**APPENDIX D**

**SAES-422**

**Format for Multistate Research Activity Accomplishments Report**

***Note:*** *This report is submitted each year of an activity's duration and is due 60 calendar days following the annual meeting. The SAES-422 is submitted electronically by AAs into NIMSS. Annual Reports for MRF projects are available to NIFA through NIMSS.*

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| **Project/Activity Number:** | **S1089** |
| **Project/Activity Title:** | **Quantification of best management practice effectiveness for water quality protection at the watershed scale** |
| **Period Covered:** | **2020-2021** |
| **Date of This Report:** | **10/25/2021** |
| **Annual Meeting Date(s):** | **09/02/2021-09/03/2021** |

**Participants:**
In-person attendees: Soni M. Pradhanang, Rafael Muñoz-Carpena, Francois Birgand, Aleksey Seshukov, Fouad Jaber, Young Gu Her

Virtual Attendees: Adel Shirmohammadi, Brian Benham, David Sample, Elizabeth Boyer Kevin Wagner, Latif Kalin, George Vellidis, Rabin Bhattarai, Sara McMillam, Sanjiv Kumar, Saurav Kumar, Shreeram Inamdar, Zachary Easton

**Brief summary of minutes of annual meeting**:

The annual meeting was held in University of Florida, FL in September 2021 focused on addressing S1089 objectives, accomplishments, and identifying potential tasks or research products to be initiated or continued by the members of the Multistate Exchange Group. Presentations of the different accomplishments and future goals to be pursued by members of S1089 were held during the annual meeting. Live and virtual members' presentations involved the members' involvement, and the project accomplishments.
The project team, both in-person and virtual attendees, spent about 2 hours discussing the journal special issue collection, brainstormed research topics, and potential journals. Dr. Muñoz-Carpena gave a brief insight to how the special issues need to be handled. He emphasized on improving science with quality publications.

The in-person project members then went to Sweetwater Branch Watershed for the field trip. The next annual meeting will be held in Texas A&M, Dallas.

The project team members decided to develop a special issue articles collection for the Journal of Environmental Management.

Below are some of the papers that are tentatively being prepared as a part of this special issue collection.

**Collaborative technical papers / reviews**

1. Using integrative metrics and data sources to characterize additive ecosystem services provided by urban stormwater management. This could be a framework paper with the first part describing the key paradigms, barriers, opportunities (where are they placed, how are they designed, what is the goal, maintenance, etc.). Case study examples that integrate at least two dimensions (social, economic, biophysical) across scales from neighborhood or watershed. (McMillan, Jaber, Birgand, Saurav)
2. Advances and gaps in the Monitoring of BMPs: a critical review of methods to enhance BMP understanding, effectiveness, modeling and design (François Birgand, Bryan Maxwell, Randall Entheridge, Tiffany Messer, et al. Jaber, Sheshukov, McMillan, Young, Hunt, Burchell, Pradhanang, Saurav)
3. VFS pesticide mitigation across scales: from edge of the field to landscapes (Rafa, Robin Sur. Stefan Reichenberger, Garey Fox, Lucie Guertault, others?
4. Progress Toward Achieving Nutrient and Sediment Reduction Goals Through Watershed Management (Beth Boyer, Soni Pradhanang, Sanjiv Kumar, Zach Easton, Kevin Wagner, Shreeram Inamdar, Philippe Vidon + (Others welcomed - regional/USA review paper)?
5. Riparian model limitations and uncertainties in predicting phosphorus at the field and watershed scale for glaciated landscape (Soni Pradhanang, Marzia Tamanna, Arthur Gold, Philippe Vidon, Shreeram Inamdar, Kelly Addy,.. (add authors)
6. Critical Scales for BMP design: Systems thinking applied to BMP development and management. (Saurav ++). Thinking of critical scale in terms of Data, Management Action, Lifecycle and Maintenance, Societal Benefit
7. Regional transferability, can different locations be harbingers of future conditions for BMP operations? (++Saurav ++)

**Investigator led technical papers (these are studies completed/soon to be completed and existing teams will write these papers)**

