Modeling Workgroup (MWG) Quarterly Review

January 9, 2024

Event webpage: Link

This meeting was recorded for internal use only to assure the accuracy of meeting notes.

ACTIONS & DECISIONS

- **Isabella Bertani will present at multiple workgroup meetings (Nontidal Network – April 17th, STAR – March 28th) where representatives from monitoring agencies regularly attend to spread the word about the water quality data portal project. If interested, these representatives will have an opportunity to review a spreadsheet listing which stations are included in the water quality portal and the minimal criteria for data to be integrated into WRTDS to estimate loads. The goal of these presentations is to let agencies know which types of gaps they may want to fill or to add the co-benefit of being used in CalCAST. Isabella will include the Model Segmentation Viewer in her presentation.**
  - **Status: In progress.**
- **Alex Gunnerson will share information about the optimization webinars with the MWG and the CBP when it is available.**
  - **Status: Optimization webinar scheduling is in progress.**
- **Alex Gunnerson will invite the RAND led team to the weekly Modeling Team meeting to have an early discussion on the workplan, especially Task 4.**
  - **Status: Completed.**
- **Gary Shenk will review and share with Bill Keeling the work he completed in the Phase 5 Watershed Model which used a curve for one- and five-year storm events to degrade the effect of BMPs.**
  - **Status: Completed.**
- **Tom Butler will follow up with Bill Keeling offline to continue the conversation on how nitrogen application on pasture is represented.**
  - **Status: In progress.**
- **The Main Bay Model (MBM) Team will work with the Watershed Modeling Team to identify a suitable path forward to address the issue of unrealistically high concentrations in watershed loadings during very low flow events.**
  - **Status: In progress.**
- **Based on the evidence provided at this Modeling Quarterly and the previous two meetings, the Modeling Workgroup decided to move forward with the growth rate proposed by Carl Cerco in October 2023 with a 32 C temperature optimum for the green algae group.**
- **Tom Parham will share Richard Tian's presentation with Maryland DNR geologists and will ask if they have the file md_sstru05.shp, as that would be useful for Richard.**
  - **Status: Completed.**
- **Richard Tian will work with Larry Sanford to acquire the shoreline erosion data on the Choptank (William Nardin's work near Horn Point and Jeff Halka and Larry**

Sanford's work near Todd's Point) and then revise the shoreline erosion approach in accordance with the observational data.
    - **Status: In progress.**
- **The MWG decided to apply the wave power approach for shoreline erosion Bay-wide. Follow up actions include:**
    - **1.) Explore the data provided by Larry for two locations in the Choptank, and revise accordingly;**
    - **2.) Leave open the possibility of a blended hydrology-wave power based approach to shoreline erosion;**
    - **3.) Reach out to determine how shoreline best management practice are being tracked to ensure this approach is compatible.**
- **Richard Tian and Nicole Cai will work with Cathy Wazniak to discuss how Maryland is utilizing this benthic algae data. Cathy will send Richard the data and set up a meeting with the three of them.**
    - **Status: In progress.**

MEETING MINUTES

10:00 Announcements and Amendments to the Agenda – Mark Bennett, USGS and Dave Montali, Tetra Tech

Summary

Dave shared there will be Phase 7 Office Hours to answer partner questions on February 5th, with the purpose of determining which Phase 7 topics to cover at the February Water Quality Goal Implementation Team (WQGIT) meeting. Lew shared in the past there has been significant input from the WQGIT, so perhaps this an opportunity to encourage engagement. This is especially important because they are the decision makers for the CBP models.

Lew shared four pieces of good news:

1. Nicole Cai has won paper of the year (William Boggess award) from the Journal of American Water Resources Association (JAWRA). This work reflects the efforts of many in the Modeling Workgroup.
    i. Nicole thanked everyone for their input on this paper.
2. We can expect fruitful modeling results in shallow water systems, especially tidal wetlands and benthic algae, thanks to the work of people like Richard Tian, Nicole Cai, and Jeremy Testa. More information on this work will be shared in future meetings.
    i. Richard said the work in the Corsica is a prototype for more extensive work throughout the Chesapeake Bay.
3. Martha Shimkin is the new director of the Chesapeake Bay Program (CBP) and she will attend the start of the second day of the quarterly meeting.
4. The Chesapeake Community Research Symposium will be held this summer (June 10-12, 2024) and abstracts are due on February 1st. You are encouraged to review the session proposals and submit abstracts.

Gary shared STAC has released two reports: one on small watershed monitoring and one on solar panel BMPs. It may be useful to review these reports.

10:15 Phase 7 Watershed Model Overview – Gary Shenk, USGS-CBPO

Gary provided an updated timeline for completion of the Phase 7 Model in time for the 2026 partnership review.

Summary

Gary began with a reminder of the four I's which form the core values of the Modeling Workgroup: integration, innovation, independence, and inclusiveness. Gary then gave an overview of the Phase 7 Development Tracks, corresponding team members creating each component of the model, and the overall timeline.

10:35 Discussion of the Phase 7 Model Overview

Summary

Dave asked if the WQGIT will consider how Best Management Practices (BMPs) are influenced by climate change. Lew said yes, the Principals' Staff Committee (PSC) has charged the CBP with understanding how BMPs will be influenced by changing hydrology. The recent stormwater RFA was awarded to RAND and PIs from Cornell, and Carnegie Mellon who will be putting together mechanistic models to understand how BMP efficiencies will change based on different physiographic regions compared future climate change and current conditions. We will be looking to apply the RAND analysis in fourth quarter of 2025. Dave asked if 2026 will be the time for decision making and if there will be enough time for consideration. Lew said the BMP efficiencies analysis will appear in scenarios but not in calibration. We will be doing many sensitivity analyses in 2026.

Lew said with respect to slide 3, the Airshed Model tracks the largest input of nitrogen to the Chesapeake watershed and tidal waters and while we do not have direct responsibility for the CMAQ model, perhaps we can include it in this diagram with a connection via a dotted line. The rigorous national work on air quality very much supports the CBP suite of models. Gary replied he had left it off because all the components represented on this slide have an associate tracking document, but he can add the Airshed Model.

Bryant Thomas asked about the timeline for model evaluation and said this should be part of conversations now during model development before we get to the year of review. Gary said he thinks this will be discussed in more detail at the WQGIT in a few weeks as it is critical to understand the interests of the WQGIT to determine which uncertainties to focus on. Existing but different methods of evaluating the models include the Total Maximum Daily Load (TMDL) indicator and CalCAST. For sensitivities, Gary thinks the Agricultural Modeling Team (AMT) will answer this question. Lew said we need to determine what decision makers want before we can focus on which uncertainty metrics to highlight. Olivia Devereux said the dialogue with the WQGIT will be important. That is something that Pennsylvania Department of Environmental Protection (PA DEP) has asked for as well as Virginia Department of Environmental Quality (VA DEQ).

