

**HEADS IN THE SAND: BEACH ACCESS AND THE PUBLIC TRUST DOCTRINE  
UNDER FUTURE CLIMATE SCENARIOS ON ILLINOIS' LAKE MICHIGAN COAST.**

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## **Abstract**

In the winter of 2020, Illinois suffered millions of dollars in coastal damage from abnormally strong waves. These waves were fueled by record high lake levels, a phenomenon expected to become increasingly likely under climate change. This paper examines the impact of climate change-induced lake level rise on beach access across the state. My mixed-methods approach combines spatial analysis of lake climate projections with legal analysis of their implications for beach access protections under the public trust doctrine. I find that up to sixty percent of existing beach spaces may be fully inundated by 2040. Furthermore, since existing public trust precedent assumes a stable lake level, it will be significantly challenged by rising water levels, leading to jurisdictional confusion for maintaining beach access even as beaches themselves steadily erode. Without significant policy intervention, Illinois may lose most of its Lake Michigan beaches.

**Heads in the Sand: Beach access and the Public Trust Doctrine under future climate scenarios on Illinois' Lake Michigan coast.**

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## Introduction

On February 6, 2020, Chicago Mayor Lori Lightfoot declared a local disaster “due to significant flooding and major damage to the city’s shoreline” following a major storm.<sup>1</sup> The storm brought waves of up to 23 feet high to the shores of Lake Michigan, eroding lakefront beaches, roads, and infrastructure, and causing up to \$37 million in damage.<sup>2</sup> While the storm itself was powerful, the unprecedented destruction caused by wave damage set this event apart from others in recent history. In January of 2020, lake levels were 581.6 feet above sea level on average, surpassing the previous record for the month by three inches and rising above the previous historical low by 5.5 feet.<sup>3</sup> The abnormally high water levels meant that waves clawed their way up much further on the shoreline, inundating areas typically considered safe from the lake’s reach. Far from being a one-off event, however, scientists predict that climate change will increase the likelihood of extreme lake levels, creating both sudden destruction like that caused by the storm and gradual erosion of the coastline permanent even in low water periods.<sup>4</sup> Such conditions will directly threaten the roadways, homes, museums, parks, and beaches that define the Illinois coastline.

This paper seeks to understand the impact of climate change-induced lake level rise on Illinois beaches. Such a fixation on beaches may seem strange given the variety of critical infrastructure located on the state’s coast. Yet, beaches have been, and continue to be, integral to the social identity of Illinois. For decades, marginalized Illinoisans have fought and died for equal access to

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<sup>1</sup> Lori E. Lightfoot, “Press Release: Mayor Lightfoot Issues Local Disaster Proclamation Due to Catastrophic Flooding and Damage along the City’s Lakefront,” *Office of the Chicago Mayor*, February 6, 2020.

<sup>2</sup> Morgan Greene, “How bitter cold winter blasts and a warming planet will chew up the Lake Michigan shoreline, faster and faster,” *Chicago Tribune*, January 17, 2020.

<sup>3</sup> Allison Goldman, “Lake Michigan Comes for Chicago’s Waterfront Real Estate,” *Chicago Magazine*, March 9, 2020.

<sup>4</sup> Frank Seglenieks and André Temgoua, “Future Water Levels of the Great Lakes under 1.5 °C to 3 °C Warmer Climates,” *Journal of Great Lakes Research* 48, no. 4 (August 1, 2022): 867.

beaches, from the deadly 1919 race riots following the death of Eugene Williams at a white beach to the “wade-ins” organized at South Side Chicago beaches throughout the 1950s and 60s.<sup>5</sup> That beaches became a primary setting for such struggles demonstrates the strength of social demand for open beach access. Today, Illinoisans continue to value access to the beach very highly: the total seasonal value of beach use in Chicago alone has been estimated to be between \$800 million and \$1 billion per year.<sup>6</sup> Any threat to beaches and beach access, therefore, must be taken seriously. Climate change’s impact on Lake Michigan deserves such consideration.

### **Overview of Research and Conceptual Framework**

To address the impact of climate change on beach access, I answer two research questions:

1. What is the potential extent of inundation of current Illinois beaches under likely climate scenarios by 2040?
2. What implications will this have for the legal frameworks under which beach access is currently protected in the state?

This paper first quantifies the physical extent of beach inundation under climate change by creating hydrologic spatial models to predict potential lake levels under various climate futures and overlaying them on a dataset of existing beaches in the state. It then discusses the implications of the spatial models for existing legal and policy frameworks to protect beach access. This legal analysis is grounded in my interpretation of the public trust doctrine, a framework that binds the state of Illinois to protect the Lake Michigan lakebed and portions of

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<sup>5</sup> Chicago Commission on Race Relations, *The Negro in Chicago: A Study of Race Relations and a Race Riot* (Chicago: University of Chicago Press, 1922), 48; Virginia Wolcott, *Race, Riots, and Roller Coasters: The Struggle over Segregated Recreation in America* (Philadelphia: University of Pennsylvania Press, 2012), 185.

<sup>6</sup> Michael J. Chrzastowski and Daniel Injerd, “Illinois State of the Beach State Report,” *Beachapedia*, Surfrider Foundation, June 27, 2017.

the lakeshore for the “public trust.” This mixed-method approach builds upon existing scientific and legal literature that discuss climate change on the lakefront and the public trust doctrine in Illinois, respectively, putting them in conversation with one another for the first time to create a comprehensive analysis of beach access under climate change.

Ultimately, I argue that climate change poses a significant threat to beach spaces in Illinois, both because of the physical extent of inundation possible and because of the legal confusion that it will create. I find that almost sixty percent of current sandy beach spaces across Illinois will be inundated under the most extreme climate scenario presented here. Simultaneously, as lake levels rise, the jurisdictional boundaries of the public trust doctrine will become increasingly uncertain. Since Illinois law lacks explicit protections for access to dry, sandy beaches, there is a real possibility that climate change will lead to the permanent loss of large swaths of beach spaces that are today enjoyed by millions of residents of the state. To mitigate this possibility, I call on the state government to create a comprehensive coastal plan for climate change, and I suggest legislation that will protect beach access even under the most extreme scenarios.

## **Background and Context**

The Illinois Coastal Management Program defines a beach as follows:

A beach is the area of unconsolidated material (sand, gravel, pebbles and possibly cobbles), either naturally occurring or artificially placed, that has an upper limit either along the line of permanent vegetation or along the lakeward edge of any coastal structure such as a revetment, bulkhead, breakwater, groin or sidewalk, and a lower limit below water where sand persists across the lake bottom and calm-water depths are no greater than six feet.<sup>7</sup>

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<sup>7</sup> “State of Illinois Coastal Management Program,” Illinois Department of Natural Resources, 2011, 55.

Such a highly specified definition is necessary given the extent of shoreline engineering on Illinois' coast. Today, Illinois is home to only one "natural" beach, Illinois Beach State Park. All others are artificially created by pier-like structures called groins constructed out into the lake to trap sediment from eroded beaches upstream.<sup>8</sup> Between and directly bordering beaches are stretches of protected shoreline where lake water intercepts a seawall, revetment, or other hardened structure.<sup>9</sup> Far from being ubiquitous, therefore, beaches comprise only 34 of Illinois' 63 miles of Lake Michigan shoreline.<sup>10</sup>

Lakefront beach access is provided to the public mostly through parks district-owned recreational facilities. Of the 33 public beaches fronting Lake Michigan in Illinois, all but two are owned by thirteen separate parks districts, with the remainder administered as state beaches by the Illinois Department of Natural Resources.<sup>11</sup> While coastal parks districts once derived their authority and funding from the state legislature, this is no longer the case, and they are instead managed by municipal governments, with only loose oversight from the state-run Illinois Coastal Management Program.<sup>12</sup> The Coastal Management Program is a non-regulatory planning framework whose focus is mostly on preventing shoreline pollution and the proliferation of invasive species, meaning that they have limited oversight over issues of beach access.<sup>13</sup> Illinois'

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<sup>8</sup> Margaret K. Scholle and Suzanne C. Walther, "Responses to Lake Michigan Water Level Rise: Trends in Exposed Sand Cover at North Avenue Beach, Chicago." *Journal of Great Lakes Research* 48, no. 3 (June 2022): 624.

<sup>9</sup> Michael J. Chrzastowski, "History of the Uniquely Designed Groins Along the Chicago Lakeshore," *Journal of Coastal Research* 2004: 21.

<sup>10</sup> Henry Rose, "The Public Trust Doctrine: Does It Provide the Public with Access to the Beaches of Lake Michigan in Illinois?," *Loyola Public Interest Law Reporter* 2 (Spring 2013): 91.

<sup>11</sup> Gerrin Cheek-Butler, "BEACH Act Illinois Coastal Beaches," *United States Environmental Protection Agency*, 2023.

<sup>12</sup> David Kennedy et al., "Final Environmental Impact Statement (FEIS) for the Illinois Coastal Management Program (ICMP)," *National Oceanic and Atmospheric Administration*, December 9, 2011: 7.

<sup>13</sup> Malcolm Cairns, "History of the Illinois Parks Districts," *Northern Illinois University Library* 23, October 1997.; Governor Pat Quinn, "Governor Quinn Signs Executive Order to Create Illinois Coastal Management Program," *Illinois Governor's Office*, December 10, 2010.



deference to municipal management has created a patchwork of beach access protections across the state, with four parks districts (most notably the Chicago Parks District) promising free, unlimited public access, with others managing access through user fees, parking restrictions, or municipal residency requirements.<sup>14</sup>

Underpinning the present delineation between state, municipal, and private jurisdiction over beaches is a long history of ever-changing state and federal interpretations of the public trust doctrine. The public trust doctrine is a legal framework that declares that state governments are sovereign over submerged lands under navigable waters to protect a public right to fishing, navigation, and commerce.<sup>15</sup> Illinois was home to one of the most pivotal public trust cases in United States history in the U.S. Supreme Court's 1892 *Illinois Central Railroad Co. v. Illinois* decision, which determined that the state government could not abdicate its responsibility to protect the "public trust" by allowing private parties to develop the bed of Lake Michigan in their own interests.<sup>16</sup> Prior to the 1892 decision, state and local governments had sold much of Illinois' lakebed and shoreline, including formerly natural beaches, to industry and commerce to advance the state's economy. In Chicago, where the case originated, the Illinois Central Railroad was allowed to carve through beaches along the southern coast and construct a depot in the lake near downtown at the expense of Lake Park, a municipally owned beach.<sup>17</sup> This stimulated a vigorous public debate between commercial and industrial boosters who backed the construction of the railroad, and city residents (particularly homeowners along Michigan Avenue, which then fronted

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<sup>14</sup> Kennedy et al., "Final Environmental Impact Statement (FEIS)," 58.

<sup>15</sup> Joseph D. Kearney and Thomas W. Merrill, "The Lakefront Steal," In *Lakefront: Public Trust and Private Rights in Chicago* (Ithaca: Cornell University Press, 2021), 15.

<sup>16</sup> *Illinois Central R. Co. v. Illinois*, 146 U.S. 387 (1892).

<sup>17</sup> Joseph D. Kearney and Thomas W. Merrill, "The Lakefront Steal," 10.

the lake) who wanted to see the land preserved for public access.<sup>18</sup> The debate fueled an 1883 lawsuit to settle once and for all who had jurisdiction over the lakefront, which would wind its way through successive courts before it reached the United States Supreme Court.<sup>19</sup>

The *Illinois Central* decision determined that the state was permanently bound to protect the “public trust” in any future decisions over lakefront development; however, it did not explicitly promise that the lakefront would remain publicly owned or accessible, or that natural beaches would be preserved. Instead, an 1896 Illinois Supreme Court ruling in *People ex rel. Moloney v. Kirk* determined that the state legislature should have significant control over the proper use of public trust land. This decision set the stage for decades of shoreline development and landfilling of Lake Michigan in the early 20<sup>th</sup> century under the approval of the state legislature, and helped create the patchwork of land uses that define the lakefront today.<sup>20</sup> In Chicago, parks districts extended the shoreline out into the lake to shape the coastal parks the city is now known for, creating artificial beaches even as natural ones were covered in fill.<sup>21</sup> Further north, residential developments were built to directly abut the lakefront, with adjacent property owners able to purchase riparian ownership of the lake’s beaches.<sup>22</sup> The state legislature became directly involved in beach protection only once during this period, as it purchased parcels that would later comprise Illinois Beach State Park in Zion in the early 1920s.<sup>23</sup> State legislative control of public trust lakefront development would last until a 1976 Illinois Supreme Court ruling, *People ex rel. Scott v. Chicago Park District*, imposed a system of judicial review on public trust cases as it

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<sup>18</sup> Joseph D. Kearney and Thomas W. Merrill, “The Lakefront Steal,” 33.

<sup>19</sup> Joseph D. Kearney and Thomas W. Merrill, “The Lakefront Case,” In *Lakefront: Public Trust and Private Rights in Chicago* (Ithaca: Cornell University Press, 2021), 54.

<sup>20</sup> *People ex rel. Attorney Gen. Moloney v. Kirk*, 162 Ill. 138 (1896).

<sup>21</sup> Bachrach, Julia Sniderman. “Parks Districts.” *Encyclopedia of Chicago*, 2005.

<sup>22</sup> Stuart Cohen and Susan Benjamin, “Introduction.” In *North Shore Chicago: Houses of the Lakefront Suburb, 1890-1940* (New York: Ancathus Press, 2004), 18.

<sup>23</sup> “About Adeline Jay Geo-Karis Illinois Beach State Park,” Illinois Department of Natural Resources, 2023.

overturned a state law that would have allowed U.S. Steel to expand its South Works campus further into the lakefront.<sup>24</sup> More importantly for beach access, however, the wording of the *Scott* decision expanded the public trust doctrine's traditional protections for navigation, fishing, and commerce to include environmental protection, natural resource conservation, and public access to the lakefront.<sup>25</sup> The precedent created by *Scott* has led to a scholarly debate, discussed in the literature review, over whether public access to both publicly and privately owned beaches would be protected under the public trust doctrine. Since lakefront development has remained mostly static in the fifty years since *Scott*, however, beach access today continues to be defined by the patchwork of mostly municipally owned beaches across the Illinois coastline.

The lack of an explicit statewide legislative mandate or public trust ruling to protect and standardize beach access in Illinois sets it apart from its fellow coastal states, leaving accessibility dependent on the abilities of individual municipalities to maintain it. This inherent vulnerability is particularly exposed by extreme lake level change caused by global warming, which has already caused a string of beach closures across the state due to rapid coastal erosion and threatens to do so again in future flooding events.<sup>26</sup> Without state resources to repair damages or implement coastal resilience projects, some municipalities have chosen to close eroded beaches indefinitely.<sup>27</sup> Under future climate scenarios, it is possible that beach closures might expand across the state, posing an existential threat to beach access for Illinois residents.

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<sup>24</sup> People ex rel. Attorney Gen. Scott v. Chicago Park District, 66 Ill. 2d 65 (1976).

<sup>25</sup> Joseph D. Kearney and Thomas W. Merrill, "The Transformation of the Public Trust Doctrine," In *Lakefront: Public Trust and Private Rights in Chicago* (Ithaca: Cornell University Press, 2021), 268.