1. Big-Data Revolution in Hydrological Forecasting Part 1– A Scientific Basis for Improving Forecast at Ungauged Basins (Sanjiv Kumar and Team)
2. Changing drought and pluvial risks in North America linked to mean-state changes in ENSO and soil moisture (Sanjiv Kumar and Team)
3. Assessing the effect of trend and stationarity on annual peak streamflow in conterminous USA (Sanjiv Kumar and Team)
4. Effect of tillage practices on nutrient loss in subsurface flow pathways (Jasmeet and team)
5. Uncertainty and guidelines to flow proportional composite sampling in stormwater BMPs (François Birgand and team)
6. City-scale return period storm data analysis for various climate change scenarios (Jaber & team)
7. Impact of cropland to prairieland conversion on hydraulic conductivities and flow rates (Jaber & team)
8. Impact of riparian vegetation on streambank critical shear stress (Jaber & team)
9. Tradeoffs in water quality following restoration of riverine floodplains. Integration of hydrodynamic, geomorphic, and biophysical metrics to predict nutrient flux using lab-based intact core experiments. (Sara McMillan & team)
10. Effect of climate change on rainfall erosivity in Southeastern, United States (Jasmeet and team)
11. Long-term effects of climate change projections on VFS pesticide mitigation under contrasting agroecological scenarios (Rafa, Amy Ritter, John West, Garey Fox, Youzhou Luo, others?)
12. Reducing the severity and frequency of HABs by optimizing conservation practices in a watershed-lake (or reservoir) system (Young and Aleksey Sheshukov); Description: Coupling watershed loading models with receiving waterbody models to see the effectiveness of conservation practices on the water quality of downstream water bodies (rather than just minimizing nutrient loads) - the water quality of a waterbody may not be immediately responsive to nutrient loading, and the timing of nutrient loading and the internal processes (or hydrodynamics) of a waterbody can be major factors controlling the water quality: in progress.
13. Understanding gaps in sediment BMP performance at critical scales and under changing climate drivers: From edge of field to streams and reservoirs (Aleksey Sheshukov, others)

14. A spatial framework for detecting water quality and targeting BMPs in agricultural watersheds (Kevin Wagner & Team)
15. Soil health effects on field and watershed scale processes (Kevin Wagner & Team)
16. Assessment of nutrient load reduction goals under a changing climate (Rabin Bhattarai and team) - in progress
17. Using earth observations to identify and track BMPs (Saurav et al)
18. Aggregate impacts of wetlands on nutrient reductions at watershed scale (Isik, Kalin, Hantush, Haas)
19. Effects of Improved Forest Dynamics in Watershed modeling (Haas, Kalin, Srivastava, Sample,)
20. Evaluating sensitivity of Nitrate N export to Organic N and Ammonium N inputs in wetlands (Ramesh, Kalin, Hantush, Anderson)
21. Modeling climate change impacts on water tables in coastal aquifer (Soni and team)
22. Lifecycle modeling of urban BMPs to assess reliability and maintenance needs (Sample and team)

**Accomplishments:**

The principal focus of this project is to evaluate the effectiveness of best management practices (BMPs) at the watershed scale. This includes the water quality and environmental benefits of mitigation practices as well as their cost effectiveness. This will be achieved through monitoring at sub-watershed scales, modeling at larger spatial scales, and analysis of uncertainty in both monitoring and modeling efforts. This report summarizes the activity on this project from October 2020 to September 2021, and the following sections highlight accomplishments from project teams:

Texas A&M (Fouad Jaber)

Texas A&M team have developed TMDL Report Selection Tool (http://Occviz.com/tmdl ). This tool uses natural language processing to understand linkages between modeling tools and impairments. Other tools such as BMP-Net, a deep neural network based on PlanetScope data, was also developed to identify vegetative and structural BMPs in the world from satellite imagery. The member of the team works closely with USEPA to develop national scale water quality models at huc8, 10, 12, and 14 digits for the entire U.S. and to develop GIS Tool for determining flood prone areas in Denton county for use in Hazard Mitigation Planning. In addition, the Texas A&M team works closely with Nature Conservancy to develop Green stormwater infrastructure prioritization maps for Dallas flooding.

