

Shoreline rehabilitation for recreation and ecological functionality

by

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A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

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College of Architecture, Planning & Design

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

2023

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## **Abstract**

Pottawatomie State Lake No. 2 is a recreational lake near Manhattan, Kansas that attracts families and anglers to enjoy a variety of activities such as fishing, camping, and picnicking. Unfortunately, the lake is showing signs of erosion and degradation near the shorelines which poses ecological concerns for aquatic species like the Largemouth Bass and accessibility and safety concerns for the site's visitors. This report aims to spotlight the importance of rehabilitating shorelines to create connections between aquatic habitat, shoreline access, camping, and day-use programming along recreational lakes in the Flint Hills Ecoregion of Kansas. With the long-term goal of establishing Pottawatomie State Lake No. 2 as a future precedent for similar lakes, this report explores design guidelines and a projective design for the site.

This report builds on research about naturalized shorelines and aims to fill the gaps between the human recreation and the ecological functionality of manmade lakes. To achieve this result, this report includes a literature review, site analysis, precedent studies, design guidelines, and a projective design. By conducting these methods of research, this project shows how to create naturalized shorelines that improve aquatic habitat for Largemouth Bass while wisely addressing the need for human recreation near the water's edge at Pottawatomie State Lake No. 2.



# Shoreline Rehabilitation

for Recreation and  
Ecological Functionality

Landscape Architecture Master Project Report

By Dylan T. Ramage

*Kansas State University 2023*

## ABSTRACT

Pottawatomie State Lake No. 2 is a recreational lake near Manhattan, Kansas that attracts families and anglers to enjoy a variety of activities such as fishing, camping, and picnicking. Unfortunately, the lake is showing signs of erosion and degradation near the shorelines which poses ecological concerns for aquatic species like the Largemouth Bass and accessibility and safety concerns for the site's visitors. This report aims to spotlight the importance of rehabilitating shorelines to create connections between aquatic habitat, shoreline access, camping, and day-use programming along recreational lakes in the Flint Hills Ecoregion of Kansas. With the long-term goal of establishing Pottawatomie State Lake No. 2 as a future precedent for similar lakes, this report explores design guidelines and a projective design for the site.

This report builds on research about naturalized shorelines and aims to fill the gaps between the human recreation and the ecological functionality of manmade lakes. To achieve this result, this report includes a literature review, site analysis, precedent studies, design guidelines, and a projective design. By conducting these methods of research, this project shows how to create naturalized shorelines that improve aquatic habitat for Largemouth Bass while wisely addressing the need for human recreation near the water's edge at Pottawatomie State Lake No. 2.

I would like to thank my major professor Lee Skabelund for pushing me and keeping me on track throughout this process. Additionally, I would like to thank my committee members Kirby Barrett and Dr. Keith Gido for working with me over the last two semesters. Each of your shared knowledge and expertise has guided me in more ways than I can express.

To my supportive and loving family, I could not have made it through these five years without your love and support. Thank you for constantly giving me encouragement to never give up.

To my fiancé Josephine, thank you for your endless love and understanding throughout this process. Your support means the world to me. You have truly pushed me to never give up and to always chase my dreams.

And to my fellow classmates, wow... what a journey! We did it! Thank you for the five years of memories I'll never forget. I wish you all the best in your future endeavors.

- Dylan

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# Glossary

Shoreline access - referring to the ability of the general public to reach and enjoy the water’s edge for recreation without the major obstruction of vegetation or hazard

Coarse woody debris - living or non-living trees and branches that are growing or have fallen into the lake, along the shoreline, or within a vegetated buffer

Impoundment or pond - a body of water that has been created through the construction of a dam

Biotic/Biota - Living (referring to vegetation and aquatic organisms in this report)

Abiotic - Non-living (referring to materials and artificial structure in this report)

Human recreation - referring to fishing, boating, walking, camping, picnicking, etc.

Shoreline rehabilitation - a variety of restorative amendments to a shoreline to increase functionality and create habitat

# CHAPTER 1

## PROJECT BACKGROUND



## RESEARCH QUESTION

How should degraded shorelines of recreational state lakes in the Flint Hills be designed to improve access for human recreation while addressing the need for naturalized edges to reduce erosion and rehabilitate game fish habitat?

## DILEMMA

Humans cause substantial ecological impacts on freshwater ecosystems through the creation of dams, which alter the natural state of streams and rivers. However, these impoundments are very important to people for purposes of recreation, including fishing, camping, hiking, and picnicking. Since Pottawatomie State Fishing Lake No. 2 is a recreational lake, its purpose is to serve visitors by providing access to the water for anglers and open space for campers and day-use visitors. However, there are signs of trampling and degradation along shorelines accompanied by a lack of native vegetation. During a conversation with Ely Sprenkle, a fisheries biologist for the Kansas Department of Wildlife and Parks for the Manhattan area, he stated that the primary sport fish targeted by anglers at Pottawatomie State Fishing Lake No. 2 are Largemouth Bass. Therefore, this species was the primary focus while designing shoreline habitat for this lake. This research project offers design solutions for vegetated shorelines and habitat for Largemouth Bass while also addressing the desire for human recreation near the water's edge.

# HISTORY OF POTTAWATOMIE STATE LAKE NO. 2

In 1953, approximately 247 acres of land in the Flint Hills donated by Dr. and Mrs. Robert L. Freidrich was designated for future development of a recreational park. In 1955, the Kansas Department of Wildlife and Parks created a 75-acre lake located approximately 2.5 miles northeast of Manhattan, Kansas known today as Pottawatomie State Fishing Lake No. 2. With a maximum depth of 30 feet, the lake is popular for family outings as well as catch and release sport fishing. Surrounding the lake, 179 acres provide wildlife refuge and tent camping along the western shore (Kansas Department of Wildlife and Parks n.d.).

Pottawatomie State Fishing Lake No. 2 was created during the “Big Dam Era” of 1935-1965. During this time, federal agencies – including the Bureau of Reclamation and U.S. Army Corps of Engineers – constructed many lakes and reservoirs. Their goal was to fulfill human recreational initiatives and to address the concerns of flood control, water supply, and power generation (Bennett 1971 ; Dirks 2020; Juracek 2015). More recently, recreational lakes like Pottawatomie State Fishing Lake No. 2 are experiencing degradation, specifically along shorelines.

Freshwater impoundments are one of the most threatened ecosystems in the world. They suffer from erosion and sedimentation caused by trampling of vegetation and adjacent land disturbances such as agriculture and development (Muenz et. al 2006). This is concerning from an ecological standpoint because erosion and sedimentation leads to shoreline degradation, loss of aquatic habitat, and chemical imbalances in the water (King et. al 2016; Kirkeeng 2017). The purpose of this report is to spotlight the importance of shoreline rehabilitation along recreational lakes in the Flint Hills Ecoregion in Kansas. This report is expected to serve as a foundation of knowledge for park managers and landscape architects to build upon in their collective efforts to protect freshwater ecosystems.

