Ecosystems Subcommittee of the Vermont Climate Council.

Task 2 Deliverables

- ✓ *Two meetings with ANR staff and task group to gather related information as required, as well as review of materials listed above and any other relevant data, information, and analyses. We envision these occurring approximately mid/end of January 2023 (to discuss findings of screening level model review) and approximately the mid/end of February 2023 (to discuss finding of second tier model review)*
- ✓ *Draft proposed modeling methodology report for review and comment, including deterministic level and refined probabilistic approaches (approximately early March 2023)*
- ✓ *One meeting to discuss and receive comment on the draft report (by March 17 2023)*
- ✓ *Final proposed methodology report for review and comment (two weeks after final [March] meeting)*
- ✓ *Presentation to Science and Data Subcommittee and the Agriculture and Ecosystems Subcommittee of the Vermont Climate Council*

*Note: Dates provided are based on a contract initiation date of December 2, 2022. If contracting is delayed, dates will be adjusted accordingly.

Task 3: Implementation of Analysis to Present Emissions Inventory Report

This task will include execution of the methodology developed in Task 2 to quantify agricultural GHGs and preparation of an agricultural inventory report to be included as a supplement to the Vermont GHG Emissions Inventory. Based on the project schedule and available project funding, this task would implement the higher resolution deterministic GHG emissions/sequestration modeling approach described in Task 2. This would still represent a significant advancement from current methods being applied statewide by, 1) applying a rigorously reviewed and scientifically vetted model, and 2) adopting a spatially distributed GHG Response Unit (GHGRU) modeling approach that capitalizes on the wealth of readily available statewide spatial data, while also making simplifying assumptions for some data requirements and reducing modeling resource demands.

Task 3 Deliverables

- ✓ *Perform statewide analysis implementing high resolution deterministic approach from the final methodology report*
- ✓ *One meeting (approximately mid/end April 2023), with ANR staff and task group to present progress and discuss interim findings*
- ✓ *Draft agricultural emissions inventory report with results of analysis for review and comment (approximately late May 2023)*
- ✓ *One meeting with ANR staff and task group to discuss results of methodology implementation and receive feedback on draft agricultural emissions inventory report (approximately early June 2023)*
- ✓ *Final agricultural emissions inventory report suitable for publication as a supplement to the Vermont GHG Emissions Inventory and Forecast report (by June 16 2023)*
- ✓ *Presentation of the final report and analysis at a meeting of the Science and Data Subcommittee and the Agriculture and Ecosystems Subcommittee of the Vermont Climate Council.*

3. Experience Supporting Development of Climate Action Work

Stone's scientists have experience in climate action work that includes projects focused on improving sustainability, resiliency, and understanding the potential impacts of climate change. Our work has involved technical data processing in automated workflows ranging from raw climate change data, downscaling, bias correction, and uncertainty analyses to the development of combined land use and climate change scenarios. We have integrated climate change impact assessments into workflows in multiple projects, enabling the development of integrated water resources and agricultural management to adapt to and mitigate climate change impacts. We have applied physically based models to better understand and predict changes in environmental outcomes to various aspects of climate change. These approaches have been crucial to finding and optimizing sustainable solutions for uncertain and changing climate conditions.

One challenge in climate change studies is that simulations of temperature and precipitation often show significant biases, making it necessary to downscale the climate model data prior to using them on the state or provincial level. Such downscaling of climate model data can be conducted with the CMhyd tool, which was developed by Stone Environmental's Senior Environmental Modeler, Hendrik Rathjens, in corporation with the USDA ARS, Purdue University, and Texas A&M (https://swat.tamu.edu/software/cmhyd,https://swat.tamu.edu/media/115265/bias_cor_man.pdf). This GCM model downscaling methodology and tool developed by Stone scientists has contributed significant benefits to the environmental modeling community by streamlining the use of these datasets. Other Stone team members have assessed coastal resilience of natural and man-made infrastructure under accelerated sea level rise due to climate change, applying and refining the Sea Level Affecting Marshes Model (SLAMM) to evaluate changes in tidal marsh areas and habitat types in response to accelerated sea level rise. Projects have included coastal areas in the Northeast, Gulf of Mexico, Mid-Atlantic and many of the USFWS coastal refuges. In New York and Connecticut, he assessed the vulnerability of roads and other infrastructure, i.e. power stations, water treatment facilities, etc., to increased inundation. He worked on 'what if' scenarios and developed decision support tools to identify proper adaptation strategies and prioritize marsh systems and protection of infrastructure affected by sea level rise under various sources of uncertainty.

The modeling efforts that Stone has led in Vermont, such as the Missisquoi Bay Watershed P Critical Source Area project, have included downscaled GCM model data to estimate how adopting agricultural conservation practices will perform to improve water quality in the face of a changing climate and more extreme events. Stone has worked on multiple efforts that include climate change resiliency including the Functioning Floodplain Initiative (FFI) web application and the Vermont Transportation Resilience Planning Tool (TRPT). These efforts have and continue to support the State's goals to build resiliency in both natural and built communities. The FFI web application uses scientifically developed methodology to find high priority projects to restore floodplain and river function, building capacity in our fluvial systems to improve water quality, increase resiliency to higher magnitude precipitation and flooding events, and protect critical habitat.