University of Florida (R. Muńoz-Carpena)

We started (1) reviewing existing BMP practices and modeling options available for Florida and other participating states and (2) exploring new ones applicable to the States. We investigated important hydrology and pollution processes in critical landscapes including preferential flow in riparian areas (Orozco-Lopez and R. Muñoz-Carpena, 2021; Guertault et al., 2021; Orozco-Lopez et al., 2021), ephemeral gully development and conservation tillage (Luquin et al., 2021), pathogen transport and concentration in agricultural irrigation ponds (Vazquez et al., 2021), impacts of irrigation at the watershed scale (Mompremier et al., 2020), algal blooms in coastal areas and lakes affected by terrestrial sources (Medina et al, 2020; Nelson et al. 2020), combining satellite remote sensing with groundwater monitoring to estimate historical wetland changes affected by upland development (Alonso et al., 2020), forecasting of stream recession hydrographs for critical events (Delforge et al., 2020), uncertainty and sensitivity analysis of models (Nelson et al., 2020; Moreno-Cadena et al., 2020). Dr. Muñoz-Carpena is also starting as Chair of this Hatch Project for the next year and will coordinate the reporting and efforts. Under the organization of this group we will also submit and develop a special journal collection on the topic of "Advances and gaps in agricultural and urban BMPs across critical scales" that will be submitted to a top-tier journal in the specialty.

Oklahoma State University (Kevin Wagner)

Oklahoma State University team has an active research project that is focused towards understanding & improving grazing land water quality. The objective of this research is to quantify nutrient, E. coli, and sediment runoff concentrations and loadings from a variety of land uses and land covers and small Watershed Monitoring. The research team also uses UAV imagery and GIS analysis for vegetation characterization, groundcover visual estimation, relative cattle/wildlife density with game camera deployment. The sub-objectives of the research include assessing "background" loadings, assessing how "background" loadings change with wildlife habitat, and assessing effects of grazing on loadings.

University of Georgia (G. Vellidis)

The University of Georgia team is currently working on the project that focuses on the measurement and simulation of the Environmental Effects of High Maize Yields in Georgia. The objectives are to (i) evaluate the water quality effects of fertilization rates used to achieve high yield goals (350 – 500 kg N ha-1), (ii) use the HYDRUS-1D transport model to simulate the system and estimate N leaching losses, (iii) Use the HYDRUS-1D and DSSAT CERES-Maize models to evaluate maize irrigation scheduling management scenarios that would result in high yields while minimizing leaching of NO3-N. Other project includes (i) Best Management Practice Evaluation in the Lower Flint River Basin, (ii) Evaluate "cutting-edge" management strategies / tools with potential to improve nitrogen and water use efficiency, (iii) Fertigation in corn and cotton, (iv)ET-based irrigation scheduling tools on smartphone platforms, (v) DSSAT (CERES-Maize and CSM-CROPGRO-Cotton), and (vi) provide data for regional modeling with SWAT in collaboration with Auburn University.

Purdue University (S. McMillan)

At Purdue University, McMillan is working on the research related to floodplain restoration in agricultural landscapes. Restored riverine floodplains trap sediments and associated pollutants, promote denitrification but enhance phosphorus release. These patterns are driven by floodplain geomorphology, soil microbes, and vegetation highlighting opportunities for restoration design. Water quality impacts of agricultural conservation practices include (i) multi-year monitoring and modeling to link water quality outputs to agricultural conservation practices, (ii) connecting stakeholders with scientists & engineers to better implement and evaluate environmental outcomes, and (iii) time series analysis using historical monitoring data for change detection.

