Modeling Workgroup Quarterly Review

January 10, 2023

Event webpage: Link

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

Actions and Decisions

- **Dave Montali will bring the question of tracking Sanitary Sewer Overflows (SSOs) for the purpose of calibration in the Watershed Model to the Wastewater Treatment Workgroup.**
  - **Status: Dave has reached out and will follow up with Matt Ries.**
- **Alex Gunnerson will invite Clifton Bell to a Modeling Ad Hoc Team meeting in March to discuss Chlorophyll related to temperature.**
  - **Status: Complete.**
- **Carl Cerco will send responses to Clifton Bell's chlorophyll question and CC Jian Shen.**
  - **Status: Complete.**
- **The Dynamic Tidal Shoreline Simulation Test Bed Approach will go forward in the Choptank and Corsica Rivers. Progress will be reported at future quarterlies, starting in April 2023.**
- **Julie Reichert-Nguyen will discuss with Larry Sanford and William Nardin how the Dynamic Tidal Shoreline Simulation Test Bed Approach might assist with quantifying the resiliency benefits of nature-based infrastructure.**
  - **Status: Complete.**
- **Andy Fitch will share the Phase 7 Watershed and Tidal Water Model Boundaries dataset with Nicole Cai and Richard Tian. Andy and Karinna Nunez will share the wetlands layer with Jian Shen and the MBM team.**
- **Lew Linker will reach out to Marc Hensel about when he can expect additional material for the SAV simulations.**
  - **Status: Complete.**
- **Alex Gunnerson will invite Marc Hensel to one of the Modeling Ad Hoc team meetings in early March to discuss incorporating his SAV work into the current SAV model in a regulatory context.**
  - **Status: Complete.**
- **Lew Linker will invite Marc Hensel to return to the April 2023 MWG Quarterly review based on the follow up conversations at the Ad Hoc meeting.**
- **Lew Linker will continue the conversation on additional scenarios for striped bass over email with Tom Parham and the team at MD DNR.**

Meeting Minutes

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

<u>Summary</u>

Lew Linker announced the most recent Modeling Team feature collection in the Journal of American Water Resources Association (JAWRA) has been posted to the [Modeling Workgroup (MWG) webpage under publications](). Lew recommended reading the feature collection as it supports the MWG's mission for the assessment of 2035 climate change.

Dave Montali announced Clifton Bell made a request to discuss algal blooms in the estuarine model, specifically the impacts of warming temperatures on chlorophyll. Clifton plans to present on this topic at the April 2023 MWG Quarterly Review in greater detail. Lew added that Clifton provided additional details and literature on chlorophyll. Lew emphasized Clifton's points will be brought to the Multiple Tributary Model (MTM) teams, especially the James River team since the chlorophyll approach Virginia has developed will be applied to the entire Bay.

Lew recommended attendees put together an abstract for the Coastal and Estuarine Research Federation (CERF). The abstract submission period for CERF 2023 opens at the end of January 2023.

10:05   [Phase 7 Watershed Model (WSM) Overview]() – Gary Shenk, USGS-CBPO

Gary provided an overall summary of progress over the last quarter.

Summary

Gary began with a review of the four core values of the (MWG): integration, innovation, independence, and inclusiveness. More information on the four values can be found on the [MWG webpage]().

Gary set the stage for 2023 by using the Phase 7 Development Tracks ([slide 3]()) and [Phase 7 Webpage]() to orient attendees with the plans for Phase 7 Model Development. Gary used Gantt charts to explain which actions the Watershed Model Team has taken and when future steps are expected to be completed. The work scheduled for 2023 will focus on improving the models, specifically the actions identified on [slide 11](). Gary concluded with a review of section 1 of the WSM documentation.

10:20   Discussion of the Phase 7 Model Overview

Summary

Dave asked if there is any work planned for Sanitary Sewer Overflows (SSOs) in Phase 7, potentially in relation to Combined Sewer Overflows (CSOs). Gary said the MWG just uses CSOs for calibration but agreed that is a good question. Gary said he does not think the MWG is allowed to decide on the inclusion of SSOs because that is in the policy realm, but the MWG does have standing to say that the inclusion of SSOs would create a better calibration. Gary suggested Dave bring this question to the Wastewater Treatment Workgroup so they can discuss if SSOs should be added to the model. Lew added that we have included and update CSOs. For SSOs, they are episodic and usually rectified, so there is not much of a management issue here, but maybe there is more of a calibration issue. In the past, the CBP partners position on SSOs is that they are accidental, unlawful, and unsuitable for inclusion into the CBP WIPs. Lew said this can be a discussion point for the future and said CSO inclusion for calibration purposes would be the interest of the MWG. Gary agreed with Lew's point. Dave said there are places in the watershed with routine SSOs, so he thinks it merits raising the question to the Wastewater Treatment

Workgroup. Dave Montali will bring the question of tracking Sanitary Sewer Overflows (SSOs) for the purpose of calibration in the Watershed Model to the Wastewater Treatment Workgroup.

Bill Keeling said the problem he has with SSOs is if they are attributed to a non-point source load, it confuses the assessment of pollutant sectors because it really is more of a point source load. Lew agreed with Bill. George Onyullo shared there are issues with communicating SSOs with management and emphasized carefully communicating this topic. Karl Berger said he hopes to see more information on SSOs be produced by the upcoming Scientific and Technical Advisory Committee (STAC) workshop. Karl also said the policy aspect of SSO treatment needs to be decided by the Wastewater Treatment Workgroup and EPA. Karl emphasized the age, density, and hydrology of systems can affect the presence of a nutrient signal of SSOs, despite not being in the watershed model. Lew said he still thinks the influence of SSOs would be small, but if we follow Bill's point, we could create a separate category for SSOs where we do not include them in the model, but we do track it externally. Dave said he will raise the issue with the Wastewater Treatment Workgroup since it is the right time to revive this conversation from before.

