NOAA Great Lakes Environmental Research Laboratory

IMPLEMENTATION PLAN 2024-2028

NOAA GLERL Implementation Plan 2024-2028

Preface

Three major stressors presently have the largest effects on the hydrology, water quality, and healthy functioning of Great Lakes ecosystems: climate change, harmful algal blooms, and invasive species. The effects of these stressors on the ecosystem directly impact not only the natural physical and biological interactions in the lakes, but also the tribes, stakeholders, and the general public who live, work, and recreate on the Great Lakes. Awareness of issues affecting the Great Lakes communities is growing, and public concern over how these stressors will directly or indirectly affect them is likewise growing.

OAR's Great Lakes Environmental Research Laboratory (GLERL) is in a unique position of strength to respond to concerns regarding how stressors affect the Great Lakes. Long-term observational research maintained by GLERL provides the baseline data necessary to detect, interpret, and predict climate and ecosystem change. These data sets are in turn supported by cutting-edge research and observational platforms. Integrated modeling approaches and proximity to the phenomena being studied put GLERL in a position to develop next-generation prediction and forecasting for the Great Lakes Region and the nation. Finally, strong partnerships with state and federal agencies, academic institutions, industry, and local communities connect GLERL directly to the public it serves.

Purpose

The overall purpose of the Implementation Plan is to:

o   Link GLERL's core research portfolio to OAR Strategic Goals
o   Identify GLERL's priority research and organizational outcomes for the FY24-FY28 period
o   Provide metrics by which GLERL can gauge progress towards achieving those outcomes
o   Communicate a unified and strategic approach to GLERL activities to staff, partners, OAR, stakeholders, and the general public, and
o   Guide budget and resource planning/discussions.

GLERL's Implementation Plan also supports OAR directives and guidelines regarding Strategic Planning for OAR Laboratories and Programs (OAR Circular 216-8, 15 June 2022).

Linkage to GLERL Strategy

This Implementation Plan is developed as an internal document to facilitate execution of Strategic Objectives the GLERL 2024-2028 Strategic Plan. As such, it provides guidance and accountability for conducting work to further the Goals and Strategic Objectives with the Strategic Plan. While this document does not represent the entire research portfolio of GLERL, it highlights the core components of that

portfolio to which GLERL is committed, and emphasizes areas where GLERL makes unique and significant contributions to OAR's research mission.

Crosswalk

NOAA has developed a Weather, Water, and Climate Strategy (Strategy) that includes outcomes and outputs which support building a Climate Ready Nation by addressing six critical challenges that NOAA and its partners are well-positioned to address. GLERL's research and development activities in the Great Lakes provide critical data and services to help address these challenges. The matrix in the Appendix illustrates the ways in which GLERL's research goals and objectives address critical societal challenges in the Great Lakes Basin and beyond.

Near-term Outcomes

To accomplish the Strategic Goals and Objectives laid out in the GLERL 2024-2028 Strategic Plan, GLERL has identified twelve (12) Near-Term Outcomes for research over the next five years. Each outcome is linked to metrics and annual (unless noted otherwise) targets, which outline the progress that GLERL should make during the FY24-FY28 period. Progress assumes that work will proceed at sustained FY23 budget levels that include both internal (OAR base) and external (reimbursable) funding.

Near-Term Outcomes were chosen to align with the Great Lakes Water Quality Agreement (GLWQA), the Great Lake Restoration Initiative (GLRI), OAR, and NOAA priorities; developed with input from GLERL science and support staff; considered internally-funded and externally-funded projects vetted through the Annual Execution Plan science planning process; and addressed relevant recommendations from the GLERL 2021 Laboratory Review/Review Response and the GLERL 2020 Organizational Health and Culture Assessment Action Plan.

Future Refinement

Near-Term Outcomes, along with their associated metrics, will be reviewed once per year during the Annual Execution Plan process, or more often as needed to accommodate possible refinements, additions, or substitutions. GLERL will maintain ongoing discussions of strategic planning with science and support staff throughout the year.

Goal 1: Explore and Promote Awareness of the Great Lakes Environment

Long-Term Outcome: Increase knowledge of the Great Lakes ecosystem to support equitable resource management and public awareness.