University of Rhode Island (S Pradhanang)

Supported by USDA-AFRI, the Pradhanang Lab is advancing research to evaluate riparian zone functions in glaciated settings for decision-support purposes with respect to N and P fluxes. Supported by the RI DOT, a study to evaluate the effectiveness of improved roadside best management practices in maintaining stormwater quality was completed in early 2021. The project developed a stormwater runoff model for sub-urban areas in Southern Rhode Island, as well as assessed model uncertainty and calibration through the application of Bayesian statistics. A research project on the impacts of saltwater intrusion in coastal aquifers due to storm surges was completed in early 2021. Observation and model-based nutrient transport research supported by EPA is still ongoing. The sUAS-thermal infra-red-based imaging study to track shallow groundwater plumes and contaminants is still underway. The statewide water uses, and availability database project started in 2020 and will end in 2022. Gold and team have been working on New England Dams and stormwater quality studies using high frequency sensors.

Kansas State University (A. Sheshukov)

At KSU, the Sheshukov watershed research lab has active projects from USDA-ARS, USDA-NRCS, and USGS on improving soil health on agricultural fields and water quality in Kansas water bodies. Specifically, the activity is focused on: (i) developing a validated methodology for defining and prioritizing areas in the agricultural landscape susceptible to ephemeral gully erosion and identifying most beneficial BMPs, (ii) providing a prediction framework for cyanoHAB occurrence in lakes and reservoirs by accounting for mechanisms that drive cyanobacterial growth and toxin production, and (iii) evaluating applicability of cotton production in Kansas and its effects on soil health. Each project is in its first year of activities, and we are collecting field data and developing datasets that will be used for specific models' validation. For the ephemeral gully project, we are collecting data from various sources (LiDAR, historic aerial imagery, historic maps, etc) to identify and map the gullies in 30 MPRAs (or >100 HUC-12 watersheds) across Kansas, Iowa, Nebraska and Missouri. The sampling equipment has been installed in Marion Reservoir (KS) for HAB specific data collection. For the cotton project, two meteo stations with above and below ground sampling equipment were installed on three fields, and evaluation of four different irrigation practices and two crop densities are presently underway. The activity in these projects will continue in 2022.

North Carolina State University (F. Birgand)

The NCSU team has an active research project that focuses on the assessment of tools used for monitoring of BMPs. The focus is on monitoring stormwater wetland nutrient influxes
UV-Vis in situ spectrophotometer is used largely for data collected. The research focuses on providing guidelines on how to obtain best data, estimating uncertainties on annual and event load values, accounting for uncertainties associated with Q-proportional sampling. The main outcome of the research is (i) sampling the entire event, in practice capture peak flow and 60% duration, assuming majority of pollutants is transported in first part, (ii) too few samples brings error, too many might not sample entire event (best guides suggest collection of ~12-16 (field based) & 30 (statistics) samples per event to estimate within 10-20% error range, and (iii) early pollutant peaks if collected can lead to overestimation of EMC, but we still want to start sampling early within the event.

University of Illinois (R. Bhattarai)

UI-UC team is currently working on few research projects such as
(i) the web-based decision support tool for winter cover crop management
(ii) Watershed-scale response of agricultural systems to drainage water management in Central Illinois
(iii) Effect of subsurface drain depth and spacing on water quality and crop yield
(iv) Probabilistic assessment of adequacy and development of nutrient load reduction goals under a changing climate
(v)Balancing water quality, nutrient management and yield goals for the sustainable intensification of agricultural systems in Illinois

Penn State University (E. Boyer)

The team has an active project on the transport of nitrogen-rich groundwater to surface waters by riparian macropore flow in an agriculturally dominated watershed. The goal is to quantify how much of the streamflow nitrogen load (under base-flow conditions in an agricultural watershed) comes from groundwater seeps, versus diffuse matrix flow through the streambed?

University of Kentucky (W. Ford)

Research at the University of Kentucky has focused on quantifying source provenance and hydrologic pathways of contaminants in karst and tile-drained landscapes, as well as the fate and transport of contaminants in headwater streams, restored stream reaches and river-tributary confluences. Research in tile drained landscapes have focused on monitoring sediment transport and flow pathway dynamics at the edge of the field. Research in heterogeneous karst watersheds has focused on impacts of flow pathways and water source dynamics on nitrate and dissolved reactive P loadings at the watershed-scale. Research in fluvial systems has focused on aquatic vegetation characterization using UAVs, impacts of stream restoration on hydrology and water quality in karst landscapes, and fate and transport of sediments and nutrients in river-tributary confluences. Research over the past year has focused on collection of novel datasets that will be implemented within hydrologic and water quality modeling frameworks in subsequent years. Datasets include high-frequency in situ sensors, stable isotopes of dissolved and particulate-bound nutrients, and remotely sensed aerial images using visible and multispectral cameras attached to UAVs.