Bill Keeling said uncertainty would seem to necessarily increase significantly with the use of unproven technologies/methods. Gary said it seems this comment may be referring to machine learning. This is a concern of the Modeling Team as well, but we will let the data speak and will keep this point in mind. Lew said in addition to the review of the MWG, Scientific and Technical Advisory Committee (STAC) will conduct an independent review with particular emphasis on new methods. The Modeling Team will be responsive to these comments.

Guido Yactayo asked about the calibration of the water quality model, specifically if it will start in the year of review or within the next two years. Guido also asked if there will be a revision to calibration procedures. Gary said calibration began when CalCAST was developed because it helps determine the calibrations for CAST, so calibration has been ongoing and will continue in other forms as well through the year of review. There is also a separate calibration to match up estimates with observed concentrations and flows involving temporal downscaling. Gary said calibration will be integral to the development of each component of the Phase 7 suite of models and we will be reviewing this method in 2026 as well.

Bill Keeling asked about the hyper-resolution hydrography inputs. Gary said the Modeling Team will explore how to use machine learning to see what can be gathered from that data. Bill said his team's review of that data found a high degree of error and said it does not inspire much confidence in him. Gary said he understands, and the data will only be used if the methods show promise in a useful and reliable product.

10:50 Update on CalCAST Development – Isabella Bertani, UMCES-CBPO

Isabella provided an update on the progress made in: 1) gathering water quality data to expand the calibration dataset for CalCAST and the dynamic watershed model, and 2) incorporating new calibration stations in CalCAST.

Summary

Isabella provided a final update on the development of a reproducible workflow to download water quality data from EPA's Water Quality Portal (WQP) project. This included motivation for this project and the stations which met criteria for different parameters using Weighted Regressions on Time, Discharge and Season (WRTDS). Isabella also described variability in station characteristics for each parameter, including land use. Isabella concluded with next steps for CalCAST development in the first quarter of 2024.

11:10 Discussion of CalCAST development

Summary

Lew said the documentation and data processing for the water quality portal is critical information that was absent before. Lew said down the road, perhaps we could write a paper or share this documentation publicly, so this tool is available more broadly. Isabella said the dataset will be available to anyone who asks for it and she is putting together a spreadsheet with the exact documentation for the dataset. Isabella said she does not plan

to formalize this into a peer reviewed manuscript now because CalCAST is the priority, but this might happen during or after the year of review.

Bill Keeling asked can the drainage areas for these stations be made available, preferably in a GIS layer of something similar, but at least a list of station ID and the drainage area would be sufficient? Isabella said yes, this will be made available as part of the dataset to be shared online, so anyone interested in this data can have it.

Norm Goulet asked Isabella why there are so many more stations considered to be a "maybe" on the total phosphorus (TP) map compared to the total nitrogen (TN) map? Isabella said one reason is that many stations have non-detects, below the detection limits, for TP. WRTDS has a method for dealing with TP non-detects, but this does not hold when a station has more than 50% of their observations to be non-detects, which is the case for many of these stations. Another reason is that since TP concentrations can be very large during high flow events, it can be difficult to know if the high readings are a true concentration or an error in the data. Right now, the portal is very inclusive of these high TP concentrations, but WRTDS rates those as highly biased. WRTDS is known to not perform as well for TP and sediment as it does for TN, because of the way those constituents behave. To ensure no stations are erroneous discarded, Isabella has classified them as maybes and will be consulting experts on this question to help with determining which stations to retain and which stations to remove. Norm said he had not thought about the non-detects but was concerned about the second point Isabella brought up regarding very high concentrations and is thankful Isabella is looking into this closely. Dave asked if total suspended solids (TSS) can be used as a proxy for TP in this case. Isabella said that is a good point, and she will see what flow data and TSS data say after that has completed its runs.

Qian Zhang asked if Isabella specified thresholds on the station retention for the model performance (retain, maybe, no)? If so, how do they compare with the model performance of the USGS-published Chesapeake Bay Nontidal Network (NTN) results? It may be a good idea to find the distribution of the model performance of the USGS results. Additionally, the USGS national assessment team has done a lot of WRTDS models and performance checking. Recently, they published a paper to help automate the model-checking process for large multi-site analysis. Isabella said she is aware of this paper. Isabella used the NTN data to identify model diagnostics to understand what represents a good model as a reference point for assessing the new stations. Isabella plans to work with Jeff Chanat, Bob Hirsch, and Doug Moyer to determine if borderline stations should be included or not. Isabella has been checking stations manually since they still recommend a person review the stations and not rely solely on the machine learning model.

Qian asked if Isabella WRTDS_K for this estimation since the interest is in true condition. Isabella said she used WRTDS_K for true condition and regular WRTDS for flow normalized results.

Bryant Thomas asked about the timing of Isabella's next step to reach out to monitoring agencies to provide feedback. Isabella said anytime between now and 2025, but she will

soon reach out to agencies with a spreadsheet listing which stations are included so they know which types of gaps they may want to fill.

Bryant asked if Isabella would let monitoring agencies know which minor changes to sample design or collections would allow the data to be incorporated in future versions of the model. While the data is often collected for a myriad of reasons, having the co-benefit of being included in the Phase 7 Watershed Model would be nice to have. Isabella suggested following guidelines from the NTN and USGS. Published work from Jeff Chanat includes minimal criteria for data to be integrated into WRTDS to estimate loads. Isabella will include these minimal criteria when she reaches out to monitoring agencies.

Bryant asked if there are any plans to do something similar for tidal stations. Lew we are currently using the tidal monitoring program stations but will be able to take advantage of more of them for tributaries based on the high spatial resolution capability of the MBM and MTMs. Phase 7 will also be the first time we can incorporate shallow water monitoring data into tidal modeling efforts. These are revolutionary changes because of the finer scale in Phase 7 and the CBP's interest in shallow water monitoring.

Mark Bennett asked if the sampling method coming out of the data portal is depth and width integrated, because that will make a huge difference on larger systems during high flow events. If integrated sampling is not employed, much particulate potential will be missed. Isabella said there is a column in the water quality portal that provides that information, but rarely is it populated, so most of the data does not have that information. NWIS is an exception, but non-USGS data often does not have that information.

11:20 Progress in Phase 7 WSM Development – Gopal Bhatt, Penn State-CBPO

The NHDplus 100K scale Phase 7 Dynamic Watershed Model (DWM) prototype with simulations of hydrology, sediment, nutrients, water temperature, dissolved oxygen (DO), and phytoplankton is now operational for the entire watershed. The DWM is using a nested model segmentation of streams and rivers with a hybrid structure for the simulation of water quality processes using HSPF and non-iterative routing models. During the last quarter, progress has been made on the implementation and testing of a simplified water quality routing for the small NHDplus streams. Gopal surveyed the ongoing model development progress on the structure and implementation of water quality routing for small streams for nitrogen and describe activities upcoming in the next quarter.

