

Managing the Effects of Climate Change on Our Water Resources

Effective water resource management requires a holistic strategy for addressing climate change adaptation, mitigation, vulnerability assessment, and resiliency. LimnoTech has broad and extensive experience related to our changing climate, including: 1) climate change research; 2) urban water resource planning to respond to climate change; 3) water sustainability planning, as made more challenging by climate change; and 4) management and mitigation of flooding; 5) quantifying the portion of financial risk exposure that is attributable to climate change. Drawing upon expertise in all of these areas, LimnoTech has developed decision-support tools that integrate sound climate science with data on short- and long-term trends in temperature and precipitation, to quantify and predict potential changes in water resource quality and abundance, and to provide decision-makers with the necessary context to make informed decisions.

LimnoTech is closely involved in the area of climate change research with a focus on global water resources. We use a hierarchical approach that includes statistical analysis of historical hydroclimatic data, numerical modeling of the relevant physical processes and watershed hydrology, and incorporation of downscaled future climate scenarios from global and regional climate models. Examples of LimnoTech's climate-related research include development of the Great Lakes Evaporation Network (GLEN) for water resource management; compilation and analysis of a long-term, global database of in situ and remotely sensed surface water temperatures for 291 lakes and reservoirs worldwide; data analysis and modeling of the effects of climate change on Great Lakes water temperatures, ice cover, and evaporation; and development of surface heat flux and evaporation algorithms for Lake Tahoe, Arctic lakes, and the Great Lakes.

LimnoTech also has an established practice in the area of urban water resources planning and development, focusing on new approaches for creating more livable cities and waterfronts. Increasingly our work incorporates planning for and adapting to the effects of climate change, including assessment of the effects of increased rainfall quantities and intensity of flooding; planning for longer and more extreme periods of drought in the southwestern United States; and anticipating the effects of sea level rise and storm surge on coastal communities and metropolitan regions along the Atlantic coast, including New York-New Jersey Harbor, Boston, Washington, DC, and the Rhode Island coastline. LimnoTech works closely with a variety of private and academic partners including the Harvard University



Graduate School of Design to develop improved strategies and methods for enhancing the resiliency and robustness of increasingly exposed coastal communities.

LimnoTech's water sustainability practice is actively providing clients with insights into how water scarcity concerns can affect water availability, quality, and related effects on society, industry and the health of aquatic ecosystems. Through our sustainability practice LimnoTech:

- Helps cities plan and design green infrastructure to create sustainable, livable communities and healthy waterways.
- Works with corporations to better understand water use in operations and the supply chain, and identify and quantify the benefits of reducing uses, minimizing risks, and mitigating impacts.
- Helps power utilities better understand the complexities of the water/energy nexus and the potential benefits of sustainable water supply solutions such as water-efficient cooling technologies, reclaimed water sources, and collaborative watershed-based approaches for improved resource management.
- Works with agri-businesses to help them optimize their operations with limited water quantity and quality impacts.

LimnoTech has also been closely involved in the development of methods for quantifying financial risk exposures from environmental liabilities related to water and water resources risk. Methodologies for calculating value-at-risk parameters for portfolio assets used by our partner firm, Equarius Risk Analytics, were developed with LimnoTech's expertise through projects exploring water supply risk and scarcity around the world.

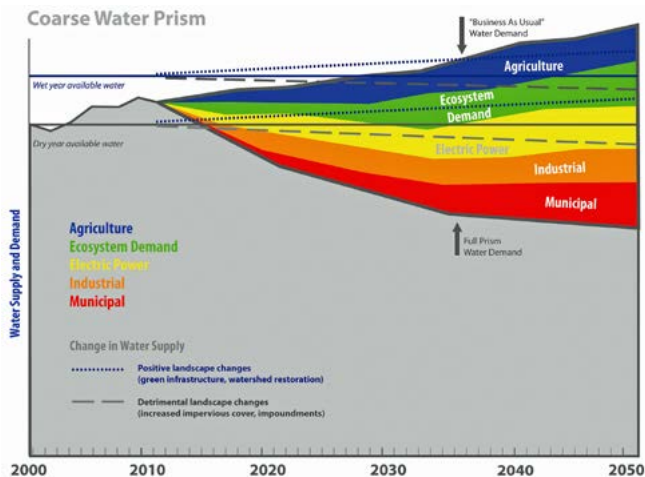


LimnoTech works with industries, energy providers, and agri-businesses to help them optimize their operations to limit water quality and quantity impacts.

The following selected projects provide some examples of recent work performed by LimnoTech that involved assessing the effects of climate change on water resources in addressing our clients' challenges.

Water Resources Trends and Implications for the Electric Power Industry

Many electric power generators have experienced water resource problems related to reduced water availability and/or increased water temperatures. These situations of physical water risk have led plants to temporarily shut down, reduce power generation, or make structural modifications to access cooling water. LimnoTech conducted a study for the Electric Power Research Institute to investigate the importance of reliable water supplies to the electric power industry, and to identify relevant trends in water quantity and quality. This study found that water resource trends can be influenced by a range of controllable and uncontrollable factors, one of the most significant being climate variability. The study noted that climate trends, including decreasing precipitation, increasing air temperature, decreasing snowpack, earlier snowmelt, and increasing drought, can significantly influence hydrology and water temperature. And because climatic factors cannot be controlled, electric utilities are finding it increasingly imperative to understand and adapt to the potential effects of climate change on their water resource management decisions. Power plants must work to anticipate and adapt to a wider range of climate and water resources variability under which they can operate to avoid excessive water risk.