# PROJECT SIGNIFICANCE TO LANDSCAPE ARCHITECTURE

When designing vegetated buffers and aquatic habitats, landscape architects should collaborate with biologists, conservationists, and other experts knowledgeable about aquatic ecosystems. It is important for landscape architects to understand implementation techniques that address erosion, sedimentation, and aquatic degradation within bodies of water and to have a basic understanding of the types of habitats suitable for specific upland and aquatic species. Basic knowledge of vegetative forms and the creation of space using biotic and abiotic elements can assist landscape architects in designing fishing and observation areas along shorelines. With several lakes lacking in vegetative biodiversity along shorelines, there is a gap between human recreational needs, demands, behaviors, and ecological functionality. Landscape architects can fill that gap through collaborative design for the rehabilitation of recreational lakes and thus better balance the need for naturalized shorelines with human access to the water.

# PERSONAL EXPERIENCE

Growing up an avid angler, I have a good understanding of where I have the most success catching fish, especially Largemouth Bass. When I came to Manhattan, Kansas as a college freshman, Pottawatomie State Lake No. 2 was the first lake I began to explore and try my luck at. I quickly realized how different it was than the lakes I was used to in Nebraska. Traditionally, I had found the most success fishing near downed trees, logs and submerged vegetation. However, Pottawatomie State Lake No. 2 does not have a plethora of that type of structure. To me, it seemed like I was either casting adjacent to rocks or out in the open water (which I personally have not had much success with, especially from the shoreline). Over the past five years of fishing at Pottawatomie State Lake No. 2, I have found that most of my catches are along the face of the earthen dam, but it never seems consistent. I believe that if Pottawatomie State Lake No. 2 had more diverse habitat types tailored towards Largemouth Bass, it would result in a more consistent and higher rate of success for anglers of all skill levels. Although I am not a fisheries biologist, my years of angling experience and observation add useful insight to the research and design process throughout this report.

# METHODS

To answer my research question, I began with a literature review that gave me a foundation of knowledge. I then used that knowledge to search for precedent studies and issues to inform my site analysis. The precedent studies also helped me discover design opportunities through the site analysis and consider design interventions for the issues that were identified during this process. Condensing the knowledge from the literature review, precedent studies, and exploratory design interventions, design guidelines were composed to inform the design process for the projective design.

A literature review was the first step in understanding the connections between shoreline functionality, aquatic habitat, fishing, camping, and day use programming. I chose this method because it was the most beneficial way to build a foundation for design guidelines for the projective design outcomes.

I completed a projective design for a specific site (Pottawatomie State Lake No. 2) because this site has the opportunity to become established as a precedent for other recreational lakes in the Flint Hills Ecoregion and Midwest. Therefore, it was important that I clearly understood the existing conditions on the site by conducting a site analysis that explores various site conditions and opportunities.

Precedent studies were completed since my project is composed of a variety of programmatic elements (fishing, camping, day use, shoreline vegetation, etc.). Therefore, it was important that my chosen precedents examine each of these areas of focus so I could bring ideas from each of them to create a cohesive design.

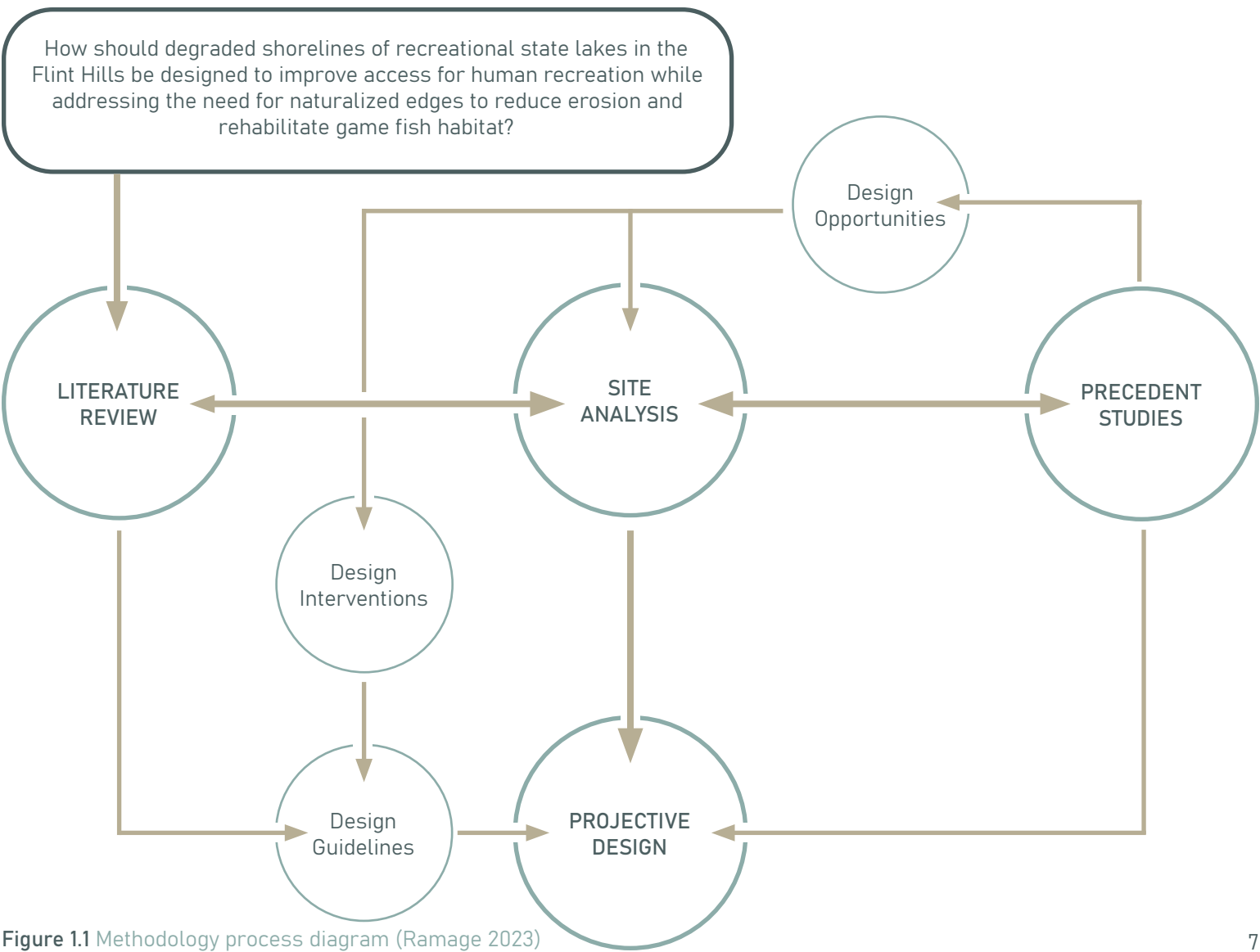


Figure 1.1 Methodology process diagram (Ramage 2023)

# CHAPTER 2

## LITERATURE REVIEW

in relation to existing conditions at  
Pottawatomie State Lake No. 2

## RESEARCH QUESTION

How should degraded shorelines of recreational state lakes in the Flint Hills be designed to improve access for human recreation while addressing the need for naturalized edges to reduce erosion and rehabilitate game fish habitat?