TRPT similarly uses science and transportation planning to identify infrastructure elements vulnerable to damage from flooding and natural processes, provides risk estimates, and determine potential mitigation measures based on vulnerability factors.

In addition to past experience, the Stone team is well educated in the science and tools needed to develop and execute a methodology for quantifying GHGs from Vermont's agricultural sector. Several members of the modeling team at Stone have advanced degrees in areas that relate to the science underlying models that can estimate GHGs from agriculture. At Stone, we foster critical thinking skills and support our staff in continuous learning so we can apply our expertise and experience to growing and changing focus areas. Modeling GHGs is a scientific discipline in which we are highly qualified and our experience with a wide range of models, agronomic modeling, tool development specific to Vermont, and climate action work more generally make us a strong candidate for this scope of work.

4. Capacity to Accomplish the Work

Stone is prepared to allocate the resources necessary to execute this project within the timeline specified below in Table 3. Our team has the capacity, knowledge, and technical capacity to successfully complete this project. It will require we establish a clear and achievable scope of work, as well as require that we maintain open and timely communication both internally at Stone and between Stone and the GWSA director and ANR staff. Our internal Stone team will have regular check ins and status updates, as well as use project management tools as described in Section 2, Task 1 to ensure we continue to make progress on specific tasks. Delays in contracting will delay the start of work and because of the aggressive timeline, delays in receiving feedback on deliverables and key decision points will make it more difficult for us to complete tasks by the specified deadlines.

Table 3. Project Schedule

Phase	Performance Measure	Deliverable	Timeframe
1	Task 1	1.00 Project Kickoff Meeting 1.01 Project workplan	January 4, 2023
2	Task 1	Ongoing project management tasks, including monthly meetings and presentations	March 17, 2023
	Task 2	Two meetings with ANR staff and task group to gather related information as required, as well as review of materials listed above and any other relevant data, information, and analyses. We envision these occurring approximately mid/end of January 2023 (to discuss findings of screening level model review) and approximately the mid/end of February 2023 (to discuss finding of second tier model review). Draft proposed methodology report for review and comment (approximately early March 2023). One meeting to discuss and receive comment on the draft report (by March 17 2023). Final proposed methodology report for review and comment (two weeks after final [March] meeting). Presentation to Science and Data Subcommittee and the Agriculture and Ecosystems Subcommittee of the Vermont Climate Council	
3	Task 1	Ongoing project management tasks, including monthly meetings and presentations.	June 16, 2023
	Task 3	Perform analysis pursuant to final methodology report. One meeting (approximately mid/end April 2023), with ANR staff and task group to present progress and discuss interim findings. Draft agricultural emissions inventory report with results of analysis	

		for review and comment (approximately late May 2023). One meeting with ANR staff and task group to discuss results of methodology implementation and receive feedback on draft agricultural emissions inventory report (approximately early June 2023). Final agricultural emissions inventory report suitable for publication as a supplement to the Vermont GHG Emissions Inventory and Forecast report (by June 16 2023). Presentation of the final report and analysis at a meeting of the Science and Data Subcommittee and the Agriculture and Ecosystems Subcommittee of the Vermont Climate Council.	

5. Cost Proposal

Stone's breakdown of estimated work and associated budget is presented below in Table 4. We expect to incur no costs for materials or supplies, all of our cost will be incurred by professional services. We have assumed at this point that all meetings will be virtual or local to Montpelier and as such, we have not included travel in this budget. If awarded the project, we are willing to revisit this if in person meetings are desired and will adjust the budget accordingly.

Table 4. Cost Proposal

Task\Subtask	Stone Team				Totals
	Jody Stryker ($161/hr)	Mike Winchell ($209/hr)	Bettina Miguez ($147/hr)	Mary Haley ($124/hr)	
Task 1: Monthly meetings and presentations (1 hr plus prep), plus bi-weekly written status updates	14	0	0	0	14
Task 1: Develop Draft Workplan	8	4	0	0	12
Task 1: Finalize Workplan	6	2	0	0	8
Task 1: Project Kickoff Meeting (2-hour meeting and prep)	4	2	0	0	6
Task 1: General Project Management	14	0	0	0	14
Task 1: Two presentations to the Vermont Climate Council (1-hour plus prep)	6	0	0	0	6
Task 1 Hours	52	8	0	0	60
Task 1 Fee ($)	$8,372	$1,672	$0	$0	$10,044
Task 2: Data Review and Compilation	16	4	16	16	52
Task 2: Screening Level Model Review	16	4	24	0	44
Task 2: In Depth Model Review	16	4	32	0	52
Task 2: Methodology Development	24	12	8	0	44
Task 2: Report of findings (draft and final)	26	4	30	0	60
Task 2 Hours	98	28	110	16	252
Task 2 Fee ($)	$15,778	$5,852	$16,170	$1,984	$39,784
Task 3: Data Preparation	0	0	16	16	32
Task 3: Implement Methodology to Estimate GHGs from Agricultural Sector in VT	24	6	40	0	70
Task 3: Report of findings (draft and final), in format suitable for Vermont GHG Emissions Inventory	24	6	32	0	62
Task 3 Hours	48	12	88	16	164
Task 3 Fee ($)	$7,728	$2,508	$12,936	$1,984	$25,156
Total Fee	$31,878	$10,032	$29,106	$3,968	$74,984

6. Certificate of Compliance

CERTIFICATE OF COMPLIANCE

For a bid to be considered valid, this form must be completed in its entirety, executed by a duly authorized representative of the bidder, and submitted as part of the response to the proposal.

