**S-1063 Quantification of Best Management Practice Effectiveness for**

**Water Quality Protection at the Watershed Scale**

Annual Meeting September 12-13, 2016

James B. Hunt Jr. Library, North Carolina State University Centennial Campus

1070 Partners Way, Raleigh, NC 27606

List of Attendees:

David Sample (Virginia Tech); François Birgand (NCSU) Fouad Jaber (TAMU) ; Changyoon Jeong (LSU); Trisha Moore (KSU); Joel Paz (MSU); Rabin Bhattarai (UIUC); Eric Drumm (UTK); Parajuli, Prem (MSU) Soni Pradhanang (URI) Ramirez Avila, John (MSU); Luis Alfonso Laurens Vallejo (MSU); Aleksey Sheshukov (KSU); Zhulu Lin (NDSU); Adel Shirmohammadi (UMD); Sara McMillan (Purdue); Jasmeet Lamba (Auburn)

Notes:

Francois Brigand chaired the S-1063 meeting on Sept 12, 2016. The meeting started with a quick overview of project and meeting goals. Other general discussions included how this s-1063 project and meetings can help foster collaboration. Since there are limited resources available in general and we all may be competing against each other, it is more appropriate and ideal to in fact collaborate within the group on papers, proposals etc. Adel Shirmohammadi emphasized on importance of project work, accountability and how these projects could be made more visible. Each university have their own way of using S-1063 project money. Most of us get a part of salary through Hatch money, some funding that could be used for committee meetings, others get travel support through Ag-experiment station.

Francois went through the Objectives :

* Monitoring
  + 1. Effectiveness of BMPs and widespread application
    2. Role of forcing functions of BMPs
    3. Fluxes at air-soil-water interface
    4. Feed existing knowledge base to existing data
* Modeling
  + 1. Watershed scale models
    2. Bmp at farm scale/urban sites
* Uncertainty Quantification
  + 1. Watershed scale models- add prediction/model uncertainty/inputs
    2. Confidence limit? Prediction limit?

General consensus was on focusing on priority BMPs and developing research proposal collaboratively.

After the brief overview , all the members introduced themselves. Seventeen members attended S-1063 meeting held in Raleigh.

As a part of brainstorm, Sunday recommended to encourage in small groups on identified themes and also come up with specialty conference in the last year of the project period and a special issue journal.

Sara McMillan from Purdue University presented objective 1 of S-1063 project. She started with providing an overview of where we ended up last time and whether or not we met the goal of targeting projects that were realistically achievable (low hanging fruits). Discussion during this session included ideas such as:

* Increase confidence in monitoring /scale up; how can be monitoring scaled up? Pollutant fate and transport at watershed scale/multiple environmental interaction
* Potential products/outcomes (slide from Sarah)
* Collaborative papers (meta-analysis-review paper?)
* Guideline for monitoring (what to do vs. what not to do?); ties along with uncertainty (if there is high degree of uncertainty then do not monitor? Same applies for modeling)
* Communicate how monitoring data are used or can be useful couple monitoring with modeling ; better job of integrating monitoring with modeling
* Categorize BMPs by management function: vegetative, structural and other
* Are BMPs additive linearly? Synergistics or antagonistics : dampening effect?
* Challenges in monitoring bmps effectiveness (group of BMPs); how to address the suite of BMPs and their effectiveness at the watershed scale.
* Partnerships with extension

As a part of objective 1, several members presented their work, progress and future goals.

Fouad Jaber from TAMU presented on green infrastructure, rain garden, permeable pavement, bioretention pond etc and included following in his presentation:

* Test all types of green infrastructure to convince people in Texas
* Social/cultural justification for demonstration of projects and monitoring requirements
* Urbanization causes water quality issues: a no no statement when it comes to State/EPA
* Permeable pavement/bioretention /detention pond/rain garden
* Bioretentio pond: include internal water storage (IWS); planted with nativeplants; 4 inches perforated pipe at bottom/survive wetness of may and October
* Water volume: flume and bubbler flow meter/pipe /levelogger/composite sampling
* Load reduction assessment from the LID/green infrastructure
* Hydrodeck commercial system
* Expanded Shale (high pressure/high temperature to produce light weight shale?); apply under asphalt /soil amendment

Pervious friction cores?

SWAT/LID module (calibrated and validated using TAMU data)

Francois Birgand from NCSU brought an interesting question regarding issues that we face in general when we work with natural waters. They are mostly unpredictable and therefore come with uncertainty which need to be clearly addressed (Predictability issues especially meteorological forcing such as Rainfall) . It was also realized and therefore discussed that as the watershed size decrease; it becomes even more difficult to measure rainfall and add uncertainty to our experiment/models.