## References

1. Ahrenstorff et al. 2008
2. Bennett 1971
3. Beresford 2022
4. Bolding et al. 2001
5. Caflisch et al. 2021
6. Chapman et al. 2014
7. City of Papillion n.d.
8. Dibble and Harrel 1997
9. Dirks 2020
10. Gabelhouse et. al. 1982
11. Havel 2009
12. Henderson et. al. 1999
13. Juracek 2015
14. Kansas Department of Wildlife and Parks n.d.
15. King et al. 2016
16. Kirkeeng 2017
17. Marion et.al. 2020
18. Michigan Natural Shoreline Partnership
19. Muenz et al. 2006
20. Nebraska Department of Natural Resources n.d.
21. Nemaha NRD n.d.
22. Pegg et al. 2015
23. Reed and Pereira 2009
24. Sass 2009
25. Severson 2007
26. Tennessee Valley Authority 2008
27. Zhu 2012
28. Conversation with Ely Sprenkle September 2022

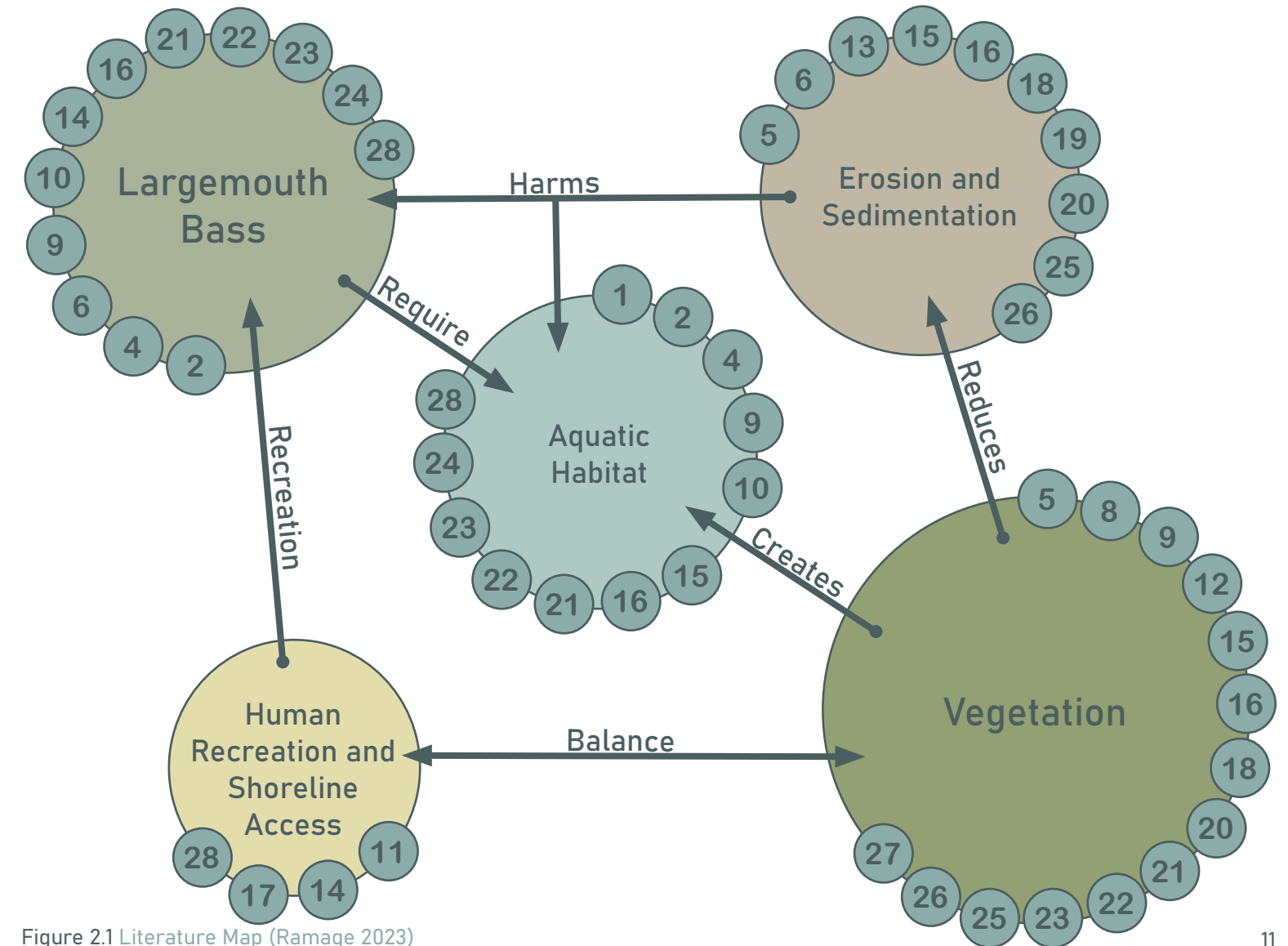


Figure 2.1 Literature Map (Ramage 2023)

## Recreation in Relation to the Shoreline

The primary purpose of Pottawatomie State Lake No. 2, according to fisheries biologist Ely Sprenkle, is to provide families, other visitors, and anglers with adequate and safe shoreline access for fishing and recreation. Therefore, it is important to maintain the user's ability to reach the water's edge, provide adequate open space for camping and picnics, and maximize the opportunities of existing infrastructure.