Summary

Gopal began with a general overview of the DWM as well as a review of previous model development progress, including milestones, incremental improvements, and prototypes. Gopal then explained the process for water quality routing of small streams, like the building blocks and overall structure. Gopal concluded with a broad summary of the previous quarter's progress and next steps for the DWM in 2024.

11:40 Discussion of Phase 7 WSM Development Progress

Summary

Lew stated this is an impressive lift, and combined with Isabella's work, sets the foundation for successful assessments in shallow waters that was not possible in Phase 6.

Vahid Rafiei had a few inquiries regarding the NHD data.

1. Why not utilize the NAM model (National Agroecosystem Model), which is already established Soil and Water Assessment Tool (SWAT)+ models National Hydrography Dataset Plus Version 2 (NHDPlus) (1:100k) for the entire US?
    a. Gary Shenk said the Modeling Team is not aware of the NAM. From quick searches on the web, it looks like it is mostly for corn and soy at the 8-digit HUC. We would be interested to explore more if there is a link.
    b. Vahid shared the link: https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.13056 and said more information can be found on their website: https://hawqs.tamu.edu/#/.
    c. Gary said to answer the broader question about why we would or would not use NAM: the task with the Dynamic Watershed Model is to temporally downscale the results of CAST, including at ungauged basins. Gary is not sure if NAM would do that better because based on a quick perusal of the paper, we would still need to calibrate individually to the stations. Having said that, the Modeling Team is not tied to any one model. We are looking for the best method available and will keep our eyes on this for future development.
2. Why use NHD 1:100k, especially considering the availability of the NHDPlus High Resolution (1:24k), which offers higher resolution and is ready for use? Vahid added this also gives some comparison between NHD 1:100k and NHD HR 1:24k: https://www.usgs.gov/news/which-nhd-product-do-you-need-and-which-do-you-have. An interesting point is that NHD 1:100k has been abandoned and has not been updated since 2012.
    a. Gary replied the Modeling Team was aware of the existence of the 1:24k, but simulating at the 1:100k is at the limit of our computing ability. The team cannot afford, computationally, to go to the 1:24k for this version. There are also more data limitation at that scale.
    b. Vahid said he is doing modeling with NHDPlus HR for the entire state of Michigan with a single node and can confirm it is easily possible with 2-3 server nodes in one month for entire Chesapeake Bay.
    c. Gary said the Modeling Team is trying to keep run times to a day or less for a 40-year hourly simulation.
    d. Vahid said the one month time frame he mentioned was for entire calibration and sensitivity analysis, not a single run, so he thinks it is still possible.

Cassie Davis asked what UNEC stands for. Gary said it stands for Unit Nutrient Export Curves. Gopal developed the method for the Phase 6 DWM. It is the method that allows him to estimate the effects of lag times.

Robert Sabo asked if these beta parameters are allowed to vary through time so the trajectory can be examined or is it a fixed effect. Gopal said WRTDS provides availability of beta parameters over time. We are interested in questions of how the beta parameter can change when the loading rate changes, with respect to management scenarios, implementation, and climate change. Gopal said for the prototypes, the DWM

has defaulted to a FluxMaster-like regression, which allows for a fixed value of the beta parameters. This is a simplifying step in development and has not eliminated the possibility of a time variable beta parameter, as this is an incremental process. Robert said he and Qian Zhang would be happy to be involved in further discussions around temporal correction, if that is a direction the team plans to pursue. Gopal said he will reach out to them and Jimmy Webber if this is the case. Robert stressed the importance of this work on beta parameters not just for modeling, but also for monitoring progress purposes, as detecting shifts in discharge concentration relationships can be the first signal of improvement. Gopal agreed and said that is part of the point of including this component in the model.

Robert asked if the calibration period for the beta parameters includes 1985 to present or only 2010 onwards. Gopal said the team used all the data available, including new data from sub-watersheds.

Robert said Gopal's work fits nicely with the most recently released goal of the recently STAC workshop report: https://www.chesapeake.org/stac/document-library/22313/.

Jian Shen asked if Gopal is planning to model carbon. Gopal said the modeling team has not had explicit discussions on how they will deal with carbon, but in HSPF there was a simulation of carbon, so we will likely be retaining that structure. Gopal recognized the importance of carbon for the estuarine model loading. Gary replied that Xuesong Zhang at U.S. Department of Agriculture Agricultural Research Service has outside funding to build a carbon model for the Chesapeake. We may be able to use this to emulate the relationship between carbon, flow, and nitrogen, but this is not guaranteed. Lew said carbon information is often missing from the watershed monitoring data, so in Phase 6 carbon was represented by organic nitrogen and assigned refractory and labile, components of carbon. If refinements are not possible, we will the methodology from Phase 6.

12:20 Development of Efficient Multi-Objective Optimization Procedures – Kalyan Deb, Pouyan Nejadhashemi, Gregorio Toscano, and Hoda Razavi, MSU

Progress on the integration of web-user and decision-making interfaces, and tasks for multi-state implementation using machine learning and parallel computing platforms was presented.

Summary

Pouyan began with an overview and timeline of the four-task optimization project. Pouyan summarized the case study of early optimization testbeds in West Virginia and the challenges of broadening lessons learned from West Virginia to the entire Chesapeake Bay Watershed. This included data analysis methods like cluster mapping, testing, and validation. Pouyan explained interactive optimization and decision-making through the lens of the user interface for the web application. Pouyan concluded with next steps for the optimization team and information about the upcoming optimization webinars.

12:40 Optimization Discussion

Summary

Lew commended the optimization team on the clarity of their communication and the usefulness of the upcoming webinars. Lew said the Modeling WG will share information about the optimization webinars with the CBP.

Olivia Devereux said she is impressed with the progress, especially the ability of the user to adjust the costs. Olivia asked how the team knows when they are done with the appropriate number of iterations to estimate the optimal cost. Pouyan said they begin by randomly selecting locations across the watershed and then testing the best BMPs across 30% of the locations. There are many methods that can be used if this initial approach is not successful.

Lew commented that there is only 15 months left on the workplan and funding for the optimization team. It would be nice to have the optimization team available during the post 2025 period of application, but this is not a guarantee.

1:00 LUNCH

2:00 Stormwater Management in a Changing Climate SWM & AG BMPs – Michelle Miro and Krista Grocholski, RAND

Existing, well-documented, open source, and public domain stormwater and/or watershed models will be applied under different future climate hydrologic conditions to determine relative change in pollutant removal efficiency in existing CBP-approved stormwater management BMPs under future increased volumes and intensities of precipitation in the Chesapeake watershed. The work will inform CBP managers of adjustments needed for urban, agricultural, or other BMP load reductions in the context of the Phase 7 Chesapeake Bay Watershed Model.

