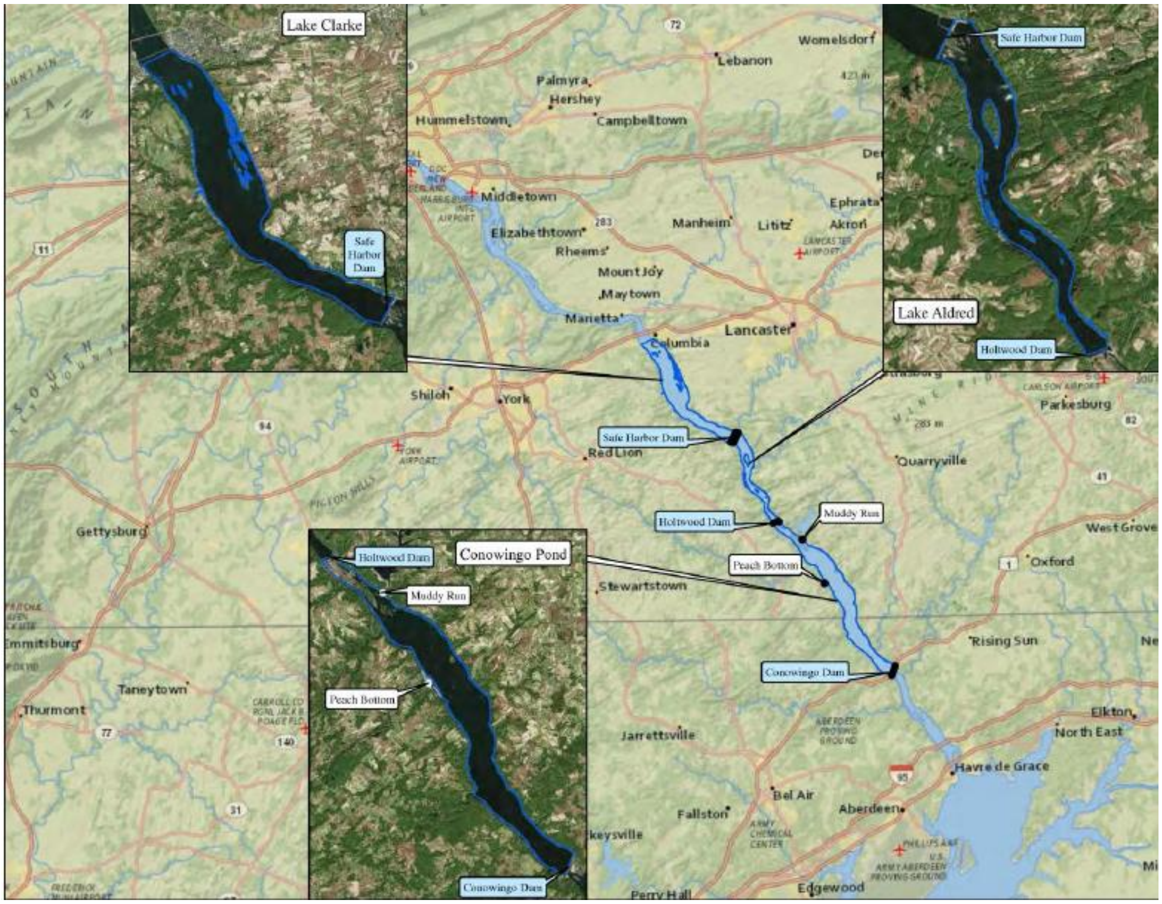
Lower Susquehanna River Reservoir System Model Enhancements Peer Review



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Maryland Department of Natural Resources & Exelon Generation Company, LLC
by
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MARYLAND DEPARTMENT OF NATURAL RESOURCES

CRC

Exelon Generation.

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Cover graphic: The cover graphic is Figure 1 of Velleux, M. and J. Hallden (2017a), referenced herein, provided courtesy of Gomez and Sullivan Engineers and Exelon Generation Company. The figure shows the project setting in context of the Susquehanna River watershed (uppermost right inset) and the system of three impoundments formed by Safe Harbor Dam (Lake Clarke). Holtwood Dam (Lake Aldred), and Conowingo Dam (Conowingo Pond).

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Executive Summary

It is estimated to cost billions of dollars to reduce nutrients and sediment loads to the Bay to improve water quality enough to support fish, shellfish and other living resources and provide safe and clean water for recreational uses by the year 2025. To that end, state and federal agencies involved with the Chesapeake Bay Program (CBP)partnership have gone to great lengths to ensure an open, science-based, and transparent process thorough all aspects of the 2017 TMDL midpoint assessment.

Toward that end and under recommendations from a 2015 report supported by the US Army Corps of Engineers (USACE), the Maryland Department of the Environment and the Maryland Department of Natural Resources (DNR), titled "The Lower Susquehanna River Watershed Assessment" [LSRWA] (USACE, 2015), the CBP partnership has worked to quantify the full impact on Chesapeake Bay aquatic resources and water quality from the changed conditions in the Lower Susquehanna River Reservoir System (LSRRS) and the principal partners to the Chesapeake Bay Watershed Agreement (*i.e.*, the U.S. Environmental Protection Agency (EPA) and the Bay watershed jurisdictional partners) are currently working to integrate findings from the LSRWA and other studies into their ongoing analyses and development of the seven watershed jurisdictions' Phase III WIPs as part of the Chesapeake Bay TMDL 2017 midpoint assessment. The more recent studies have included, among others, an Exelon supported effort by WEST (Water Environmental Sedimentation Technology) Consultants, Inc. and HDR, Inc. to "develop a two phased-modeling approach that would enhance and complement the existing Phase 6 Chesapeake Bay Watershed Model (CBWSM) as well as the inputs to the Bay Water Quality and Sediment Transport Model (WQSTM)."

To ensure that the suite of models under development by the Exelon contractors were credible, transparent and of the necessary quality to be used in the midpoint assessment, the Maryland DNR requested an independent expert review panel. Time lines dictated that this panel work in parallel with the model developers, although final review comments were not made until completion of the modeling teams' final reports. The Chesapeake Research Consortium (CRC) was tasked with assembling the review panel consisting of 4 independent reviewers with expertise in hydrodynamic, sediment transport, mass balance models, and water quality processes. The CRC coordinated the review and, in collaboration with Exelon's consultant (Gomez and Sullivan Engineers, D.P.C.), organized conference calls and review activities. In addition, the CRC developed and maintained a website with relevant information. The website URL (active since 8 June, 2016) is http://www.chesapeake.org/conowingo_model.

The final reviews from the 4- member review panel were all supportive of the LSRRS model enhancement effort. All agreed that the model results will provide a better understanding of Conowingo Pond's impacts to the Bay and that the models were reasonable and credible as defined by the goals of the effort. The CBP Modeling Work Group agreed with this assessment and has incorporated the results of the developed Lower Susquehanna River Reservoir System models as additional lines of evidence for assessing Conowingo Pond impacts to the Bay. At the time of this writing, the CBP's Scientific Technical Advisory Committee (STAC) is, as part of its 2017 TMDL midpoint assessment process, overseeing review of the Phase 6 CBWSM and the WQSTM. The reviewers are considering the reasonableness of CBP's application of the new LSRRS modeling results and are cognizant of the reports, reviews and responses presented here.

Background

Basic Background on the LSRRS

Basic background about the Susquehanna River and the Lower Susquehanna River Reservoir System (LSRRS) has been provided in the CRC published STAC Workshop Report about a January 2016 workshop entitled "Conowingo Influence on Chesapeake Water Quality" (Linker *et al.*, 2016a). That brief introduction is reproduced verbatim below, for reader convenience.

> The Susquehanna River is the largest tributary to both the Chesapeake Bay and to the Atlantic Slope. It drains more than 71,000 square kilometers (27,500 square miles) across New York, central and eastern Pennsylvania, and northeastern Maryland (**Figure 1**). Annually, the Susquehanna River contributes about 41 percent of the total nitrogen (TN), 25 percent of the total phosphorus (TP), and 27 percent of the suspended sediment (SS) to the tidal Bay (Linker et al. 2016). Thus, changes in these inputs from the Susquehanna are significant to the overall status of the Bay.
>
> Between 1910 and 1931, a series of three hydropower plants were constructed along the lower 62 km (39 miles) to harness the river power generated by a steepened gradient and the high volume of water which moves through a deeply incised bedrock channel before crossing the Piedmont Fall Line (Reusser et al. 2006). Since construction, the three tiered reservoir system has neared full sediment storage capacity (Table 1); only Conowingo Pond has limited potential to trap additional sediments and associated nutrients, estimated at less than about 5 percent of original storage volume. In aggregate, this system of reservoirs has come very close to its full capacity in terms of sediment storage over the past 90 years. At present, Conowingo Reservoir has been estimated to be about 94 percent full; the others approximately 100 percent full (Reed and Hoffman 1997, USACE 2014, Langland 2015).

Table 1: Reservoir features along the LSSR (Reed and Hoffman, 1997, US ACE 2014).

Reservoir (Dam) Area in ha/mi^2	Susquehanna River Mile Upstream of Havre D'Grace	Year	Watershed Area at Dam miles^2	Initial Water Storage Capacity (1000s of acre-ft)	Estimated Existing Sediment Storage Capacity (% original)
Lake Clarke (Safe Harbor Dam) 2,970 / 11.5	32	1931		150	0%
Lake Aldred (Holtwood Dam) 971 / 3.75	25	1910	26,740	60	0%
Conowingo Pond (Conowingo Dam) 3,600 / 14	10	1928	27,100	310	~5 %

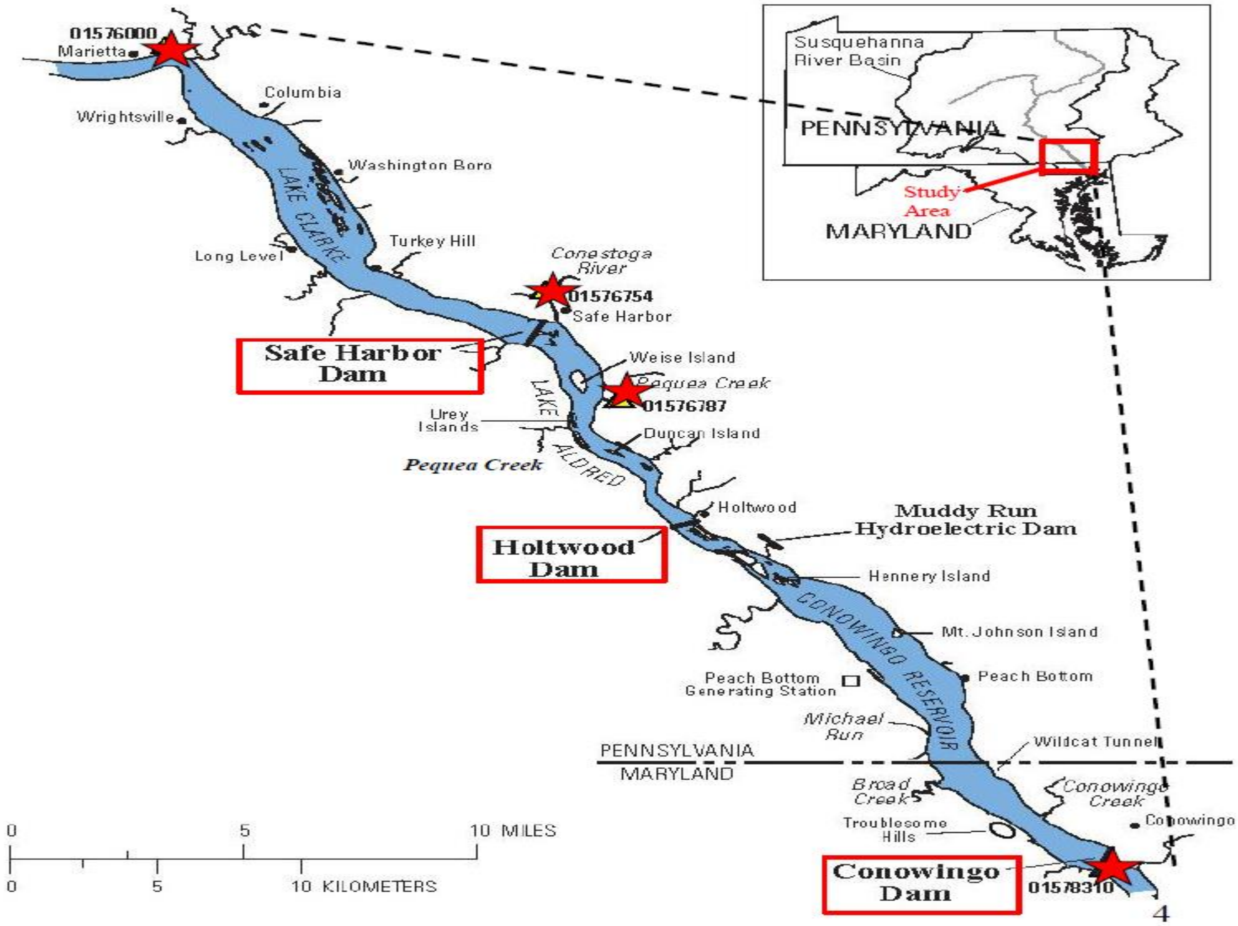

Figure 1. The three reservoirs of the lower Susquehanna (source: Langland 2016 workshop presentation: *Sediment Transport and Bathymetric History in Three Reservoirs, Lower Susquehanna River Basin, Pennsylvania and Maryland 1900-2015* http://www.chesapeake.org/stac/presentations/249_Langland%20STAC_Res_mtng_1-2016_new.pdf)

The Chesapeake Bay Program (CBP) is a state-federal partnership engaged in restoring the United States' largest estuary. Chesapeake Bay restoration work has been underway for three decades and since 2010 has been supported by the nation's most extensive total maximum daily load (TMDL) program (USEPA 2010, Linker et al. 2013). The Chesapeake TMDL requires the states of the Chesapeake watershed to establish appropriate uses for their waters, to adopt water quality standards that are protective of those uses, and to identify and list waterways that are impaired by pollutants, causing them to fail to meet the adopted water quality standards. The 2010 Chesapeake TMDL was developed with the assumption that the Conowingo Reservoir was still effectively trapping nutrients and sediment. However, increasing evidence suggests that the system may have reached its trapping capacity, and thus may no longer provide the water quality benefits provided since dam construction. As the 2017 Midpoint Assessment and TMDL model update approaches, assumptions regarding the reservoir's trapping efficiency require careful reconsideration. Loss of trapping capacity could require offsets and additional watershed management to meet the TMDL objectives.

To address scientific and technical aspects of the influence Conowingo infill has on tidal Chesapeake water quality, the Chesapeake Bay Program Science and Technical Advisory Committee (STAC) held a workshop titled "Conowingo Infill Influence on Chesapeake Water Quality" on January 13-14, 2016 in Annapolis, Maryland. The workshop was a scientific discussion among a group of over 70 participants invited by the workshop steering committee. A report was written summarizing the ideas presented at the workshop (as developed from either completed scientific research or reports of work in progress) and the major consensus conclusions of the STAC panel. See Linker et al. (2016).

The workshop was supported by the STAC because of a recognition that on-going changes in the net trapping efficiency of the reservoirs in the lower Susquehanna River Basin (primarily changes in Conowingo Pond) could have substantial impact on nutrient delivery to the Chesapeake Bay, and those impacts could limit progress in achieving the water quality and ecosystem goals of the Bay Agreement and TMDL.

Background on LSRRS In-Filling and Related Studies

Current levels of sediment and nutrient loading from the Susquehanna River and other Chesapeake Bay tributaries are known to have a negative impact on water quality in the Chesapeake Bay. In this regard, there is current concern about recent increases in amounts of sediment and associated phosphorus from upstream sources that are coming through and over Conowingo Dam. Studies conducted over the past two decades have indicated that this is an expected effect of reservoir filling, with more recent studies (in the past five years) concluding that the trapping capacity of the Conowingo Pond reservoir is close to, and may soon reach, its full effective storage capacity, a condition which is sometimes referred to as "dynamic equilibrium" to reflect the fact that outputs and inputs of sediments will be effectively equal when averaged over a decade or more.

Such a "dynamic equilibrium" condition has existed for many decades in the two upstream reservoirs of the Lower Susquehanna River Reservoir System (LSRRS) (*i.e.*, in Lake Clarke and Lake Aldred) and USGS researchers suggested in 1996 that Conowingo Pond could possibly "reach equilibrium with sediment transport of the river during the next 10 to 20 years" (Reed and Hoffman, 1996). Following other bathymetry measurements, a subsequent 2009 USGS report (Langland, 2009) suggested that the reservoir's "remaining capacity may be filled in 15 to 20 years". Given a lack of scientific consensus of the reservoir's life at the time (including lack of precise definitions of the terms "equilibrium" and "capacity"), the Chesapeake Bay Program (CBP) partnership assumed for planning purposes in advance of the 2010 TMDL requirements, that the reservoir would perform similarly to that observed in the mid-1990s, and with plans to re-visit the issue at a later date. Now, and based on more recent analyses of the issue, there is a growing consensus that the condition is eminent and that partnership assumptions about reservoir performance will need to be modified in the current year (2017) as part of the TMDL mid-point assessment.

In particular, a 2012 USGS study (Hirsch, 2012) reported dramatic increase in both phosphorus and sediment over Conowingo Dam between 1996 and 2011, in contrast much more positive trends detected at the LSRRS inlet at Marietta, PA. Subsequent studies (including other USGS reports and several peer-reviewed journal publications (Zhang et al., 2013, 2016a,b) supported the conclusion that reservoir performance had rapidly declined in recent years over a wide range of flow conditions. In this regard, a 2014 USGS survey reported an estimation that by 2011 the Conowingo Pond (reservoir) may have already reached about 92% of its storage capacity for sediment (Langland, 2015). Another 2015 report titled "The Lower Susquehanna River Watershed Assessment" (LSRWA) (USACE, 2015) concluded that although "previously it was thought that Conowingo still had net trapping capacity for decades to come, Conowingo Reservoir is essentially at full capacity and "a state of dynamic equilibrium now exists." Other reported finding were that increases in sediment and associated nutrient loads entering the Bay are "causing adverse impacts to the Chesapeake Bay ecosystem" and that the changes to the Conowingo Reservoir sediment and nutrient trapping capacity would keep the Bay from meeting water quality standards in 2025, even with full attainment of all of the then extant Watershed Implementation Plans (WIPs), as agreed in a STAC Review Report (Friedrichs et al., 2014) and further confirmed by Linker et al. (2016b) . Specific recommendations from the LSRWA final report included the following:

1. Before 2017, the CBP partnership (including partner agencies, academic researchers, and other independent non-government organizations) should quantify the full impact on Chesapeake Bay aquatic resources and water quality from the changed conditions in the LSRRS.
2. The U.S. Environmental Protection Agency (EPA) and the Bay watershed jurisdictional partners should integrate findings from the LSRWA and other studies into their ongoing analyses and development of the seven watershed jurisdictions' Phase III WIPs as part of the Chesapeake Bay TMDL 2017 midpoint assessment;
3. The partnership should develop and implement management options that offset impacts to the upper Chesapeake Bay ecosystem from increased sediment-associated nutrient loads; and
4. The partnership should commit to enhanced long-term monitoring and analysis of sediment and nutrient processes in the lower Susquehanna River and upper Chesapeake Bay to promote adaptive management.

In response to these recommendations, Exelon Generation Company, LLC, agreed to fund approximately $3.5 million to monitor and evaluate the impacts of six high flow events of between 100,000 and 400,000 cfs at Conowingo Dam over a 2-year period to help inform the EPA Chesapeake Bay Program (CBP) midpoint assessment of the 2010 total maximum daily load (TMDL). Three high flow events, all less than 200,000 cfs, were monitored between 2015 and 2016. Due to a lack of high flow events during the 2-year period, Exelon focused their resources on developing a Conowingo specific modeling exercise, contracted to WEST (Water Environmental Sedimentation Technology) Consultants, Inc. and HDR, Inc. to augment the monitoring information for the midpoint assessment. The suite of Conowingo specific model results are being included in the EPA CBP partnership decision tools associated with the midpoint assessment Phase 6 model and are being used as one line of evidence in determining the LSRRS impacts on meeting Bay water quality standards. The models will thus be used to enhance the partnerships ability to represent the reservoir system in the Chesapeake Bay Watershed Model used to inform the TMDL process and WIP implementation by the jurisdictions. The Conowingo specific model results will also inform Exelon's 401 Water

Quality Certification application process as it pertains to the relicensing of Conowingo Dam. Exelon is requesting a new 46 year license.

Background to the "LSRRS Model Enhancements Peer Review" and Next Steps

To ensure that the suite of models under development by the Exelon contractors were credible, transparent and of the necessary quality to be used in the midpoint assessment, the Maryland DNR requested an independent expert review panel. Time lines dictated that this panel work in parallel with the model developers, although final review comments were not made until completion of the modeling teams' final reports. The Chesapeake Research Consortium (CRC) was tasked with assembling the review panel consisting of 4 independent reviewers with expertise in hydrodynamic, sediment transport, mass balance models, and water quality processes. The CRC coordinated the review and, in collaboration with Exelon's consultant (Gomez and Sullivan Engineers, D.P.C.), organized conference calls and review activities. In addition, the CRC developed and maintained a website with relevant information, including the original proposal (work plan) for the modeling effort, peer review scope of work, meeting minutes, the final modeling reports and the review panel assessments.

CRC's website for the "Independent Review of Exelon's LSRRS Model-Enhancements Efforts" has been active since 8 June, 2017, and can be accessed at http://www.chesapeake.org/conowingo_model. Additional background for and description of the review process can be found in the "Background" section of the review website and also within the "Scope of Work for Lower Susquehanna River Reservoir System Model Enhancements Peer Review." The latter is provided under the "Documents" section of the aforementioned website and is also included herewith as **Appendix A**.

Based on the generally favorable outcome of the reviews (as documented in a subsequent section of this report), the CBP Modeling Work Group has been incorporating the results from the developed Lower Susquehanna River Reservoir System models as additional lines of evidence for assessing Conowingo Pond's impacts to the Bay. In addition, the CBP's Scientific Technical Advisory Committee (STAC) as part of the midpoint assessment, is in the process of reviewing the Phase 6 Chesapeake Bay Watershed Model and the Water Quality and Sediment Transport Model and these reviews will be considering the reasonableness of CBP's application of the new LSRRS models and results.

Panel Process and Meeting Minutes

Beginning with a first conference call on April 6, 2016, the modeling team and the panel both conducted their work concurrently. There were three additional peer review conference calls over the course of the next four months, with additional calls on April 18, May 20, and August 16, 2016, as also recorded in **Table 1**, which is a timeline of events during the review process. See **Appendix B** for the minutes of all four calls. These minutes are also provided at http://www.chesapeake.org/conowingo_model/minutes.html.

Table 1. Dates of Key Events in the Review Process

Peer Review Conference Calls (see minutes in Appendix B)	**Status Updates by Modeling Team to CBP**	**Model Report Documents Submitted for Review**	**Peer Reviews Completed**	**Response Documents Completed**
April 6, 2016 No. 1	March 10, 2016 Update to CBP on WEST effort	July, 2016 WEST "Draft in Progress" Report	November, 2016 Reviews of WEST draft Report (Scott and Wilcock)	July, 2017 WEST Responses to Comments from Drs. Scott and Wilcock (West, 2016; West, 2017b)
April 18, 2016 No. 2	March 29, 2016 Update to CBP on effort	April, 2017 Drafts of HDR HSTA[a] and CPMBM[b] Reports	May, 2017 Reviews of draft HDR reports on HSTA (Scott and Wilcock and CPMBM (Brady and Martin)	July, 2017 HDR Responses to Comments from Drs. Brady and Martin (HDR, 2017b)
May 20, 2016 No. 3	May 5, 2016 Update to CBP on HDR effort	June, 2017 Final HDR HSTA[a] and CPMBM[b] Reports		
August 18, 2016 No. 4	August 16, 2016 Update to CBP on HDR effort	June, 2017 Addendum: HDR HSTA[c] Report		
June 1, 2017 No. 5				

[a] HDR HSTA Report = HDR's report titled "Hydrodynamic and Sediment Transport Analysis." The final report is Velleux and Hallden (2017a) in the "References Cited" section.
[b] HDR CPMBM Report = HDR's report titled "Conowingo Pond Mass Balance Model." The final report is Fitzpatrick (2017a) in the "References Cited" section.
[c] Addendum: HDR HSTA[c] Report = HDR's Report titled "Addendum: Hydrodynamic and Sediment Transport Analysis." This report was created as an outgrowth of the review and is listed as Velleux and Hallden (2017b) in the "References Cited" section.

Over the course of this work, the WEST and HDR teams made several "presentations of status" to the Chesapeake Bay Program Office's Water Quality Modeling Team. Dates of these presentations are included in the second column of **Table 1**. PDF-formatted files of those Microsoft Powerpoint® presentations have also been posted in the "Documents" section of the CRC's review website here: http://www.chesapeake.org/conowingo_model/status.html. Reviewers were presented with these same materials, wither inside or outside of the Water Quality Modeling Team meetings, and were also presented with other preliminary data and interim findings along the way, in response to specific requests. In no case were any such requests for backup materials denied.

The first draft of the report from West Consultants, Inc., was dated July 27, 2016, and was submitted for peer review in early August, 2016. During the period of August to November, the two panel experts with primary expertise in hydrodynamics and sediment transport (S. Scott and P. Wilcock) completed reviews of that work. (See **Table 1**.) Over the course of the first half of 2017, the WEST team responded to these comments and finalized their report. During this period, the HDR, Inc. team continued their efforts on the Conowingo Pond hydrodynamic and sediment transport analyses as well as the Conowingo Pond Mass Balance Model (CPMBM), taking due advantage of the WEST team's results and incoming results from other on-going studies. Note that the CPMBM effort is a model designed to track the input and output balance of different classes and forms of sediment, carbon, nitrogen, and phosphorus (among other related biogeochemical parameters) over time by coupling models of biochemical transformation and sediment layering with the physical models of hydrodynamics and sediment transport. It relies on experimental data, some of which was still under collection at the time by a team of investigators at the University of Maryland Center for Environmental Science. The work by HDR, Inc., was reported in three separate documents (see **Table 1** footnotes)

Review Reports

Curricula Vitae of the four review panelists are provided in **Appendix C** and have been placed on the CRC's panel review web site (http://www.chesapeake.org/conowingo_model/team.html). The four reviewers were divided in expertise between material relating to hydrodynamics and sediment transport (Scott and Wilcock) and materials relating to biogeochemistry and the overall "mass balance" modeling of the Conowingo Pond. See **Table 1** for the final split of reviewing efforts.

In May of 2017, reviewers were given a set of questions designed to guide and facilitate comments on the HDR reports, and each was asked to provide brief written reports on the documents they were assigned to address these questions. The group reviewed, finalized, and agreed to the guiding questions during the summer of 2016. The final set of ***peer review questions*** guided the review and were as follows:

1. Is the modeling approach reasonable and credible to satisfy the goals defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*?
2. Do the Lake Clarke/Lake Aldred HEC-RAS Model (HEC-RAS Model) and Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Do they inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?
3. Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.
4. Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?
5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input

datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

The final reviews from the 4 members of the review panel are provided on the pages that follow. These have also been posted to the CRC's panel review website. All four reviews were generally supportive of the LSRRS model enhancement effort. All agreed that the model results will provide a better understanding of the Conowingo Pond impacts to the Bay now that it has reached "dynamic equilibrium" and that the models were reasonable and credible as defined by the goals of the effort.

Nonetheless, all reviewers did have some questions, comments and suggestions for the modeling team, which led to some changes in the "Final" (published) version of the reports as well as an "Addendum" to one of the reports – see Velleux and Halden, 2017b. To document these changes, both modeling teams (West Consultants, Inc. and HDR, Inc.) prepared response documents. These are provided subsequently, in a following section on "Modeling Team Responses to Reviewer Reports."

On the following pages, the six individual reviewer reports are presented in the following order:

1. Dr. Steve Scott's review of the July, 2016, draft report titled "Lake Clarke and Lake Aldred Sediment Transport Modeling: Draft Report (In Progress)," authored by WEST Consultants, Inc.
2. Dr. Peter Wilcock's review of the July, 2016, draft report titled "Lake Clarke and Lake Aldred Sediment Transport Modeling: Draft Report (In Progress)," authored by WEST Consultants, Inc.
3. Dr. Steve Scott's review of the April, 2017 draft HDR, Inc. report titled "Hydrodynamic and Sediment Transport Analysis" authored primarily by M. Velleux and J. Halden.
4. Dr. Peter Wilcock's review of the April, 2017 draft HDR, Inc. report titled "Hydrodynamic and Sediment Transport Analysis" by M. Velleux and J. Halden.
5. Dr. Damian Brady's review of the April, 2017 draft HDR, Inc. report titled "Conowingo Pond Mass Balance Model" by J. Fitzpatrick.
6. Dr. James Martin's review of the April, 2017 draft HDR, Inc. report titled "Conowingo Pond Mass Balance Model" by J. Fitzpatrick.

As of August 2017, these reviewer reports are also available for download at the following web site <http://www.chesapeake.org/conowingo_model/comments.html>

1. Dr. Steve Scott's review of the July, 2016, draft report titled "Lake Clarke and Lake Aldred Sediment Transport Modeling: Draft Report (In Progress)," authored by WEST Consultants, Inc.

Review of the Exelon One-Dimensional Sediment Transport Model of Lake Clarke and Lake Aldred: Final Review Summary

By
Stephen Scott, PhD, PE

November 21, 2016

BACKGROUND

The Exelon Corporation contracted with West Engineering to build a one dimensional (1D) HECRAS sediment transport model of Lake Clarke and Lake Aldred on the lower Susquehanna River to evaluate sediment transport characteristics of the reservoirs. Lake Clarke, the uppermost reservoir, discharges into Lake Aldred, which in turn discharges into the lowermost Conowingo Reservoir. Flows through Lake Clarke are regulated through Safe Harbor Dam for hydropower production, while the un-regulated flows out of Lake Aldred are controlled by a dam that operates as a weir. Lake Clarke is approximately 11 miles in length (from Wrights Ferry Bridge to the dam) with Lake Aldred about 7 miles long. The uppermost reaches of both reservoirs are relatively wide compared to the lower 4 miles with the upper reach of Lake Clarke containing a higher percentage of sand sized sediments. The lower reaches for both reservoirs have higher percentages of silt and clay in the bed. The average discharge through the reservoirs is approximately 30,000 cfs, however, periodic large storms pass flows up to 600,000 cfs or greater. The United States Geological Survey (USGS) has conducted numerous studies on sediment transport characteristics of the Lower Susquehanna River to gain a better understanding of how sediment transports through the system and specifically how the trapping efficiency of the reservoirs is changing with time. To support their studies suspended sediment data are collected at Marietta, Pennsylvania above Lake Clarke and at the lowermost Conowingo Dam below Lake Aldred. Generally, a good suspended sediment data record is available for flows approximately less than 400,000 cfs at these locations. No suspended sediment data have been collected at Safe Harbor or Holtwood Dam until recently. For flows greater than 400,000 cfs, the river is highly turbulent and dangerous to either navigate or sample from a location on Conowingo Dam. The maximum flow sampled at Marietta (inflow to the reservoir system) is approximately 450,000 cfs, while a few samples have been taken at Conowingo Dam for flows ranging from 500,000 – 600,000 cfs. It is important to understand the sediment dynamics of these large storms because they potentially can discharge much more than the annual sediment load into Chesapeake Bay in a short period of time, thus possibly having a negative impact on water quality in the bay. If suspended sediment sampling were possible below all the lowermost dams through the full range of discharge, a sediment mass balance could be determined which would provide critical information on the quantities of sediment entering the system for large storms as well as quantities of sediment scoured from the bed. These data would then be used as a total sediment boundary condition for Chesapeake Bay water qualities models. Because these data were not currently available, sediment transport was simulated through the three reservoir systems by a number of numerical modeling efforts to better understand the potential sediment loads passing through the reservoirs for varying time periods and large flood events.

In 1995, Hainly et al of the USGS developed a HEC-6 sediment transport model of the three reservoir systems using flow and sediment boundary conditions that were available at the time. Their goal was to validate the model to bed change over time, using bathymetry surveys as a comparison. To validate the model to bathymetry changes, they had to coarsen the inflowing load to encourage deposition thus the model was not further utilized. In 2012, Exelon used the Hainly USGS model and simulated a number of flow scenarios (Exelon 2012).

In 2009, the Lower Susquehanna River Watershed Assessment Study was initiated by the Baltimore District of the US Army Corps of Engineers (USACE). Two modeling efforts were conducted to evaluate sediment transport through the lower reservoirs. The USGS constructed a 1D sediment transport model based on the most current version of HECRAS created by the Hydrologic Engineering Center USACE (Langland 2014). This model was used to evaluate sediment transport through the three reservoirs for the time period of 2008-2011, including Tropical Storm Lee which occurred from September 7 – 16, 2011. The Engineering Research and Development Center (ERDC), Corps of Engineers, located at Vicksburg, Mississippi, developed a 2D model of Conowingo Reservoir using the Adaptive Hydraulics (AdH) modeling system developed at ERDC (Scott 2014). The purpose of this model was to evaluate sedimentation characteristics of Conowingo Reservoir for the time period of 2008-2011. The USGS model provided the flow and sediment boundary conditions for the AdH model for this time period. In addition to developing the 2D model, the ERDC collected a number of bed samples from Conowingo Reservoirs to determine the critical bed shear stress for erosion and erosion rate. The bed of Conowingo consists of a relatively high percentage of fine sediments (silts and clays), thus erosion processes are strongly influenced by the cohesive properties of the fines. To investigate this, the ERDC used the SedFlume, a laboratory scale flume to evaluate the erosion properties of the samples. The sediment cores were approximately 12 inches in depth, with SedFlume erosion characteristics evaluated along the length of the core. Generally, the less consolidated layers located at the top of the core have a lower critical shear stress with the more consolidated and dense lower layers more resistant to erosion. The SedFlume data were used by the AdH model to define the threshold of erosion over the entire area of the reservoir, and the rate that the bed erodes give the hydrodynamic conditions within the reservoir.

A number of scenarios were investigated with the AdH model: 1) The scour potential for large infrequent floods such as Tropical Storm Lee; 2) The effects of dredging the reservoir to restore sediment trapping capacity; 3) The feasibility of methodologies for moving sediment past the dam; and 4) Providing sediment discharge output to the Chesapeake Bay water quality model.

The USGS 1D model was validated based on the measured suspended sediment data below Conowingo Reservoir, and not on volumetric bed change within the upper two reservoirs. The model was adjusted to provide sediment discharge that would reflect the range of the measured concentrations below Conowingo Dam

INTRODUCTION

The Exelon Corporation is currently evaluating sediment transport through the reservoirs using an improved version of HECRAS which is fully unsteady, unlike the quasi-unsteady version of HECRAS used in the LSWRA study. The Exelon modeling philosophy is also different from the USGS effort under the LSWRA study. Whereas the USGS validated the 1D model to measured sediment discharge below Conowingo Dam, the Exelon model was validated to volumetric bed change within the upper two reservoirs, much like the earlier 1995 study conducted by the USGS. Thus, the magnitude of sediment transport throughout the upper two reservoirs during the calibration and validation simulations is based on comparison of volumetric changes in the bed and not outflow of sediment through Conowingo Dam.

The review of the modeling effort was guided by the following five questions concerning the design, construction, and application of the Exelon HECRAS model.

1. **Is the modeling approach reasonable and credible to satisfy the goals defined in the Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment?**

   Previous water quality models applied to the lower reservoir system were not movable bed models, and thus assumed the sediment and nutrients entering the upstream boundary transported through the reservoirs without interacting with the bed. The upper two reservoirs were assumed to be in dynamic equilibrium, thus assuming sediment pass through was considered a reasonable assumption. However, dynamic equilibrium suggests a long term stability of the bed (years or decades) and does not account for deposition and erosion occurring over shorter time scales. This model has the capability to account for temporal and spatial variations in sediment transport thus providing enhanced analysis capability.

2. **Do the Lake Clarke/Lake Aldred HEC-RAS Model (HEC-RAS Model) and Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Do they inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?**

   These models provide the capability to calculate a mass balance of sediment and nutrients through the reservoir system which is critical for assessing the impact of reservoir sedimentation on water quality in the Susquehanna River and ultimately Chesapeake Bay. The degree to which these models represent actual field conditions is highly dependent on input boundary condition data. Given sufficient high quality boundary condition data, the models will provide reasonable estimates of total sediment and nutrient loads throughout the reservoir system, thus providing a better understanding of how the system responds to not only average flow conditions, but also to flood events that periodically occur.