A. **NON COLLUSION:** Bidder hereby certifies that the prices quoted have been arrived at without collusion and that no prior information concerning these prices has been received from or given to a competitive company. If there is sufficient evidence to warrant investigation of the bid/contract process by the Office of the Attorney General, bidder understands that this paragraph might be used as a basis for litigation.

B. **CONTRACT TERMS:** Bidder hereby acknowledges that is has read, understands and agrees to the terms of this RFP, including Attachment C: Standard State Contract Provisions, and any other contract attachments included with this RFP.

C. **FORM OF PAYMENT:** Does Bidder accept the Visa Purchasing Card as a form of payment?

____ Yes ✓ No

D. **WORKER CLASSIFICATION COMPLIANCE REQUIREMENT:** In accordance with Section 32 of The Vermont Recovery and Reinvestment Act of 2009 (Act No. 54), the following provisions and requirements apply to Bidder when the amount of its bid exceeds $250,000.00.

Self-Reporting. Bidder hereby self-reports the following information relating to past violations, convictions, suspensions, and any other information related to past performance relative to coding and classification of workers, that occurred in the previous 12 months.

Summary of Detailed Information	Date of Notification	Outcome

Subcontractor Reporting. Bidder hereby acknowledges and agrees that if it is a successful bidder, prior to execution of any contract resulting from this RFP, Bidder will provide to the State a list of all proposed subcontractors and subcontractors' subcontractors, together with the identity of those subcontractors' workers compensation insurance providers, and additional required or requested information, as applicable, in accordance with Section 32 of The Vermont Recovery and Reinvestment Act of 2009 (Act No. 54), and Bidder will provide any update of such list to the State as additional subcontractors are hired. Bidder further acknowledges and agrees that the failure to submit subcontractor reporting in accordance with Section 32 of The Vermont Recovery and Reinvestment Act of 2009 (Act No. 54) will constitute non-compliance and may result in cancellation of contract and/or restriction from bidding on future state contracts.

E. **Executive Order 05 – 16: Climate Change Considerations in State Procurements Certification**

Bidder certifies to the following (Bidder may attach any desired explanation or substantiation. Please also note that Bidder may be asked to provide documentation for any applicable claims):

1. Bidder owns, leases or utilizes, for business purposes, space that has received:
   - ❑ Energy Star® Certification
   - ❑ LEED®, Green Globes®, or Living Buildings Challenge℠ Certification
   - ❑ Other internationally recognized building certification:

_____

2. Bidder has received incentives or rebates from an Energy Efficiency Utility or Energy Efficiency Program in the last five years for energy efficient improvements made at bidder's place of business. Please explain:
   In September 2019, we worked with our building's landlord to install solar panels on our rooftop to partially power our business operations. To date, we have saved over 302,963 pounds in CO2 emissions.

3. Please Check all that apply:
   - ☑ Bidder can claim on-site renewable power or anaerobic-digester power ("cow-power"). Or bidder consumes renewable electricity through voluntary purchase or offset, provided no such claimed power can be double-claimed by another party.
   - ❑ Bidder uses renewable biomass or bio-fuel for the purposes of thermal (heat) energy at its place of business.
   - ☑ Bidder's heating system has modern, high-efficiency units (boilers, furnaces, stoves, etc.), having reduced emissions of particulate matter and other air pollutants.
   - ☑ Bidder tracks its energy consumption and harmful greenhouse gas emissions. What tool is used to do this?Solar Edge in conjunction with Green Mountain Power
   - ☑ Bidder promotes the use of plug-in electric vehicles by providing electric vehicle charging, electric fleet vehicles, preferred parking, designated parking, purchase or lease incentives, etc..
   - ☑ Bidder offers employees an option for a fossil fuel divestment retirement account.
   - ☑ Bidder offers products or services that reduce waste, conserve water, or promote energy efficiency and conservation. Please explain:

We provide clients with scientific tools, information, and analysis to help solve environmental challenges. Our areas of expertise include environmental assessment and remediation; environmental planning and policy development; environmental monitoring and modeling; the evaluation, siting, and design of agricultural, developed lands, forest land, and natural resource water quality projects and practices; stream and ecological restoration; and geospatial and data analysis, visualization, and application development. In Vermont much of our work focuses on understanding and addressing the impacts of Vermont's land use on the natural environment, strengthening ecosystem and community resilience to climate change, and promoting sustainable development and site reuse.

4. Please list any additional practices that promote clean energy and take action to address climate change.

Good business practices and environmental stewardship go together. We consider it our duty to promote, preserve, and protect the environment in both our day-to-day operations and as part of our long-term business model. We actively support a wide range of organizations and networks across Vermont through direct financial support (via memberships, sponsorships, and donations), as well as volunteering time and resources. Stone has a dedicated team that meets regularly to ensure we're doing our part as environmental stewards. We promote the use of recycled and environmentally friendly products and practices as often as possible, provide composting and recycling services, and offer flexibility for staff to work remotely. Our office currently provides and is expanding the number of charging stations for staff using electric and hybrid vehicles. As a corporate sponsor of the ESSEX Plan, Stone is actively working to adopt policies and practices for reducing greenhouse gas emissions and our overall impact on climate change.