<sup>26</sup> Dan Egan, "A Battle Between a Great City and a Great Lake," *New York Times*, July 7, 2021.

<sup>27</sup> Lucas Naber, "It's Official: Two Rogers Park Beaches Gone," *Rodgers Edge Reporter*, January 16, 2020.

In what follows, this paper first explores the existing scientific and legal literature surrounding beach access and the public trust doctrine under climate change. I next introduce the methodology used to create the spatial models and legal interpretations that form the bulk of my analysis. The paper then presents the results of both spatial and legal analyses, using three case studies from municipalities across the Illinois coast to better understand how local spaces will be affected. Finally, I synthesize these results into a discussion of their implications for future coastal planning in Illinois.

### **Literature Review - Introduction**

This paper seeks to explore both the spatial reality of climate change for Lake Michigan's beaches and its legal implications for public access. Thus, the literature review is divided into two thematic sections, legal and scientific. The legal section examines the literature on the relationship between the public trust doctrine, beach access, and climate change, first at a national level and then specific to Illinois. The scientific section delves into the literature on climate impacts on Lake Michigan, first at a general level and then specific to beach access. The two are then synthesized to reveal a potential climate future in which the scientific reality of accelerated beach erosion and its unprecedented redefinition of the legal boundaries between state, municipal, and private jurisdictions contribute to a high degree of uncertainty regarding the future of Illinois beaches.

### **Legal Literature Review**

#### *Beach Access, Public Trust Doctrine, and Climate Change across the Coastal United States*

As mentioned in the background section, the public trust doctrine is a legal framework that declares that the state is sovereign over submerged lands under navigable waters for the purposes

of protecting a public right to fishing, navigation, and commerce.<sup>28</sup> Under the equal footing doctrine, which provides that every state enters the Union on an equivalent footing with the original states, the federal government transferred equivalent public trust duties to each state at the time of their acceptance into the Union.<sup>29</sup> How each state judiciary has chosen to apply and interpret the public trust doctrine, however, differs based on their own unique precedents.<sup>30</sup>

Broadly, state interpretations vary both in the geographic scope they assign to the public trust and the specific public trust rights that they recognize.<sup>31</sup> Regarding geographic scope, state interpretations of the public trust doctrine can be divided into three categories with respect to boundaries between public and private coastal land:

The first and largest category of states are those states that recognize that private title ends and state title begins at the median high water mark. Second, are those states that recognize private title to the mean low water mark but find a public trust easement over the foreshore. Finally, Texas and New Jersey have recognized that the public trust extends all the way to the first line of vegetation, covering the whole dry sand beach.<sup>32</sup>

Some states have chosen to interpret the public trust doctrine more expansively as a mechanism to protect public rights beyond those granted by the equal footing doctrine, including but not limited to the rights to walk along the beach, to bathe, to swim, to hunt, to skate, and to conduct other primarily recreational activities.<sup>33</sup> In spite of these differences, there are fundamental truths about the public trust doctrine applicable to every state: it at least protects rights to fishing, navigation, and commerce within its bounds, it constitutes a uniquely strong form of property

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<sup>28</sup> Joseph D. Kearney and Thomas W. Merrill, “The Lakefront Steal,” In *Lakefront: Public Trust and Private Rights in Chicago* (Ithaca: Cornell University Press, 2021), 15.

<sup>29</sup> Northwest Ordinance of 1787, ch. 8, art. V, 1 STAT. 50, 53 (1789).

<sup>30</sup> Kenneth K. Kilbert, “The Public Trust Doctrine and the Great Lakes Shoreline,” *Cleveland State Law Review* 58, no. 1 (2010): 24.

<sup>31</sup> Margaret E. Peloso and Margaret R. Caldwell, “Dynamic Property Rights: The Public Trust Doctrine and Takings in a Changing Climate,” *Stanford Environmental Law Journal* 30, no. 1 (2011): 57.

<sup>32</sup> Margaret E. Peloso and Margaret R. Caldwell, “Dynamic Property Rights,” 57.

<sup>33</sup> Henry Rose, “The Public Trust Doctrine,” 93.

title that cannot be given to private ownership except when doing so will serve a greater public purpose, and, even if public trust lands are owned by private properties, it does not allow the state to abdicate its interest in protecting public trust uses on those lands.<sup>34</sup>

Across coastal states, as sea or Great Lake levels rise, the current boundaries between public trust and private ownership such as the high water mark, low water mark, or first line of vegetation will advance landward, massively expanding the amount of land subject to public trust protections in a fashion unlike anything before seen under common law.<sup>35</sup> This inland movement of the public trust will occur without regard for existing property boundaries, as the state's need to protect the public trust is a dominant property interest that supersedes private ownership.<sup>36</sup> However, what implications the advance of the public trust will have for beach access is state-specific and depends both on the differing interpretations of the doctrine highlighted above and on other legal methods through which beach access is protected.

In most states, access to a dry, sandy beach protected through other legal means in addition to the public trust doctrine.<sup>37</sup> A few coastal states such as Texas and California have codified the public right to the beach in statute, while others use customary use doctrines or site-specific easements to provide continued access to the shoreline where it has been historically used for beach recreation purposes.<sup>38</sup> Illinois beaches, being owned and operated by individual parks districts, are protected by the latter. According to the literature, easement-based beach protections are

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<sup>34</sup> *Martin v. Waddell*, 41 U.S. 367, 383 (1842); *Illinois Central R. Co. v. Illinois*, 146 U.S. 387 (1892).

<sup>35</sup> Margaret E. Peloso and Margaret R. Caldwell, "Dynamic Property Rights," 58.

<sup>36</sup> Tim Eichenberg, Sean Bothwell, and Darcy Vaughn, "Climate Change and the Public Trust Doctrine: Using an Ancient Doctrine to Adapt to Rising Sea Levels in San Francisco Bay Pacific Region Edition," *Golden Gate University Environmental Law Journal* 3, no. 2 (2010 2009): 261; Meg Caldwell and Craig Holt Segall, "No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access along the California Coast Symposium: Litigating Takings," *Ecology Law Quarterly* 34, no. 2 (2007): 568.

<sup>37</sup> Margaret E. Peloso and Margaret R. Caldwell, "Dynamic Property Rights," 92.

<sup>38</sup> Margaret E. Peloso and Margaret R. Caldwell, "Dynamic Property Rights," 93-94.

understood to apply to a particular place on a platted map.<sup>39</sup> As sea or Great Lake levels rise and the land set aside for beach under existing easements is inundated, those easements may not migrate landward with the changing coastline. So, scholars argue that while the protections of the public trust will advance as the shore does, there is a distinct possibility that the right to access to a dry, sandy beach will be lost. This fate contrasts with that of beaches in states where access is protected purely by the public trust, as in those cases, the public right of access will attach to the beach regardless of inland movement.<sup>40</sup>

Taken together, existing literature on the public trust doctrine under climate change has grappled with the implications of sea or Great Lake level rise for public trust property boundaries and beach access across coastal states. However, much of the literature focuses on states that abut tidal coasts, where there are often more robust histories of beach access legislation, a greater body of recent public trust precedent regarding coastal development, and a firmer understanding of the impact of climate change on sea level rise.<sup>41</sup> Because the doctrine is interpreted at the state level, meaning that state interpretations vary in both the geographic extent of area protected by the public trust and the specific rights recognized under it, literature on climate change and the public trust from other states can have limited applicability to Illinois-specific precedent.<sup>42</sup>

Scholarship on climate change's impact on the public trust doctrine in Illinois is minimal if not

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<sup>39</sup> Joseph W. Singer, *Property Law: Rules, Policies, and Practices* (Boston: Aspen Publishing, 2006), 207-215.

<sup>40</sup> *Matthews v. Bay Head Improvement Association*, 471 A.2d 355 (N.J. 1984); *State ex rel. Thornton v. Hay*, 462 P.2d 671, 676 (Or. 1969).

<sup>41</sup> See: Carolyn Ginno, "Do Mess with Texas: Why Rolling Easements May Provide a Solution to the Loss of Public Beaches Due to Climate Change-Induced Landward Coastal Migration Comments," *San Diego Journal of Climate & Energy Law* 8 (2017 2016): 225-48; Lara D. Guercio, "Climate Change Adaptation and Coastal Property Rights: A Massachusetts Case Study," *Boston College Environmental Affairs Law Review* 40, no. 2 (2013): 349-401; Sarah Weiss Rozalis, "New Jersey's Legal Duty to Manage Its Coastline in Preparation for the Wrath of Climate Change," *Villanova Environmental Law Journal* 29, no. 2 (2018): 205-28.

<sup>42</sup> Margaret E. Peloso and Margaret R. Caldwell, "Dynamic Property Rights," 109.

non-existent, creating a gap in the research that this paper intends to fill. Below, I discuss current legal understandings of the public trust doctrine in Illinois.

*Beach Access, The Public Trust Doctrine, and Climate Change in Illinois*

To analyze the implications of climate change for the public trust doctrine and beach access in Illinois, it is first necessary to understand how Illinois' public trust precedent differs from that of other states both in terms of geographic scope and rights recognized.

Although Illinois law was the impetus for perhaps the most pivotal public trust case in history in *Illinois Central Railroad Co. v. Illinois*, Illinois courts have not dealt with the question of the geographic boundaries of the public trust doctrine for over a century. In 1911's *Wilton v. Van Hessen*, the Illinois Supreme Court found that the state's responsibility over submerged lands included "the shore or the space between the high and low water marks," including exposed beachfront under the protection of the public trust doctrine.<sup>43</sup> The Illinois Supreme Court later ruled in 1917 that the state's title extends up to the water's edge at the still-water shoreline, or where "the water usually stands when free from disturbing causes," granting the beachfront to private ownership.<sup>44</sup> Local legal scholars such as Henry Rose and Kenneth Kilbert argue that although the state of Illinois has relinquished title to land up to the water's edge to private or municipal ownership, precedent from *Van Hessen* suggests that it maintains a responsibility to protect the public trust interest on the exposed beachfront below the high-water mark regardless of ownership.<sup>45</sup> Such an interpretation would align Illinois with peer Great Lakes states that enforce the public trust on private land, defining the property line and the public trust boundary

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<sup>43</sup> *Wilton v. Van Hessen*, 249 Ill. 182, 94 N.E. 134 (1911).

<sup>44</sup> *Brundage v. Knox*, 279 Ill. 450, 117 N.E. 123 (1917).

<sup>45</sup> Henry Rose, "The Public Trust Doctrine," 93.



as two different things. For example, a majority opinion of the Michigan Supreme Court in 2005's *Glass v. Goeckel* ruled that the state's responsibility to enforce the public trust doctrine extends to the Ordinary High-Water Mark (OHWM), or the point on the shoreline where the presence and action of water has left a distinct mark.<sup>46</sup> Like in Illinois, the coastal property line in Michigan is at Lake Michigan's still-water shoreline, so the court's decision set the precedent that public trust protections can extend to privately owned land between the still-water shoreline and the OHWM. Across the United States, every coastal and Great Lakes state except Ohio and Illinois have explicitly recognized public trust rights up to the ordinary high-water mark.<sup>47</sup> Nevertheless, without a recent, explicit ruling of Illinois courts, the public trust boundary of the state remains undetermined. In practice, the Illinois Department of Natural Resources enforces the public trust and property boundaries at the still-water shoreline, denying traditional public trust rights landward of the property boundary.<sup>48</sup>

As for the rights protected under the public trust doctrine in Illinois, the U.S. Supreme Court first recognized the traditional uses of fishing, navigation, and commerce in its 1892 *Illinois Central Railroad Co. v. Illinois* decision, discussed further in the background section of this paper.<sup>49</sup> Beyond this, a 1976 Illinois Supreme Court decision in *Scott v. Chicago Park District* identified "recreational uses, including bathing, swimming, and other shore activities" as protected public trust rights on the state's Lake Michigan shoreline.<sup>50</sup> The definition of "recreational uses" in the *Scott* decision was left intentionally broad to expand the scope of activities included in the public

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<sup>46</sup> *Glass v. Goeckel*, 262 Mich. App. 29 (2004).

<sup>47</sup> Betsy Marshall, "It's a Shore Thing: Applying the Public Trust Doctrine to Indiana's Great Lake Shores in *Gundersen v. State*," *Ecology Law Quarterly* 47, no. 2 (April 2020): 725.

<sup>48</sup> "State of Illinois Coastal Management Program," Illinois Department of Natural Resources, 55.

<sup>49</sup> *Illinois Central R. Co. v. Illinois*, 146 U.S. 387 (1892).

<sup>50</sup> *People ex rel. Attorney Gen. Scott v. Chicago Park District*, 66 Ill. 2d 65 (1976).

trust doctrine, meaning that there should be no barrier to recognizing the public's right to beach access on public trust land across all 63 miles of Illinois Lake Michigan coastline.<sup>51</sup> Because there has not been a recent, explicit ruling on whether beach access is a specific protected activity, however, there remains enough uncertainty for the state government to not enforce it, leaving landward beach access in the hands of the private and municipal entities that own lake abutting properties.<sup>52</sup>

The lack of a recent ruling on the public trust doctrine in Illinois courts explains why Illinois beach access continues to be defined by a patchwork of parks district-owned recreational facilities as described in the background section of this paper. However, given the extreme likelihood of the public trust doctrine being recognized up to the ordinary high-water mark and of beach access being identified as a protected right on public trust land if a case were to be tried, it is likely that the regulation of beach access in Illinois could be significantly different in the near future than it is today. For the purposes of this paper, beach access will have two distinct definitions: that which is currently provided by municipal governments at designated beaches (the "current beach"), and that which could or should be provided on private property up to the ordinary high-water mark if a court case were to test it (the "possible beach"). These definitions will be incorporated into the subsequent legal analysis. In both cases, however, the delineation between state, local, and private jurisdictions under the public trust doctrine is based on definitions of a "still-water shoreline" or an "ordinary high-water mark" that assume predictable Lake Michigan water levels. In the era of climate change, increasingly extreme fluctuations in

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<sup>51</sup> Kenneth K. Kilbert, "The Public Trust Doctrine and the Great Lakes Shoreline," 50.

<sup>52</sup> Terra Bowling, "Lake Michigan Shoreline Management," *National Sea Grant Law Center and University of Mississippi School of Law*, June 2019: 25.

lake levels threaten to upend this status quo by fundamentally changing what spaces these terms refer to, potentially leading to renewed conflicts over the right to the lakefront.

Perhaps because of the uncertainty surrounding public trust interpretations in Illinois, there has yet to be a study that addresses the implications of climate change-induced lake level fluctuations for the jurisdictional boundaries of the public trust in Illinois and its impact on public beach access. This is the gap that this paper intends to fill. Other studies on climate change on Illinois' Lake Michigan shoreline have had a narrower, non-legal focus, and represent a field of study that is just starting to emerge at the time of writing. For example, coastal hydrologists have studied the impact of lake level rise on coastal habitat loss and sand cover erosion at Illinois beaches, attempting to project findings from the last decade of unprecedented lake level change into the future to estimate long-term climate impacts.<sup>53</sup> A recent report from the Environmental Law and Policy Center of the Midwest highlights the potential risk of pollution release from lakefront toxic risks in the event of lake level rise.<sup>54</sup> And local community organizers have studied and organized around the threat of lake level change to vulnerable lakefront communities, like in South Shore, Chicago.<sup>55</sup> Through a comprehensive legal and spatial study of climate change and beach access in Illinois, this paper seeks to add to the growing body of literature calling for the recognition of climate change's potential to upend status quo institutions.