Auburn University (J. Lamba)

Research at the Auburn university has focusses on field and lab scale, mixed with mathematical modeling, modeling non-point source pollution and wetland nutrient cycles addressing all the four objectives. Research examples include land use change and climate variability and extremes, with the goal of improving predictability and quantifying uncertainty in availability of natural resources at sub-seasonal to decadal time scales, and providing data driven quantitative information to decision makers about long-term management of natural resources.

University of Maryland (A. Shirmohammadi)

The University of Maryland has been working on interfacing SWAT Hydrologic/Water Quality model with Agent-Based Modeling and Diagnostic Decision Support System (DDSS) to facilitate targeted BMP implementation with social, economic, and policy feasibilities included. The team expanded their approach to include nonlinear optimization in the form of Genetic Algorithms (GAs) and social modeling strategy to better account for heterogeneity in individual behavior in cases where spatial fluctuations in mean behavior are mild within a study watershed. The team is using existing database from multiple sources (USGS, NLCD, NLDAS,

SSURGO, etc.) and collecting IRB approved stakeholder surveys to use for calibration and validation of our multi-faceted modeling technologies

**Outputs:**
Publications, conferences, reports and thesis:
Journals: 78; Conference Presentations: not reported; Proceedings: NA; Reports/Other: 11;
Thesis/Dissertations: 5; Model Development: Not reported.; Proposals: 31

**Impacts**

**Activities:**
The technical committee and the officers met virtually every other month to discuss project objectives and plan for the annual meeting.
**Publications:**

**Peer Reviewed Journal Papers**
Publications


1. Budhathoki., S., J. Lamba, P. Srivastava, K. Malhotra, S. Katuwal, and T. R. Way. 2021. Using X-ray Computed Tomography to Quantify Variability in Soil Macropore Characteristics in Pastures. Soil and Tillage Research. Accepted.
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13. Tian, D., X. He, P. Srivastava, L. Kalin (2021), "A hybrid framework for forecasting monthly reservoir inflow based on machine learning techniques with dynamic climate forecasts, satellite-based data, and climate

phenomenon information", Stochastic Environmental Research and Risk Assessment. https://doi.org/10.1007/s00477-021-02023-y.
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61. Selecting Reliable Models for TMDL https://doi.org/10.1061/(ASCE)HE.1943-5584.0002102 (Kumar)
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63. ASCE-EWRI Manual of Practice for TMDL development (in press) (Kumar)
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*Thesis/Dissertation:*

1. Radcliff, Cory, "Quantifying the source and pathway of dissolved reactive phosphate in karst drainage of the Inner-Bluegrass" (2021). *Theses and Dissertations--Biosystems and Agricultural Engineering*. 81.
2. Nazari, Saeid, "Impact of preferential flow, source water connectivity, and agricultural management practices on sediment and particulate phosphorus dynamics in midwestern tile-drained landscapes" (2021). *Theses and Dissertations--Biosystems and Agricultural Engineering*. 82.
3. Nayeb Yazdi, M., 2020. Understanding the role of scale in assessing sediment and nutrient loads from Coastal Plain watersheds delivered to the Chesapeake Bay, Ph.D. Dissertation, Virginia Tech, p. 181, Advisor: **D. Sample**.
4. Jahan, K. J., 2021. Effectiveness of Roadside Best Management Practices (BMPs) on Maintaining Stormwater Quality Through Monitoring and Modeling. Doctoral Dissertation submitted **to** University of Rhode Island (Advisor: **S. M. Pradhanang**)
5. Tamanna, M, 2021 Optimization of Riparian Zone Nitrogen and Phosphorus Management through the Development of Riparian Model Doctoral. Dissertation submitted to University of Rhode Island (Advisor: **S. M. Pradhanang**)