F. Acknowledge receipt of the following Addenda:

Addendum No.:_____ Dated:_____

Addendum No.:_____ Dated:_____

Addendum No.:_____ _____

Bidder Name: Stone Environmental, Inc.

Address: 535 Stone Cutters Way

Montpelier, VT 05602

By: _____

Signature of Bidder (or Representative)

Contact Name Jody Stryker

Telephone: 802.444.5790

Fax: 802.229.5417

E-Mail: jstryker@stone-env.com

Name: Mike Winchell, Vice President

(Type or Print)

Appendix A. Key Staff Resumes

Jody Stryker / *Senior Environmental Modeler*



Jody has interdisciplinary training in environmental sciences and engineering, with a concentration on hydrological processes and sediment transport. At Stone, she conducts research using a broad range of model applications and data analysis techniques, ranging from field-scale APEX modeling of surface and subsurface transport and agronomic practices to air dispersion modeling for risk assessment. She values collaboration and integrated solutions to environmental challenges. Jody currently manages several projects with objectives that aim to increase sustainability and resilience of our environmental and agricultural systems, including the development of data-driven web application tools to incentivize agricultural conservation practices and high priority floodplain and river reconnection projects.

Years of Experience / 11

Years of Experience at Stone / 6

Education

Ph.D., Civil and Environmental Engineering, 2016, University of Vermont – "Sediment Mobilization from Streambank Failures: Model Development and Climate Impact Studies"

M.S., Civil and Environmental Engineering, 2012, University of Vermont

B.S., Environmental Science, 2004, University of Miami

Skills

Environmental modeling applications including APEX, PRZM, PWC, DHSVM, BSTEM, HEC-RAS, SWAT, AERMOD, and others

Programming in Python, C, Visual Basic, Fortran, R, and others

Data analysis and statistics

ArcGIS and spatial analysis

Development and assessment of methodologies

Writing, editing, presenting, and professional communication skills

Project management

Working knowledge of French and Spanish

Related Project Experience

Development of a Web-based Tool for Quantifying Effectiveness of Farm-Level Conservation Practices in Reducing Pesticide Runoff/ 2022–Present

Project manager and lead on APEX modeling framework development component of this project. The goal is to develop a user-friendly web tool that allows users to get quantitative estimates of the effects of conservation practice implementation on runoff and associated pesticide losses. Responsibilities include design of the APEX pesticide transport modeling approach at the field and farm scale, (e.g., determining pesticide application inputs, cropping cycle input options, conservation/stewardship practice options, and how to quantify off-target pesticide transport and reductions), evaluation of model behavior, and comparison of the predictions of off-site pesticide transport reductions with expected values from the peer-reviewed literature.

Agricultural Stewardship Tool Modifications / 2022–Present

Leads continuing development of Stone's web-based tool, the Farm Phosphorus Reduction Planner (Farm-PREP), to meet the needs of the Vermont Agency of Agriculture, Food, and Markets. This will add functionality to the tool for simulating pasture/grazing and associated management options.

Farm-PREP Modification / 2021–Present

Leads ongoing development of Stone's web-based tool, the Farm Phosphorus Reduction Planner (Farm-PREP), to meet the needs of the Vermont Agency of Agriculture, Food and Markets. This includes modifications to the application workflow to support the State's innovative Pay for Phosphorus programs, as well as development of additional requested functionality. This work includes changing the baseline phosphorus runoff to be based on assumptions from Vermont's Lake Champlain Total Maximum Daily Loads (TMDLs) and assignment of baseline management to represent similar assumptions as were assumed in the TMDL SWAT modeling conducted by EPA.

Phase 2 of the Vermont Functioning Floodplain Initiative: Functioning Floodplain Assessment, Mapping, Valuation, and Tracking to Support Floodplain Restoration and Protection in the Lake Champlain Basin / 2019–Present

Manages Stone's role within an interdisciplinary team working to expand Phase 1 FFI methods to enhance departure analysis of the connection status of Vermont rivers and floodplains and expand valuation metrics and tools to engage stakeholders. Assists with design of a web-based tool to prioritize and

visualize implemented reconnection projects to track progress towards implementing the Lake Champlain TMDL and naturalize river-floodplain interactions.

Comparison of Stewardship Evaluation Tools for the Vermont Environmental Stewardship Program / 2019–2021

Project manager and technical lead in evaluating and comparing outputs from two different USDA stewardship models/tools (APEX and RSET). Led development of field-scale APEX models for over 50 fields and multiple usage scenarios. Automated processing of simulation results and comparison with RSET outputs. Preparation of reports and project deliverables.

Enhancement of APEX Farm and Field-Scale Modeling to Simulate the Impacts of Manure Processing Technologies / 2018–2019

Model development/enhancement to include the impact of alternative manure processing technologies on field and farm-scale phosphorus loading. Also assisted in incorporation of these technologies in the web-based application for optimization of practices (Farm-PREP). Responsibilities included model development and back-end programming, client communication, preparation of memos and progress/project reports.

Development of Global Parameter Set and Calibration/Validation of APEX Models using Edge of Field and Tile Monitoring Data / NEWTRIENT and Lake Champlain Basin Program / 2018–2019

Calibrated and validated APEX models to edge-of-field and tile drain monitoring data in Vermont and New York. Development of a global parameter site for incorporation into the web-based application (FarmPREP) for optimization of farm management practices and aiding in reaching phosphorus loading goals (TMDLs) in the Lake Champlain Basin is ongoing. This involves multi-parameter optimization with respect to flow, sediment, and nutrient loading, as well as visualization and reporting of results.