3. **Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.**

The degree of certainty of modeling results is highly dependent on measured boundary conditions. The calibration procedures for the HECRAS model were adequate given the available hydrodynamic, sediment, and bed survey data. The flow and stage data sets provided by the USGS were complete for the simulation periods. However, suspended sediment data were lacking for discharges greater than 450,000 cfs, and thus it was necessary to extrapolate the data for higher flows at the upstream boundary (Marietta). Bed sediment grain size data were adequately represented in the model for both reservoirs. However, the erosion characteristics of the mixed sediment beds in the model were not measured, and thus were highly uncertain. Periodic bed surveys in both reservoirs provided adequate trends in bed change to enable an approximate volumetric calibration.

The model results indicate the system is net depositional even for a relatively large flow event such as Tropical Storm Lee (~600,000 cfs). Erosion of the bed mostly occurred in areas consisting of primarily sand, with minimal erosion of areas consisting of a mix of sand, silt, and clay. These mixed sediment areas occurred in channel reaches with the highest velocities and subsequent bed shear for the Tropical Storm Lee event.

4. **Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?**

The model provides the Chesapeake Bay program models with an input sediment boundary condition for Conowingo Reservoir. The modeling approach was appropriate and model results reflect sorting of the bed based on the volumetric calibration. However, the potential bed scour load range due to infrequent large storms should be represented by model simulations that vary the highly uncertain bed erosion coefficients. The Water Quality models used to rout sediment to Chesapeake Bay should consider this range of scour loads in their simulations.

This modeling effort represents a significant improvement over previous efforts in terms of how the model was applied and the calibration process. The USGS 1D model developed under the LSWRA study was calibrated to suspended sediment load data measured below Conowingo Reservoir. Approximately 98 percent of the measured data represented flows less than 400,000 cfs, with less than 1 percent representing flows on the order of 500,000 to 600,000 cfs. An exponential curve fit was applied to the data for predictive purposes. The result was that for the peak flow of the Tropical Storm Lee event, very high sediment loads were predicted to be discharged from Conowingo (5 million tons per day). The 1D modeling model was then calibrated to produce this sediment load at Conowingo Reservoir. To achieve this result either significantly higher sediment discharge entered the model upstream boundary at Marietta or and/or significant scour occurred in the reservoirs. The USGS model predicted approximately twice the load delivered to Conowingo Reservoir. The Exelon model results are based on existing boundary condition data and calibration of bed change over time which is a more appropriate and meaningful approach. The Chesapeake Bay Program models should utilize the Exelon 1D model results for rating curve development below Holtwood Dam.

5. **While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.)**

   The model results are only as good as the boundary conditions used to populate the model. Additional data collection activities are underway that should provide much needed information that will improve the quality of the simulations. Additional studies should be conducted on the erosion potential of mixed bed sediments in the reservoirs. Although general data are available in the literature, it is necessary to develop site-specific erosion coefficients for each reservoir.

   The 1D model provides a useful and efficient method for evaluating sediment transport through reservoirs in series. However, these models have limitations in terms of representing flow distributions that vary laterally in channels and bed layer properties. A 2D model more thoroughly represents the physics of alluvial channels and may be more useful in evaluating site specific sediment transport.

   The sediment transport models applied to the lower Susquehanna are limited by the inflowing sediment and bed sediment erosion data available. Until more definitive data become available, model sediment load output should be presented as a range of possible outcomes based on the uncertainty of variables in the model such as erosion coefficients.

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Scott, S.H. and Sharp, J.A., 2014 (February Draft). Sediment Transport Characteristics of Conowingo Reservoir, Attachment B-2: SedFlume Erosion Data and Analysis, ERDC: U.S. Army Corps of Engineers.

2. Dr. Peter Wilcock's review of the July, 2016, draft report from WEST Consultants, Inc.

Review of: West Consultants, July 2016, *Lake Clarke and Lake Aldred Sediment Transport Modeling, Draft Report (In Progress)* for Exelon Energy Corp. Report received via email on 1 August 2016.

Review by: Peter Wilcock, Ph.D. 12 October 2016

Review Comments

West Consultants, Inc. has developed a HEC-RAS 5.0 model of sediment transport and associated morphodynamic change for Lake Clarke and Lake Aldred. The motivation underlying the modeling is to provide information on sediment flux through the reservoirs and into Conowingo Pond.

The model was calibrated for the period 2008-2013 (which includes Tropical Storm Lee). The model was then run for the period 2008-2015 to add a two-year verification period. The last two years contained no large flows. Although the absence of high flows in 2013-2015 could be argued to provide a different flow regime useful for verification, a larger issue is that the rate of sediment transport is much larger at higher flows and no verification of model performance at high flows was possible. In the end, calibration was done for the full 2008-2015 period because "an iterative calibration process was required to further balance differences between the two periods and achieve modeled volume changes within the target ranges for both reservoirs." The end result is a calibrated, but not verified model. A calibrated model is useful for the purposes defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*. In particular, the RAS model provides a physical basis for estimating sediment loadings to Conowingo Pond as a function of observed loadings at upstream gaging stations.

Calibration of the model was achieved primarily against observed changes in reservoir bed elevation. This approach was necessitated by the absence of sediment transport data at the downstream end of the model reach. The available bed elevation was limited, primarily because of the smaller number of bed observations at the earliest time period (2008). In the end, only cross sections that closely matched in space in 2008, 2013, and 2015 were used to develop the model topography. Calibration against change in bed elevation is, in fact, the most challenging and revealing basis for calibrating a morphodynamic model because successful matching of changes in bed elevation requires that all components of the model – flow, transport rate, and scour/deposition – must function well. If any part of the model is off, progressive changes in bed elevation over time will make a credible match to observations unlikely.

The selection of model parameters and functions appears reasonable and consistent. As presented, the modeled results match observed changes in bed volume remarkably well (Figures 3-9 and 3-10). However, these plots show cumulative sediment volume change summed over each reservoir as a whole, combining the scour and deposition of all individual reaches. When the cumulative sediment volume changes are examined for individual modeled reaches, the agreement is less good. The modeled change in bed volume falls outside of the estimated range of observed bed volume change in nine of 18 cases (nine modeled reaches for two time periods; Tables 3-1 and 3-2). That is, although the estimated sediment volume change in half of the modeled reaches falls outside of the observed range, positive (deposition) and negative (scour) errors tend to offset such that the overall sediment storage in each reservoir matches very well.

Application of the model as a predictive tool requires an understanding of whether the close balance between positive and negative error observed over the modeled period of 2008-2015 is likely to occur under different conditions. A reliable forecast of sediment storage and release for each reservoir as a whole is sufficient for using the RAS estimates to drive forecasts of input to Conowingo Pond. But how can one be sure that the positive and negative errors at the reach scale will continue to cancel under forecast conditions? The patterns and mechanisms of the discrepancy between modeled and observed sediment volume change is worth more careful examination in order to evaluate the forecast ability of the RAS model.

The model calibration is based on sediment volume change defined over bed areas between cross sections at which elevation change could be measured. A related but different model test would be to show the predicted vs observed bed elevations for the actual model sections. This is the actual information available to match to the model. To be precise, the model uses bathymetry developed from a "set of common cross-sections … based on those with good spatial agreement between the USGS survey and model datasets and the Gomez and Sullivan bathymetry data." It would be useful to develop plots for each of these cross-sections, with each plot showing both observed and predicted bathymetry for all three time periods (2008, 2013, 2015).

Response to Review Questions

1. Is the modeling approach reasonable and credible to satisfy the goals defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*?

The calibrated model is useful for the purposes defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*. In particular, the RAS model provides a physical basis for estimating sediment loadings to Conowingo Pond as a function of observed loadings at upstream gaging stations.

2. Does the Lake Clarke/Lake Aldred HEC-RAS Model (HEC-RAS Model) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Does it inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?

The HEC-RAS model is the best effort yet to capture the response of Lake Clarke/Lake Aldred to water and sediment supply. The spatially integrated patterns of sediment scour and deposition have an excellent match to observations. This is an important advance in understanding the sediment storage behavior of the Lower Susquehanna River Reservoir System.

3. Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.

The documented assumptions, parameter values, and function selection are within reasonable bounds. The model appears to function in a credible fashion.

4. Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?

The model provides reasonable predictions of the change in bed sediment storage. This is the appropriate information needed link upstream water and sediment input to the sediment delivered to Conowingo Pond.

5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

(1) Further exploration of model results would be useful for developing confidence in the ability of the model to forecast future conditions. Although the model shows an excellent agreement between predicted and observed bed volume change integrated over each reservoir, predicted and observed bed volume change does not match for half of the modeled reaches. A better understanding of the discrepancy between predicted and observed at the scale of local model reaches would be useful for evaluating model performance under future conditions.

(2) The HEC-RAS model predictions have uncertainty. A basis is needed for propagating that uncertainty into the model for the Conowingo Pond. How will that be done?

(3) A better explanation is needed for some of the calibration adjustments discussed in the text:

> Overall, the model initially under predicted deposition for the system as a whole, though results varied by sub-area. To increase deposition, ***the sediment loading at Marietta was increased by 2030% at various flows***. This resulted in loading values still well within the range of scatter in the observed loading, and matched the HEC-6 input values (Hainly, et al., 1995) very closely for several flows.

prw: Although within the range of scatter, not all changes to the sediment loading may be plausible. A plot of the Marietta sediment loading actually used would be useful for review.

> Finally, ***hybrid bed gradations were created for many cross-sections, with the percent clay and cohesive parameters adjusted to promote or resist scour.*** The changes were relatively small: increases or decreases in clay composition of less than 4% of the total sample, and cohesive parameters limited to the range measured in the SEDFLUME analysis of Conowingo sediments

prw: small changes in clay composition or cohesive parameters can have a large effect on transport or scour. The nature of the "hybrid" bed gradations and the adjustments in percent clay and cohesive parameters is needed.

End of Review

Peter Wilcock 12 October 2016

3. Dr. Steve Scott's review of the April, 2017 draft HDR, Inc. report titled "Hydrodynamic and Sediment Transport Analysis" authored primarily by M. Velleux and J. Halden.

Review of the Exelon Three-Dimensional Sediment Transport Model of Conowingo Reservoir

By
Stephen Scott, PhD, PE

November 21, 2016

BACKGROUND

The Exelon Corporation contracted with HDR consultants to build, calibrate, and execute a three dimensional (3D) sediment transport model of Conowingo Reservoir on the lower Susquehanna River to evaluate sediment transport characteristics of the reservoir. The model was part of a suite of models designated as the Conowingo Pond Mass Balance Model (CPMBM). This 3D model was designed to be used in conjunction with the HECRAS model of the uppermost reservoirs Lake Aldred and Lake Clark previously developed by West Consultants under contract with Exelon. These models provide a system wide approach to evaluating sediment transport and water quality issues associated with the Susquehanna River and associated reservoirs, as well as sediment and nutrient loadings to Chesapeake Bay from the river system.

INTRODUCTION

Currently, estimates of nutrient and sediment loadings to Chesapeake Bay from the Susquehanna River system are provided by HSPF, a numerical model developed by the USEPA to route sediment and nutrients through the lower Susquehanna River to Chesapeake Bay. The current version of the model is for routing only and not moveable bed sediment transport modeling, and is, therefore, heavily dependent on measured flow, nutrient, and suspended sediment concentrations throughout the Lower Susquehanna River basin. In some cases, such as the reservoirs, these data are lacking, or there are significant data gaps due to infrequent large flow events that deliver substantial wash load and bed material load to the bay. To address these empirical data gaps, the United States Geological Survey (USGS) and Exelon have initiated a comprehensive sampling program for the Lower Susquehanna. In addition to this effort, Exelon has developed a system wide approach to modeling the lower reservoirs which builds on previous modeling efforts by the US Army Corps of Engineers (USACE) and the USGS. This system wide approach includes a one dimensional model of the upper two reservoirs that provide an inflowing sediment boundary condition for Conowingo Reservoir. The models were developed, calibrated, and executed to evaluate long term simulations of bed change and sediment loading to Chesapeake Bay.

REPORT REVIEW

The review of the modeling effort was guided by the following five questions concerning the design, construction, and application of the CPMBM.

1. **Is the modeling approach reasonable and credible to satisfy the goals defined in the Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment?**

The two upper reservoirs, Lake Clark and Lake Aldred, are considered to be in dynamic equilibrium in that there is no long term sediment storage. However, Conowingo Reservoir has some sediment storage capacity remaining although it appears close to an equilibrium condition. Analysis of this type of system requires a multi-dimensional model that can evaluate both spatial and temporal sediment erosion and deposition. The CPMBM model was appropriately designed and applied for this application. The model calibration procedures were rigorous and successful given the lack of measured flow and sediment data. The model application demonstrated its usefulness as a tool for evaluating management scenarios as well as for simulating both short and long term sediment transport events. Use of this model in conjunction with the HECRAS model of the upper two reservoirs will provide the best estimate of sediment loadings to Chesapeake Bay in lieu of a substantial and complete empirical data set which is not currently available.

2. **Do the Lake Clarke/Lake Aldred HEC-RAS Model (HEC-RAS Model) and Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Do they inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?**

The system-wide modeling strategy implemented by Exelon is the correct approach to estimating sediment transport within the reservoirs and sediment loadings into Chesapeake Bay. Although suspended sediment measurements below Conowingo are available, there are relatively few data for the large flow events that not only deliver large quantities of sediments from upstream of Conowingo, but also have high potential for scouring and transporting sediments through the system. These high flow events not only change the morphology of the reservoirs but also significantly impact Chesapeake Bay water quality. The suite of models developed by Exelon provides the tool needed for better understanding the complexity of sediment transport through this system. As more and better empirical data become available, model predictions should improve accordingly. The end result is a useful tool for managing the watersheds and reservoirs and therefore can assist in determining the impacts of sediment and nutrient loads discharged into Chesapeake Bay.

3. **Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.**

The CPMBM modeling platform is well suited for modeling the lower Susquehanna River and its associated reservoirs. The construction, calibration, and application of the model represents an improvement over previous models applied to the system including the following:

-A system-wide approach with movable bed sediment transport modeling in one, two, and three dimensions

-Development of a sediment boundary condition at Holtwood Dam from fully unsteady sediment transport simulations of the upper 2 reservoirs utilizing a 1D model calibrated to historical bed change in the reservoirs

-Enhancement of the cohesive sediment transport theory in the model by incorporating the relationship between clay content, plasticity, and cohesive erosion parameters, thus augmenting the existing SedFlume data

- Development of a multi-layered bed based on historical sediment cores including coal

-Calibrated the 3D model to bed change by performing a thorough analysis of historical bathymetry surveys

-Simulated the models as one system in fully unsteady mode to evaluate both long term and short term bed change and to evaluate the capability of the model to reproduce measured bed change and sediment loads and concentrations

-Demonstrated the applicability of the model as a management tool for evaluating base versus plan type scenarios

The calibration and modeling results were good considering the lack of sediment boundary condition data and the high uncertainty of historical reservoir bathymetric surveys and cohesive sediment erosion characteristics. Model results comparing computed and measured suspended sediment concentrations were quite good considering the substantial uncertainty generally found in suspended sediment data when evaluated as a function of discharge. This was particularly evident for the Tropical Storm Lee event in September 2011 in which very high concentrations were measured (>3000 mg/l).

The long term simulations of bed change produced reasonable results in terms of reservoir annual average deposition or scour. As expected there were some differences in spatial deposition and erosion patterns when comparing the change in survey elevations to computed elevations, however, the overall sedimentation trends were adequately depicted within the inherent range of uncertainty.

4. **Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?**

To date there has been a high degree of dependency of Bay Program models on the measured data set. Gaps in the measured data, particularly for Susquehanna River flows greater than 400,000 cfs, add to the uncertainty of mass balance calculations in terms of water quality impacts to the Bay. Curve fits have typically been applied to the data to extend the measured data set for predictive purposes. These curve fits tend to be poorly correlated and may significantly over-predict loads transported to the bay for high flows.

The CPMBM model provides a more representative system-wide approach for determining a mass balance through the reservoir system utilizing unsteady non-uniform sediment transport theory. Measured suspended sediment concentrations resulting from instantaneous grab samples provide only a point in time, whereas, a properly calibrated model can provide a continuous record based on unsteady non-uniform transport of sediment. Integration of the continuous flow and concentration model output will provide the best estimate for load delivered through the system.

In lieu of a comprehensive measured data set, the output from the CPMBM model represents the best sediment boundary condition data available to the Bay models, and thus should be utilized by the models in subsequent water quality / mass balance simulations.

5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.)

The development of a calibrated movable bed sediment transport model is critical for predicting morphology change in the lower Susquehanna River and the associated reservoirs as well as determining long and short term sediment loadings to the Bay. The linked models will provide a platform for not only evaluating impacts, but running management scenarios as demonstrated in the report. The accuracy of the models is highly dependent on boundary condition data such as measured sediment concentrations and cohesive bed material erosion and deposition properties. The on-going data collection efforts are critical for both understanding how the system works and the continued improvement of the models. Currently, the CPMBM model is calibrated to the best available data. As field data collection progresses, the model should be continually updated and validated using the up-to-date boundary condition data, thus improving model prediction capability.

It is apparent from this and previous studies that further work is needed in two areas to better understand the sediment transport characteristics of the river and reservoir system. The relationship of bed sediment cohesive properties to erosion needs to be further explored. The SedFlume work as well as the clay plasticity relations presented in this report represent a good start to future studies. However, as stated in the report, there are cohesive bed sediments in areas of the reservoirs that appear to be stable even though computed shear stresses on the bed well exceed the erosion threshold. The role of bed sediment consolidation and resistance to erosion, particularly in areas that are subjected to high bed shear stresses, needs to be further evaluated. I recommend involving experts in this field of study to help design field and laboratory studies to clarify the reservoir cohesive sediment behavior and to help improve model capability in this area.

The dominant sediment process in the reservoirs is deposition. It is critical that this process be correctly represented in the models for both morphology change and mass balance calculations. All the models applied to the reservoir problem to date have had difficulty with replicating both spatial and quantitative deposition patterns. Typically, inflowing sediment size and concentration are adjusted to increase or decrease deposition when calibrating the model. Many models treat sediment as individual grains, assigning the fall velocity according to their size. In some cases, depending on the type of sediment and the settling environment, the particles may flocculate thus having a different fall velocity than the primary particle. Other factors that may influence sedimentation in the model are mesh resolution and how turbulence is represented in the model. I recommend further lab and numerical studies to improve the deposition process capability in the models.

4. Dr. Peter Wilcock's review of the April, 2017 draft HDR, Inc. report titled "Hydrodynamic and Sediment Transport Analysis" by M. Velleux and J. Halden.

Review of: HDR Consultants, April 2017, *Hydrodynamic and Sediment Transport Analyses for Conowingo Pond,* report for Exelon Energy Corp. Report downloaded 1 May 2017.

Review by: Peter Wilcock, Ph.D. 30 May 2017

Review Comments

HDR has developed a coupled hydrodynamic, sediment transport, and nutrient model, the Conowingo Pond Mass Balance Model (CPMBM) for the purpose of simulating sediment and nutrient loads. This report describes the development and performance of the hydrodynamic and sediment portions of the model. The model uses sediment inputs estimated by a HEC-RAS model of Lake Clarke and Lake Aldred developed by WEST consultants in 2016.

The hydrodynamic simulations appear to work well. The choice of model parameters (roughness, in particular) is in a reasonable range. It is, of course, much easier to accurately estimate water surface elevation than it is to estimate sediment transport and bed elevation changes. It would be surprising if the hydrodynamics worked poorly.

At the heart of the sediment transport model is a balance between rates of sediment erosion and sediment deposition. Deposition rates are based on standard fall velocities. Erosion rates are much harder to estimate for a bed containing a mixture of cohesive and cohesionless grains. The model apparently uses two different methods for estimating the boundary stress for initiating erosion (τ_{ce}) and uses a constant rate of erosion when $\tau > \tau_{ce}$. Thus, the bed in each cell erodes at a constant rate for as long as the stress exceed the critical. Although the erosion rate is surely not constant in all cells and for all flows, this assumption is simple and consistent with the available information from the SEDFLUME experiments. One might hope that a more detailed erosion rate model might be possible after effort has been made to sample and test the reservoir sediment, but I concur that this is not the case. It is preferable to have a simple model that falls within a reasonable range than to have a detailed model that provides no better (and possibly worse) estimates.

The report is generally well written and documented. The model development, calibration, and results are presented clearly, although some points of clarification would be useful.

p. 27: "Erosion thresholds were calibrated so that computed bed elevation changes over the course of the simulation were in rough agreement with spatial and temporal pattern and pond-wide average bed elevation change determined from interpolated bathymetric survey results." prw: More detail is needed here. Is this calibration for the entire model run or only for the initial time steps? What values of erosion threshold were selected in the end? Are these values different from those determined from Equations 2-16 and 3-1? In what cases?

p. 28: "Dimensionless diameters and critical shear stress values for each particle type were then determined based on effective diameter using Equations 2-15, 2-16, and 2-19." prw: I believe this should be Equations 2-16, 2-17, and 2-20. It is also not clear when 2-16 is used and when Equation 3-1 is used. Is it 2-16 always for *in-situ* material and 3-1 only for material deposited during the simulation?

p. 33: "Consequently, erosion thresholds for initial bed layers at the start of simulations were adjusted during sediment transport model calibration." Is this applied only to the surface layer, or to the full bed? What were the adjusted values for erosion thresholds? Are they in a reasonable range?

Equations 3-1 and 3-2. These relations are used to estimate τ_{ce}, at least in some cases. First, the relation between % clay and plasticity index is rather poor (Figure 7), as may be expected for cohesive sediments. Second, it is not clear when this relation is used to estimate τ_{ce}. Is it only for sediment that is deposited during the simulation? Is it also used when there is scour? Also, the reference for Jacobs et al. (2011) is not given.

p. 27: "The erosion rate used for simulations was assigned as **0.002 cm/s** (0.236 feet/hour) …"
p. 33: "Whenever the shear stress acting on the bed exceeded the critical shear stress for erosion, sediments were assumed to erode at a rate of 1.18 feet/hour (**0.01 cm/s**), which is within the range of USACE (2014) SEDFLUME results." These two sentences indicate two different values of erosion rate. Please reconcile.

The behavior of the sediment bed under scour conditions remains poorly known. This is a problem with available input rather than the model, although this problem necessarily limits the possible fidelity of any model. In the long simulation (1997-2014), 18 of the model grid cells show scour greater than 30 cm (Figure 66), which exceeds the depth of any characterization of bed behavior. In the 2008 to 2014 comparison of surveyed and simulated elevation change (Figure 69), 25 of the cells in the simulation and 56 of the cells in the observed (about one-fifth of the cells) show scour greater than 30 cm.

Response to Review Questions

1. Is the modeling approach reasonable and credible to satisfy the goals defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*?

The calibrated model is useful for the purposes defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*. The hydrodynamic and sediment transport models selected are appropriate and current; the specific model developed made effective use of the available data.

2. Does the Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Does it inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?

The model is clearly an advance over previous efforts. Previous models were limited in their dimensionality. Additional information has become available that allows for a more accurate model. This model comes much closer to matching observed changes in reservoir bed elevation than any previous model.

3. Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.

Beyond uncertainty in the estimates of the critical stress for sediment erosion, the choice of input parameters was clear and credible. The simulated sediment load at Conowingo Dam matches the USGS observations remarkably well.

4. Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?

These model results are close to the best one can hope for in terms of informing the CBP models. The simulated water and sediment flux is consistent with observations using a credible, appropriately formulated model. There will remain considerable uncertainty in the modeled results, but a better answer will not be available without extensive and long term further monitoring covering a wide range of different flow conditions.

5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

Estimating sediment entrainment. There is a need to be clearer about how values of τ_{ce} were calculated and which value of erosion rate was used. Beyond that, there is a broader need to understand how model results may be sensitive to the choice of τ_{ce} and erosion rate.

(i) a report of values of τ_{ce} and erosion rate used in the final simulation is needed, including an assessment of whether all values used are reasonable and consistent. Were the values used and the rules applied consistent across the reservoir? Did they change with time?

(ii) some estimate of the sensitivity of model results to the choice of τ_{ce} and erosion rate would be useful.

Grain Size. The model uses four grain sizes (clay, silt, sand, gravel) as well as a nominal grain size for coal. It would be useful to compare simulated *vs.* observed grain size of the sediment load at Conowingo Dam. This provides a separate basis for evaluating model performance. Similarly, it would be useful to compare the beginning and ending grain size of the reservoir bed. If the transport of different grain sizes is off, progressive sorting of the bed should show that effect clearly.

Uncertainty. The report notes that “uncertainties in flows at Holtwood contribute to uncertainties in sediment load estimates” and the “Uncertainties in SSC estimates contribute to uncertainties in sediment load estimates”. It would be useful to explore how uncertainties in the upstream boundary condition, as well as uncertainties in the bottom boundary condition for sediment erosion, may contribute to uncertainties in the simulated loads at Conowingo Dam. It would be informative to propagate uncertainty in the upstream *and* bottom boundary conditions into uncertainty in the CPMBM predictions.

End of Review

Peter Wilcock 30 May 2017

5. Dr. Damian Brady's review of the April, 2017 draft HDR, Inc. report titled "Conowingo Pond Mass Balance Model" by J. Fitzpatrick.

A Review of HDR's "Conowingo Pond Mass Balance Model"
May 2017
Damian C. Brady, Ph.D.

The review addresses the following questions:

1. Is the modeling approach reasonable and credible to satisfy the goals defined in the Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment?

Yes, there are a considerable list of limitations with this modeling framework as laid out plainly by the modelers; however, on the whole, the approach is reasonable and credible. The constraints on the model appear to be more related to boundary conditions. That is, the model is very sensitive to the upstream nutrient loading. Said upstream nutrient loading appears to have a strong flow-concentration relationship that does not exist in the available data. The only internal dynamics that appear to require some work is the settling and distribution of particulate organic matter. The model calculates a significant spatial gradient that may not reflect the data for percent sediment bed composition and may need to be revisited. Sediment transport and settling rates are notoriously difficult to calibrate. Perhaps the most relevant and interesting modeling approach is the incorporation of an archive stack that allows SFM to account for long term changes in sediment erosion and deposition. This reviewer would have liked to see the CPMBM fully coupled version run with and without this archive stacking approach to determine how necessary this aspect of the model is.

2. Do the Lake Clarke/Lake Aldred HEC-RAS Model (HEC-RAS Model) and Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Do they inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?

Yes, with the caveat that surrounding models, specifically the upstream WSM model output, would need to improve to incorporate some of the advances put forth here. Again, one way to test the importance of the advances by the HDR team would be to examine nutrient and carbon loading with and without archive stacking. Clearly, one of the major conclusions drawn from this current effort is that large resuspension events are decreasing the trapping efficiency of the reservoir system, but that most of this resuspended material is relatively inert (G3). However, it should be kept in mind (and I believe the modelers know this better than this reviewer) that the fractionation of this material is a convenient discretization and that eventually, the Bay Program would consider a more continuous solution for the issue of organic matter diagenesis. However, the answer to the question as stated: "Do they inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?" is yes because the alternative of assuming a uniform bioavailablility of resuspended sediments is clearly and oversimplification that this model solves.

3. Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.

The answer to this question is partly contained in the answers to Questions 1 and 2. However, the other large limitation is the lack of explicit processes in the water column. It would appear that there is more data in the sediments of this system than the water column which is unusual. Given these constraints, the modelers took an approach that assumes very little processing of the material within the reservoir. These assumptions are not egregious, however, it should be noted that under low flow conditions, these processes would be expected to have a large influence on the results. Because this model is focused on the potential effects at higher flows, the assumptions in the model are even more defensible. Models are at their best when they are informing the management community of data and process level gaps in our understanding. This model appears to point to a systematic assumption in the upstream nutrient loading model (concentration-flow relationship) that is undermining this downstream model. Additionally, the modelers point out the need for better information on G-partitioning, however, frankly, this reviewer contends that the G-fractioning is less an issue than upstream boundary conditions and general complexities of modeling sediment transport correctly. One last point for the modelers/Bay program to consider is more calibration of the flows at which resuspension occurs, it would appear that the model results at high flow are sensitive to this threshold and it is not clear in the modeling report how this value is determined.

4. Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?

The short answer is yes. As a reviewer I would be interested in discussing some of these results with the Bay program. How this information would be used is perhaps the better question. That is, there is an argument to be made that says these results argue that Conowingo is largely a pass through and Holtwood loading generally equals Conowingo Loading. Consistent trapping efficiency appears to result in consistent linear responses under various management conditions. Under 2011 conditions this does not hold true and so 18 year averaging may hide some of the utility of the model to capture extreme events that may have non-linear effects downstream (that is, extreme events like Tropical Storm Lee may have effects in the Bay that are not simply scaled to its effects on loading).

5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

What follows is a list of potential improvements, not necessarily crucial improvements:

1) Modeling the water column with a process based RCA-like model
2) Empirical study of the relationship between flow and resuspension in this system
3) More in depth modeling of sediment transport to homogenize organic content of the sediment to determine if the current spatial gradient is ameliorating loads to the bay by having resuspended material with high organic content far from the dam.
4) Revisiting some of the ratios and assumptions regarding the relationship between water quality parameters within the assumptions of the model: From page 8: "For PON we utilized the observed TN reported by UMCES from the flux cores (0-1 cm); due to concerns of the presence of coal in the surface sediments, for POC we multiplied the observed TN reported by UMCES from the flux cores (0-1 cm) by 8." and "In part, this is due to the "recipe" for making carbon loading and concentration estimates for CPMBM based on the USEPA WSM. The recipe, as described earlier, estimates POC eight times the WSM PON concentration. Since NOx is between a third and half of the total organic nitrogen, this limits the estimated maximum value of TC to about half of the observed value and helps explain the discrepancy in CPMBM computed TC versus the observed data." and DOP is assumed to be 22.6% of P.

One suggestion would be to allow these relationships to vary using a monte carlo approach and the observed range for Chesapeake Bay data. In some models with very quick run times like the stand-alone SFM model, this may be fairly simple, whereas in the fully coupled model, this would be more difficult.

BELOW ARE COMMENTS REGARDING THE REPORT AND SOME QUESTIONS FOR THE [our group's upcoming] JUNE1ST PHONE CALL

1. Introduction

"Has begun implementation…" should probably be "has been implementing since 19XX"
"However, the estimated dissolved oxygen…" should really not say 'over-estimate' but rather say that it may not be correctly estimating.
"Conservative approach" or perhaps more accurately, "relatively simple approach"
"...has been asked" by whom? May want to reword this.
"This assumption appeared…" under what circumstances (which model implementation? The Chesapeake Bay models?)

2. Methods
Define acronyms.
"In this application, the SFM was modified so that under the 10 cm active depth, there is an archive stack that is comprised of another one-hundred-forty 1 cm slices and a deep bed layer that is 3 meters in depth." This line is slightly confusing. 10cm plus 140*1cm slices equals 150 cm. What is meant by the 3m deep bed? Is that another 150cm? Or a stand alone layer that is about 3m deep (in reading further, I think the latter is the case, disregard).
Why no diagenesis in the deep bed?

Still not clear how the model gets deposition right...simply the deposited material in ECOMSED? (CPBMB uses a mass balance approach using the difference between the loadings in WSM to assume the rest is deposited). One suggestion might be to fit the ammonia data and compare deposition with Boynton?

DATA SOURCES AND ANALYSIS
7cm/year at the mouth of Broad Creek. Emphasizes the importance of the erosion/deposition SFM addition.
Interesting that %TN:TP ratios are so much lower than Redfield...but nitrification-denitrification could explain.

Figure 3 missing?

Missing parenthesis on page 6 after pers. comm.
Figure 6: Is it possible that there were significant vertical structure in individual cores?

Profiles not shown for NH4, SRP, and Fe but they generally increase down core.

Long cores: what did a vertical profile of pore water look like for these cores?
Negative slopes for carbon diagenesis (hypotheses?)

PAGE 7
Units on carbon-TCO2 and nitrogen-NH4? Also, nitrogen is misspelled here.

Is there a reason to discount two of the data points for nitrogen and go with 7.0e10-5/day?

PAGE 8

Be clear that TN is multiplied by 8 due to Redfield. ALthough I agree that ignoring the carbon data directly due is the right decision.
I think Figure 10/11 is mis-referenced?
Would it be possible to see the fits? And were the parameters constrained in any way?

PAGE 9
The text between Page 8 and 9 could be made more clear.
'Make a statement on how…"
"Since, the diagenesis experiments are estimating
a blended reactivity rate (i.e., a mix of G1 and G2), these results may imply that there is a
slightly greater percentage of G2 material in Conowingo Pond sediments, hence the
lower blended rate."

I wonder if one more statement regarding how these data can be used in the modeling effort would be advisable. If one is simply measuring the blend of rates, there is no way to disentangle the rates to apply to the traditional reactivity classes.

Part C on PAGE 10 - 'multiplying'

It would be useful if references were provided (or justification) for some of the assumptions on Page 10. For instance, is 22.6% a standard obtained from the literature or from an analysis of the CIMS database for the typical percentage of organic phosphorus? Overall, the process is clever and certainly useful.

Is Figure 11 mislabeled as Run 05?

PAGE 12: Deposition is still generally higher in the model than Boynton (this appears to be addressed when discussing N deposition on Figure 12). A potential question for HDR: usually Boynton's estimates are assumed to include resuspension and are therefore assumed to be higher than net deposition. If this is the case, are the estimates of deposition useful enough for this comparison?

Climatology approach: Is it worth adding a run that uses the actual temperature record for 2015? I see the generally point of the climatological runs, but interannual differences may be important to the overall mass balance, especially if management and climate are changing conditions in a non-random way. One could simply use the climatology for the entire run and then use 2015 during the last year of the SFM simulation.

PAGE 13: Comparisons look reasonable but the variability in the observed data demonstrate that if one is really trying to fit the observed data, real overlying water column conditions would be necessary. Since the goal of this project is to compute loading on the order of years-decades, I understand the reason to construct the model accordingly.

POP percentages are mentioned twice in paragraph.

PAGE 14
"A potential source of the excess inorganic P might be attributed to the deposition of
PIP." Some clarification here would be helpful. Deposition of P observable or in the model?

High variability in observed phosphorus fluxes: are they an indication of more variable DO conditions than previously thought?

PAGE 15 - by dividing EPA's loads by their estimate of flow to get concentration and then in turn using a different flow, it brings up the issue of how much flow is used by EPA to calculate concentration. A question for the group.

Are there details of how HDR calculates flow? Could be explicit about this before the RESULTS section.

PAGE 16 - I agree with the approach of performing the DO calculation to further refine which simulation (RUN 1, 2, or 3) should be used when estimating bioavailablilty ratios. But is the exclusion of photosynthesis/respiration problematic?

Top of PAGE 17 - nutrient concentration was taken from USEPA, not loading, correct?

If inflow concentration is a problem, does this only happen at high flows? And in turn, is that due to the flow-concentration relationships in WSM?

Ultimately, the relationship between flow and concentrations is a linear positive one according to the model and not in the data. This contributes to the mismatch in phosphorus loading. But can we trust that the data is adequate to conclude that there is no relationship between flow and concentration?

PAGE 19 - change the use of the word 'recipe'

PAGE 20 - 'will focus' changed to 'focused'

PAGE 21 - Label the section where discussion will follow for the reader's benefit.

PAGE 22 - Figure 50 - it is not clear if this is data or a model. If it is a model, then the resuspension under flow is a function of a parameter, correct?

PAGE 23 - How were management scenarios chosen? A 10.5% reduction seems very specific.

PAGE 24 - are the figure references correct here?

6. Dr. James Martin's review of the April, 2017 draft HDR, Inc. report titled "Conowingo Pond Mass Balance Model" by J. Fitzpatrick.

Peer Review:
Conowingo Pond Mass Balance Model
Exelon Generation Company, LLC

April 2017

By:

James L. Martin, Ph.D., P.E., D. WRE, F. EWRI, F. *ASCE*

26 May 2017

General Charge and Limits of the Review

Exelon Generation Company, LLC (Exelon) submitted in January 2016 the "Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment." That proposal outlined studies to be conducted in support of the 2017 Chesapeake Bay Total Maximum Daily Load Midpoint Assessment. Included in that proposal was the development of the Conowingo Pond Mass Balance Model (CPMBM). The (CPMBM) was intended to allow for an improved evaluation of the extent to which changes in sediment storage and nutrient bioreactivity within the Pond affect sediment and nutrient delivery to the Bay. That model was subsequently developed by HDR on behalf of Exelon and under management of Gomez and Sullivan Engineers, D.P.C. and consisted of coupled hydrodynamic, sediment transport, sediment nutrient flux and water quality mass balance models for Conowingo Pond. In addition to the model development, four external reviewers were selected through and in coordination with the Chesapeake Research Consortium (CRC) to provide independent reviews of the model enhancements.

The results of that model development are described in two reports produced in April 2017: "Conowingo Pond Mass Balance Model" and "Hydrodynamic and Sediment Transport Analyses for Conowingo Pond." The charge for this review was limited to the sediment nutrient flux and water quality mass balance model for Conowingo Pond model.

Overview and General Comments

The following represents this reviewers understanding of Conowingo Pond Mass Balance Model based on the subject report and prior information provided to facilitate the model development and review.

