

# Leveraging Artificial Intelligence and Machine Learning to Advance Chesapeake Bay Research and Management: A review of status, challenges, and opportunities

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February 24-25, 2025  
SERC, Edgewater, MD

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UMCES / CBP  
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# Workshop Objectives

This workshop gathered federal, state, and academic partners to synthesize the **state of the science on AI/ML** approaches, identify research needs, and improve science coordination.

1. Summarize **recent AI/ML applications** to the Chesapeake Bay ecosystem and lessons learned
2. Identify the **challenges and gaps** in applying AI/ML approaches to Chesapeake Bay data
3. Develop **recommendations** and identify **opportunities** for harnessing the power of AI/ML approaches to address Chesapeake Bay issues

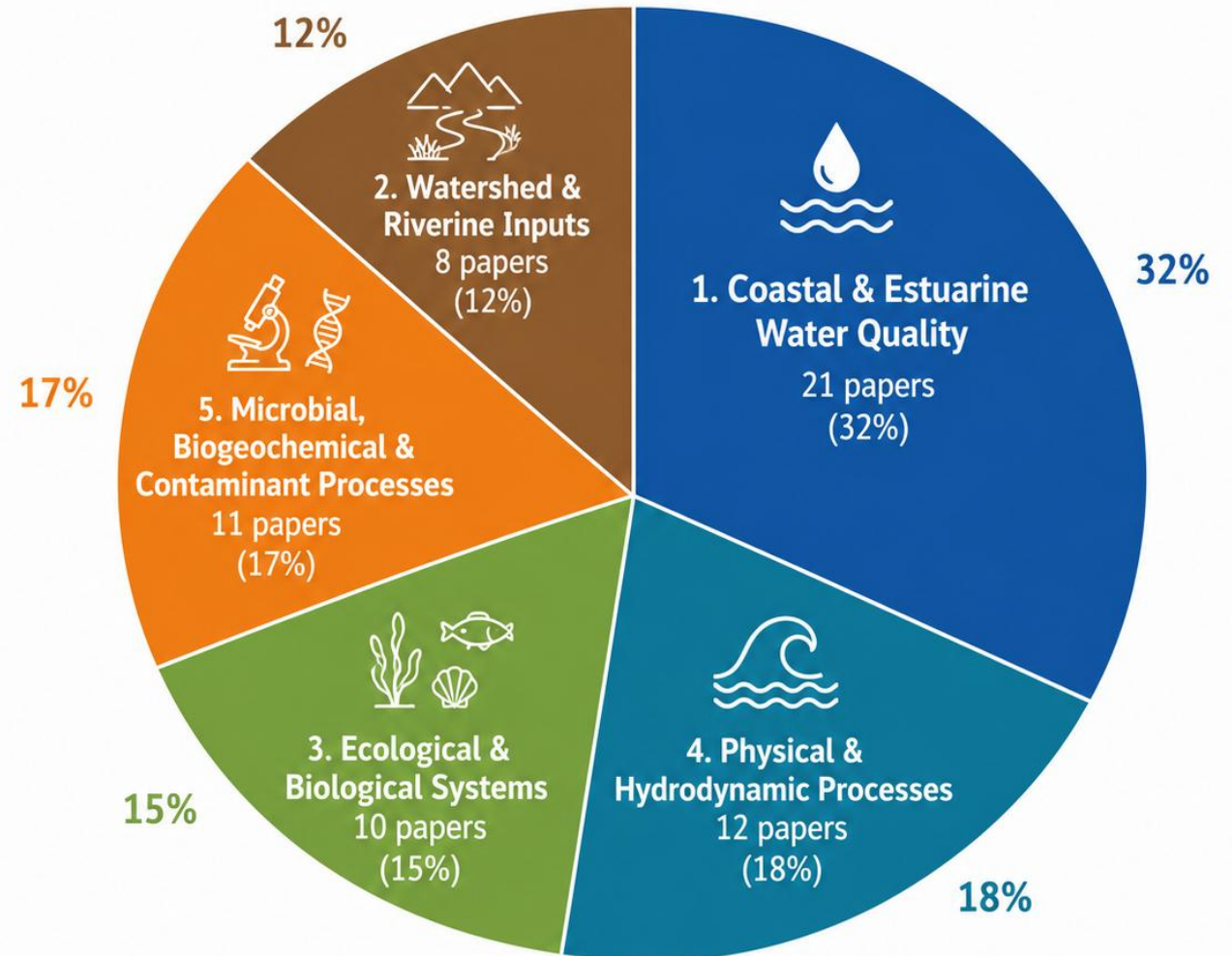


# Applications of AI/ML

- Prediction & Forecasting
- Gap Filling & Data Reconstruction
- Pattern Recognition & Classification
- Process Inference & Driver Attribution
- Scenario Analysis & Decision Support
- And more!