Farm-Scale Optimization of the Farm Phosphorus Reduction Planner Tool (Farm-PREP) / Lake Champlain Basin Program / 2017–2018

Contributed to development of farm-scale phosphorus targets, development of web-based APEX tool for predicting and optimizing phosphorus loss, and well as model implementation and testing. Also assisted in preparing project related proposal, QMP, QAPP and progress report documents.

Evaluation of Humidome Flux Data and Vapor Phase Deposition in Comparison to Spray Drift Deposition Gradients / 2018–2019

Compared humidome flux data to relevant field study flux data to assess the potential for developing a correction factor to relate humidome and field flux rates. Assessed trends in environmental variables associated with humidome studies. Developed deposition with distance curves for vapor phase and spray drift deposition, in conjunction with visual effect dose-response curves to determine if/where overlap occurs. Conducted sensitivity analysis on different environmental conditions to find extremes in curve gradients and determine impacts of weather factors deposition profiles. Presented results at EPA's 2019 spring EMPM.

Field Volatility Modeling

Conducted air volatility modeling to estimate flux rates of agricultural compounds during and post application, using three methods (one includes use of EPA preferred air dispersion modeling system AERMOD). Also conducted modeling of vapor phase deposition under representative environmental conditions. In addition to model application, this included preparation of inputs from field-collected data and summarization of results in tabular and report format. Has developed and implemented a more automated approach to these modeling efforts by developing scripts to process meteorological data collected by field team, compile field data, write and execute various models, as well as post-process model results.

Tile Drain Modeling with RZWQM / 2017

Modeled tile drain systems using field-scale process-based model to simulate pesticide leaching in tile drains and surface runoff. This included comparison of model performance to SWAT and assessment of expected environmental concentrations in an associated static water body.

Michael Winchell/ *Vice President / Senior Environmental Modeler*



Mike has been a part of Stone for the last 20 years and serves as both the Vice President and Environmental Systems Modeling Service Line Leader. Over the course of his tenure at Stone, Mike has led technical geospatial analysis and modeling efforts, as well as managed projects across nearly all of Stone's areas of expertise. As a senior environmental modeler, he both manages and serves as the technical lead on a broad range of environmental modeling, spatial analysis, and software application development projects. His areas of expertise include simulation and analysis of agricultural best management practices, integration of GIS with environmental models, and model interface development.

Years of Experience / 26

Years of Experience at Stone / 20

Education
M.S., Hydrology and Water Resources, 1997, University of Arizona, Tucson, Arizona

B.S., Environmental Systems Technology, Department of Agricultural and Biological Engineering, 1994, Cornell University, Ithaca, New York

Skills
Project Management

Programming Experience: VB.NET, ArcObjects, FORTRAN, C/C++, Python

Environmental Models: SWAT, APEX, SWMM, RZWQM, ALMANAC, VFSMOD, PRZM/EXAMS, VVWM, HEC-RAS, HEC-HMS, TOPMODEL, SAC-SMA, AGDISP, AgDRIFT

Professional and Community Activities
American Chemical Society (ACS)

Society of Environmental Toxicology and Chemistry (SETAC)

CropLife America, Environmental Risk Assessment Committee and Environmental Exposure Working Group

Related Project Experience

NCASI PFAS PRZM Model Guidance Document / National Council for Air and Stream Improvement, Inc / 2020–2021
Provided senior technical support for developing a guidance document for state regulators and modelers on using EPA's Pesticide Root Zone Model (PRZM) as a screening-level model for assessing potential PFAS leaching to groundwater resulting from land-applied biosolids. This report details steps for tailoring hydrologic processes to specific local climate, soil, and groundwater conditions and running PRZM to estimate screening level PFAS concentrations in groundwater.

NEBRA PFAS Modeling / North East Biosolids & Residuals Association and the Maine Water Environment Association / 2019 / Maine
As the project manager, developed and implemented PWC model to estimate PFAS groundwater concentrations following biosolids applications in Maine agricultural fields. Analyzed results and determined PFAS levels in biosolids that would not lead to exceedance of set groundwater limits.

Pesticide Exposure Modeling in a Small Catchment in Belgium / Confidential Client / 2016–2017 / Belgium
Led an innovative application of the SWAT model to determine herbicide sources areas within a small agricultural catchment in Belgium. Detailed field-level agronomics were compiled to parameterize a SWAT model that was used to distinguish between elevated concentrations resulting from diffuse sources and elevated concentrations driven by non-point sources. The analysis resulted in a report used by the client to help guide stewardship programs the watershed.

Comprehensive Eutrophication Model Development and Management Scenario Evaluation/Prespa Lake, Macedonia / UNDP / 2014–2016 / Macedonia
Served as the project manager and technical lead in the development of a coupled watershed and in-lake water quality model to assess the water quality management alternatives for the Prespa Lake watershed in Macedonia. The SWAT model developed to simulate the loads entering Prespa Lake was used to assess current nutrient phosphorous critical source areas and to evaluate the potential water quality benefits of alternative management practices.