During my initial site visit in September 2022, I observed the immediate land cover around the lake and found that the majority of shoreline areas are turf grass mowed to the water's edge. This is beneficial for providing open space for recreational access to the shoreline but increases erosion in some areas. There are no apparent pedestrian paths around the lake, but the earthen dam is mowed on the crest to allow pedestrians to traverse across, in addition to maintenance paths on the south side of the dam and near the outflow. Pottawatomie State Fishing Lake No. 2 would greatly benefit from shoreline rehabilitation to improve water quality and the connection to nature for users by introducing native plant species and implementing pedestrian trails that improve shoreline access (including areas of universal access to provide rich experiences for users of all abilities). The shorelines are showing signs of erosion, degradation, and lake sedimentation. Shoreline and upland rehabilitation measures should address stabilization needs while balancing the desire for shoreline access for fishing, observation, and user enjoyment.

Although this project primarily focuses on shoreline functionality — connections and improvements to existing circulation infrastructure and programmatic elements will be important to improve the overall functionality of the park. In addition to fishing, this project aims to improve connections from the shoreline to camping, hiking, and day use facilities. In turn, this will improve the human connection to nature, wildlife observation opportunities, and landscape aesthetics of the park.

## Camping

Pottawatomie State Lake No. 2 currently offers primitive camping on its western shores. This provides great opportunities for families to immerse themselves in nature, be close to the water, and relax. Campsites at the project site are not clearly designated, so visitors are allowed to set up their tents wherever they see fit. This type of campsite can lead to degradation over time because it allows more space for visitors to trample vegetation and disturb more surface area within the campsite. To reduce the environmental impact, campsites should be designated to a specific location for tents and parking to minimize the amount of trampled vegetation. This would allow ample space for native vegetation to be established around perimeters (Marion et al. 2020). Additionally, tent pads are an effective sustainable camping best management practice (BMP) that work to delineate spaces where campers can set up tents and their belongings (Marion et al. 2020). Tent pads can be lined with rocks, logs, or treated lumber depending on the desired aesthetic (Marion et al. 2020).

Parking is another concern to consider. Currently, Pottawatomie State Lake No. 2 has a seemingly large amount of gravel roadways which allow places for people to park near their campsites. It is important to assess the locations of these roadways and adjacencies to proposed tent pad locations. There are opportunities to better connect campsites with the shoreline at Pottawatomie State Lake No. 2, as well as design spaces that feel more intimate using native vegetation. Grasses and sedges are the most resistant to the effects of trampling (Marion et al. 2020). Therefore, grasses and sedges are most suitable to reintroduce to the campsite.

Fire pits are a staple to camping, allowing people to roast marshmallows for s'mores, gather and socialize, and keep warm during cooler weather. However, fire pits pose a challenge to implementing native vegetation because there is a greater chance of accidental spread of fire. All fires should be burned in fire rings that are clear of built structures or flammable material within twenty-five feet (Beresford 2022). Additionally, low hanging branches should be pruned to assure overhead trees do not get damaged or ignite wildfires.

The implementation of native vegetation to create buffers will work to create more designated spaces within the campsite, which would provide campers with a sense of more privacy and connection to nature. Creating an ecologically diverse campsite with direct visual and physical access to the shoreline will better connect campers to the rest of the site as a whole and provide a better user experience. Additionally, vegetated buffers will work to clean stormwater runoff from campsites to improve the water quality of the lake, especially along the shorelines for fish.

## Hiking

Although the property is mostly known for the fishing lake, there is approximately 179 acres that provide excellent opportunity for trail system development for users to further immerse themselves in nature. There are several existing plant ecotypes ranging from native upland prairie, woodland, and the water's edge (riparian). Although unable to clarify (as I was not able to get in contact with anyone from the Kansas Department of Parks and Wildlife), occasional youth hunts take place within the park. There is an area in the northeast corner of the park that is gated off and labeled as "special events area," which is where I think this area is located. Minimal trails will be planned for this area if that happens to be the case. However, to capitalize on each of the ecosystems, the creation of an interconnected trail system would provide users with exposure to various flora, wildlife observation opportunities, and a educational opportunities.

Currently, there is minimal access on the east side of the lake but designing a trail system that allows users to access that side would be a great addition to the hiking amenity. "Trail systems with loops are appealing because they offer variety. Trail users seek the adventure of starting down one path and returning to the same point by way of a different trail. Loops let visitors enjoy trails of varying distance, difficulty, and surroundings in the same outing" (Havel 2009, 14). It is important to provide a variety

of trails to accommodate for a variety of users. Trail users can include people with walking disabilities, walkers, hikers, trail runners, endurance athletes, etc. — each of these user groups requiring different qualities and difficulties in a trail (Havel 2009). The implementation of a trail system provides an opportunity to link all programmatic elements on the site together with the benefits of naturalized shorelines.

## Day Use

Day use facilities typically include open or enclosed shelters, amphitheaters, playgrounds, beaches, or other areas available to the public within a property. Facilities can typically be reserved (and generate revenue for the property) for large group picnics, family reunions, and other events. Pottawatomie State Lake No. 2 has a day-use zone on its northern shores but does not provide much programming for site users. There is a boat ramp, bathroom facilities, and parking, but there is no available shelter for people to gather. This part of the site is very open with minimal tree cover, so there is a great opportunity to improve programming for the day-use zone while keeping sustainability and ecological functionality of the shoreline at the forefront of the design process.

## Fishing

With Largemouth Bass (*Micropterus salmoides*) being the primary sport fish targeted by shoreline and boat anglers at this lake, shoreline habitat will be designed to best suit the Largemouth Bass and its forage. According to the Kansas Department of Wildlife and Parks, Pottawatomie State Fishing Lake No. 2 has a “fair” rating of Largemouth Bass, but the population is holding steady according to the 2022 fish samples. The rating of a fish population is derived from opinion of the fisheries biologist based on site observations and numbers during sampling. Ratings range from poor, fair, good, or excellent for population and fish size (Kansas Department of Wildlife and Parks n.d.). Per Ely Sprengle, fish samples are taken by gill nets and electrofishing techniques where fish length and weight are recorded.

Largemouth Bass are arguably one of the easiest fish to catch, especially the smaller specimens (Gabelhouse et al. 1982). However, bass fishing takes skill and stealth to be successful, especially from the shore. Small bass will readily bite artificial lures (spinners, jigs, plastic worms, etc.) and natural baits (minnows, frogs, worms, and grasshoppers). Larger bass can also be caught with these methods but are more difficult to catch than smaller ones because they can easily eat prey fish like bluegill (Gabelhouse et al. 1982). Fishing for



**Figure 2.2** Largemouth Bass at Pottawatomie State Lake No. 2 (Ramage2023)

Largemouth Bass varies by season. In the winter and early spring, bass are slow and inactive due to cold water. However, late spring through fall offers good fishing opportunities near the shorelines as bass tend to relate to structure in the warm water for spawning and foraging (Gabelhouse et al. 1982).