Proposals

1. Impact of Broiler Litter Application Method on Phosphorus Loss in Leachate. AAES Agriculture Research Enhancement and Seed (ARES) funding program. Grant amount $50,000 (PI: Jasmeet Lamba)
2. Understanding Preferential Flow Patterns in No-Till Manured Pastures Using Dye Tracer and X-Ray CT Image Analysis. USGS-AWRRI. Grant amount $5,000 (Co-PI Lamba)
3. Leveraging Machine Learning for Sustainable Water and Nutrient Management Across Agro Climatic Zones. USDA-NIFA. Grant amount $650,000 (Co-PI Lamba)
4. A Transdisciplinary Approach to Secure the Safety of the Food Supply System While Protecting the Environment. USDA-NIFA. Grant amount $10 million. (Co-PI Lamba)
5. "A coupled natural-human framework for risk assessment of coastal communities from land-use and climate change", National Academy of Science – Restore, 2020-2023, $1,110,000, (Co-PI Kalin and Kumar).
6. "Coupling SWAT and WetQual for Improved N, P, and C Processing in Wetland Dominated Agricultural Watersheds", USDA-NIFA, 2020-2024, $499,932 (PI Kalin).
7. "Ecohydrology and Watershed Modeling", US-EPA, 2020-2021, $25,000 (PI Kalin).
8. FACT: Interactive Deep Learning Platform and Multi-source Data Integration for Improved Soil Moisture Forecasting (PI Kumar, Co-PIs: W. Lee, and I. Rangwala). Funded by USDA-NIFA. Total support: $500K, Project period: Sept. 2020 to Aug. 2023.