Application of the SWMM Model for a National Urban Pesticide Exposure Risk Assessment / Pyrethroid Working Group / 2012–Present / United States
Developed and applied a novel pesticide exposure modeling approach for urban environments using the Stormwater Management Model (SWMM).

The approach was used to predict the concentrations of urban-applied pesticides in surface waters un in order to determine the potential ecological effects of pesticide use. Served as the project manager and technical lead.

A National Assessment of an Insecticide Fate and Transport in Flowing Water Bodies / Confidential Client / 2013–Present / United States

Led an approach for assessing pesticide exposure concentrations in flowing water bodies across a geographically diverse set of watersheds throughout the United States using the SWAT model. Serving as project manager and technical lead.

A National Assessment of Insecticide Concentrations in Static Water Bodies / Confidential Client / 2013–2016 / United States

Developed an approach for assessing pesticide exposure concentrations in static water bodies associated with high-risk agricultural uses across geographically diverse regions of the United States. Serving as technical lead.

Optimization and Basin-Wide Implementation of Farm Phosphorus Reduction Planner Tool / Lake Champlain Basin Program / 2017–Present / Vermont

Project manager and lead modeler in the development of the Farm-P Reduction Planner Tool (Farm-PREP). Developed updated agronomic management schedules for APEX, participated in tool design strategy, led interviews with stakeholders to gather user feedback on the use of the tool, led multiple educational workshops to potential users and stakeholders for Farm-PREP.

Rangeland Modeling of Natural Resources Inventory (NRI) Data with the APEX Model / Texas A&M University / 2018–Present / Vermont

Project manager and technical lead in the development of an APEX interface to automate the extraction of data and parameterization of APEX model simulations for rangeland grazing sites from the NRSC Natural Resources Inventory (NRI) database. Worked closely with Texas A&M and NRCS researchers to define tool requirements and use cases. Helped in establishing APEX grazing scenarios representative of a range of heard management strategies.

Development of STAR, a Web-Based APEX Tool for Optimizing Best Management Practices and Conservation Planning on Vermont Farms / Natural Resources Conservation Service / 2013–2015 / Vermont

Project manager and lead modeler in the development of a web-based conservation planning tool using the APEX model developed for use by the Vermont Natural Resources Conservation Service (NRCS). Databases and management inputs specific to Vermont agricultural systems were designed and tested using field data collected from a parallel field monitoring effort.

Development and Support of the ArcSWAT and ArcAPEX Interfaces / Texas A&M University / 2004–Present / Vermont

Project manager and lead developer for the ArcGIS interface to the ArcSWAT and ArcAPEX water quality models. These GIS-based interfaces streamline the application of these models for water quality and environmental assessments using readily available GIS datasets.

Development of an APEX Model Interface for Precision Farming / Texas A&M University / 2017–2018 / Vermont

Led the ArcGIS component of this new interface to allow sub-field delineation of APEX models to support precision farming. Co-led the design and workflow of the tool to meet Texas A&M user requirements.

Simulation of Potential Pesticide Exposure in the California Delta for Endangered Species Assessments / Confidential Client / 2012–2013 / California

Led the development of a watershed scale SWAT model for prediction of pesticide concentrations within the water bodies of the California Delta. Incorporated multiple streamflow and chemical monitoring data locations in the calibration and validation of the model. Served as project manager and technical lead.

Bettina Miguez / *Environmental Modeler*



Bettina joins Stone Environmental with fifteen years' experience in environmental modeling, human health risk assessments, and environmental policy. Her work has spanned North and South America, in the private and public sectors. Prior to joining Stone, Bettina worked in the Uruguayan Agricultural Ministry, where she negotiated the regulatory specifications of a major new irrigation law with peer ministries, as well as co-wrote the national guidelines for field application of dairy effluent.

Years of Experience / 15

Years of Experience at Stone / 2

Education
Master of Science, Soil Science, 2014, University of Wisconsin – Madison

Bachelor of Science & Engineering, Environmental Engineering, 2006, Princeton University

Certificate in Humans and the Global Environment, 2014, Nelson Institute of Environmental Studies, University of Wisconsin – Madison

Professional Certifications
Engineer in Training (EIT), 2007

Certificate in Journey of Facilitation and Collaboration, 2012, Living Giving Enterprises, LLC.

Skills
Watershed modeling, environmental policy, soil physics, nutrient management

Surface Nutrient Models (SWAT, SWAT+, APEX)

Python, SQL, MATLAB, Visual Basic (Excel), HTML

Fluent in English and Spanish

Professional proficiency in Portuguese and French

Honors and Awards
Davis UWC Scholar

Champ Tanner Agricultural Physics Award

Employment History

Stone Environmental, Inc. / Montpelier, Vermont
Environmental Modeler / March 2020—Present
Set up SWAT and SWAT+ models of agricultural watersheds. Prepared an updated soil map of a Belgian catchment using available geographic information and soil boring data. Evaluated the performance of SEAWAVE-QEX on estimates of maximum rolling average concentrations of chemicals in a watershed. Assisted in QA/QC process for various projects.

Ministry of Agriculture / Montevideo, Uruguay
Environmental Regulator / 2015—2019
Negotiated terms for the regulatory application of a new nationwide irrigation law; co-authored nationwide guidelines for dairy effluent application, represented Uruguay in forum for Sustainable Development Goals regarding freshwater use efficiency and extraction, led the development and testing of new online irrigation permitting software, developed surface water nutrient models, and planned a strategic environmental assessment of the San Salvador watershed.