## Distribution of Applications Across Major Environmental Domains

(Total = 62 papers)



- 1. **Coastal & Estuarine Water Quality:** DO, hypoxia dynamics; Chl-a, phytoplankton blooms; TSS, turbidity, water clarity
- 2. **Watershed & Riverine Inputs:** Riverine N and P transport; baseflow nitrate
- 3. **Ecological & Biological Systems:** Stream health; SAV and phytoplankton; fish and shellfish
- 4. **Physical & Hydrodynamic Processes:** Storm surge, coastal flooding; waves, wave energy, and water level
- 5. **Microbial, Biogeochemical & Contaminant Processes:** Soil respiration and carbon cycling; microbial communities, taxonomy, and DNA-based indicators; emerging contaminants

# Workshop Report

## Leveraging Artificial Intelligence and Machine Learning to Advance Chesapeake Bay Research and Management: A Review of Status, Challenges, and Opportunities



STAC Workshop Review  
February 24-25, 2025  
Edgewater, MD



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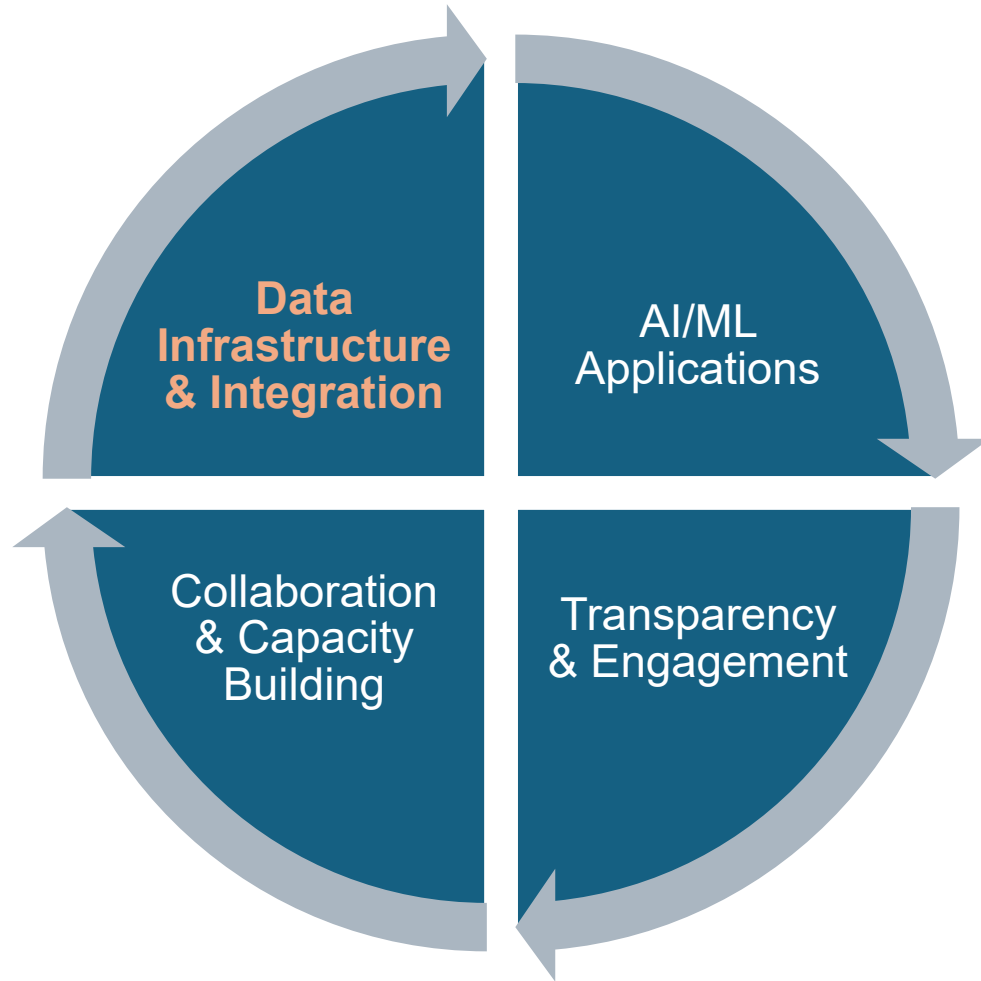
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[https://www.chesapeake.org/stac/wp-content/uploads/2025/11/FINAL\\_Leveraging-AI-and-ML\\_25-005-1.pdf](https://www.chesapeake.org/stac/wp-content/uploads/2025/11/FINAL_Leveraging-AI-and-ML_25-005-1.pdf)



