Chesapeake Bay Program
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Modeling Workgroup Meeting

Tuesday, September 15th, 2026
9:00 AM – 12:00 PM

[Visit the meeting webpage for meeting materials and additional information.]

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

Purpose: This is the special meeting for the Modeling Workgroup to convene with Modeling Workgroup Members and Interested Parties to approve the following: Phase 7 Watershed Sediment Model in the DWSM and CalCAST, and Phase 7 CAST Stream Scale.

Summary:

- ✓ Approved: Phase 7 CalCAST Sediment Simulation.
- ✓ Approved: Phase 7 DWSM Sediment Simulation.
- ✓ Approved: Use of NHD 1:24K in Phase 7 CAST.

Minutes

I. Welcome **(9:00 - 9:05 AM)**
Lead: ***Dave Montali*** *(Tetra Tech)* and ***Mark Bennett*** *(U.S. Geological Survey)*, MWG Co-Chairs.

II. Phase 7 CalCAST Sediment Simulation **(9:05 – 9:50 AM)**

Lead: ***Joseph Delesantro*** *(Koniag IT Systems)*
Material: Meeting webpage here.

Joseph Delesantro: This presentation is of the Phase 7 CalCAST Sediment Simulation and the calibration of sediment transport parameters informing Phase 7 CAST (Chesapeake Assessment Scenario Tool) and the Dynamic Watershed Model (DWSM). In Phase 7, CalCAST, CAST, DWSM, and the Main Bay Model (MBM) operate as a fully integrated model suite under the Chesapeake Bay Program (CBP) umbrella, using shared partnership-vetted data to eliminate Phase 6 structural inconsistencies caused by external models.

The core architecture of the CAST sediment model, inherited from Phase 6, is the RUSLE2 formulation (Revised Universal Soil Loss Equation, Version 2) that calculates the Edge of Field (EOF) sediment loading rate, which is averaged across the hydro-period by DWSM, multiplied by land use acreage and Best Management Practice (BMP) efficiencies to generate the EOF load. Attenuation and transport factors calibrated within CalCAST to estimate sediment mass losses from Edge-of-Stream and Edge-of-River. Direct loads include point sources or sources with separately defined transport, while DWSM calibrates the River-to-Bay delivery multiplier.

The EOF sediment loading rates were recalculated at a 10-meter spatial resolution evaluating runoff, the *K* soil erodibility coefficient, the *LS* slope length and steepness, and *C* land cover factor, while omitting the *P* practice factor (which is accounted for downstream via BMPs). Spatial resolution transitioned from the Phase 6 Land-River Segment (LRSEG/HUC12) scale to the Phase 7 catchment-county scale (NHD Plus 1:100K catchments), expanding to 16 distinct CAST land classes. To resolve fine-scale anomalous extreme loading estimates generated at the 10-meter catchment level without altering broader LRSEG-scale regional means or distributions, we applied a strict 1%-99% bounding filter. Across the 16 land classes, forested land and wetlands exhibited the lowest EOF loading rates, whereas construction had the highest loading rate (slide 13-15).

Sediment transport within CalCAST calibrates land-to-water delivery using an updated Index of Connectivity (*IC*) calculated for each of the 16 land cover classes across all catchments. CalCAST fits global Bayesian parameters, a multiplier alpha and an offset gamma, on the *IC*, which is then multiplied by calibrated global beta delivery factors (slides 18-19). Additional land-to-water transport predictors evaluated in CalCAST include non-road impervious, valley-and-ridge carbonate geology, and the baseflow index, all of which were shown to significantly attenuate sediment connectivity. Stream-to-river transport calibration incorporates USGS reservoir area head loading datasets using a single calibrated global beta parameter. The monitoring calibration network expanded from 60 stations in Phase 6 to 152 stations in Phase 7, capturing single land-use catchments and headwater monitoring catchments spanning 0.5 km^2 to 1.0 km^2.

Model performance evaluated on the log load scale achieved a $R^2 > 0.91$ (slide 23). On the yield scale (lbs/acre), Phase 7 inputs demonstrated substantial performance gains over Phase 6 inputs in both R^2 and Root Mean Square Error (RMSE), alongside superior temporal trend predictions across calibration stations (slide 24). Evaluating the model strictly across the 60 legacy Phase 6 Non-Tidal Network (NTN) stations yielded a comparable R^2 with a lower RMSE and tighter fit (slide 27).