Sander Geophysics / Punta del Este & Durazno, Uruguay
Logistics Coordinator / 2014—2015
Single-handedly coordinated with national aviation authorities in Argentina, Brazil, and Uruguay to support an airborne geophysical survey of Uruguay, obtained flight clearances and issued NOTARs for aeromagnetic survey flights, and obtained import and export permits for specialized equipment.

Universidad Católica del Uruguay / Montevideo, Uruguay
Adjunct Professor / 2014—2015
Prepared 60+ hours of direct instruction and coding exercises in Python 3.x for the Introductory Programming course for Audiovisual Engineering students.

University of Wisconsin–Madison / Madison, Wisconsin
Research Assistant, Department of Soil Science / 2010—2013
Designed and conducted research on solute fluxes using hydrological, chemical, and photographic data in an ag. Modeled water flow using HYDRUS. Determined bromide and chloride concentrations in soil water samples. Traced preferential flow patterns with image segmentation and color spaces.

ENVIRON International / Princeton, New Jersey
Associate Engineer / 2007—2010

Developed risk criteria to guide corrective action for RCRA Facility Investigation and Corrective Measures Proposal at two manufacturing facilities in Ohio with releases from underground storage tanks, on-site waste disposal areas, and hazardous storage units, assessed human health risk to support selection of remediation alternatives at a New York state river impacted with PCBs, PAHs, lead, and mercury, secured Ohio EPA approval for early termination of a surface impoundment post-closure program at an electroplating facility. Carried out residential and commercial vapor intrusion sampling as well as groundwater sampling at remediation sites.

Related Project Experience

Development of a Web-based Tool for Quantifying Effectiveness of Farm-Level Conservation Practices in Reducing Pesticide Runoff / Syngenta Crop Protection / 2022 / Montpelier, Vermont

Set up PRZM models and similarly parameterized APEX models to compare runoff, sediment and pesticide loads. Set up APEX models with different conservation practices.

Simplified Crop Growth Modeling to Support Residue Study Interpretation / Syngenta Crop Protection / 2022 / Montpelier, Vermont

Set up APEX models for sites with different crops located in different continents. Assessed sensitivity of using increasingly more complete daily weather data sets. Compared model performance to study trial data. Assessed sensitivity to different soil textures, heat units and other parameters.

SWAT Scenario Tool Enhancements for Flowing Water Exposure Assessment / Syngenta Crop Protection / 2021—2022 / Montpelier, Vermont

Selected small watersheds in the continental US with considerable pesticide monitoring data to evaluate the results from the SWAT Scenario Tool. Set up ArcSWAT models for the three watershed and automate management scenarios with high and low chemical applications. Run SEAWAVE-QEX model for each of the watershed/chemical pairs. Used scripts to calculate annual statistics of chemical concentrations and compare observed/SEAWAVE-QEX results to model results.

SEAWAVE-QEX in the GKb Catchment/ Bayer AG / 2020—2021 / Montpelier, Vermont

Prepared a comprehensive evaluation of SEAWAVE-QEX model performance on estimating annual statistics for three different active ingredients and a metabolite in the GKb catchment (Belgium). Assessed performance of different subsampling intervals and methods on model results, as well as for the purpose of calculating Sampling Bias Factors (SBF). Compared model performance to SWAT model performance in estimating statistics of concern.

SWAT+ model of GKb Catchment/ Bayer AG / 2020—2021 / Montpelier, Vermont

Set up SWAT+ model of GKb catchment and evaluated new features such as floodplain delineation and conditional management applications. Created a soils map based on high resolution soil survey and regional soil profiles. Work included testing and improving on the SWAT+ model conditional management options directly with model developers. Wrote scripts to automate runs to test probabilistic management operations.

Syngenta SWAT Tool / Bayer AG / 2020—2021 / Montpelier, Vermont

Set up ArcSWAT models of two Midwestern watersheds and compared model results to available streamflow and pesticide monitoring data at the outlet.

Measuring Drainage and Solute Fluxes In a Sandy Soil Using Cylindrical Tube Lysimeters (Master's Thesis) / University of Wisconsin-Madison / Department of Soil Science / 2010—2013

Project included design, fieldwork, modeling and laboratory work. The goal was to evaluate the performance of tube lysimeters to capture drainage from the soil column above them. Custom-made lysimeters were first tested in a laboratory setting. Fieldwork included installing the lysimeters in sandy soils where potatoes were cropped, spaced according to lengths determined by two-dimensional soil modeling of water fluxes. The field plot was artificially irrigated with water and a colored dye. Lysimeters were sampled to measure water volume. Laboratory work included determining dye concentration using a customized adjustment to colorimetric methods.

Mary Haley / *GIS Specialist*



Mary is a GIS professional with four years of experience leveraging advanced level GIS services to a range of technical projects. Prior to joining Stone, she applied her skills to the Vermont Agency of Transportation, where she administered geodatabases and mapping services with python automation, developed ArcGIS Online web maps and tools, and led field work for the terrestrial LiDAR scanning program. At Stone, she draws on her diverse design and field experience to support application development and geospatial analysis projects.