# Workshop Recommendations

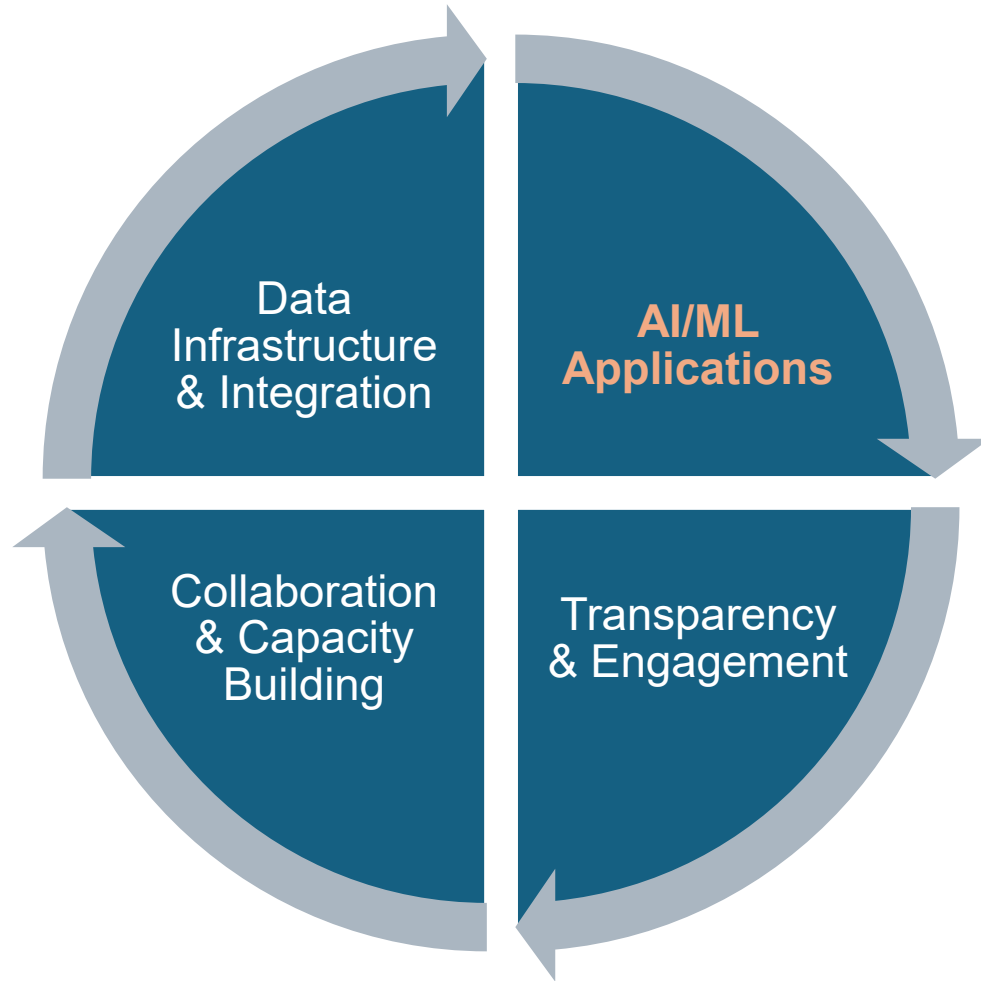


## 1. Strengthen data infrastructure and integration for AI/ML applications

- Harmonize spatial and temporal datasets across programs and ensure consistent metadata.
- Leverage diverse datasets, including satellite, in-situ, and high-frequency data, for modeling, monitoring, and filling water quality data gaps. (\*MB1)
- Design monitoring and data processing efforts so that resulting products are problem-relevant and can be readily incorporated into AI/ML workflows.
- Build harmonized response and predictor datasets and develop exemplar use cases to guide widespread AI/ML applications. (\*MB3)