Data Sources and Analysis

This section of the report provided the results on an in-depth review of historical sediment data as well as the University of Maryland Center for Environmental Science (2015-2016) field and laboratory measurements. These data were used for model evaluation. In addition, the analysis of N was used to estimate diagenesis rates for G3. Commonly in diagenesis applications the diagenesis rate for G3 is assumed to be zero, but a non-zero rate was believed more reasonable for an application in which diagenesis of relatively deep sediments (with large G3 fractions) will be considered. This analysis was presented to the independent reviewers earlier in the study who agreed with the approach (e.g. memo dated 9 November 2016).

Model Overview

The CPMBM was based on existing and widely accepted models which were applied by a highly respected and experienced modeling team. The hydrodynamic and sediment transport studies were based on the ECOM (Estuarine, Coastal, and Ocean Model) hydrodynamic framework along with its integrated SEDZLJS (SEDiment dynamics by Ziegler, Lick, Jones, and Sandford) sediment transport module, together referred to as ECOMSED. The application of ECOMSED is described in the report "Hydrodynamic and Sediment Transport Analyses for Conowingo Pond." For the water quality mass balance model, ECOMSED provided the morphometry, changes in water elevation, advective flows and mixing. ECOMSED also provided changes in bed elevation based on deposition and erosion of sediments.

The water quality mass balance model was based on the Row, Column, and Advanced Ecological Simulation Program (RCA; Row-Column AESOP) water quality model developed by HDR. The RCA is a generalized water quality model capable of simulating the fate and transport of conventional and toxic pollutants in surface waters. For conventional pollution, state variables in RCA include dissolved oxygen, various forms of phytoplankton, dissolved inorganic nutrients, particulate organic nutrients, dissolved and particulate organic carbon.

RCA also includes a nutrient flux submodel developed for the USEPA Chesapeake Bay Program (DiToro and Fitzpatrick 1993) which simulates the deposition of organic matter to the sediment bed, the sequent diagenesis or decomposition and burial of this organic matter, and the resulting end-products of sediment oxygen demand and inorganic nutrient flux. The sediment flux model was originally described in Di Toro et al. (1990) and is also described in Di Toro (2001), Brady et al. (2013) and Testa et al. (2013). Versions of the sediment diagenesis submodel have also been incorporated into a variety of other models, such as the CE-QUAL-ICM, WASP, QUAL-2K and others.

The sediment flux (diagenesis) model (SFM) subdivides particulate organic matter (POM) into G classes, including G1 (labile; half-life of weeks to months), G2 (refractory; half-life on the order of a year), and G3 (inert components). The SFM model is driven by the flux of particulate organic matter (POM) from the water column in the form of carbon, nitrogen and phosphorus (PON, POC, and PON) were the POM is subdivided into G1, G2 and G3 fractions based on an assumed reactivity (e.g. typically assumed to be 65 % labile or G1). Based on POM decomposition (diagenesis) in the sediments and anaerobic processes (nitrification, methanogenesis, etc.) the sediment model computes the distribution of POM among G classes as well as dissolved materials, which along with water column dissolved oxygen and dissolved nutrient concentrations are used to compute sediment oxygen demand and nutrient fluxes between the water column and sediment layer.

The original SFM (DiToro and Fitzpatrick 1993) was based on assuming a relatively thin (oxic) surface layer overlaying a somewhat thicker (approximately 10 cm) anaerobic sediment layer. That construction was adequate for the purpose of predicting sediment oxygen demand and nutrient fluxes. However that construct could not be used to predict the impact of deposition on the spatial distribution of POM in the sediments or scour on the sediment distribution and flux of sediments to the water column. Since the prediction of the deposition and scour of POM was a major goal of this study, HDR modified the SFM to include a “stack” of a series of layers (140 layers each 1 cm in thickness) overlying a deep bed layer (3 meters in depth). The construct was based on an existing sediment bed framework widely used in the toxicant model. The revised construct allowed estimation of the G-class distribution of POM and dissolved nutrients in each layer as well as the impact of the deposition and erosion of sediments (based on ECOMSED predictions). That modification allowed, for example, the prediction of the G-class composition of scoured POM which was critical to meet the objectives of this study. The modification is also considered to be a significant advancement in the SFM.

In addition to the coupled RCA and SFM, a stand-alone version of the original SFM was used in the analysis of historical data and data collected as part of this study. The stand-alone model did not include the impact of scour.

Model Application

As this reviewer understands it, the model construct was designed largely to address two major questions:

- What is the reactivity (e.g. G1, G2, G3 carbon, nitrogen and phosphorus) of the material being scoured from the sediment bed and entering the water column?
- What is the composition (G1, G2 and G3 carbon, nitrogen and phosphorus) of the scoured nutrients entering the water column in Conowingo Pond and being transported out of Conowingo Pond into Chesapeake Bay?

As described above, ECOMSED provided the morphometry, changes in water elevation, advective flows and mixing to RCA. ECOMSED also provided the rates of scour and deposition. Nutrient loadings entering Conowingo Pond were based on estimates from the watershed model (Phase 6, Beta 2) modified for Holtwood based on a computed flow balance from ECOMSED along with estimates of nutrient loads from ungauged sources. The ECOMSED application included inflows and the operation of the dam, which allowed variations in the water surface to be used as a check on mass balance. That analysis indicated that the inflows had to be recomputed to ensure a mass balance, which is not unusual in reservoir modeling studies.

The first model application was based on the stand-alone SFM. The boundary conditions for the application were based on the Chesapeake Bay watershed model (Phase 6, Beta 2) for Holtwood Dam (Lake Aldred), Muddy Creek, Broad Creek and Conowingo Dam (Conowingo Pond). For application in th stand-alone SFM these boundary conditions were converted to model input using the protocol developed for the Chesapeake Bay Program by Carl Cerco for use in the stand-alone SFM. As noted later (3.2 Calibration to Storm Event Data) the fractional split, such as between dissolved and particulate ON, were held constant regardless of flows (assumed 60% dissolved for the case of ON). The G-class splits (G1, G2, and G3) for phytoplankton were assigned based on DiToro and Fitzpatrick (1993), while the G-class splits for non-phytoplankton POM were estimated by model calibration (using the stand-alone SFM). However, as indicated, and given the lack of a multi-year calibration flux data set, there was some uncertainty as to which of the G-fraction splits provided the best calibration.

For the CPMBM the loads were first converted to concentrations and then applied with the revised flows (assumed by this reviewer to apply to all inflows) to compute loadings to Conowingo Pond, since the flows used (based on ECOMSED) varied from those from the Chesapeake Bay watershed model. It is also assumed by this reviewer that the protocols and splits as developed and tested, using the stand-alone SFM model (described above), were also utilized on the CPMBM.

Although RCA is capable of advanced eutrophication simulation, for this application water column nutrients were treated as non-reactive (conservative) and subject only to transport (advection and mixing) and settling. An exception was dissolved oxygen (DO) and aqueous CH_4, where CH_4 oxidation represented a loss of DO in the water column. DO reaeration was also included. Predicted DO was then be checked against observations as an additional check of the application. The general approach was discussed during the course of the independent review process and is considered reasonable given the retention time of the system, lack of available water quality data in the surface water, and goals of the study.

The evaluation of the model application was based on comparing predictions to observations below the dam and in the sediment bed. The stand-alone model was first used while the ECOMSED model was in development. In the bed, comparisons were only made for nitrogen and phosphorus. Comparisons with carbon fractions was problematic due to the presence and influence of coal. The model was run over an 18year period from 1997-2015. Comparisons between observations and predictions were reasonable considering the lack of data to drive the model. Two management scenarios were then run to determine the impact of load variations on C, N, and P exported or trapped in the reservoir.

Reviewer Responses to Peer Review Questions

1. **Question**: Is the modeling approach reasonable and credible to satisfy the goals defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*?

   Response: Yes.

   In the above cited proposal the stated goal was to “enhance and complement the existing Phase 6 HSPF Watershed Model (HSPF) as well as the inputs to the Bay Water Quality and Sediment Transport Model (WQSTM).” To accomplish that goal, a two phased plan was developed, one phase of which was to develop a “coupled hydrodynamic, sediment transport, sediment nutrient flux and water quality mass balance model for Conowingo Pond – the Conowingo Pond Mass Balance Model (CPMBM).” As stated in the proposal this “model will allow for an improved evaluation of the extent to which changes in sediment storage and nutrient bioreactivity within the Pond affect sediment and nutrient delivery to the Bay. The output from this model combined with the results of the UMCES biogeochemical experiment being conducted as part of the Integrated Monitoring Program will allow for improved inputs to the WQSTM.”

   This review dealt only with the water quality mass balance model (CPMBM), one component of the second modeling phase. That model was linked to the hydrodynamic model, which provided morphometric and transport information (advection, mixing). The sediment transport model provided erosion and sedimentation. The water quality portion of the model considers the fate and transport of dissolved and particulate nutrients within Conowingo Pond and its sediment bed. A key component of the water quality model was a sediment flux model enhanced to allow prediction of sedimentation and scour. That modeling system, along with data from the UMCES study, was used to develop estimates of the magnitude and composition of exports from the Conowingo Pond and the reactivity or those exports, in completion of the stated goals of the study.

2. **Question**: Does the Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Do they inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?

   Response: Yes

   The CPMBM effort produced a number of results/products that should be of added value, including:

   - The data provided by the University of Maryland Center for Environmental Science (2015-2016) field and laboratory measurements conducted with funding provided by

Exelon and under management of Gomez and Sullivan Engineers, D.P.C. These data should contribute to the understanding of the sediments and sediment dynamics in the Conowingo Pond.

- The information generated in the development and through application of the CPMBM, including:
    - An analysis of flows in order to achieve a water balance (from ECOMSED).
    - An analyses of the UMCES data and development of estimates of diagenesis rates.
    - An analysis of nutrient inputs entering Conowingo Pond from its upstream boundary from the USEPA CBP watershed model.
        - An analysis of the protocol used to partition those loads among model fractions (e.g. between dissolved and particulate ON).
        - An analysis of the G-class distribution of particulate-phase nutrients delivered to the Pond from the USEPA CBP watershed model.
    - An analysis of the confounding impacts of coal.
    - An analysis of spatial variations in Conowingo pond (e.g. decrease in sediment C, N, P along the length of the pond).
    - An analysis of the availability and quality of water column nutrient data in the surface water and sediment bed of Conowingo Pond.
    - Relationships between loads and nutrient exports from Conowingo Pond as a function of flow (e.g. such as during scour events).
    - An analysis of the nutrient trapping efficiency of Conowingo Pond (and changes in that efficiency with time and flows; e.g. maximum output/input about 2.5 during 2011).
    - The G-fractions for exported POM and changes in those fractions as a function of flow (e.g. higher G3, lower G1 and G2, during higher flows).

- The development of a suite of models which could and should be used and refined in subsequent studies as data become available to provide improved information to the watershed and bay models.

3. **Question**: Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.

Model Assumptions

The models used in this study included ECOMSED, RCA (along with the coupled sediment flux model) and a stand-alone version of the sediment flux model. All of these models have all been widely used and accepted, so there was little reason to question the models or assumptions on which they were developed.

Then assumptions with regard to the HDR application include the grid geometry, inflows, dam controls (outflows), and sediment parameters discussed and reviewed separately. For the water quality mass balance model, the major assumption was that nutrients (dissolved and particulate) and phytoplankton acted as conservative materials, only subject to transport and settling. The exceptions were dissolved oxygen (subject to reaeration and depletion via methane oxidation) and methane (subject to oxidation). Given the residence time of the system and lack of data to support a more detailed eutrophication model, these assumptions seem reasonable.

Model Input

<u>Constants and Coefficients</u>

The number of model input parameters was limited. The water quality mass balance model was driven by the hydrodynamic and sediment transport model, evaluated elsewhere. The linkage between the transport and RCA model is well established and has been used and tested in a wide variety of applications. Although the water quality model is capable of advanced eutrophication simulations, for this application simulated water quality constituents were only subject to transport and settling. Therefore, the only major input to the water column portion of the water quality mass balance model were the settling coefficients. The settling rates were based on a weighted-average of the clay and silt settling velocities provided by the sediment transport model, which seems reasonable. However, as noted in the water quality mass balance report, the settling rates resulted in excess settling in the upper portion of the pond, and hence while reasonable are a source of predictive uncertainty.

The majority of the input constants and coefficients impacting the water quality mass balance model were associated with the sediment flux model, both standalone and coupled with RCA. The sediment flux model requires specification of a relatively large number of rates and coefficients. However, the majority of these are considered constants and typically not altered in model applications (with possible exception of partition coefficients for phosphorus and a limited number of other coefficients). QUAL2K for example, does not allow user access to the rates and coefficients for the sediment flux model. The HDR modelers are also expert in the development and application of the sediment flux model. Therefore the assumptions and input for the sediment flux model are considered appropriate. One exception was the computation of the diagenesis rate of G3, commonly assumed inert with a decomposition rate of 0. However, since this application included deeply buried sediments it was reasonable to assume that a rate term should be utilized, which was derived from an analysis of the UMCES data.

Model Parameters

Driving factors for the model application included flows and boundary conditions (or loads). A flow balance was achieved by the ECOMSED model, which adds some confidence to the flows. The nutrient and phytoplankton (as C) loads were obtained from the CB watershed model. While the only reasonable alternative, there was no way to test the inputs other than through their impact on reservoir exports and sediment concentrations.

In addition to estimates of external loads/concentrations, estimates were also required for converted the watershed model outputs to the forms of inputs simulated by the water quality mass balance model. The estimates were based on the protocols developed for the Chesapeake Bay model, which was reasonable. However, as stated in the CPMBM report, some of the ratios held constant should probably have been varied as a function of flow.

Finally, for external loads/concentrations, estimates of the split of the organic materials among G-classes was required. For phytoplankton, the estimates were based on commonly used values as originally proposed by DiToro and Fitzpatrick (1993). For non-phytoplankton OM, the splits were based on calibration using the stand-alone sediment flux model, which seemed reasonable.

Model results

The determination of whether model performance is "reasonable" and the confidence that can be placed in model predictions is typically assessed by qualitative and quantitative statistical comparisons of model predictions and observations as described by Fitzpatrick (2009) in "Assessing skill of estuarine and coastal eutrophication models for water quality managers." The operative phase in this review question is "Given the data which were available to the modelers." In this application, these comparisons were largely not possible due to the paucity of water quality data. For surface waters quality data were limited to temperature and dissolved oxygen data collected by Exelon during 1998-2000. Sediment data were limited to data collected by SRBC in 2000 and UMCES field efforts, both of which exhibited considerable spatial and sample variability. Model comparison were then limited to comparisons with the sediment data and observed water quality in the reservoir outflows from the USGS gaging station (USGS 01578310) located just downstream of the Conowingo Dam. As a result the evaluation of the application and reasonableness of predictions has to be based more on a qualitative assessment. Confidence in the models and modelers lends credence to the model results, as well as hopefully the external expert reviews. Given the limitations of the model, as described in the Summary and Conclusions (Section 6), the CPMBM results are reasonable and support the stated conclusions.

4. **Question:** Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?

Response: Yes

See response to questions 2-3

5. **Question:** While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

   Response:

   The CPMBM modeling framework is considered adequate given the goals of this study, particularly with the addition of multiple layers to the sediment flux model. No major deficiencies or improvements in the model structure (ECOMSED, RCA with the sediment flux model, or the stand-alone SFM) were noted. One improvement of the sediment flux model that could be considered would be the inclusion of iron as a state variable, along with iron speciation in order to more realistically capture the impacts of phosphorus sequestration in iron rich sediments.

   The primary limitation of the model application to this study and potential future studies are the data that were available to drive the model and to evaluate model predictions, both in the water column and bed. Given the relative importance of the export from this system the paucity of data available in Conowingo Pond is surprising to this reviewer. The development and implementation of a detailed monitoring plan to support further model development and application and the use of these data and models to develop a further understanding the processes in the Conowingo Pond and impacting its exports is recommended.

Responses from the Modeling Team

The Exelon modeling team's responses to the reviewer reports and comments are provided in this section. As of August 2017, these reviewer reports are also available for download at the following web site <http://www.chesapeake.org/conowingo_model/responses.html>. The three documents can be found on the following pages, in the order listed below:

1. WEST Consultants, Inc. Response to Comments from Dr. Scott
2. WEST Consultants, Inc. Response to Comments from Dr. Wilcock
3. HDR, Inc. Response to Comments from Drs. Brady and Martin

1. WEST Consultants, Inc. Response to Comments from Dr. Scott

Responses to Steve Scott's Comments Made November 21, 2016 on WEST Draft Report from July 27, 2016

<u>Question 1</u>

No response needed.

<u>Question 2</u>

No response needed.

<u>Question 3</u>

Scott Comment:
The degree of certainty of modeling results is highly dependent on measured boundary conditions. The calibration procedures for the HECRAS model were adequate given the available hydrodynamic, sediment, and bed survey data. The flow and stage data sets provided by the USGS were complete for the simulation periods. However, suspended sediment data were lacking for discharges greater than 450,000 cfs, and thus it was necessary to extrapolate the data for higher flows at the upstream boundary (Marietta). Bed sediment grain size data were adequately represented in the model for both reservoirs. However, the erosion characteristics of the mixed sediment beds in the model were not measured, and thus were highly uncertain. Periodic bed surveys in both reservoirs provided adequate trends in bed change to enable an approximate volumetric calibration.

The model results indicate the system is net depositional even for a relatively large flow event such as Tropical Storm Lee (~600,000 cfs). Erosion of the bed mostly occurred in areas consisting of primarily sand, with minimal erosion of areas consisting of a mix of sand, silt, and clay. These mixed sediment areas occurred in channel reaches with the highest velocities and subsequent bed shear for the Tropical Storm Lee event.

Response:

1) "…However, suspended sediment data were lacking for discharges greater than 450,000 cfs, and thus it was necessary to extrapolate the data for higher flows at the upstream boundary (Marietta)…" *This is true. Extrapolation was performed using a best fit line, sensitivity to sediment loading was performed prior to calibration, and the overall sediment loading curve (amount and gradations) was adjusted as part of the calibration process.*

2) "The model results indicate the system is net depositional even for a relatively large flow event such as Tropical Storm Lee…" *Evaluation of net system mass change is dependent on the time window. The reviewer's comment is correct for the time window encompassing the entire storm but seems to imply that the modeled system never experienced negative net mass change. This is not the case. The modeled system was net depositional during the rising and falling limbs of TS Lee, but experienced net scour near the peak of the storm hydrograph. The model predicted negative net system mass change during the portion of the hydrograph above ~575,000 cfs on the rising limb and above ~640,000 cfs on the falling limb (at Marietta), a condition which lasted for a period of about 19 hours.*

3) "Erosion of the bed mostly occurred in areas consisting of primarily sand, with minimal erosion of areas consisting of a mix of sand, silt, and clay. These mixed sediment areas occurred in channel reaches with the highest velocities and subsequent bed shear for the Tropical Storm Lee event. *It is unclear where the reviewer's information about the sediment mixtures associated with the areas with the greatest modeled velocities came from the WEST model or from other sources. While it is true that the sand size class accounted for most reservoir mass change during Tropical Storm Lee, which suggests that areas of the bed with a greater proportion of sand experienced more scour overall during that event, the median grain size (D50) of the cover layer at each cross section was not well correlated with the modeled velocity at the peak of TS Lee.*

Some bed sediment mixtures varied considerably throughout the simulation, and the state of the bed at a given location often dictated its response to a particular storm event. Figure 1 compares discharge with the modeled D50 of the cover layer for a cross section a short distance downstream of Pequea Creek in Lake Aldred for part of the simulation period. The location was chosen due to the presence of very coarse sands and even some fine gravel at the beginning of the simulation, which makes changes in the D50 more distinct. The plots show the D50 fining during periods of low to moderate flows (there's little change at very low flows) and coarsening during periods of larger flows as finer size classes are selectively scoured. The cross section experienced three other storm events of around 300,000 cfs or greater during the year leading up to TS Lee, so the bed was already very coarse when Lee occurred. If the modeled sediment mixture varied so significantly for a single cross section over the course of the simulation, and responded differently to changes in velocity and shear stress depending on the pre-storm bed state, it is probably not advisable to draw general conclusions about the relationships between bed sediment mixtures and hydraulic factors based on TS Lee alone. (Also, this armoring may have limited scour during the event, again illustrating the sensitivity of net mass change during large storms to bed state.)

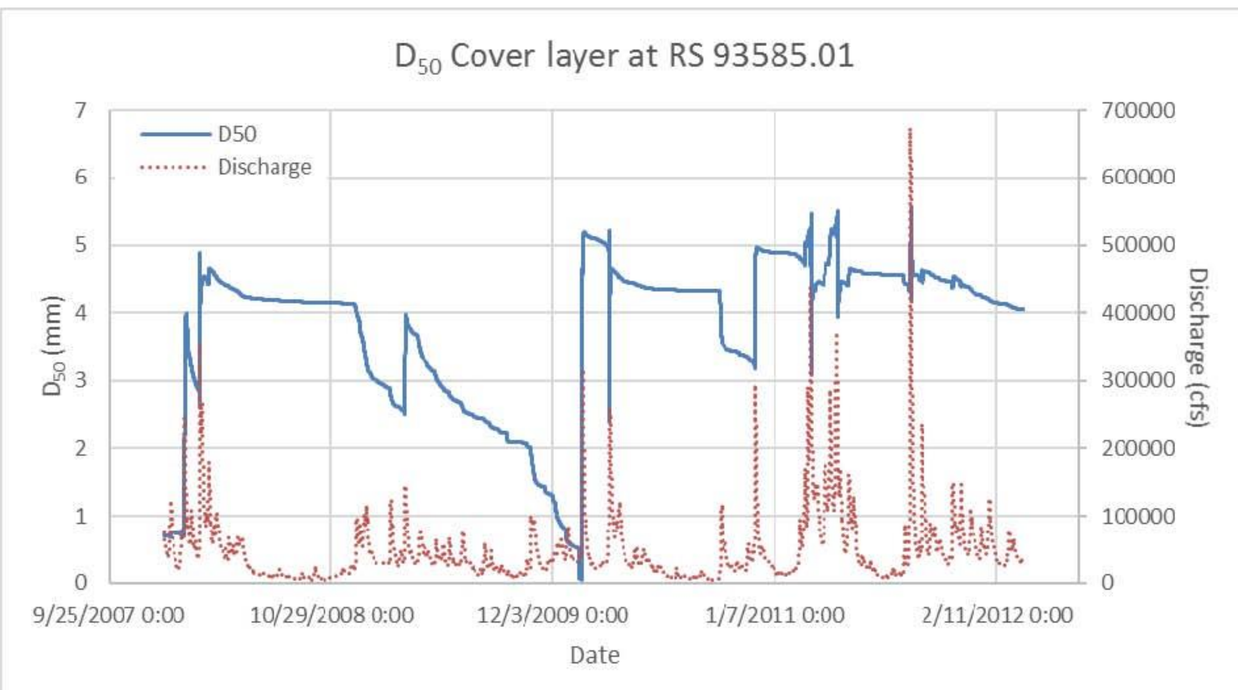


Figure 1

Question 4

Scott Comment:
The modeling approach was appropriate and model results reflect sorting of the bed based on the volumetric calibration. However, the potential bed scour load range due to infrequent large storms should be represented by model simulations that vary the highly uncertain bed erosion coefficients. The Water Quality models used to rout [sic] sediment to Chesapeake Bay should consider this range of scour loads in their simulations.

Response: We agree that users of the modeled results should consider ranges of scour loads for given discharges, given both the uncertainty in the model inputs and the variation in the modeled results based on factors such as reservoir bed state. While there is uncertainty in the selected cohesive bed parameters, their values were carefully selected within a reasonable range as part of the calibration and verification process. Varying them and re-running the model would certainly affect the resulting output loads, but it would also mean that the model would no longer be calibrated to bed volume change.

Question 5

Agree with comments, no response needed.

2. WEST Consultants, Inc. Response to Comments from Dr. Wilcock

Responses to Peter Wilcock's Comments Made October 12, 2016 on WEST Draft Report from July 27, 2016 [Taken from document dated 11/8/2016 from West Consultants]

Page 3

Comment: Further exploration of model results would be useful for developing confidence in the ability of the model to forecast future conditions. Although the model shows an excellent agreement between predicted and observed bed volume change integrated over each reservoir, predicted and observed bed volume change does not match for half of the modeled reaches. A better understanding of the discrepancy between predicted and observed at the scale of local model reaches would be useful for evaluating model performance under future conditions.

Response: General trends are already described in the sensitivity analysis as are the actual modeled volume and target range values. A detailed analysis of the sub-areas is probably not warranted, especially when the most likely cause is simply an inability of the 1D model to replicate 3D hydrodynamics within the system.

Page 3

Comment: The HEC-RAS model predictions have uncertainty. A basis is needed for propagating that uncertainty into the model for the Conowingo Pond. How will that be done?

Response: This is certainly an important question; however, it is probably beyond the scope of our project to comment on the specific use of the outputs in other models. We suggest that HDR, the Chesapeake Bay Program, and other users include this type of analysis based on the way they use the outputs (e.g. sediment rating curves vs. hourly loading time series) from the HEC-RAS model.

Page 3

Comment: A better explanation is needed for some of the calibration adjustments discussed in the text:

"***Overall, the model initially under predicted deposition for the system as a whole, though results varied by sub-area. To increase deposition, the sediment loading at Marietta was increased by 20-30% at various flows. This resulted in loading values still well within the range of scatter in the observed loading, and matched the HEC-6 input values (Hainly, et al., 1995) very closely for several flows."***

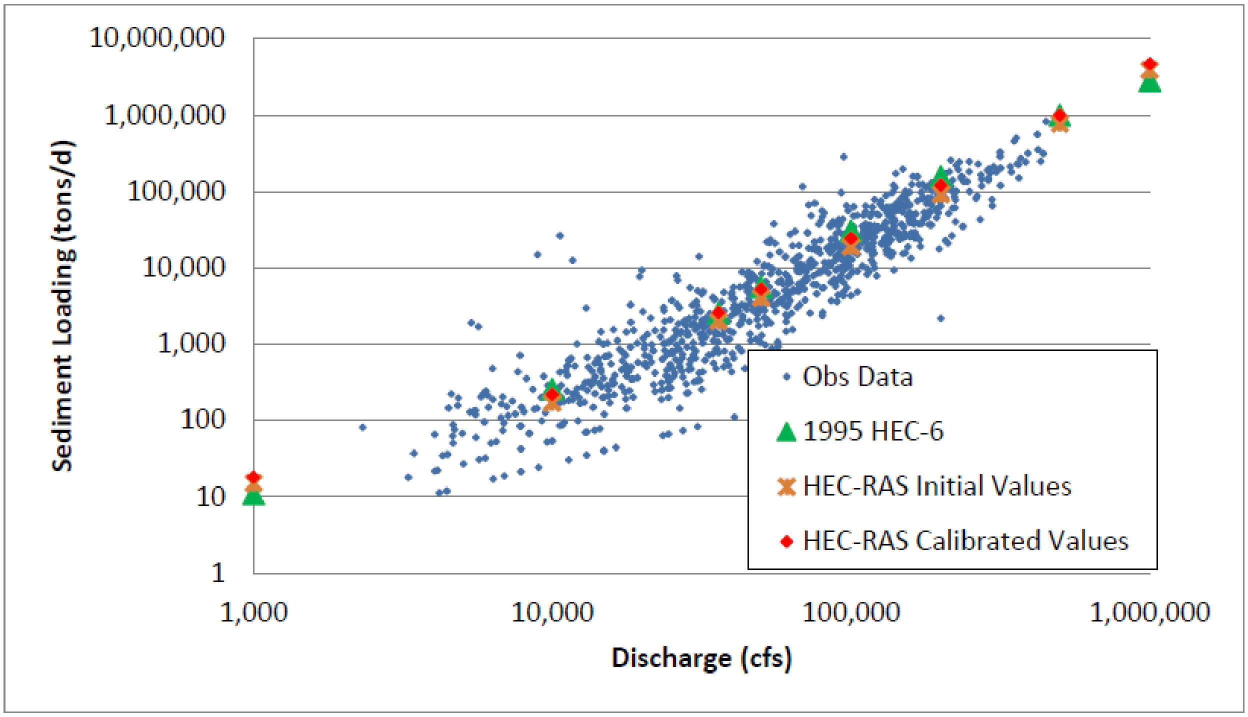
prw: Although within the range of scatter, not all changes to the sediment loading may be plausible. A plot of the Marietta sediment loading actually used would be useful for review.

Response: The report draft was updated to reflect this suggestion. The scatter plot showing the rating curve fit to the observed data was moved from the model development section to the calibration section (3.2.3), and the highlighted sentences were added to the paragraph in question:

"Overall, the model initially under predicted deposition for the system as a whole, though results varied by sub-area. To increase deposition, the sediment loading at Marietta was increased by 20-30%

at various flows. This resulted in loading values still well within the range of scatter in the observed loading. Figure 3.9 shows a logarithmic plot of sediment load by discharge at Marietta, and presents a comparison of the final rating curve used in the calibrated model with the initial rating curve fit to the observed data and the rating curve used in the HEC-6 model by Hainly et al. (1995)."

[Ed: The referenced Figure 3.9 is provided below.]



The final loading values are included in Appendix B; we feel these together provide adequate explanation.

<u>Page 3</u>

Comment: Small changes in clay composition or cohesive parameters can have a large effect on transport or scour. The nature of the "hybrid" bed gradations and the adjustments in percent clay and cohesive parameters is needed.

Response: The original and hybrid bed gradations and corresponding cohesive parameters are included in Table 2-3 and Appendix B. The verification section (3.3) states this, and we didn't feel it was logical to reference the final values prior to detailing additional changes made during the verification process.

3. HDR, Inc. Response to Comments from Drs. Brady and Martin

HDR

RESPONSIVENESS SUMMARY: CONOWINGO POND MASS BALANCE MODEL PEER REVIEW

Exelon Generation Company, LLC
300 Exelon Way
Kennett Square, Pennsylvania

June 2017

Responsiveness Summary: Conowingo Pond Mass Balance Model Peer Review

As part of the overall model development and application process, the hydrodynamic and sediment transport and nutrient transport components of the Conowingo Pond Mass Balance Model (CPMBM) were subject to peer review and critique by an external review panel. The peer review panel was comprised of the following expert panelists:

- Dr. Steve Scott (University of Mississippi), hydrodynamics and sediment transport
- Dr. Peter Wilcock (Utah State University) , hydrodynamics and sediment transport
- Dr. Damian Brady (), nutrient transport
- Dr. James L. Martin (Mississippi State University), nutrient transport

The panel was charged with addressing the following questions as part of their review and critique:

1. Is the modeling approach reasonable and credible to satisfy the goals defined in the Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment?
2. Does the Conowingo Pond Mass Balance Model (CPMBM) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Does it inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?
3. Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.
4. Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?
5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

Panelist comments and questions, responses to them, and subsequent modifications to the CPMBM reports are tabulated in the responsiveness summary that follows.

ID	Reviewer	Comment/Question	Response	Action/Revision
1	S. Scott	I have a question about the simulated bed elevation change for the long term and short term simulations. I assume the long term simulations begin with the 1997 bathymetry and the short term simulations start with the 2008 bathymetry.	The bed elevation initial conditions for long-term and short-term simulations are always "measured" conditions, where "measured" means that we spatially interpolated discrete bathymetric measurements over the model grid. Thus, long-term model runs start with spatially interpolated elevations from the 1996 survey and short-term runs start with spatially interpolated elevations from the 2008 survey. The only differences between long-term and short-term model set-ups are: (1) the long-term starts in January 1997 with initial bed elevations defined from a spatial interpolation using 1996 bathymetric survey (which provides data for the area from approximately Muddy Creek to Conowingo Dam); and (2) the short-term model starts in January 2008 with initial elevations defined from a spatial interpolation using the 2008 bathymetric survey (which, relative to the 1996 survey, provides more data for the area from Muddy Creek to Conowingo Dam).	No further action required
2	S. Scott	Figures 63 and 67 detail results for the long term simulations for the 2011 year and 2008 to 2011 year. The net elevation change for these simulations is -3.43 and -1.03 respectively. I assume that the change in bathymetry for 2011 and between 2008 and 2011 is based on changes relating back to 1997. I assume the	Figure 63 is part of the sequence that shows cumulative and annual bed elevation for the long-term model. The simulated cumulative change is the model result at the end of 2011 minus the model condition at the start of the run in 1997.	No further action required

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
		short term simulations begin with the 2008 bathymetry. Is this the 2008 survey bathymetry or the 2008 bathymetry taken from the long term simulation relating back to 1997?	The simulated annual change is the model result at the end of 2011 minus the model result at the start of 2011. The simulated annual bed elevation difference for 2011 was -3.43 cm. Please note that the bed area involved is the entire model domain. Figure 67 presents a comparison of the differences between spatial interpolations for two bathymetric surveys (left panel) and the difference between long-term model results for the corresponding timeframe (right panel). The long-term simulation began in 1997. The difference displayed on the right panel is the simulation result at the end of 2011 minus the simulation result at the start of 2008. The simulated difference over those 4 years is -1.03 cm. Please note that the bed area being involved is limited to the area surveyed (Muddy Creek to Conowingo Dam). [See discussion of Figures H-4 and J-1 below.]	
3	S. Scott	Figures H-4 and J-1 show the short term simulations for year 2011 and 2008-2011. The net bed elevation change for these simulations is -8.69 and -7.4 respectively. I do not understand why there is more scour for the short term simulation for 2011 than for the long term simulation of 2011. I assume all model parameters remain the same, why the difference? Also, the model bed area is smaller for the long term simulation than for the short term simulation. The only reason I can think of is that the 2008 bathymetry from the long term	With respect to Figures H-4 and J-1, the stated bed surface areas differ because two different types of comparisons are made. In Figure H-4, simulation results (in both panels) are shown for the entire model domain, with the left panel being the cumulative result and the right panel being the annual result. In Figure J-1, a comparison is made between differences in spatially interpolated bed elevations	No further action required

ID	Reviewer	Comment/Question	Response	Action/Revision
		simulation indicated increased depth in the lower 3 miles of the reservoir (deposition rate lower in that area) thus lower shear stresses in 2011, and for the short term simulation the 2008 bathymetry from survey was used and the lower 3 miles had more deposition (shallower) and bed shear stresses were higher thus more erosion in 2011. Please clarify.	over time (left panel) and simulation results for the same timeframe (right panel). The type of comparison shown in Figure J-1 is necessarily limited to the area where bathymetric data were collected and interpolated. Please note that when bathymetric interpolations and model results are compared, the area upstream of Muddy Creek is shown as "white" because year-by-year bed surveys did not occur upstream of Muddy Creek. With respect to net bed elevation differences between the long-term and short-term models, there at several factors at play that include: • Long-term and short-term model parameterizations are identical other than for the difference in initial bed elevations. Thus, initial conditions for bed composition (the grain size distribution in each bed layer of each grid cell) and initial erosion resistance conditions are also identical. • The way SEDZLJS works, and given our customization so that tau critical is a function of clay content (as a surrogate for plasticity index), the erosion resistance of the bed can change over time. Those changes in erosion resistance include changes attributable due to the accumulation of sediment	

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
			layers over the course of a simulation, differences in clay content that evolve over time (relative to the initial condition), and the shear stress exposure history of the bed. The shear stress exposure history is itself influenced by water depth and bed elevations. Each of these factors leads to a situation where the erosion resistance of each bed layer in each grid cell differs when you start from the same condition but let the bed evolve for 15 years (1997-2011) versus 4 years (2008-2011). The event in 2005 is a contributor to this difference. • These above factors affect evolution of bed elevations in the model and in turn influence hydrodynamic calculations, leading to differences in behavior during high flow events, most notably during TS Lee in 2011. Differences in bed elevations can affect flow velocities, shear stresses, erosion, deposition, and the shear stress exposure history of each grid cell. In addition, the 1996 bathymetric survey (which was the starting point for the long-term run) has more measurement uncertainty and less data density than other surveys. Interpolated bed elevations based on 1996 measurements have more interpolation/extrapolation error and appear to be unrepresentatively low in	

ID	Reviewer	Comment/Question	Response	Action/Revision
			some areas and perhaps too high in other areas. For example, the 3-6 meter differences in interpolated elevations that occur on a cell by cell basis between the 1996 and 2008 surveys may not be representative. Other factors also affect things but this is a place to start the discussion.	
4	P. Wilcock	p. 27: "Erosion thresholds were calibrated so that computed bed elevation changes over the course of the simulation were in rough agreement with spatial and temporal pattern and pond-wide average bed elevation change determined from interpolated bathymetric survey results." prw: More detail is needed here. Is this calibration for the entire model run or only for the initial time steps? What values of erosion threshold were selected in the end? Are these values different from those determined from Equations 2-16 and 3-1? In what cases?	The calibration of erosion thresholds represents the selection of values that the model uses as initial conditions for each cell and layer in the sediment bed (i.e., conditions at the start of a run). As noted in the report, the apparent erosion resistance of the bed exceeds values that were determined from site-specific SEDFLUME measurements or otherwise estimated from relationships to plasticity index. (Thus, the need for calibration.) Equation (2-16) is relevant to the behavior of individual grains and their potential transport from the bed under conditions where bed behavior is non-cohesive. Thus, it is not applicable to establishing initial conditions for erosion resistance, which is a function of how the overall matrix of particles in the bed behaves (which is generally cohesive). Similarly, Equation (3-1) is relevant to sediments that deposit to the bed during a simulation and which are considered to behave in a cohesive manner.	Text in Sections 2.2.2, 3.1.4.4, and 3.3.2.2 of the hydro/sedtran report was revised to provide more detail.