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<sup>53</sup> Ethan J. Theuerkauf and Katherine N. Braun, "Rapid Water Level Rise Drives Unprecedented Coastal Habitat Loss along the Great Lakes of North America." *Journal of Great Lakes Research* 47, no. 4 (August 1, 2021): 945–54; Margaret K. Scholle, and Suzanne C. Walther. "Responses to Lake Michigan Water Level Rise: Trends in Exposed Sand Cover at North Avenue Beach, Chicago." *Journal of Great Lakes Research* 48, no. 3 (June 2022): 623–32; etc.

<sup>54</sup> Kiana Courtney et al., "Rising Waters: Climate Change Impacts and Toxic Risks to Lake Michigan's Shoreline Communities," *Environmental Law and Policy Center*, June 2022.

<sup>55</sup> Maxwell Evans, "South Side Lakefront Erosion Has Been Ignored For Too Long, Neighbors Say. Now, They're Demanding Answers," *Block Club Chicago*, January 23, 2020; Delta Institute, "South Shore Community Shoreline Resilience Planning," November 2023.

## Scientific Literature Review

### *Climate Change on Lake Michigan*

Far from being a distant future, the effects of climate change have already been made manifest on Lake Michigan water levels in recent years. In 2013, water levels reached a record low monthly average of 576 feet, only to rise by six feet in just seven years to a high of 582.2 feet by 2020.<sup>56</sup> The extreme variability seen in these years reflects predicted trends for Lake Michigan under increasingly likely climate change scenarios. Climate scientists predict that lake levels will be subjected to a “tug-of-war” between competing forces of evaporation and precipitation as affected by rising temperatures and the increasing variability of polar vortex events.<sup>57</sup> In some years, a combination of high temperatures and low ice levels will increase evaporation and lead to low lake levels, while in others, high ice cover and precipitation will drive lake level rise to unprecedented heights. As global temperatures continue to rise, so too will the extremity of variability between highs and lows on Lake Michigan. As depicted in Figure 1 below, for both 1.5-degree and 2-degree Celsius global mean temperature increases, the expected range of values for the lake’s water level increases by a meter, while a 2.5 or 3-degree Celsius increase might lead to an over two-meter increase in range.<sup>58</sup> Even as scientific models become more sophisticated, there remains a high degree of uncertainty over the magnitude and speed of potential lake level changes between years. Planning for climate change on the coast of Lake Michigan will require adaptation to a wider variety of water levels than on tidal coasts where sea levels are only expected to rise.

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<sup>56</sup> “Lake Michigan Lake Levels 1960-2022,” Indiana Department of Natural Resources, Detroit Corps of Engineers, accessed October 21, 2023.

<sup>57</sup> A. D. Gronewold et al., “A Tug-of-War Within the Hydrologic Cycle of a Continental Freshwater Basin,” *Geophysical Research Letters* 48, no. 4 (2021): e2020GL090374.

<sup>58</sup> Frank Seglenieks and André Temgoua, “Future Water Levels of the Great Lakes,” 878.

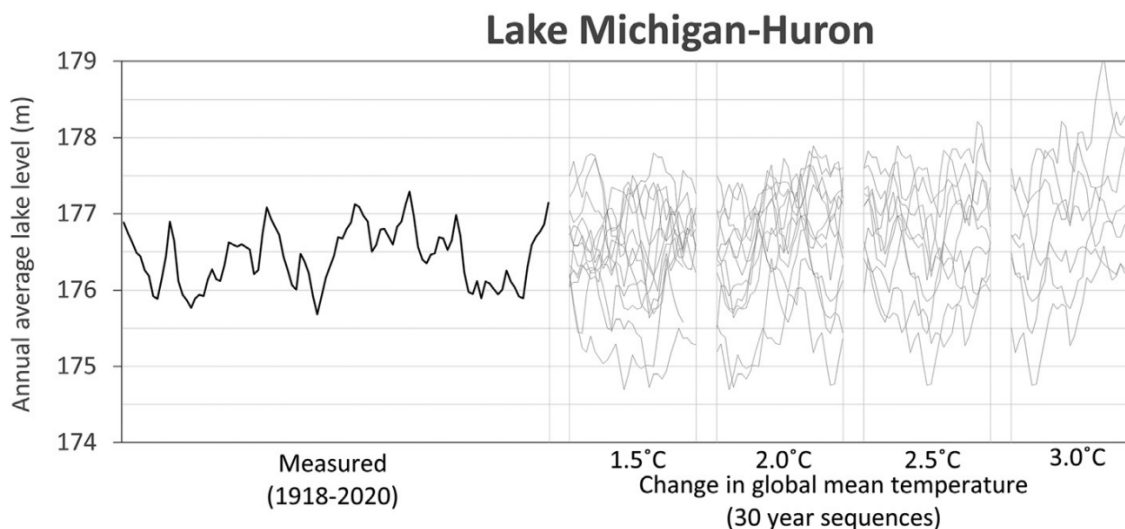


Fig 1. Variability in annual Lake Michigan-Huron water levels, referenced to ILGD85.<sup>59</sup>

### *Climate Change and Beaches*

Of particular concern for beach access is the threat of flooding in periods of high water levels on Lake Michigan. Wave energy increases with higher water levels, compounding the erosional impact of flooding on beaches.<sup>60</sup> In particular, storm events that create periodic wave inundation lead to sand loss that is markedly more extreme than that caused by gradual lake level rise alone.<sup>61</sup> Thus, rapid increases in lake level are a main driver of mass erosional loss of sandy beaches as the shoreline is shifted landward.<sup>62</sup> In areas where beaches do not abut infrastructure or shoreline armoring, the shoreline can recover from erosive high lake level phases during extended low periods as sand accretes naturally; however, since climate change will increase the rapid fluctuation of lake levels, full recovery of these beaches is unlikely.<sup>63</sup> Illinois Beach State

<sup>59</sup> Frank Seglenieks and André Temgoua, “Future Water Levels of the Great Lakes,” 871.

<sup>60</sup> G.A. Meadows et al., “The Relationship between Great Lakes Water Levels, Wave Energies, and Shoreline Damage,” *Bulletin of the American Meteorological Society* 78, no. 4 (April 1, 1997): 675.

<sup>61</sup> Margaret K. Scholle and Suzanne C. Walther, “Responses to Lake Michigan Water Level Rise,” 623.

<sup>62</sup> Ethan J. Theuerkauf and Katherine N. Braun, “Rapid Water Level Rise, 945.”

<sup>63</sup> Ethan J. Theuerkauf et al., “Improving Coastal Resilience Planning with Respect to Long-Term Water Level Fluctuations by Examining Decadal Coastal Profile Behavior at Sandy, Harbor Filet Beaches along Lake Michigan in the Great Lakes of North America.” *Shore & Beach* 90, no. 3 (Summer 2022): 36.

Park is the only beach in the state not abutting some form of armored shoreline, such as the concrete revetments and protected harbors found lining much of Chicago's Lake Michigan lakefront.<sup>64</sup> These types of shoreline protection are effective at protecting near-water infrastructure, but also block natural movements of sediment that would replenish neighboring beaches.<sup>65</sup> Thus, in a climate future of periodic flooding from high-water levels, the vast majority of Illinois beaches will experience extreme erosion that they are unable to naturally recover from even in low water level periods, leading to a net decrease in sand cover over time and the potential erasure of entire beaches.<sup>66</sup> Despite the existential threat that climate change poses to Illinois beaches, however, there is little current understanding of the spatial extent of beach loss that it may cause.

### *Conclusion*

Taken together, therefore, Illinois beach access is threatened by the scientific reality of climate-change-induced lake level fluctuations, which will erode sandy beaches over time and limit the potential for public access to the lakefront. The fluctuating water levels will also continually redefine spatial boundaries between state, municipal, and private jurisdictions over the lakefront, creating uncertainty over the legal responsibility for the protection and restoration of public beach access. This paper seeks to fill in gaps within the scientific and legal literature to achieve a more comprehensive understanding of the implications of climate change on beach access.

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<sup>64</sup> Michael J. Chrzastowski, "History of the Uniquely Designed Groins Along the Chicago Lakeshore," 19.

<sup>65</sup> Margaret K. Scholle and Suzanne C. Walther, "Responses to Lake Michigan Water Level Rise," 625.

<sup>66</sup> Ethan J. Theuerkauf et al., "Improving Coastal Resilience Planning," 42.

## Data and Methodology

This paper employs a mixed-methods approach. The physical possibility of accessing a beach is a spatial problem: at high lake levels, the beach disappears under waves of inundation, making access impossible. The paper first spatially represents and quantifies the extent of beach inundation under two potential climate change scenarios to estimate the impact of climate change on Illinois beaches. Access is not only a question of space, but also of legal possibility: the existence of a beach does not necessarily guarantee its use by all. The paper subsequently applies the findings of the spatial analysis to understand how beach access will change under the existing legal and regulatory framework for coastal protection in Illinois. Thus, I use two distinct but intertwined methodologies, one spatial and the other legal.

### *Spatial Analysis of Beach Inundation - Baseline*

To spatially represent the impact of changing lake levels on the beach, a historical baseline must first be defined. Traditionally, the measurements of the 1985 International Great Lakes Datum are used as reference for establishing benchmark water level elevations across the Great Lakes watershed.<sup>67</sup> The 1985 Datum (hereafter referred to as IGLD85) defines a standardized Ordinary High-Water Mark of 581.5 feet measured at Calumet Harbor, Chicago, IL that sets the boundaries between private and state/federal jurisdictions under the public trust doctrine<sup>68</sup> (and as covered in the literature review, while Illinois' current responsibility over beach access ends at the water's edge, a legal challenge would extend it to the OHWM). It should be noted that international data are meant to be revised every 25 to 35 years, meaning that IGLD85 has long

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<sup>67</sup> "Brochure on the International Great Lakes Datum 1985," Coordinating Committee on Great Lakes Basic Hydraulic and Hydrological Data, January 1992. <https://www.ijc.org/sites/default/files/C53.pdf>.

<sup>68</sup> "Guidelines for the Submittal of Applications for Illinois Department of Natural Resources, Office of Water Resources Permits for Shore Protection Projects in Lake Michigan." Office of Water Resources, Illinois Department of Natural Resources, November 2015.

since expired and may be less applicable to modern lake conditions.<sup>69</sup> IGLD85 also represents a snapshot in time that fails to account for the natural fluctuations in lake levels between seasons and years. For this reason, most scientific studies of Lake Michigan water levels choose baselines that are either averages calculated over several years of lake level measurements or full representations of lake level change over a delimited period.<sup>70</sup> Nevertheless, since the baseline set by IGLD85 is still used for policymaking in Illinois, which is most relevant for the legal aims of my analysis, it is employed in this paper.

To spatially represent the physical extent of beaches under baseline conditions, I trace all sandy beaches on the state's Lake Michigan coast using satellite imagery from the most recent occasion when the lake's ordinary high-water mark was measured at 581.5 feet, April of 2021.<sup>71</sup> This imagery is publicly available in ESRI's Wayback Living Atlas, which is integrated into the ArcGIS software I use for this analysis. There are several drawbacks to this baseline. Choosing to capture the beach in any specified period will always be a generalization, as beach extent is an ever-evolving phenomena affected by season, current, littoral sand drift, water level, human interference, the surrounding built environment, and more.<sup>72</sup> The spring of 2021 followed an anomalously erosive 2020 season that saw beaches shrink significantly from a combination of high water levels and strong storm surges, meaning that data from 2021 may not be a "normal"

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<sup>69</sup> "International Great Lakes Datum of 1985." National Geodetic Survey, National Oceanic and Atmospheric Administration, 2023.

<sup>70</sup> Miraj B. Kayastha, Xinyu Ye, Chenfu Huang, and Pengfei Xue. "Future Rise of the Great Lakes Water Levels under Climate Change." *Journal of Hydrology* 612 (September 10, 2022).; Frank Seglenieks and André Temgoua, "Future Water Levels of the Great Lakes under 1.5 °C to 3 °C Warmer Climates," *Journal of Great Lakes Research* 48, no. 4 (August 1, 2022): 867.

<sup>71</sup> "Verified Monthly Means at Calumet Harbor, IL." Water Levels, Tides and Currents, National Oceanic and Atmospheric Administration. Last updated October 31, 2023.

<sup>72</sup> Margaret K. Scholle and Suzanne C. Walther, "Responses to Lake Michigan Water Level Rise: Trends in Exposed Sand Cover at North Avenue Beach, Chicago," *Journal of Great Lakes Research* 48, no. 3 (June 2022): 625.



representation of beach extent under the expectations of IGLD85.<sup>73</sup> Yet, a 2021 baseline is relevant to modern and future beach trends, and most importantly allows for effective comparison between the standardized water conditions defined by IGLD85 and climate futures.

### *Spatial Analysis of Beach Inundation - Analysis*

To represent the effects of climate change on the spatial dimension of beach access, I create two distinct models. The first (hereinafter the “7.5-foot model” or the “ELPC model”) spatially represents a potential “worst-case scenario” of 7.5 feet of lake level change from the datum baseline to estimate beach inundation and erosion under extreme floodings events. Measuring worst-case scenarios is valuable because beach erosion accelerates during major storm events that cause periodic inundation of landward sand deposits, leaving lasting effects on beaches even during calmer conditions.<sup>74</sup> The second model (hereinafter the “2.5-foot model” or the “Kayastha model”) takes a more conservative approach, describing a projected future high-water period of 2.5 feet of lake level change from the datum baseline. The longer-term focus of annual average water level datasets provides a more robust understanding of how the Ordinary High-Water Mark might shift landward during high water periods. Since the OHWM is used to delineate legal jurisdictions, this understanding directly fuels the subsequent legal analysis.

I create these models using the enhanced bathtub method, a GIS tool developed by coastal geomorphologists that incorporates beach slope, surface roughness, and hydrological connectivity in its representations of coastal flooding. The tool is publicly available from the ArcCoast Tools plugin for ArcGIS 10.3.2. All the data inputs employed by the tool to create the model are similarly publicly available. The tool requires four main inputs: a spatial

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<sup>73</sup> Ethan J. Theuerkauf and Katherine N. Braun, “Rapid Water Level Rise Drives Unprecedented Coastal Habitat Loss along the Great Lakes of North America,” *Journal of Great Lakes Research* 47, no. 4 (August 1, 2021): 945.