Dave asked what the plan is for approving the documentation. Gary said right now there is nothing to approve, and the documentation will not be final until the end of Phase 7 development. However, MWG members are encouraged to read the draft documentation and provide comments for consideration. When it comes time to approve, the section will be introduced in one quarter and approval will be requested at the following quarter.

10:30 **Update on CalCAST Development: Annual flow and loads** – **Isabella Bertani, UMCES**

Isabella provided an update on the progress made in the development of CalCAST (Chesapeake Assessment Scenario Tool), specifically focusing on adding the capability to predict flow and loads at an annual time step. CalCAST is a relatively parsimonious Bayesian modeling tool that is being developed to test predictors and spatially calibrate parameters that will ultimately inform prediction of flow and loads at monitoring stations throughout the watershed.

<u>Summary</u>

Isabella began with a review of CalCAST and the major points from her presentation at the October 2022 MWG Quarterly Review. Isabella then explained the model formulation and observed vs. predicted results for annual total flow, annual stormflow, and annual flow normalized total nitrogen (TN). Isabella explained how CalCAST accounts for lags in nutrient transport on slides 17 & 18. Isabella concluded that the core code machinery has been developed and the plan for 2023 is to improve the model.

10:50 Discussion of CalCAST development

<u>Summary</u>

Dave asked how observed stormflows are calculated. Isabella said the observed flows are an estimation which are calculated using a separated hydrograph and the Weighted Regression, Time, Discharge, and Season (WRTDS) method.

Lew asked about slide 9, specifically if point sources are accounted for. Isabella said yes, they are accounted properly.

Lew asked about the 400 monitoring stations and starting periods for CalCAST input. Isabella said there are 400 monitoring stations for flow, but not that many for sediment, nitrogen, and phosphorus. Isabella said the data being used goes back to the 1980s. Lew suggested Isabella consider censoring the phosphorus data in the 1980s because much of it was not flow weighted sampling as it needs to be for phosphorus and sediment. Based on previous modeling calibration efforts, Lew said it would make sense to start using phosphorus data from 1992 to present. Isabella said she would look into this point. Isabella said USGS already does some censoring of the data in the earlier period, but she will still consider the point.

Robert Sabo commented about the WRTDS time series on slide 19, saying that the time series are very smooth and there might be some noise missing. Robert asked if it would be helpful for CalCAST to use some sort of Monte Carlo simulation to run thousands of WRTDS time series and get a better sense of the noise for response variables. Robert said while the trends capture the spatial gradient nicely, he would like to see greater acknowledgement of the uncertainty with the flow normalized time series. Isabella replied the beauty of a Bayesian approach is that uncertainty in WRTDS can be accounted for because the response variables are treated as random variables with an uncertainty associated with it, which is derived from WRTDS. Isabella said the inability to match the trend over time might exist because of the accounting for lag times. However, Isabella believes there is opportunity to improve the treatment of lag times. Isabella said BMPs are another source of uncertainty for trends over time. Robert asked when WRTDS response variables are treated as random factors with uncertainties, do they affect the subsequent parameterization of the predictor variables. Isabella said it does not affect the model performance much, but that might be because the work was done on a smaller more uniform watershed with less variability across monitoring stations. Isabella said the potential improvements in model performance still make it a worthwhile line of exploration.

Bill Keeling said there is much angst surrounding inputs, specifically questions of sufficient input quality, meaning that higher resolution does not change the principal of garbage-in, garbage-out. Isabella replied she agreed that is a problem and said processes that can be modeled at a finer scale will likely yield finer results, but that this will not change this specific problem for inputs that remain at a larger scale. Bill said that is fine, but it can lead to members of the public misinterpreting these outputs from CAST, which are often used in dash boards, because they are not fully aware of the limitations. Gary added that CalCAST and the WSM are being run at a finer scale to take advantage of finer scale inputs. For management purposes, like dashboards, the Water Quality Goal Implementation Team (WQGIT) will make the decision about the scale of the data. Robert Sabo said for nitrogen in CalCAST, the CAST input data (fertilizer, manure, etc.) seems to be largely predictive of spatiotemporal patterns.

Samuel Canfield asked if the residuals on slide 19 might be a result of likelihood selection, such as Gaussian or Poisson, and if other likelihoods would be more helpful. Samuel also asked if the lag times would vary based on land use or if the lag times are static across the watershed. Isabella replied that in this formulation of CalCAST, the lag times are static over land use, time, and hydrology, because it is a flow normalized model. However, the capability exists to model how the lag time coefficient changes over time and land use, they just have not been tested yet. Isabella said she has been using a Gaussian log normal likelihood for now and thinks the flat residuals are a result of the combination of inputs, BMPs, and lags. Isabella would first like to explore model formulation before exploring likelihood selection later on.

11:30 [Development of Efficient Multi-Objective Optimization Procedures](#) – **Gregorio Toscano, Kalyan Deb, Pouyan Nejadhashemi, and Hoda Razavi, MSU**

> Progress in the development of efficient multi-objective (MO) optimization procedures for all the CBPO BMPs and land uses were discussed.

Summary

Gregorio gave an overview of status of the project and progress made since the [last presentation to the MWG at October 2022 Quarterly Review](#). Gregorio detailed the underlying software structure and next steps for project development. Gregorio noted that all the BMPs have been implemented into the optimization framework.

Gregorio said other potential uses for optimization include innovization analysis, which is defined as learning from optimization results and introducing new ideas, products, and services different from the existing ones. Gregorio gave an example of an innovization experiment and the three ranking strategies derived from the combined pareto front ([slides 25-28](#)). Gregorio outlined the results of these methods and then identified areas of future work.

11:50   Optimization Discussion

Summary

Dave asked if the current optimization framework has the BMP forest buffer on fenced pasture corridor represented. Gregorio said yes it has been included in the optimization framework. Dave said that is interesting to him because it is coming out in a way he would not expect. Dave would expect that BMP to be cheaper and more effective. Gregorio said the studies done do not include the land conversion BMP. Dave reiterated the need to be able to play around with the land conversion BMPs.