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
5	P. Wilcock	p. 28: "Dimensionless diameters and critical shear stress values for each particle type were then determined based on effective diameter using Equations 2-15, 2-16, and 2-19." prw: I believe this should be Equations 2-16, 2-17, and 2-20. It is also not clear when 2-16 is used and when Equation 3-1 is used. Is it 2-16 always for in-situ material and 3-1 only for material deposited during the simulation?	Equation (2-16) is relevant to the behavior of individual grains and their potential transport from the bed under conditions where bed behavior is non-cohesive. Equation (3-1) is relevant to sediments that deposit to the bed during a simulation and which are considered to behave in a cohesive manner.	Equation numbers throughout the report text were updated as needed.
6	P. Wilcock	p. 33: "Consequently, erosion thresholds for initial bed layers at the start of simulations were adjusted during sediment transport model calibration." Is this applied only to the surface layer, or to the full bed? What were the adjusted values for erosion thresholds? Are they in a reasonable range?	The extent to which erosion thresholds required adjustment was based on comparisons to interpolated bed elevation differences as determined from spatially interpolated bathymetric surveys. Ultimately, the depth of net erosion for a grid cell is a function of erosion threshold, erosion rate, the duration of shear stresses in excess of the erosion threshold, and the total thickness of sediment (including any deposition) at any location. The duration of shear stresses in excess of the erosion threshold is a function of the hydrograph only and not subject to calibration. For simplicity, and broadly consistent with SEDFLUME measurements and subject to the constraint that fluxes were consistent with nutrient transport measurements, erosion rates were assumed to be 0.002 cm/s and were not otherwise subject to calibration. Thus, only initial erosion thresholds were varied during model calibration.	Figures displaying erosion thresholds, by bed layer, at the start of simulations were added to Attachment 1 (only available in electronic form).

ID	Reviewer	Comment/Question	Response	Action/Revision
			The same erosion threshold was typically assigned through the entire thickness of the initial bed for each grid cell. Assigned thresholds were often in the range of 40-60 dynes/cm^2 (4-6 Pa). However, in a few locations where shear stresses are largest or where net erosion over time was limited regardless of shear stress, larger erosion thresholds (100-200 dynes/cm^2; (10-20 Pa)were required. From an empirical perspective, calibrated initial erosion thresholds are reasonable in that they simultaneously satisfy net bed elevation changes over time and nutrient constraints. [Demonstration of flux constraints for nutrients is detailed in the nutrient transport model report.]	
7	P. Wilcock	Equations 3-1 and 3-2. These relations are used to estimate τ_{ce}, at least in some cases. First, the relation between % clay and plasticity index is rather poor (Figure 7), as may be expected for cohesive sediments. Second, it is not clear when this relation is used to estimate τ_{ce}. Is it only for sediment that is deposited during the simulation? Is it also used when there is scour? Also, the reference for Jacobs et al. (2011) is not given.	Equations (3-1) and (3-2) are used within the code to assign τ_{ce} values for sediment layers that form by deposition during the course of a simulation at the time it deposits. Other logic in the SEDZLJS code (and assigned parameters) control how erosion resistance of deposited sediments evolves over time. Ultimately, (cohesive) deposited sediment layers will have time variable erosion thresholds bounded by the clay content/plasticity index relation expressed by Equations (3-1) and (3-2) as a lower bound and the initial bed condition and/or the maximum exerted shear stress as an upper bound.	Text in Sections 3.1.4.4, and 3.3.2.2 of the hydro/sedtran report was revised to provide more detail. The citation for Jacobs et al. (2011) was also added to list of references.

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
8	P. Wilcock	p. 27: "The erosion rate used for simulations was assigned as 0.002 cm/s (0.236 feet/hour) …" p. 33: "Whenever the shear stress acting on the bed exceeded the critical shear stress for erosion, sediments were assumed to erode at a rate of 1.18 feet/hour (0.01 cm/s), which is within the range of USACE (2014) SEDFLUME results." These two sentences indicate two different values of erosion rate. Please reconcile.	The erosion rate of 0.002 cm/s is value of practical consequence. However, for completeness and clarity, it should be noted that the SEDZLJS framework requires inputs for cohesive and non-cohesive modes of erosion. The rate of 0.002 cm/s is the rate used for cohesive erosion. The rate of 0.01 cm/s is the rate that would be used for non-cohesive erosion. For the application to Conowingo Pond, the model was parameterized such that the 0.002 cm/s erosion rate would be used in nearly every case.	Text in Section 3.1.4.4 describing the erosion rate was moved to Section 3.3.2.2 of the hydro/sedtran report. The text was also modified to indicate both cohesive and non-cohesive erosion rates.
9	P. Wilcock	The behavior of the sediment bed under scour conditions remains poorly known. This is a problem with available input rather than the model, although this problem necessarily limits the possible fidelity of any model. In the long simulation (1997-2014), 18 of the model grid cells show scour greater than 30 cm (Figure 66), which exceeds the depth of any characterization of bed behavior. In the 2008 to 2014 comparison of surveyed and simulated elevation change (Figure 69), 25 of the cells in the simulation and 56 of the cells in the observed (about one-fifth of the cells) show scour greater than 30 cm.	As the reviewer noted, characterization of erosion rates and thresholds was limited to the USACE (2014) SEDFLUME effort. The depth of net bed elevation changes over time (as inferred from differences between interpolated bathymetric survey results) generally exceeds the depth to which bed erosion rates and thresholds have been characterized (~30 cm). However, other sediment sampling and characterization efforts have generated samples from a range of depth intervals, including approximately 300 cm below the sediment surface. The present hydrodynamic and sediment transport model development effort made extensive use of the full array of site data that have been generated to date. Thus, as	No further action required.

ID	Reviewer	Comment/Question	Response	Action/Revision
			noted by the reviewer, the problem is largely a reflection of available input rather than the model (which necessarily impose limit on any model).	
10	P. Wilcock	**Estimating sediment entrainment.** There is a need to be clearer about how values of τ_{cr} were calculated and which value of erosion rate was used. Beyond that, there is a broader need to understand how model results may be sensitive to the choice of τ_{cr} and erosion rate. i. A report of values of τ_{cr} and erosion rate used in the final simulation is needed, including an assessment of whether all values used are reasonable and consistent. Were the values used and the rules applied consistent across the reservoir? Did they change with time? ii. Some estimate of the sensitivity of model results to the choice of τ_{cr} and erosion rate would be useful.	As described in responses to Comments 4-8, more detail regarding selection and evolution of erosion threshold and rate values has been provided. For all practical purposes, erosion rates were consistently 0.002 cm/s. Initial erosion threshold values were calibrated such that they conformed to empirical net bed elevation changes over time and nutrient cycling constraints. As the sediment bed evolves over time during a simulation, and layers are added to or removed from it, erosion thresholds can vary from a lower bound determined by the clay content-plasticity index relation and an upper bound limited by the initial condition and/or the maximum applied shear stress. Given the uncertainty associated with upstream/boundary loads and grain size distributions, bed sediment conditions (e.g., grain sizes, erosion thresholds and rates, etc.), the potential utility of model sensitivity analysis is of limited value at this time because model responses are influenced by more than factors controlling sediment entrainment.	No revisions were incorporated into the report. Sensitivity analyses are beyond the present scope of study objectives.

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
11	P. Wilcock	**Grain Size.** The model uses four grain sizes (clay, silt, sand, gravel) as well as a nominal grain size for coal. It would be useful to compare simulated vs. observed grain size of the sediment load at Conowingo Dam. This provides a separate basis for evaluating model performance. Similarly, it would be useful to compare the beginning and ending grain size of the reservoir bed. If the transport of different grain sizes is off, progressive sorting of the bed should show that effect clearly.	The value of efforts to evaluate bed composition changes was discussed by project team over the course of model development. Although evaluations of bed composition over time have some appeal and merit, we concluded that the relative benefit of such evaluations is more limited than might be recognized. They are unlikely to provide insight into processes that control sediment transport within Conowingo Pond because: • Model conditions that evolve over a simulation are a response to uncertain boundary loads and setting velocities for each size class, erosion thresholds, etc. • Initial grain size distributions for each grid cell in each layer of the bed, as estimated from sparse data that were interpolated in vertical and horizontal, are very uncertain (e.g., large Root Mean Square Error of interpolation). • Further, data from a roughly 25-year period were used to establish initial bed conditions. Given such uncertainties, the departure from, or conformance to, any initial bed composition over time would not be dispositive of whether erosion and deposition processes (and corresponding sediment sorting) are appropriately	No revisions were incorporated into the report. Analyses of bed composition are beyond the present scope of study objectives.

ID	Reviewer	Comment/Question	Response	Action/Revision
			parameterized. For example, the relative increase or decrease in any size class within the bed could be the result of error in loads and/or settling velocities and/or erosion characteristics and/or the initial bed composition and/or any combination of the these factors. As an outgrowth of these data limitations, model development was guided by empirical constraints arising from net bed elevation changes over time as inferred from successive bathymetric surveys and erosion and deposition flux constraints imposed by measured nutrient fluxes (including sediment oxygen demand). It should be noted that the constraints imposed by nutrient fluxes are surrogates for differential transport and sorting of grain sizes in the sediment bed. Nutrients are more closely associated with clay- and silt-sized particles. Thus, the generally close correspondence between the model and inferred bed elevation changes and the subsequent successful simulation of the suite of nutrients was judged to be more indicative of model performance than uncertain comparisons to bed composition changes.	
12	P. Wilcock	**Uncertainty.** The report notes that "uncertainties in flows at Holtwood contribute to uncertainties in sediment load estimates" and the "Uncertainties in SSC	It is unclear how, or even if, USEPA would be able to incorporate this sort of information into to its TMDL assessment	No revisions were incorporated into the report. Uncertainty

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		estimates contribute to uncertainties in sediment load estimates". It would be useful to explore how uncertainties in the upstream boundary condition, as well as uncertainties in the bottom boundary condition for sediment erosion, may contribute to uncertainties in the simulated loads at Conowingo Dam. It would be informative to propagate uncertainty in the upstream and bottom boundary conditions into uncertainty in the CPMBM predictions.	efforts. Also, the level of effort required to establish uncertainty limits or perform statistical evaluations of uncertainty bounds is relatively high. Consequently, efforts to evaluate uncertainty were not pursued.	analyses are beyond the present scope of study objectives.
13	D. Brady	Dr. Brady provided a list of potential improvements to the water quality portion of the CPMBM. These included: 1. Modeling the water column with a process based RCA-like model 2. Empirical study of the relationship between flow and resuspension in this system 3. More in depth modeling of sediment transport to homogenize organic content of the sediment to determine if the current spatial gradient is ameliorating loads to the bay by having resuspended material with high organic content far from the dam. 4. Revisiting some of the ratios and assumptions regarding the relationship between water quality parameters within the assumptions of the model.	The available time and budget do not permit these improvements to be performed at this time. The USEPA has moved forward with the 2017 Re-assessment of the Chesapeake Bay nutrient TMDL and would not accept any new findings that might arise from such analysis. However, we will provide additional thoughts on the recommendations for improvement. 1. There are very limited in-situ Conowingo Pond data with which to perform calibration of a process-based RCA-like water quality model. Most of the available data are measured by the USGS downstream of Conowingo Dam 2. Empirical studies of flow and resuspension have been performed by the USGS and were reviewed as part of the sediment transport modeling effort 3. If additional sediment transport modeling were to be conducted that effort should focus on modifying the settling rates used for silts and clays such that	No revisions were made to the report.

ID	Reviewer	Comment/Question	Response	Action/Revision
			settling of suspended solids would be more widely deposited along the length of the reservoir 4. The sediment cores do in fact contain coal and this, therefore, makes the determination of the organic carbon content of the sediments virtually impossible to determine; hence our simplifying assumption. This recommendation would need to be discussed with the USEPA/USACE developers of the watershed and Bay water quality models, as HDR was instructed to utilize the recipe developed by the USEPA and the USACE.	
14	D. Brady	Introduction. "has begun implementation"	Agree with suggested wording change	Report has been revised
15	D. Brady	Introduction. "However, the estimated dissolved oxygen"	Agree with suggested wording change	Report has been revised
16	D. Brady	Introduction. "has been asked"	Agree with recommendation to change wording	Report has been revised
17	D. Brady	Introduction. "This assumption appeared"	The wording in the report is clear that the assumption refers to the original SFM	No revision was made to the report.
18	D. Brady	Methods. Comment on definition of the sediment bed layers	Agree with the recommendation for clarification	Report has been revised.
19	D. Brady	Methods. Why no diagenesis in the deep bed?	Certainly there would be no G1 or G2 material expected to be found at this depth, i.e., greater than 1.5 meters in depth. It is also likely that there may be additional G-classes which have even less reactive organic matter than assumed for G3. However, it was beyond the scope of this study to add additional state-	The report has been revised to clarify the rationale for not including diagenesis at depth.

ID	Reviewer	Comment/Question	Response	Action/Revision
			variables to SFM to represent additional G-classes. We were concerned that if we allowed G3 to react in the deep bed, the model would produce unrealistically low values of sediment POM at depth.	
20	D. Brady	Methods. Still not clear how the model gets deposition … one suggestion is to fit ammonia data and compare to Boynton	HDR believes that the report is clear on how deposition and erosion occurs in the water quality portion of CPMBM and it is driven by information provided by the sediment transport model, ECOMSED, portion of the CPMBM. Sediment ammonia data are only available for a period of one year and would be insufficient to specify deposition for the 18-year calibration period.	A minor revision was made to the report.
21	D. Brady	Methods. CPBMB uses a mass balance approach using the difference between the loadings in WSM to assume the rest is deposited	Dr. Brady is incorrect. The "difference" approach to estimating deposition was only used for the stand-alone version of the SFM, not the CPMBM. In the CPMBM model, loadings from the WSM model served as inputs and deposition was determined based on settling rates, bottom shear stresses and tau critical for deposition and erosion as provided by ECOMSED	No revision was made to the report.
22	D. Brady	Data Sources and Analysis. Figure 3 is missing.	During the conversion process from Microsoft Word to PDF, figure 3 was lost	HDR will use a different PDF conversion tool and ensure that Figure 3 is contained in the report
23	D. Brady	Data Sources and Analysis. Missing parenthesis		Report text was corrected

ID	Reviewer	Comment/Question	Response	Action/Revision
24	D. Brady	Data Sources and Analysis. Is it possible that there was significant vertical structure in individual cores?	There does not appear to any structure of N or P going down core. Figure 6 did not show other core data in the figure. This has been corrected.	Figure 6 has been revised.
25	D. Brady	Data Sources and Analysis. Profiles not shown for NH4, SRP and Fe.	NH4 and SRP data were not available for the 2000 SRBC data. Fe data (not shown) do not show vertical structure either.	No revision was made to the report.
26	D. Brady	Data Sources and Analysis. Long cores – what did vertical profiles of pore water show?	Pore water NH4, SRP and Fe was only analyzed for the August 26-Sept2 long core. Generally, NH4 increased down core, but the patterns were irregular. SRP pore water concentrations were generally low (1-5 umol/L) with slight, but irregular, increases in concentration going down core. Fe tended to be very irregular going down core.	No revision was made to the report.
27	D. Brady	Data Sources and Analysis. Question raised concerning negative regression slopes for carbon	At this time HDR does not have any hypotheses for the negative slopes. This may more a question for Dr. Cornwell (UMCES), who performed the diagenesis experiments.	No revision was made to the report.
28	D. Brady	Data Sources and Analysis. Page 7 – units missing for CO2 and NH4 and misspelling of nitrogen	Report revised to add units and correct spelling.	Report revised to add units and correct spelling.
29	D. Brady	Data Sources and Analysis, Page 7 – is there a reason to discount the two data points for nitrogen and go with 7.0E-5 umol/g-day	HDR dropped to points for carbon not nitrogen. The reason for dropping them is that the rates were greater than or equal ot the G2 diagenesis rate.	No revision was made to the report.
30	D. Brady	Data Sources and Analysis, Page 8. Be clear that the TN is multiplied by 8 (to get TC) due to Redfield.	Dr. Brady is incorrect to assume that the ratio of 8 was chosen due to Redfield. Rather it is tied to the "recipe" developed by the USEPA and USACE for estimating watershed loading information.	No revision was made to the report.

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
31	D. Brady	Data Sources and Analysis, Figures 10 and 11 are mis-referenced. Were the parameters constrained in any way?	The original figures 10 and 11 were left out of the report. The parameters were not constrained.	Figures 10 and 11 have been added to the report and the remaining text and figures have been re-numbered appropriately.
32	D. Brady	Data Sources and Analysis, The text between pages 8 and 9 could be more clear.	HDR agrees with the recommendation.	The report has been revised appropriately.
33	D. Brady	2.3 Application of the Stand-alone SFM. Page 10 change multiply to multiplying		The report has been revised appropriately.
34	D. Brady	2.3 Application of the Stand-alone SFM. Page 10 provide references	The report cites information provided by Carl Cerco (pers.comm.) – no further reference is required.	No revision was made to the report.
35	D. Brady	2.3 Application of the Stand-alone SFM. Boyton's estimates of deposition are assumed to include resuspension	Dr. Boynton deployed sediment traps, which captured particles are two or three depths in the water column. Dr. Brady is correct that the bottom most sediment trap appears to capture some resuspended material. In our analysis, HDR excluded data from the bottom most trap and, therefore, feel comfortable that the estimates only reflect deposition.	No revision was made to the report.
36	D. Brady	2.3 Application of the Stand-alone SFM. Climatology approach. Use of actual 2015 temperature data.	HDR modeled 1997-2014. We are not sure how using 2015 data would apply in this instance. It is also outside of HDR's original scope.	No revision was made to the report.
37	D. Brady	2.3 Application of the Stand-alone SFM. POP percentages are mentioned twice.	They are mentioned twice – one reference in relationship to the comparison to POP data and the second reference to describe the percentage POP relative to the total P	No revision was made to the report.
38	D. Brady	2.3 Application of the Stand-alone SFM. Page 14. Explanation of the excess inorganic P being attributed to	HDR has some questions concerning nutrient estimates provided by the	A minor revision to the report was made

ID	*Reviewer*	*Comment/Question*	*Response*	*Action/Revision*
		deposition of PIP.	USEPA watershed model and the "recipe" for doing the nutrient splits provided by the USACE. However, the problem may also be related to the stand-alone SFM as well.	to clarify the rationale for attributing the problem to the deposition of PIP.
39	D. Brady	2.3 Application of the Stand-alone SFM. Page 14. High variability in observed P fluxes.	HDR does not have a reason for the high variability in the P fluxes. They do not seem to be driven by DO as per discussions with Dr. Cornwell	No revision was made to the report.
40	D. Brady	2.4 CPMBM Setup. Questions concerning flows	Details of the procedure that HDR used to calculate flows is provided in the CPMBM sediment transport report.	No revision was made to the report.
41	D. Brady	2.4 CPMBM Setup. Question concerning exclusion of photosynthesis (P)/respiration (R) problematic.	It is difficult to confidentially answer this question without additional data and without model revisions, which was outside the initial scope of this analysis. However, the average residence time within Conowingo Pond, as estimated from the CPMBM hydrodynamic/ sediment transport model is about 4 days. Therefore P-R may not be that important.	No revision was made to the report.
42	D. Brady	2.4 CPMBM Setup. Nutrient concentration was taken from USEPA, not loading?	HDR back-estimated nutrient concentrations based on load and flow and then used the HDR flow estimates and back-calculated nutrient concentrations to generate loadings.	No revision was made to the report.
43	D. Brady	3.1 Calibration. If inflow concentration is a problem, does this only happen at high flows?	The answer to the question depends on the water quality parameter of interest. For example, DON appears to be under-estimated at low flows,	No revision was made to the report.
44	D. Brady	3.1 Calibration. Ultimately, the relationship between flow and concentrations is a linear positive one according to the model and not in the data. This	Dr. Brady's statement certainly appears true for dissolved P forms, but this is largely driven by information provided	No revision was made to the report.

ID	Reviewer	Comment/Question	Response	Action/Revision
		contributes to the mismatch in phosphorus loading. But can we trust that the data is adequate to conclude that there is no relationship between flow and concentration?	by the watershed model. It is less clear for particulate P. Model and data suggest that as flows increase, so does particulate P.	
45	D. Brady	3.2 Calibration to Storm Event Data. Page 19, change the use of the word "recipe"	The report will be changed	The word recipe has been changed to methodology throughout the report
46	D. Brady	3.3 Sediment Composition Calibration. Page 20. change "will focus" to "focused"		The report was modified to read "focused"
47	D. Brady	3.3 Sediment Composition Calibration. Page 21. Label the section where discussion will follow.	Discussion follows in Section 4. Report will be modified.	The report has been revised as appropriate.
48	D. Brady	4. Results. Page 22. Figure 50 - it is not clear if this is data or a model. If it is a model, then the resuspension under flow is a function of a parameter, correct?	Due to the addition of figures 10 and 11 to the report, Figure 50 to which Dr. Brady refers should be Figure 52. The results presented are model computations and resuspension is determined by computations provided by the CPMBM hydrodynamic/sediment transport model and are determined by the critical shear stress for erosion model parameter.	The report has been modified to more clearly state that Figure 52 is based on model computations.
49	D. Brady	5. Management Scenarios. Page 23. How were management scenarios chosen?	Management scenarios were based on information provided by the USEPA.	The report has been modified to clarify where the choice of scenarios came from.
50	D. Brady	5. Management Scenarios. Page 24. are the figure references correct here?	No the figure references were incorrect and the report was modified to correct the error.	The report has been revised appropriately.
51	J. Martin	Page 10. One improvement of the sediment flux model that could be considered would be the inclusion of iron as a state variable, along with iron speciation in order to	In order to fully implement this recommendation, which is outside of the initial scope of this study, it would be	No revision was made to the report.

ID	Reviewer	Comment/Question	Response	Action/Revision
		more realistically capture the impacts of phosphorus sequestration in iron rich sediments.	necessary to have estimates of iron loadings to Conowingo Pond, which is not included in the USEPA WSM. HDR believes that increasing the P partitioning coefficients well above those used in the USEPA Chesapeake Bay model and arrived at via the calibration of SFM to Chesapeake Bay data and that are reflective of the higher levels of Fe contained in Conowingo Pond sediments is a reasonable approach.	

Chesapeake Bay Program Follow-Up

By the time of this writing, the Chesapeake Bay Program's (CBP's) Modeling Work Group had agreed with the overall assessment of this review and had incorporated the results of the developed Lower Susquehanna River Reservoir models as additional lines of evidence for assessing the Conowingo Pond impacts to the Bay. At the time of this writing, the CBP's Scientific Technical Advisory Committee (STAC) is in the process of reviewing the Phase 6 Chesapeake Bay Watershed Model and the Water Quality and Sediment Transport Model. These reviews are part of the midpoint assessment, and these reviews will be considering the reasonableness of CBP's application of the new LSRRS models and results, as reviewed here.

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Appendix A: Scope of Work

Appendix A: Scope of Work for
Lower Susquehanna River Reservoir System Model Enhancements Peer Review

In 2014 Exelon Generation Company, LLC (Exelon), in cooperation with the Maryland Department of Natural Resources (MDNR), Maryland Department of the Environment (MDE), University of Maryland Center for Environmental Science (UMCES), U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (the Corps), and the U.S. Environmental Protection Agency (USEPA) Chesapeake Bay Program, initiated the multi-year Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Program (Integrated Monitoring Program). The primary goals of this Program are to:

1. Determine the impact, if any, of storm events between 100,000 and 400,000 cfs on sediment and associated nutrient loads entering the Lower Susquehanna River from upstream sources (including Conowingo Pond), and
2. Determine the potential resulting impacts of storm events, if any, on Bay water quality from sediment and nutrients entering Conowingo Pond from upstream sources, scouring from sediment behind Conowingo Dam and passing through the Dam.

The original study was to target up to six storm events with flows equaling or exceeding 100,000 cfs. At the conclusion of all field efforts, the results of the Integrated Monitoring Program were to be used to update the suite of Chesapeake Bay (the Bay) Watershed and Water Quality models for use in the 2017 TMDL Midpoint Assessment. As of the date of this memo (March 2016), two official sampling events have occurred, both of which had peak flows less than 182,000 cfs.[1][2] In late 2015, due to a lack of storm events in the target flow range and the lack of available corresponding empirical data, Program partners began discussing alternative approaches that could be implemented in early 2016 to supplement the modeling efforts associated with the Midpoint Assessment.

From these conversations, Exelon developed a two phased-modeling approach that would enhance and complement the existing Phase 6 HSPF Watershed Model (HSPF) as well as the inputs to the Bay Water Quality and Sediment Transport Model (WQSTM). The two phased modeling approach includes developing:

1. An enhanced one-dimensional HEC-RAS model of Lake Clarke and Lake Aldred, similar in nature to the one developed by the USGS as part of the Lower Susquehanna River Watershed Assessment (LSRWA). Enhancements in the new model will include a longer calibration and verification period based on 2013 and 2015 bathymetry that were not previously available to the LSRWA modelers, modeling of suspended sediment load plus estimates of bed load, individual cohesive soil properties for each soil group, and true unsteady flow. The output from this model will result in

[1] Sampling Event No. 1 occurred April 6-14, 2015 with peak flows of 146,000 and 182,000 cfs. Sampling Event No. 2 occurred April 22-25, 2015 with a peak flow of 125,000 cfs.
[2] In addition, supplemental data were collected at Marietta, Holtwood, and Conowingo during a February 2016 high flow event (peak flows ~180,000 cfs). Although data were collected, this was not considered an official sampling event.

improved sediment loads from Lake Clarke and Lake Aldred, which can then be used to re-parameterize HSPF and improve the sediment loads entering Conowingo Pond (the Pond); and

2. A coupled hydrodynamic, sediment transport, sediment nutrient flux and water quality mass balance model for Conowingo Pond – the Conowingo Pond Mass Balance Model (CPMBM). This model will allow for an improved evaluation of the extent to which changes in sediment storage and nutrient bioreactivity within the Pond affect sediment and nutrient delivery to the Bay. The output from this model combined with the results of the UMCES biogeochemical experiments being conducted as part of the Integrated Monitoring Program will allow for improved inputs to the WQSTM.

As part of this modeling effort, the Exelon team agreed to work closely with the Chesapeake Bay Program (CBP) Modeling Workgroup and Corps modelers throughout this process to ensure that all parties are in agreement on the methods used, deliverables provided, and implementation of results into the suite of CBP models (specifically Phase 6 CBP Watershed Model and WQSTM). In addition, Exelon agreed that all modeling efforts and reports will be subject to two independent reviews, including (1) interim review and guidance from an independent modeling evaluation group to be contracted and coordinated by the Chesapeake Research Consortium (CRC) and (2) final review as part of a larger review of the CBP's Phase 6 Watershed Model that is already scheduled for 2016 as part of the activities of the CBP's Scientific and Technical Advisory Committee (STAC). The modeling evaluation group comprises four independent reviewers who have been collaboratively selected through consensus agreement among representatives of the Exelon team (specifically Ms. Kim Long, and Mssrs Tom and Tim Sullivan), MDNR (specifically Mr. Bruce Michael), and the CRC (specifically Dr. William Ball). The evaluation group will review the modeling methods, results, and reports and provide feedback and comments as appropriate. Comments provided by the evaluators will be taken under advisement by the Exelon team. Enclosed below is the proposed scope of work for the independent modeling evaluation group.

TASK 1.0 Bi-weekly status update call
Tentative Schedule: Bi-weekly, Week of March 1 – June 30, 2016 - 1.5 hours/call

The independent peer reviewers will participate in up to 8 bi-weekly, or as needed, status update calls with the Exelon Modeling team. These calls will be scheduled, arranged and paid for by the Exelon Modeling Team and will be open to attendance by all members of the CBP Modeling Workgroup and other interested parties having related technical expertise and currently involved with the CBP. Discussion will center on the current status of each model, areas of concern or issues which have arose, next steps, and other pertinent questions. The peer reviewers will provide feedback, comments, and observations to the Exelon modeling team during or following these discussions. Exelon will be responsible for drafting meeting minutes following the conclusion of each call. The minutes meetings will be subjected to review and approval (or dissent) from all four independent reviewers and Dr. Ball. The finalized meeting minutes will then be made publicly available via a web site to be maintained by the CRC.

TASK 2.0 Preliminary Review Products
Tentative Schedule: Monthly, April – June 2016

The peer reviewers will prepare independent interim review products following the completion of major modeling milestones. The interim review products will consist of 1-2 page memos to be completed by each peer reviewer focused on their specific area(s) of expertise. Memos will include descriptions of the review work completed, observations, potential areas for further consideration, and other pertinent comments. It is anticipated that no more than 3 interim work products would be prepared as part of this effort. The Exelon team may prepare interim responses to these documents if it so chooses. These interim memos and associated responses will be made publicly available on the website to be maintained by the CRC.

TASK 3.0 Peer Reviewer Final Report
Tentative Schedule: May-June 2016

Following completion of all models and review of the final modeling reports, each peer reviewer will develop a final, independent report that discusses the modeling methods used and the results.

TASK 4.0 Chesapeake Research Consortium Final Report
Tentative Schedule: May – June 2016

CRC will compile each peer reviewer's final report into one final document for publication.

TASK 5.0 Chesapeake Research Consortium Project Management
Tentative Schedule: March – June 2016

CRC staff, specifically including its Executive Director, William Ball, will provide support and product documentation services throughout the review process on an as needed basis. Such support will include subcontracting reviewer involvement, and the posting of final meeting minutes and review products on a web site to be maintained by the CRC. Support may also include, on an as-needed and as-available basis: participation in bi-weekly calls, review of meeting minutes, and review and comment on interim reviewer products. In addition to Dr. Ball's direct involvement in the aforementioned activities, other CRC staff and subcontractors will assist with aspects of report production and web site maintenance.

Appendix B: Minutes of Peer Review Conference Calls

On following pages, minutes are provided for the five peer-review conference calls listed in Table 1. These are provided in the following order.

1. Peer Review Conference Call No. 1 (April 6, 2016)
2. Peer Review Conference Call No. 2 (April 18, 2016
3. Peer Review Conference Call No. 3 (May 20, 2016)
4. Peer Review Conference Call No. 4 (August 18, 2016)
5. Peer Review Conference Call No. 5 (June 1, 2017)

1. Minutes of Peer Review Conference Call No. 1 (April 6, 2016)

LOWER SUSQUEHANNA RIVER RESERVOIR SYSTEM MODELING ENHANCEMENTS
PEER REVIEW CALL NO.1
WEDNESDAY APRIL 6, 2016 2:00-3:00

ATTENDEES:

Tim Sullivan (GSE)	Tom Sullivan (GSE)	Gary Lemay (GSE)
Marty Teal (WEST)	Jon Viducich (WEST)	Jim Fitzpatrick (HDR)
Mark Velleux (HDR)	Kim Long (Exelon)	Bruce Michael (MDNR)
Bill Ball (CRC)	Steve Scott (Reviewer)	Peter Wilcock (Reviewer)
James Martin (Reviewer)	Damian Brady (Reviewer)	

NOTES:

The call started with introductions, background for the modeling efforts, and an overview of the peer review.

Discussion then centered on the peer review scope of work and logistics. The Scope of Work document which had been previously circulated was reviewed. Logistics discussed included review and meeting coordination, development of a website, and roles for each reviewer, the CRC, and Exelon. The group agreed that while the reviewers would examine the modeling effort as a whole, Steve Scott and Peter Wilcock would focus primarily on hydrodynamics and sediment transport while James Martin and Damian Brady would focus on sediment and nutrient flux. Peter noted that the scope of work was vague in regard to the specific questions the reviewers are supposed to be answering. The group agreed to work together on a list of questions and provide them to the reviewers to focus their review (**ACTION ITEM**).

James asked if the contact information for the call participants could be circulated. Bill agreed to provide that to them (**ACTION ITEM**). James also asked which documents would be best to review first for background information. Tim noted the LSR Integrated Sediment and Nutrient Monitoring Plan and Exelon Modeling Workplan would be a good first step. Bruce Michael noted the Lower Susquehanna River Watershed Assessment would be another good document. Tom Sullivan also recommended the Conowingo Hydroelectric Project Final License Application filed with FERC. Tim will provide these documents to the reviewers (**ACTION ITEM**). Bill also noted that all correspondence should be directed to him and Tim. They will then make sure it gets distributed to the appropriate people.

Marty Teal then provided a high level overview of the HEC-RAS model of Lakes Clarke and Aldred. Steve noted that he had developed a list of questions and data needs which he would forward to Bill and Tim for distribution to the modelers. Peter noted that he had three things he'd be looking for: 1) calibration information; 2) assessment in uncertainty in change in sediment volume, quality of the bed elevation data; and 3) sensitivity of the rating curves. He also asked how the uncertainty in the RAS model was propagating into the Conowingo Pond Mass Balance Model (CPMBM), if applicable.

Jim Fitzpatrick then provided an overview of the CPMBM.

Next steps were then discussed. Tim noted that the next call would likely be the week of April 18th. Between now and then the reviewers were to begin to get up to speed on the background information previously provided and provide any questions or comments they have to Tim and Bill. The Exelon team will continue work on the models and reports and review any questions received from the reviewers (**ACTION ITEM**).

ACTION ITEMS:

1. The Exelon team will work with CRC to develop a list of review questions for the reviewers, circulate by next call.
2. Bill to provide call participant contact information to the group
3. Tim to provide additional background information to the reviewers (LSRWA and Conowingo FLA)
4. Steve to provide Tim and Bill with his preliminary list of HEC-RAS questions and data needs
5. Tim to setup the next review call for the week of 4/18
6. Reviewers to get up to speed on pertinent background information and provide any questions to Tim and Bill

2. Minutes of Peer Review Conference Call No. 2 (April 18, 2016)

LOWER SUSQUEHANNA RIVER RESERVOIR SYSTEM MODELING ENHANCEMENTS
PEER REVIEW CALL NO.2
MONDAY APRIL 18, 2016 11:00-12:00

ATTENDEES:

Tim Sullivan (GSE)	Kim Long (Exelon)	Marty Teal (WEST)
Mark Velleux (HDR)	Bruce Michael (MDNR)	Matthew Trommatter (CRC)
Bill Ball (CRC)	Steve Scott (Reviewer)	Peter Wilcock (Reviewer)
James Martin (Reviewer)	Damian Brady (Reviewer)	

NOTES:

Tim Sullivan kicked off the call by reviewing the agenda.

The first agenda item discussed was a status update on action items from the last call. Tim noted that most action items had been completed. The two big action items from the last call were 1) the development of a list of questions to focus the review, and 2) Peer reviewers conducting the necessary background research to get up to speed. It was noted that these were both still ongoing.

Discussion then focused on the status of the reviewer's background research, if there were any questions or comments on the information previously provided, or if there were additional sources of information needed. No questions or comments were received on the information previously provided. Tim noted that James, Peter, and Steve had submitted a list of questions/additional data needs which will help to support their reviews. Tim agreed to circulate these requests to the other reviewers and to the appropriate Exelon team members for responses (**ACTION ITEM**). The group agreed that moving forward questions or data requests from the reviewers should be sent to Tim and Bill Ball with the other reviewers copied (**ACTION ITEM**).

Tim noted that the list of questions to focus the review is still being developed, however, one of the global questions will be: *is the modeling effort conducted by the Exelon team an improvement on the existing understanding of the Lower Susquehanna Reservoir System (including an improvement on the existing models)?* Tim noted that given this it will be important for the reviewers to have a firm understanding of the models which have already been developed (e.g., USGS HEC-RAS model, AdH model, HSPF Watershed Model) (**ACTION ITEM**).

The group then discussed the peer review website (to be developed once contracts have been finalized) and what information will be included on it. The group agreed that the majority of the information that will be included will be general information such as the reviewer's scope of work, meeting agenda's, meeting minutes, presentations, etc.). Bill noted that he will be posting the Peer reviewers CV's to the website. He will circulate the reviewers CV's for review prior to posting (**ACTION ITEM**).

The reviewers then provided an overview of the questions and data requests which have been submitted since the last call.