Summary

Michelle began with an overview of the project and project team. Michelle and Krista walked through the objectives, research steps, and outputs of each of the five activities under this project. These activities are: Vulnerability Assessment Tool, Climate Resilience Decision Support Tool, Resilient Design Guidance Manual, BMP Climate Sensitivity Modeling for Stormwater and Agricultural BMPs, and Outreach, Dissemination, and Training.

2:20 Discussion of Stormwater Management in a Changing Climate SWM & AG BMPs

Summary

Lew said this team previously developed the climate adapted Intensity, Duration, Frequency (IDF) curves for all counties in the Chesapeake watershed, which is an important step in overturning the engineering principle of stationarity. This has inspired other work throughout the country.

Lew said he will invite this team back to the MWG in April and July so the draft workplan can be reviewed. The MWG will need to determine which BMPs this team

should review, in accordance with the charge from the highest level of the partnership, to examine the influence of climate change on BMPs. This will certainly include efficiency BMPs, the BMPs that are most applied, and the BMPs we expect will change the most.

Gary and Lew said Task 4 (slides 7-9) will be of particular importance to the MWG. Gary said there are multiple ways to interpret Task 4, which include different versions of SWAT or different ways of approaching climate change. It will be important to discuss this while the workplan is still in early development. Lew invited the RAND led team to a modeling team weekly meeting at some point in the next month to discuss the workplan for Task 4. Norm Goulet said he has invited the RAND led team to the Urban Stormwater Workgroup, as he agreed it will be important to coordinate feedback on the draft workplan.

Dave said in this informal discussion, it might be helpful to discuss consistency between how the CBP has represented climate change scenarios and how the RAND led team represents climate change scenarios. Another point of conversation is how will removal efficiencies be changed and remain in line with the BMP expert panels. Lew said we will likely use difference in BMP removal efficiency relative to what the BMP expert panel decided. Michelle agreed the team will need to determine between absolute and relative removal efficiencies early in the project.

Bill Keeling said in the Phase 5 suite of models, there was a curve with one- and five-year storm event where the intensity degraded the effect of the BMP in question. This never went to zero, which it probably should, for a 100-year storm event. Bill Keeling suggested Gary should dig this work up to see if it may be helpful. Gary said it was not intended for climate change but instead to represent different storm events. Gary produced the formulation and the CBP groups parameterized the curve. So this process may be useful if we are looking at parameterizing the short term effect, to complement the long term effects being investigated by this group. Lew said this is flow only, so we would need to also include phenology and other future climate conditions. Lew expects future climate hydrology to change the overall baseline. Lew suggested exploring if this component is still in play today.

Norm said another consideration for the team is to work closely with the jurisdictions on their design manuals, with attention to those who have recently updated their manuals already. It will be important to keep this in mind. Lew said yes, this is key, and when Atlas 15 arrives we will need to start using this as a transition in the 2030s.

2:30 **Crop Yield Calculations for Estimating Nutrient Application and Projecting Future Demand – Joseph Delesantro, ORISE-CBPO**

We aggregated crop yield data for 24 crops accounting for 95% of cropland N application and estimate annual crop yields from 1950 to 2022 using weather, climate, soil, and topographic variables. We then applied trend analyses to estimate the farmer expected yields, which attract nutrient application, and average yields to inform CAST scenarios.

Summary

Joseph began with the caveat that all this information is preliminary and draft. Joseph showed plots that illustrate how cropland area is changing along with crop yields. Joseph explained the importance of crop yields and how they are tied to nutrient application. Joseph then outlined the planned path for investigating these trends and data (slide 6), which included steps for crop and weather data collection to create an annual estimation of yields. Joseph discussed preliminary statistical modeling results, various trends analysis options, and examples of applying trend analysis to annual estimates. Joseph concluded with next steps for this analysis (slide 19).

2:50 Discussion of Crop Yield Calculations for Estimating Nutrient Application and Projecting Future Demand

Summary

Bill said pasture has tons of forage grown as a yield goal. Why can't yield goals for pasture also be developed? Tom Butler said we have been looking for data on this so we would be interested in getting the data you might have that represents the coverage at the watershed scale.

Bill asked how does tons per acre of hay equate to bushels per acre of small grains? Olivia said yield units can be different and are kept separate in the source data. Bill said they were in the same graph, so what units are being depicted? Joseph said in the census of agriculture, this is small grain hay. Bill said to him this means straw. Joseph said he has been using the nomenclature coming directly from the data sources (USDA NASS census of agriculture), but terms can be changed to help with clarity. On the topic of yield units, the units don't need to be consistent across crops, but they do need to be consistent across crops through time. In the past, we were representing 11 crops with true yield, which accounted for 70-75% of nitrogen application. The rest of the crops were being represented with their yield units. With these developments, we can represent 95% of crops with yield units and hope to reach 100% of crops measured this way. Robert Sabo said the key for the time term is illustrated in the time series below that highlights the dramatic rise in corn yields.

Gary said the MWG will used the true yield in the dynamic model. Robert said this is fantastic.

Lew said Joseph is bringing an important contribution and asked for legumes, are they a part of the 24 crops of nitrogen applications? Is yield increasing for legumes? If yield is increasing, is it because of better seed or better management? Joseph said peanuts are one of the 24 crops, and there may be a few other legumes. Robert said soybeans have plenty of other data. Timothy and green peas seem to have fewer data available.

Bill Keeling said he disagrees that pasture gets zero fertilizer applied. As Bill understands it, there is significant acreage of pasture getting nitrogen fertilization in VA. Bill said a big issue for Virginia is that they cannot get credit for nutrient management on pasture. We know some pastures are being fertilized and others are not, so we need some way to credit management actions on the ground, so we need to change the way the CBP accounts for this. Olivia Devereux said Bill is correct. Tom replied he hears what Bill is saying and the current precedent for how pasture is dealt with is 14 pounds per acre. Nutrient management expert panels did not come to a consensus on what to do. Bill

replied that originally they put forward nutrient management criteria, which for Virginia was 68 pounds of nitrogen per acre, and other states like New York did not have that level of nutrient application. Bill noted Virginia's growing season is longer and has species like Bermuda Grass, so we cannot have a one size fits all approach to this question. Virginia has roughly half of pasture in the watershed, so they need some relief. Tom said Bill is right and he hears what he is saying. Currently there is one rate for everyone, and it is about 14 pounds of nitrogen per acre. Tom emphasized the AMT is looking into this question of changing the representation of pasture nitrogen application rates and welcomed Bill to share the data with him either directly or through Tim Larson (VA's representative on the AMT). Bill said prior to Phase 6 the precedent included credit for nitrogen in pasture. Tom said in ongoing discussions about Phase 7, this is an opportunity to revisit this during land use and crop type conversations. Tom said this is the time to get this in and supports Bill to continue providing input, both directly and through Tim. Bill said his concern is pasture is represented as having zero fertilizer applied. Tom said to try and improve this, the AMT has put out a survey to gather data inputs. Tom will follow up with Bill Keeling offline to continue this conversation on how nitrogen application on pasture is represented.