Strategic Objective 1.1 - Survey and spatially characterize the Great Lakes.

Strategic Objective 1.2 - Communicate to stakeholders and the public the ecological, economic, and cultural value of the Great Lakes.

1.1 Near-Term Outcome: Enhance field work capability by expanding research platform capacity, effectiveness, and efficiency to carry out research on the Great Lakes.	**Champion:** Branch Chief, Observing Systems and Advanced Technology

Metric 1.1.1 – Annual number of Great Lakes field work research platform additions or improvements made.

Description: GLERL field work research platforms support surveying and sampling of both physical and biological features not only for OAR, but for all NOAA line offices operating in the Great Lakes. To support a NOAA-wide need for expanding field work and acquiring research data on physical conditions, benthic habitats, harmful algal blooms, unique deep-water sinkhole features, and other phenomena in the Great Lakes, GLERL will maintain and improve a diverse array of research platforms needed for NOAA missions in the Great Lakes, including updating existing platforms to improve research capacity, efficiency, safety, and operational capabilities.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	1	1	1	1

Metric 1.1.2 – Cumulative increase in square kilometers of benthic habitat surveyed compared to FY21.

Description: GLERL conducts acoustic multibeam surveys to support benthic habitat mapping for a variety of NOAA missions in the Great Lakes. Demand for survey information is increasing, and GLERL operates several vessels capable of using advanced survey technology to begin meeting this demand. Furthermore, the addition of new equipment and a Small-Waterplane-Area Twin Hull (SWATH) vessel to the existing fleet of GLERL survey platforms in FY23 will increase benthic habitat surveying capabilities.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
100 sq. km	450 sq. km	750 sq. km	1200 sq. km	1200 sq. km

1.2 Near-Term Outcome: Improve public and stakeholder awareness, accessibility, and interfaces for key Great Lakes data sets.

Champion: Data Manager, Great Lakes Environmental Research Laboratory

Metric 1.2.1 – Annual number of new data sets, data products, user data interfaces, or data visualization services equitably provided to a wide diversity of constituents.

Description: GLERL plays key roles in collecting, hosting, archiving, and maintaining key Great Lakes datasets and data products that are used by the scientific community, decision-makers, and the public. These include, but are not limited to, the Great Lakes Aquatic Non-Indigenous Species Information System (GLANSIS), the CoastWatch Great Lakes node, the Great Lakes Operational Forecast System (GLOFS), Great Lakes Ice Cover data, and Harmful Algal Bloom/Hypoxia products. Sustaining and enhancing high-quality data sets and improving data services such as interfaces and visualizations will ensure critical information is provided to scientists, managers, and the public so they can track and address the effect of Great Lakes ecosystem stressors including climate change, harmful algal blooms, and non-indigenous species.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	1	2	2	2

Goal 2: Detect Changes in the Great Lakes Ecosystem

Long-Term Outcome: Produce, analyze, and interpret long-term observation records needed to address climate change, understand the Great Lakes ecosystem, and inform the public.

Strategic Objective 2.1 - Sustain and advance Great Lakes observational capacity.

Strategic Objective 2.2 - Identify and address gaps in Great Lakes observations needed to understand causes of variability and change in freshwater regional ecosystems.

2.1 Near-Term Outcome: Maintain long-term Great Lakes observations critical to monitoring and predicting the effects of climate change on the Great Lakes.	**Champion:** Branch Chief, Ecosystem Dynamics

Metric 2.1.1 – Annual number of long-term physical or biological data sets providing data for addressing changes in the Great Lakes.

Description: Tracking the effects of climate change requires long-term observational records to detect and document changes over time in the physical, chemical, and biological components of the Great Lakes. GLERL maintains a unique, core set of long-term ecosystem records that are used not only by NOAA but also by a wide variety of Federal, State, and external partners as well as stakeholders and decision-makers. It is critical that GLERL maintains these records to facilitate ongoing study of impacts of climate change on the Great Lakes.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
6	6	6	6	6

2.2 Near-Term Outcome: Analyze and forecast effects of seasonal variability and climate change on the Great Lakes ecosystem to reduce risk and improve resilience.	**Champion:** Branch Chief, Integrated Physical and Ecological Modeling and Forecasting

Metric 2.2.1 – Annual number of assessments on impacts of seasonal variability and climate change on the Great Lakes ecosystem.