Lew said the innovization approach seems informative and asked if this needs to be done initially for every county in the watershed as set up for the user. Pouyan Nejadhashemi replied these four counties are a test bed for expanding to the entire watershed and the team wanted to look at counties neither dominated by urban or agriculture, so these counties were identified. Additionally, Pouyan discussed how counties can be grouped by a similar characteristic (say land use) or by state, which is what they did with the eleven counties in West Virginia. By grouping counties, this assists with clustering results and reducing computational time. Lew said he is hearing it might not necessarily need to be done for every county and that this produces high information content for decision makers. Kalyan said initially they were planning on dividing counties by agriculture dominated vs urban dominated, but it turned out the seven BMPs were very common across the board. Kalyan said a larger study could look at different ways to divide up the counties and could be more helpful across the entire watershed. Kalyan said they will keep the other BMPs considered but will put more emphasis on those seven common BMPs across the watershed.

Lew asked if stormwater BMPs are set aside as a separate or are considered in the regulated areas. Pouyan said the definition of BMPs has been copied from the current system of CAST. Lew asked if a user in a county with a high level of stormwater management can still optimize even if they are forced to invest a certain amount in that BMP. Pouyan said the optimization

interface allows for forcing a certain percentage of BMPs to be in a specific category to simulate this point.

Olivia Devereux asked if it is possible to generate results with existing BMPs as the starting point. This would basically mean building a scenario on top of an annual progress scenario. Pouyan replied yes, it is possible, and he does not see any problem with testing this. Pouyan offered a separate meeting to test this functionality.

Lew said once the optimization team is ready, they should let Lew know so the optimization testing team can be augmented and begin providing feedback on the optimization feedback. Dave said the testing team should not start until all BMPs are included and the impacts on both nitrogen and phosphorus are indicated in the framework. Dave said the reviewers are going to need to be included in the tool. Dave said urban nutrient management is off the table for West Virginia, so it will be interesting to see which BMPs come to the top after that one is removed. Lew agreed with Dave on the parameters for restarting the feedback group and said there will need to be time for teaching them. Dave said the ideal audience for this group is those developing WIPs and those on the Water Quality Goal Implementation Team.

Dave suggested categorizing counties by land uses. Pouyan asked if the current land use layer includes cropland. Dave replied it starts with crop, pasture, and hay, but then there are about 10 different types for each of those categories. Olivia said land use changes every year and that matters for how BMPs are credited. Lew asked if Olivia is talking about wildly different years. Olivia said the year really does matter for BMP crediting, especially with CSO hookups. Olivia asked if it is possible to prioritize BMPs among several counties in a larger geography. Pouyan replied this version was started as a test bed where each county was originally run individually. After this process, they tried to group county by urban or agriculture dominated. The team will next try to compare pasture, cropland, and hay. Kalyan said optimization can be run for multiple counties right now and clustered which can be used to identify higher level rules for BMP knowledge. Kalyan said the innovization study was run for individual counties for the sake of generating knowledge. Lew said we may want to focus on specific land use years like 2010 and 2035.

Gregorio shared that phosphorus costs are already computing, and it only needs to be brought into the objective function. Gregorio added that all BMPs including land conversion are in the optimization framework, but the innovization study only focused on efficiency BMPs.

Dave said there may be differences in best starting points for animal agriculture versus crop agriculture. For example, counties with greater poultry production will probably have a greater effect on manure transport BMPs.

Olivia suggested working with Lisa Beatty to see how this could work with the Pennsylvania Criteria Assessment Protocol Teams, who put together the plans in Pennsylvania for the Total Maximum Daily Load.

Dave asked Olivia if they could identify manure data by county. Olivia said we have all this data, and it is downloadable from CAST. Dave asked Lew if CAST can do something, we can specify the same thing in optimization. Lew said he believes that is correct and applies to scenarios as well. Olivia said none of that is a problem and said there are some BMPs that change the concentration of nutrients in manure and quantity of manure, so it must be happening. Pouyan asked what we know about manure hauling, such as any rule of thumbs. Olivia said we only

track manure being shipped from one county to another or from one county outside of the watershed. Intra-county manure hauling is not counted because manure is only counted at the county scale.

12:20 LUNCH

1:00 [Progress in Phase 7 WSM Development](#) – Gopal Bhatt, Penn State

> The NHDplus scale Phase 7 Dynamic Watershed Model (DWM) was expanded to include simulation of nutrients, water temperature, DO, and phytoplankton. 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 Simple Routing models. Gopal provided an overview of the progress made during this quarter on the aspects of (a) incorporation of CalCAST nitrogen and phosphorus in an operational DWM framework, (b) verification of flow, sediment, nitrogen, and phosphorus simulations, and (c) considerations for the computational requirements, and (d) the next steps.

<u>Summary</u>

Gopal began with an overview of the progress in the development of the DWM in each quarter of 2022. The main focus of his presentation was the nutrient aspect of the model. Gopal gave a reminder of the framework of DWM, how it interfaces with CalCAST, and the purpose of the DWM.

Gopal focused on the structure of the NHD Scale Nutrient Model. This involved a comparison of observed vs. simulated loads for total nitrogen (TN), total phosphorus (TP), and suspended sediment (SS). Gopal next described model verification for CalCAST vs. DWM for flow, sediment, nitrogen, and phosphorus. Gopal concluded with computational requirements and the next steps in DWM development.

1:30 Discussion of Phase 7 WSM Development Progress

<u>Summary</u>

Lew asked a question about [slide 6](#), specifically the loop in the upper left quadrant. Lew supposed the nitrogen and phosphorus specification will be done by land segment and land use. Gopal said this is correct and we are using the same prototype information from Phase 6, but that will be an area of interest for future investigations. The previous conversations about differences in lag times will be different because the breakouts depend on each land use. Lew asked if the initial dataset representing loads from the land is routed via a precipitation function into the land use simulation. Gopal said that is correct. Lew said this slide will be a good source of information because the graphic is very informative.