Calibrated land-to-water delivery factors averaged in the 0.20 range, with no individual catchment factor exceeding 1.0 (slide 28). Calibrated stream-to-river reservoir factors defaulted to 1.0 for the vast majority of non-impounded stream reaches, while several hundred impounded reaches exhibited sharp sediment attenuation (slide 28). The floodplain delivery factor averaged 0.84 in CalCAST (slide 29).

Updates to stream bed and bank erosion and floodplain deposition were derived from Greg Noe's USGS team, transitioning from 42 sites in Phase 6 to dendrochronology sediment flux measurements across 120 Mid-Atlantic streams, extrapolated to NHD Plus reaches via Random Forest regression incorporating land use, hydrology, soils, topography, and FACET channel morphology (slides 30-32).

Re-evaluating watershed loading rates shifted stream bank erosion and floodplain deposition from 54 lbs/ft/yr at the 1:100K stream scale (~10 million lbs/yr watershed-wide) in Phase 6 down to 14.42 lbs/ft/yr applied at the 1:24K stream scale (~4.45 million lbs/yr watershed-wide) in Phase 7 due to enhanced fine-scale stream network representation (slide 35).

Discussion on Phase 7 Sediment Model in CalCAST **(9:50 – 10:05 AM)**

Q: *Guido Yactayo:* You showed on Slide 2, 4 & 18 the parameters and variables that some are subject to calibration. Are there plans for a sensitivity analysis? What is the effect of changing these parameters and what is the noise most sensitive to? And on slide 18 regarding the land to water factors, how different are the two datasets between SPARROW and CalCAST?

- ***A:*** *Joseph Delesantro:* This is a Bayesian model, therefore we get a posterior estimate that gives us a sense of uncertainty. This is of course different from a sensitivity analysis, something we can pursue, but we will be providing the uncertainty estimates of the calibrated parameters and that can be found in the documentation. This will provide us a level of uncertainty, although different from a formal uncertainty analysis, where high posterior uncertainty reflects low sensitivity, whereas tight uncertainty bounds indicate strong cause and effect relationships.

  Second, we can see the calibrated land-to-water factors on slide 28 and none of them exceed 1. While explicit comparative histograms against SPARROW are not compiled for the presentation, the overall mean land-to-water connectivity (~0.2) remains highly consistent between Phase 6 and 7.

- ***Q:*** *Guido Yactayo:* you mentioned that there is a hand calibration and not an automatic calibration, what would that encompass?
    - ***A:*** *Joseph Delesantro:* the manual hand calibration hasn't been conducted yet. It should be noted that CalCAST is all automated using a Bayesian empirical calibration.
    - ***A:*** *Gopal Bhatt:* The hand calibration occurs downstream within the DWSM to refine simulated sediment concentration distributions against grab samples and match monthly/annual WRTDS load targets (Weighted Regressions on Time, Discharge, and Seasons).

Q: *Larry Band:* Two questions: how are RUSLE2 factors calculated across heterogeneous field patches within an NHD catchment? Second, in the IC formula, would the impedance weighting factor be calibrated per land use class?

- ***A:*** *Joseph Delesantro:* RUSLE2 rates are calculated and averaged at the NHD catchment scale independently for each of the 16 CAST land cover classes based on the specific *C* factor. The weighting factor, which uses land cover weighting tailored to heterogeneous Bay terrain, is set uncalibrated per class, whereas the global multipliers alpha and the offset gamma parameters are calibrated across all classes.

Comment: *Lewis Linker:* the forest and pasture cover ~80% of total watershed area near 0 lbs/acre loading, meaning overall watershed sediment loading is overwhelmingly driven by cropland, construction, and pervious/impervious solar installation. Also, I wonder if aggregating 10-meter grid K factors to the NHD Plus catchment scale would improve spatial accounting over Phase 6, considering the high K erodibility near streams and valleys.

- ***Response:*** *Joseph Delesantro:* the NHD Plus catchments explicitly isolate steep valleys from level terrain within the same hydrogeomorphic basin, eliminating Phase 6 LRSEG spatial averaging artifacts.

III. Phase 7 DWSM Sediment Simulation **(10:05 – 11:05 AM)**

Lead: ***Gopal Bhatt*** *(Penn State-CBPO)*

Material: Meeting webpage here.