Perspectives that Francois Birgand provided during his presentation include:

* High frequency monitoring
* S::can spectrolyser
* Need an algorithm to tease out spectral signatures
* Turbidity corrected spectrum (company does it)
* TP is linked with PON or to DOC
* Covaraibility between light absorbance and other parameters could be possible: color of the water and other parameters. Phosphate do not usually absorb color, but if it is colored then there might be an absorbance
* Chemometrics to create algorithm
* Partial least square regression correlates spectral data with chemical concentrations.
* Reduce dimensions of spectra
* Fiteval, Ritter and munoz-Carpena, 2013 JH paper for goodness of fit
* PLS fit for variety of nutrients (Fe, Si, Mn)
* Antifouling system (pumping water to S::can out of the water system)

Other materials include:

Multiplexor autosampler developed at his lab was an interesting piece of instrument that could be of value to the group. Bioreactors rejuvenation /capacity could be increased through wet and dry cycles to optimize bioreactor system.

Discussion during this talk included:

Collaborate: replicate works in multiple areas

* Sri (UDEL), Matt (UF came up with a proposal NSF (technical things you need to do to prevent crashes of sensors): manufacturers do not give you complete troubleshooting guideline and therefore it is necessary to take a lead on coming up with guidelines to troubleshoot sensors/ assess bmps effectiveness/
* Francois mentioned that in order to clean foulig of the S::CAN sensor, his team uses, cuvette, rinse with oxalic acid to get rid of iron and manganese and run the sensors
* Questions about availability of cheap and effective sensors came from Sarah.
* Since these high frequency sensors are expensive, have steep learning curve, come with high maintenance cost, there is a good incentives to come up with good sensors that could serve monitoring purpose.

Sarah presented her research and included following interesting details:

Mitigation of hydrologic, water quality and ecosystem impact in urban watersheds

* Variable flow in terms of streamflow
* Net effect on in-stream function
* Storm water control systems in urban system
* Urbanizations threat to the streams (cartoon nice one)
* Solution to the urban threats: Stormwater control measures (SCM)
* Could we take some well monitored storm ? wetpond; outflow isotopes O18 and Tritium to tease out signature change
* SCM contributes water throughout the tail end of the hydrograph

Discussion question included queries such as how do small watershed data collection tie with USGS? Adel responsed to this question by enlightening the group with **modularization of Chesapeake watershed model**. He also wanted to discuss whether we can look at BMP efficiencies at the smaller scale ? How can we influence the discussion in this area? There are upscale and downscale issues with the BMPs efficiencies; although some site scale tools are available through EPA. Some of the Ag community questionon scaling issues of BMPs. Efficiency to measure BMP effectiveness measure is not linear: functionality hung off and then go down leading to complexities in scaling up/down of BMPs.

Joel Paz, MSU discussed about declining groundwater levels in alluvial aquifer and resulting increase in nutrient loads. He discussed about on-farm water storage systems that captures surface runoff and irrigation tail water from ag-fields –nutrient load reduction efficiency. Harvested/recycled water from water storage system during winter is used to irrigate in dry months. If there is a change in field hydrology/less GW storage ; then there will be less surface water available downstream. How can this be addressed and studied through BMPs?

Objective 2:

Prem Parajuli, MSU started objective 2 BMP Modeling through brief overview of the goals that were planned in the previous meeting. These included:

* Assessment of BMP function under climate change scenarios?
* Best model for quantifying and predicting BMP function at the watershed scale.
* Is it CO2 concentration or precipitation? How do you account for climate change ? parameters?
* Targeting BMPs? Combined effect? Synergistic vs antagonistic results? How do we assess these results in terms of sensitivity, efficiency etc?
* Denitrification in the pond? Depth, surface area, temperature, settling velocity?
* Groundwater and surface water use?
* Review of current literature; where do we stand now?
* Generate a QA/QC and accreditation
* Any new model **SWAT/LID module** should go as products/outcome of S-1063
* TASABE: model calibration and validation guideline special issues could be of interest that can include modeling guidelines/sensitivity/uncertainty.