Description: Even though the Great Lakes contain roughly 21% of global freshwater volume, existing climate models evaluating future climate scenarios are using overly-simplified, one-dimensional surface representations of the Great Lakes. GLERL is working towards more accurately representing Great Lakes ecosystem responses to climate change at seasonal and regional scales. Work will integrate long-term records, models, and analyses to assess climate scenarios, water levels, heat budgets, seasonal mixing cycles, and ecosystem impacts in the Great Lakes.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	1	2	2	1

2.3 Near-Term Outcome: Address a critical data gap in Great Lakes winter observations by advancing Great Lakes observational capacity to include year-round data acquisition that accomplishes *in situ* winter data collection.

Champion: Branch Chiefs, Observing Systems and Advanced Technology and Ecosystem Dynamics

Metric 2.3.1 – Annual Number of *in situ* Great Lakes winter data sets collected.

Description: GLERL long-term records demonstrate that climate change is already affecting winter ice dynamics across all the Great Lakes, yet most physical, chemical, and ecological sampling of the lakes take place during the summer open-water period. Winter lake processes are not well studied or fully understood at this time. New information on winter lake conditions is essential for understanding how climate impacts already in process will affect seasonal differences among key physical and ecological lake processes. This requires development and deployment of new fixed and mobile instrumentation capable of operating under ice.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	2	2	1	1

Goal 3: Make Forecasts Better

Long-Term Outcome: Improve accuracy, precision, and efficiency of forecasts and predictions to save lives and property as well as support a vibrant and resilient economy.

Strategic Objective 3.1 - Develop Great Lakes components of the unified and integrated Earth System Model.

Strategic Objective 3.2 - Design tools and applications to forecast high impact Great Lakes climate, weather, water, and ecosystem events.

Strategic Objective 3.3 - Transition science to operational products that meets users' current and future needs.

3.1 Near-Term Outcome: Develop next-generation predictions for high-impact water level and coastal inundation events in the Great Lakes.	**Champion:** Branch Chief, Integrated Physical and Ecological Modeling and Forecasting

Metric 3.1.1 – Annual number of activities in which GLERL participates to assess stakeholder needs for lake level information and decision support tools.

Description: A diverse array of stakeholders in the Great Lakes region rely on forecasts and predictions to plan for or respond to high impact lake level events such as long-term changes in lake water levels or coastal flooding. To ensure that stakeholder needs are considered during model development and testing, GLERL and its partners will engage with stakeholders to better understand the kind of data and decision-making tools stakeholders need as well as the temporal and spatial scales for which forecasts, predictions, and decision support tools are required. This information will be used to determine how best to deliver lake level data to stakeholders in collaboration with partners.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	2	2	2	2

Metric 3.1.2 – Annual number of model improvements undergoing development, calibration, validation, and readiness testing for water level predictions in the Great Lakes.

Description: Improvement of Great Lakes water level and coastal inundation (flood) predictions requires developing predictions for sub-seasonal and annual time scales as well as synoptic scale events. These advancements will require coupling multiple models, including to the NOAA National Water Model, ice models, and regional wind wave models. This work will have a high impact on public safety planning and response to changes in Great Lakes water levels and coastal flooding events. It will also address management issues of concern to the International Joint Commission, the bilateral water management body responsible for addressing joint management of Great Lakes water resources between the United States and Canada.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	1	2	2	2

3.2 Near-Term Outcome: Improve monitoring and prediction of factors affecting water quality and drinking water supplies, including Harmful Algal Blooms (HABs) and hypoxia.

Champion: Branch Chief, Integrated Physical and Ecological Modeling and Forecasting

Metric 3.2.1 – Annual number of actions taken to improve observation or prediction of factors affecting water quality in vulnerable areas of the Great Lakes.