Robert said just to emphasize the Virginia issue Bill raised, the distribution of cow-calf operations is heavily located in the southern parts of the bay watershed. Accounting for cattle herds and grazing removal rates will be a very valuable contribution as it has a big impact on the mass balances. Robert said he thinks overall, the CBP has all the data it needs to get at a reasonable removal rate because we already have pasture manure deposition, so we could do a back calculation to get a removal rate. Bill said he thinks this is part of the confusion when we see need listed in CAST. Need is not crop uptake in this case, and crop uptake on a 200 bushel yield of corn can be vastly different from uptake levels for a different crop. Bill emphasized we likely need to go back to crop yield, or utilization, for the plant.

Gary said Bill's point relates to slide 5, where the blue line represents the producer's expectation of where fertilization levels would be best and the orange line is the uptake and removal. These two lines are converted using different methods. Bill is right in that in the previous phases, there was one metric of crop uptake, which also was standing in for what people were expecting. With this approach for pasture, we would think about the expectation line as different from the uptake line. Bill replied in this case, his point would be the orange line is above the blue line. Gary said we can translate expected yield to application can differ for different crops, and pasture is a major example. By drawing two lines, it allows us to examine these concepts more clearly by separating them. We look forward to improving this in Phase 7.

Robert said regarding model development, is this a regression approach or is Joseph trying to leverage some neural network models? Joseph said he explored some widely used neural network approaches in the literature, which seem to be most effective at the county scale for crops like corn and soybeans but likely not as effective for sweet potatoes or sorghum silage. To keep everything similar, Joseph used a multivariate linear model regressed to the available data, with some bootstrapped validation. Also explored non-linear functions, but they provided little improvement for the associated cost of the

added complexity. Robert expressed interest in hearing more about these developments, and offered support from EPA-ORD on this topic.

Robert said with expected crop yield, it almost feels like a parallel to flow normalized load, but it seems like we are keeping track of the better true condition yield over time, which is a valuable metric for communicating with states and farmers. Joseph said this is a good point and they are collecting true yield information on many more crops than they have been able to in the past.

Robert shared this resource on the corn nitrogen rate calculator. Robert said in regards to the corn and soy rate calculator for HTF states, ideally we could find a similar calculator for the Bay states. Tom Bulter said he believes Charlie White at Penn State University (PSU) has done work on a PA based tool that is like what you mentioned. Robert said Illinois reported that 76% of farmers fertilized at the MRTN rate. It would be valuable if the PSU tool could maybe get us similar info. May be helpful for the AMT to explore this further.

Lew mentioned about slide 13, specifically that the urban areas have high precipitation values, and said we may want to specify urban inputs given the work of the RAND team. Lew asked if the urban line in the plot is representative of urban areas of a particular size and how it is generated. Joseph said he has not extracted the urban areas yet, so this is likely an artifact of things overlapping. Joseph suggested looking at the different growth regions, in this case borrowed from Phase 6 documentation, and here urban areas have been masked out. Lew said despite misinterpreting the figure, it might still be useful for the Urban Stormwater Workgroup and the RAND led team to simulate higher temperatures and higher precipitation inputs for urban areas.

Lew shared two links to STAC workshops:

1. STAC workshop on Solar Farms, Landscapes, and Water Quality
2. STAC workshop on Local Monitoring

3:10 Progress of the Agricultural Modeling Team – Tom Butler, EPA-CBPO

Tom described progress of the Ag Modeling Team in its role in determining the agricultural data inputs for the Phase 7 Watershed Model.

Summary

Tom began with a brief reminder of the AMT's structure and purpose in Phase 7. Tom provided a snapshot of the AMT's progress in working on inputs for crop yields and land uses. Tom emphasized the role of the AMT in working with the MWG to provide input on agriculturally relevant sensitivities. Tom concluded with an invitation to the AMT meeting on Friday, January 12th.

3:25 Discussion of Agricultural Modeling Team Progress

Summary

Dave asked what the manure generation conversation on January 12th will entail. Is that percent solids, nitrogen and phosphorus content, amount manure? Tom said the conversation will begin with data sources for animal units, percentage of time in pasture

vs confined space, and manure acres. Dave was thinking more along the lines of how much manure is generated per animal. Tom said they will not discuss that yet, but will start to get into that conversation in a bit.

Lew said the CBP is tracking inputs (manures and fertilizers, with yields), but is it also tracking atmospheric deposition in this case? That would seem to influence pasture. Tom said he defers to Gary, not that atmospheric deposition is not tracked, but it is likely done differently. Lew said observations in this drop should be available at a fairly specific level. Lew recommended that Joseph and Tom look into this, as it is not decided by farmers but is part of the baseline scenario. Gary said we track mass balance and track the inputs, so the real question for the AMT is whether farmers are taking this input into account and reducing their input accordingly. If they do soil testing, then they are implicitly doing this. Lew said this is a small component comparatively, but worth considering. Jesse Bash in his work with Rocky Mountain National Park, they spoke with farmers who said that atmospheric deposition is such a small fraction of what they are dealing with, they do not really pay attention to it. Gary is correct it would be implicitly covered through soil testing. Lew said that is a fair answer.

Robert Sabo asked on slide 9, for Tom to explain what the uptake reduction represents. Tom said since these are sensitivities, it is for the MWG to define, but it is representing the sensitivity of a pound of nitrogen added to being removed through uptake. This sensitivity gets multiplied by the watershed wide average and the land river segment average to produce the load. Gary said if you add one pound of commercial fertilizer, you get .15 pounds off at the edge of stream load. If counteracted by increasing the uptake by one pound, you will only get a reduction of 0.03, so the aggregate increase is .12 pounds. This was for Phase 6 and based on an analysis of Phase 5, and we got comments asking us to take another look at the sensitivities. Joseph will be working on this at some point and will be presented to the MWG during Phase 7. Robert asked if a greater look into surplus trajectories or nutrient use efficiency could inform these sensitivities. Gary said no, because one is assuming all the sensitivities are the same and this matches the literature. Robert said many machine learning models for the Chesapeake Bay use surplus metrics, so it would be helpful to continue this conversation to the extent possible.