9. Investigation of soil moisture predictability on sub-seasonal to inter-annual time scales (PI Kumar). Funded by AAES AgrSEED program, Total support $50K; Project period: Oct. 2019 to Sept. 2021.
10. Fox, J., **Ford, W.,** Malzone, J., Armstead, M. GP-GO: The Appalachian SUCCESS Program: Strengthening students classified as Underrepresented in STEM by inspiring Confidence, Curriculum and Enriching Sensing Skillsets. NSF GP-GO. $314,807. Role: Co-Investigator. September 2021-August 2024.
11. **Ford, W.I.** RII Track-4: Elucidating controls of sediment phosphorus delivery to tile-drains. NSF-EPSCoR, RII-4, $226,757. Role: Principal Investigator. January 2021 to December 2022.
12. **Ford, W.I.,** Fox, J., Sama. M. Impact of regenerative stream design on water and nitrogen budgets at reach to watershed scales. USDA-AFRI, $750,000. Role: PD. *Submitted*
13. Messer, T., **Ford, W.**, Bartlet-Hunt Shannon. Implications of Microplastic Contributions from Biosolid Applications to the Nitrogen Cycle in Agroecosystems. USDA-AFRI, $750,000. Role: Co-PD, *Submitted.*
14. **Easton, Z.M.**, D.R. Fuka, and R.R. White. Developing and evaluating rapidly deployable inexpensive weather, soil moisture, shock, and streamflow sensors to aid the monitoring, inspection, and rehabilitation of aging dams. USDA-Cooperative Agreement. $75,000. June 2021-Nov 2021.
15. **Easton, Z.M.** and D.R. Fuka. Integrating the SWAT Model into the MINT Framework. DARPA-USC $64,000. June 2021-Nov 2021
16. Collick, A.S., **Z.M. Easton**, and R. Bryant. UMES Stormwater Management Research Facility: Investigating nutrient and sediment reduction from poultry house stormwater drainage systems. USDA NIFA $399,000. Sept 2020-Aug 2022.
17. **Easton, Z.M**. A Systematic Review of Chesapeake Bay Climate Change Impacts on Tidal and Near Tidal BMPs. NOAA-CBP $73,400. Dec 2020-Sept 2021.
18. **Easton, Z.M.** A Conservation Effects Assessment Project (CEAP) Watershed Assessment Study: A collaboration between the University of Vermont, Virginia Tech, the Natural Resources Conservation Service, and the Agricultural Research Service. USDA CEAP $123,000. Oct 2020-Sept 2022.
19. Flood Reduction Potential of Urban Forests in Virginia Beach: Development of urban watershed models that improve calculation of evapotranspiration and soil moisture to assess the flood reduction benefits of urban forests in coastal Virginia. Amount: $92,276. PIs: **D. Sample**, D. McGlauglin, Y. Shao, 1/1/2020-10/31/2022. Sponsor: City of Virginia Beach, The Nature Conservancy.
20. Bluestone River, Mountain Run, and Lewis Creek PCB TMDLs: Data Analysis and Modeling, and TMDL Development Statement of Work, VA Department of Environmental Quality, $649,950, 06/01/2019 - 01/31/2022, PI: **B. Benham**.
21. TMDL Implementation Plan Development for Buffalo River (Amherst and Nelson Counties) Statement of Work, VA Department of Environmental Quality, $27,155, 07/01/2019 - 10/30/2020, PI: **B. Benham**.
22. TMDL Implementation Plan Development for McClure River (Dickenson County), VA Department of Environmental Quality, $21,660, 06/01/2019 - 05/31/2020, PI: **B. Benham**.
23. White, R., D.R. Fuka, E. Feuerbacher, **Z.M. Easton**. Collaborative Research: CPS: Medium: Greener Pastures: A pasture sanitation cyber physical system for environmental enhancement and animal monitoring. NSF CPS (Cyber-Physical Systems). $998,232. June 2021-May 2024.
24. Designing ESD for Climate Change for Increased Resiliency: Assessing the impact of climate change on hydrology, upland environmental site design (ESD) practices and downstream channel stability. Amount: $107,250. PIs: **D. Sample**, T.W, Thompson, 7/1/2021-12/31/2022. Sponsor: Chesapeake Bay Trust (thru Tetratech, Inc.)
25. Savage, B., **Pradhanang, S. M**., Boving, T. Mapping Bedrock and Saltwater Intrusion in Rhode Island, USGS $90,000 (09/2021-08/2022)
26. Kayastha-**Pradhanang, S**, Kumar, R, and Rashid T, Floating Treatment Wetland System (FTWS) - Sustainable green technology to remediate polluted surface water bodies in the COVID 19-era**,** Asia-Pacific Network $78,000 (09/2021-08/2023)
27. **Pradhanang, S. M**., Boving, T., and Savage, B. The Rhode Island Water Resources Board (RIWRB) and University of Rhode Island (URI) Statewide Water Withdrawal Data Enhancement and Database Development Project. RIWRB-USGS 197,488 (10/20-09/22)
28. **Pradhanang, S. M**., and Boving T., Harmful Algal Blooms (HABs): Treatment Optimization Protocol (TOP) Development, RI Department of Health $34,980 (05/20-08/20)
29. J. Aguilar, A. Sheshukov, B. Golden, L. Haag, D. Devlin. Collaborative Research on Cotton Production in Thermo-limited Regions of the High Plains. Ogallala Aquifer program, USDA-ARS. $300,000. (09/2020 - 08/2025)

30. T. Moore, A. Sheshukov, L. Shamir, D. Flippo. Integrated data science - mechanistic modeling framework to predict cyanoHABS in contrasting freshwater systems. USGS $249,776 (10/2020-09/2023)
31. T. Franti, A. Sheshukov, T. Cruse, B. Gelder, J. Lory. NRCS Ephemeral Gully Erosion Planning Grant PHASE 2: A Regional Assessment of High-Risk Areas for Ephemeral Gully Formation. USDA-NRCS $344,538 (09/2021-12/2023)