## Largemouth Bass Habitat

Shorelines are an integral part of Largemouth Bass survival, serving as suitable places for spawning and foraging. Bass spend a majority of the year in shallow areas adjacent to shorelines (Dirks 2020). Properly vegetated shorelines provide adequate habitat that attract Largemouth Bass and their prey. “Aquatic plants serve as structural refugia that influences prey availability and provide substrate for the attachment of invertebrates that fish feed upon” (Dibble and Harrel 1997, 74). Aquatic plants, such as hardstem bulrush, create habitat for spawning fishes because they provide cover, shade, and produce oxygen in the water (Reed and Pereira 2009). Since predatory fish (such as bass) and prey fish are often attracted to the same types of structure, it allows predators to be less selective. However, within these structural habitats, there are a variety of spaces naturally created to protect prey fishes, which works to balance out the predator-prey interactions (Ahrenstorff et al. 2008).

In addition to aquatic vegetation, coarse woody debris is an integral element of habitat for Largemouth Bass. If there is coarse woody habitat near shorelines, bass will likely be in less than six feet of water and utilize the woody structure as cover (Ahrenstorff et al. 2008). Coarse woody debris naturally occurs where there are trees adjacent to the shoreline where branches fall into the water. In areas where woody debris cannot be naturally dropped in the littoral zone (the area below the waterline that is too deep for emergent vegetation), the placement of artificial brush piles ranging in depths from zero to 20 feet of water is a recommended strategy in creating year-round habitat for Largemouth Bass and their prey. Brush piles can be in the form of recycled Christmas trees or cut cedars, fallen branches, or sticks arranged to form brush piles. Evergreen trees and brush piles, although an intricate and necessary form of structure, need to be replaced every three years due to the decomposition process. Each of these methods should be weighted to ensure the structure sinks to the bottom of the lake (Bolding et al. 2001).

Artificial structure made from low and high-density polypropylene (safe for water) can be used in combination with natural structure. Unlike natural structure, artificial structure does not decompose over time. Artificial structure made from PVC must not be used as it leaches chemicals into the water over time. Brush piles create intricate spaces that attract smaller, forage fish in addition to predatory fish through the creation of large shadows (Ahrenstorff et al. 2008; Bolding et al. 2001; Dirks 2020). Therefore, it is important to understand how the sun affects structures in the water column and place them in areas where they cast the largest shadow.

Shorelines serve as spawning areas for Largemouth Bass and provide habitat for juvenile fishes. Specifically, Largemouth Bass



prefer spawning habitat that is in depths of one to four feet that provides a combination of aquatic vegetation, woody debris, sand, gravel, and large rocks (Bennett 1971; Bolding et al. 2001). Additionally, bass tend to spawn near vertical structures like docks because they provide large cover and shade (Pegg et al. 2015).

“Black basses (*Micropterus spp.*) prefer nesting near physical structure because it increases mating, hatching, and nesting success” (Sass 2009, 6). Once hatched from the spawn, juvenile bass tend to relate to habitats that provide dense cover of aquatic vegetation (water lilies and pondweed), woody debris, and fine gravel (Pegg et al 2015). Therefore, a healthy and diverse shoreline that is composed of biotic and abiotic elements is vital for the health and success of the fish population in an impoundment.

## Naturalized Shoreline Buffers

Erosion is one of the most significant causes of shoreline degradation. Erosion can be caused by chronic wave action against non-vegetated or unprotected shorelines or excess stormwater runoff from the surrounding context (Severson 2007, i). Many state recreational lakes have a high percentage of manicured grass as ground cover to provide visitors with open space for camping and other recreational activities. Due to shallow root systems, manicured grass (regularly mowed – short in height with compacted soils from regular use by people and vehicles) does very little in contributing to the stabilization of shorelines and infiltration of water into the soil – especially when mowed to the water’s edge (Tennessee Valley Authority/ TVA 2008). Erosion of shorelines and excess stormwater runoff that is not captured leads to sedimentation of an impoundment – losing 1% capacity each year in some cases (Juracek 2015). However, native vegetation can reduce the effects of erosion and sedimentation by creating a shoreline buffer (Severson 2007, i).

A properly vegetated shoreline should consist of four major zones including the littoral zone, emergent zone, riparian zone, and upland zone (Caflisch et al. 2021). **The littoral zone** is the area below the waterline that is too deep for emergent vegetation. This zone is one to four feet deep or more if the water is clear. This allows sunlight to penetrate through, which is the ideal place to have native aquatic plants (Caflisch et al. 2021). If a slope is shallower, there is more opportunity to grow aquatic plants because sunlight is able to penetrate more surface area before light can no longer reach the bottom (Gidley et al. 2012). **The emergent zone** is the part of the bank slope that is in less than twelve inches of water. This area is most suitable for native emergent aquatic plants such as rushes (*Juncus*) and arrowhead (*Sagittaria*) (Caflisch et al. 2021). **The riparian zone** is the part of the bank slope that is typically above water level but can become inundated during heavy rain events. The soil in the riparian zone is almost always saturated, except during very dry periods (Caflisch et al. 2021). “Native riparian plants protect the stream bank and shoreline from the erosive forces of moving water. The deep, extensive root structure of native grasses, shrubs,

and trees prevents erosion and undercutting of banks” (TVA 2008, 2). Due to the nature of a tight, extensive root system, native riparian vegetation acts as a filter to increase the water quality of freshwater systems by slowing runoff, filtering contaminants and sediment, and increasing infiltration (TVA 2008). **The upland zone** associated with a vegetated shoreline is the driest zone because the slope forces water to run downhill. This zone is a vital stormwater runoff buffer. The water level of the lake does not reach this level, so the plants in this zone need to be drought tolerant. Native perennials and grasses are best for this zone, although shrubs and trees can also be important as they help cool habitats along the water’s edge and create structural diversity (Caflisch et al. 2021).

The combination of these plant communities work to filter suspended sediments, contaminants, and nitrates that create algal blooms, which can be detrimental to aquatic ecosystems by threatening less tolerant species of fish (Zhu 2012). As previously stated, many man-made recreational lakes have manicured grass mowed to the water’s edge rather than vegetative buffers. The absence of native aquatic and shoreline vegetation poses health concerns for fish, because it results in a high level of suspended sediment. Disturbances along shorelines due to chronic wave action and water runoff increases the amount of suspended sediment. This is especially concerning for fish as the suspended particles are abrasive to the mucus coating on their gills, which could impede their ability to create oxygen over time from extended exposure to suspended sediment (Chapman et al. 2014). Since aquatic vegetation in the form of riparian buffers work to hold precipitation and cleanse stormwater runoff along shorelines, strategic implementation and management of these ecosystems is vital.