Lew asked Joseph when the MWG can anticipate a conversation to revisit the sensitivities. Joseph said this is a great question for Gary, but he thinks with the work on the crop yield estimates and trends 90% of that is done and now needs evaluating and decision making. It should not be too long before Joseph moves onto the sensitivities question, depending on how the crop yields data project wraps up. Lew added a 100% answer may not be needed to make progress, but it would not be terrible to hold at a 90% complete component, assuming it is operational. Joseph agreed on fading between tasks. Dave emphasized listening to Gary, Isabella, and Gopal's needs.

3:35 ADJOURN

Participants: Alex Gunnerson, Arianna Johns, Ashley Hullinger, August Goldfischer, Bill Keeling, Bryant Thomas, Caitlin Bolton, Carlington Wallace, Cassie Davis, Chaopeng Shen, Clifton Bell, Clint Gill, Dave Montali, Eli Podyma, Gary Shenk, George Doumit, George

Onyullo, Gopal Bhatt, Gregorio Toscano, Guido Yactayo, Hassan Mirsajadi, Hoda Razavi, Isabella Bertani, Jeremy Hanson, Jesse Bash, Jian Shen, Jodi Ryder, Jonathan Leiman, Joseph Delesantro, Joseph Zhang, KC Filippino, Kalyan Deb, Karinna Nunez, Kevin McLean, Kimberly Dagen, Krista Romita Grocholski, Larry Sanford, Leonard Schugam, Lew Linker, Mark Bennett, Michelle Miro, Mukhtar Ibrahim, Nicole Cai, Norm Goulet, Olivia Devereux, Pouyan Nejahashemi, Qian Zhang, Richard Tian, Robert Burgholzer, Robert Sabo, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Tish Robertson, Tom Butler, Tyler Trostle, Vahid Rafiei, Zhenghua Jin, Zhengui Wang.

Chesapeake Bay Program
Science. Restoration. Partnership.

Modeling Workgroup Quarterly Review

January 10, 2024

Event webpage: Link
For Remote Access - WebEx Link:
https://umces.webex.com/umces/j.php?MTID=m96f00c362a7eb98cc0aee3bf6547e66e
Meeting number: 2620 259 6989 **Password:** d3A66qnzQvZ
Phone number: +1-408-418-9388 **Access code**: 2620 259 6989
This meeting will be recorded for internal use only to assure the accuracy of meeting notes.
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10:00 Announcements and Amendments to the Agenda – Dave Montali, Tetra Tech and Mark Bennett, USGS

Lew shared four pieces of good news:

1. Nicole Cai has won paper of the year (William Boggess award) from the Journal of American Water Resources Association (JAWRA). This work reflects the efforts of many in the modeling workgroup.
    i. Nicole thanked everyone for their input on this paper.
2. We can expect fruitful modeling results in shallow water systems, especially tidal wetlands and benthic algae, thanks to the work of people like Richard Tian, Nicole Cai, and Jeremy Testa. More information on this work will be shared in future meetings.
    i. Richard said the work in the Corsica is a prototype for more extensive work throughout the Chesapeake Bay.
3. Martha Shimkin is the new director of the CBP and she will attend the start of the second day of the quarterly meeting.
    i. Martha shared her values and overarching goals for the Chesapeake Bay Program.
4. The Chesapeake Community Research Symposium will be held this summer (June 10-12, 2024) and abstracts are due on February 1st. You are encouraged to review the session proposals and submit abstracts.

Dave shared there will be Phase 7 Office Hours to answer partner questions on February 5th, with the purpose of determining which Phase 7 topics to cover at the February WQGIT meeting. Lew shared in the past there has been significant input from the WQGIT, so perhaps this an opportunity to encourage engagement. This is especially important because they are the decision makers for the models.

10:15 Update on Main Bay Model (MBM) Progress – Zhengui Wang and Joseph Zhang, VIMS

Progress in the MBM development was presented.

Summary

Zhengui began by walking through improvements to the MBM over the last quarter, specifically the simulation of DO and bottom temperature. Zhengui then explained how shoreline erosion and atmospheric deposition loadings were added to the model and how those factors affected key water quality parameters. Zhengui provided an update on the modeling workflow for the inputs and watershed loading allocation. One remaining issue is unrealistically high concentrations in watershed loadings during very low flow events. There is a work-around the MBM team identified, but it has implications for the TMDL, so they will work with watershed modeling team to identify a suitable path forward. Zhengui concluded with a summary of improvements and next steps for MBM development.

10:45 Discussion of the Main Bay Model (MBM) Progress

Summary

Lew emphasized P7 is as good or better, so it is encouraging to already see improvement for critical parameters like bottom DO. Lew said there have been considerable refinements and improvements since the previous quarterly presentation.

Lew said TP shoreline erosion was essentially equivalent to point sources in Phase 6, but the shoreline erosion loads were particulate inorganic phosphorus and only had the ability to become relevant in the MBM if they were transferred to anerobic waters where it has the capability of becoming phosphate. Zhengui said with new TP information, it can be tracked through these changes in stages.

On slide 17, Lew said the watershed loading is a large improvement. Lew suggested including a loading point for the NPDES permit at Hart-Miller Island by the mouth of the Back River.

On slide 18, Lew asked if there are differences in flow for loading of water quality constituents and if there are any benefits of standardizing. Joseph Zhang said this is a plotting issue and many of the dots are just too small to be seen. Zhengui said many of the loading points are small and there is a nutrient concentration associated with this flow rate.

Larry Sanford asked about the bottom temperature effects on slide 7, specifically if this is a diffusive flux. Zhengui said yes when the water temperature is cooling it allows the sediment to release heat. Larry asked if that also applies for shallow water. Larry asked if

direct solar radiation is included for bottom sediments. Joseph said yes. Richard asked about sediment layer thickness. Zhengui said it is about 2 meters when temperature is increasing and there is a smaller value when temperature is cooling. Richard said this is different from a diagenesis conception. Zhengui said yes, this is different. Richard said in CH3D, they used the equilibrium temperature. Richard asked if they used the watershed loading prediction for temperature and DO. Zhengui said yes and they noticed for low flow rates, the temperature was showing up as zero. For DO, there may also be some zero values. Richard said for CH3D, we use temperature for saturation discharged on the surface waters. Zhengui said the sediment diagenesis layer is 2cm thick and the heat exchange is 2m thick. Richard was thinking the diagenesis process is also regulated by temperature, and asked what the inputs are. Zhengui said they use bottom water temperature because they do not have sediment temperatures. Lew said this seems right to him. Richard asked if they simulate sediment temperature of the 2m thickness. Zhengui said yes, they give it a well-mixed profile with a single value.

Gary said in Phase 6 there were different sources for flow and mass, and if both inputs are from watershed model. Zhengui said the data is from Phase 6. Zhengui said nutrient concentration is a critical component of MBM results, so when there is a discrepancy, it is very noticeable. Joseph added that this small timing difference is the cause of the issues, so the MBM team is thinking of spreading out the flow over space. Lew said this was sometimes an issue that required a model trick, like a minimum flow. Gary said it is great to see the improvement here. Gary added the criticism from CESR was the lack of interannual variability for hypoxia and response to changes in nutrients, so that should be a major focus of our work. Joseph agreed.