**Reports:**

1. National Academies of Sciences, Engineering, and Medicine. 2020. Review of the New York City Watershed Protection Program. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25851 (**Boyer, Easton, Pradhanang**)
2. **Easton, Z.M.**, K., Stephenson, A. Collick, P.M. Fleming, E. Kellner, J. Martin, M. Ribaudo, and G. Shenk. 2020. Increasing Effectiveness and Reducing the Cost of Non-Point Source Best Management Practice Implementation: Is Targeting the Answer? STAC Publication Number 20-002.
3. **Sample, D.J.**, Nayeb Yazdi, M., Wang, X., and Shahed Behrouz, M., 2021. Characterization of Runoff Water Quality, Treatment in Noncomforming Ponds, and Modeling Implications for the City of Virginia Beach, Virginia, Final Report, p. 170.
4. Kline, K., Moneymaker, J., & **Benham, B**. 2020. A Water Quality Improvement Plan to Reduce Bacterial Contamination and Sediment Loads in Buffalo River located in Amherst County, Virginia.: A Water Quality Improvement Plan to Reduce Bacterial Contamination and Sediment Loads in Buffalo River located in Amherst County, Virginia. Virginia Department of Environmental Quality.
5. **Pradhanang, S. M**., Boving, T.B, Brown, R and Jahan, K., 2021. Effectiveness of roadside best management practices in managing water quality (submitted to the Rhode Island Department of Transportation).
6. **Pradhanang, S. M**., Boving, T.B and Panthi, J., Ismail, M., and Shrestha, S., 2020. Assessing Saltwater Intrusion under Extreme Storm Conditions for Coastal Aquifers (submitted to the Rhode Island Housing and Urban Development).

Book Chapters:

1. **Pradhanang, S. M**. and Jahan*, K., 2021 Urban Water Security for Sustainable Cities in the Context of Climate Change. *In* Pandey et al. eds *Water, Climate Change, and Sustainability*, Wiley Publications.
2. **Pradhanang, S.M**., and Jahan*, K., 2021 Structural Best Management Practices and Watershed Management. *In Encyclopedia of the UN Sustainable Development: Clean Water and Sanitation.* Springer Publications
3. **Pradhanang, S. M.,** and Tamanna*, M. 2020 Water Management: South Asia. *In* Wang, Y. ed., 2020. *Fresh Water and Watersheds*. CRC Press

**Conference presentations**

1. Workshop for the Association of Clean Water Administrators on Natural Language Processing for TMDL review (Texas A&M- Kumar)
2. 3-introductory and advanced workshops on watershed/water quality modeling (Texas A&M- Srini
3. 25 Stream restoration and green stormwater infrastructure workshops (Texas A&M- Jaber)
4. Kmetz, J., Aiken, R., Young, K., Pradhanang, S.M. Allen, L.,2021. Submarine Groundwater Discharge (SGD) resolved at high resolutions in Rhode Island Coastal Estuaries, Ninigret and Green Hill Ponds, using small Unmanned Aircraft System (sUAS) deployed Thermal Infrared (TIR) imaging, UCOWR, NWRI June 10, 2021
5. Young, K., Pradhanang, S.M., Kmetz, J., Aiken,R., Allen, L., 2021, Analysis of Submarine Groundwater Discharge (SGD) temporal dynamics in Northern Ninigret Pond, Coastal Rhode Island using Radon-222 and small Unmanned Aircraft Systems (sUAS) deployed Thermal Infrared (TIR) imaging, UCOWR, NWRI June 10, 2021

6. Young, K., Pradhanang, S.M., 2021.Small Unmanned Aircraft (sUAS) deployed thermal infrared (TIR) imaging for environmental surveys with implications in submarine groundwater discharge (SGD): methods, challenges, and novel opportunities. UCOWR, NWRI June 10, 2021
7. Pradhanang, S.M., Campbell, A. and Kouhi, S., 2020, December. Streamflow High Spells Analysis to Evaluate Flood Risks and Severity. In *AGU Fall Meeting Abstracts* (Vol. 2020, pp. GC084-0005).
8. Pradhanang, S. M., Meisinger, E., Kirby, K., and Kmetz, J., 2020. Water Treatment Innovation Using Floating Wetland Islands, North American Lake Management Society, November 18, 2020.

**Model development**

Students Mentored: 19