Description: Great Lakes water quality is affected by many factors, including nutrient loading, hypoxia, and Harmful Algal Blooms (HABs). For instance, HABs occur annually within the Great Lakes and impact water quality by reducing light and oxygen levels as well as introducing toxins into the food web. In some cases, HABs cause food web disruptions, fish die-offs, and unsafe drinking water. Warming caused by climate change is altering the duration, intensity, and dynamics of HABs in the Great Lakes. To detect and track rapid change in water quality dynamics, GLERL will conduct observation efforts to spatially and temporally capture events such as HABs and hypoxic conditions. GLERL will develop integrated modeling systems to address the need for reliable extended forecasts of water quality parameters.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	1	2	2	2

3.3 Near-Term Outcome: Develop cutting-edge observation and modeling systems for improving forecasts of high impact events in the Great Lakes.

Champion: Branch Chief, Integrated Physical and Ecological Modeling and Forecasting

Metric 3.3.1 – Annual number of observational or model development activities completed to improve forecasts of high impact Great Lakes events

Description: Understanding the set of physical or biological conditions causing high impact events in the Great Lakes such as meteotsunamis, lake effect snow, oil spill dynamics, or rapid spread of an invasive species is critical to improving detection, forecasting, and prediction for such events. Integration of atmospheric, hydrological, ice, terrestrial, biogeochemical, ecological, and climate models is necessary to improve forecasting skill, reduce model uncertainty, and prepare models for research to operational transitions. GLERL will therefore simultaneously conduct research on observational measurement of high impact events as well as predictive model development.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	2	3	3	3

Goal 4: Drive Innovative Science

Long-Term Outcome: Cultivate and deliver mission-relevant research to lead the environmental science community.

Strategic Objective 4.1 - Reinforce a culture of innovation and adaptability.

Strategic Objective 4.2 - Invest in high-risk, high-reward science.

Strategic Objective 4.3 - Accelerate the delivery of mission-ready, next-generation science.

4.1 Near-Term Outcome: Advance next-generation in situ and remotely sensed Great Lakes observations through expansion and integration of novel sensors, platforms such as uncrewed systems (UxS), and data algorithms.	**Champion:** Branch Chief, Observing Systems and Advanced Technology

Metric 4.1.1 – Annual number of new Great Lakes in situ and remote sensing sensors, platforms, and algorithms developed.

Description: Advanced observation capabilities are critical to monitoring changing conditions across the Great Lakes. For instance, NOAA and NASA next-generation satellites are transitioning from multi-spectral to hyper-spectral sensor technology to improve capabilities for tracking harmful algal blooms, ice coverage, and oil spills. The transition to new remote sensing platforms requires observations to ground truth remotely-sensed data as well as development and validation of data-processing algorithms that work in the unique, large-scale freshwater environments of the Great Lakes. Novel uncrewed systems and advanced sensors are expanding the capability to gather observations in situ over a wide range of environmental conditions.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	2	3	3	3

4.2 Near-Term Outcome: Conduct 'omics analyses to address critical ecosystem threats such as Harmful Algal Blooms, invasive species, and changes to Great Lakes food webs.	**Champion:** Branch Chief, Ecosystem Dynamics

Metric 4.2.1 – Annual number of Great Lakes ecosystem assessments completed using 'omics-based data analyses.

Description: Advances in high-throughput analyses of microbiological compounds such as DNA, proteins, and metabolites are allowing scientists to sample and monitor species composition, distribution, and interactions that were not previously possible. GLERL will conduct innovative research using 'omics to better understand how different strains or species in Harmful Algal Blooms affect factors such as the toxicity or duration the bloom, to detect and monitor the spread of invasive species in the Great Lakes, and to address questions about how changing food web interactions are affecting Great Lakes ecosystem dynamics.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	2	3	3	3

4.3 Near-Term Outcome: Monitoring and analyzing emerging issues and threats in the Great Lakes.	Champion: Director, Great Lakes Environmental Research Laboratory

Metric 4.3.1 – Annual number of new studies addressing emerging issues or threats in freshwater ecosystems.

Description: GLERL is well-positioned to play a leading role in research that addresses critical data gaps and emerging issues affecting freshwater ecosystems because the Great Lakes provide an excellent, logistically-tractable, natural laboratory for investigating a variety of natural and human-caused phenomena. Research will address emerging issues, including but not limited to, novel observation networks to measure and address climate impacts on freshwater acidification and evaporative flux, cutting-edge coupling of physical and biological models to address food web and invasive species dynamics, and advances in integrative models for sea ice and oil spill prediction.