Richard asked how they include atmospheric deposition in the MBM. Zhengui said point source, non-point source, and shoreline erosion are all exterior, they come from the boundaries. However, atmospheric deposition comes from the surface so it needs to be included separately, through a flux value in the surface grid cell to do the loading directly. Lew said we have extensive coastal shelf boundary conditions, which is useful in addition to this flexible approach. Lew said we will be updating to the newest CMAQ over the course of 2024. Would be helpful to track this to for understanding coastal boundary conditions and small changes in concentrations which matter because of the huge exchanges in flow.

11:00 **Further Refinement of the Temperature Dependence of Algal Growth Rates in the MBM and MTMs –Tish Robertson, DEQ; Carl Cerco, Attain; and Richard Tian UMCES-CBPO**

Tish has expanded on Carl Cerco's examination of the shallow water monitoring data of continuous temperature and chlorophyll observations and other data sources for the purpose of refining the algal growth response to temperature in the MBMs and MTMs. The Modeling Workgroup decided how to apply the current understanding of how temperature effects algal growth rates in the Phase 7 MBM.

Summary

Tish began with an overview of the work Carl presented at the October 2023 quarterly review. Tish then explained what quantile regression analysis is and why she believes it is an appropriate method to use in assessing Carl's results. Following an explanation of the methods used here, Tish shared results which support the proposed green algae group temperature growth curve presented by Carl. Tish concluded with a few, key limitations of this analysis.

11:30 Discussion of the Refinement of the Temperature Dependence of Algal Growth Rates

Summary

Lew reminded the group that in July 2023, Clifton Bell provided some compelling evidence that chlorophyll was not increasing indefinitely above 32 C, with support from the literature. Then Carl, with the help of Isabella, looked at shallow water monitoring data and saw a plateau around 32 C. Tish then used piecewise quantile regression analysis and her results corroborated the previous two analyses. This body of evidence is important given the increasing focus on shallow water chlorophyll and climate change impacts. Lew said this curve would apply to green algae group.

Lew asked for agreeing or disagreeing comments. Larry Sanford said that makes sense to me as for present day conditions, but it is not so clear about climate change effects. However, Larry caveated this is a bit outside of his expertise. Clifton said in Phase 5 or 6 the optimum was closer to 25 degrees, and asked Tish if she looked at the natural break points in the data. Tish said she did not look for natural break points and just used 32 C because that is what Carl had proposed. Lew added in Phase 5 that there was not as much focus on shallow waters and the James Chlorophyll assessment was not in place, so it was less of a concern back then.

Cathy Wazniak said she concurs with the leveling off. Cathy asked how many sites had cyanobacteria blooms? Cathy believes their optimum temperature for growth is between 30–32.5 C. Tish replied that at almost all the tidal fresh sites, chlorophyll showed a negative relationship with temperature at temperatures greater than 32. Tish guessed cyanobacteria blooms would be more prominent at those sites before the others.

Dave asked if STAC will weigh in on this question at the May Climate Change 3.0 Workshop. Lew said yes, they will likely weigh in and the MWG will listen to STAC's review as always on these topics.

Lew asked for any objections and none were raised. Based on the evidence provided at this modeling quarterly and the previous two meetings, the Modeling Workgroup decided to move forward with the growth rate proposed by Carl Cerco in October 2023 with a 32 C temperature optimum for the green algae group.

11:40 Sediment Input Approach – Richard Tian, UMCES-CBPO

Shoreline Erosion Testbeds of Corsica and Choptank Rivers – Richard Tian, UMCES-CBPO

Richard provided progress on the new dynamic input of shoreline erosion inputs based on 1) wave power (f wave speed, wave energy, and depth), 2) shoreline height, 3) protected shoreline, 4) bulk density, 5) sand, silt, clay classes, 6) eroded shoreline TN & TP species.

Summary

Richard began by reviewing the recent and historical data available for measuring shoreline, structure, percent protected, bank height, and recession rates for Maryland and Virginia.

Richard then compared the Phase 6 modeling methodology with the proposed wave-driven, time dependent dynamic simulation of shoreline erosion for Phase 7 models. Richard emphasized the importance of this question because coastline erosion is a challenge, particularly under future climate change and sea level rise conditions. Richard used the Corsica River as a case study to explore the proposed Phase 7 methodology by generating spatially distributed wave-driven shoreline erosion estimates.

Richard concluded with some key questions for the MWG to consider.

12:10 Discussion of Shoreline Erosion Testbeds.

Summary – 2:10:19

Richard said he tried to get data from Jeff Halka, but he did not have any and suggested looking for data created by Katie Hopkins at the CBPO in the past. Richard reviewed these files and was able to reproduce the results, so he is somewhat confident he understands them.

Tom Parham said he will pass along the presentation to Maryland DNR Geologists for comments. Richard asked Tom to ask the MD DNR Geologists whether they have the file md_sstru05.shp, as that would be useful for him.

Lew commended Richard for drawing on the history of this approach. Lew referenced the first presentation on this topic in April 2023, where the team had proposed using recession rates and shoreline erosion based on the idea of precipitation, but Larry Sanford then introduced a more scientifically sound approach at the Fall 2023 Quarterly Review. Richard has demonstrated that this improved approach is fully operationalized and provides a much finer representation of shoreline erosion compared to before. The MBM team has agreed with this approach. Given this body of information, Lew asked for any objections to Richard's first two questions:

1. Using a wave powered approach for shoreline erosion recession rates.
2. Using a protected shoreline rate similar to 1998-2000. Anything beyond, whether it is hardened or living shoreline, will qualify for credit.

Larry Sanford said this seems like a good approach to partition spatially and temporally, but we have not tested this approach fully. The older precipitation-based approach may still be useful, so Larry did not recommend disregarding that option completely. There are a few data datasets we can test well for dynamic temporal changes, specifically two spots on the Choptank (one near Horn Point led by William Nordin and one near Todd's Point where Larry and Jeff Halka worked on). Lew suggested Richard commit to working

with Larry to get this data and apply them to calculations of shoreline erosion. Based on these comments, Lew suggested the new proposed decision be "Proceed as outlined with the wave power approach unless further analysis of observational and experimental sites gives us further information, such as a blended approach of wave power and hydrology." This would allow practitioners to move forward with model development and apply this bay-wide. Richard added the approach so far has been data driven at the scale of CH3D cells. Richard noted that he explored high erosion rates upstream of Cambridge, which was interesting because there is low-wave power in that area. Larry said there is still uncertainty as to whether the same unit of wave power produces more erosion after a large precipitation event compared to a dry period, so we should allow this possible influence of precipitation to persist and be modifiable depending on the data available.