## Conclusion

Since Pottawatomie State Fishing Lake No. 2 is intended for recreation, it would greatly benefit from shoreline rehabilitation to improve human interaction with the shoreline and increase the diversity of habitat for target fish species like Largemouth Bass. Through this review, I have highlighted the significance of naturalized shorelines of recreational lakes, gathered research explaining habitat requirements for the Largemouth Bass, and provided the foundation of knowledge to assess the need for shoreline enhancement at Pottawatomie State Fishing Lake No. 2.



**Figure 2.3** Rock-lined shoreline at Pottawatomie State Lake No. 2 (Ramage 2023)



# CHAPTER 3

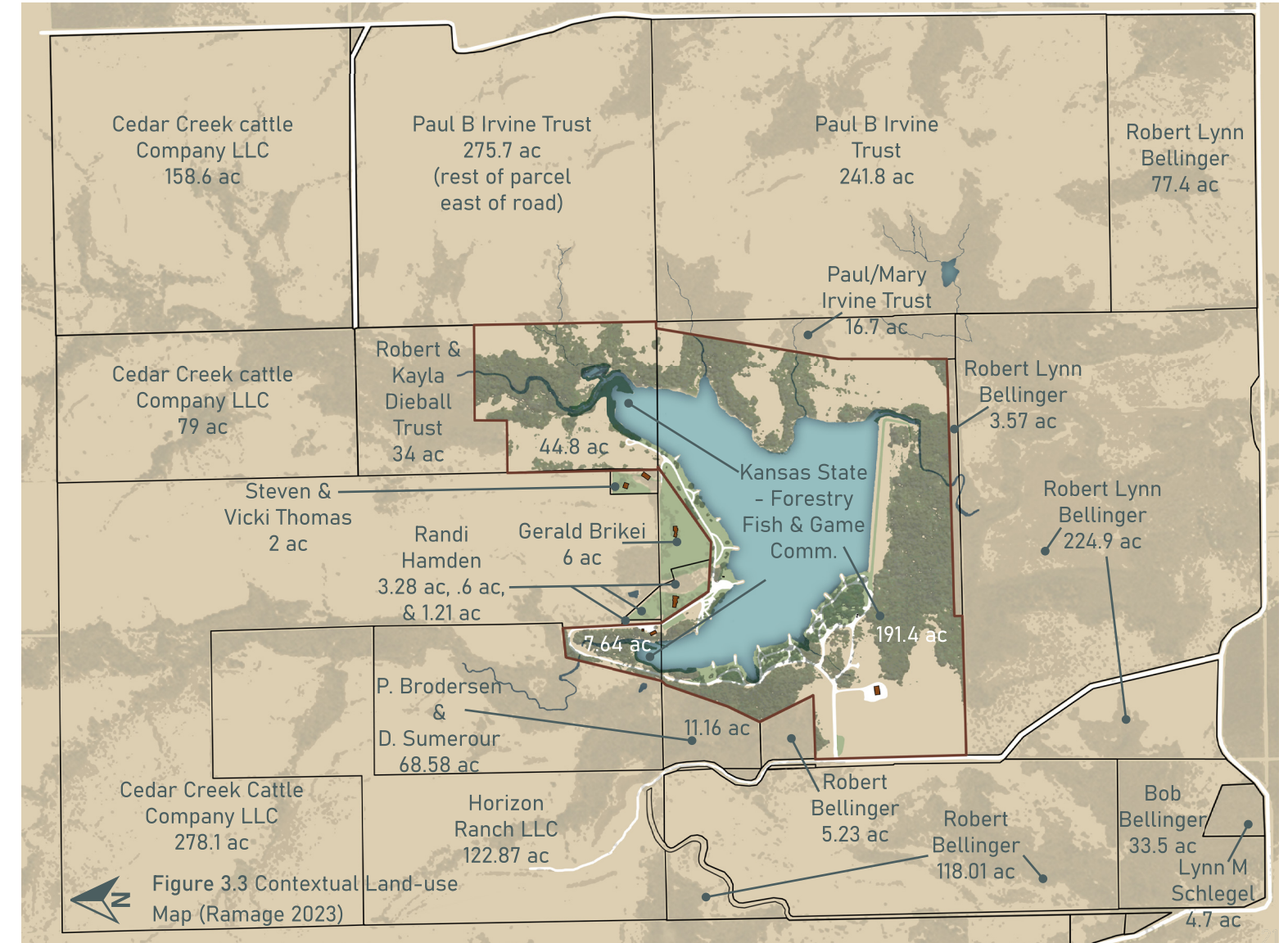
## Site Analysis



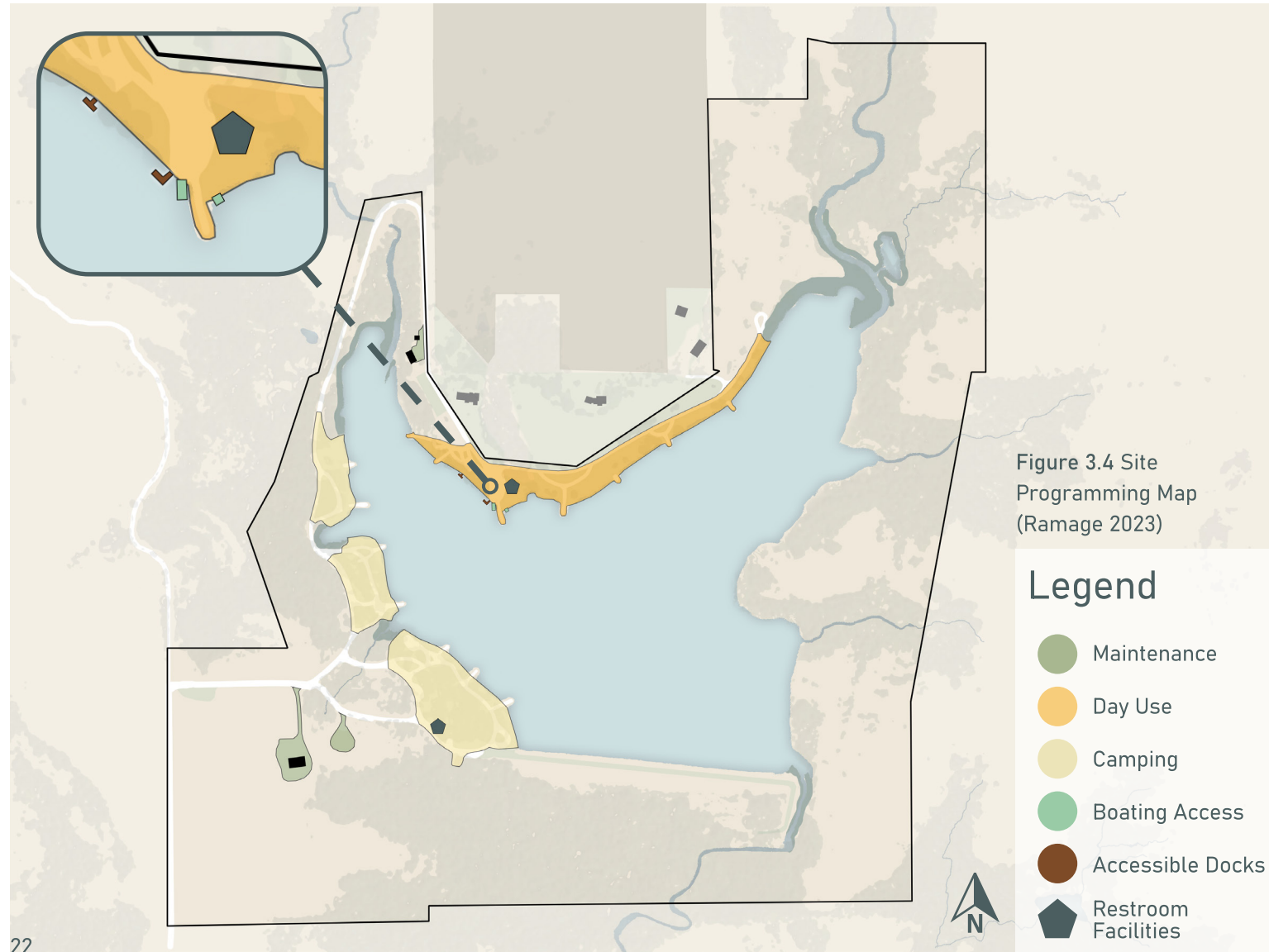
# Site Analysis

## Context

Pottawatomie State Lake No. 2 is located approximately 2.5 miles northeast of Manhattan, Kansas. The park is surrounded by large parcels of agricultural ranch land composed of tallgrass prairie, wooded drainages, and ample Eastern Red Cedar. Additionally, there are residential parcels adjacent to the northern shorelines of the park. If the Kansas Department of Wildlife and Parks wanted to expand the park in the future, surrounding parcels of land would have to be purchased from private trusts and other landowners.