Lew asked if another explanation for [slide 7](#) is that segmentation creates artifacts and if we changed the legend we should see different values. Gopal said that is correct. Dave said perhaps an explainable reason in West Virginia for differences in crop loading is manure transport. Gopal said whatever the reason, he believes the trends displayed are a function of the inputs. Gopal said the current image on this slide is temporary while he investigates further.

For the result slides, Lew asked if the results are year on year. Gopal said no, they are the average annual load at nontidal network monitoring stations with WRTDS loads.

Dave asked if any effect is expected because of no withdrawals or point sources being included. Gopal replied that withdrawals and point sources were only excluded for flow, they were included for nutrients. Gopal said based on his recent analysis, once loads from concentrated animal feeding operations, water surface atmospheric deposition, and the aggregation effect are resolved, so too shall the differences between the DWM and CalCAST be mostly resolved.

Lew asked how much new stream surface area is being added and the corresponding atmospheric deposition loads being added. Lew said it would be good to note this question for further investigation. Gopal agreed.

1:50   **A Path forward on CAST Assessment of 2025 WIP Outcomes** – **Gary Shenk, CBPO**

> A proposal from Maryland to resolve and assign work on portions of the three PSC decisions related to CAST from the August 29, 2022, PSC meeting was discussed.

Summary

On behalf of Maryland, Gary presented a path forward on CAST. Gary gave an overview of the background, proposal, and next steps for the partnership.

2:00   **Discussion of A Path forward on CAST**

Summary

Lew said Gary presented the information here very well and it illustrates the charge the MWG needs to carry out.

Dave said this is really an input problem, not really a MWG problem. Dave said he has concerns about number 3 and is interested to see how the WQGIT and its subgroups address these problems. Dave said some of the things represented in the model simply are not realistic and that has been a recurring concern of his for West Virginia. Dave said perhaps it would be wise to not have as frequent updates to the model.

Gary said the number of changes to model depends on the question you are trying to ask. If you are trying to assess if you did what you said would be done, then it should be kept the same. If you want to reflect what is on the ground, it should be updated more frequently. Lew said it seems like two years was too frequent for updates. Olivia said the concern by the states is usually that new BMPs and updated BMP history are not introduced without updates to the model. Olivia said this point will be part of the discussion.

2:20   **ADJOURN**
Participants: Alex Gunnerson, Andy Fitch, Anna Kasko, Arianna Johns, Bill Keeling, Breck Sullivan, Carlington Wallace, Cassie Davis, Clifton Bell, Clint Gill, Dave Montali, Denice Wardrop, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano, Guido Yactayo, Hoda Razavi, Isabella Bertani, Jesse Bash, Jhih-Shyang Shih, Jonathan Leiman, Karinna Nunez, Karl Berger, Karl Blankenship, Katie Walker, Kalyanmoy Deb, Kevin McLean, Kristin Saunders, Larry Sanford, Leonard Schugam, Lew Linker, Lisa Beatty, Mark Bennett, Mukhtar Ibrahim, Nicole Cai, Normand Goulet, Olivia Devereux, Pouyan Nejadhashemi, Rebecca Murphy,

Richard Tian, Robert Sabo, Samuel Canfield, Sarah McDonald, Scott Heidel, Sophia Grossweiler, Steve Beiber, Tish Robertson, Tom Butler, Zhengui Wang.

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

Summary

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Dave Montali announced Clifton Bell made a request to discuss algal blooms in the estuarine model, specifically the impacts of warming temperatures on chlorophyll. Clifton plans to present on this topic at the April 2023 MWG Quarterly Review in greater detail. Lew added that Clifton provided additional details and literature on chlorophyll. Lew emphasized Clifton's points will be brought to the Multiple Tributary Model (MTM) teams, especially the James River team since the chlorophyll approach Virginia has developed will be applied to the entire Bay. Carl Cerco said he will send Clifton some clarifications and additional information. Jian Shen explained that he ran some experiments that found the curve is not the only factor, and that light limitation is a major factor. Jian said he can review the documentation and send any additional information to Carl and Clifton.

Lew recommended attendees put together an abstract for the Coastal and Estuarine Research Federation Conference 2023 (CERF 2023). The abstract submission period opens at end of January 2023 and will close in May 2023. The MWG will have a session on climate change at CERF and attendees are suggested to submit to this session or other CERF 2023 sessions.

10:05   Update on Main Bay Model (MBM) Progress – Jian Shen, VIMS Update

Progress with the MBM over the last quarter was described. In the quarters of 2022 and into 2023 the MBM is focused on developing the workflow to generate all inputs including atmospheric deposition and shoreline erosion, improving the SAV simulation, using initial Phase 7 WSM inputs of hydrology and loads, refining the mesh for the simulation of shallow water dynamics, and refining living resource linkages. The MBM team conducted the first simulations using the 'two-step' approach.

Summary

Jian Shen provided progress updates on MBM development, specifically in relation to revisions to the model grid, preliminary model calibration experiments using the new grid, new python tools generated for this workflow, and the enabling of the model to run in decoupled mode.

10:40 Discussion of the Main Bay Model (MBM) Progress

Summary

Lew asked what the boundary conditions for the Chesapeake and Delaware Canal (C&D Canal) are on slide 3. Jian replied for the preliminary calibration it is an open boundary, but it is still in the testing period. Jian added that he is looking at Polychlorinated Biphenyls (PCBs) for this boundary because there are different concentrations between the Chesapeake Bay and Delaware Bay. Jian said these differences can be seen in the sediment profiles in the canal. Lew said the team may want to spend more time on C&D boundary condition assumptions for elevation, salinity, and water quality.

Lew asked how surface and bottoms are defined in the simulation on slide 13. Jian replied that the field of observation is about 0.5 meter, so the first one or two grid cells for surface. The bottom is more difficult and will not always be the same. Jian said the model is used to calculate the bottom layer here. Lew said it is interesting to show the plots of the salinity and temperature throughout the entire water column with the simulations on top and bottom.