Joseph Zhang said he reached out to Karinna Nunez to ask about the shoreline hardening and erosion data stored within the Center for Coastal Resources Management shoreline inventory database. Joseph recommended Richard explore this data as baseline information. Lew said the MWG could ask the WQGIT if they would like shoreline management practices to be incorporated in this shoreline erosion rate question.

Larry said we will additionally have to identify the precipitation data, but that should not be too difficult. Lew suggested exploring the watershed model for this source.

Carl Friedrichs said we need to reduce the amount of shoreline erosion potential that is currently being considered in the models, as the extent of shoreline protection practices has increased dramatically over the past 20 years. Otherwise, we might be overestimating the total sediment load, especially going forward. Lew agreed we need to keep in mind best management practices for shoreline erosion calculations and work with the WQGIT and other workgroups as appropriate. We do have temporal data limitations, which influence what can be done. Dave said it will be important to coordinate with the WQGIT since we may not have complete knowledge of where shoreline protection practices have been implemented and understand how this baseline differs from other products.

The MWG decided to apply the wave power approach for shoreline erosion Bay-wide with three provisions: 1.) Explore the data provided by Larry for two locations in the Choptank, and revise accordingly; 2.) Leave open the possibility of a blended hydrology-wave power based approach to shoreline erosion; 3.) Reach out to decision makers at the WQGIT about how shoreline best management practice are being tracked to ensure this approach is compatible.

12:35 Progress on the James and Potomac MTMs – Nicole Cai, ORISE-CBPO

Initial work on the James and Potomac MTMs were described.

Summary

Nicole began with some updates on horizontal and vertical grid construction in the Potomac and James Rivers. Nicole provided information on watershed loading, physical simulations, and hydrodynamics. Nicole ran sensitivity tests of main Bay hypoxia on the Potomac and noted the responses of DO, chlorophyll-a, phosphate, and ammonium.

Nicole then presented results of sensitivity tests on the James River model, focusing on the impacts of benthic algae on phosphorus reduction.

12:55 Discussion of James and Potomac MTM Progress

Summary

Lew said these presentations demonstrate major progress.

Richard said it would be helpful to have observations of benthic algae and resuspension. Lew agreed but said the CBP does not have observational data and it would be infeasible to acquire given cost and time constraints. Lew said without the observations, the simulations can go forward with light penetration to the sediment. Cathy Wazniak said MD DNR has added benthic chlorophyll monitoring at their fixed benthic monitoring program. The addition started in 2021, if Richard or Nicole are interested in checking the modeled Bay-wide benthic algae with that data. George Mason University also has estimates of benthic filamentous algae in the tidal fresh Potomac. Cathy added that at some of their sites the readings can be as high as 200 to 500 micrograms per cubic unit. MD DNR has variability per year and amongst sites but is still pursuing funding for randomized sites. Lew and Richard said this is wonderful and the CBP will try to use the data. Lew asked Richard to work with Cathy and CC him on utilizing this benthic algae data. Richard said he thought MD DNR did this work in the Atlantic coastal bays. Cathy said this is correct, but the monitoring in the coastal bays has been going on for longer in conjunction with the national coastal assessment.

Lew asked what the relative biomass between benthic algae and phytoplankton are in the shallow water samples. Cathy said MD DNR does not always monitor benthic and water column chlorophyll in the same sites, plus it can be very variable, but they can find very productive shallow water systems. Lew said this is expected in systems with high shallow water light penetration and was an addition to the Phase 2 watershed model. The most important processor of nutrients in shallow waters is benthic algae biomass. Cathy said other data sources include Cassie Gurbisz and Judy O'Neil on the flats on benthic filamentous algae, Chris Jones at George Mason University has been doing similar work, and EPA Region 3 has been doing river and streams benthic algae monitoring over the last two years.

Richard said in the Choptank the observations show wide variation in chlorophyll levels, and said the team's leading theory is the variability is caused by the resuspension of benthic algae. Cathy said there is resuspension and transport, given different conditions. Cathy said the team is curious where benthic filamentous algae from the flats ends up. In 2010, there were major issues where the benthic filamentous algae would float up to the surface in late summer due to oxygen bubbles and production, and fouled fishing gear downstream. Working with Greg Boyer at Southern University of New York, they found toxins and are interested in how that might affect shellfish, so they are curious as to the spatial distribution of this phenomena. Richard said he will try to help with this, one example being particle tracking in SCHISM allowing for estimating location. Cathy said this would be awesome and Judy O'Neil might have related information for this. Lew said the CBP has increasingly more interest in shallow water systems, so it would be helpful to employ this data in the MTMs, tidal embayments, and living resource

modeling efforts. Larry said high resolution modeling of this nature should be considered more frequently in the shallow water small group of the Beyond 2025 Steering Committee. Lew said other venues to bring this information could be STAC or MTM/MBM meetings. These are all opportunities to highlight the importance of fine scale, benthic algae, and living resources in shallow water areas. Potential test areas could be embayments in the Potomac or the Wicomico river.

Larry applauded the idea of bringing in benthic algae and noted that the sediment transport literature shows benthic algae generally help prevent erosion by forming mats, except when they become extremely productive and float up on oxygen bubbles. One example of this is in the Florida Everglades. There is a lot more work to do here and it is great to include them.

Norm said this is outside of his expertise but was wondering why there was not a larger response to the simulated 30% decrease in phosphorus. Lew said test conditions and sensitivity scenarios can bring light to this question. Nicole said she only reduced the concentration of phosphorus, but production can be limited for multiple reasons, like nitrogen instead. Generally, where phosphorus is more limiting, a 30% reduction seems to equate to a 15% reduction in production. There is still uncertainty, so sensitivity tests and calibration can help answer this question.

1:15 ADJOURN

Participants: Alex Gunnerson, Angie Wei, Arianna Johns, Ashley Hullinger, Bill Keeling, Caitlin Bolton, Carl Friedrichs, Carlington Wallace, Cathy Wazniak, Chaopeng Shen, Clifton Bell, Dave Montali, Gary Shenk, George Onyullo, Gopal Bhatt, Guido Yactayo, Isabella Bertani, Jesse Bash, Jian Zhao, Jian Shen, Jodi Ryder, Jonathan Leiman, Joseph Delesantro, Joseph Zhang, KC Filippino, Kevin McLean, Larry Sanford, Lew Linker, Marjy Friedrichs, Martha Shimkin, Mukhtar Ibrahim, Nicole Cai, Norm Goulet, Qubin Qin, Rebecca Murphy, Richard Tian, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Steve Bieber, Suzanne Trevena, Tish Robertson, Tom Parham, Tyler Trostle, Vahid Rafiei, Zhenghua Jin, Zhengui Wang.