## Site Analysis

### Programming

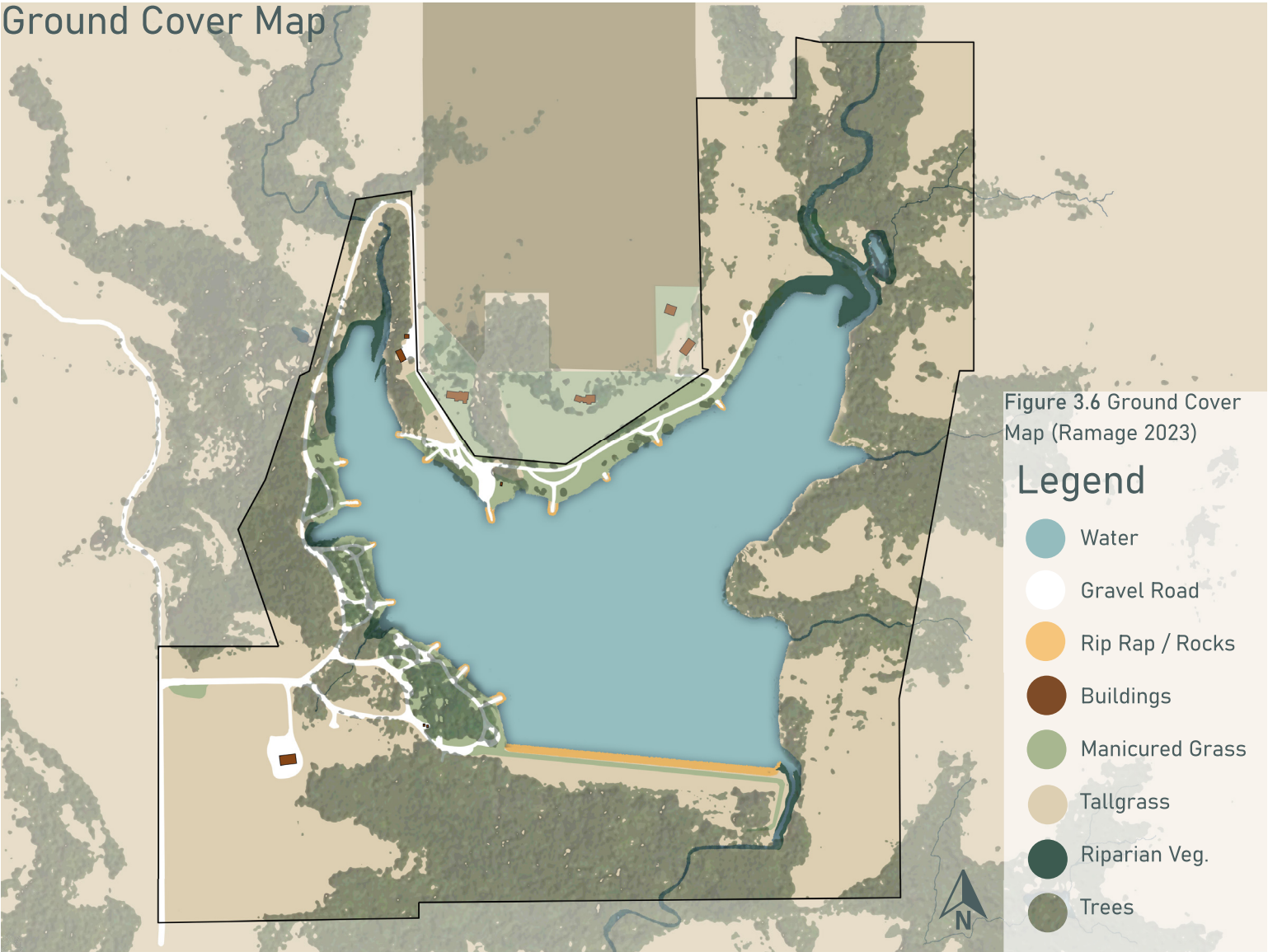
There are two maintenance buildings located on site where equipment is stored. The primary day use area is located along the northern shores of the lake and provides amenities such as accessible fishing docks, boat and kayak ramp, a restroom facility, and seven rock jetties that allow people direct access to deeper water. There are residential properties adjacent to the day use area, which is a good reason to maintain that use rather than plan for it to transform into campsites. The current camping zone consists of three sections. The primary camping area is located in the southwest corner by the dam. This is where the second restroom facility can be found on site. The park is restricted to informal tent camping on the west side of the lake. The benefit of keeping the camping designated to this zone is that there are a large number of established trees to keep people comfortable during the summer. No camping is allowed in the day use area. As seen in the image on the right, visitors are able to set up camp wherever they would like, which leads to trampling of vegetation.