FY24 Target	FY25 Target	FY26 Target	FY27 Target	FY28 Target
1	2	2	2	2

Goal 5: Commit to Equity, Diversity, Inclusion, and Accessibility

Long-Term Outcome: Increase the workforce diversity and improve equitable delivery of information and services to underrepresented and underserved communities.

Strategic Objective 5.1 - Build and retain a diverse, highly capable workforce.

Strategic Objective 5.2 - Enhance outreach and equitable delivery of information and services to underrepresented and underserved communities.

5.1 Near-Term Outcome: Create and implement a unified Action Plan for increasing workforce diversity and inclusion.	**Champion:** Equal Employment Opportunity, Diversity, and Inclusion Committee, Great Lakes Environmental Research Laboratory

Metric 5.1.1 – Annual number of activities from GLERL's EEO DIA Committee Action Plan for Increased Diversity and Inclusion implemented.

Description: To identify, prioritize, and track activities needed to increase workforce diversity and inclusion, GLERL will convene an Equal Opportunity Employment, Diversity, and Inclusion Committee whose charge will be to develop and implement activities from a lab-wide Action Plan. To attract, recruit, and retain a diverse workforce, this plan will take into account relevant recommendations from the GLERL Organizational Health and Culture Assessment Plan Action Plan, the GLERL 2021 Science Review, and the 2021 OAR DEI Implementation Plan.

FY24 Target	**FY25 Target**	**FY26 Target**	**FY27 Target**	**FY28 Target**
1	1	1	2	2

5.2 Near-Term Outcome: Increase outreach activities and delivery of information and services to underrepresented groups and underserved stakeholders.	**Champion:** Equal Employment Opportunity, Diversity, and Inclusion Committee, Great Lakes Environmental Research Laboratory

Metric 5.2.1 – Annual number of outreach or service delivery activities to underrepresented or underserved communities conducted.

Description: GLERL will increase outreach efforts to enhance relationships with underrepresented groups including minority-serving institutions, community colleges, tribal colleges, and scientific conferences or professional societies that specifically include work with minority communities. GLERL also seeks to build better communications with delivery of services to underserved minority, tribal, and low-income stakeholder communities in the Great Lakes Region, especially coastal communities who live, work, or recreate on the lakes.

FY24 Target	**FY25 Target**	**FY26 Target**	**FY27 Target**	**FY28 Target**
1	2	3	3	3

APPENDIX

Critical Societal Challenges Crosswalk Analysis

We know that threats to our communities and ecosystems has continued to grow over time, driven in part due to a warming climate. Climate and environmental risks in the Great Lakes include but are not limited to extreme lake levels—both high and low; coastal hazards include high waves, floods, and rip currents; loss of ice cover; water quality; harmful algal blooms; invasive species; oils spills; and other events. These issues cause significant impacts on Great Lakes stakeholders in innumerable ways. Integrated, actionable Earth system intelligence and decision support are required across a range of stakeholder audiences and timescales to help society mitigate and adapt to these compounding impacts, in close collaboration with private industry. These services must be equitably delivered to communities in a manner that meets the needs of their unique circumstances.

GLERL has been monitoring and addressing these societal impacts throughout the Great Lakes region. NOAA has developed a Weather, Water, and Climate Strategy (Strategy) that includes outcomes and outputs which support building a Climate Ready Nation by addressing six critical challenges that NOAA and its partners are well-positioned to address. GLERL's research and development activities in the Great Lakes provide critical data and services to help address these challenges. The matrix that follows illustrates the ways in which GLERL's research goals and objectives address critical societal challenges in the Great Lakes Basin and beyond.