<sup>74</sup> Ethan J. Theuerkauf and Katherine N. Braun, “Rapid Water Level Rise,” 948.

representation of the coastline under “current” conditions, a digital elevation model (DEM) representing the slope of the beach, a surface roughness coefficient indicating the “roughness” of the beach (i.e. presence of rocks and/or built objects) as defined by FEMA, and the estimated inundation water level under the scenarios I have outlined above.<sup>75</sup> The first two of these inputs are derived from LIDAR Digital Terrain Model (DTM) created using high resolution topographic information commonly available in NASA or NOAA datasets, while the surface roughness coefficient is provided by FEMA.<sup>76</sup> These factors are included to more accurately represent the study sites and the potential effects of coastal flooding on them. For example, a rough, gradual slope tends to result in reduced inland inundation, whereas a steep and smooth slope has the opposite effect.<sup>77</sup> Similarly, geomorphological differences in coastal lands can have a significant impact on inundation: coves and enclosed spaces tend to increase wave height, which leads to more flooding.<sup>78</sup> Due to this level of specificity, the enhanced bathtub model is robustly defined; for more information on how the enhanced bathtub model is calculated, please read Lauren Lyn Williams and Melanie Lück-Vogel’s 2020 paper on its development and use.<sup>79</sup> It must be noted that a key limitation of the enhanced bathtub model for my analysis is that it displays the effects of inundation, not erosion. Because erosion often occurs without the full inundation of beach spaces, it is likely that the results of the bathtub model may underestimate total beach loss under future climate change scenarios.

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<sup>75</sup> Lauren Lyn Williams and Melanie Lück-Vogel, “Comparative Assessment of the GIS Based Bathtub Model,” 8.

<sup>76</sup> Lauren Lyn Williams and Melanie Lück-Vogel, “Comparative Assessment of the GIS Based Bathtub Model,” 7.

<sup>77</sup> K Hejazi, G AmirReza, A Abolfazl. Numerical Modeling of Breaking Solitary Wave Run Up In Surf Zone Using Incompressible Smoothed Particle Hydrodynamics (Isph). Proceedings of 35th Conference on Coastal Engineering, Antalya, Turkey, 2016.

<sup>78</sup> Xingong Li, C. J. Grady, and A. Townsend Peterson. “Delineating Sea Level Rise Inundation Using a Graph Traversal Algorithm,” *Marine Geodesy* 37, no. 2 (April 3, 2014): 267–81.

<sup>79</sup> Lauren Lyn Williams and Melanie Lück-Vogel, “Comparative Assessment of the GIS Based Bathtub Model.”

The 7.5-foot model borrows heavily from the Environmental Law and Policy Center's 2022 "Rising Waters" report, which measured the impact of increased lake levels on sources of industrial pollution. In that report, ELPC studied linear projections of peak water levels up to the year 2040 based on trends measured between 2000 and 2021. They found that peak water levels of up to 7.5 feet above the datum baseline lie within a 95% confidence interval by 2040. This interval was spatially represented in increments of half a meter to demonstrate progressively extreme risks to sites of industrial pollution. ELPC cautions that their spatial models "should be considered as risks during extreme storms occurring during high water periods."<sup>80</sup> Their focus on extreme flooding events is attractive, as storm events that create periodic inundation are a major cause of beach erosion.<sup>81</sup> My spatial analysis recreates ELPC's climate predictions in an enhanced bathtub model and layers them on the sandy beaches I have traced to visualize the extent of inundation during extreme weather events, transforming ELPC's research into a novel representation of beach access beyond their original focus on industrial pollution.

For the 2.5-foot spatial model, I translate Kayastha et al.'s projections of future peak water levels on Lake Michigan into another enhanced bathtub model to represent changes to the ordinary high-water mark. In their 2022 paper, Kayastha et al. implemented a robust three-dimensional regional climate modeling system to track changes to the net basin supply of the Great Lakes over time, which is broadly defined as the sum of over-lake precipitation and basin runoff minus lake evaporation. They found that peak water levels are projected to increase by up to 0.8 meters (or around 2.5 feet) by 2040, which is the upper limit of a range of values that includes severe

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<sup>80</sup> Kiana Courtney et al., "Rising Waters: Climate Change Impacts and Toxic Risks to Lake Michigan's Shoreline Communities," *Environmental Law and Policy Center*, June 2022: 30.

<sup>81</sup> Ethan J. Theuerkauf and Katherine N. Braun. "Rapid Water Level Rise," 950.

fluctuations.<sup>82</sup> The unique robustness of their climate modeling relative to the broader body of scientific literature increases the credibility of Kayastha et al.'s projections for understanding the future of the high-water mark. Their projected date range is also attractive to this study, as 2040 lines up with the chosen interval for the first part of the analysis. To spatially represent this, I create another enhanced bathtub model that depicts water levels of 584 feet above sea level rise, an approximate 0.8-meter (or 2.5 foot) increase from the baseline of 581.5 feet. I then layer this model on to beach tracings as in the first part of the analysis to show the location of the new potential high-water mark on existing beachfront land.

#### *Spatial Analysis of Beach Inundation – Case Studies*

Following the construction of the two models and the creation of initial summary statistics to represent their impacts state-wide, I employ three case studies to map the inundation effects predicted by the models on to local spaces. The case studies focus on beaches in the South Shore neighborhood of Chicago, the municipality of Kenilworth, and the Illinois Beach State Park in Beach Park and Zion. Each of these locations are situated within vastly different hydrologic and geomorphological contexts, so the intent of the case studies is to better understand how lake level change can have heterogeneous effects on the spatial extent of beach inundation. Each case study also frames the subsequent legal analysis.

#### *Legal Analysis of Beach Access Protections*

After conducting spatial analysis of the extent of flooding on beaches, the paper turns to a legal analysis of the implications of lake level change for existing protections for public beach access in Illinois. This analysis will synthesize two buckets of primary source material: case law

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<sup>82</sup> Miraj B. Kayastha, Xinyu Ye, Chenfu Huang, and Pengfei Xue. "Future Rise of the Great Lakes," 869.

establishing precedent related to the public trust doctrine in Illinois, and current municipal, state, and federal legal codes that delineate jurisdiction over the beach.

The case law analysis will analyze how the state's interpretation of the public trust doctrine might be affected by changing lake levels. A careful examination of the public trust doctrine is vital to the project's aims. The doctrine delineates the boundary between state authority over public waterways and the landward edge of private or municipal ownership, based on the flawed assumption that lake levels will not significantly change. Given that jurisdiction is extremely relevant to determining responsibility for protecting beach access, it is necessary to understand who might control the beaches if climate change causes an upheaval of the public trust. Without a clearer ruling on the extent of Illinois' current public trust boundary or its implications for beach access, however, the implications of the public trust may simply be ignored in Illinois' response to climate change on Lake Michigan.

This understanding is further refined through analyses of specific municipal and state legal protections for beach access relevant to the three case study locations included in the spatial analysis: South Shore Chicago, Kenilworth, and Illinois Beach State Park. As covered in the background section, beach access in Illinois is currently defined by jurisdictional fragmentation due to Illinois' unclear interpretation of the public trust doctrine. Thus, on a practical level, it is necessary to understand how local actors will respond to the threat of climate change to beach access within their jurisdictions. The three case study locations are the ideal settings for such an analysis, because they represent three very different legal contexts and ideological underpinnings: Chicago is a major city that prides itself on its lakefront access, Kenilworth is a small municipality in which most beaches are owned by private homeowners, and Illinois Beach State Park is the only area on the coastline directly administered by the state Department of

Natural Resources. Through a comprehensive analysis of the legal codes passed by each level of government involved in regulating beaches within each of these locations, this analysis not only reveals the complicated nature of legislating the lakefront but also examines how the current careful balance between jurisdictional powers might be upset by the increasingly extreme lake level fluctuations caused by climate change. Thus, these analyses of the public trust doctrine and the case study locations are combined into a coherent narrative about Lake Michigan legal protections and the potential for their disruption in the scenarios set out by the spatial analysis.

### **Results and Data Analysis - Introduction**

The effects of global climate change pose a serious threat to Lake Michigan beaches in Illinois. The purpose of this paper is to use spatial and legal methods to describe the scope and implications of that threat to argue for its proper consideration in future coastal planning.

This results section first presents the findings of two spatial climate projections used to describe the impact of lake level change on the inundation of Illinois beaches. These findings take the form of summary statistics calculated at a statewide level, by individual municipality, and through three local-level case studies. The spatial analysis finds that while the severity of inundation varies significantly by locality, almost sixty percent of all beach spaces across the state will be inundated by 2040 under the most extreme climate scenario presented here.

Furthermore, the three case studies demonstrate that climate-induced beach loss directly affects a vast array of lakefront stakeholders with diverse needs, from the loss of the private beaches of the wealthy homeowners of Kenilworth to the erasure of highly cherished public access in the densely populated South Shore neighborhood or at the state's last remaining "natural" beach at Illinois Beach State Park.

The second portion of the results section builds on the results of the spatial analysis to explore the legal implications of lake level inundation for the existing frameworks that protect beach access today. It approaches the problem through a statewide interpretation of the public trust doctrine and coastal management policies, in which analysis is divided into two sections: one on the effects of lake level change on public beach spaces, and another on private beach spaces. It then attempts to understand the local effects of lake level change by analyzing the municipal beach protections applicable to the same three case studies presented in the spatial section. The variety of scopes through which both types of findings are presented hopes to spur recognition of the problem on a hyper-local, municipal, and statewide level. This section finds that the landward movement of the public trust boundary under climate change will have greater effects on jurisdictional confusion over beach access in private than public beach spaces. Nonetheless, in both cases, existing state and municipal policy will play the greatest role in deciding the fate of beach access in the short term. Since these bodies of law lack intentional, explicit protections for beach access that promise its maintenance in the event of significant beach inundation, it is possible and even likely that beaches projected to be lost under the predictions of the spatial model will indeed vanish without significant policy change.

## **Spatial Results and Data Analysis**

### *Introduction*

Below, I present the results of the two spatial models implemented in this study. The first section describes basic takeaways about the current state of beaches in Illinois, while the second and third sections summarize the results of the two models presented in the methodology section: one based on a scenario of 7.5 feet of lake level change, and another based on a scenario of 2.5 feet of lake level change. Finally, the remaining sections introduce case studies on South Shore

Chicago, Kenilworth, and Illinois Beach State Park to delve more deeply into the local effects of the beach inundation projected by the two models.

### *Beach Spaces in Illinois*

Based on my analysis of satellite imagery taken in 2021, there are 1,413,935 square feet (or 32.46 acres) of sandy beach in Illinois. Chicago is home to a plurality of these beach spaces, with its 493,788.19 square feet comprising approximately 34.92% of all beaches in the state. The other approximately 920,146.81 square feet of beach (or 65.08% of the total) on the coastline is divided between thirteen other municipalities, with the second-largest total share of beach falling within the borders of Beach Park, IL as part of Illinois Beach State Park.

Ownership of and access to beaches differs significantly by municipality. Chicago, for example, has only one privately owned beach, a small inlet in the South Shore neighborhood. Its other 493,630.20 square feet of beach space (or 99.97% of the city's total) are city-owned and publicly accessible. By contrast, municipalities further up the coastline, particularly in the wealthy North Shore area, tend to have greater shares of privately owned than publicly owned beaches.

Winnetka is the most extreme example of this, with approximately 73.03% of its beaches being privately-owned and, in practice, reserved for private owners' exclusive use. It should be noted that while private ownership almost exclusively implies private access, public ownership does not necessarily imply public access. For example, in North Chicago, 24,707.06 square feet of beach (or 81.38% of the city's total) is owned by the military as part of the Naval Station Great Lakes complex and is reserved for the exclusive use of military personnel. A full table delineating beach area and ownership by municipality can be found below in Table 1.



City	Square Feet of Beach (Total)	Square Feet of Beach (Public)	Square Feet of Beach (Private)	% Private Beach
Chicago	493,788.19	493,630.20	1,577.99	<b>0.32%</b>
Evanston	58,047.97	50,936.42	7,111.56	<b>12.25%</b>
Wilmette	68,219.06	52,113.92	16,105.14	<b>23.61%</b>
Kenilworth	5,638.04	2405.02	3,233.02	<b>57.35%</b>
Winnetka	66,928.58	17,125.59	48,879.72	<b>73.03%</b>
Glencoe	32,630.49	10,210.08	22,420.41	<b>68.71%</b>
Highland Park	112,485.97	43,943.34	68,542.62	<b>60.93%</b>
Lake Forest	97,563.62	43,355.48	54,208.14	<b>55.56%</b>
Lake Bluff	26,843.07	10,611.70	16,231.36	<b>60.46%</b>
North Chicago	30,360.45	30,360.45	0.00	<b>0.00%</b>
Waukegan	79,659.61	79,659.61	0.00	<b>0.00%</b>
Beach Park	161,757.15	161,757.15	0.00	<b>0.00%</b>
Zion	160,793.08	142,094.33	18,698.75	<b>11.63%</b>
Winthrop Harbor	19,219.90	19,219.90	0.00	<b>0.00%</b>

*Table 1 – Beach area and ownership by Illinois municipality.*

### *Inundation Findings – 7.5-foot Model*

The first part of the spatial analysis of beach inundation estimates a climate change scenario in which lake levels rise to 589 feet above sea level, a 7.5-foot increase above the standard of 581.5 feet used to represent the “normal” Ordinary High-Water Mark (OHWM) under the 1985 International Great Lakes Datum. As noted in the methodology section, this scenario is meant to represent the impacts of extreme flooding on beaches during major storm events. It is not meant to be a representation of a stable, long-term OHWM, and is thus less relevant for analyses of public trust boundaries. Two representative outputs of this model from beaches in Highland Park and Evanston can be found in *Appendix I: Representative Outputs of the 7.5-foot Model*.

If lake levels rise to 589 feet above sea level, across the Illinois coastline 823,472.40 square feet of beaches (or 58.24%) will be fully inundated. The effects of such inundation are not evenly

distributed. North Shore beaches will be hit particularly hard, with beaches in the cities of Evanston, Wilmette, and Kenilworth facing inundation of 75% or more. By contrast, further up the coast, Waukegan and Winthrop Harbor beaches will face inundation below 45%, well below the state average. In Chicago, beach inundation will reach 52.87%. A full table delineating beach inundation by municipality can be found below in Table 2.

<b>City</b>	<b>Square Feet of Beach (Public and Private)</b>	<b>Estimated Square Feet of Beach Inundation - 589 ft</b>	<b>Estimated % of Beach Inundated - 589 ft</b>
Chicago	493,788.19	261,050.77	<b>52.87%</b>
Evanston	58,047.97	43,577.65	<b>75.07%</b>
Wilmette	68,219.06	51,542.59	<b>75.56%</b>
Kenilworth	5,638.04	4,640.13	<b>82.30%</b>
Winnetka	66,928.58	40,681.22	<b>60.78%</b>
Glencoe	32,630.49	23,594.92	<b>72.31%</b>
Highland Park	112,485.97	75197.36	<b>66.85%</b>
Lake Forest	97,563.62	56016.35	<b>57.42%</b>
Lake Bluff	26,843.07	13484.26	<b>50.23%</b>
North Chicago	30,360.45	24203.92	<b>79.72%</b>
Waukegan	79,659.61	30,395.38	<b>38.16%</b>
Beach Park (IBSP)	161,757.15	76,918.65	<b>47.55%</b>
Zion (IBSP)	160,793.08	113,686.09	<b>70.70%</b>
Winthrop Harbor	19,219.90	8,577.57	<b>44.63%</b>

*Table 2 – Beach inundation under the 7.5-foot model by Illinois municipality.*

The differences in beach inundation between municipalities can be partially explained by the variations in beach geomorphology, slope, and roughness incorporated into the enhanced bathtub model to maximize the accuracy of its hydrological representations. The results of this analysis, however, should not be treated as a substitute for local, on-the-ground hydrological study. A key flaw of this method of spatial modeling is that it can only represent inundation, not long-term beach erosion that often occurs without full inundation of beach spaces.