On slide 14, Lew noted that many of these observations do not have a pycnocline and thought it was a wind event that might be the cause. Lew said this demonstrates improvements in wind forcing because of the improvements in predicted salinity. Jian agreed and replied there are huge freshwater impacts as well. Lew asked if the data for each event is from a single cruise. Jian said they just compared the model with observations points at different times.

Lew emphasized the heart of the SCHISM models will be the python workflow tools and they will be the keys for success.

Lew asked about the tributary calibrations and the improvements gained from using Nicole's attention to navigation channels in the grid. Lew asked of the MBM Team, "Do we want to use the same exact channels in the MTMs and MBM to ensure compatible results, despite differences in the rest of the grid. Jian said this is a good idea. Nicole agreed and said this would be helpful to remain consistent. Nicole said the total volume and land-boundary should remain consistent, especially for the Potomac.

10:50 Multiple Tributary Model (MTM) Request for Assistance (RFA) Update – Lew Linker, EPA-CBPO

Lew provided an update on the MTM RFA.

Summary

Lew said to expect the MTM RFA out in mid-January. The MTM teams should start in Quarter 3 2023, sometime around July. They will cover the Potomac, James, York, Rappahannock, Patapsco, and Choptank. Most likely Nicole and Richard will lead the Potomac, James, and York development. Nicole and Richard will also provide the key components for the MTM teams to calibrate: the hydrodynamics, grids, and boundary conditions. Nicole and Richard will provide

expert guidance to the MTM teams and the MTM work will be deeply collaborative and integrated with the MBM team led by Joseph Zhang.

11:00   Discussion of Approaches to MTM Selection

Summary

Larry Sanford asked when the MTM RFA will be released. Lew said the RFA will be released in mid-January.

11:05   [Progress on Phase 7 Watershed and Tidal Water Model Boundaries](#) – Andy Fitch, USGS-CBPO

Andy described the final product of updated and refined model boundaries for the Phase 7 Watershed Model, MBM, and MTMs including spatially detailed estimates of the tidal wetlands.

Summary

Andy began with a review of the reasons why this work is being completed and the previous actions and decisions that have been taken. Andy concluded with the next steps, which are mostly related to documentation and integration into the model.

11:20   Discussion of Phase 7 Watershed and Tidal Water Model Boundaries

Summary

Dave asked if the new tidal shoreline has been implemented yet. Andy said it has not been implemented yet, but Nicole and Richard have tested an earlier iteration. Andy said the dataset could be ready for sharing at any time. Lew said the modeling team is ready to work with this dataset now and it would be great to get it in the hands of practitioners.

Lew asked Andy to work with Gary Shenk to record this work in the Phase 7 Documentation.

Lew said one thing to consider when looking at this work is climate change and the Bay beyond 2035. Lew asked if we were to look at our best estimates of growth, sea level rise, and tidal wetlands in 2075, what would be the feasibility of the same type of product for 2075. Andy replied the source data would ultimately be different, but it is probably feasible because the other NOAA sea level rise scenarios would be more usable. Andy developed a process to put together these datasets based on previous experimentation with the 0-foot sea level rise dataset.

Julie asked if low marsh is included within the tidal boundary. Andy said yes, he believes it is included on the land side. Karinna Nunez confirmed this is the case. Lew said the model does not distinguish between high and low marsh; it just has tidal wetlands and that serves the model's purposes for now. Karinna said their intention is to distinguish between the types of marsh in future efforts. Julie said the Climate Resiliency Workgroup is very interested in this and will stay in contact about this work.

Jian asked if the MBM team could get the boundary layer for the wetlands. Karinna said they have the inventory for the tidal shorelines, and she can provide that layer. Andy said they can work with Jian to get him that data.

Jian asked if the updated tidal shoreline layer includes the Atlantic coastal bays of the eastern shore. Andy said the Atlantic coast side is being added to the Phase 7 WSM from the Delaware River down to the Chesapeake Bay mouth. Andy said they can work with Jian to get him that data.

Richard Tian asked if a shoreline would be available for earlier years, such as 1991. Andy replied they could give an earlier version of the shoreline, but it would be very difficult if not impossible to give a version associated with a specific year. Andy emphasized it is very difficult to associate a time with the shoreline layer because some parts of the data come from different years. Dave asked if an exact year would be needed, and instead maybe just a decade like 1991 to 2000 would be sufficient and there was general agreement that that was the correct path forward for the 1991-2000 base.

Lew said the path forward for shoreline erosion starts with the shoreline erosion dataset from Jeff Halka in Phase 6 since it is quite a task to simulate the nutrient and sediment loads. From there, Larry Sanford's work will take a constant input and make it dynamic based on wave energy and indicate if having a dynamic shoreline input makes a difference. Lew said we are data constrained and will most likely use this dataset.

11:30 [**Tidal Marsh Migration In Response to Sea Level Rise**](#) – **Molly Mitchell, Karinna Nunez, Christine Tombleson, and Julie Herman, Center for Coastal Resources Management VIMS**

The report *Synthesis of Shoreline, Sea Level Rise, and Marsh Migration Data for Wetland Restoration Targeting* was presented.

<u>Summary</u>

Molly Mitchell began by describing the project, its scope, and which components may be of interest to the MWG. Molly compared the structure, assumptions, and results of four different marsh migration models in response to sea level rise. Molly explained the differences between marsh models come from water level alignment not being precise, the resolution of underlying data, the source of underlying data, and differing model parameters. Molly concluded there are not strong patterns between marsh model parameters and migration results. Another conclusion was that results are not consistent across study sites.

11:40 Discussion of Tidal Marsh Migration in Response to Sea Level Rise

<u>Summary</u>

Samuel Canfield asked if the current marsh is removed and the Integrated Valuation of Ecosystem Services and Tradeoffs (INVEST) model relies on predicting based on where marsh already exists, then would INVEST naturally under predict because there is no marsh to begin with. Molly said yes and no. The danger of saying you can only migrate where marsh already exists can lead to underestimating because marsh might be created in new areas going forward. However, saying marsh will always be created where the tide allows will probably lead to overestimating. At a broad scale it is hard to generalize but at a finer scale better decisions can be made to answer these questions. Julie Herman said in the study they removed the marshes from

the output, not from the input, so when comparing, they did not adjust the inputs. Molly said that is correct. Differences in output have nothing to do with the method, it is how specific models like INVEST consider preexisting marsh.