Gopal Bhatt: this presentation is to review the Phase 7 DWSM Sediment Simulation, with the primary objective to supply hourly to daily temporal nutrient and sediment loading inputs to the MBM and multiple tributary models (MTM), supporting scenario applications, and enabling collaborative research. DWSM operates in tandem with CAST (which functions at the LRSEG) and CalCAST. CalCAST provides Bayesian-calibrated land-to-water and stream-to-river delivery factors. DWSM receives land-use inputs from CAST and transport factors from CalCAST, reconstructing hourly-to-daily time steps to simulate watershed hydrology and water quality, calibrating against monitoring stations, and calculating river-to-bay delivery factors for mainstem rivers to feed back to CAST.

Spatial aggregation converts CAST's 51 land uses into 18 land uses (16 natural, agricultural, and urban classes plus feeding space and combined sewer system) mapped to NHD 1:100K catchments. In contrast to Phase 6, where SPARROW delivery factors were lumped at the LRSEG scale, Phase 7 applies land-to-water and stream-to-river delivery factors directly at the NHD 1:100K catchment scale, allowing every acre of land use to be dynamically corrected based on its specific location within the watershed.

DWSM utilizes nested model segmentation that partitions the watershed into NHD 1:100K small streams and river mainstems. River mainstems are simulated using HSPF (Hydrological Simulation Program – FORTRAN), whereas small streams employ Generalized Stream Network (GSN) routing. Hydraulic routing in GSN uses Manning's equation for open channel flow with an explicit Euler non-iterative time-stepping scheme that conserves mass at each time step. Water quality routing in GSN applies four WRTDS-derived beta parameters accounting for input-driven trends, flow variability, and seasonal sine-cosine variations while conserving long-term average annual stream transport factors.

Key DWSM inputs supplied by CAST include 18 land uses on an annual scale, direct flow loads (municipal, industrial, septic, rapid infiltration), monthly detached sediment loads for agricultural land, monthly cover fractions, RUSLE2-derived EOF sediment loads, and NHD catchment-scale transport factors.

From the July 2026 hydrologic calibration verification, demonstrating marked Nash-Sutcliffe Efficiency (NSE) improvements for daily and monthly streamflow over Phase 6 and early 2026 beta versions of Phase 7 (slides 9-10). Additionally, after receiving feedback from partners, we examined five stations with >30% average annual flow bias, resulting in some stations being used solely for verification and not calibration.

There is a 3-step calibration workflow in the DWSM. Step 1 calibrates five deterministic HSPF land parameters (two soil matrix sediment detachment parameters, two wash-off transport parameters, and the NVSI aeolian erosion parameter), against RUSLE2 average annual EOF yield targets across 235 land segments. Simulated wash-off rates matched agricultural detached sediment data targets for crops (~4 tons/acre/yr) and pasture (median <0.1 tons/acre/yr; slides 14-15). Low-loading outliers (<10^2 tons/acre/yr) occurred in segments where simulated surface runoff was insufficient to drive the required sediment transport response (slide 16). Step 2 routes EOF loads through small streams using CalCAST land-to-water/stream-to-river delivery factors and GSN beta parameters without direct DWSM re-calibration (Slide 18). Step 3 performs automated rule-based riverine calibration over 30 iterations, adjusting HSPF soil erodibility parameters upstream based on cumulative frequency distribution (CFD) mismatches with observed grab sample concentrations and nudging log-scale distributions to match WRTDS loads for suspended sediment, total nitrogen, and total phosphorus (Slide 19). A subsequent manual hand-calibration step remains pending to refine specific station concentration and load fits.

DWSM performance at River Input Monitoring (RIM) stations plus Marietta demonstrated comparable or superior NSE and bias metrics to Phase 6, even prior to hand-calibration (Slide 20). In a case study of the Choptank River, Phase 7 daily grab sample concentration fits improved dramatically (R^2 = 0.45, tighter scatter, improved CFD fit) over Phase 6 (Slides 21-22). However, annual load NSE was distorted by extreme flow years in 1999 and 2011 (Tropical Storm Lee, flows > 5,500 cfs). In 1999, simulated flow matched observations but observed grab concentrations remained unexpectedly low (<60 mg/L) despite flows exceeding 3,000 cfs, pointing to observational/WRTDS load estimation uncertainty or slight high-flow concentration overestimation (Slides 24-29). Transitioning to WRTDS-K is anticipated to enhance load comparison statistics.