### *Inundation Findings – 2.5-foot Model*

The second part of the spatial analysis of beach inundation is based on a more conservative climate change scenario in which lake levels rise to 584 feet above sea level, 2.5 feet above the 581.5-foot datum. This scenario, based on Kayastha et al.'s prediction of up to 0.8 meters of lake level change by 2040, is intended to represent a realistic long-term Ordinary High-Water Mark relevant for the public trust doctrine. Two representative outputs of this model from beaches in Glencoe and Evanston can be found in *Appendix II: Representative Outputs of the 2.5-foot Model*.

Under this scenario, across the Illinois coastline 207,702.95 square feet of beaches (or 14.69%) will be fully inundated. As in the previous model, the effects of inundation are not evenly distributed across coastal municipalities. In contrast to the previous model, however, which municipalities will be hardest hit under this scenario changes significantly. North Chicago and neighboring Waukegan will experience the greatest beach inundation, with 39.14% and 24.58% of their beaches, respectively, being inundated by 2.5 feet of lake level change. By contrast, those North Shore communities like Evanston, Wilmette, and Kenilworth that will experience the greatest amount of inundation under 7.5 feet of lake level change have beach inundation statistics around the average for the 2.5-foot model. The diverging results of the two models reveals the need for all municipalities to plan for multiple scenarios of climate change-induced lake level rise. A full table delineating beach inundation by municipality can be found in Table 3.

City	Square Feet of Beach (Public and Private)	Estimated Square Feet of Beach Inundation - <b>584 ft</b>	Estimated % of Beach Inundated - <b>584 ft</b>
Chicago	493,788.19	66,795.74	<b>13.53%</b>
Evanston	58,047.97	8,665.06	<b>14.92%</b>
Wilmette	68,219.06	11,494.26	<b>16.85%</b>
Kenilworth	5,638.04	1,194.92	<b>21.19%</b>
Winnetka	66,928.58	9,545.33	<b>14.26%</b>
Glencoe	32,630.49	2,731.39	<b>8.37%</b>
Highland Park	112,485.97	20,020.59	<b>17.80%</b>
Lake Forest	97,563.62	13,685.18	<b>14.03%</b>
Lake Bluff	26,843.07	3,650.51	<b>13.60%</b>
North Chicago	30,360.45	11,884.12	<b>39.14%</b>
Waukegan	79,659.61	19,579.91	<b>24.58%</b>
Beach Park (IBSP)	161,757.15	25,346.55	<b>15.67%</b>
Zion (IBSP)	160,793.08	12,682.01	<b>7.89%</b>
Winthrop Harbor	19,219.90	506.4	<b>2.63%</b>

*Table 3 – Beach inundation under the 2.5-foot model by Illinois municipality.*

## Spatial Case Studies

### *Spatial Case Study One: South Shore, Chicago, IL*

South Shore is a densely populated lakefront neighborhood on the South Side of Chicago. It is one of the only neighborhoods in the city of Chicago where private property directly meets Lake Michigan. Due to extensive erosion in the area, only one privately-owned beach remains.

Beyond that, beach access in the neighborhood is provided by two major parks: Rainbow Beach and the South Shore Cultural Center. In both parks, Black residents fought for decades for access to their formerly segregated beaches, making them important heritage areas to preserve and

maintain beach access from the threat of climate change.<sup>83</sup> Combined, the public and private beaches comprise 53,311.02 square feet. Under the first climate scenario, in which 7.5 feet of lake level change occurs, South Shore will experience inundation of 91.73% of its beaches; under the second climate scenario, in which 2.5 feet of lake level change occurs, 24.15% of its beaches would be inundated. In *Appendix III: South Shore, Chicago, IL Case Study Models* are two maps of both climate models imposed on South Shore beaches.

#### *Spatial Case Study Two: Kenilworth, IL*

Kenilworth has the smallest coastline and least amount of total square feet of beach of any municipality in the state of Illinois. It owns just two public beaches, Mahoney Park and Kenilworth Beach, which combined comprise 2,405.02 square feet of its total 5,538.04. While Mahoney Park's beach is owned by the city, it is not publicly accessible for beach recreation.<sup>84</sup> The remainder of its beaches are owned and maintained exclusively by private single-family homeowners. Under the first climate scenario, in which 7.5 feet of lake level change would occur, Kenilworth will experience inundation of 82.30% of its beaches; under the second scenario, 21.19% of its beaches will be inundated. In *Appendix IV: Kenilworth, IL Case Study Model* is a single composite map of the two models superimposed on Kenilworth's beaches.

#### *Spatial Case Study Three: Illinois Beach State Park, IL*

Illinois Beach State Park is the only "natural" beach in the state of Illinois, and the only site directly administered by the state government's Department of Natural Resources.<sup>85</sup> Both of these factors make it a uniquely interesting study site for understanding the impacts of changing

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<sup>83</sup> Chicago Park District, "Rainbow Beach," accessed February 13, 2024; Chicago Park District, "South Shore Cultural Center Park," accessed February 13, 2024.

<sup>84</sup> Village of Kenilworth, IL Code of Ordinances, § 95.01.

<sup>85</sup> "About Adeline Jay Geo-Karis Illinois Beach State Park," Illinois Department of Natural Resources, 2023.

lake levels on beach spaces; indeed, it is one of the only sites in the state where beach erosion trends have been thoroughly documented in coastal literature. It is also one of the most visited state parks in Illinois, making it a key site for Illinoisans from across the state to enjoy beach access. Between its North and South units, Illinois Beach State Park comprises 303,851.48 square feet of publicly accessible beach space (while the entire park is technically a “beach”, I here refer to the sandy expanse below the first line of vegetation as defined in the background section). Under the 7.5-foot model, the park will experience 59.13% beach inundation; under the second, 11.78% inundation. In *Appendix V: Illinois Beach State Park Case Study Model* are three maps demonstrating the impact of the two models on key parts of the park.

### *Spatial Conclusion*

In the methodology section of this paper, I wrote that the purpose of this spatial analysis was to represent and quantify the extent of beach inundation to estimate the impact of climate change on Illinois beaches. This model accomplishes that goal. It presents two summary statistics: 58.24% beach inundation statewide under the 7.5-foot model, and 14.69% inundation under the 2.5-foot model. It also lends itself to more refined analysis at a smaller scale through the three case studies. Future research can use these models as a tool to understand municipal or hyperlocal effects to inform coastal planning efforts in areas of interest. However, critical questions remain. This model represents inundation rather than erosion, so the erosive effects of these two scenarios on sandy beach spaces remains unknown. As previous research demonstrates that sand loss occurs more rapidly from periodic high-energy waves than from inundation, it is likely that significantly more beach space will be lost than what is shown in these models.<sup>86</sup> Also unknown are the effects of inundation duration on beach loss. As mentioned in the literature review, I

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<sup>86</sup> Margaret K. Scholle and Suzanne C. Walther, “Responses to Lake Michigan Water Level Rise,” 623.

chose to map the most extreme of high lake levels because the destructive impact of high lake levels on beaches will remain even when lake levels sink once more.<sup>87</sup> But how long lake levels need to remain at such heights to leave long-lasting impacts on beach spaces is not currently understood. Future research should reinterpret the results of this study through a coastal geomorphological perspective to create a more scientific understanding of the impact of climate change on all beach spaces across the state.

## **Legal Results and Data Analysis**

### *Introduction*

Below, I present the results of the legal analysis of this study. The first three sections build on the description of the public trust doctrine in Illinois presented in the literature review to highlight the potential implications of climate change for public and private beach spaces. The last three sections use the three case studies to understand how local responses to climate change may differ across municipalities based on their various legal approaches to protecting beach access. The analysis finds that response to beach inundation under existing legal frameworks will differ significantly between public and private spaces and across locales, presenting the need for a comprehensive statewide plan for responding to climate change.

### *Illinois' Public Trust Doctrine, Beaches, and Climate Change*

The spatial analysis section of this paper demonstrates that by 2040, Illinois coastal spaces may be significantly inundated as Lake Michigan water levels rise to heights unprecedented in the current era. With such a rise, the state responsibility to protect the public trust will migrate landward as the still-water shoreline and the ordinary high-water mark do, with potentially

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<sup>87</sup> Ethan J. Theuerkauf et al., "Improving Coastal Resilience Planning," 36.

striking but extremely complex, undetermined implications for beaches. Adding to this complexity is, as discussed in the literature review, the state's current practice of limiting the public trust's jurisdiction over access to private beaches in contrast to the likelihood that public trust responsibility would be extended to all beaches regardless of ownership with an updated ruling. This section attempts to grapple with the complexity of climate change's impact on beach access under the public trust doctrine by sorting analysis into two types of beach spaces: beaches that are currently publicly accessible (the "current beach"), and beaches that are today controlled by private owners but which could or should be publicly accessible to the ordinary high-water mark if a court case were to test it (the "possible beach"). It should be noted that the following analyses are based on my best possible interpretation of existing case law, and the findings presented are not a substitute for a lawsuit that would test these theories in court.

#### *The Public Trust Doctrine and Climate Change on "Current Beach" Spaces*

In "current beach" spaces, where beaches are currently publicly accessible and front public land that is also publicly accessible, the landward movement of the public trust boundary will likely not result in a legal crisis under Illinois' current or potential future interpretations of the public trust doctrine. The state's interest in protecting the public trust right to the coastline is a dominant form of property interest that supersedes both private and municipal ownership, so as the public trust boundary moves landward over municipal beaches, the state public trust jurisdiction will overlap with and supersede municipal property.<sup>88</sup> In practice, such a change should have little effect on beach access because municipal parks and the state's public trust directive share the

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<sup>88</sup> Tim Eichenberg, Sean Bothwell, and Darcy Vaughn, "Climate Change and the Public Trust Doctrine: Using an Ancient Doctrine to Adapt to Rising Sea Levels in San Francisco Bay Pacific Region Edition," *Golden Gate University Environmental Law Journal* 3, no. 2 (2010 2009): 261; Meg Caldwell and Craig Holt Segall, "No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access along the California Coast Symposium: Litigating Takings," *Ecology Law Quarterly* 34, no. 2 (2007): 568.



same goal: protecting public access to the shoreline. Since municipalities and the state Department of Natural Resources already work closely to prevent erosion and protect shoreline access in publicly owned spaces, Illinois would not be abdicating its public trust doctrine in allowing municipal parks to continue to exercise primary control over such spaces.<sup>89</sup> In fact, since the passage of the Shore Lands for Park Use Act, municipal parks districts have acted as the effective implementor of the state public trust doctrine over submerged lands bordering municipal parks.<sup>90</sup> That said, in many Illinois municipalities, who has access to the beach is managed through user fees, parking restrictions, or municipal residency requirements, and such management has inequitable effects on low-income and minority populations.<sup>91</sup> If the state were to have dominant jurisdiction over municipally-owned beach spaces, it could use this position to mandate more inclusive policies as the public trust doctrine aims to provide universal access.

The lack of a serious legal crisis regarding access to municipally owned beachfront spaces in a potential climate future does not preclude those spaces from becoming inaccessible, however. The spatial analysis section of this paper demonstrates that almost sixty percent of beach spaces statewide may be inundated, including individual municipal beaches that will be almost fully inundated such as Evanston's Clark Street Beach (see *Appendix I: Representative Outputs of the 7.5-foot Model*). Since Illinois lacks comprehensive statewide legal protections for beach access, municipally owned beaches are the product of site-specific easements.<sup>92</sup> As Great Lake levels rise and the land set aside for beaches under existing easements is inundated, those easements will not migrate landward with the changing coastline. And while Illinois' current interpretation

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<sup>89</sup> Lake Michigan Shore Line Act. 615 ILCS 55.

<sup>90</sup> Shore Lands for Park Use Act. 615 ILCS 105.

<sup>91</sup> Samuel Kling and Lucas Stephens, "The Right to the Shoreline: Race, Exclusion, and Public Beaches in Metropolitan Chicago," *The Chicago Council on Global Affairs*, September 2020.

<sup>92</sup> Shore Lands for Park Use Act. 615 ILCS 105.

of the public trust doctrine can protect public access to the lakefront in general, and protect the public's specific rights to bathe, swim, and perform other common beach-related activities, it is insufficient to mandate the preservation of publicly-accessible lakefront as dry, sandy beach without additional state law.<sup>93</sup> Without explicit policies to protect and preserve beach spaces, the practical ability to recreate on a dry, sandy municipal beach may be lost even as the municipality and state remain in compliance with their duty to protect public trust access to the lakefront.

*The Public Trust Doctrine and Climate Change on "Possible Beach" Spaces*

In "possible beach" spaces, those beaches that front private property and are today controlled by private owners but which could be publicly accessible up to the ordinary high-water mark (OHWM) if a court case were to test it, a landward movement of the public trust boundary due to climate change will confound the current complex delineation between private and state jurisdictions and eliminate the possibility of beach access on those spaces.

Illinois' current interpretation of the boundary between private and public land ownership under the public trust doctrine is based on a 1917 opinion that ruled that private owners' lakefront property title extends up to the water's edge at the still-water shoreline.<sup>94</sup> The literature review also found that the state public trust boundary could be defined by the OHWM regardless of the location of the property boundary. Thus, the ordinary high-water mark and the still-water shoreline are both relevant boundaries for understanding climate change's jurisdictional impact over "possible beach" spaces. Regarding the still-water shoreline boundary, since Lake Michigan water levels naturally fluctuate even in the absence of climate change-induced extremities, the Illinois Department of Natural Resources interprets that boundary as shifting in accordance with

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<sup>93</sup> People ex rel. Attorney Gen. Scott v. Chicago Park District, 66 Ill. 2d 65 (1976).

<sup>94</sup> Brundage v. Knox, 279 Ill. 450, 117 N.E. 123 (1917).

changing lake levels.<sup>95</sup> Under state law, this boundary is redetermined each year as part of IDNR's annual survey of the shoreline of Lake Michigan.<sup>96</sup> The ordinary high-water mark boundary also shifts in accordance with changing lake levels, but these changes are calculated on a much more long-term basis. As noted in the methodology section, the current standardized ordinary high-water mark is based on a 1985 International Great Lakes Datum, which sets the OHWM at 581.5 feet above sea level. The international datum is meant to be revised every 25 to 35 years in response to changing lake levels, but the current datum has long since expired and is not particularly relevant to current lake conditions, not to mention future lake conditions under climate change.<sup>97</sup> Thus, as currently defined, the still-water shoreline boundary would be responsive to climate change-induced lake fluctuations, and the OHWM boundary would not.