Lew Linker said the MWG would need to generalize the lessons from this study since they cannot afford to ask questions in specific geographic areas.

Lew asked if it is possible to use a Sea Level Affecting Marshes Model (SLAMM) model to get a broad view for 2075 climate change scenarios. Molly replied that the larger the resolution of each scale, the more likely one is to overestimate in large, flat lying areas. Molly emphasized the need to understand the limitations of each model. Molly said the other limitation is the specific scenario that is being run.

Richard Tian said he uses a lot of marsh data from NOAA for future predictions. Richard asked if the NOAA data is adequate for projections or if other models are suitable. Molly replied all of the models have strengths and weaknesses and said one of her comments about the NOAA model is that marsh categories were determined based on elevations, which makes more sense for the Atlantic coast but less so for the Chesapeake Bay because of the many tributaries to the estuary. Molly said it is fine to use the SLAMM model if there is no distinction within the term marsh.

12:20 LUNCH

12:45 [Test Beds for Dynamic Tidal Shoreline Nutrient and Sediment Loads](#) – Larry Sanford, UMCES; Richard Tian, UMCES; Nicole Cai, ORISE and Carl Cerco, Attain

Estimated shoreline erosion loads are a constant average input in the Phase 6 assessment. However, dynamic inputs of shoreline TSS, TN, and TP may be important in the finer scales of Phase 7. To assess the importance of dynamic shoreline loads in the MBM and MTMs, two test beds of the Corsica and Choptank simulations will be used. Dynamic inputs of shoreline loads require input estimates of 1) wave power (function of wave speed, wave energy, and depth), 2) shoreline height, 3) protected shoreline, 4) bulk density, 5) sand, silt, & clay classes, 6) eroded shoreline, and 7) TN & TP species.

<u>Summary</u>

Lew began with the preface that this is a decisional agenda item, and the proposal is to go ahead with a test bed approach for a dynamic shoreline erosion methodology in the Choptank and Corsica Rivers.

Larry outlined the case for a dynamic tidal shoreline on [slide 2](#). To explain key concepts, Larry presented a case study in the erosion of Todd's Point in the lower Choptank River from 2002 to 2003. Larry shared some conclusions from this work and other research.

Larry said they are proposing this methodology and applying it as a test case for the Corsica and Choptank rivers, specifically the Choptank MTM. In these situations, the kinks can be worked out and depending on how it goes, applied to the entire Bay for evaluation.

1:20   Discussion of Dynamic Tidal Shoreline Simulation Test Bed Approach

Summary

Lew said this approach meets the CBP where it is on this topic.

Lew asked if the variable h represents bank height on <u>slide 11</u>. Larry said yes, it does. Lew replied that is good because bank height will give us a sense of how much erosion, sediment, and nutrient will be making it into the bay relative to different bank heights. Larry said some students of his have done work on traveling around the bay categorizing shoreline status, such as if it is armored or not. Lew asked if for this proposal we could use bank height and wave strength as it is to apportion shoreline erosion by time and bank heights. Larry said yes, the easiest way to do it is to pull directly from wave model generated results. Lew said we have a way to adjust for what we see on the long-term erosion rate.

Lew said this is a good approach that is relatively low cost and high payoff, which will be quantified when the test bed has been completed. Larry replied that it may be that the most nutrient rich sediments move quickly into deeper waters, because clay and silt may be more likely to stay suspended in the water column. Lew said we can encourage the MTM teams to use high frequency turbidity monitors.

Carl Cerco said he is surprised if the bank is completely inundated, the edge erosion goes down to almost completely zero. Larry said the marsh literature indicates that edge erosion is a function of wave energy, and wave energy is basically zero when the bank is inundated since most of the wave energy is released at impact.

Carl emphasized the need to coordinate with the WSM. Carl said somethings to work out will include how to bulkhead things. Larry replied it depends on the time scale of the WSM inputs. One might want to do an annual average, which would allow for some adjustments. Lew replied the assessments in the watershed are long term averages and thinks this will be fine. Lew said the assumption will be protected shorelines will not move, but otherwise shoreline height and wave energy will be considered dynamically.

Jian said this is a good approach and said there might be an additional consideration in the WSM about different settling velocities for phosphorus. Jian said the wave information should be available from the wave model, but the challenge might be a shoreline inventory, so Jian suggested using the Virginia Institute of Marine Science (VIMS) shoreline layer.

Julie Reichert-Nguyen asked from a Climate Resiliency Workgroup perspective if this method is able to quantify the resiliency benefits of nature-based infrastructure, like oyster reefs or marsh restoration efforts. Larry said William Nardin and others are doing work on oyster reefs serving as a growing breakwater on near shore. Their work has shown that oyster castles can keep up with sea level rise and they have been using modeled results. Julie suggested find a time to speak about this further.

Gary Shenk asked if alpha prime is spatially explicit and how spatially explicit is it. Larry said it is spatially explicit and you can think of it as being an erodibility coefficient or property of the hardness of the shoreline. Alpha prime would be smaller for marshes than a well consolidated bank. Carl said the level of alpha prime is consistent with Jeff Halka's shoreline erosion estimates. Carl said one cannot have more spatial detail than the resolution of the original erosion estimates. Larry said what has been found in the scientific literature is that it has to be averaged

over some spatial distance, because at finer scale it does not apply. Gary said the erosion rates in the WSM are kept the same, this is a way to divide them up temporally. Gary said he does not think there is any other feedback from the estuarine model to the WSM, besides climate change impacts. Everything else would be derived from the original estimate that the WSM team already has.

Dave asked if there are any objections to proceeding with this approach. No one objected, so this test case will go forward. Progress will be reported at future quarterlies, starting in April 2023.