LimnoTech developed the Water Prism decision-support tool to evaluate the benefits of multi-sector water-saving strategies.

With support from the Electric Power Research Institute (EPRI), LimnoTech developed a decision-support system (Water Prism) to evaluate benefits of multi-sector water-saving strategies. WaterPrism addresses the challenge of sustainable water management and competing uses among municipal, industrial, energy, and agricultural users. It supports the design of programs that minimize competition and conflicts over water, and provides better information for making decisions related to water rights, water allocation, and water resources management. Water Prism scenarios are

constructed to explore how the implementation of various water-saving strategies may result in a shift of the demand curve so that water needs will be met within the bounds of available supply for a 50-year time horizon under various climate change scenarios.



LimnoTech's IERM modeling system will help researchers evaluate the effectiveness of water level regulation plans in response to changes in climate and water availability.

Development of an Integrated Ecological Response Model for the Upper Great Lakes System

Recent studies by the International Joint Commission have addressed the concern that existing water-level regulation criteria in the Upper Great Lakes system may be contributing to unsustainable ecological impacts. LimnoTech is working with the Environmental Technical Working Groups (ETWGs) and others to develop an Integrated Ecological Response Model (IERM) to evaluate the impacts of water level regulation, basin supply, and climate change on indicators of ecological performance for these studies. LimnoTech is configuring the IERM to evaluate the impacts of a range of water level conditions, including potential climate change scenarios, on ecological indicators for key locations within Lakes Superior, Michigan, Huron, and Erie. The results of each integrated modeling effort will be incorporated into the Shared Vision Model, a decision-support tool to facilitate comparisons of environmental and economic benefits and impacts for regulation plan alternatives.

This decision-support system condenses results from more than 600 ecological indicators into the 32 most important indicators for decision-making. It allows direct comparison between management scenarios for indicators within six categories and covering various geographic regions within the system. Users of the decision tool have the ability to control which indicators are considered, as well as the weighting factors used to describe each indicator.



Photo: USEPA

LimnoTech is developing models to help predict the effects of climate-related extreme events on Great Lakes ecosystems.

Effects of Extreme Climate Change-Induced Events on the Great Lakes

Climate change-induced extreme events are expected to increasingly affect the Great Lakes ecosystem and ecosystem services, with associated impacts on social and economic well-being. Despite mounting evidence of the severity of these effects, knowledge is limited about how the climate, ecological, and social systems in the Great Lakes interact. LimnoTech is working as a subcontractor to the University of Michigan on an NSF-funded five-year project to develop models to predict the impact of climate change-related extreme events on nutrient loading and associated ecological responses. The Maumee watershed and Western Basin of Lake Erie are being used as a site for development of these models. The project team will also develop management systems that support adaptation to these conditions. This study will advance scientific understanding of coupled human-climate-water quality systems, and inform and influence future decision-making in the Great Lakes region.

Characterizing and Understanding the Impact of Climate Warming on Large Inland Water Bodies

LimnoTech is playing a lead role in the Global Lake Temperature Collaboration (GLTC), an international effort to analyze the global patterns, mechanisms, and impacts of lake warming throughout the world. The GLTC initiative has assembled a database of nearly 300 lakes and reservoirs, as well as trends in air temperature, cloud cover, and other climatic factors that influence water temperature. LimnoTech is also working with investigators in the Global Lake Ecological Observatory Network (GLEON) and the Great Lakes Evaporation Network (GLEN) to investigate the impacts of climate change on lake evaporation, ice cover, and water temperature across a gradient of lakes from the Arctic to the Great Lakes. Historical trends and models of physical lake processes will aid in the prediction of future lake dynamics and ecosystem impacts, such as eutrophication and harmful algal blooms.

Analysis of Potomac Water Levels Based on Available Gage Data for Washington Harbour. Washington Harbour is a private luxury development on the Potomac River waterfront in Georgetown, Washington, DC. The site is prone to flooding because of its proximity to the river and its relatively low ground elevation. The property owner wanted to investigate a permanent, aesthetically pleasing floodwall or berm for flood control to replace the tall and obtrusive temporary floodgates currently used. LimnoTech performed a statistical analysis of historic water level data to determine a suitable top elevation for the proposed floodwall or berm. LimnoTech also conducted a long-term trend analysis of water levels to evaluate the future likelihood of an increase in the number of days of high-water events caused by factors such as climate change. Results of the analysis demonstrated that Washington Harbour could reduce the number of days of potential flooding by more than half through the construction of a one- to two-foot-high floodwall or berm. The long-term climate trend analysis showed increasing water levels of 5 to 8 inches over the last three decades. Because this could mean a small but significant increase in the number of future flooding events, a safety factor was recommended for any proposed new floodwall or berm to account for rising water levels.

Support to Chiquita for Improvements in Rain-Fed and Irrigated Agriculture

In collaboration with World Wildlife Fund (WWF) International, LimnoTech conducted a water footprint assessment of bananas produced in Central America and lettuce produced in the U.S. The objective was to compile critical baseline water data and related information to help validate the importance of further engagement on water issues, identify key priority areas, and provide a high-level indication of best practices. The results support an improved understanding of the differences between growing regions in terms of water requirements and also show the benefits of various irrigation practices and technologies to mitigate the impacts of climate change. Chiquita is building on the results to support development of a corporate water strategy.



LimnoTech's footprint assessment supported an improved understanding of the differences between growing regions in terms of water requirements and also showed the benefits of various irrigation practices and technologies to mitigate impacts of climate change.