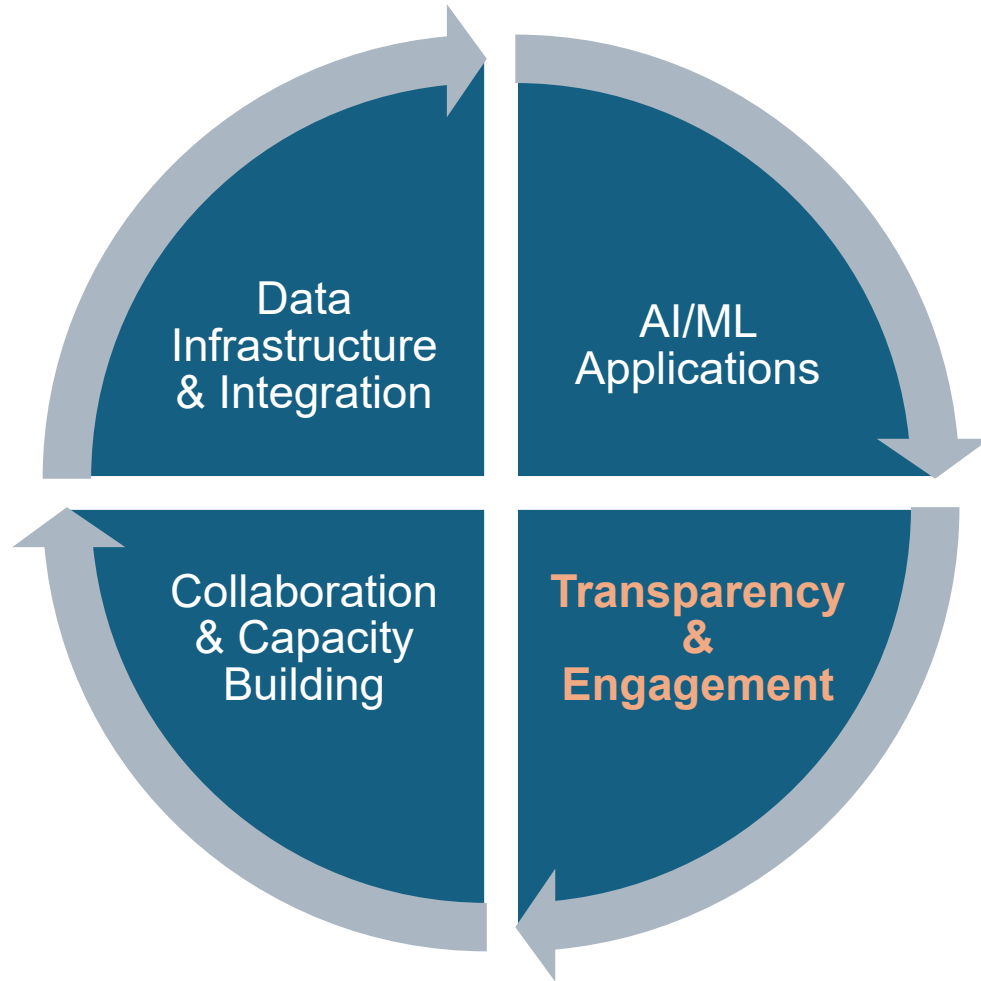
# Workshop Recommendations



## 2. Leverage AI/ML for Chesapeake Bay tidal and non-tidal regions restoration and decision support

- Use AI/ML to assess restoration practices, evaluate progress, and identify drivers.
- **Enhance Watershed and Estuarine Models by integrating AI/ML model outputs and insights. (\*MB2)**
- Develop accessible AI-driven tools (e.g., Chesapeake-specific LLMs) for scenario planning to help identify management priorities.