Richard Tian said the wave model is already running in the Corsica and he is working to implement the sediment transport model in the Corsica as well. Because the Corsica is smaller, it is a good place to test before bringing to the Choptank for a full test case.

1:30 **[Climate Change and Striped Bass Chesapeake Habitat](#)** – **Tom Parham, Andrew Keppel, Jim Uphoff, and Renee Karrh, MD-DNR**

Progress in an analysis to assess DO and water temperature related striped bass summer habitat conditions, Bay-wide, by State, and by CB Segment, under 2025 and 2055 climate conditions was discussed. Key Bay restoration/climate scenarios of Full WIP3 Implementation and No Action scenarios was used to estimate change in the quantity/quality of habitat rated as Suitable, Tolerable, Marginal, or Unsuitable.

Summary

Tom Parham began with some context on the economic importance of Striped Bass for the Chesapeake Bay. Tom gave an overview of the current status of Striped Bass considering climate change impacts and nutrient and sediment reduction.

Tom specified that they are breaking Striped Bass populations into two parts: migratory and resident striped bass. This presentation and work are focused on resident striped bass which are mostly male and immature females. This work was inspired by reports of the changing summer location of resident striped bass and the desire to apply the monitoring data to understand where striped bass are experiencing a habitat squeeze.

The presentation brought forward a series of research questions starting on [slide 13](#). Tom provided some conclusions and a summary of future conditions.

2:20 **Discussion of Climate Change and Striped Bass Chesapeake Habitat**

Summary

Lew said this is fantastic work, has extensive explanatory power, and offers hope under various climate change scenarios. Richard said this presentation is great because it is a great application of the model results for powerful prediction.

Lew talked about climate change scenarios and differences in watershed implementation plans (WIPs). Lew offered the modeling team's work on 2025 and 2055 scenarios for the striped bass team. Tom suggested having a follow up conversation so direct comparisons can be made. Lew said it is solid and polished but can add more to the work.

Gary said the gold standard of a co-benefit is monetization. Gary asked if one can produce a value for dollar per cubic meter of restored habitat depending on the time series available. Jim

Uphoff replied these numbers were done for recreational purposes so the numbers are a bit more suspect, the data are point estimates, and natural resources economics can be very difficult. All these reasons make a metric like dollar per cubic meter of restored habitat difficult to generate. Erik Zlokovitz said in addition to what Jim Uphoff said regarding economics of the striped bass fishery, NOAA Fisheries service does an economic "add-on survey" with the Marine Recreational Information Program fisheries survey once every 3 or 5 years, but not every year. The contact is Sabrina Lovell - NOAA Federal sabrina.lovell@noaa.gov. The most recent NOAA economics report is from 2019 and one can get information on Maryland commercial and recreational fishing in that report.

Richard asked about the suitable habitat on slide 23 for July/August 2020. Richard said it seems like in July of 2020 the suitable habitat was similar to the projected results for suitable habitat in 2055. Richard asked if they think the model might be underestimating the results for 2055. Lew said he thinks this is just indicative of the impact of temperature is having.

Dave's major takeaways from the presentation were that while the future for striped bass looks stark under climate change, it would be much worse if not mitigative actions were taken in regard to sediment and nutrient pollution. Dave said this is a good example of how the MWG efforts can be applied to support living resource considerations.

2:30 **Forecasting the Relative Roles of Climate Change and Habitat Management On Chesapeake SAV** – Marc Hensel and Christopher Patrick, VIMS

> To predict how climate change and human activities will affect future SAV habitat, 40 years of aerial survey, ground observation and water quality data are used in a structural equation modelling approach to describe how different seasonal variables have controlled annual cover in each SAV community across the Bay to date. Then the projected effects of climate change (i.e., temperature rise, precipitation, and nutrient and sediment loads) and human activities (i.e., nutrient input management) are used to estimate climate change influence on Chesapeake's SAV communities.

<u>Summary</u>

Marc began with the major question this work seeks to address: "How will climate change and human activities affect the major communities of submersed aquatic vegetation in the Chesapeake Bay?" To address the overall question, Marc posed and answered three sub questions throughout the presentation.

1. How have past environmental conditions affected seagrass communities?
2. How will environmental conditions shift with climate change & with human activities?
3. How will shifting conditions and shifting species affect seagrass meadow coverage into the future?

Marc concluded with the following take home messages:

1. Temperature increases will widen the shift in dominant species, and management must adjust accordingly.
2. Nutrient reductions in the tidal fresh/oligohaline & *Ruppia* zones are essential, especially because the new dominants respond best to nutrient management.

3. Active regional habitat management offsets and prevents the effects of global climate change, targeted nutrient management that benefits climate-tolerant species encourages continued recovery.

Marc recommended exploring [this application](#) further.

2:50   Discussion of Forecasting the Relative Roles of Climate Change and Habitat Management On SAV

<u>Summary</u>

Dave asked what the no further action scenario means. Lew said that would be a no action since 1985 scenario and the growth that would occur from no additional actions. It is analogous to Tom's comparison of WIP III and no action scenarios.

Dave asked if Marc used the climate change scenarios with an increase in sea level rise and salinity. Lew confirmed the modeling team has provided the 2025 climate and 2055 climate. Lew said the complete scenarios were provided so they were able to treat it like observational data.

Gary asked if the nutrients on [slide 7](#) are being considered as two separate variables. Marc said yes, they were considered separately. Gary said it strikes him that the emphasis on controlling nitrogen vs phosphorus will change based on species presence and distribution now and under future climate change scenarios. Marc said yes, this is a good point and should be used in decision making. One example is widgeon grass.

Jim Uphoff said if we are to look at food web effects, we need zooplankton monitoring to resume. We have a 20-year gap.

Lew shared a speculative idea, which he attributed to Richard Tian's origin, that it might be suitable to consider this work in the SAV assessment for the Chesapeake. Lew said this is worth future consideration and discussion. Richard said at this point, our current SAV model is not doing a good job, so this could be an improvement for our SAV assessment. Lew invited Marc to come back to the Modeling Ad Hoc team and the April 2023 MWG Quarterly review for further discussion.