To summarize, sediment calibration was performed using RUSLE2 EOF sediment loads and Phase 7 CalCAST sediment transport factors along with Phase 7 CAST inputs. Sediment model is performing as good or better to that of Phase 6 model. We will take this further to use the calibrated hydrology and sediment model to setup for developing an integrated water quality calibration, including Nitrogen and Phosphorus.

Discussion on Phase 7 Sediment Simulation (11:05 – 11:20 AM)

Q: *Normand Goulet:* on Slide 20, I observe a spatial trend that overpredicts loads over WRTDS with larger watersheds. Could you explain this?

- ***A:*** *Gopal Bhatt:* We did notice this trend, where there is slight overprediction for Potomac and Marietta. We do not have an explanation for that because we are applying the calibration process the same way for all the stations and there is no hand calibration at this point. It would also be fair to say that in Phase 6, there is a level of uncertainty around WRTDS estimates, and especially sediment. Anything smaller than ±15% is our target.

Decision Request: The Modeling Workgroup will be asked to approve the Phase 7 CalCAST sediment simulation and resulting transport parameters to allow moving forward to a final Phase 7 nutrient simulation. Also, the Modeling Workgroup will be asked to approve the process used in the DWSM sediment calibration which incorporates Phase 7 inputs, RUSLE2 EOF sediment loads, and transport factors along with previously approved DWSM hydrology calibration.

***Note:** the votes below represent the support for Phase 7 CalCAST and DWSM Sediment simulation.*

Name:	Vote:	Comments:
Scott Heidel (PA)	4 – General Support	None
George Onyullo (DC)	3 – Stand Aside	None
Guido Yactayo (MD)	3 – Stand Aside	None
Megan Maggard (WV)	4 – General Support	None
Bill Keeling (VA)	3 – Stand Aside	Conditional, pending our review of the C and other factors and the potential that could lead to changes in one or more numbers used
Cassandra Davis (NY)	4 – General Support	None
Joseph Schell (DE)	3 – Stand Aside	None
Tom Butler (EPA)	3 – Stand Aside	None

IV. Use of Stream Scales in Phase 7 CAST & The Watershed Model (11:30 – 11:50 AM)

Lead: ***Alex Gunnerson*** *(Koniag IT Systems)*
Material: Meeting webpage here.

Alex Gunnerson: This presentation is to review the modeling team's recommendation of stream scale use in Phase 7 CAST, specifically addressing which NHD product flowlines should be utilized to calculate stream length characteristics at the LRSEG scale. There is an operational discrepancy between draft Phase 7 CAST that uses high resolution NHD 1:24K flowlines to quantify stream length and count Best Management Practices (BMP), while the DWSM operates on the NHD 1:100K catchment flow networks.

In Phase 6, NHD 1:100K flowlines were aggregated to LRSEGs to derive a single stream length value determining stream bed and bank erosion loads and establishing eligible stream length limits for stream restoration BMPs, while DWSM lacked explicit flowlines for stream length and instead mapped stream locations within CAST LRSEGs to aggregate SPARROW delivery factors.

For Phase 7, two distinct structural choices are proposed: to adopt high-resolution 1:24K flowlines for stream length in Phase 7 CAST while maintaining 1:100K catchment routing within CalCAST and DWSM; or revert CAST to Phase 6 baseline by using 1:100K flowlines aggregate to LRSEGs. Aggregating 1:24K flowlines substantially increases the total stream length characteristic compared to 1:100K lines, directly impacting calculated catchment density and stream bed and bank erosion loading rates.

The change to the use of NHD 1:24K originates from three primary issues that arose from Phase 6 CAST. First, 1:24K mapping directly resolves formal Phase 6 review feedback from the District of Columbia (D.C.) where 1:100K flowlines caused stream length undercounting across urban drainages, such as Rock Creek. Second, 1:24K flowlines eliminate major regional GIS artifacts present in 1:100K datasets across Western Virginia and Eastern West Virginia where stream density was low/non-existent. Third, spatial proximity evaluations demonstrated that 1:24K flowlines align significantly better with reported stream restoration BMPs (where coordinate data was available). Analyzing coordinate data across sectors at distance buffers of 10 meters, 30 meters, and 100 meters from 1st and 2nd order NHD streams, 1:24K flow lines captured a substantially higher percentage of verified stream restoration opportunities than 1:100K lines (Slide 11).