# Workshop Recommendations

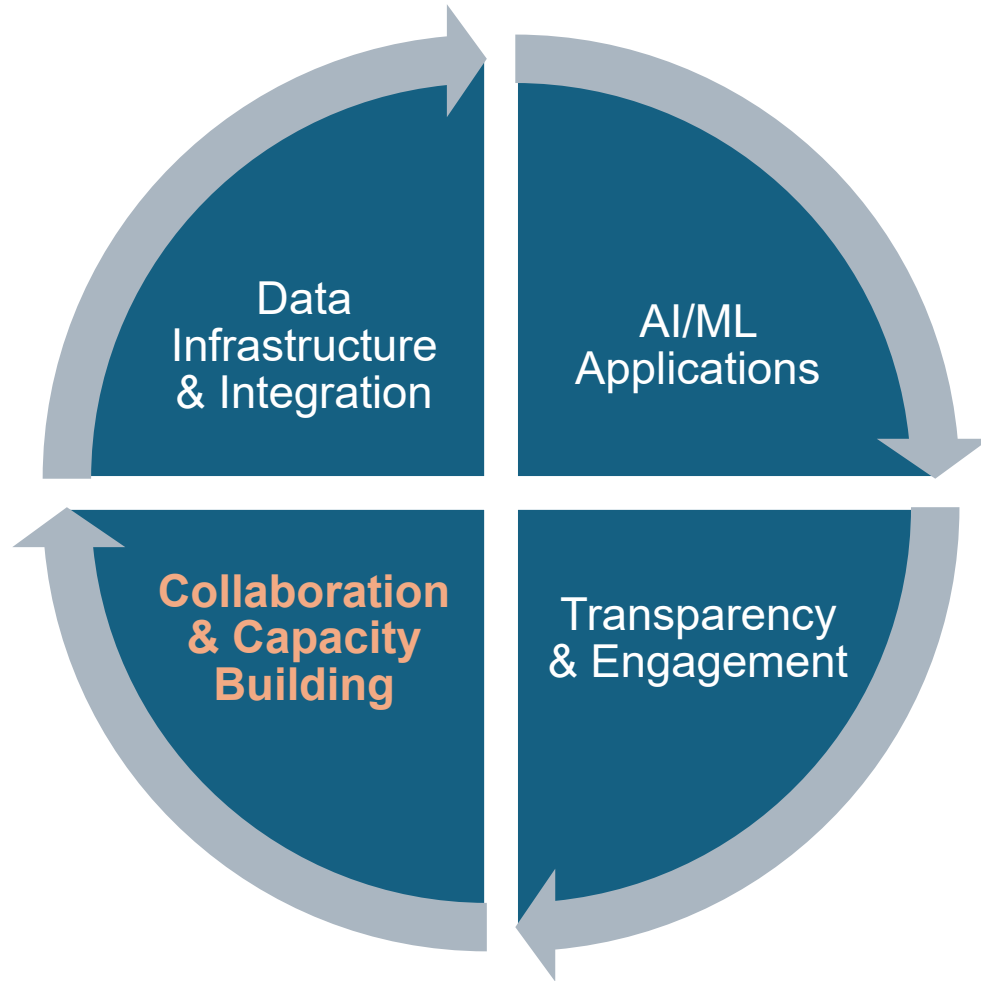


## 3. Promote transparency and engage managers and stakeholders

- Advance explainable AI and uncertainty protocols so that results are interpretable and trusted.
- Couple AI/ML with tailored data visualizations to improve interpretability and use.
- Foster close engagement of managers and decision-makers at all stages of AI/ML projects to ensure products align with management priorities and can be effectively applied.
- Use tailored communication strategies to translate AI/ML insights into actionable guidance for restoration planning.



# Workshop Recommendations



## 4. Build collaboration and capacity

- Establish a Chesapeake Bay AI/ML network (e.g., **Ches-BRAIN**) to foster collaboration and conversations and to make it easier for managers to connect with AI/ML experts. ***(Ches-BRAIN: Chesapeake Bay Research with Artificial Intelligence and Networking)***
- Invest in training and literacy programs so that scientists, managers, and decision-makers can effectively use AI/ML tools and outputs.
- Encourage participatory events such as Hackathons to spark innovation and strengthen cross-sector collaboration.



# Adopting AI/ML for Management

- ❖ **Data readiness:** Consistent monitoring, metadata, and QA/QC workflows
- ❖ **Stability & robustness:** Methods must perform consistently across time and datasets
- ❖ **Interpretability & transparency:** Outputs must be explainable and traceable
- ❖ **Defensibility:** Results must hold up under regulatory and stakeholder scrutiny
- ❖ **Integration with existing methods:** Complement trusted approaches (e.g., WRTDS, watershed models)
- ❖ **Workflow alignment:** Fit within decision cycles and reporting processes



# WRTDS as a Reference

- ❖ **Handles variability explicitly:** Separates long-term trends from hydrologic fluctuations
- ❖ **Stable over time:** Results evolve gradually, not erratically
- ❖ **Interpretable by design:** Structure aligns with physical understanding
- ❖ **Transparent and traceable:** Assumptions and workflows are clear
- ❖ **Communicates uncertainty:** Provides ranges and context, not single values
- ❖ **Aligned with decision needs:** Supports trend evaluation and policy decisions