Discussion then centered on the review timeline and logistics. Given that the review has started later than originally planned the scope of work is now somewhat out-of-date regarding interim work products and reviewer involvement in model development. After some discussion, the group agreed that there would no longer be interim work products as proposed in the scope of work. Instead, given the fact that the models are in different stages (HEC-RAS model is done, Conowingo Pond Mass Balance Model (CPMBM) development is ongoing) the reviewers will complete their review as follows (**ACTION ITEM**):

- Those reviewers who are reviewing both the HEC-RAS model and the CPMBM will develop one report on the HEC-RAS model (with their review starting now) and then a second report on the CPMBM once that model has been completed. The two reports will then be merged into one document which will also discuss the full modeling approach (i.e. from Marietta to Conowingo).
- Those reviewers who are just reviewing the CPMBM will only have to develop one report once the CPMBM is completed.

The question was then raised as to whether the reviewers responsible for the CPMBM should be involved in the development of it, as originally envisioned in the scope of work. The Exelon team will evaluate if this will be practical or not given the current status of the models and report back (**ACTION ITEM**).

Marty Teal and Mark Velleux then provided updates on the progress of their modeling efforts. WEST is in the process of developing the final report for the HEC-RAS modeling while HDR is in the final stages of hydrodynamic and sediment transport model development and sediment flux model setup. The Exelon team will provide a schedule for when the WEST report will be available for review by the next call (**ACTION ITEM**). The Exelon team will also provide clarity to the reviewers on how they will respond to questions and data requests (i.e. in the final report or as a standalone document) (**ACTION ITEM**).

<u>ACTION ITEMS</u>:

1. Tim to circulate questions and data requests received so far to all reviewers
2. Exelon team to develop list of questions to focus the peer review
3. Moving forward, the reviewers will submit all questions and requests to Tim and Bill and copy the other reviewers
4. Peer reviewers to review available information to ensure they have a firm understanding of the existing LSR models and data.
5. Bill to circulate the reviewers CV's to all reviewers
6. Reviewers will submit work products in accordance with the modified approach agreed upon during this call as opposed to what is described in the scope of work
7. Exelon team to regroup regarding logistics for the CPMBM review
8. Exelon team will provide a schedule for when the HEC-RAS report will be ready. Will also provide clarity on how they will be responding to reviewer questions/data requests
9. Exelon team will review action items assigned to them, determine when they will be completed, and then schedule next call (tentatively week of May 9th or 16th)

Minutes of Peer Review Conference Call No. 3 (May 20, 2016)

LOWER SUSQUEHANNA RIVER RESERVOIR SYSTEM MODELING ENHANCEMENTS
PEER REVIEW CALL NO.3
FRIDAY MAY 20, 2016 11:00-12:00

ATTENDEES:

Tim Sullivan (GSE)	Kim Long (Exelon)	Jon Viducich (WEST)
Mark Velleux (HDR)	Jim Fitzpatrick (HDR)	Bruce Michael (MDNR)
Bill Ball (CRC)	Steve Scott (Reviewer)	Peter Wilcock (Reviewer)
James Martin (Reviewer)	Damian Brady (Reviewer)	Tom Sullivan (GSE)
Gary Lemay (GSE)		

NOTES:

Tim Sullivan kicked off the call by reviewing the agenda.

The first agenda item was to revisit the action items from the last call. Action items noted included: 1) proposed list of peer review questions; 2) logistics of the Conowingo Pond Mass Balance Model (CPMBM) review; 3) HEC-RAS report schedule; 4) logistics for Exelon responses to Reviewer questions; and 5) website development.

Tim provided an overview of the proposed logistics for the CPMBM review. Tim noted that the Hydrodynamic-Sediment Transport portion of the model is nearing completion. An interim deliverable would be provided to the reviewers for their review and comment. Comments received from that review would be incorporated into the final report. For the Sediment-Nutrient Flux portion of the model a conference call would be held with the SFM reviewers and Jim Fitzpatrick once all UMCES data had been received and reviewed. The call would discuss the contents of the data and how it will be used in the model. Following completion of the SFM portion of the model an interim deliverable would be provided to the reviewers for their review and comment. Comments received from that review would be incorporated into the final report. The group agreed with this approach. Tim will provide the group with an approximate schedule for when the interim deliverables and final report will be ready for review (**ACTION ITEM**).

Tim then informed the group that Exelon is currently targeting the end of June for when the Lake Clarke and Lake Aldred HEC-RAS report will be ready for review. The deadline for when that review would need to be completed by had not been determined yet (**ACTION ITEM**).

In regard to responding to questions received from the reviewers, Tim noted that Exelon will incorporate their responses into the HEC-RAS final report and either the CPMBM interim deliverable or final report. The Peer Reviewers were asked to review and update their original lists of questions and resubmit to Tim and Bill Ball (**ACTION ITEM**). The group agreed with this approach.

The draft list of review questions was then discussed by the group. While the group agreed on the overall intent and objectives of the review it was agreed that the actual questions should be revised and reworked. The questions will be updated and recirculated for finalization, the final list of questions will be posted to the website (**ACTION ITEM**).

Bill Ball then noted that the review website should be online by the week of May 23rd (**ACTION ITEM**).

Jim Fitzpatrick and Mark Velleux then provided a status update on the CPMBM.

Next steps and action items from this call were then discussed and the call was adjourned.

ACTION ITEMS:

1. The Exelon team will determine an approximate schedule for the various phases of the CPMBM review, including: UMCES data conference call, hydrodynamic-sediment transport interim deliverable, SFM interim deliverable, and final report.
2. The Exelon team will provide HEC-RAS report to the reviewers by the end of June. The group will work together to identify the deadline for when this review will need to be completed by.
3. The reviewers will review and update their original lists of questions and requests and then re-submit to Tim Sullivan and Bill Ball.
4. The Exelon team will revise the proposed review questions and recirculate to the group
5. Bill will work to get the website online by the week of May 23rd
6. The Exelon team will schedule the Jim Fitzpatrick, Damian Brady, and James Martin UMCES data conference call for some time in the next 2 weeks or so.
7. Tim to schedule the next full group call, likely the week of June 20th or June 27th

Minutes of Peer Review Conference Call No. 4 (August 18, 2017)

LOWER SUSQUEHANNA RIVER RESERVOIR SYSTEM MODELING ENHANCEMENTS
PEER REVIEW CALL NO.4
TUESDAY AUGUST 16, 2016 11:00-12:00

ATTENDEES:

Tim Sullivan (GSE)	Kim Long (Exelon)	Jon Viducich (WEST)
Mark Velleux (HDR)	Jim Fitzpatrick (HDR)	Bruce Michael (MDNR)
Steve Scott (Reviewer)	James Martin (Reviewer)	Tom Sullivan (GSE)
Gary Lemay (GSE)	Matthew Trommatter (CRC)	

NOTES:

Tim Sullivan kicked off the call by reviewing the agenda.

The first agenda item was to revisit the action items from the last call. Action items noted included: 1) determining review schedule; 2) modeling status update; 3) finalizing the peer review guiding questions; 4) setting up a conference call with a subset of the group to discuss the results of the UMCES work.

Tim provided an overview of the proposed schedule including when deliverables from the peer reviewers would be due. The group agreed on the proposed schedule laid out. Tim agreed to circulate the final review schedule to the team following the call [**ACTION ITEM**].

Tim then led discussion on the updated guiding questions the peer reviewers will use when reviewing the draft reports from the Exelon team. The group agreed on and finalized the updated list of questions. Tim to provide final set of questions to CRC so that they can be posted to the website [**ACTION ITEM**].

Jon Viducich then provided an update on the HEC-RAS modeling efforts as well as an overview of the draft HEC-RAS report. Steve Scott noted that the responsiveness matrix included with the WEST report was very helpful and requested that HDR follow a similar format [**ACTION ITEM**]. Mark Velleux and Jim Fitzpatrick then provided updates on the HDR modeling effort. It was noted that while some UMCES data had been received by the Exelon team, there were still a number of datasets outstanding which were delaying modeling efforts. A potential call with Jim, Damian Brady, and James Martin to review the UMCES data already received was then discussed [**ACTION ITEM**].

The group then discussed miscellaneous outstanding items, including: discussing when the next full group call would likely be (not until after review of at least the WEST HEC-RAS model [**ACTION ITEM**]), and the website hosted by CRC. The group was asked to review the website and provide comments to CRC as soon as possible [**ACTION ITEM**].

Next steps and action items from this call were then discussed and the call was adjourned.

ACTION ITEMS:

1. Tim to circulate final review schedule to group
2. Tim to circulate final set of guiding questions to the group. CRC to post to website.
3. HDR to include responsiveness matrix similar to the one found in the draft HEC-RAS report in their reports prior to distribution to the peer reviewers.

4. The review team will review the CRC website and provide any comments to Bill Ball or Matthew Trommatter
5. Jim to regroup with Damian and James about a potential call to discuss UMCES results
6. Tim to schedule the next full group call, likely not until HEC-RAS report review has been completed

Minutes of Peer Review Conference Call No. 5 (June 1, 2017)

LOWER SUSQUEHANNA RIVER RESERVOIR SYSTEM MODELING ENHANCEMENTS
PEER REVIEW CALL NO.5
THURSDAY JUNE 1, 2017 10:00-12:00

ATTENDEES:

Tim Sullivan (GSE)	Andrea Danucalov (Exelon)	Tom Sullivan (GSE)
Mark Velleux (HDR)	Jim Fitzpatrick (HDR)	Bruce Michael (MDNR)
Steve Scott (Reviewer)	James Martin (Reviewer)	Peter Wilcock (Reviewer)
Damian Brady (Reviewer)	Matthew Trommatter (CRC)	Bill Ball (CRC)

NOTES:

Tim Sullivan kicked off the meeting and provided an overview of the goals for the call. The purpose of the call was to discuss the final Conowingo Pond Mass Balance Model (CPMBM) reports prepared by HDR, the peer reviewers comments, and any questions the group had.

Discussion focused first on the hydrodynamic sediment transport model. Peter Wilcock and Steve Scott each provided their thoughts on the report and modeling effort and asked several clarifying questions, all of which were included in their written comments. Mark Velleux provided insights to the questions asked.

Discussion then focused on the sediment-nutrient flux model. James Martin and Damian Brady provided their thoughts on the report and modeling effort and asked several clarifying questions, all of which were included in their written comments. Jim Fitzpatrick provided insights to the questions asked.

Through this discussion, several revisions to the hydrodynamic sediment transport and sediment-nutrient flux reports were identified. HDR agreed to update and finalize their reports to address the comments raised. The group also agreed that HDR would prepare a responsiveness summary, which would provide responses to the Peer Reviewer comments received [**ACTION ITEM**]. The responsiveness summary would accompany the final reports.

Discussion then focused on next steps and potential future enhancements or additional work. Tim Sullivan noted that the next, and final, steps included HDR finalizing their reports and preparing their responsiveness summary and the CRC preparing their final report [**ACTION ITEM**]. Discussion pertaining to any additional enhancements or future work is beyond the scope of this modeling effort. The modeling effort successfully achieved the goals and objectives originally set forth in the work plan.

Next steps and action items from this call were reviewed and the call was adjourned.

ACTION ITEMS:

1. Meeting minutes to be drafted and provided to the CRC for inclusion in the final report
2. HDR to finalize their reports and responsiveness summary
3. CRC to develop their final report

Appendix C: Resumes of Peer Review Panel Members

Resumes for the four reviewers follow, in alphabetic order, for:

1. Dr. Damian Brady
2. Dr. James Martin
3. Dr. Steve Scott
4. Dr. Peter Wilcock

1. Resume for Dr. Damian Brady

Dr. Damian Brady’s 2016 Curriculum Vitae is provided on pages C-3 through C17.

DAMIAN C. BRADY, PH.D.
Assistant Professor
Assistant Director for Research at Maine Sea Grant
University of Maine
School of Marine Sciences
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193 Clarks Cove Road ● Walpole, ME 04573
Cell (207) 312-8752
Twitter : @BradyBunchDMC
E-mail: damian.brady@maine.edu

EDUCATION

University of Delaware, Graduate College of Marine Studies, Lewes, DE (2008)
Ph.D. in Marine Biology-Biochemistry
Graduate Advisor: Timothy E. Targett, Ph.D.

Roger Williams University, Bristol, RI (May 2000)
Bachelor of Science with honors (Magna cum laude) - Marine Biology
Minor - Chemistry

Sea Education Association (SEA), Woods Hole, MA (Fall 1998)

RESEARCH AND LEADERSHIP

Assistant Research Professor, School of Marine Sciences, University of Maine (2010-present)

Assistant Director for Research at Maine Sea Grant (October 2014 – present)

Acting Interim Director of the University of Maine's Ira C. Darling Marine Center (Summer 2014)

Co-Leader of Research Theme 1: Environmental Carrying Capacities for Coastal Seas in NSF's EPSCoR Sustainable Ecological Aquaculture Network (September 2014 – present)

Assistant Director of NSF-funded: "Water Sustainability and Climate Category 3 Collaborative: Impacts of Climate Change on the Phenology of Linked Agriculture-Water Systems" project

Environmental Monitoring Task Manager for the University of Maine led DeepCwind Consortium and Maine Aqua Ventus Offshore Wind Energy Initiatives (2011-present)

Post-doctoral Researcher, Department of Civil and Environmental Engineering, University of Delaware (2007-2010)

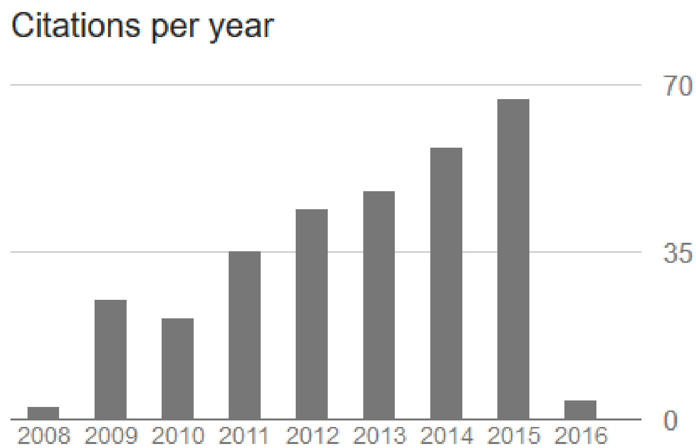
Research Assistant, University of Delaware, Lewes, DE (2001-2008)

PH.D. Dissertation: Behavior of juvenile estuary-dependent fish in relation to the spatial and temporal dynamics of diel-cycling hypoxia in an estuarine tributary

Undergraduate Senior Honors Program, Roger Williams University, Bristol, RI (2000)
Honors Thesis title: The effect of temperature and salinity on the optimum growth rate of *Tautoga onitis*

PUBLICATIONS

As of 1/1/2016: h-index = 9



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Grieve, C., **Brady, D.C.,** and Polet, H. (2014) Best practices for managing, measuring, and mitigating the benthic impact of fishing - Part 1. Marine Stewardship Council Science Series 2: 18-88

Miller, M.H., Targett, T.E., & **Brady, D.C.** (*accepted pending revisions*) Movement patterns of summer flounder (*Paralichthys dentatus*) in relation to diel-cycling hypoxia in an estuarine tributary. *Marine Ecology Progress Series*

Aikman, F., **Brady, D.C.,** Brush, M.J., Burke, P. Cerco, C.F., Fitzpatrick, J.J., He, R., Jacobs, G.A., Kemp, W.M., & Wiggert, J.D. (2014) Modeling approaches for scenario forecasts of Gulf of Mexico hypoxia. *Edited by* D.M. Kidwell, A.J. Lewitus, & E. Turner. White Paper from the Hypoxic Zone Modeling Technical

Review Meeting, 17-19 April 2013 at the Mississippi State University Science and Technology Center at NASA's Stennis Space Center in Mississippi, 46 pp.

Testa, J.M., Li, Y., Lee, Y., Li, M., **Brady, D.C.,** Di Toro, D.M., & Kemp, W.M. (2014) Quantifying the effects of nutrient loading on dissolved O_2 cycling and hypoxia in Chesapeake Bay using a coupled hydrodynamic-biogeochemical model. *Journal of Marine Systems*, 139: 139-158

Grieve, C., **Brady, D.C.**, & Polet, H. (2014) Best practices for managing, measuring, and mitigating the benthic impacts of fishing – Part 1. *Marine Stewardship Council Science Series* 2: 18-88. (Cited by the Institute for European Environmental Policy: Allocating fishing opportunities using environmental criteria and being proposed as the guide for determining impact as a criterion for allocating quota)

Brady, D.C. & Targett, T.E. (2013) Movement of juvenile weakfish (*Cynoscion regalis*) and spot (*Leiostomus xanthurus*) in relation to diel-cycling hypoxia in an estuarine tributary: Assessment using acoustic telemetry. *Marine Ecology Progress Series*, 491: 199-219

Brady, D.C., Testa, JM., Di Toro, D.M., Boynton, W.R., & Kemp, W.M. (2013) Sediment Flux Modeling: Application and validation for coastal systems. *Estuarine, Coastal, and Shelf Science* 117: 107-124

Testa, J.M., **Brady, D.C.**, Di Toro, D.M., Boynton, W.R., Cornwell, J.C., & Kemp, W.M. (2013) Sediment Flux Modeling: Simulating nitrogen, phosphorus, and silica cycles. *Estuarine, Coastal and Shelf Science*, 131: 245-263

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Zhang, Q., **Brady, D.C.**, & Ball, W.P. (2013) Long-term seasonal trends of nitrogen, phosphorus, and suspended sediment load from the non-tidal Susquehanna River Basin to Chesapeake Bay. *Science of the Total Environment*, 452-453: 208-221

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Brady, D.C. & Targett, T.E. (2010) Characterizing the escape response of air-saturation and hypoxia-acclimated juvenile summer flounder (*Paralichthys dentatus*) to diel-cycling hypoxia. *Journal of Fish Biology*, **77**(1): 137-152.

Breitburg, D.L., Craig, J.K., Fulford, R.S., Rose, K.A., Boynton, W.R., **Brady, D.C.**, Ciotti, B.J., Diaz, R.J., Friedland, K.D., Hagy, J.D. III, Hart, D.R., Hines, A.H., Houde, E.D., Kolesar, S.E., Nixon, S.W., Rice, J.A., Secor, D.H., & Targett, T.E. (2009) Nutrient enrichment and fisheries exploitation: interactive effects on estuarine living resources and their management. *Hydrobiologia*, 629(1): 31-47.

Tyler, R.M., **Brady, D.C.**, & Targett, T.E. (2009) Temporal and spatial dynamics of diel-cycling dissolved oxygen in estuarine tributaries. *Estuaries and Coasts.* 32(1): 123-145.

Brady, D.C., Tuzzolino, D.M., & Targett, T.E. (2009) Behavioral responses of juvenile weakfish, *Cynoscion regalis,* to diel-cycling hypoxia: swimming speed, angular correlation, expected displacement and effects of hypoxia acclimation. *Canadian Journal of Fisheries and Aquatic Sciences.* 66(3): 415-424.

Fennel, K., **Brady, D.C.**, Di Toro, D.M., Fulweiler, R., Gardner, W.S., Giblin, A., McCarthy, M.J., Rao, A., Seitzinger, S., Thouvenot-Korppoo, & Tobias, C. (2009) Modeling denitrification in aquatic sediments. *Biogeochemistry.* **93**(1-2): 159-178.

CBEO Project Team: Ball, W.P., **Brady, D.C.**, Brooks, M.T., Burns, R, Cuker, B.E., Di Toro, D.M., Gross, T.F., Kemp, W.M., Murray, L., Murphy, R.R., Perlman, E., Piasecki, M., Testa, J.M., & Zaslavsky, I. (2008) Prototype system for multi-disciplinary shared cyberinfrastructure: Chesapeake Bay Environmental Observatory (CBEO). *Journal of Hydrologic Engineering, ASCE*. **13**(10): 960-970.

FUNDING HISTORY in ECOLOGICAL MODELING (co-investigator or co-author)

Brady, D.C., Xue, H., Chai, F., Zou, Q., Segee, B., & Cousins, S. MRI Track1: Acquisition of High Performance Computing to Model Coastal Responses to a Changing Environment. NSF Major Research Instrumentation -09/01/2015-08/31/2017 $266,309

Brady, D.C., Boss, E., Thomas, A, Morse, D., and Newell, C. Aquaculture Site Prospecting: Developing Remote Sensing Capabilities for the Aquaculture Community of Maine - National Strategic Initiative for National Sea Grant - 09/01/2015-08/31/2017 $227,208

Brady, D.C. Characterizing the Penobscot River estuarine transition zone to determine environmental challenges for Atlantic salmon, their prey, and other sea-run species. NOAA Cooperative Institute of the North Atlantic Region – 01/01/2015-12/31/2015 $66,893.

Brady, D.C. Development of a coupled hydrodynamic-biological decision support model for sea lice management. Northeast Regional Aquaculture Center - $200,000. Decision pending.

Unfunded: Projecting Climate-related Shifts in American Lobster Habitat and Connectivity: integrated Modeling to Inform Sustainable Management. Wahle, R.A. (Lead PI), Brady, D.C., Chen, Y., Incze, L., Xue, H. (UMaine), Shank, B, and Stock, C. (NOAA). Funding Agency NOAA Climate Program Office, funded at $1,066,000

Unfunded: Developing Modeling and Observational Systems in Northern New England to Examine the Potential Impact of Ocean and Coastal Acidification on the American Lobster. Brady, D.C. (Lead PI), Wahle, R.A., Mayer, L.M., Xue, H., Smith, S.M. (UMaine), Salisbury, J. (UNH), Fields, D. (Bigelow), and Arnold, S. (Island Institute). Funding Agency: NOAA CSCOR, funded at $1,496,000

The Development of On-Land, Closed Containment Integrated Multitrophic Sustainable Aquaculture by means of Ecological Diversity. Pryor, T. (Acadia Harvesting), Barrett, A. (Acadia Harvesting), Brady, D.C. (UMaine). Funding Agency: NSF Small Business Innovation Research Phase II. Project Period: 10/1/2014-9/31/2016 funded at $750,000

Water Sustainability and Climate Category 3 Collaborative: Impacts of Climate Change on the Phenology of Linked Agriculture-Water Systems. Ball, W.P. (Director), Harmon, C. (JHU – Associate Director), Brady, D.C. (UMaine – Assistant Director), Testa, J.M., Kemp, W.M., Wainger, L. (UMCES), and Ortiz-Bobra, A. (Cornell). Funding Agency: NSF. Project Period: 09/01/2014 – 08/31/2017 funded at $2,500,000

Maine EPSCoR: The Nexus of Coastal Marine Social-Environmental Systems. *Part of the Writing Team.* Funding Agency NSF EPSCoR. Project Period: 11/1/2014-10/31/2019 funded at $20,000,000

Application of a Shallow-water Model for Use in Supporting Chesapeake Bay Management Decision-making. Investigators: Testa, J.M., Li, M. (UMCES), & Brady, D.C. (University of Maine). Funding Agency: Environmental Protection Agency. Project Period: 03/2014-02/2016 funded at $73,333

The role of wild and farmed fish in modulating infectious pressure of the sea louse (*Lepeophtherius salmonis* Kroyer 1837). Investigators: Bricknell, I. & Brady, D.C. (University of Maine). Funding Agency: NOAA National Sea Grant. Project Period 2013-2015 funded at $697,826.

TMDL Model and Data Evaluation for Delaware's Inland Bays. Investigator: Brady, D.C. (University of Maine). Funding Agency: Delaware Center for the Inland Bays. Project Period: 2012-2013 funded at $15,000.

Validating and improving a mechanistic sediment flux modeling framework to simulate a climate and nutrient management driven transition from eutrophication to oligotrophication. Investigators: **Brady, D.C.** (University of Maine)**,** Di Toro, D.M. (University of Delaware (UD)), Nixon, S. (University of Rhode Island), & Fulweiler, R. (Boston University). Funding Agency: Rhode Island Sea Grant. Project Period: 2011-2012 funded at $10,000.

Feasibility Study for Operational Regional Coastal Ecosystem Management Models. Investigators: Fitzpatrick, J. (HDR|HydroQual), Di Toro, D.M. (UD), Scavia, D. (University of Michigan), De Pinto, J. (LimnoTech, Inc.), Kemp, W.M. (University of Maryland Center for Environmental Sciences), & **Brady, D.C.** (University of Maine). Funding Agency: NOAA Center for Sponsored Coastal Ocean Research. Project Period: 2011-2014 funded at $500,000.

Can TMDL Models Reproduce the Nutrient Loading-Hypoxia Relationship? Investigators: Di Toro, D.M. (UD), **Brady, D.C.** (University of Maine), & Ball, W.P. (Johns Hopkins University). Funding Agency: Water Environment Research Federation (WERF). Project Period: 2010-2014 funded at $175,000.

NASA EPSCoR Research Project: Building and Enhancing a Competitive and Sustainable Remote Sensing Infrastructure for Critical Zone Studies and Cutting Edge Research. Investigators: Mullan, M, Yan, X-H, Sparks, D., Di Toro, D.M., Klemas, V., Jo, Y-H., & **Brady, D.C.** (UD). Funding Agency: NASA EPSCoR. Project Period: 2008 – 2011 funded at $749,769 and matched at $750,124.

Collaborative research: Process Based Statistical Interpolation Methods for Improved Analysis of WATERS Test-bed Observations and Water Quality Models. Investigators: Ball, W.P., Curriero, F. (JHU), Di Toro, D.M., & **Brady, D.C.** (UD). Funding Agency: National Science Foundation – Environmental Engineering. Project Period 2009 – 2012 funded at $252,193

CHRP07: Modeling Hypoxia and ecological responses to Climate and Nutrients. Investigators: Kemp, W.M., Li, M., North, E., Boynton, W., Secor, D., (University of Maryland Center for Environmental Studies), Di Toro, D.M., **Brady, D.C.** (UD), & Fennel, K. (Dalhousie University). Funding Agency: NOAA's Coastal Hypoxia Research Program. Project Period 2007 – 2012 funded at $2,321,845

A Prototype System for Multi-Disciplinary Shared Cyberinfrastructure – Chesapeake Bay Environmental Observatory (CBEO). Investigators: Gross, T. (Chesapeake Research Consortium), Ball, W.P. (JHU), Di Toro, D.M. (UD), Kemp, W.M. (UMCES), Piasecki, M. (Drexel University), & Burns, R. (JHU). Funding Agency: National Science Foundation - Cyberinfrastructure. Project Period: 2007-2010 funded at $2,149,906

Integrated Water Quality Monitoring, Habitat Mapping, and Fish Tracking with an Automated Underwater Vehicle. Investigators: Trembanis, A., Di Toro, D.M. & Targett, T.E. (UD). Funding Agency: Delaware EPSCoR Seed Grant Program. Project Period 2006 funded at $48,000.

Linking Water Quality Models with Individual-based Models to Investigate Impacts of Diel-cycling Hypoxia on Nursery Habitat Quality for Estuarine Dependent Fishes. Investigators: Targett, T.E., Di Toro, D.M. (UD), & Diaz, R.J. (College of William and Mary). Funding agency: NOAA Coastal Hypoxia Research Program. Project Period: 2005-2008

Impact of Hypoxia on Quality and Quantity of Estuarine Nursery Habitat: Patterns of in situ Growth and Swimming Avoidance Activity & Costs in Estuarine-Dependent Fishes. Investigator: Targett. T.E. (UD) Funding Agency: Delaware Sea Grant Program, NOAA, Grant No. NA03OAR4170011 (project R/F 23). Project Period: Feb. 1, 2003 – Jan. 31, 2005

FUNDING HISTORY – OTHER

FSML Planning for the Future of the Darling Marine Center. Investigators: Perry, M.J., **Brady, D.C.**, Chai, F., Lindsay, S., & Steneck, R. (University of Maine). Funding Agency: National Science Foundation. Project Period: 9/1/2013-9/1/2015 funded at $24,993

Maine Aqua Ventus I: Floating Offshore Wind Energy. Investigators: Dagher, H. (Advanced Composites Center) & **Brady, D.C.** (University of Maine). Funding Agency: Department of Energy's Offshore Wind Advanced Technology Demonstration Projects. Project Period: 2013-2014 funded at $4,000,000.

Developing wildlife monitoring capabilities for weather buoys in the Gulf of Maine. Investigators: **Brady, D.C.** (University of Maine) & Adams, E. (BioDiversity Research Institute). Funding Agency: Maine Sea Grant. Project Period: 2013-2014 funded at $5,400.

CONTRIBUTED AND INVITED RESEARCH PRESENTATIONS

***LEADERSHIP in the ECOLOGICAL MODELING COMMUNITY*:**

Co-chair of the Coastal and Estuarine Research Federation (CERF) Session: SCI-163 Timing is Everything: Phenology in Coastal Marine Ecosystems with Kemp, W.M., & Testa, J.M. (2015)

Leader of the NOAA North Atlantic Regional Team on the 2015 Theme - "Linking freshwater and ocean dynamics towards integrative ecosystem modeling: opportunities and challenges" with Dr. Adrian Jordaan - August 27-28th Norrie Point Environmental Center, NY

Co-chair of the Coastal and Estuarine Research Federation (CERF) Session: SCI-039 Synthesis Research in Estuarine and Coastal Science: Focus on Process and Application with Kemp, W.M., Testa, J.M., & Boynton, W.P. (2013)

Conference Organizing and Scientific Committee Member for Sea Lice 2014 in Portland, ME. And Chair of the Sea Lice Modeling Session: The 10th International Sea Lice Conference will be the first hosted in the U.S. from August 31st to September 5th

Chair of the Aquaculture Modeling Session at the Northeast Aquaculture Conference and Exposition on January 14th-16th 2015 in Portland, ME

MEDIA EXPERIENCE: January 23rd, 2015: Guest on WERU's Coastal Conversations: Ocean Acidification

Brady, D.C., Byron, C., Anderson, P. & Costa-Pierce. The Sustainable Ecological Aquaculture Network (SEANET). Coastal and Estuarine Research Federation meeting in Portland, OR - November 2015

Brady, D.C. Environmental Effects of Offshore Wind Development. Maine State Science Fair: February 20th, 2015

Brady, D.C. Northeast Aquaculture Convention and Exposition, Portland, ME January 16th, 2015. <u>Contributed Paper:</u> Modeling of Bivalve Aquaculture Spatial Impacts on Sediments (BASIS)

Brady D.C. 1st Annual Maine Aquaculture Research and Development Forum at the Northeast Aquaculture Convention and Exposition, Portland, ME January 14th, 2015: <u>Invited Feature:</u> The role of estuarine science in informing the location and dynamics of growing areas

Brady, D.C. Damariscotta River Association, Damariscotta, ME January 8th, 2015: <u>Invited Feature:</u> Damariscotta River Estuary: Where have we been and where are we going?

Brady, D.C. Maine Department of Environmental Protection, Augusta, ME December 17th, 2014: <u>Invited Feature:</u> How Models Influence Environmental Policy

Decision-Making: Lessons Learned from Models of Nutrient Loading and Hypoxia

Brady, D.C. The George J. Mitchell Center for Sustainability Solutions Invited Presenter, Orono, ME September 15th 2014: Invited Feature - How Models Influence Environmental Policy Decision-Making: Lessons Learned from Models of Nutrient Loading and Hypoxia

Ball, W.P., Zhang, Q., **Brady, D.C.**, Boynton, W. American Geophysical Union Fall Meeting December 15th-19th 2014, San Francisco, CA: Contributed Paper: Long-Term Loads of Nutrients and Sediment from Non-Tidal Regions of the Chesapeake Bay Watershed

Lasley-Rasher, R., Stevens, J., Lipsky, C., **Brady, D.C.**, Jumars, P. American Fisheries Society, August 17th-21st 2014: Contributed Poster: Exploring the importance of top-down and bottom-up drivers of mysid shrimp distribution in the Penobscot Estuary, Maine

Frederick, C., Pietrak, M., Barker, S., **Brady, D.C.,** & Bricknell, I. Sea Lice 2014 August 31st-September 5th, 2014: Contributed Paper: Where are all the sea lice? A First glance at sentinel fish in Cobscook Bay

Brady, D.C. The State of Maine's legislatively Convened Ocean Acidification Panel, August 1st, 2014: Invited Paper: The Potential Role of Water Quality Modeling in Coastal Acidification Management

Brady, D.C. Chesapeake Bay Program Modeling Workgroup April 1st, 2014: Invited Presentation: TMDL Models and Hypoxic Volume: A Long-term Modeling Approach

Brady, D.C. Center for the Inland Bays Science and Technical Advisory Committee, Lewes, DE March 28, 2014: Invited Paper: Water quality Modeling in Delaware's Inland Bays: Where Have We Been and Where Should We Go?

Brady, D.C. Climate Solutions Expo and Summit, March 15th, 2014: Invited Presentation: Climate Implications of Floating Offshore Wind Energy in Maine

Bayer, S.R., Wahle, R.A., **Brady, D.C.**, Brooks, D.A. & Jumars, P.A. Association for the Sciences of Limnology and Oceanography: Ocean Sciences, Honolulu, HI, February 23-28 Contributed Poster: Scale of fertilization success in an exploited broadcast spawner: From an individual to an estuary

Oppenheim, N.G., Wahle, R.A., & **Brady, D.C.** Association for the Sciences of Limnology and Oceanography: Ocean Sciences, Honolulu, HI, February 23-28 Contributed Poster: Can we forecast the future of the American lobster fishery from a larval settlement index?

Brady, D.C., Testa, J.M., Sanford, L.P., Cornwell, J.C., Newell, R.I.E., Newell, C., & Richardson, J. Coastal and Estuarine Research Federation Meeting, San Diego, CA, November 3-7 2013 Invited Paper: Sediment flux modeling of Bivalve Aquaculture Spatial Impacts on Sediments (BASIS)

Brady, D.C. Maine Maritime Academy, Castine, ME, October 21 2013 Invited Seminar: Floating Offshore Wind Energy Development: Monitoring and Permitting Next Generation Technology

Brady, D.C. Island Institute Energy Conference, Belfast Bay, ME, October 18 2013 Invited Presentation: Floating Offshore Wind Energy Development in Maine: Updates from DeepCwind and Maine Aqua Ventus

Zhang, Q., Brady, D.C., & Ball, W.P., Community Surface Dynamics Modeling System Annual Meeting, Boulder, CO, March 23-25, 2013 Contributed Paper: Long-term Seasonal Trends of Nitrogen, Phosphorus, and Suspended Sediment Load from the Non-tidal Susquehanna River Basin to Chesapeake Bay

Brady, D.C., Fitzpatrick, J., Scavia, D., DePinto, J., Kemp, W.M., & Di Toro, D.M. Association for the Sciences of Limnology and Oceanography: Aquatic Sciences, New Orleans, February 17-22, 2013. Invited Paper: Feasibility study for operational regional coastal ecosystem management models

Brady, D.C., Di Toro, D.M., Targett, T.E. & Kemp, W.M. Association for the Sciences of Limnology and Oceanography: Aquatic Sciences, New Orleans, February 17-22, 2013. Contributed Paper: Coupling the spatial and temporal dynamics of hypoxia with juvenile estuary dependent fish behavior

Brady, D.C. U.S.-Canadian Lobsterman Town Meeting, Portland, ME March 2012. Environmental Effects of Offshore Wind Development: The DeepCwind Case Study

Brady, D.C., Testa, J., Di Toro, D.M., Boynton, W.R. & Kemp, W.M. Coastal and Estuarine Research Federation Meeting, Daytona, FL, November 2011. Contributed Paper: Estimating organic matter deposition and decay with a long-term sediment flux database and mechanistic model

Ball, W.P., Bosch, J.A., Brady, D.C., Di Toro, D.M., Kemp, W.M., Murphy, R.R., & Testa, J.M. Association of Environmental Engineering and Science Professors, Tampa Bay, FL, July 2011. Contributed Paper: Hypoxia in Chesapeake Bay: Mining decades of data for new insights

Brady, D.C., Testa, J., Di Toro, D.M., & Kemp, W.M. Chesapeake Bay Modeling Symposium, Annapolis, MD, May 2010. Invited Paper: Sediment-Water Oxygen and Nutrient Exchanges in Chesapeake Bay: Insights from Model-Data Comparisons

CBEO Project Team: Ball, W.P., Burns, R, Cuker, B.E., Di Toro, D.M., Kemp, W.M., Murray, L., Piasecki, M., Zaslavsky, I., Aguayo, M., Bosch, J., Brady, D.C., Murphy, R.R., Perlman, E., Rodriguez, M., Testa, J.M., & Whitenack, T. American Geophysical Union, San Francisco, CA, December 2009 Contributed Paper: The Design and Application of a Chesapeake Bay Environmental Observatory

Brady, D.C. & Targett, T.E. Coastal and Estuarine Research Federation, Portland, OR, November 2009. Contributed Paper: Movement of juvenile weakfish (*Cynoscion* *regalis*) and spot (*Leiostomus xanthurus*) in relation to diel-cycling hypoxia in an estuarine tributary: Assessment using acoustic telemetry

Brady, D.C., Di Toro, D.M., Kirby, J.T., Xu, L., & Targett, T.E. Estuarine Research Federation Conference, Providence, RI, November 2007. Contributed Paper: Water quality modeling of diel-cycling hypoxia in Delaware's Coastal Bays

Brady, D.C., Tuzzolino, D.M., & Targett, T.E. 31st Annual Larval Fish Conference, St. John's, Newfoundland, Canada, July 2007. Contributed Paper: Laboratory and field evaluation of juvenile weakfish (*Cynoscion regalis*) behavioral responses to diel-cycling hypoxia in estuarine tributaries.