As lake levels begin to change, they will create an increasing disconnect between the physical spaces occupied by the still-water shoreline and ordinary high-water mark, and their legally defined bounds. For example, under the more conservative climate change scenario tested in the spatial analysis section, the physical still-water shoreline and OHWM will both migrate landward by 2.5 feet. Since IDNR's interpretation of the still-water shoreline is recalculated every year, the legal boundary between private and state property will migrate landward by 2.5 feet to match the physical movement of the still-water shoreline. But since the legal OHWM is calculated on a 25-to-35-year cycle, the public trust boundary will not match the movement of the physical OHWM. As lake levels continue to rise, the legal still-water shoreline will migrate further landward with the advancing lake and surpass the static legal OHWM, which will make

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<sup>95</sup> Illinois Department of Natural Resources, "State of Illinois Coastal Management Program," 55.

<sup>96</sup> Rivers, Lakes, and Streams Act. 615 ILCS 5.

<sup>97</sup> "International Great Lakes Datum of 1985." National Geodetic Survey, National Oceanic and Atmospheric Administration, 2023.

little sense spatially or jurisdictionally. Climate change will expose a fundamental flaw in how the OHWM is calculated and, since the OHWM is critical to defining the state's public trust boundary, it presents an uncertain future for how the public trust will be understood in a climate future that upends the legal definitions it has thus far relied on.

As lake levels advance landward, they will inundate and subsume existing "possible beach" spaces as detailed in the spatial analysis section of this paper. Private landowners have no explicit mandate to restore beach spaces, and in many cases may not do so, choosing instead to construct revetments or seawalls to protect landward structures. Such revetments and seawalls are typically subject to regulation by IDNR below the OHWM but given the high degree of uncertainty surrounding the OHWM as described above, private interests may be able to exploit this uncertainty to construct shoreline structures as they please. In such cases, the legally important still-water shoreline and the OHWM will become nothing more than two water stains on the side of a seawall. Where "possible beach" might still exist, the extent of state public trust jurisdiction over them will also be unclear. Thus, climate change's impact on Lake Michigan water levels will result in great jurisdictional confusion in beach spaces that front private property. Multiple levels of clarification are needed to better understand the potential effects of this problem. First, a ruling on whether the public trust doctrine protects public beach access on privately-owned beaches will clarify the "possible beach" and IDNR's responsibility to protect the public trust below the OHWM. Second, a more effective and responsive way of calculating the OHWM will clarify where the public trust boundary will land as lake levels continue to fluctuate. Finally, a more comprehensive state policy acknowledgement of and response to its changing coastline would more accurately convey the legal implications of climate change for the lakefront better than this thesis ever could.

## Legal Case Studies

While the public trust doctrine serves as a guiding principle for the implementation of coastal policy statewide, individual locales differ significantly both in their physical share of shoreline devoted to, and their legal protections for, beaches. These differences profoundly affect what policy and legal mechanisms will be employed in different areas of the Illinois shoreline as they respond to the same fundamental challenge of beach inundation. The spatial analysis section of this paper introduced three local case studies in the South Shore neighborhood of Chicago, the village of Kenilworth, IL, and the Illinois Beach State Park. Below, I discuss the challenges faced by each in responding to climate change-induced beach inundation as affected by existing local legal and policy approaches to maintaining beach access.

### *Legal Case Study One: South Shore, Chicago, IL*

The South Shore neighborhood of Chicago is poised to undergo extensive inundation of almost 92% of its beach spaces under the most extreme climate scenario. The effects of climate change have already been made manifest in the neighborhood: during the January 2020 weather event that caused so much damage to the Illinois lakefront, floodwaters encroached upon South Shore residences several blocks from the lake.<sup>98</sup> Without a coordinated response from the city or state thus far, individual private property owners have been responsible for fortifying their lakefront properties, costing one lakefront apartment building some \$450,000 since 2020 alone.<sup>99</sup> The financial burden of such climate resiliency projects explains why only one privately-owned beach in South Shore remains today. In response, local residents have organized a “South Side Lakefront Erosion Task Force” with the backing of two state representatives and the local city

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<sup>98</sup> Kiana Courtney et al., “Rising Waters: Climate Change Impacts and Toxic Risks,” 16.

<sup>99</sup> Dan Egan, “A Battle Between a Great City and a Great Lake,” *New York Times*, July 7, 2021.

alderman to call attention to what they see as a racially unequal policy response to lakefront flooding.<sup>100</sup> In 2022, the state budget allocated \$5 million to the Chicago Department of Transportation to build breakwaters between 67<sup>th</sup> and 73<sup>rd</sup> Streets, protecting private lakefront properties and the South Shore Cultural Center.<sup>101</sup> Residents tout this allocation as a victory for racial equity in access to the lakefront, but it should be noted that while the breakwater project will help prevent the erosion of the beach at the publicly-accessible Cultural Center, it does not promise to expand public access to the privately-owned portion of the South Shore shoreline.<sup>102</sup>

The advocacy of the South Shore community to protect its lakefront speak to the need for more comprehensive lakefront planning to protect beach access in Chicago. All public beaches in the city, including Rainbow Beach and the South Shore Cultural Center, are operated by the Chicago Parks District, which also serves as the implementor of the state's public trust responsibilities through the Shore Lands for Park Use Act. However, the maintenance and renewal of the city shoreline is dictated by an intergovernmental agreement between the city, the state Department of Natural Resources, and the United States Army Corps of Engineers.<sup>103</sup> Since 1996, the Army Corps of Engineers has been responsible for implementing the Chicago Shoreline Protection Project, which has replaced eight miles of the lakefront with stone revetments to protect landward transportation infrastructure and, in some cases, nourished beaches to enhance public access.<sup>104</sup> This project notably did not include any improvements to the South Shore neighborhood. Now, a new Army Corps study set to be completed in 2025 will focus on areas not covered by the original Shoreline Protection Project, including a special focus on coastal

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<sup>100</sup> Maxwell Evans, "South Side Lakefront Erosion Has Been Ignored For Too Long, Neighbors Say. Now, They're Demanding Answers," *Block Club Chicago*, January 23, 2020.

<sup>101</sup> An Act Concerning Appropriations. ILGA Public Act 102-1122.

<sup>102</sup> Siri Chilukuri, "On Chicago's South Side, neighbors fight to keep Lake Michigan at bay," *Grist*, August 8, 2023.

<sup>103</sup> "Shoreline Protection Project," City of Chicago, Chicago Department of Transportation.

<sup>104</sup> Water Resources Development Act of 1996, Pub. L. No. 104-303, 110 Stat. 3658 (1996).

planning in South Shore.<sup>105</sup> Such a framework for coastal protection has the potential to make a significant positive difference in the ability of the Chicago lakefront to withstand climate change-induced lake flooding; however, there is no evidence that any of the actors involved operate under any explicit mandate to protect and preserve beach spaces. Without such a mandate, the Army Corps' overt focus on shoreline engineering may skew the city's coastal planning efforts towards replacing at-risk beaches with concrete revetments, even when other options would be effective at both preventing coastal erosion and maintaining crucial beach access. Such a fear is not ungrounded in evidence. In 2020, Howard and Rogers beaches on the north side of the city were closed permanently, their sandy expanses replaced with boulders as temporary protection against high lake levels.<sup>106</sup> Four years later, the beaches have yet to return. As a neighborhood vulnerable to erosion, South Shore may see its beaches suffer a similar fate without an explicit change in beach policy by the governmental partners working to protect the city's lakefront.

*Legal Case Study Two: Kenilworth, IL*

The village of Kenilworth is also poised to experience significant inundation across its two public beaches and handful of private beaches, with around 82% of its beaches being fully inundated under the most severe climate scenario presented in the spatial analysis. Kenilworth's only publicly accessible and publicly owned beach, "The Kenilworth Beach," is operated by the village's parks district. It has received significant local attention in recent years as the village government debates on how best to address beach erosion.<sup>107</sup> On March 19<sup>th</sup>, 2024, residents of the village will vote on a public referendum to devote \$2.5 million in bonds to an improvement project that would reconstruct the beach's shoreline protection groin system and add additional

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<sup>105</sup> "Chicago Shoreline General Reevaluation Report," United States Army Corps of Engineers, Chicago District.

<sup>106</sup> Stefano Esposito, "Storms force closure of Howard, Rogers beaches," *Chicago Sun-Times*, January 16, 2020.

<sup>107</sup> "Kenilworth Beach," Village of Kenilworth, 2023.

sand to the beach through beach nourishment. These bonds would be financed through a local property tax increase roughly equivalent to \$126 on a home with a \$1 million equalized assessed value.<sup>108</sup> This referendum came about following a study demonstrating that the beach's current groin is failing, causing high-energy waves to reach the shoreline and resulting in a usable beach space that is "minimal during high water levels."<sup>109</sup> Initial polling shows that a majority of Kenilworth residents are in favor of the referendum, and a plurality cite additional sand area as the most major need for the beach. If the referendum fails, the village government would consider financing the project through private donations instead.<sup>110</sup>

Kenilworth's reliance on a public referendum or private donations for a one-time beach improvement project demonstrates the vulnerability of beach access on the North Shore. Without a comprehensive framework for statewide coastal planning or the local capacity to create long-term coastal plans, individual municipalities are forced to turn to their constituencies to drum up support for beach protection projects. While, if passed, the referendum would provide a temporary salve for Kenilworth's erosion problem, repeating this model of beach protection policy in a climate future that increases the rate of inundation and erosion of the village's lakefront may not be the most effective method of protecting the beach. Current public financial support for beach access in Kenilworth is encouraging, but without any explicit legal mandate or stable financial model to protect future beach access, there is a real chance that The Kenilworth Beach will be lost. Kenilworth and other North Shore towns should consider entering an intergovernmental agreement with one another and the state of Illinois to coordinate region-wide coastal planning efforts, like those being conducted in Chicago under the Army Corps of

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<sup>108</sup> "Beach Improvement Project," Village of Kenilworth, February 16, 2024.

<sup>109</sup> "Construction of Shore Protection Project at the Kenilworth Beach," Illinois Department of Natural Resources, Office of Water Resources Public Notice, July 27, 2023.

<sup>110</sup> "Beach Improvement Project," Village of Kenilworth.



Engineers. Greater involvement of the state government in financing and planning for beach access could ensure greater stability across the region and less fragmentation between the efforts of individual municipalities. If such an intergovernmental agreement were to occur, the state government should stipulate that North Shore towns must make their beaches truly accessible to the public as a precondition for receiving state funding. Entering The Kenilworth Beach requires the purchase of a season pass, which costs a minimum of \$200 for non-residents of the village.<sup>111</sup> Such policies are pervasive across the North Shore and create racially and socioeconomically exclusionary conditions that must not be supported by state funding.

In addition to The Kenilworth Beach, Kenilworth is home to 3,133.02 square feet of private beaches. These private beaches exclusively front single-family properties, which are built on bluffs a significant elevation above the beach. To protect the bluffs and prevent property damage in the event of slope failure, the Village of Kenilworth's Steep Slope Ordinance requires that all construction be set back by at least 35 feet from the top of the bluff.<sup>112</sup> It also outlaws the construction of erosion control structures such as revetments or seawalls on the lakeward side of the bluff.<sup>113</sup> As bluff erosion accelerates under climate scenarios in which lake level fluctuations increase in extremity, it is unclear how the Village of Kenilworth will enforce its 35-foot setback rule, but private homes that are today in compliance with the slope ordinance may find soon themselves in violation of it as slope erosion begins to threaten structures on top of the bluff. This presents an additional layer of legal confusion for Kenilworth private property owners on top of the uncertainty surrounding the public trust doctrine discussed in the "possible beach"

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<sup>111</sup> "Kenilworth Beach," Village of Kenilworth.

<sup>112</sup> Village of Kenilworth, IL Code of Ordinances. § 154.03. Steep Slope Regulations: Definitions.

<sup>113</sup> Soren Hall, "Winnetka Village Council Lake Michigan Regulatory Permitting Process," U.S. Army Corps of Engineers, January 10, 2023.

section of the above legal analysis. Most importantly for beaches, however, the stringency of the Steep Slope Ordinance means that revetments and seawalls will not be allowed to replace beach spaces on private property. As current beaches are inundated and bluff slopes erode, beaches will be allowed to naturally migrate landward as the lake does, presenting an optimistic legal future for the continued existence of Kenilworth beaches. Public access to such spaces is not guaranteed, but with a future court ruling that expands public trust access to private property, these beaches may become a significant public asset.

*Legal Case Study Three: Illinois Beach State Park, IL*

Illinois Beach State Park is projected to experience up to sixty percent inundation of its sandy beach spaces by 2040 under the most extreme climate projection tested in my spatial analysis. Perhaps unlike any other site in Illinois, the park's struggles with beach erosion have long been documented and planned for. Extensive Illinois Department of Natural Resources studies have discovered that the park has lost over 100 acres of coastal habitat to beach erosion in the past 80 years.<sup>114</sup> Between 2017 and 2020, the park lost 10 acres of beach as shoreline erosion accelerated, and the January 2020 storm alone caused an additional 1.5 acres of beach loss.<sup>115</sup> In response, the state is implementing a \$73 million shoreline stabilization project that will emplace rubble revetments offshore to reduce the erosive impact of storm waves without ruining access to the beach, and will also renourish the beach with an additional 430,000 cubic yards of sand.<sup>116</sup> The project represents a significant investment (the largest capital project in IDNR history) into a

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<sup>114</sup> Katherine Braun, "A Vanishing Coast," Illinois State Geological Survey, August 27, 2020.

<sup>115</sup> Jenny Bueno and Kevin M. Engelbert, "Illinois Beach State Park: A Dynamic Shoreline," Illinois State Geological Survey, September 11, 2020; Katherine Braun, "A Vanishing Coast," Illinois State Geological Survey.

<sup>116</sup> "State tackling harmful Lake Michigan shoreline erosion at Illinois Beach State Park," Illinois Department of Natural Resources, January 12, 2023.

novel method of protecting beach access on the state-owned shoreline.<sup>117</sup> If the project is successful at preventing erosion, it will increase the site's resilience to future lake level fluctuations projected under climate change.

Beach access at Illinois Beach State Park has received an enormous amount of attention and investment relative to other beaches across the state shoreline in large part thanks to jurisdictional consolidation. The park is owned and operated solely by the Illinois Department of Natural Resources. Under the State Parks Act, IDNR has an explicit mandate to preserve and enhance public access to parks sites and can enact any rule or project necessary to achieve that aim.<sup>118</sup> Thus, without having to consider the needs of any additional stakeholder beyond the public interest of Illinoisans, such as municipal governments, parks districts, forest preserves, or private property owners, IDNR is free to implement its public trust duty as it sees fit. The State Parks Act also enables the department to collaborate with other state and federal programs to build capacity for planning, research, and funding to directly implement beach access protection projects. In the case of the recent shoreline stabilization project, IDNR leveraged relationships with the Illinois State Geological Survey and the University of Illinois to conduct the geomorphological research necessary to plan the innovative design of the submerged revetments, receiving additional monitoring and technical support from federal programs such as NOAA, EPA, and the Army Corps of Engineers.<sup>119</sup> Funding was secured through the state Capital Development Board using appropriations from the legislature's bipartisan Rebuild Illinois capital plan.<sup>120</sup> Because IDNR is mandated to protect beach access at the state park, and because it has

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<sup>117</sup> Laura Barnes, "Underwater innovation at Illinois Beach State Park to help mitigate coastal erosion," Illinois Sustainable Technology Center, Prairie Research Institute, February 18, 2022.