Soni Pradhanang, University of Rhode Island presented her current work on modeling source waters of RI, some challenges and limitations with ungagged watersheds. Discussion included interesting questions such as:

* Always at the small watershed scale when monitoring BMPS. How do the models do to capture behavior?
* Models based on CN will not present storm-by-storm response. Depends on what we want from models? Taken models and “misused” them. For relative impact assessment, they do very well: daily (hydrology = ok, water quality = horrible; annual = great!)
* Need to be very clear and specific for using these models for BMPs.
* What timestep (daily, hourly)? If model can do hourly timestep, are the model calculations well suited to this?
* Significant contribution – which models are suitable for this challenge: how are the models integrating BMPs into the code? What is the methodology for simulating a BMP?
* Spatial and temporal scales are important
* Models of BMPs are empirical… what about process-based models like **RHESSys**?
* Monitoring of flow in very low-flow systems

Simulating fast versus slow processes (bgc – daily might be fine; but hydro needs sub-hourly data)

David Sample; Virginia Tech presented his work on Virginia BMP Modeling. David and his teams’ work included Floating wetland modeling: mimicing natural wetland; developing EPA SWMM model at catchment scale; computations for the ratios for N removal rate as a function of raft coverage.

The current method that for calculation of N removal is also used by Bay program

Discussion question included:

If it were used as surrounding on water body, will it act as a vegetative filter strips; biofilm and flocculation that is important? Response included: N removal efficiency of 50% although is small is not reasonable and is also due to the loss of water/it is all about the exchange and mixing

David also presented his work on C=climate change impacts on urban Runoff . Some interesting details include:

* Site: Fairfax, Virginia
* 900 existing BMPs
* 3 USGS gages
* **R-SWMM** (single event, lumped), C\* model for water quality sub model
* Removal efficiency of detention ponds
* Virginia Beach SWMM modeling sites: SWMM site allocations:
* Compare with runoff reduction method (in compliance with state regulatory need)

Aleksey Sheshukov (KSU) showed his project activities in Kansas which included 12 HUC watersheds, watershed restoration and protection strategies; Field lab (study effect son ag-mgt practices in water quality): flumes and ISCO samplers

Sediment loss form ag-fields and ephemeral gully erosion (G**IS/topo-index modeling** for gully ID, soil loss monitoring using field soil moisture sensors and photogrammetry);mRural urban partnership (BMP implementation in rural areas to offset sediment runoff from urban areas) (integrate **SWAT to SW**MM model)

Rabin Bhattaria, University of Illinois-UC presented research related to Clean water for sustainable future. His research findings included:

* Winter cover crops, fertilizer rates, nutrient flushing high during winter as bare ground tend to flush high flux of contaminants
* How we can reduce nutrient using BMPs?
* Tile drained: modified hydrology? Difficult for replicate high flows
* What is the denitrification rate? Nitrogen flux overall at the watershed scale
* Handle uptake and denitrification: model does okay in N loss
* Will farmer comply to any change?-scenarios?
* Scenario analysis: 10% reduction in fertilizer application (no reduction for soybean; works for corn)
* Winter cover crop (cereal Rye): harvest in mid-October: may increase yield; reduce leaching : may be good option?

Rabin also presented his recent work on subsurface bioreactor for nutrient removal. He is developing a tool to size a proper bioreactor : development of process based model for subsurface bioreactor (DRAINMOD);**Excel VBA function** (what if analysis DRAINMOD) which will be made available to the group if needed.

Other tools include

WQIA Tool ? (Water quality impact assessment tool); Analytical tools (APEX)

Cropping practice effects on P load (nutrient management: no effect as such)

Adel Shirmohamadi, Univ. Maryland suggested the team that the meeting should have less presentation. It should include report at State Level which can be of 3-5 minutes highlight.

Adel presented few slides that included information about S-COSM (sustainable community oriented sustainable management) ;energy dynamics, modeling at watershed scale, landscape and population attitude, bioindicators for ecosystem diagnosis, diagnostic decision support system [ddds}, climate population and landuse impacts/sustainability); Perspective expert system (PES): Assign proper BMPs based on DSS [SWAT with DDSS] ; identify spatial hotspots

Socio-ecological health and water quality issues were also discussed. Few important questions/issues that were addressed were:

* What are the reason for involving communities at the local level in stormwater management?
* What are some different ways to involve the public in the stormwater management?
* What are the potential outcomes of involving public?
* Participatory approach/change in perception
* Create a resilient system

Some important thought from Adel included:

* Climate change and adaptation DDSS:
* Robust BMPs needed in the interest of climate change; community based, participatory implementation strategies
* TMDL update for climate change is must
* First order mean value theorem for uncertainty analysis
* What are the uncertainties /what percentage reduction is needed under these different climate scenarios?
* Latin hypercube monte carlo- uncertainty analysis

Day 2

Francois Birgand lead the group to give an overview of Objective 3: “Uncertainty as affected by model representation of watershed processes and model input data. “

It was realized that good practices on model development/application is necessary. Focus should be given on Modeling/monitoring uncertainty (sample collection, holding, storage, analysis etc). Standard practice for measuring uncertainty need to be established ( For example, qa/qc methodology to reduce uncertainty). Example: Bioreactor: excel based VB macro; R program?