Targett, T.E., Brady, D.C., & Stierhoff, K.L. Ecological Impacts on Living Resources Workshop, Stennis Space Center, Bay St. Louis, MS. March 2007. Contributed paper: Diel-cycling hypoxia in shallow estuarine waters: Impacts on fish growth and movements.

Brady, D.C. & Di Toro, D.M. Denitrification Modeling Across Terrestrial, Freshwater, and Marine Systems. The Institute of Ecosystems Studies, Millbrook, NY. November 2006. Invited Presentation: Sediment Flux Modeling: Special Emphasis on Denitrification

Brady, D.C., Tuzzolino, D.M., & Targett, T.E. Tidal Finfish Advisory Council, Delaware Department of Natural Resources & Environmental Control. Dover, DE. November 2006. Invited Presentation. Examining the resource value of benthic habitats affected by low dissolved oxygen to weakfish and summer flounder

Brady, D.C., Tyler, R.M., & Targett, T.E. 7th Annual Shallow Water Science and Management Conference, Atlantic City, NJ. September 2006. Contributed Paper: Spatial and Temporal Variability in Diel-Cycling Hypoxia: Causes and Consequences

Brady, D.C. Delaware's Center for the Inland Bays Science and Technical Advisory Committee, Lewes, DE. January 2006. Invited Presentation: A How to Guide for Estuary-Dependent Fish Avoiding Hypoxia in Delaware's Inland Bays

Brady, D.C., Tuzzolino, D.M., & Targett, T.E. Estuarine Research Federation Conference. Norfolk, VA. October 2005. Contributed Paper. Hypoxia-induced searching strategies of juvenile weakfish: How do interacting kineses facilitate hypoxia avoidance and survival?

Brady, D.C. American Fisheries Society 135th Annual Meeting. Anchorage, AK. September 2005. Contributed Paper: Integrating fish behavior and water quality models: Hypoxia-induced searching strategies of juvenile weakfish

Brady, D.C. Mid-Atlantic Chapter-American Fisheries Society Annual Meeting, Rider University, NJ. 2005. Invited Presentation. Searching for oxygen: Deriving a mechanistic understanding of weakfish behavior during hypoxia

Brady, D.C. & Targett, T.E. Flatfish Biology Conference. Westbrook, CT. December 2004. Contributed Paper: Behavioral responses of summer flounder and weakfish to declining dissolved oxygen: interspecific and intraspecific comparisons

Brady, D.C. University of Delaware College of Marine Studies Graduate Student Symposium. Lewes, DE. November 2004. Invited Presentation: Behavioral responses of fishes to declining dissolved oxygen: avoidance and acclimation

Brady, D.C., & Targett, T.E. VI International Congress on the Biology of Fish. Manaus, Brazil. August 2004: Contributed Paper. Behavioral responses of juvenile estuarine-dependant fishes to declining dissolved oxygen: avoidance, recovery, and acclimation

Brady, D.C. & Targett, T.E. Tidal Finfish Advisory Council, Delaware Department of Natural Resources & Environmental Control. Dover, DE. June 2004: Invited Presentation. Moving targets: linking water quality to juvenile weakfish and summer flounder

Brady, D.C. & Stierhoff, K.L. UD College of Marine Studies Ocean Current Lecture Series. Lewes, DE. 2002: Invited Presentation. The stresses on fish and graduate students in and around Delaware Bay

FELLOWSHIPS AND DISTINCTIONS

Frances Severance Award for Best Thesis or Dissertation in the College of Marine and Earth Studies Marine Biosciences Program, University of Delaware, Lewes, DE, 2008

Center for the Inland Bays Award for demonstrating research excellence that advances the resource management and educational missions of the center, Center for the Inland Bays, Rehoboth, DE, 2008

Best Student Oral Presentation at the Mid-Atlantic Chapter of the American Fisheries Society, Rider University, Lawrenceville, NJ. 2005.

Best Student Oral Presentation in the “Fish Locomotion” Symposium.VI International Congress on the Biology of Fish, Manaus, Brazil. August 2004.

Marian R. Okie Fellowship for academic and research excellence and demonstrated leadership abilities. University of Delaware Graduate College of Marine Studies. 2004 – 2005

Marine Biology/Biochemistry Program Fellow. University of Delaware Graduate College of Marine Studies. 2001-2002.

TEACHING & EDUCATION EXPERIENCE

Master’s and Ph.D. Student Committees: Skylar Bayer, Jennifer McHenry, Kevin Du Clos, Kevin Staples, and Catherine Fredericks (UMaine’s School of Marine Sciences), Danielle Martin and Brett Gerrard (UMaine’s School of Earth and Climate Sciences), and Kisei Tanaka (UMaine’s Climate Change Institute), Sarah Fischer (University of Delaware’s College of Earth, Ocean, and the Environment)

Post-doc Advisor to Rachel Lasley-Rasher, Ph.D. (NSF Biological Oceanography Fellowship) and Kelly Cole, Ph.D. (NSF New England Sustainability Consortium)

Capstone Project Advisor for UMaine Student, Marina Van der Eb: "Behavioral model of Atlantic salmon in relation to sea lice infectious pressure" and Brianna Smith "Nutrient, Light, and Productivity Dynamics in the Damariscotta River Estuary"

May/June 2011-present: MATLAB for Marine Scientists (2 CR) at the Darling Marine Center at the University of Maine

Fall 2012 and 2013: Developer of and Lecturer in SMS 500: Marine Biology, the University of Maine's 1st Graduate Level Marine Biology course and a requirement for graduate students

2011-2013: Guest lecturer in the Semester by the Sea Program at the Darling Marine Center at the University of Maine in Human Impacts on the Ocean: "Eutrophication in the Coastal Ocean" & "Environmental Impacts of Offshore Wind", Benthic Ecology: "Movement Ecology", and Estuarine Oceanography: "The role of models in estuarine management"

2010-2012: Adjunct Professor at Husson University, Bangor, ME teaching the laboratory sections of General Biology II and Principles of Chemistry I & II

2005-2009: Guest Lecturer at the University of Delaware in Advanced Water Quality Modeling, Eutrophication and Sediment Flux Modeling & Fish Topics

2005: Guest Lecturer at Delaware State University in Marine Biology: "The Functional Role of Estuaries: Can We Break Them?"

2000: Wildlife Educator, Wildlife Conservation Society, Bronx Zoo. Taught wildlife science to K-12th grade.

2000: Education Consultant, Metis Associates, New York, New York, Data analysis particularly concerning program development and evaluation in K-12th grade education

Summer 1996 & 1997: Marine Mammal Demonstration Narrator and Assistant Trainer, Wildlife Conservation Society New York Aquarium for Wildlife Conservation. Narrated marine mammal demonstrations (three shows daily for 1400 people) and assisted in care, training and behavioral observations for California sea lions, Atlantic bottle-nosed dolphins, and beluga whales.

UNIVERSITY SERVICE, CONSULTING, & VOLUNTEER OUTREACH

Environmental Monitoring and Permitting Task Manager for the DeepCwind Consortium and Maine Aqua Ventus I (2012-present)

- Received Finding of No Significant Impact (FONSI) for Monhegan Island Floating Offshore Wind Test Site (2012) – First permitted project of its kind in the US
- Received Finding of No Significant Impact (FONSI) for the Castine, ME Floating Offshore Wind Test Site (2013) – First floating offshore wind turbine connected to the grid in the US
- Only DOE Offshore Wind Technology funded project to have no environmental monitoring and permitting spending holds

Proposal and Natural Resource Management Review:

- Member of the Environmental Effects Panel for the Gulf of Mexico Research Initiative RFP-I (2011), RFP-II (2012), and RFP-I (2015) to investigate the impacts of the Deepwater Horizon Oil Spill
- Technical Advisory Committee for Maine Sea Grant's Healthy Beaches Program (2015-present)
- Reviewer for New Jersey, Puerto Rico, and Oregon Sea Grant Full Proposals: July 2013. Reviewer for Maryland Sea Grant 2015
- Advisor to the Maine Coastal Mapping Initiative and the Maine Coastal Atlas Project, both run by the State of Maine's Coastal Program: 2013-present
- Member of NOAA's Northern Gulf of Mexico Hypoxia Modeling Technical Review Team: April 17-18, 2013, Stennis Space Center, MS
- Member of the Comprehensive Management Plan team for Delaware's Inland Bays and editor of the State of the Bay report for Delaware's Inland Bays (2011-present)
- Panel Reviewer for Connecticut and New York Sea Grant: Long Island Sound Study Pre-proposals and Full Proposals: 2012
- Panel Reviewer for Virginia Sea Grant Pre-proposals 2011
- Member of the Peer Advisory Panel for the National Oceanic and Atmospheric Association (NOAA) Coastal Hypoxia Research Program. February 2010.

Reviewed Manuscripts or Book Chapters for Estuarine and Coastal Shelf Science (named a top reviewer in 2015), Estuaries and Coasts, Marine Ecology Progress Series, Climatic Change, Conservation Physiology, Journal of Marine Systems, Fisheries Oceanography, Journal of the American Water Resources Association, Fishery Bulletin, Journal of Environmental Management, African Journal of Biotechnology, Journal of Experimental Marine Biology and Ecology, Fisheries Research, and Garland Scientific, Hydrobiologia, Journal of Fish Disease

Senior Modeling Consultant for Chesapeake Biogeochemical Associates: Philadelphia Water District Project 09/01/2015-08/31/2017

Serve on the University of Maine's Ira C. Darling Marine Center Safety Committee (2012-present)

Marine Biology Educator for the University of Maine's College of Natural Sciences, Forestry, and Agriculture Freshman Orientation (Fall 2011-present) and the Darling Marine Center Dive-In Program for High School Seniors (Summer 2011-present)

Consultant for the Marine Stewardship Council regarding the environmental effects of fishing gear on habitat (September 2011)

Scientific Advisor for the Hurricane Island Foundation Center for Science and Leadership Field Research Station (2011-present)

Served on the University of Delaware's College of Earth, Ocean, and Environment Search Committee for an Academic Coordinator

Student Representative for the University of Delaware's Graduate College of Marine Studies Academic Council, 2005-2007.

University of Delaware College of Marine Studies Lunch Lecture Series for Research Experience for Undergraduate (REU) interns, "Applying to Graduate School in the Marine Sciences" (Summers 2003-2006).

Marine Biology Educator, Partnership for the Delaware Estuary, Wilmington, DE (2004)

Marine Biology Educator, Mariner Middle School, Milford, DE (2002-2003)

Marine Biology Educator, H.B. DuPont Middle School, Hockessin, DE (2002-2003 & 2006)

Marine Biology Educator, Governor's School for Excellence, Lewes, DE (2001-2004) Judge, Sussex County Science Fair (2002)

University of Delaware College of Marine Studies Ocean Currents Lecture Series Lecturer (2002).

GRADUATE COURSES

Marine Biology (A-); Marine Biochemistry (A); Coastal Field Biology (A); Statistics in the Marine Sciences (A); Ecology and Evolution of Coral Reefs (A); Genetics of Marine Organisms (A); Marine Inorganic Chemistry (A); Writing Papers in the Marine Sciences (A-); Ichthyology: Systematics, Physiology, & Ecology (A); Introductory PERL for Biologists (A); Advanced Water Quality Modeling (A-); Physiology of Marine Organisms (A); ; Topics in Fish Biology (7 semesters, A's); Benthic Boundary Layer Seminar (A); Marine Biology-Biochemistry Seminar (2 semesters, A), Eutrophication and Sediment Flux Modeling (A-), Principles of Water Quality Criteria (audited)

GPA: 3.93

UNDERGRADUATE COURSES in the SCIENCES

Biology I & II; Principles of Chemistry I & II; Calculus I & II; Expository Writing; Critical Writing for Science Majors; Marine Zoology; Organic Chemistry I & II; Probability and Statistics; Physics I & II; Introduction to Speech Communication; Scientific Communication; Principles of Oceanography; Practical Oceanographic Research; Nautical Science; Marine Technology; Maritime Studies; Ichthyology; Animal Behavior; Environmental Analysis II; Botany; Evolution; Freshwater/Estuarine Ecology; Herpetology; Marine Phycology; Biochemistry; Ornithology; Instrumental Methods of Analysis; Advanced Chemistry Lab

GPA: 3.71

PROFESSIONAL AFFILIATIONS

American Fisheries Society

Mid-Atlantic Chapter Member (2002-2008)

Mid-Atlantic Chapter Student Representative 2004

Estuaries and Early Life History Sections Member

The Coastal & Estuarine Research Federation

New England Estuarine Research Society

Association for the Sciences of Limnology and Oceanography

SKILLS AND CERTIFICATION

Programming: ArcGIS Editor, FORTRAN, MATLAB®, SQL Server, and VBA

Statistical Packages: SAS, SPSS, Systat, and DTREG

Ecosystem Modeling Experience: ECOPATH: Completed 30 Hours Instructional Time in "Ecosystem Modeling using EcoPath with EcoSim", March 12-15, 2012

Water Quality Modeling: Row Column AESOP (RCA), Sediment Flux Modeling (SFM), Chesapeake Bay Eutrophication Model (CE-Qual-ICM)

Hydrodynamic Modeling: Estuarine Coastal Ocean Model with Sediment module (ECOMSED), Regional Ocean Modeling System (ROMS), Larval Transport Lagrangian Model (LTRANS – completed 2 day training at Horn Point Laboratory with Dr. Elizabeth North)

Watershed Modeling: Hydrologic Simulation Program – FORTRAN (HSPF)

NAUI Open Water Dive (1999)

USCG Small Boat Operators Certification (2001)

REFERENCES

Dr. Dominic M. Di Toro, Professor, University of Delaware-Department of Civil & Environmental Engineering

Email: dditoro@ce.udel.edu Phone: (302) 831-4092

Dr. Peter Jumars, Professor, University of Maine – School of Marine Sciences

Email: jumars@maine.edu Phone: (207) 563-8101

Dr. Timothy E. Targett, Professor, University of Delaware

Email: ttargett@udel.edu Phone: (302) 645-4396

Dr. W.M. Kemp, Professor, University of Maryland Center for Environmental Science

Email: kemp@umces.edu Phone: (410) 221-8490

2. Resume for Dr. James Martin

Dr. James Martin’s 2016 Curriculum Vitae is provided on pages C19 through C52

JAMES LENIAL MARTIN, Ph.D., P.E., D. WRE, F. ASCE

Professor and Kelly Gene Cook, Sr. Chair in Civil Engineering
Department of Civil and Environmental Engineering
Mississippi State University

223 Walker Engineering Building
Box 9546
Mississippi State, MS 39762

Voice: (662) 325-7194
Fax: (662) 325-7189
E-mail: jmartin@cee.msstate.edu

BIRTHPLACE

December 4, 1947
Amarillo, Texas

AREA OF SPECIALIZATION:

Water quality modeling and environmental software development.

EDUCATION

Ph.D. in Civil/Environmental Engineering, Texas A & M University, College Station, Texas, 1984 (Major Prof: Dr. Steve Chapra).

B.S. in Civil Engineering, Texas A & M University, College Station, Texas, 1981.

M.S. in Biology/Aquatic Biology, Southwest Texas State University, San Marcos, Texas, 1976.

B.S. in Wildlife Science, Texas A & M University, College Station, Texas, 1970.

SUMMARY OF QUALIFICATIONS AND EXPERIENCE:

James L. Martin, Ph.D., P.E., has over 30 years of experience in conducting and managing water quality modeling projects. Previously, he conducted studies while a Research Civil Engineer with the Water Quality and Contaminant Modeling Branch with the U.S. Army Corps of Engineers Waterways Experiment Station (WES), while Vice President and Director of Engineering with AScI Corporation, and while a Research Environmental Scientist with the U.S Environmental Protection Agency at its Large Lakes Research Station. For five years he provided contract support to the U.S. EPA Center for Exposure Assessment Modeling through model development, providing technical assistance to the EPA, state and local agencies, and through model application. He has authored/co-authored over 100 technical reports and publications, including E.P.A. guidance documents and model user documentation. He is the former Editor of the ASCE Journal of Energy Engineering, former Chair of the Executive Committee, ASCE Energy Division, and former member of the ASCE Technical Activities Committee (TAC). He has been involved in the development of a number of hydrodynamic and water quality models in common usage. He is author of the textbook Hydro-Environmental Analysis: Fresh-Water Environments (December 2013), senior editor and author of Energy Production and Reservoir Water Quality (2007) and senior author of the textbook Hydrodynamics and Transport for Water Quality Modeling (1999). He is a Diplomate, Water Resources Engineering, American Academy of Water Resources Engineers and Fellow, American Society of Civil Engineers. He is presently a Professor and Kelly Gene Cook, Sr. Chair in the Department of Civil and Environmental Engineering, Mississippi State University.

PROFESSIONAL REGISTRATION

Registered Professional Engineer in Florida (inactive, 46293)

Registered Professional Engineer in Georgia (inactive, 20491),

Registered professional Engineer in Mississippi (9949)

Diplomate, Water Resources Engineer (00107), American Academy of Water Resource Engineers

PROFESSIONAL EXPERIENCE

Professor and Kelly Gene Cook, Sr. Chair in Civil and Environmental Engineering, Department of Civil and Environmental Engineering, Mississippi State University, 2001-present. Teaches and conducts research concerning water quality modeling and assessment.

Visiting Professor. Universiti teknologi Malaysia, Department of Civil Engineering, Skudai, Malaysia. July 2008 and July-August 2011.

Research Civil Engineer, US Army Engineer Research and Development Center, Waterways Experiment Station, Water Quality and Contaminant Modeling Branch, 1999-2001. Conducted research and applied studies concerning water quality modeling and assessment.

Vice President, AScI Corporation, 1993-1999. Assisted the President, AScI Corporation, in the overall management and operations of an international environmental contracting firm, headquartered in McLean, Virginia.

Director of Engineering, AScI Corporation, 1990-1993. Directed engineering operations of an international environmental contracting firm, headquartered in McLean, Virginia. Assisted in the planning of projects, communication with client offices, selection of staff and other corporate responsibilities. Conducted mathematical modeling studies and model development for various clients.

Manager, AScI Corporation at the USEPA Environmental Laboratory, Athens, Georgia, 1988-1990. Supervised multi-disciplinary staff and provided technical support for the Center for Exposure Assessment Modeling. Tested and refined exposure assessment techniques as well as provided training in assessment modeling for EPA and state personnel. Developed and applied mathematical models of contaminant transport and fate.

Research Environmental Scientist, Large Lakes Research Station, U.S. Environmental Protection Agency, 1986 - 1988. Served as Project Manager for a research team dealing with data acquisition and mathematical modeling of toxic substances in the Great Lakes as well as Project Officer for extramural research dealing with mathematical modeling activities. Acted as a consultant to the EPA and other government agencies on mathematical modeling and represented EPA on committees and work groups at the International level.

Civil Engineer, Water Quality Modeling Group, Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station, 1984-1986. Involved in the development and application of water quality models. Served as principal investigator on studies of reservoir tailwaters, effects of peaking hydropower on fisheries habitat, riverine water quality under steady and unsteady flow, development and application of a two-dimensional hydrodynamic and water quality model, and other studies. Acted as a consultant to Corp offices and other government agencies on water quality and contaminant modeling.

Lecturer, Civil Engineering, Texas A & M University, 1984. Instructed courses in Engineering Analysis, Water Resources Engineering, Computer Applications in Engineering and Construction (Numerical Methods) and Environmental Engineering Laboratories.

Research Assistant, Civil Engineering, Texas A & M University, 1980-1984. Involved in collection and analysis of water, sediment, and biota samples for nutrients, trace metals, and selected organic contaminants; environmental impact assessment.

Teaching Assistant, Chemistry, Texas A & M University, 1979. Instructed laboratories in inorganic chemistry.

Biology Instructor, Victoria Texas C.I.S.D., 1976-1979. Instructed secondary courses in Biology.

Laboratory Instructor, Biology, Southwest Texas State University, 1974-1976. Instructed laboratories in Biology, Mammalogy, Wildlife Management, Field Biology.

Science Instructor, Nixon, Texas I.S.D., 1971-1974. Instructed secondary courses in Mathematics, Physics, Earth Science, and Chemistry.

MILITARY EXPERIENCE

Texas Army National Guard (Enlisted, SP 5), 1st Battalion (Airborne Infantry), 143d Infantry, 1971-1977.

AWARDS AND HONORS

Sigma Xi – Member

Certificate of Commendation, Department of the Army, June 1996

AScI Award for Distinguished Achievement, 1991

Certification of Appreciation, American Society of Civil Engineers, Environmental Management, 1996

Certificate of Commendation, Department of the Army, June 1999

Certificate of Commendation, Department of the Army, June 2000

Hydraulic Achievement Award 2004, Mississippi American Society of Civil Engineers

Elected Fellow, American Society of Civil Engineers (F. ASCE), July 2005

Founding Diplomate, Water Resources Engineering (D. WRE), American Academy of Water Resources Engineers (October 2005)

Elected to Bagley College of Engineering Academy of Fellows, Mississippi State University, February 2006.

Elected to GeoResources Institute Research Fellow, Mississippi State University (2008)

Nominated by College of Engineering for the MSU Faculty Achievement Award (2012)

Nominated by College of Engineering for the Giles Distinguished Professorship (2013)

Elected to Bagley College of Engineering Academy of Distinguished Teachers (2013)

American Society of Civil Engineers Samuel Arnold Greeley Award “For the paper “Modeling the Factors Controlling Phytoplankton in the St. Louis Bay Estuary, Mississippi and Evaluating Estuarine Responses to Nutrient Load (co-author), 2016

PROFESSIONAL SERVICE

American Society of Civil Engineers

- Fellow, American Society of Civil Engineers (2005-present)
- Member, American Society of Civil Engineers (1985-2005)
- Editor-in-Chief, ASCE Journal of Energy Engineering (2002-2005)

Chair, Energy Division, Executive Committee (2005-2006)

Past-Chair, Executive Committee, Energy Division (2006-2007)

Member, Editorial Board, Energy Division (2002-2007)

Chair, Environmental Effects Committee, Energy Division (2005-2007)

Member, Task Committee on Energy Production and Reservoir Water Quality (2002-2007)

Chair, ASCE Paper Awards Committee (2007-2010)

Member, ASCE Visioning Implementation Subcommittee (2007-2010)

Member, ASCE Technical Activities Committee (2007-2010)

Member- ASCE COPRI Marine Renewable Energy - In Stream Hydrokinetic Sub-Committee Member (2010-Present)

Member-ASCE EWRI Total Maximum Load Task Committee (2012-present)

Member-ASCE EWRI Watershed Management Technical Committee (2015-Present)

Reviewer for Journal of Environmental Engineering

Reviewer for Journal of Energy Engineering

North American Lake Management Society

Member and Associate Editor

Sigma Xi – Member

Delegate, Universities Council on Water Resources (UCOWR).

Mississippi Department of Environmental Quality

Member, Mississippi Department of Environmental Quality's Nutrient Task Force (2004-present)

Member, Conjunctive Use Task Force (2012-Present)

UNIVERSITY SERVICE

- MSU University Service
  - Elected Member Robert Holland Faculty Senate Faculty Senate (2005-2007, 2013-2015)
  - Student Affairs committee, Robert Holland Faculty Senate (2005-2007).
  - University P&T Committee (2009-2012)
- College of Engineering
  - University P&T Committee (2007-2010)
  - Distance Education Committee (2007-2010)
  - Dean Search Committee (2014-2015)
  - BCOE Graduate Student Hall of Fame Selection Committee (2014-present)
- Department of Civil and Environmental Engineering

- Chair of CE Department Scholarship Committee (2007-present)
- Chair of CE Department Graduate Committee (2007-present)
- Member, CE Department P&T Committee (2012-present)
- Graduate Coordinator (2007-present)

PANELS AND ADVISORY BOARDS (RECENT)

Member, June 1999-August 2001, Peer Review Panel, Total Maximum Daily Load Group, Modeling Studies of the Savannah Harbor (invited and funded participant by CE District Savannah and USEPA Region 4)

Member, June 1999-August 2001, Modeling Technical Review Panel, Modeling Studies of the Savannah Harbor (invited and funded participant by CE District Savannah)

Member, June 2001-Present, American Society of Civil Engineers, Energy Engineering Division (EY), Committee on Environmental Effects, Task Committee For Developing Guidelines Manual on Reservoir and River Hydrodynamic and Water Quality Modeling Related to Energy Production (product to be Guidelines Manual).

Member, August 2001-2002, Expert Review Panel, Delaware Estuary Water Quality Model, Delaware River Basins Commission (invited and funded participant in November 29-30, 2001 peer review meetings) Member, August 2001-2002, Expert Review Panel, Delaware Estuary Water Quality Model, Delaware River Basins Commission (invited and funded participant in November 29-30, 2001 peer review meetings)

Member, September-December, 2001, Review Panel for Workshop for Development of a Water Budget for Tampa Bay, Florida, Tampa Bay National Estuary Program (NEP), Tampa, FL (invited panelist, at December 4-5, 2001 meeting to aid in synthesizing workshop recommendations and developing research plans for the NEP)

Member, Expert Panel on Simplified Approaches for Modeling Sediment Movement, Joint EPA/COE Workshop on Sediment Processes, New Orleans, LA, January 22-24, 2002 (Panel product was white paper).

Member, Invited Participant in Modeling Session in workshop “Science to Support Nutrient-Management Decisions Related to Hypoxia in the Northern Gulf of Mexico and Water Quality in the Mississippi River Basin,” October 16-18, 2002, St. Louis, MO.

Invited Peer Review Panelist, “LOTOX 2 Peer Review Session,” July 16-17, 2003, New York City, NY.

Invited Peer Review Panelist, U.S. Environmental Protection Agency, Great Lakes National Program Office, peer review of the Lake Michigan Mass Balance PCB Modeling. 2004.

Invited Peer Review Panelist, Environmental Protection Agency, Office of Water, draft cumulative impacts analysis (CIA) report for the Uniform National Discharge Standards (UNDS; coordinated by Versar). 2004.

Invited Peer Review Panelist, St. Johns Water Management District's model evaluation group for the Indian River Lagoon studies. 2004-2005.

Member, August 2001-Present, Expert Review Panel, Delaware Estuary PCB Model, Delaware River Basins Commission (invited and funded participant).

Invited Expert Review, 2008. Modeling studies of Bow River, Alberta, CA.

Invited Expert Review. 2010. Provided review of modeling group of Universidad Nacional de Colombia within the framework of the project for “Dynamic water quality modeling of the River Bogotá” developed for the Water Utility Empresa de Acueducto y Alcantarillado de Bogotá, EAAB by Universidad Nacional de Colombia – Bogotá, March 2010, Bogota, Colombia.

Invited Expert Review, 2008-2011. Proposed Surface Water Withdrawals from the St. Johns and Ocklawaha Rivers, St. Johns River Water Management District, Palatka, FL

Subject Mater Expert, 2010-Present, Tampa Bay Studies, Tampa Bay National Estuary Program and Southwest Florida Water Management District

EXPERT TESTIMONY

Law Environmental, Atlanta, Georgia: Provided expert review of modeling studies on the Dugdemona River, Louisiana (January-March 2002).

Southeast Clean Water Network, Tallahassee, FL: Provided expert review, deposition and court testimony related to modeling studies used in development of a discharge permit to the Lower St. Johns River, FL. (January through February 2002).

PUBLICATIONS: ENVIRONMENTAL SOFTWARE

Public Domain

1. **MICHRIV**: A screening level model for metals transport in rivers. Co-author of final documentation. Distributed by U.S. EPA Large Lakes Research Station, Grosse Ile, MI.

2. **STEADY**: A screening level model for dissolved oxygen and temperature in rivers. Author of code and documentation. Distributed by U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

3. **WASP**: A generalized modeling framework for modeling eutrophication and organic chemicals in surface waters. Co-author of documentation and code (Versions 4-8). Distributed by U.S. EPA Center for Exposure Assessment Modeling (CEAM), Athens, GA

4. **META4**: A generalized modeling framework for modeling metals transport and speciation in surface waters. Co-author of documentation and code. Distributed by U.S. EPA Hazardous Waste Reduction Laboratory, Cincinnati, OH.

5. **FLWASP**: A generalized modeling framework for modeling eutrophication and solids transport. Co-author of documentation and code. Distributed by South Florida Water Management District, West Palm Beach, FL.

6. **CE-QUAL-ICM**: Organic Chemical Model, a generalized model of organic contaminants specifically designed for coupling with multi-dimensional hydrodynamic models. Contributor to organic chemical model and co-author of user documentation. Distributed by U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

7. **CE-QUAL-W2**: A two-dimensional (x/z) hydrodynamic and water quality (eutrophication) model. Principal author of Version 1.0 and model code. Distributed by U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

8. **CE-QUAL-RIV1**: A one-dimensional hydrodynamic and quality model.

Contributing author and code developer for Version 1.0-3.0 and documentation. Distributed by U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

9. **EPD-RIV1**: A one-dimensional hydrodynamic and quality model. Senior author of user documentation and code (based on CE-QUAL-RIV1). Distributed by Georgia Environmental Protection Division, Atlanta, GA.

10. **RIVMOD**: A one-dimensional hydrodynamic model for rivers. Co-author of user documentation. Distributed by U.S. EPA Center for Exposure Assessment Modeling (CEAM), Athens, GA

11. **STREAM**. A one-dimensional dissolved oxygen model for streams and rivers. Co-author of model and user documentation. Mississippi Department of Environmental Quality, TMDL/WLA Branch, Surface Water Division.

12. **LAKE2K**, a one-dimensional (vertical) reservoir water quality model. Co-author of model and user documentation (with Steve Chapra and Rene Camacho)

Proprietary

1. **OMNIWASP**: A modified version of the WASP eutrophication model including the impact of macrophytes. Co-author of documentation and code. Developed for Omni Environmental, Princeton, New Jersey.
2. **WIN/WASP +**. A modified version of WASP developed for Windows95, Contributor to code development and design. AScI Corporation, Environmental Engineering Division, Athens, GA.
3. **STEADY-STATE**: A modified version of the WASP organic chemical model (TOXIWASP) designed to compute steady-state concentration distributions in water and sediment. Principal developer. Developed for Hart Crowser, Seattle, WA.

PUBLICATIONS: TECHNICAL BOOKS

1. Dortch, M.S. and **J.L. Martin**. 1988. "Water quality modeling in regulated stream environments", In: Alternatives in Regulated Flow Management (Ed. J.A. Gore). CRC Press, Boca Raton, FL.

2. Medine, Allen J., **Martin, James L**., 2002. Development of the Metal Speciation-based Metal Exposure and Transformation Assessment Model (META4): Application to Copper and Zinc Problems in the Alamosa River, Colorado. In: Fate and Transport of Chemicals in the Environment: Impacts, Monitoring and Remediation. R.L. Lipnick, R.P. Mason, M.L. Phillips, and C.U. Pittman (Eds.) ACS Publications, Washington.

3. McCutcheon, S.C., **J.L. Martin** and T.O. Barnwell, Jr. 1993. "Water Quality," In Handbook of Hydrology (Ed. D.R. Maidment), McGraw-Hill, New York, NY, pp. 11.1-11.73.

4. **Martin, J.L.** and S.C. McCutcheon. 1999. Hydrodynamics and Transport in Water Quality Modeling CRC Press, Boca Raton, FL, 794 p.

5. French, R, S.C. McCutcheon, and **J.L. Martin**. 1999. “Environmental Hydraulics,” In: Hydraulic Design Handbook (Ed. L.W. Mays), McGraw-Hill, New York, NY, pp.5.1-5.31.

6. **J. L. Martin**, J. Edinger, J. A. Gordon and J. Higgins (Editors). 2007. Energy Production and Reservoir Water Quality, American Society of Civil Engineers, Reston, VA.

    a. **James L. Martin**, Craig Hesterlee and Jeffery A. Ballweber. 2007. "Chapter 2: Energy Production, Reservoir and River Water Quality: Regulatory Framework," IN: J. L. Martin, J. Edinger, J. A. Gordon and J. Higgins (Editors). 2007. Energy Production and Reservoir Water Quality, American Society of Civil Engineers, Reston, VA.

b. Scott Wells, J. Russell Manson and **James L. Martin**. 2007. "Chapter 4: Energy Production, Reservoir and River Water Quality: Numerical Hydrodynamic and Transport Models for Reservoirs," IN: J. L. Martin, J. Edinger, J. A. Gordon and J. Higgins (Editors). 2007. Energy Production and Reservoir Water Quality, American Society of Civil Engineers, Reston, VA.

c. John Eric Edinger, **James Martin**, and Gregory Pelletier. 2007. "Chapter 5: Energy Production, Reservoir and River Water Quality: Water Quality Modeling Theory," IN: J. L. Martin, J. Edinger, J. A. Gordon and J. Higgins (Editors). 2007. Energy Production and Reservoir Water Quality, American Society of Civil Engineers, Reston, VA.

d. Edward Buchak, Jerad Bales and **James Martin**. 2007. "Chapter 6: Energy Production, Reservoir and River Water Quality: Modeling Systems and Their Application," IN: J. L. Martin, J. Edinger, J. A. Gordon and J. Higgins (Editors). 2007. Energy Production and Reservoir Water Quality, American Society of Civil Engineers, Reston, VA.

7. Alarcon, V. J., McAnally, W. H., Diaz-Ramirez, J.**, Martin, J**., & Cartwright, J. H. 2009. A Hydrological Model of the Mobile River Watershed. In G. Maroulis, T.E. Simos (Eds.), Computational Methods in Science and Engineering: Advances in Computational Science.. Paramus, New Jersey: American Institute of Physics. Volume 1148, 641-645.

8. Alarcon, V. J., McAnally, W. H., Wasson, L. L., **Martin, J**., & Cartwright, J. H. 2009. Using NEXRAD Precipitation Data for Enriching Hydrological and Hydrodynamic Models in the Northern Gulf of Mexico. Computational Methods in Science and Engineering: Advances in Computational Science (Maroulis, G. and Simos, T. E., Eds.). American Institute of Physics. Volume 1148, 646-650.

9. Aziz, W., Alarcon, V. J., McAnally, W. H., **Martin, J**., & Cartwright, J. H. 2009. An Application of the Mesh Generation and Refinement Tool to Mobile Bay, Alabama, USA. Computational Methods in Science and Engineering: Advances in Computational Science (Maroulis, G. and Simos, T. E., Eds.). Paramus, New Jersey: American Institute of Physics. Volume 1148, 651-656.

10. **Martin, J.L.** 2013. Hydro-Environmental Analysis: Freshwater Environments. CRC Press. Boca Raton, Fl. 567 pages (December 11, 2013). ISBN-10: 1482206072

PUBLICATIONS: BOOKS (NON-TECHNICAL)

1. Martin, James, Joyce Martin. 2007. Backyard Visions: The Ruby-Throated Hummingbird. ISBN 978-1-4303-1769-2, Lulu.com, Rochester, NY. 96 pp.

2. Martin, James, Joyce Martin. 2007. The Rookery at Noxubee Wildlife Refuge. ISBN 978-1-4303-2356-3, Lulu.com, Rochester, NY. 100 pp.

3. Martin, James, Joyce Martin. 2007. Images of North American Big Game. ISBN 978-1-4357-0076-5, Lulu.com, Rochester, NY, 108 pp.

4. Martin, James, Joyce Martin. 2008. The Red-cockaded Woodpecker at Noxubee National Wildlife Refuge, Lulu.com, Rochester, NY. 32 pp.

5. Martin, James, Joyce Martin. 2008. The Eagles at Noxubee NWR: Our 2008 Diary, Lulu.com, Rochester, NY. 56 pp.

6. Martin, James, Joyce Martin. 2014. The Great American Bluebird, Blurb.com, 32 pp.

7. Martin, James, Joyce Martin. 2014. Hummingbirds of the U.S.A., a Pictorial Essay, Lulu.com, Rochester, NY. 88 pp.

PUBLICATIONS: THESIS/DISSERTATION

1. **Martin, J.L.** "An analysis of the community and population dynamics of the helminths of Sigmodon hispidus (Rodentia: Cricetiade) from the area of San Marcos, Texas", M.S. Thesis, Southwest Texas State University, San Marcos, TX, 112 p., 1976.
2. **Martin, J.L.** "Models of diel variations of water quality in a stratified eutrophic reservoir (Lake Livingston, Texas)", Ph.D. Dissertation, Texas A & M University, College Station, TX, 359 p., 1984.