GLERL Goals and Strategic Objectives			NOAA Weather, Water, and Climate Strategy Critical Societal Challenges				
			Extreme Events & Cascading Hazards	Coastal Resilience	The Changing Ocean	Water Availability, Quality, and Risk	Monitoring and Modeling for Climate Change Mitigation
			Communities across the U.S., particularly underserved communities, face enduring, compounding risks from extreme, high-impact weather, water, and climate events, which have become more severe and more frequent in recent decades.	*U.S. coastal communities, economies, and ecosystems, as well as the natural and built infrastructure on which they depend, are increasingly impacted by accelerating changes at the coast — the continued impacts of severe storms coupled with the impacts of rising seas, variable Great Lakes water levels, the warming ocean, loss of sea ice, changing ecology, reduced water quality, and coastal erosion and shoreline change, among others. Creating resilience to these changes requires risk-informed decision making and adaptation via enhanced emergency response, coastal data collection, and predictive capabilities, as well as equitable service delivery and decision support. A resilient coastal zone is required to reduce the risk of adverse impacts on our coastal and ocean infrastructure, ecosystems, marine transportation, tourism, recreation and other key economic sectors at the coast.*	*The ocean is a dynamic and connected component of the earth system. Ocean warming, decreasing sea-ice, changing currents, rising seas, ocean acidification and deoxygenation are affecting the nation's valuable living marine resources and the many ocean-dependent businesses and communities. These changes impact the nation's security through many sectors from marine navigation, transportation and energy to fisheries, aquaculture and protected resources.*	*The U.S. is facing emerging threats to our economic and national security, and ecosystem and habitat health, from competing demands for our increasingly limited and stressed water supply and other water risks nationwide, in the context of aging water infrastructure, degrading water quality, population growth, and climate change.*	*Worldwide, there is now widespread recognition of the impact of greenhouse gas emissions on the climate system, leading to dangerous, accelerated warming. Within the U.S. and internationally, there is a growing demand for information about current and future greenhouse gas emissions, their impact on the state of the global climate system, and options and effectiveness of climate change mitigation measures at different scales.*
GOAL 1 – Explore and Promote Awareness of the Great Lakes Environment	*Long-Term Outcome: Increase knowledge of the Great Lakes ecosystem to support equitable resource management and public awareness.*	1.1 Survey and spatially characterize the Great Lakes.				‡	
		1.2 Communicate to stakeholders and the public the ecological, economic, and cultural value of the Great Lakes.		‡	‡		
GOAL 2 – Detect Changes in the Great Lakes Ecosystem	*Long-Term Outcome: Produce, analyze, and interpret long-term observation records needed to address climate change, understand the Great Lakes ecosystem, and inform the public.*	2.1 Sustain and advance Great Lakes observational capacity.			‡		‡
		2.2 Identify and address gaps in Great Lakes observations needed to understand causes of variability and change in freshwater regional ecosystems.			‡	‡	

III

Goal	Long-Term Outcome	Objective					
GOAL 3 – Make Forecasts Better	*Long-Term Outcome: Improve accuracy, precision, and efficiency of forecasts and predictions to save lives and property as well as support a vibrant and resilient economy.*	3.1 Develop Great Lakes components of the unified and integrated Earth System Model.	‡	‡		‡	
		3.2 Design tools and applications to forecast high impact Great Lakes climate, weather, water, and ecosystem events.	‡	‡		‡	
		3.3 Transition science to operational products that meets users' current and future needs.	‡			‡	
GOAL 4 – Drive Innovative Science	*Long-Term Outcome: Cultivate and deliver mission-relevant research to lead the environmental science community*	4.1 Reinforce a culture of innovation and adaptability.			‡	‡	
		4.2 Invest in high-risk, high-reward science.			‡	‡	
		4.3 Accelerate the delivery of mission-ready, next-generation science.	‡		‡	‡	
GOAL 5 – Commit to Equity, Diversity, Inclusion, and Accessibility	*Long-Term Outcome: Increase the workforce diversity and improve equitable delivery of information and services to underrepresented and underserved communities.*	5.1 Build and retain a diverse, highly capable workforce.					
		5.2 Enhance outreach and equitable delivery of information and services to underrepresented and underserved communities.	‡	‡	‡	‡	‡

Mapping Key: Correlation: ‡

Source: NOAA's Weather Water and Climate Strategy FY2023-2027: https://www.noaa.gov/sites/default/files/2022-12/NOAA-FY23-27-Weather-Water-and-Climate-Strategy-12092022.pdf