Years of Experience / 4

Years of Experience at Stone / <1

Education
Professional GIS Certificate, 2018, Michigan State University

B.S., Environmental Science, 2016, Endicott College

Skills
Geospatial & data analysis,

Application Development

Mobile Data Solutions

Data Inventory/Compilation

Metadata Development

Geodatabase Creation and Development

Asset Inventory

Data Visualization

Data Collection

ArcGIS Online, ArcGIS Pro, ArcMAP,ArcGIS Online, ArcGIS Collector, StoryMaps, Field Maps, Survey123, Feature Manipulation Engine

Static Terrestrial LiDAR Data Collection

Python Programming

Honors and Awards
Phi Sigma Biological Honor Society Member

Science, Technology, and Mathematics Academic Award

Employment History

Stone Environmental, Inc. / Montpelier, Vermont
GIS Specialist / 2022–Present

Supports application development projects related to a variety of GIS and data management efforts as a member of the Geospatial and Data Services team. Utilizes ArcGIS Online and ArcGIS Pro to manage geospatial data, create informative maps and applications, and perform advanced spatial analysis. Develops Python programming scripts to assist with the automation of data validation, management, and development. Collaborates with and supports team members to complete projects.

Vermont Agency of Transportation / Barre City, Vermont
GIS Professional IV / 2019–2022

Provided advanced-level GIS services to multiple business units within the Project Delivery Bureau and trained and supported other GIS staff within the section. Administered the Right of Way section's enterprise geodatabase and mapping services through complex Python scripting language data processing scripts. Built and maintained ArcOnline web maps, tools, and applications for field data collection while using complex Arcade expressions for custom configuration. Developed expertise in using and configuring ArcOnline StoryMaps and dashboards, Collector App, Field Maps App, and Survey123 forms. Acted as team lead for the static terrestrial LiDAR scanning program. Coordinated fieldwork and processed point cloud data to set standards and performed analyses for project requests. Managed large GIS projects/programs including defining the needs, requirements, and specifications that leveraged spatial data or GIS technology (i.e Right of Way Spatial Data Hub, Vermont Land Inventory, Survey Photo Monument Inventory, Vermont GPS on Benchmarks Web Application). Administered and provided user support for the VT CORS Network and VECTOR website. Serviced the complex infrastructure for the 18 reference stations including the specialized software that digests, monitors, and relays RTN/VRS and single base solutions. Submitted work order requests and reviewed proposals for consultant projects and reviewed project deliverables to ensure deliverables met standards. Assisted with the development, expenditure planning, and justification for relevant work programs.

Vermont Agency of Transportation / Barre City, Vermont
GIS Professional II / 2019

Provided intermediate level GIS services for the Right of Way and Survey Units. Worked closely with the Land Survey Manager to interpret property deeds, surveys, and related documents for cataloging in the section's database to be displayed in the various web applications. Conducted static 3D terrestrial

LiDAR scans for numerous project types including asset monitoring, material volume calculations, pavement analysis, historical preservation, and as-built structures. Performed standard processing procedures to produce deliverables from the LiDAR scan project and developed methods for various in-house analyses. Updated documentation and metadata for GIS datasets and services. Utilized Python, HTML, ESRI Arcade, and SQL scripting languages to develop and maintain complex processing automation scripts for CADD to GIS data conversion and web application display. Developed the protocols and data collection maps used in the Survey Photo Monument Inventory.

Vermont Agency of Transportation / Barre City, Vermont
GIS Professional II (Temporary) / 2018 – 2019

Provided basic level GIS services and assistance to the Right of Way and Survey units. Fulfilled CADD to GIS data conversions, survey and right of way plan georeferencing, and right of way digitization requests. Utilized basic Python and ESRI Arcade scripting languages to create and update data processes and web map pop-ups. Supported senior staff with static 3D Terrestrial LiDAR field scans.

Related Project Experience

Vermont Community Broadband Board GIS Services / Vermont Community Broadband Board / 2022–Present

Developed Python automation scripts to better track and manage the data services being displayed in the ArcGIS Hub site developed for Board and public use. This work ensures prompt data management practices and factors appropriate access various to public and confidential datasets for specific users.

New York Geographic Information Gateway / New York State Department of State, Office of Planning & Development / 2022–Present

Assisted with the migration of data from existing servers and geodatabases into the ArcOnline platform. Developed Python automation scripts to catalog and validate existing metadata and ArcOnline tags to streamline future user interaction in ArGIS Open Data Portal. Improved existing automation employed to upload datasets to ArcOnline while ensuring appropriate data properties are preserved. Supported staff in the development of user feedback surveys to improve the design and experience of users with the new ArcGIS Hub site.

Phosphorus Control Plans for the Vermont Lake Champlain Basin / Vermont Agency of Transportation / 2022–Present

Developed an automated phosphorus reduction tracking system to identify current infrastructure condition changes over time for swales and culverts. Provided support for ArcGIS FieldMaps data collection apps used by VTrans fieldworkers in addition to updating and developing ArcGIS StoryMaps and Dashboards. The latter applications are used for visualizing progress of phosphorus reduction and to provide an interactive and informative display of steps taken by VTrans to meet phosphorus reduction targets.

Publications and Presentations

Co-Presenter, FHWA GIS in Transportation, Leveraging GIS for Right of Way: Vermont State Property Parcel Map Presentation / 2021

Co-Presenter, Vermont Agency of Transportation & National Geodetic Survey, GPS on Benchmarks Workshop Webinar / 2021