PUBLICATION: JOURNALS

1. **Martin, J.L.** and J. Ilika. "Review: Ayers, D.M. Bioscientific Terminology" Reading World, 14: 28, 1974.
2. **Martin, J.L.** and D.G. Huffman. "An analysis of the community and population dynamics of the helminths of Sigmodon hispidus (Rodentia: Cricetidae) from three central Texas vegetational regions", Proceedings of the Helmintho. Soc. Wash. 47: 247-255; 1980.
3. **Martin, J.L.**, B. Batchelor and S.C. Chapra. "Modification of a metal adsorption model to describe the effect of pH." J. Water Poll. Control Fed.: pp. 425-427; 1985.
4. **Martin, J.L.** "Application of a two-dimensional model to DeGray Lake, Arkansas." Am. Society Civil Engineers, Journal of the Environmental Engineering Division. Vol. 114(2), pp. 317-336; April 1988.
5. **Martin, J.L.**, W.L. Richardson, S.C. McCutcheon and J.F. Paul. "Modeling Studies for Planning: The Green Bay Project," Water Resources Bulletin 27(3), pp. 429-436, June 1991.
6. Wang, P.F. and **J.L. Martin**. "Temperature and Conductivity Simulations of the Buffalo River, NY," J. Great Lakes Research 17(4), pp. 495-503, Dec. 1991.Velleux, M.L., J.E. Rathbun, R.G. Kreis, Jr., **J.L. Martin**, M.J. Mac, and M.L. Tuchman. "Investigation of Contaminant Transport from the Saginaw Confined Disposal Facility," J. Great Lakes Research 19(1), pp. 158-174, 1993.

8. Lung. W.S., **J.L. Martin** and S.C. McCutcheon. "Eutrophication and Mixing Analysis of Embayments in Prince Williams Sound, Alaska," ASCE J. Environmental Engineering Division. 119(5), pp. 811-824, 1993.James, R. T., **J.L. Martin**, T. Wool and P.F. Wang. "A Sediment Resuspension and Eutrophication Model of Lake Okeechobee," J. American Water Resources Association, 33(3), pp. 661-680, 1997. Wang, P.F., **J.L. Martin**, T.A. Wool and T. Mill. "Fate and Transport of Metam Spill in the Sacramento River," ASCE J. Environmental Engineering Division, pp. 704-712, July 1997Wang, P.F., **J.L. Martin,** and T. Wool. "Water Quality Modeling and Eutrophication in Tampa Bay, Florida," Estuarine, Coastal and Shelf Science, 49, pp. 1-20, 1999.

12. **Martin, J.L**. and C. Hesterlee. "Energy Production And Reservoir And River Water Quality: Regulatory Framework," ASCE J. Energy Engineering, 129(3), pp. 33-59, 2002.

13. **Martin, J.L**. "Linear Superposition in TMDL Applications: The Steady-State Response Matrix Revisited," J. American Water Resources Association 43(5), pp. 1270-1279, 2007.

14. J. N. Diaz - Ramirez, V. J. Alarcon, Z. Duan, M. L. Tagert, W. H. McAnally, **J. L. Martin**, C. G. O'Hara, 2008. "Impacts of Land Use Characterization in Modeling Hydrology and Sediments for the Luxapallila Creek Watershed, Alabama and Mississippi," Transactions of the American Society of Agricultural and Biological Engineers, Vol. 51(1): 139-151

15. Alarcon V. J., McAnally, W., Diaz-Ramirez, J., **Martin, J.,** Cartwright, J., 2008. A Hydrological Model of the Mobile River Watershed, Southeastern USA. Proceedings ICCMSE 2008, American Institute of Physics.

16. Alarcon V. J., McAnally, W., Wasson, L., **Martin, J.**, Cartwright, J., 2008. Using NEXRAD Precipitation Data for Enriching Hydrological and Hydrodynamic Models in the Northern Gulf of Mexico. Proceedings ICCMSE 2008, American Institute of Physics.

17. Aziz, W., Alarcon V. J., McAnally, W., **Martin, J**., Cartwright, J., 2008. An Application of the Mesh Generation and Refinement Tool to Mobile Bay, Alabama, USA. Proceedings ICCMSE 2008, American Institute of Physics.

18. Duan, Z., Jairo N. Diaz, **James L. Martin** and William H. McAnally. 2008. "Effects of Land-Use Change on St. Louis Bay Watershed Simulations," Journal of Coastal Research, Special Issue 52, pp. 117-124.

19. Diaz-Ramirez, Jairo, Zhiyong Duan, William McAnally, and **James Martin**, 2008. "Sensitivity of the HSPF Model to Land Use/Land Cover Datasets," Journal of Coastal Research, Special Issue 52, pp. 89-94.

20. Diaz-Ramirez, J.N., V. Alarcon, Z. Duan, M.L. Tagert, W. H. McAnally, **J. L. Martin**, and C.G. O'Hara. 2008. Impacts of Land Use Characterization in Modeling Hydrology and Sediments for the Luxapallila Creek Watershed, Alabama/Mississippi. Transactions of the ASABE 51(1): 139-151.

21. Duan, Zhiyong, **James L. Martin**, William H. McAnally, and Richard L. Stockstill. 2009. Combined Effects of Wind and Streamflow on Gas-Liquid Transfer Rate, J. Envir. Engrg. Volume 135, Issue 8, pp. 653-659 (August 2009)

22. Duan, Zhiyong, **James L. Martin**, Richard L. Stockstill, William H. McAnally, David H. Bridges. 2009. Modeling Streamflow-Driven Gas-Liquid Transfer Rate, Environmental Engineering Science. January 2009, 26(1): 155-162

23. Diaz-Ramirez, J.N., B.E. Johnson, W.H. McAnally, **J.L. Martin**, V.J. Alarcon, and J.J. Ramirez-Avila. Global Parameter Sensitivity and Uncertainty of the USEPA HSPF Model: A Hydrology Model Evaluation in Alabama and Mississippi. Submitted to Environmental Modeling & Software [In review since March, 2009).

24. Wilkerson, G. Wayne, William H. McAnally, **James L. Martin**, Jeff A. Ballweber, Kim Collins Pevey, Jairo Diaz-Ramirez, and Austin Moore. 2010. "Latis: A Spatial Decision Support System to Assess Low-Impact Site Development Strategies," Advances in Civil Engineering, Volume 2010 (2010), Article ID 810402, 18 pages.

25. Edinger, John E. and **James L. Martin**. 2010. "Effects of the Addition of Multi-Slip Docks On Reservoir Flushing and Water Quality: Hydrodynamic Modeling; Aquatic Impact; Regulatory Limits," Journal of Transdisciplinary Environmental Studies vol. 9, no. 1, 2010

26. Diaz-Ramirez, J.N., W.H. McAnally and **J.L. Martin**. 2011. "Analysis of Hydrologic Processes Applying the HSPF Model in Selected watersheds in Alabama, Mississippi and

Puerto Rico," Applied Engineering in Agriculture, vol. 27(6), pp. 937-954.

27. Yi Xiong, Vladimir J. Alarcon, **James L. Martin**, William H. McAnally. 2012. "WASP_SEDDEER: Incorporation of SEDDEER into WASP," Energy and Environment Research, Vol 2, No 1, 157-181.

28. Camacho, Rene A. and **James L. Martin**. 2012. "Hydrodynamic Modeling of First Order Transport Time Scales in the St. Louis Bay Estuary, Mississippi, the ASCE J. Environmental Engineering, 10.1061/(ASCE)EE.1943-7870.0000647

29. Diaz-Ramirez, Jairo N., William McAnally, and James Martin. 2012. "Sensitivity of Simulating Hydrologic Processes to Gauge and Radar Rainfall Data in Subtropical Coastal Catchments," Water Resour Manage (2012) 26:3515–3538.

30. Xiong, Y. V. J. Alarcon, J. L. Martin, W. H. McAnally. 2012. "SEDDEER: A Sediment Transport Model for Water Quality Modeling," Transactions ASABE, Vol. 55(6): 2147-2161.

31. Diaz-Ramirez, J., Camacho, R., McAnally, W. and Martin, J. 2012. "Parameter uncertainty methods in evaluating a lumped hydrological model. Obras y Proyectos 12, 42-56

32. Camacho, R.A. and Martin, J.L., 2013. Bayesian Monte Carlo for evaluation of uncertainty in hydrodynamic models of coastal systems. Journal of Coastal Research, Special Issue No. 65

33. Diaz-Ramirez, Jairo N.. Billy E. Johnson. 2013. William H. McAnally, James L. Martin, Vladimir J. Alarcon and Rene A. Camacho. 2013. "Estimation and Propagation of Parameter Uncertainty in Lumped Hydrological Models: A Case Study of HSPF Model Applied to Luxapallila Creek," J Hydrogeol Hydrol Eng, 2:1

34. Diaz-Ramirez J, Martin JL, William HM. 2013. Modelling Phosphorus Export from Humid Subtropical Agricultural Fields: A Case Study Using the HSPF Model in the Mississippi Alluvial Plain. J Earth Sci Clim Change 4: 162. doi:10.4172/2157-7617.1000162

35. Diaz-Ramirez, Jairo, James L. Martin, William H. McAnally and Richard Rebich. 2013. "Modeling Phosphorus Export from Humid Subtropical Agricultural Fields: A Case Study using the HSPF Model in the Mississippi Alluvial Plain," Invited paper, Earth Sci Clim Change 2013, 4:6

36. Camacho, Rene A., James L. Martin, William McAnally, Jairo Diaz-Ramirez, Pete Sucsy, Hugo Rodriguez, and Song Zhang. 2014. "Uncertainty analysis of estuarine hydrodynamic models: an evaluation of input data uncertainty in the Weeks Bay estuary, Alabama," Applied Ocean research, 47(2104) pp. 138-153.

37. VanZwieten, James, William McAnally, Jameel Ahmad, Trey Davis, James Martin, Mark Bevelhimer, Allison Cribbs, Renee Lippert, and Thomas Hudon. 2014. "In-Stream Hydrokinetic Power – A Review and Appraisal," ASCE *Journal of Energy Engineering, 10.1061/(ASCE)EY.1943-7897.0000197*

38. Camacho, René A., James L. Martin, Jairo Diaz-Ramirez, William McAnally, Hugo Rodriguez, Peter Suscy, and Song Zhang. (2014). "Uncertainty analysis of estuarine hydrodynamic models: An evaluation of input data uncertainty in the Weeks Bay estuary, Alabama," Applied Ocean Research 47 (2014) 138–153

39. Camacho, R.A, Martin, J.L, Watson, B., Paul, M., Zheng, L., and Stribling, J. (2015). Modeling the Factors Controlling Phytoplankton in the St. Louis Bay Estuary, Mississippi and Evaluating Estuarine Responses to Nutrient Load Modifications. ASCE J. Environ. Eng.,

141(3) (**2016 Samuel Arnold Greeley Award winning paper for "the paper that makes the most valuable contribution to the environmental engineering profession")**

40. Rene A. Camacho, James L. Martin, William McAnally, Jairo Dıaz-Ramirez, Hugo Rodriguez, Peter Sucsy, and Song Zhang. 2015."A Comparison of Bayesian Methods for Uncertainty Analysis In Hydraulic And Hydrodynamic Modeling," *American Water Resources Association,* Volume 51, Issue 5, pages 1372–1393, October 2015

41. Martinez-Guerra, Edith, Yi Jiang, Gordon Lee, Bahareh Kokabian, Sara Fast, Dennis D. Truax, James L. Martin, Benjamin S. and Veera Gnaneswar Gude. 2015. "Wetlands for Wastewater Treatment," Water Environment Research, Volume 87, Number 10

PUBLICATIONS: CONFERENCE PROCEEDINGS (REFEREED)

1. **Martin, J.L**. and J. Wlosinksi. "A comparison of reservoir oxygen predictions from one and two-dimensional models." In: Lake and Reservoir Management, Vol. II., Proc. 5th Annu. Conf. Int. Symp. N. Am. Lake Manage. Soc., N. Am. Lake Manage, Soc., Washington, DC, pp. 98-103, 1986.

2. Wang, P.F., S. C. McCutcheon, M. Zakikhani and **J.L. Martin**. "Environmental Support Needed for Hydraulics and Sediment Transport Research in Environmental Protection," Section 14.0 of Proceedings of National Science Foundation Workshop on Equipment and Facilities Needs for Hydraulics Research, U.S.A.E. Waterways Experiment Station, Vicksburg, MS, 1991.

3. Morrison, G., A. Janicki, D. Wade, **J. Martin**, G. Vargo and R. Johannson. "Estimated Nitrogen Fluxes and Nitrogen-Chlorophyll Relationships in Tampa Bay, 1985-1994," Proceedings of the Tampa Bay Area Scientific Information Symposium 3. (Ed. S. Treat), Tampa, FL, 1997.

4. J.L. Martin , C. Hesterlee and T. Cole. "Two-Dimensional Reservoir Water Quality Modeling using CEQUAL-W2 on Selected Reservoirs," Proceedings of the 1999 Georgia Water Resources Conference, Athens, GA.

5. Medine, Allen J. and **James L. Martin**. "Development of a Metal Exposure and Transformation Assessment Model for use in Watershed Management, Restoration and TMDL Analyses," Proceedings of Watershed 2000, Water Environment Federation and British Columbia Water and Waste Association and Western Canada Water and Wastewater Association, July 8-12, 2000.

6. M. Dortch , **J.L. Martin**, B.E. Johnson and P. Deliman. "Corps TMDL Modeling Activities," Proceedings of Watershed Management 2000, Am. Society of Civil Engineers, Baltimore, MD, 2000.

7. Hendrickson, J., **J.L. Martin**, and C. Cerco. "Photo-Decomposition Model for Colored Dissolved Organic Matter In A Blackwater Estuary." Proceedings of the AWRA Conference on Water Quality Monitoring and Modeling, April 30-May 2, San Antonio, TX, 2001.

8. **Martin, J.L**., Dorothy Tillman, Carl Cerco, John Hendrickson, and Mark Dortch. "A Three-Dimensional Water Quality Model for estimating TMDLs in a Blackwater River Estuary, the Lower St. Johns River, FL", Estuarine and Coastal Modeling, Proceedings of the 7th International Conference (Ed. M. Spaulding), American Society of Civil Engineers, Reston, VA., 2002.

9. **Martin, J.L.**, Barry Bunch , and Ajit Vaidya. "A Modeling Framework for Determination of Total Maximum Daily Loads to the Grand Calumet Watershed, Indiana," Proceedings,

National TMDL Science and Policy 2002, November 13-16, Phoenix, AZ., 2002.

10. D. DeLeon, T. Thornburg, and **J. Martin**, 2004. “Preventing Sediment Recontamination in an Urban Waterway, Tacoma, Washington.” Proceedings of the 77th Annual Water Environment Federation Technical Exhibition and Conference, New Orleans, October 2-6, 2004.

11. Vladimir J. Alarcon, Charles G. O’Hara, William McAnally, James Martin, Jairo Diaz, and Zhiyong Duan. 2005. “Sensitivity of HSPF-Estimated Flow-Rate To Topographical Parameter Values For A Coastal Watershed In Mississippi,” Proceedings, Geographic Information Systems And Water Resources IV, AWRA Spring Specialty Conference, Houston, Texas, May 8-10, 2006.

12. Vladimir J. Alarcon, Charles G. O’Hara, William McAnally, **James Martin**, Jairo Diaz, and Zhiyong Duan. 2005. “Influence of Elevation Dataset On Watershed Delineation Of Three Catchments In Mississippi,” Proceedings, Geographic Information Systems And Water Resources IV, AWRA Spring Specialty Conference, Houston, Texas, May 8-10, 2006.

13. Alarcon, V. J., O'Hara, C. G., Viger, R., Toll, D., Diaz, J., Tagert, M. L., McAnally, W., and **Martin, J**., 2006. Rapid Prototyping Capabilities for Evaluating Current and Future NASA Data in Multi-Scale Sensitivity Analysis in Watershed Hydrology Modeling. Eos Trans. AGU, 87(52), Fall Meet. Suppl., Abstract IN33B-1350.

14. Wilkerson, G. Wayne, William H. McAnally, **James L. Martin**, Jeffrey A. Ballweber, Kim Collins, and Gaurav Savant. 2007. “LATIS: A Spatial Decision Support System to Assess Low Impact Site Development Strategies,” Proceedings of the 2nd National Low Impact Development Conference, March 12-14, 2007, Wilmington, NC

15. Diaz, J.N, W.H. McAnally, **J.L. Martin**, 2007. Evaluation of HSPF Uncertainty Bounds. Proceedings of the Fourth Conference on Watershed Management to Meet Quality and TMDLs, March 10-14, San Antonio, TX.

16. Duan, Z., **J. Martin**, W. McAnally, and R. Stockstill. 2007. “Formulations for Wind-driven Gas-liquid Transfer Rate,“ Proceedings of the ASCE/EWRI World Environmental and Water Resources Congress 2007, Tampa, FL.

17. Duan, Z., Jairo N. Diaz, **James L. Martin** and William H. McAnally. 2007. “Effects of Land Use Change on the Simulations of Hydrologic and Water Quality Parameters for the St. Louis Bay Watershed,” Proceedings of FLUCOM 2007, Tallahassee, FL.

18. Diaz-Ramirez, Jairo, Zhiyong Duan, William McAnally, and **James Martin**, “Sensitivity of the HSPF Model to Land Use/Land Cover Datasets,” Proceedings of FLUCOM 2007, Tallahassee, FL.

19. Alarcon V. J., W. McAnally, J. Diaz-Ramirez, **J. Martin**, and J. Cartwright, 2008. A Hydrological Model of the Mobile River Watershed, Southeastern USA. Proceedings ICCMSE 2008, American Institute of Physics.

20. Diaz-Ramirez, J. N., W. H. McAnally, and **J. L. Martin**. 2008. Parameter Uncertainty Propagation on Streamflow Simulations and Parameter Sensitivity Evaluation of a Lumped Watershed Model: A Case Study. World Environmental & Water Resources Conference, Honolulu, HI, May 13-16. Meeting of the Environmental & Water Resources Institute of ASCE, Reston, VA.

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7. **Martin, J.L.** and J. Nestler. "Cumberland river hydropower studies, steady flow analysis," Presented at the April 30, 1986 Workshop on Tailwaters, American Fisheries Societies Trout Subcommittee, Southern Division, Tech Aqua, TN.
8. **Martin, J.L.** and J. Nestler. "Cumberland river hydropower studies, unsteady flow analysis," Presented at the April 30, 1986 Workshop on Tailwaters, American Fisheries Societies Trout Subcommittee, Southern Division, Tech Aqua, TN.
9. Smith, V.E., J.E. Rathbun, W.A. Frez, S.G. Rood, M.D. Mullin and **J.L. Martin**. "Use of Persistent PCB Congeners as Environmental Tracers," Presented at the Nov. 9-12, 1987 meeting of the Soc. of Environ. Toxicology and Chemistry, Pensacola, FL.
10. Richardson, W.L., R. Kreis, M.D. Mullin, **J.L. Martin**, and J. Filkens. "Results of the Binational Study of the Great Lakes Upper Connecting Channels-- The Detroit River," Presented at the May 5-11, 1988 meeting of the American Chemical Society, Toronto, Ontario.

11. Richardson, W.L., R.G. Kreis, and **J.L. Martin**. "A Modeling Framework for Planning a Mass Balance Project for Green Bay, Lake Michigan," Presented at the May 17-20, 1988 meeting of the International Association for Great Lakes Research, Hamilton, Ontario.
12. Rygwelski, K.R., **J.L. Martin**, W.L. Richardson and S.L. Kleiber. "Mass Budget of Toxic and Conventional Pollutants in the Trenton Channel," Presented at the May 17-20, 1988 meeting of the International Association for Great Lakes Research, Hamilton, Ontario.
13. **Martin, J.L.**, W.L. Richardson, S.C. McCutcheon, and J.F. Paul. "Modeling Studies for Planning: The Green Bay Project," Presented at the 24 Annual Conference of the American Water Resources Association, November 6-11, 1988, Milwaukee, WI.
14. Paul, J.F., W.L. Richardson, **J.L. Martin**, and S.C. McCutcheon. "Modeling Toxic Substances in Green Bay: Development of the Modeling Framework," Presented at the 24 Annual Conference of the American Water Resources Association, November 6-11, 1988, Milwaukee, WI.
15. Richardson, W.L., **J.L. Martin**, J.F. Paul, and S.C. McCutcheon, "Influence of Modeling in Planning Large Scale, Integrated Water Quality Studies: Green Bay Case Study," Presented at the 24 Annual Conference of the American Water Resources Association, November 6-11, 1988, Milwaukee, WI.
16. **Martin, J.L.** "Modeling the Migration and Effects of PCBs from Confined Disposal Facilities," Presented at the Ninth Annual Meeting of the Society of Environmental Toxicology and Chemistry, Nov. 13-17, 1988, Arlington, VA.
17. **Martin, J.L.** , M. Velleux and K. Rygwelski. "Screening Level PCB Model of Green Bay, Lake Michigan,"Presented at the 32nd Conference of the International Association for Great Lakes Research, May 30-June 2, 1989, Madison, WI.
18. **Martin, J.L.** , S. McCutcheon and M. Zakikhani. "Modeling the Migration of PCBs from Confined Disposal Facilities," Presented at the 32nd Conference of the International Association for Great Lakes Research, May 30-June 2, 1989, Madison, WI.
19. Velleux, M., **Martin, J**., Rathbun, J., and Kreis,R. "Observed and Predicted Impacts of Contaminant Transport from the Saginaw Diked Facility," presented at the 33 rd Conference of the Society of Environmental Toxicology and Chemistry (SETAC), October 30-November 4, 1989, Toronto, Ontario.
20. W. Lung, **J. L. Martin** and S. McCutcheon. "Eutrophication Potential in Selected Embayments of Price William Sound Following Fertilizer Application," Presented at the 11th meeting of the Society for Environmental Toxicology and Chemistry, November 11-15, 1990, Arlington, VA.
21. Wang, P.F. and **J.L. Martin**. "Mass Balance Modeling of the Buffalo River, NY: Hydrodynamics and Transport," Presented at the 34th Conference of the International Association for Great Lakes Research, June 2-6, 1991, Buffalo, NY.
22. **Martin, J.L.** and W.L. Richardson. "Mass Balance Modeling of Selected Great Lakes Areas of Concern, An Overview," Presented at the 34th Conference of the International Association for Great Lakes Research, June 2-6, 1991, Buffalo, NY.
23. Morrison, G., **J. Martin**, H. Greening. "Use of the WASP4 model to develop load reduction goals for nutrients in the Tampa Bay watershed," Presented at the 12th International Estuarine Research Federation Conference, November 14-18, 1993, Hilton Head Island, SC.
24. Wang, P.F., **J.L. Martin**, and G. Morrison. "Nutrient Budget Analysis for Tampa Bay,

Florida," Presented at the 14th International Symposium on Lake and Reservoir Management, October 31-November 5, 1994, Orlando, FL.

25. Wool, T., **J.L. Martin**, and R. Schottman. "The Linked Watershed/Waterbody Model (LWWM): A Watershed Management Modeling System," Presented at the 14th International Symposium on Lake and Reservoir Management, October 31-November 5, 1994, Orlando, FL.

26. Greening, H, R. Eckenrod, G. Morrison, T. Janecki and **J. Martin**. "Using Seagrass Water Quality Requirements to Determine Watershed Management Targets for Tampa Bay, Florida" Presented at the 13th Conference of the Estuarine Research Federation, November 12-16, 1995, Corpus Christi, TX.

27. **J.L. Martin** and T. Wool. "The Linked Watershed/Waterbody Model (LWWM): A Watershed Management Modeling System," Presented at the American Society of Civil Engineers Environmental Management 1996, March 28, 1996, Tampa, FL.

28. Morrison, G., A. Janicki, D. Wade, **J. Martin**, G. Vargo and R. Johannson. "Estimated Nitrogen Fluxes and Nitrogen-Chlorophyll Relationships in Tampa Bay, 1985-1994," Tampa Bay Area Scientific Information Symposium 3, 1996, Tampa, FL.

29. **Martin, J.L**., L. Owoputi, and M. Lichte. "Water Quality Model Application to Youghiogheny River Lake and Youghiogheny River, Pennsylvania," Presented at the 17th International Symposium on Lake and Reservoir Management, December 2-5, 1997, Houston, TX.

30. T. Wool, **J.L. Martin**, R. Olson, R. Burke III, and J. Geenfield. "Development of a State-of-the-Art Riverine Total Maximum Daily Load Water Quality Model," Presented at the 17th International Symposium on Lake and Reservoir Management, December 2-5, 1997, Houston, TX.

31. L. Owoputi, and **J.L. Martin.** "Water Quality Model Application to Stonewall Jackson Lake and River, Pennsylvania," Presented at the 18th International Symposium on Lake and Reservoir Management, November 10-13, 1998, Banff, Alberta.

32. **J.L. Martin** , C. Hesterlee and T. Cole. "Two-Dimensional Reservoir Water Quality Modeling using CEQUAL-W2 on Selected Reservoirs," Presented at the 1999 Georgia Water Resources Conference, Athens, GA.

33. **J.L. Martin**. "Total maximum Daily Loads, and Overview," Invited paper presented at the American Association of Port Authorities Harbors, Navigation & Environment Seminar, February 2, 2000, Miami, FL.

34. M. Dortch , **J.L. Martin**, B.E. Johnson and P. Deliman. "Corps TMDL Modeling Activities," Presented at Watershed Management and Operations Management 2000, June 21-24, 2000, Fort Collins, CO.

35. M. Dortch and **J.L. Martin**. "TMDLs, the Process and Potential Impact to the Corps, Presented at Water 2000 – Watershed Management in the 21st Century – A Team Approach, August 28-30, 2000, St. Paul, MN.

36. Medine, A.J. and **J.L. Martin**. "Development of a Metal Exposure and Transformation Model for Use in Watershed Management, Restoration and TMDL Analysis, Watershed 2000, July 9-12, 2000, Vancouver, BC.

37. Medine, A.J. and **J.L. Martin**. "Development of the Speciation-Based Exposure and Transformation Assessment Model (META4): Application to Copper and Zinc Problems in the Alamosa River, Colorado," Presented at the American Chemical Society, Environmental Chemistry Division Symposium, August, 2000, Boulder, CO.

38. **Martin, J.L**. "TMDL Modeling using CE-QUAL-ICM in Grand Calumet River Watershed," Presented at Water Quality Workshop 2000-2010, February 23-24, 2000, Nashville, TN.

39. Hendrickson, J., **J.L. Martin**, and C. Cerco. "Photo-Decomposition Model For Colored Dissolved Organic Matter In A Blackwater Estuary." Presented at the AWRA Conference on Water Quality Monitoring and Modeling, April 30-May 2, 2001, San Antonio, TX.

40. **Martin, J.L.** "The Total Maximum Daily Load Program: Modeling Implications, " Presented to the Navy Space and Naval Warfare Systems Command, June 27, 2001, San Diego, CA.

41. **Martin, J.L.** and M.S. Dortch. "Coupling of Hydraulic and Environmental Quality Models: Issues and Approaches, " Invited keynote presentation at the General Fluids, Hydrodynamics, Transport Processes and Environmental Fluids Session, ASCE/ASME 2001 Mechanics And Materials Conference, June 27-29, 2001, San Diego, CA.

42. **Martin, J.L**., Dorothy Tillman, Carl Cerco, John Hendrickson, and Mark Dortch. "A Three-Dimensional Water Quality Model for estimating TMDLs in a Blackwater River Estuary, the Lower St. Johns River, FL Presented at the 7th International Conference on Estuarine and Coastal Modeling, November 5-7, 2001, St. Petersburg, FL.

43. **Martin, J.L.** "Empirical Methods to Evaluate Stability," presented at the Sediment Stability Workshop, sponsored by the U.S. EPA, USACE, and U.S. Navy, January 22-24, 2002, New Orleans, LA.

44. **Martin, J.L.**, Barry Bunch , and Ajit Vaidya. "A Modeling Framework for Determination of Total Maximum Daily Loads to the Grand Calumet Watershed, Indiana," National TMDL Science and Policy 2002, November 13-16, Phoenix, AZ.

45. T. Wool, R.B. Ambrose, **J. Martin**, S. Davie, and W. Anderson. "Modifications of WASP for simulating periphyton dynamics," National TMDL Science and Policy 2003, Chicago, IL, November 16-18, 2003.

46. **Martin, J.L.** "Water Quality Modeling: Current Trends Current Issues," Invited presentation at the U.S. EPA's Office of Research and Development, Ecosystem Research Division, Athens, GA , September 15, 2004.

47. **Martin, J.L.** "Low Flow Analysis of the Big Sunflower River," 2004 Joint Section Meeting of the American Society of Civil Engineers and Association of Engineering Geologists, September 23-24, Vicksburg, Mississippi.

48. De Leon, D., T. Thornburg, and **J. L. Martin**, 2004. "Preventing sediment recontamination in an urban waterway, Tacoma, Washington," Proceedings of the 77th Annual Water Environment Federation Technical Exhibition and Conference (WEFTEC), New Orleans, October 2-6, 2004

49. Alarcon, V. J., O'Hara, C. G., McAnally, W., **Martin, J**., Diaz, J., Duan, Z., 2006. "Influence of Elevation dataset on Watershed Delineation of Three Catchments in Mississippi". Geographic Information Systems and Water Resources IV AWRA Spring Specialty Conference, Houston, TX.

50. Alarcon, V. J., O'Hara, C. G., McAnally, W., **Martin, J**., Diaz, J., Duan, Z., 2006. "Sensitivity of HSPF-estimated Flow-rate to Topographical Parameter Values for a Coastal Watershed in Mississippi". Geographic Information Systems and Water Resources IV AWRA Spring Specialty Conference, Houston, TX.

51. Duan, Zhiyong and *James L. Martin*. 2007. "Evaluation of Gas-Liquid Transfer Rate Formulae," Presented at the MS ASCE Section Meeting, November 2nd, 2006

52. Diaz, J.N, W.H. McAnally**, J.L. Martin**, 2007. “Evaluation of HSPF Uncertainty Bounds,” Fourth Conference on Watershed Management to Meet Quality and TMDLs, March 10-13, San Antonio, TX.

53. Wilkerson, G. Wayne, William H. McAnally, **James L. Martin**, Jeffrey A. Ballweber, Kim Collins, and Gaurav Savant. 2007. “LATIS: A Spatial Decision Support System to Assess Low Impact Site Development Strategies,” 2nd National Low Impact Development Conference, March 12-14, 2007, Wilmington, NC.

54. Diaz, J.N., W.H. McAnally, and **J.L. Martin**. 2007. “Evaluation of HSPF Uncertainty Bounds Due to Potential Evapotranspiration Bias and Parameter Variability,” Presented at the 37th Annual Mississippi Water Resources Conference, April 24-25, Jackson, MS.

55. McAnally, W.H., **J.L. Martin**, M.L. Tagert and J. Sharp. 2007. “Modeling Mobile Bay Sediments with New Technologies,” Presented at the 37th Annual Mississippi Water Resources Conference, April 24-25, Jackson, MS.

56. Duan, Z. and **J.L. Martin**. 2007. “Integration of Impact Factors of Gas-Liquid Transfer Rate,” Presented at the 37th Annual Mississippi Water Resources Conference, April 24-25, Jackson, MS.

57. Tagert, M.L., Q. White, **J.L. Martin**, and J. Pote. 2007. “Water Quality Impacts of Failing Septic Systems in a Coastal Area,” Presented at the 37th Annual Mississippi Water Resources Conference, April 24-25, Jackson, MS.

58. Tagert, Mary Love., Jonathan Pote, **James Martin**, and Quinton White. 2007. “Geospatial Technologies for Assessing Water Quality Impacts of Failing Septic Systems in a Coastal Area,” Presented at NOAA’s Coastal Geo Tools Conference, March 2007, Myrtle Beach, SC.

59. Duan, Z., **J. Martin**, W. McAnally, and R. Stockstill. 2007. “Formulations for Wind-driven Gas-liquid Transfer Rate, “ ASCE/EWRI World Environmental and Water Resources Congress 2007, Tampa, FL.

60. Duan, Z., Jairo N. Diaz, **James L. Martin** and William H. McAnally. 2007. “Effects of Land Use Change on the Simulations of Hydrologic and Water Quality Parameters for the St. Louis Bay Watershed,” FLUCOME, Ninth International Symposium on Fluid Control, Measurement and Visualization September 16-19, 2007, Tallahassee, FL.

61. Diaz-Ramirez, Jairo, Zhiyong Duan, William McAnally, and **James Martin**, “Sensitivity of the HSPF Model to Land Use/Land Cover Datasets,” FLUCOME, Ninth International Symposium on Fluid Control, Measurement and Visualization September 16-19, 2007, Tallahassee, FL.

62. Ramirez-Avila, J., J.N. Diaz-Ramirez, **J.L. Martin**, and W.H. McAnally. 2008. “Sediment Transport using HEC-RAS 4.0.” Presented at the April 15-16, 2008 Mississippi Water Resources Conference, Jackson, MS.

63. Diaz-Ramirez, Jiaro, V. J. Alarcon, W.H. McAnally, **and J.L. Martin**. 2008. “The Mobile River Basin: A Review pf Physiographic, Climatic, Water Quantity and Water Quality Characteristics,” Presented at the April 15-16, 2008 Mississippi Water Resources Conference, Jackson, MS.Ramirez-Avila, J., J.N. Diaz-Ramirez, J.L. Martin, and W.H. McAnally. 2008. “Sediment Transport using HEC-RAS 4.0.” Presented at the April 15-16, 2008 Mississippi Water Resources Conference, Jackson, MS.

64. **James L. Martin**, William H. McAnally, Richie McComas, and Sandra Ortega-Achury. 2008. “Data Collection for Model and Remote Sensing Evaluation in the Mobile Bay,” Gulf

of Mexico Alliance, 1st Annual Monitoring Forum, St. Petersburg, FL, June 3-6, 2008

65. Ramírez-Avila, J.J., W.H. McAnally, **J.L. Martin**, S.L. Ortega-Achury, and J.N. Diaz-Ramirez. 2008. Evaluation and Prediction of Sediment Loads within the Town Creek Watershed. 50 Years of Soil and Water Research in a Changing Agricultural Environment Conference, Oxford, MS, September 3-5. Meeting of the Agricultural Research Service, U.S. Department of Agriculture.

66. Ortega-Achury,Sandra L., William H. McAnally, John J. Ramirez Avila, and **James L. Martin**, 2009. Water quality assessment in the Town Creek Watershed, MS. Presented at the Mississippi Water Resource Conference, Tunica, MS, August 5-9, 2009.

67. Ramírez-Avila, John J., Eddy J. Langendoen, William H. McAnally, and **James L. Martin**. 2009. Identification of streambank erosion processes and channel changes in Northeastern Mississippi. Presented at the Mississippi Water Resource Conference, Tunica, MS, August 5-9, 2009

68. Ramírez-Avila J.J., S.L. Ortega-Achury, W.H. McAnally, **J.L. Martin**, and J.N. Díaz-Ramírez. 2009. Evaluation and Prediction of Sediment and Phosphorus Loads Within the Town Creek Watershed, MS. Northern Gulf Institute Annual Conference, Biloxi, May 20-21. Meeting of the Northern Gulf Institute, MSU, MS.

69. Ramírez-Avila J.J., W.H. McAnally, **J.L. Martin**, E. Langendoen, S.L. Ortega Achury, and J.N. Díaz-Ramírez. 2009. Northern Gulf Institute Annual Conference, Biloxi, May 20-21. Meeting of the Northern Gulf Institute, MSU, MS. [Poster].

70. J. M. Prince, J. D. Madsen, D. R. Shaw, J. L. Harvill, G. E. Ervin**, J. L. Martin**, and S. A. Samson. Modeling Eurasian Watermilfoil (Myriophyllum spicatum) with Geographic Information Systems. Midsouth Aquatic Plant Management Society Conference. Sep. 15-17, 2009, Lake Guntersville State Park, AL.

71. Diaz-Ramirez, J.N., W.H. McAnally, and **J.L. Martin**. 2010. "Rainfall Database Effects on Hydrology Simulation in a Small Coastal Catchment," Alabama Water Resources Conference, September 8-10, Perdido Beach Resort, Orange Beach, Alabama.

72. Diaz-Ramirez, J.N., W.H. McAnally, **J.L. Martin**, K. McNeal, J.E. Ezell, J. Sharp, K. Pevey, M. Follum, and S. Phipps. 2010. "Assessment of Weeks Bay and Its Watershed, Alabama," Alabama Water Resources Conference, September 8-10, Perdido Beach Resort, Orange Beach, Alabama. [Poster].

73. Diaz-Ramirez, J.N., W.H. McAnally, and **J.L. Martin**. 2010. "Hydrological Modeling of Coastal Catchments in Alabama," Northern Gulf Institute Annual Conference, Mobile, May 18-20. Meeting of the Northern Gulf Institute, MSU, MS.

74. Diaz-Ramirez, J.N., B.E. Johnson, W.H. McAnally, and **J.L. Martin**. 2010. "Comparison of Lumped and Distributed Hydrologic Models for the Runoff Simulation of a Large Watershed in Alabama and Mississippi," Northern Gulf Institute Annual Conference, Mobile, May 18-20. Meeting of the Northern Gulf Institute, MSU, MS.