Collaborative work may include broad opinion paper: model calibration; lack of uncertainty assessment papers? ; Strategies/methods for load calculation (16 different methods available)? Overall refined method development was deemed necessary. Francois’s presented his research and addressed that :

* Uncertainty in sampling frequency varies by contaminants (for Phosphorus it is even higher)
* Rating curve has less error if polynomial distribution used vs power relationship (addressing uncertainty)
* No one size fits all method to account for uncertainty
* Heavily dependent on statistical methods (find all the published algorithms on load assessment)
* Depends on the size/scale of BMP levels/watershed size
* High frequency measurement for flashy system e.g., Percentage of the total mass that occurs in 2% of the time (M2% concept) (uncertainty associated with mass loads, and idea of % time mass for loads occurring (to capture hot moments)
* differences in scale between flashy events (hot moments) of stormwater runoff versus receiving streams, and implementation of BMPs. Independence of storm events at scale of watershed in terms of flow. But nutrient concentrations are not independent of each other. How events are linked together? Lots of information embedded in succession of events
* Take advantage of autocorrelation to address uncertainty (4 times 4 events or 16 random events?)
* Ways to fill in missing data? Add in small patched (uncertainty will be lot less instead of getting rid of missing data completely)

In addition, members had many insightful thoughts, which are presented below:

Sampling/treatment strategy: example of stream restoration (upstream-restoration site1-restoration site2-downstream location); need to have absolutely complete record (high frequency data; ways to patch missing data)

* Minimize error band (by developing appropriate sampling strategy: be able to understand data and patch missing data)
* Full proportionate Composite sampling not a bad method if you have good flow measurement.
* Continuous micro flow of contaminant (~$5000)-fraction collector)
* Categorize BMPS in precisely defined system
* Comprehensive review: Common sensing techniques and their reliability (Francois, Rabin, Sarah, Soni, Prem)
* Emerging water quality sensing technologies for BMP efficiency assessment (uncertainty assessment inclusive)-
* Intermittent flow issues/sustained drain in tile drain/seasonal issues of low flow
* Input data uncertainty

Other details pertinent to this meeting include:

Next year meeting venue: MSU (the golden triangle airport)

Elections: Chairing committee

Chair: Prem Parajuli

Vice Chair: Sara McMilan

Secretary: Soni Pradhanang

Action Items for coming years were discussed as groups divided based on Objectives:

Immediate Goals:

1. Common Repository of Tools: May be GitHub
2. Website? Sarah is taking care of website (NIMSS website available): build on to the existing website (Dan Storm S-1042) or <http://s1004.okstate.edu>
3. Basecamp for teachers free

Group 1:Monitoring: White paper

* IR1: Emerging water quality sensing technologies for BMP efficiency assessment (uncertainty assessment inclusive)

Group 2 : Modeling

Goal1: Group paper: modeling paper

* Comprehensive assessment of how models handle BMPs (how do current models represent BMPs): structural, management, vegetative BMPs

1. JEQ, TASABE, JAWRA
2. Lead: Soni,
3. Co-authors: Tim, Rabin, John, Fouad, Aleksy, Eric, Prem, Zhu
4. Google Drive: populate all the literature
5. Basecamp
6. Outline; section
7. Conference call to discuss paper plan and progress

Goal2: Analysis of predictability, suitability and reliability of BMPs on water quality maintenance.

Hypothetical watershed?

Lead : Zhu Lu, Soni Pradhanang, Aleksy, Tim, Rabin, Fouad

Individual BMP target

Goal 3: Proposal:

* Regional Coordination Network: Meeting at the NSF (deadline: 1/4/2017)

1. Full Proposal? (Tim Sunday will email all with information)
2. Collaborators outside of USA could be included Water for Agriculture USDA/NIFA

Goal4: Discussion paper

BMPs effectiveness in the interest of climate change: Model focused

Lead: Aleksey

Fouad: SWAT/LID paper in review: SWAT 16 may come soon as will have LID module included. SWAT/LID model can be made available if needed

Excel Marco VB tool Bioreactor

SSURGO Tool for SWAT 2009? SWAT 2012: Aleksy

SWMM

R-SWMM