Raleigh Hood asked about the role of temperature in *Ruppia* abundance. Raleigh said he was under the impression *Ruppia* could suffer die offs from extreme temperature events. Marc said *Ruppia* is not as affected by higher temperatures based on what they saw in their work, but marine heat waves may play a role.

Raleigh Hood asked about salinity impacts on *Ruppia* and if there were salinity barriers. Marc replied they do not have great spatial change data on this topic but based on what limited information is available in the literature, it seems to indicate that widgeon grass can move into higher salinity areas when the water is clear and other species have vacated.

3:00   [Review of the 2020, 2021, and 2022 Summer Hypoxia Forecasts and Proposed Refinements](#) – Isabella Bertani, UMCES

Isabella reviewed the previous three years of Summer Hypoxia Forecasts since she and a team of VIMS, UMCES, DNR, and University of Michigan PI had refined the methodology. Further refinements to the method for the 2023 forecast were discussed.

Summary

Isabella began with the reminder that the main purpose of the Hypoxia Forecasts is communication to the public, so the model is mainly statistical, simple, and data driven. Isabella said refinements have been made since the previous model results are not believed to be the best representation of hypoxic volume. Isabella explained how new refinements represent best practices in ecological forecasting and now the CBP does an assessment of the forecast.

Isabella outlined some draft ideas for further model refinements based on the level of effort and time required to implement (slides 14-16). Isabella said these are all ideas at this point and will be brought to the larger group that weighs in on these matters for their input.

3:20   Discussion of Summer Hypoxia Forecast Refinements

Summary

Lew said that the long-term climate change temperature increases and their impacts on hypoxia as well as the inclusion of atmospheric deposition loads to the tidal Bay waters seem to be worthwhile improvements.

Marjy Friedrichs asked about changing the dissolved oxygen levels to be less than 3 mg/L instead of 2 mg/L since the research suggests living resources are more sensitive to the drop off after 3 mg/L. Lew said this is a good point and will help it resonate with decision makers, because of the 3 mg/l DO criteria for the Deep Water designated use.

Dave asked if there is a need to distinguish between 3 mg/L and 2 mg/L because it does not align with dissolved oxygen criteria. Isabella said she does not know of a way of doing that with this simple model since it is not designed to address the criteria assessment. This model is designed for the communication of overall hypoxic volume, not management. Richard said this might not be doable, but if we wanted to do what Dave suggested it might be better to have a difference between 1 mg/L for deep channel and 3 mg/L elsewhere. Lew said he is thinking we should back away from making this more akin to management forecasts and keep it similar to as it is now in communicating to the public.

Lew said some next steps might involve getting input from the broader Hypoxia Forecast Model group on the one or two improvements to consider and then moving forward to implement based on the time available. Isabella agreed. Lew said progress can be reported at the April Quarterly.

Jian Shen said he was surprised the model did such a good job despite not including wind. Isabella said the team has been interested in wind since she agrees it is a good predictor usually, but they do not have a good prediction of what wind will be in early June when they build and release the model. Isabella said maybe they can still explore including those variables to say these are the predictors that are important for explanatory power later on, but when trying to include wind previously it made the model less effective because of the model purpose. Jian Shen agreed with that reasoning. Tom Parham suggested considering North Atlantic Oscillation strength to be able predict wind direction and ultimately Bay mixing strength. Marjy said while wind is critical for calculating oxygen concentration at a given time, it is a short-term disruption. Dave asked if a tropical storm or hurricane is a larger disruption for the hypoxic volume. Jian replied that day to day or month to month it matters but looking at the whole average of the period it is not a problem.

Karl Berger said if the team changes the summer hypoxic forecast, it helps for elected officials to know if one can change it back in time as well so there is consistency. Isabella agreed with Karl's point on consistency, and said they present the metric as relative to previous years and run the previous years with the same metrics. While the different agencies all have slightly different metrics, they agree in magnitude. Karl said that the hypoxia forecast is one of the pieces used to brief upper management and that they seem to engage with the content. Marjy thanked Karl for the feedback said and that is really good to hear. To directly answer Karl's question, if the team did change to dissolved oxygen < 3 mg/L from dissolved oxygen < 2 mg/L, they would definitely have to change all our estimates (VIMS, CBP, MD DNR) and also change the historical estimates as well. The only confusion would be if someone looked at an old report, but Marjy does not think that would happen often.

Richard asked how uncertainty was quantified. Isabella said the benefit of a probabilistic model is the statistical framework allows for better understanding of uncertainty. This produces a full probability distribution that allows for uncertainty prediction.

3:30   ADJOURN

Participants: A.K. Leight, Alex Gunnerson, Andrew Keppel, Andy Fitch, Angela Giuliano, Arianna Johns, Bill Keeling, Carlington Wallace, Cassie Davis, Carl Cerco, Dave Montali, Diana Domotor, Erik Zlokovitz, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano, Guido Yactayo, Hannah Nisonson, Hassan Mirsajadi, Isabella Bertani, Jamileh Soueidan, Jesse Bash, Jian Shen, Jim Uphoff, John Clune, Jonathan Leiman, Julie Herman, Julie Reichert-Nguyen, Karinna Nunez, Karl Berger, Karl Blankenship, Katie Walker, KC Filippino, Kevin McLean, Kristin Saunders, Kyle Hinson, Larry Sanford, Leonard Schugam, Lew Linker, Lisa Beatty, Mandy Bromilow, Marc Hensel, Marek Topolski, Mark Bennett, Marjy Friedrichs, Molly Mitchell, Mukhtar Ibrahim, Nicole Cai, Normand Goulet, Qubin Qin, Raleigh Hood, Rebecca Murphy, Renee Karrh, Richard Tian, Ron Vogel, Rudoplh Lukacovic, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Tish Robertson, Tom Butler, Tom Parham, Zhengui Wang.