75. McAnally, W.H., J. Cartwright, R. Jackson, **J. Martin**, and J.N. Diaz-Ramirez. 2010," Sulis - A Tool for Healthy Watersheds, Healthy Oceans, Healthy Ecosystems," Northern Gulf Institute Annual Conference, Mobile, May 18-20. Meeting of the Northern Gulf Institute, MSU, MS. [Presentation and Poster]

76. Ramírez-Avila, J. J, E. J. Langendoen, W. H. McAnally, **J. L. Martin** and S. L. Ortega-Achury, 2010. "A Sediment Budget for Town Creek Watershed: Preliminary Results from Streambank Erosion Processes and Rates Assessment, " ASABE Annual International

Meeting.

77. Diaz-Ramirez, J.N., W.H. McAnally, J.L. Martin, K. McNeal, J.E. Ezell, J. Sharp, K. Pevey, M. Follum, and S. Phipps. 2010. "Assessment of Weeks Bay and Its Watershed, Alabama," Alabama Water Resources Conference, September 8-10, Perdido Beach Resort, Orange Beach, Alabama. [Poster].

78. Ramírez-Avila, J. J, E. J. Langendoen, W. H. McAnally, J. L. Martin and S. L. Ortega-Achury, 2010. "A Sediment Budget for Town Creek Watershed: Preliminary Results from Streambank Erosion Processes and Rates Assessment," ASABE Annual International Meeting.

79. Salazar, G., A. Moore, W. Wilkerson, J. Diaz-Ramirez, and **J. Martin**. 2010. "Developing a User-Friendly Tool for BMP/LID Modeling Using VBA Programming," Northern Gulf Institute Annual Conference, Mobile, May 18-20. Meeting of the Northern Gulf Institute, MSU, MS. [Poster]

80. Diaz-Ramirez, J.N., W.H. McAnally, **J.L. Martin.** 2010. "A Review of HSPF Evaluations on the Southern United States and Puerto Rico. 21st Century Watershed Technology: Improving Water Quality and the Environment," February 21-24, Costa Rica. Meeting of the ASABE and EARTH University

81. Ramirez-Avila, J. J., McAnally, W. H., Langendoen, E. J., Ortega-Achury, S. L., & Martin, J. (2011). "Assessment and Prediction of Streambank Erosion Rates in the Town Creek Watershed." 2011 NGI Annual Conference. Mobile, AL: Northern Gulf Institute.

82. Ramirez-Avila, J. J., McAnally, W. H., Langendoen, E. J., Ortega-Achury, S. L., & Martin, J. (2011). "Changes in Suspended Sediment Transport in the Town Creek Watershed: Interpretation of Sediment Rating Curves," 2011 NGI Annual Conference. Mobile, AL: Northern Gulf Institute.

83. Alarcon, V. J., McAnally, W. H., Xiong, Y., & Martin, J. (2011). Modeling and Simulation of Hydrodynamics and Dye Transport in Grand Bay, MS, and Perdido Bay, FL. 2011 Northern Gulf Institute Conference. Mobile, AL.

84. McAnally, W. H., Evans, D., Martin, J., Sloan, J., & Alarcon, V. J. (2011). Sediment and Mercury Path and Fate Modeling. 2011 Northern Gulf Institute Conference. Mobile, AL.

85. Ramírez-Avila, J. J., E.J. Langendoen, W. H. McAnally, S.L. Ortega-Achury, J.L. Martin, R. Bingner. 2012. Assessing and Modeling Sediment Loads from Stream Corridor Erosion along the Town Creek in Mississippi. 2012 Mississippi Water Resources Conference. Jackson, Mississippi, April 3-4, 2012.

86. Ramírez-Avila, J. J., S.L. Ortega-Achury, W. H. McAnally, J.L. Martin, J. Diaz. 2012. Runoff Quality Effects of Simulated Conservation Practice Scenarios in a Mississippi Delta's Watershed. 2012 Mississippi Water Resources Conference. Jackson, Mississippi, April 3-4, 2012.

87. Pérez-Gutiérrez, Juan D., James L. Martin, and John J. Ramirez-Avila. 2015. "A Review of the Technical Approaches Used for TMDLs Development in Mississippi," ASABE Annual International Meeting, New Orleans, Louisiana, July 26 – 29, 2015

88. Martin, James L., Deva K. Borah, Edith Martinez-Guerra and Juan D. Pérez-Gutiérrez. 2015. "TMDL Modeling Approaches, Model Surveys, and Advances," World Environmental and Water Resources Congress 2015: Water without Borders, Reston, VAS

PRESENTATIONS: WORKSHOPS AND LECTURES:

1. **Martin, J.L.** "Reservoir processes: Considerations in modeling reservoir processes," Presented at the Hydrologic Engineering Center training course on Water Quality Modeling of Rivers and Reservoirs, 25 February-March 1, 1985, Davis, CA.
2. **Martin, J.L.** "An overview of recent developments in water quality modeling from the EWQOS program," Presented at the US Army Engineers Pacific Ocean Division's EWQOS briefing, December 16-20, 1985, Honolulu, HI.
3. **Martin, J.L.** "An overview of water quality modeling capabilities at the Waterways Experiment Station," presented at the January 27, 1986 meeting of the Chesapeake Bay Program's Water Quality Modeling Subgroup, Baltimore, MD.
4. Dortch, M.S., **J.L. Martin**, M. Zimmerman, and D. Hamlin. "Water quality modeling of regulated streams," Presented at the 28-30 October, 1986, USACE Workshop on Reservoir Releases, Atlanta, GA.
5. **Martin, J.L.**, M.S. Dortch, J. Wlosinski and M. Zimmerman. "Reservoir Water Quality Modeling," Presented at the March 30-April 3, 1987 USAE Workshop on Reservoir Water Quality Modeling, Denver, CO.
6. **Martin, J.L.**, R.B. Ambrose, T. Wool, W. Lung, S. McCutcheon, Selected lectures presented at the U.S. EPA Workshop on "Estuarine Waste Load Allocation," September 11-13, 1990, Athens, GA.
7. McCutcheon, S.C., **J.L. Martin** and E.Z. Hosseinipour. "Modeling of Contaminated Sediment Movement," Presented at the Contaminated Sediment Seminar Series on Remedial Approaches for Sites with Contaminated Sediments, June 18-19, 1991, Atlanta Georgia, and June 20, Philadelphia, PA.
8. **Martin, J.L.**, R.B. Ambrose, and T. Wool. Selected Topics on Water Quality Modeling presented at the U.S. EPA Workshop "Introduction to Water Quality Modeling" April 8-12, 1991, Athens, GA.
9. **Martin, J.L.** and R.B. Ambrose. "Water Quality Modeling," Presented to the Institute for Meteorology and Water, May 13-23, 1991, Warsaw, Poland.
10. **Martin, J.L.**, R.B. Ambrose, J. Connolly and T. Wool. Selected topics on water quality modeling presented at the U.S. EPA Workshop "Advanced Water Quality Modeling with the Water Analysis Simulation Program", July 29-August 2, 1991, Boulder, CO.
11. **Martin, J.L.**, and T. Wool. "Water Quality Modeling with the Water Analysis Simulation Program", Presented at the AScI workshop, August 16-20, 1993, Portland, OR.
12. **Martin, J.L**. "Hydrodynamic Modeling," Presented at the U.S. EPA Great Lakes Program Office's Mass Balance and Risk Assessment Workshop," November 14-17, 1994, Ann Arbor, MI.
13. **Martin, J.L**. "Contaminant Modeling," Presented at the U.S. EPA Great Lakes Program Office's Mass Balance and Risk Assessment Workshop," November 14-17, 1994, Ann Arbor, MI.
14. **Martin, J.L.**, and T. Wool. "Water Quality Modeling with the Water Analysis Simulation Program", Presented to the New York Department of Water Control, January 22-25, 1994, Valhalla, NY.
15. **Martin, J.L.**, and T. Wool. Selected topics on water quality modeling presented at the AScI workshop "Water Quality Modeling with the Water Analysis Simulation Program", January 22-25, 1996, Kissimmee, FL.

16. **Martin, J.L.**, and T. Wool. Selected topics on water quality modeling presented at the AScI workshop "Linked Watershed Waterbody Model", January 23-26, 1996, Kissimmee, FL.
17. **Martin, J.L.**, and T. Wool. Selected topics on water quality modeling presented at the AScI workshop "Water Quality Modeling with the Water Analysis Simulation Program", September 23-27, 1996, Athens, GA.
18. **Martin, J.L.**, and T. Wool. "Water Quality Modeling with the Water Analysis Simulation Program", Presented to the Alberta Department of Environmental Protection, March 22-25, 1997, Edmonton, Alberta.
19. **Martin, J.L.**, and T. Wool. Selected topics on water quality modeling presented at the AScI workshop "Water Quality Modeling with the Water Analysis Simulation Program", October 27-30, 1997, Athens, GA.
20. **Martin, J.L.**, and T. Wool. Selected topics on water quality modeling presented at the AScI workshop "Water Quality Modeling with the Water Analysis Simulation Program", March 1-5, 1997, Washington, D.C.
21. **Martin, J.L.** and T. Wool. Selected topics on water quality modeling presented at the AScI workshop "Water Quality Modeling with the Water Analysis Simulation Program", October 7-9, 1998, Athens, GA.
22. **Martin, J.L**. "Watershed Hydrology and Runoff Processes," Presented at the Short Course on Water Quality Modeling and TMDL Development, University of Georgia, January 11-15, 1999, Athens, GA.
23. **Martin, J.L**. and C. Hesterlee. "A Primer on Waste Load Allocation and TMDL Modeling", Presented to the Mississippi Department of Environmental Quality, January 25-28, 1999, Jackson, MS.
24. **Martin, J.L**. and T. Wool. "Short Course 2: Water Quality Modeling and TMDL Development, the WASP Model," Presented at the Short Course on Water Quality Modeling and TMDL Development, University of Georgia, May 11-15, 1999, Athens, GA.
25. **J.L. Martin**, "Overview of Selected Applications of CE-QUAL-W2", Presented at the CE-QUAL-W2 Workshop, August 20, 1999, Portland, OR
26. **J.L. Martin**, "Application of CE-QUAL-W2 to J. Percy Priest Reservoir", Presented at the CE-QUAL-W2 Workshop, August 21-24, 2000, Portland, OR
27. **Martin, J.L.** and A. Wool. Selected topics on water quality modeling presented at the EPA Region 4 workshop "TMDLs and Water Quality Modeling with the Water Analysis Simulation Program", June 18-22, 2001, Atlanta, GA.
28. **Martin, J.L.** and A. Vaidya. Selected topics on TMDL Development and Waste Load Allocations presented to the Indiana Department of Environmental Management, October 30, 2001, Indianapolis, IN.
29. **Martin, J.L.** 2002. Presentation on "Empirical Methods to Evaluate Stability," and invited panelist, Sediment Stability Workshop, sponsored by the U.S. EPA, USACE, and U.S. Navy, January 22-24, 2002, New Orleans, LA.
30. **Martin, J.L.** Invited presentation on modeling needs at workshop "Science to Support Nutrient-Management Decisions Related to Hypoxia in the Northern Gulf of Mexico and Water Quality in the Mississippi River Basin," October 16-18, 2002, St. Louis, MO.
31. **Martin, J.L.** Workshop on "Water Quality Modeling," Presented to the National Environment and Planning Agency, Kingston, Jamaica, August 9-13, 2004.

32. **Martin, J.L.** "Water Quality Modeling: Current Trends Current Issues," Invited presentation at the U.S. EPA's Office of Research and Development, Ecosystem Research Division, Athens, GA , September 15, 2004.

33. **Martin, J.L**. Workshop on "Water Quality and Eutrophication Modeling," Presented to the St. Johns Water Management District, July 12-13, 2005.

34. **Martin, J.L**. and Andy Stoddard. "WASP Water Quality Modeling," Presented to the Florida Department of Environmental Protection, June 3-4, 2008, Tallahassee, FL

35. **Martin, J.L**. and Noor Baharim Hashim "TMDLs and Waste Load Allocations Strategies in the U.S.", Presented to the Malaysia Department of Environment, State Office of Johor, Johor, Malaysia, 15 July, 2008

36. **Martin, J.L**. and Noor Baharim Hashim TMDLs and Waste Load Allocations Strategies in the U.S.", Presented to the Malaysia Department of the Environment, State Office of Senlangor, Kuala Lampur, Malaysia, 17 July, 2008

37. **Martin, J.L**. and Noor Baharim Hashim "Water Quality Modeling in the U.S. : History and Current Practices," Presented to the National Hydraulic Research Institute of Malaysia (NAHRIM), Kuala Lampur, Malaysia, 18 July 2008

38. **James L. Martin** and Ali Erturk. 2010. "Modeling with HEC-RAS," July 13-17, 2009, IGEM Akademy, İstanbul, Turkey (see flyer in Appendix, course was canceled)

39. **James L. Martin**, Jairo N. Díaz and John J. Ramirez , Mississippi State University; Carlos A. González and Luis A. Camacho, National University of Colombia. 2010. "The IV International Engineering Seminar, Universidad Nacional de Colombia, Environmental Issues in Developing Countries, "July 6th – 30th, 2010.

40. **James L. Martin**. Short Talk: Applied water Quality Modeling, Dean Alumni, University Teknologi Malaysia (UTM), Johor, Malaysia, 5 July 2011.

41. **James L. Martin**. Applied water Quality Modeling, Langkawi Malaysia, 12-14 July 2011.

42. **James L**. **Martin**. Selected invited topics on water quality modeling, Presented at the U.S. EPA Workshop on the Water Analysis Simulation Program, August 6-10, 2012, Atlanta Georgia

43. **James L. Martin**. Selected invited topics on water quality modeling, Presented at the U.S. EPA Workshop on the Water Analysis Simulation Program, July 15-19, 2013, Atlanta Georgia

44. James L. Martin. Research Needs, presented to National Academy of Sciences, National Academy of Engineering, National Research Council, Advisory Group for The Gulf Research Program. November, 2013, Long Beach, MS.

45. G. Padmanabhan, **James L. Martin**, Andrew Parker, Deva K. Borah, and Yusuf Mohamoud. 2014. Short Course: "Modeling for Watershed Management and TMDL Development," World Environmental and Water Resources Congress. Portland, Oregon. June 1, 2014

46. **James L. Martin**. 2014. Invited presenter at U.S. Environmental Protection Agency Workshop, "The Water Analysis Simulation Program,' August 4-8, 2014, USEPA Region 4, Atlanta, GA

47. G. Padmanabhan, James L. Martin, Andrew Parker, Deva K. Borah, and Yusuf Mohamoud. 2015. Short Course: "Modeling for Watershed Management and TMDL

Development," World Environmental and Water Resources Congress. Austin, Texas. May 16, 2015

48. James L. Martin. 2015. Invited presenter at U.S. Environmental Protection Agency Workshop, "The Water Analysis Simulation Program,' July 27-31, USEPA Region 4, Atlanta, GA

49. G. Padmanabhan, James L. Martin, Andrew Parker, Deva K. Borah, and Yusuf Mohamoud. 2015. Short Course: "Modeling for Watershed Management and TMDL Development (Part 1 & 2)," EWRI Watershed Management Symposium 2015, Reston, VA

COURSES TAUGHT

Number Title

CE 3523/3503: Water Resources Engineering: Hydraulics of closed conduits; groundwater hydraulics; open channel flow; reservoir and storage analysis; hydraulic structures ad machinery. (S02, S03, F03; class removed from curriculum in 2004)

CE 2803: Environmental Engineering Issues: An overview of the scientific, social and legal issues impacting environmental management and protection in the United States. (F07, F08, F09, F10, F11, F12, F13, F14, S15, F15)

CE 3803: Environmental and Water Resources Engineering I: An introduction to the analysis and designing of systems for hydraulic and hydrologic management, water supply, and wastewater reclamation (F05, F06, Summer 05, 06 & 07)

CE 3813: Environmental and Water Resources Engineering II: Pressurized flow in pipe networks. Analysis and design of water distribution , stormwater collection and sanitary sewer systems.(F05, S06, S07, S08, S09, S10, S11, S1q2, S13)

CE 4523/6523: Open Channel Hydraulics: Continuity. energy and momentum principles in open channel flow; flow resistance; uniform and non-uniform flow; channel controls and transitions; unsteady flow routing. (F01, 02, 05, 07, 08, F09)

CE 4533/6533: Computations in Water Resources: Review of relevant numerical analysis; numerical methods for kinematic wave, St. Venant, Boussinesq and depth-averaged equations; simulation of one- and two-dimensional free-surface flows. (S07, S09, F11, F13, F15)

CE 4990/6990: Numerical Methods in Civil Engineering; . A survey of numerical methods for civil engineering practice, with applications in MATLAB and Visual Basic. (Summer 06, S12)

CE 8573: Hydro-environmental Analysis: Environmental engineering aspects of physical/chemical/ biological processes impacting conventional and toxic materials in surface waters. Characteristics of rivers/streams, lakes and estuaries related to environmental quality (F06, F08, F10, F12, F14)

CE 8923: Surface Water Quality Modeling: Water quality modeling of conventional pollutants in surface waters and their impacts (pathogens, temperature, dissolved oxygen, nutrients, and aquatic plants in relation to issues such as health impacts, hypoxia, nuisance and harmful algal blooms). Discussion of the present state-of-the-art of modeling and a review of recent trends. (S02, S04, S06, S07, S08, S10, S12, S14)

CE 8933: Water Quality Modeling II : Water quality model of toxic materials. Modeling of the fate and transport of toxic materials in surface waters including pH and acidification, legacy persistent organic pollutants, metals, mercury, oil spills and emerging pollutants. (F04, S09, S11, S13, S15)

CE 7000: Problems: Modeling River Systems Using HEC-RAS (S02, 3 students)

CE 7000: Problems: Visual Basic Applications in Civil Engineering (S05, F07, S08, summer 08, F10)

CE 7000: Problems: Water Quality Modeling Approaches to Contaminants (F07)

CE 8990: Problems: Numerical Methods in Water Resources Engineering (summer 07)

PROFESSIONAL CONSULTING (2001-PRESENT)

1. Hart Crowser, Seattle, Washington. Provided expert review of documents related to the Thea Foss Waterway superfund site (November 2001-January 2002).
2. Law Environmental, Atlanta, Georgia: Provided expert review of modeling studies on the Dugdemona River, Louisiana (January-March 2002).
3. Southeast Clean Water Network, Tallahassee, FL: Provided expert review, deposition and court testimony related to modeling studies used in development of a discharge permit to the Lower St. Johns River, FL. (January through February 2002).
4. HydroQual, Inc. Developed modifications of the one-dimensional hydrodynamic model CE-QUAL-RIV1 (February through March 2002).
5. GBMc & Associates, Bryant, AR, Provided technical review of water quality modeling studies.(February-March 2006).
6. PBS&J, Provided technical review of WASP model application to Joes Creek, FL (Jan-Mar 2007)
7. PBS&J, Provided technical review and data collection recommendations for the Winter Haven Chain of Lakes, FL (Jan-March 2007)
8. City of Calgary, Alberta, provided expert review of Bow River modeling studies (Jan-March 2007)
9. Southern California Coastal Water Research Project, modeling of Loma Alta Slough (June-December 2011)
10. Revision of the USEPA Rates and Kinetics Manual, CADMUS engineering, January-December, 2015.
11. Eutrophication TMDL study in the Santa Margarita River, Camp Pendleton, SPAWAR SY STEMS CENTER PACIFIC. U/S. Navy (April 2012-December 2015)

3. Resume for Dr. Steve Scott

Dr. Steve Scott's 2016 three-page resumé is provided on pages C54 through C56

Stephen H. Scott, PhD, PE
Waterways Experiment Station
Coastal and Hydraulics Laboratory
River Sedimentation Engineering Branch
3909 Halls Ferry Road
Vicksburg, MS 39180
(601) 634-2371; E-mail: scotts@wes.army.mil

1. EDUCATION:

Universities attended with Degree Year:

University of Mississippi B.A. 1976
Major - Biology/Psychology
University of Mississippi B.S.M.E. 1983
Major - Mechanical Engineering
Mississippi State University M.S.M.E. 1989
WES Graduate Center
Major - Mechanical Engineering
Colorado State University Ph.D 1997
Major - Hydraulic Engineering
Dissertation: The Effect of Fine Sediment Rheology on Coarse Sediment Transport in Pipes

2. PROFESSIONAL REGISTRATION:

Engineer in Training, Mississippi, 1984
Professional Engineering Registration, Mississippi, 1991

3. PROFESSIONAL EXPERIENCE:

1989 - present: Research Hydraulic Engineer in the Coastal and Hydraulics Laboratory at Waterways Experiment Station, U.S. Army Corps of Engineers. Research activities include dredging studies, river and estuarine sedimentation studies, and numerical modeling of river and estuary hydrodynamics and sedimentation processes.

1985 - 1989: Research Civil Engineer in the Structures Laboratory at Waterways Experiment Station, U.S. Army Corps of Engineers. Research activities include analysis of weapons effects, nuclear blast simulation studies, development of man-portable demolition munitions, and evaluation of blast effects on structures with two-dimensional numerical models.

4. PROFESSIONAL PUBLICATIONS:

a. Refereed publications

Meyer, L.D. and Scott, S.H., "Possible Errors During Field Evaluations of Sediment Size Distributions," Paper number 81- 2044, American Society of Agricultural Engineers, 1979.

Scott, S.H., "Uncertainty Analysis of Dredge Production Measurement and Calculation," *ASCE Journal of Waterway, Port, Coastal, and Ocean Engineering, Volume 119 No. 2, March/April 1993.*

Scott, S.H., “Hydraulic Transport of Fine and Coarse Sediment Mixtures in Pipes”, *ASCE Journal of Transportation*, Volume 128, No. 1, February 2002.

b. Project Reports

Scott, S.H., "Laboratory Testing of Methods to Increase Hopper Dredge Payloads", Dredging Research Program, Technical Report, March 1991

Scott, S.H., "The Application of Electrical Resistivity Methods for Measuring Dredged Material Density in Hopper Bins", Dredging Research Program Technical Note, September 1992

Scott, S.H., "The Application of Ultrasonic Surface Detectors to Hopper Dredge Production Monitoring", ASCE Conference Paper, October 1992

Scott, S.H., "The Development and Application of Electrical Resistivity Methods for Determining Density Profiles in Dredge Hoppers, WEDA Dredging Conference Paper, April 1993

Scott, S.H., et al, "Technologies for Hopper Dredge Production and Process Monitoring", Dredging Research Program Technical Report DRP-95-2, Hydraulics Laboratory Waterways Experiment Station, February 1995

Scott, S.H., "Users Guide to CUTPRO Cutterhead Dredge Modeling Program", Instruction Report CHL-98-1, Coastal and Hydraulics Laboratory, April 1998

Scott, S.H., et al, "CH3D-SED Computational Modeling of the Old River Control Complex", Volume 3 of the Lower Mississippi River Sediment Study Summary, May 1999.

Scott, S.H., "ERDC Sediment Transport studies on Twelve Mile Creek and Lake Hartwell in support of the EPA selected remedy for Twelve Mile Creek / Lake Hartwell", Final Report to the EPA Region 4, May 2000.

Scott, S.H., "Application of Dredge Monitoring Systems to Dredge Contract Administration Quality Assurance", Dredging Research Program Technical Note, August 2000.

Scott, S.H., "Sediment Mobilization Potential in the Roanoke River and Welch Creek, NC", Final Report to the EPA Region 4, June 2001

Scott, S.H., "Transport and Fate of Sediment and Dioxin TEQ from Welch Creek for Selected Storm Surge and Probabilistic Storm Events", Technical Note to the EPA Region 4, December 2001.

Scott, S.H., "Sediment Erosion and Transport Potential in Welch Creek", Technical Report to the EPA Region 4, April 2002.

Scott, S.H., "Evaluation of Hydraulic Dredge Productivity: Hydraulic Dredging of Indiana Harbor Canal, ISPAT Inland Incorporated Plant 1 Dock", Technical Report to industry sponsor, October 2003

Scott, S.H., "Sediment Transport Relationships for Simulation of Morphology Change in Rivers and Estuaries", Technical Report to the Regional Sediment Management Research Program, January 2003.

Scott, S.H., "Impact of In-Stream Dam Removal on the Morphology of Twelve Mile Creek", Technical Report to the EPA Region 4, February 2003.

Scott, S.H., "Predicting Sediment Transport Dynamics in Ephemeral Channels: A Review of Literature", Technical Report to the Arid Regions Research Program, September 2003.

Scott, S.H., "Considerations for Morphological Modeling of Rivers", Technical Report to the Regional Sediment Management Research Program, October 2003.

Scott, S.H., "Effects of Roanoke River Stage on the Hydrodynamics and Sediment Transport Potential of Welch Creek", Technical Note to the EPA Region 4, January 2004.

Scott, S.H., “Application of the SAM Computer Program for Truckee River Stable Channel Analysis”, Technical Note to the Urban Flooding Research Program, January 2004

Scott, S.H., “Evaluation of Selected Two-Dimensional Hydrodynamic and Sediment Transport Numerical Models for Simulation of Channel Morphology Change”, ERDC Technical Note, February 2004.

Scott, S.H., “Feasibility Study: Inducing Channel Scour by Elevating Existing Dikes and Revetments in Pool 2 of the Arkansas River”, Technical Report to the Little Rock District Corps of Engineers, September 2004.

Scott, S.H., “Evaluation of Techniques to Reduce Sand Bar Formation Below the Redeye Crossing Dike Field”, Technical Report to the New Orleans District Corps of Engineers, October 2004.

Scott, S.H., “Two Dimensional Simulation of Truckee River Hydrodynamics”, Final Report to Urban Flooding Research Program, May 2006.

Scott, S.H., “2D Simulation of Truckee River Sediment Transport Potential”, Final Report to Urban Flooding Research Program, May 2006

Scott, S.H., “Ocoee River Sediment Transport Potential”, Project Report to EPA, June 2007.

Scott, S.H., “Thompson Run Arched Culvert Sedimentation Study”, Project Report to the Corps of Engineers Pittsburg District, June 2008

Scott, S.H., “Sediment Transport and Fate from South Bay Fluvial Channels”, Project Report to Corps of Engineers San Francisco District, July 2009

Scott, S.H., “Simulation of Coal Fly Ash Erosion, Transport, and Fate from the Emory River at TVA Kingston”, ERDCWES Project Report to the EPA, June 2010

Scott, S.H., “Model Simulation of Kissimmee River Restoration Plan: River Reach from S65C to S65D”, ERDCWES Project Report to the Jacksonville District Corps of Engineers, January 2011

Scott, S.H., “Sediment Transport Simulations to Support the Monitored Natural Recovery Process for Watts Bar Reservoir”, ERDCWES Project Report to the EPA, October 2011

Scott, S.H., “Stability and Transport of Residual Sediment Bars in Twelve-Mile Creek”, Project Report to the EPA, April 2012.

Scott, S.H., “Long Term Simulation of Residual Fly Ash Transport and Fate in the Watts Bar Reservoir System”, ERDCWES Project Report to the EPA, June 2012

Scott, S.H., “Evaluation of Sediment Impacts from Removal of Easley Central Dam”, Project Report to the EPA, June 2012.

Scott, S.H., et al, “Two Dimensional Hydrodynamic Analysis of the Moose Creek Floodway”, Technical Report TR-12-20, Engineering Research and Development Center, September 2012

Scott, S.H., “Sediment Transport Characteristics of Conowingo Reservoir”, ERDCWES Project Report to the Baltimore District, October 2013

Scott, S.H., “Impact of Flood Flows on Residual Fly ash Distribution in the Emory, Clinch, and Tennessee River Reaches of Watts Bar Reservoir”, ERDCWES Project Report to the EPA, January 2014

4. Resume for Dr. Peter Wilcock

Dr. Peter Wilcock's 2016 two-page Biographical Sketch is provided on pages C58 and C59

Peter Richard Wilcock
Professor and Head, Dept. of Watershed Sciences, Utah State University
5210 Old Main Hill, Logan Utah 84321. wilcock@usu.edu O: 435 797-2463; M: 443 564-6253

PROFESSIONAL PREPARATION

University of Illinois, Urbana, IL, Dept. of Geography, B.S. (*summa cum laude*), May, 1978.
McGill University, Montreal, PQ, Dept. of Geography, M.Sc., 1981
Massachusetts Institute of Technology, Cambridge MA.,
Dept. of Earth, Atmospheric, and Planetary Sciences, Ph.D., 1987

APPOINTMENTS

2014 - present: Professor and Head, Department of Watershed Sciences, Utah State University
1987 - 2014: The Johns Hopkins University, Dept. of Geography and Environmental Engineering;
1997 - 2014: tenured Full Professor; 1993 - 1997: Associate Professor; 1987 - 1993: Assistant Professoı
Assoc. Dept. Chair 2004 – 2014; ABET chair 2004 – 2014.
Joint appointments: Dept. of Civil Engineering, Dept. of Earth and Planetary Science

HONORS

American Geophysical Union, Fellow (2013)
Recognizes members who have attained acknowledged eminence in the Earth and space sciences as valued by the:
peers and vetted by a committee of Fellows
Borland Lecturer in Hydraulics (2013)
Hydrology Days, American Geophysical Union, Fort Collins, CO
American Society of Civil Engineers, Hans Albert Einstein Award (2008)
Awarded for significant contributions to the engineering profession in the area of erosion control, sedimentation and/or waterway development.

SELECT PROFESSIONAL ACTIVITIES

National Ctr. for Earth-Surface Dynamics (NCED), Lead PI, Stream Restoration Integrated Program 2003-2
Freeport McMoRan, Inc., Evaluation and strategy for control of mine sediment deposition, 2014 – present.
Minnesota Pollution Control Agency, Lead PI, Collaborative for Sediment Source Reduction, Minnesota Ri
Basin, Control of watershed sediment yield in a stakeholder context, 2012 – present.
Sediment Transport and Stream Restoration Short Courses:
Univ. California, (w/ G.M. Kondolf, UCB), (5 day course) Annual, 2003 - present.
Utah State University (w/ J. Schmidt, P. Belmont) (5 or 10 day course) Annual, 2004 - present.
University of Maryland (w/ Margaret Palmer, UMCP) (5 day course) Annual, 2005 - 2009
U.S. Bureau of Reclamation, Sedimentation & River Hydraulics (Denver, 2008; Taichung, Taiwan, 201
US Forest Service, Stream System Technology Center. Co-developed software, manual, and primer for practical predictions of sediment transport in coarse-bedded streams, 2005-2009.
Am. Geophysical Union, Journal Geophysical Research – Earth Surfaces, Associate editor, 2002-2006.
Memberships: American Society of Civil Engineers (member), American Geophysical Union (Fellow), Geological Society of America (member)
U.S. Department of Justice, Denver CO. Expert witness for reserved water rights claimed by the US Forest Service in the Snake River Basin Adjudication, Idaho, 1999-2004.
Fairfax County Water Authority, Fairfax VA. Expert witness for contested application hearing regarding a water intake on the Potomac River, Maryland Administrative Law Court, 1998-1999.
Advisory and Review Panels
BAYSTAT Science Advisory Panel, Governor's Bay Cabinet, State of Maryland (2007-2014)
Advisory Committee on Water Information, U.S.D.I. Subcommittee on Sedimentation (current)
National Research Council, Water Science and Technology Board, Review Committees
U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, 2010-2013.
River Basin and Coastal Systems Planning (Panel Chair), Committee to Assess U.S. Army Corps of

Engineers Water Resources Project Planning. 2002-2004.
Science and Planning for the Grand Canyon Monitoring and Research Center, 1998-1999

WATer and Environmental Research Systems (WATERS) Network. Member, WATERS Network Conceptual Design Team. 2008 – 2009

Past review panels: EPA (stream monitoring), USACE (urban streams), USBR (Trinity River Adaptive Management), CALFED (Workplan)

RECENT PUBLICATIONS (over 100 peer-reviewed publications)

Khosronejad, A., A. T. Hansen, J. L. Kozarek, K. Guentzel, M. Hondzo, M. Guala, P. Wilcock, J. C. Finlay, and F. Sotiropoulos, 2016. Large eddy simulation of turbulence and solute transport in a forested headwater stream, J. Geophys. Res. Earth Surf., 121, doi:10.1002/2014JF003423.

Schmelter, M.L., P.R. Wilcock, M. Hooten, and D.K. Stevens, 2015. Multi-Fraction Bayesian Sediment Transport Model. *J. Marine Science and Engineering*, *3*, 1066-1092; doi:10.3390/jmse3031066.

Smith, S.M.C and P.R. Wilcock, 2015. Upland Sediment Supply and its Relation to Watershed Sediment Delivery in the Contemporary Mid-Atlantic Piedmont (U.S.A.). *Geomorphology*, 232 (2015) 33–46.

Grams, P.E and P.R. Wilcock,, 2014. Transport of fine sediment over a coarse, immobile river bed. *J Geophysical Research – Earth Surface.* 119 , 188 – 211, doi:10.1002/2013JF002925.

Lisle, T.E., P. Wilcock, J. Buffington, and K. Bunte, 2014. Can Rapid Assessment Protocols Be Used to Judge Sediment Impairment in Gravel-bed Streams? *J Am. Water Res. Assoc*. (JAWRA) 51(2): 373-387. DOI: 10.1111/jawr.12255.

Wilkerson, G.V., D.R. Kandel, L.A. Perg, W.E. Dietrich, P.R. Wilcock and M.R. Whiles, 2014. Continental-scale relationship between bankfull width and drainage area for single-thread alluvial channels, *Water Resources Research*, DOI: 10.1002/2013WR013916.

Jacobi, S.K., B.F. Hobbs, P.R. Wilcock, 2013. Bayesian framework for cost-effective control and research of non-point source sediment, *J. of Water Resources Planning and Management*, ASCE. 139(5):534-543

Niezgoda, S.L., P.R. Wilcock, D.W.Baker, J.M. Price, J.M. Castro, J.C. Curran, T. Wynn-Thompson, J.S.Schwartz, F.D.Shields, 2013.Defining a stream restoration body of knowledge as a basis for national certification *J. Hydraulic Eng.*, 140:123-136. DOI: 10.1061/(ASCE)HY.1943-7900.0000814

Podolak, C.J.P and P.R. Wilcock, 2013. Experimental study of the response of a gravel streambed to increased sediment supply, *Earth Surf. Processes Landforms,* DOI: 10.1002/esp.3468

Singh, A., J.A. Czuba, E. Foufoula-Georgiou, J.D.G. Marr, C. Hill, S. Johnson, C. Ellis, J. Mullin, C.H. Orr, P.R. Wilcock, M. Hondzo, and C. Paola, (2013). StreamLab Collaboratory: Experiments, data sets, and research synthesis, *Water Resour. Res*.49. 1746–1752, doi:10.1002/wrcr.20142.

Erwin, S.O., J.C. Schmidt, J.M. Wheaton, and P.R. Wilcock, 2012. Closing a sediment budget for a reconfigured reach of the Provo River, Utah. *Water Resources Research* VOL. 48, W10512, doi:10.1029/2011WR011035.

Kenney, M., P. Wilcock, B. Hobbs, N. Flores, D. Martinez, 2012. Is Urban Stream Restoration Worth It?, *J. Am. Water Res. Assoc.* DOI:10.1111/j.1752-1688.2011.00635.x

Major, J.J., J.E. O'Connor, C. J. Podolak, M.K. Keith, G.E. Grant, K.R. Spicer, S. Pittman, H.M. Bragg, J.R. Wallick, D.Q. Tanner, A. Rhode, P.R. Wilcock, 2012, Geomorphic response of the Sandy River, Oregon, following removal of Marmot Dam, *Prof. Paper 1792*, U.S. Geological Survey.

Salant, N.L., J.C. Schmidt, P.E. Budy, P.R. Wilcock, 2012. Unintended consequences of restoration: Loss of riffle habitats and gravel substrates following weir installation, submitted to *J. Env. Mgt.* 109 154-163.

Schmelter, M.L., S.O. Erwin, P.R. Wilcock, 2012. Accounting for Uncertainty in Cumulative Sediment Transport using a Bayesian Approach, *Geomorphology*. Volumes 175–176, 15 November 2012, Pages 1–13

Singh, A., E. Foufoula-Georgiou, F. Porte-Agel, and P. Wilcock, 2012. Coupled dynamics of the co-evolution of bed topography, flow turbulence and sediment transport in an experimental flume. *J. Geophysical Research – Earth Surface.* VOL. 117, F04016, doi:10.1029/2011JF002323

Wilcock, P.R., 2012. Stream restoration in gravel-bed rivers, Ch. 12 in Church, M., Biron, P. and Roy, A. (eds.), *Gravel Bed Rivers: Processes, Tools, Environments*, pp. 137-149, John Wiley and Sons, Chichester, U.K. ISBN: 978-0-470-68890-8.