Regarding stream bed and bank erosion loads derived from Greg Noe's USGS team, since total watershed-wide sediment loading is held constant, expanding calculated stream length would alter the calculation, and reduce the watershed-wide unit loading rate from 26.74 lbs/ft/yr at the 1:100K scale down to 14.42 lbs/ft/yr at the 1:24K scale (Slide 12). On a jurisdictional level, moving to 1:24K increases stream length and total bed/bank sediment load allocations in DC and Virginia to rectify historical undercounts, while slightly reducing calculated load allocations in surrounding jurisdictions to maintain overall watershed mass balance.

Decision Request: The Modeling Workgroup will be asked to either approve a switch to NHD 1:24K flowlines for Phase 7 CAST stream length or retain the NHD 1:100K flowlines used in Phase 6 CAST for Phase 7 CAST.

***Note:** Votes below represent support for the use of 1:24K in Phase 7 CAST.*

Name:	Vote:	Comments:
Scott Heidel (PA)	4 – General Support	None
George Onyullo (DC)	4 – General Support	We support the use of 1:24K, but additional work/clarification is needed on Load calculations.
Guido Yactayo (MD)	4 – General Support	None
Megan Maggard (WV)	4 – General Support	None
Bill Keeling (VA)	3 – Stand Aside	None
Cassandra Davis (NY)	4 – General Support	None
Joseph Schell (DE)	3- Stand Aside	None
Tom Butler (EPA)	3 – Stand Aside	None

Discussion on the Use of Stream Scales in P7 CAST & the Watershed Model **(11:50 – 12:00 PM)**

Comment from chat: *Bill Keeling:* Option 2 requires data manipulations that option 1 does not need. Each time there are manipulations, there are opportunities for errors and mistakes to impact outcomes.

- ***Response:*** *Joseph Delesnatro:* stream routing remains identical across all three models at the 1:100K scale, meaning 1:24K stream length serves strictly as an internal catchment attribute rather than a routing alteration. Something else to consider is that when Phase 6 was built, many parameters were being pulled from different models like Phase 5, SPARROW, etc. There were many differences between the models that could have introduced errors and uncertainty. So, a precedent has already been set on the ability to pull data from different sources.

Q: *Guido Yactayo:* Could you discuss more on the load distributions because while the watershed unit rate decreased by half, Maryland's annual load remained nearly unchanged despite a 79% increase in stream miles noted in the technical memo?

- ***A:*** *Joseph Delesantro:* unit rates are established globally at the watershed scale rather than the state scale, and that net delivery changes are constrained downstream by the fundamental model assumption of mass balance between stream bank erosion and floodplain deposition.

Comment: *George Onyullo:* DC is in strong support in principle for 1:24K high-resolution mapping because it aligns directly with DC's planning scale. However, there remains some confusion regarding the newly calculated stream bed and bank erosion, noting that edge-of-field urban loading adjustments (such as non-road impervious sediment accounting) would be reconciled during final model integration but the increase from 1:100K to 1:24K are more than doubled.

- ***Response:*** *Alex Gunnerson:* Thank you for the comment. We can chat offline and discuss the calculations done.

V. Adjourn **(12:00 PM)**

Next meeting: October 27th-28th from 9AM-3PM.

Attendance:

- Lewis Linker, EPA
- Alex Gunnerson, Koniag
- Dave Montali, Tetra Tech
- Gabriel Duran, CRC
- Joseph Delesantro, Koniag
- Gopal Bhatt, PSU
- Normand Goulet, NVRC
- Joseph Schell, DNREC
- Sophia Grossweiler, MDE
- Qian Zhang, UMCES
- Andrew Leight, MDA
- Richard Tian, UMCES
- Kelly Gable, EPA
- Jian Shen, VIMS
- Suman Budhathoki, UMCES
- George Onyullo, DC DOEE
- Tom Butler, EPA
- Guido Yactayo, MDE
- Bill Keeling, VA DEQ
- Cass Klingaman, NY DEC
- Kevin Mclean, VA DEQ
- Megan Maggard, WV DEP
- Alisha Mulkey, MDA
- Leonard Schugam, MDE
- Ashley Hullinger, PA DEP
- KC Filippino, HRPDC
- Cassandra Davis, NY DEC
- Larry Band, UVA
- Sam Merrill, NGEM
- Auston Smith, EPA
- Jeremy Testa, UMCES