<sup>118</sup> State Parks Act, 20 ILCS 835.

<sup>119</sup> "State tackling harmful Lake Michigan shoreline erosion," Illinois Department of Natural Resources.

<sup>120</sup> "Gov. Pritzker Signs Historic Bipartisan \$45 Billion Rebuild Illinois Capital Plan," Illinois Office of the Governor, June 28, 2019.

the backing of multiple state agencies and the state legislature, the implementation of beach access preservation projects is relatively smooth under its existing legal jurisdiction. This sound legal backing, in combination with the climate resilient project already being implemented, presents a relatively certain future for beach access at the park so long as funding is maintained.

### *Legal Conclusion*

The legal future of beach access in Illinois under climate change is defined by uncertainty. Statewide, the public trust doctrine will have very different effects on beach access depending on both beach ownership and locale. “Current beaches,” those publicly accessible beach spaces that front other public land, will not face a significant public trust boundary crisis as the lake migrates landward, but without an explicit legal mandate to maintain those spaces as dry, sandy beaches, there is a real possibility that beach access will be lost as municipal and state actors work to protect other lakefront infrastructure against climate change. “Possible beaches,” those beach spaces that are privately-owned and front private land but could be publicly accessible with a state court ruling, face an extremely complex legal future as the current public trust boundary relies on an outdated definition of the ordinary high-water mark that does not respond to the changing lake conditions caused by climate change. More clarification via a ruling or act of the state legislature is needed to determine whether “possible beaches” are public accessible and whether the public trust boundary will change with climate change. Finally, beach access in South Shore, Kenilworth, and the Illinois Beach State Park under climate change will be significantly influenced by the extent to which local and state actors are already engaged in its preservation under existing law. Beach access in South Shore and Illinois Beach State Park will rely heavily on intergovernmental action, while Kenilworth’s beaches will depend on private support in the absence of significant government intervention. This diversity of potential

responses, or lack thereof, speaks in large part to the current lack of consideration of the implications of climate change for beach access in state and local policy in Illinois.

### **Discussion and Policy Recommendations**

Heads in the Sand is a foray into a body of literature that, for the most part, does not yet exist. A handful of studies have estimated the impact of climate change on Lake Michigan water levels, an even smaller number have analyzed the implications of climate change for lakefront infrastructure in Illinois, and, to the best of my knowledge, none have spatially analyzed climate change's impact on beach access or made any broader connections to coastal law via the public trust doctrine. I identify this gap in the literature not to make this paper seem self-important; rather, I do so to call for the production of additional, more technically sound studies that combine geomorphological and legal analysis to better understand how climate change will impact the spatial and legal natures of the lakefront.

More in-depth studies are needed because even this initial foray finds an undeniable truth: climate change induced lake level fluctuations pose a significant threat to beaches in the state. Almost sixty percent of current sandy beach spaces across Illinois will be inundated under the most extreme climate scenario presented in my spatial analysis, and actual beach loss may be much greater than this given that this study does not represent erosive impact. While inundation will vary significantly by coastal region due to geomorphological factors such as beach slope and surface roughness, meaning that some municipalities will experience much more drastic beach inundation than others, the results of the spatial model indicate a clear need for all coastal stakeholders to take climate change seriously. This need is substantiated by the results of the legal analysis, which describe a future of legal uncertainty for beach access under the public trust doctrine depending on beach ownership and locale. Outside of Illinois Beach State Park, existing

coastal law and policy contains no explicit mandate to protect and preserve sandy beach anywhere in the state. As small municipalities like Kenilworth turn to private funding to maintain their beaches and as Chicago increasingly relies on the revetment-happy advice of the Army Corps of Engineers, beaches today face an existential threat that will only be exacerbated by increased lake levels.

Further research can increase the certainty of these findings by:

- I. Conducting site-specific hydrological and geomorphological analysis for each beach in Illinois to better represent erosion than the spatial models presented here;
- II. Employing a wider range of spatial models to better represent the diversity of potential impacts of climate change on lake levels;
- III. Applying a more thorough knowledge of Illinois case law to better understand how public trust doctrine precedent will be impacted by climate change;
- IV. Conducting legal and spatial case studies for all thirteen coastal municipalities across the state, not just three;
- V. And consulting with state and municipal coastal managers to understand internal governmental plans for climate change, if they exist.

Nevertheless, the scientific and legal understanding of the implications of climate change for beach access need not be finely polished for discussion of coastal policy change to begin. The most immediate step that the state government must take is to assign the Department of Natural Resources to create a comprehensive planning document in collaboration with scientific and legal experts to better understand the threat of climate change for the lakefront across all 63 miles of Illinois' Lake Michigan coast. In addition to beaches, the state's lakefront is home to critical transportation infrastructure, world-class museums, major universities, industrial

brownfields, a military base, and a nuclear waste site. The state government must better understand the impact of climate change-induced lake level fluctuation on all of these land uses to protect a wide variety of lakefront stakeholders. This plan must also develop a detailed, specific, and implementable toolbox of coastal erosion preventative projects that the state can implement in collaboration with municipal and private stakeholders. These projects should be implemented as soon as funding is available, both to address the widespread erosion and inundation that communities are already experiencing and to prepare for a climate future in which these threats are only exacerbated.

With regards to beach access specifically, Illinois should look to other coastal states to shore up its interpretation of the public trust doctrine to protect the right to beach access in the event of widespread lake inundation. Any momentum to enhance beach access protections must begin with a clarified ruling of the extent of the public trust doctrine's jurisdiction over public access to private beaches in the state. As mentioned in the literature review, it is highly likely that the Illinois Supreme Court would find that common beach activities are a protected right up to the ordinary high-water mark under the public trust doctrine.<sup>121</sup> Such a ruling would greatly expand the state's legal responsibility to protect beach access, and would force the state to consider how the changing boundaries of the public trust doctrine under uncertain climate futures might impact public trust beaches, as other coastal states are currently obligated to do. At the time of writing, no other coastal state has legislatively or judicially addressed the implications of a climate change-induced advancing public trust boundary on beach access rights. Scholars have suggested a few potential solutions to this policy problem that, for now, remain in the theoretical realm. The most popular of these focuses on "rolling easements", a term originated in Texas'

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<sup>121</sup> Kenneth K. Kilbert, "The Public Trust Doctrine and the Great Lakes Shoreline," 50.

Open Beaches Act that describes “a broad collection of policies under which human activities are required to yield the right of way to naturally migrating shores.”<sup>122</sup> A rolling easement policy in Illinois would guarantee the survival of a natural shoreline by mandating a government purchase, repossession, or temporary rental of any formerly private construction that comes to sit on public trust land through the advancement of Great Lake levels, justly compensating private property owners while preserving public trust beach access.<sup>123</sup> Other policy strategies mentioned in the literature include tying permit approvals for construction on private property to deed restrictions that would require private property owners to demolish structures that end up on public trust land due to Great Lake level change, or proactively purchasing land expected to be inundated by climate change from private owners to remove existing structures and allow the beach to migrate landward.<sup>124</sup> A final alternative, and perhaps a likely one, is for the state government to take no anticipatory action and deal with the problem only once lake level change is actively threatening both the public trust and private property. These solutions may include ordering property owners from their land with limited or no compensation, or intentionally (and illegally) abdicating the public trust in favor of allowing property owners to remain.<sup>125</sup>

Beyond an overhaul of Illinois’ interpretation of the public trust doctrine, there are smaller policy changes that can have a substantial impact on preserving beach access at the state or local level. State or local legislators must pass laws that codify access to existing beaches as an inalienable right of their constituents. Such legislation would hold state and local governments responsible for protecting beaches from future inundation and erosion so as to not violate the public right to

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<sup>122</sup> James G. Titus, “Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners,” *Maryland Law Review* 57, no. 4: 1313.

<sup>123</sup> James G. Titus, “Rising Seas, Coastal Erosion, and the Takings Clause,” 1315.

<sup>124</sup> Tim Eichenberg, Sean Bothwell, and Darcy Vaughn, “Climate Change and the Public Trust Doctrine,” 275; James G. Titus, “Rising Seas, Coastal Erosion, and the Takings Clause,” 1311.

<sup>125</sup> James G. Titus, “Rising Seas, Coastal Erosion, and the Takings Clause,” 1318.



the beach. Precedent for this exists in multiple other coastal states, including in California, where the California Coastal Act enshrines the right to public access to all sandy beaches into the state constitution.<sup>126</sup> Depending on how a “public” is defined, such legislation may also eliminate the problem of inequitable policies that restrict beach access through expensive fees or residential requirements, as is so common on the North Shore.<sup>127</sup>

To conclude, I would like to return to an assertion that I made in the introduction of the paper. To Illinoisans, beaches matter. It matters that every summer, millions of Illinoisans take days off, spend their hard-earned wages, travel tens, hundreds, thousands of miles to go to the beach. It matters that Black Illinoisans spent decades demonstrating, protesting, risking their lives to fight for the beach. It matters that a dry, sandy expanse stirs up something in the psyche that a dull concrete revetment cannot. If climate change poses a significant threat to the beach, then it must matter, too. It is the duty of our elected officials to protect our common interest, and there is nothing more democratic, more American, than a beach. Policymakers must plan to protect this valuable resource as the climate crisis encroaches upon our lakefront.

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<sup>126</sup> California Coastal Act of 1976. CA Public Resources Code Division 20.

<sup>127</sup> Samuel Kling and Lucas Stephens, “The Right to the Shoreline: Race, Exclusion, and Public Beaches in Metropolitan Chicago,” *The Chicago Council on Global Affairs*, September 2020.

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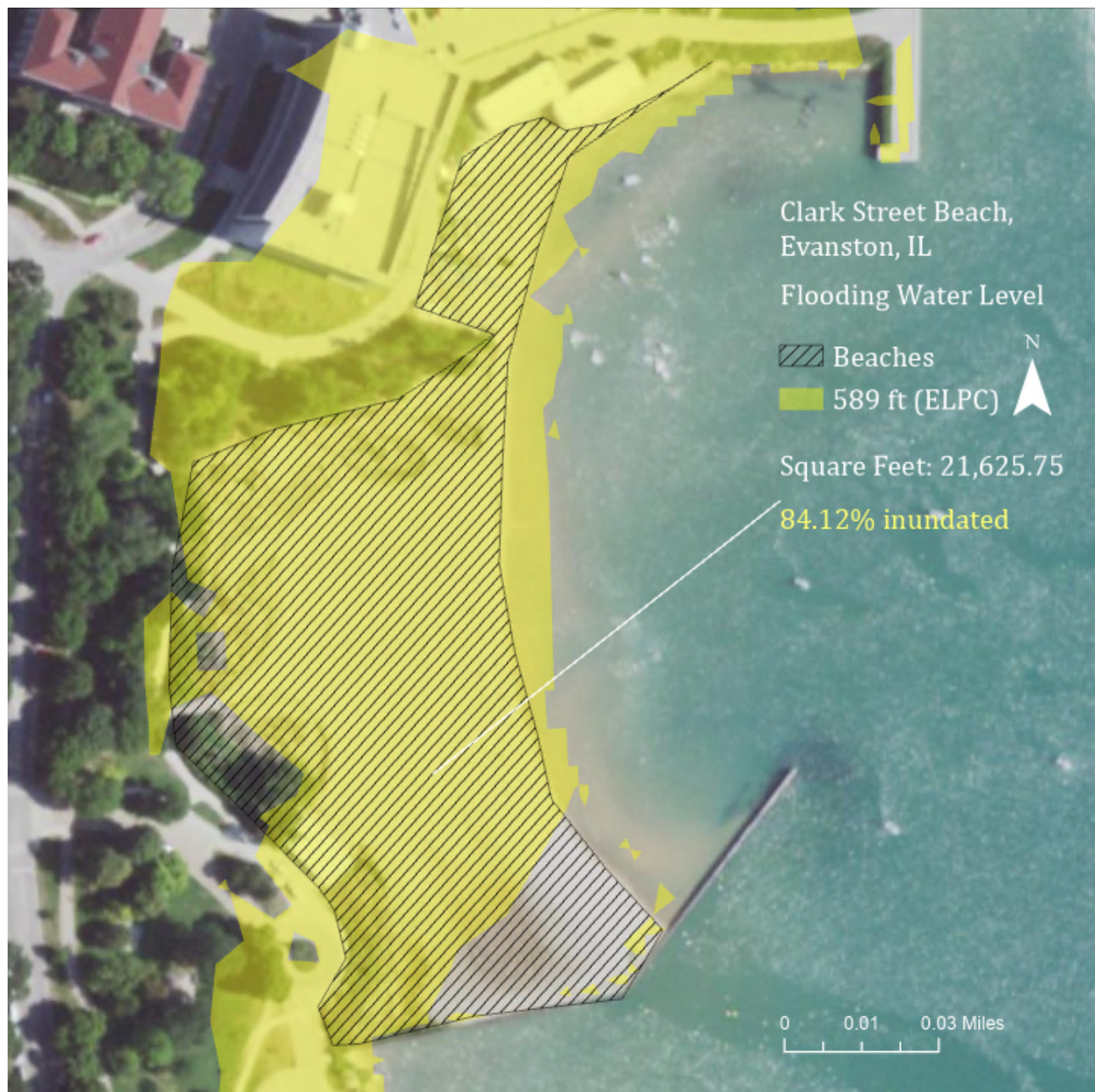
**Appendices**

*Appendix I: Representative Outputs of the 7.5-foot Model*



*Image 1.1: Inundation model of a private beach in Highland Park, IL under the 589 ft. scenario.*





*Image 1.2. Inundation model of Clark Street Beach in Evanston, IL under the 589 ft. scenario.*

*Appendix II: Representative Outputs of the 2.5-foot Model*

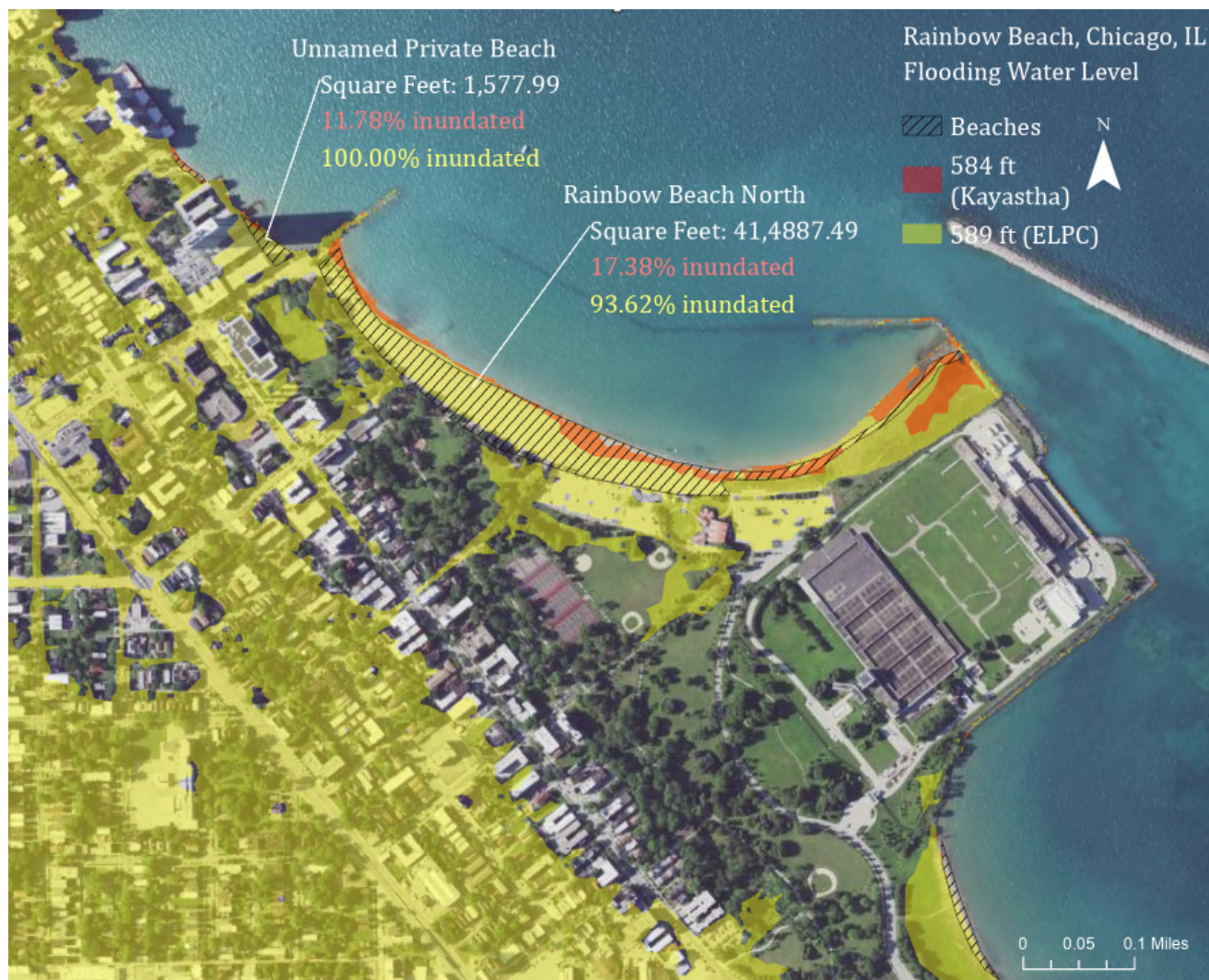


*Image 2.1: Inundation model of Glencoe Beach in Glencoe, IL under the 584 ft. scenario.*

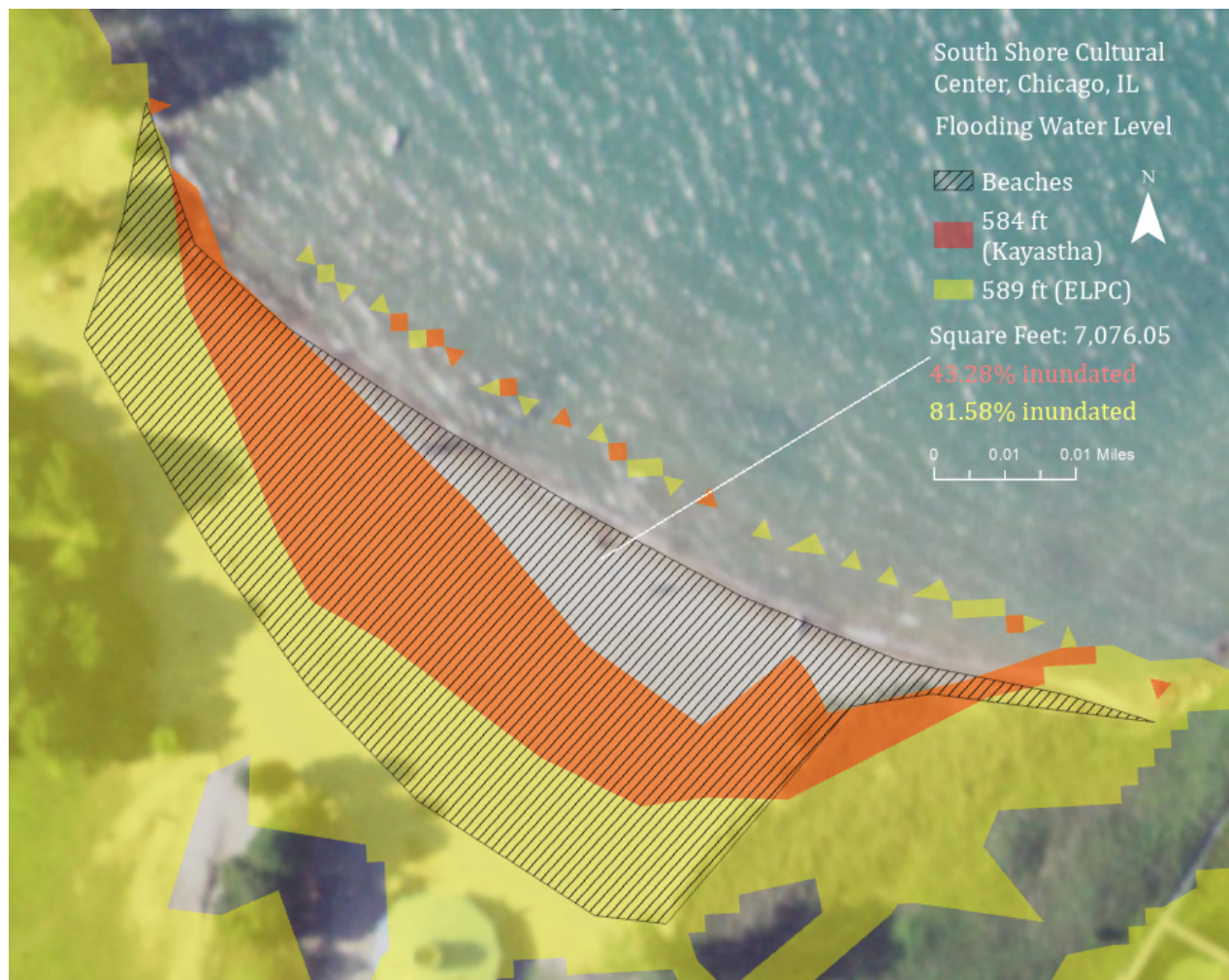


Image 2.2: Inundation model of 57<sup>th</sup> Street Beach in Chicago, IL under the 584 ft. scenario.

*Appendix III: South Shore, Chicago, IL Case Study Models*



*Image 3.1: Inundation models of Rainbow Beach and a private beach in South Shore, Chicago, IL using predictions from both the 584 ft. and 589 ft. scenarios.*



*Image 3.1: Inundation model of the South Shore Cultural Center in South Shore, Chicago, IL using predictions from both the 584 ft. and 589 ft. scenarios.*

*Appendix IV: Kenilworth, IL Case Study Model*

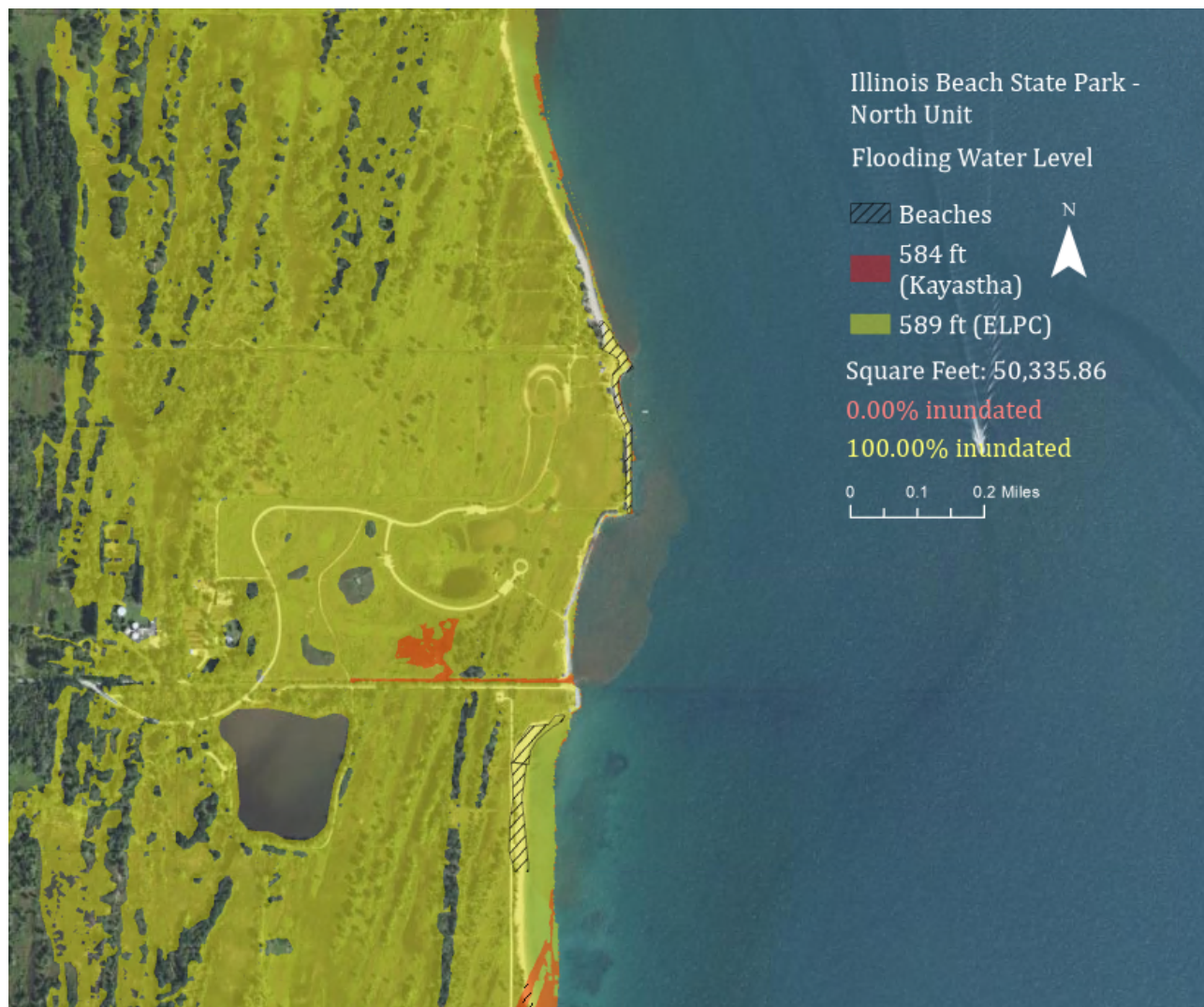


*Image 4.1: Inundation model of Kenilworth's beaches using predictions from both the 584 ft. and 589 ft. scenarios. This map depicts the entirety of Kenilworth's coastline.*

*Appendix V: Illinois Beach State Park Case Study Model*



*Image 5.1: Inundation model of the IBSP main entrance using predictions from both the 584 ft. and 589 ft. scenarios.*



*Image 5.2: Inundation model of the IBSP North Unit using predictions from both the 584 ft. and 589 ft. scenarios.*



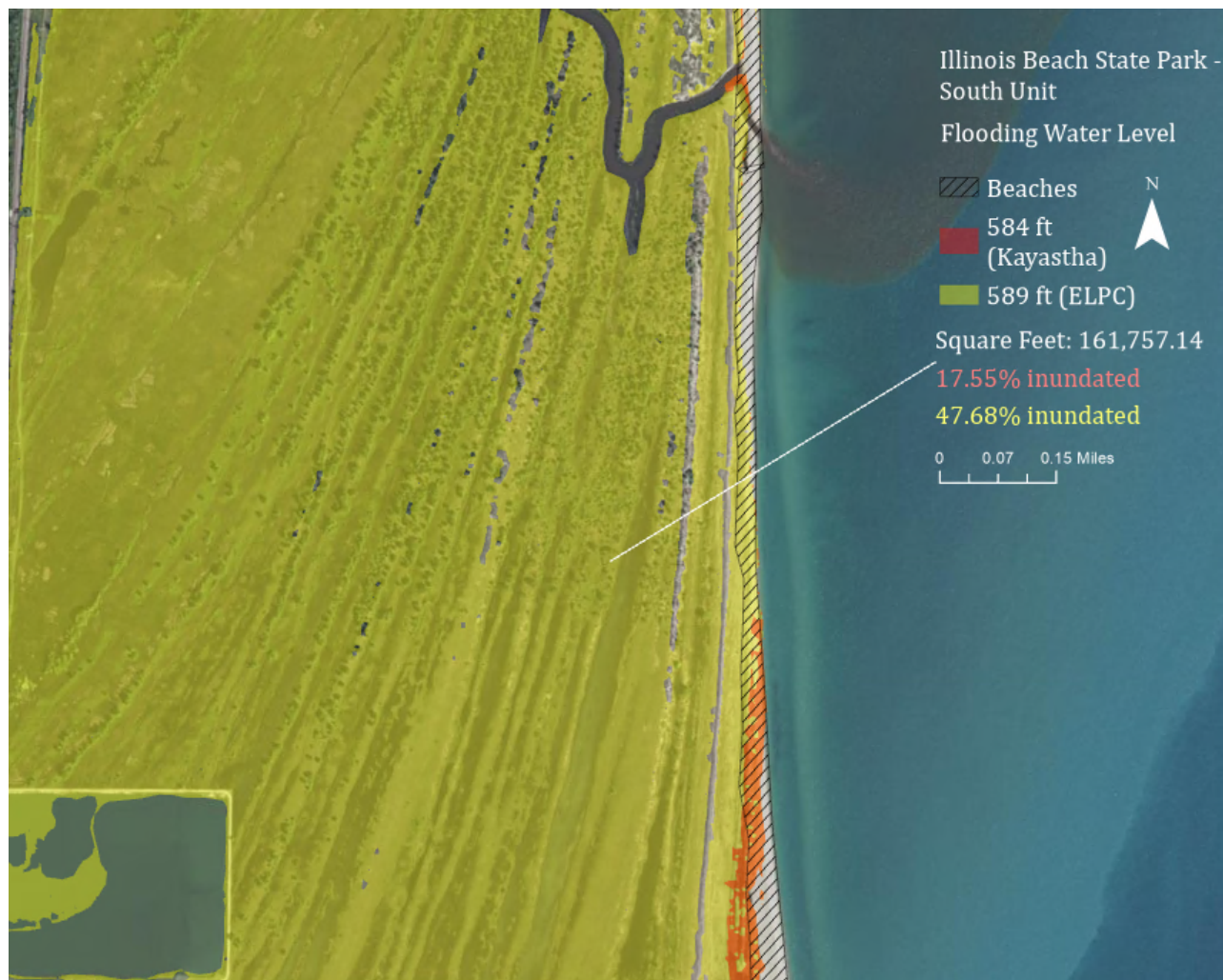


Image 5.3: Inundation model of the IBSP South Unit using predictions from both the 584 ft. and 589 ft. scenarios.