Figure 3.5 Shoreline Camping  
Photo (Ramage 2023)



# Ground Cover Map

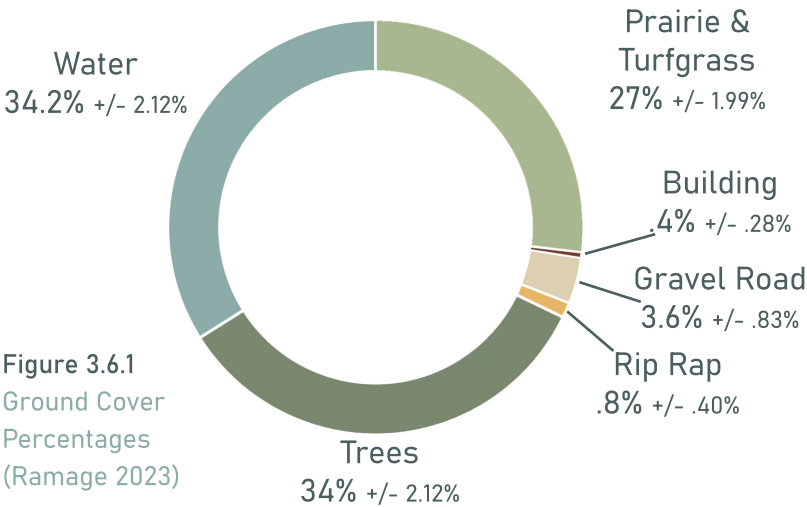
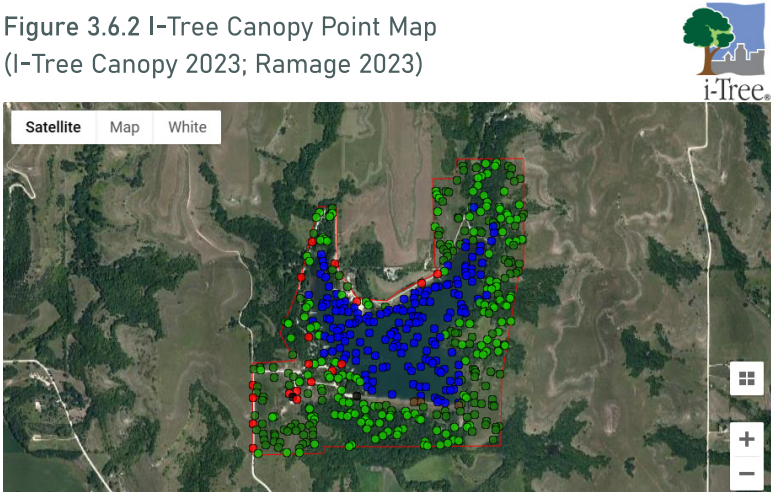


# Site Analysis

## Ground Cover and I-Tree Canopy

This analysis was conducted to gain a basic understanding of the area of existing ground covers. I-Tree Canopy is a software that allows users to accurately estimate (95% confidence) tree canopy coverage in addition to ground covers such as grass and water. This tool randomly generates points within a site boundary created by the user, and the user assigns the point to a classification of tree, water, rocks, etc. 500-1,000 data points are suggested for accurate calculations. Once completed, I-Tree Canopy calculates the percent of coverage for each class as well as tree benefits for the respective site.

Figure 3.6.2 I-Tree Canopy Point Map (I-Tree Canopy 2023; Ramage 2023)



For this assessment, 500 randomly generated points were assigned to a category within the site boundary. Upon calculation, I-Tree Canopy estimated **annual removal** of 74 lbs per acre of Carbon Monoxide, 403 lbs per acre of Nitrogen Dioxide, 4,058 lbs per acre of Ozone, and 256 lbs per acre of Sulfur Dioxide. Additionally, the trees on site contribute to annually avoiding 18 gallons per acre of runoff. The trees within the park intercept an average of 3,095 gallons of stormwater per acre each year. With only 34% canopy coverage, more trees can be planted to improve the environmental benefits of the park.





Figure 3.7 Panoramic View of Pottawatomie State Lake No. 2 (Ramage 2023)

# Site Analysis

## Existing Shoreline Conditions and Analysis

The shoreline condition analysis was completed in November 2022. A limitation of this analysis is that the research was conducted in late fall, which means most signs of aquatic vegetation were freeze killed. Additionally, there is no bathymetric map (contours of lake bottom), so visual classifications for the slope adjacent to the shoreline had to be made. The shoreline was divided into nine zones based on similarities of characteristics and condition.



Figure 3.8 Shoreline Zone Map (Ramage 2023)

## Decision of Criteria to Examine

The literature review served as a foundation of knowledge for the observation of possible issues and opportunities throughout the site analysis and design process. The criteria examined include the average degree of shoreline erosion, lake bottom slope, immediate shoreline cover, the presence of vegetation, coarse woody debris, and if docks and rock jetties were found within each zone.

The degree of shoreline erosion indicates the severity of design interventions needed to resolve the problem. The lake bottom slope dictates the possibility of aquatic vegetation growth, and the suitability for habitat implementation. Immediate shoreline ground cover typically corresponds with severity of erosion. Inventorying existing aquatic, emergent, and riparian vegetation indicates the need for vegetated buffers in each zone. The presence of docks and rock jetties in each zone reveals the diversity of aquatic habitat structure that already exists within the lake from these features.



Average degree of shoreline erosion	Tier 0 No significant signs	Tier 1 erosion 0-1 ft drop	Tier 2 erosion 1-2 ft drop	Tier 3 erosion 2-3 ft drop	Tier 4 erosion 3+ ft drop
Typical Lake bottom slope (visual)	Shallow	gradual	Semi-steep	steep	
Immediate Shoreline cover	turfgrass	Riprap/ boulder	gravel	non-manicured vegetation	Other (Specify)
Aquatic vegetation	none	minimal	Semi-dense	dense	
Emergent Vegetation	none	minimal	Semi-dense	dense	
Riparian vegetation	none	minimal	Semi-dense	dense	
Visible coarse woody debris	none	minimal	Semi-dense	dense	
Dock	Yes	No		Table 1 Shoreline Analysis Criteria (Ramage 2023)	
Rock Jetty	Yes	No			

# Site Analysis

## Existing Shoreline Conditions and Analysis - Criteria

**Typical Lake Bottom Slope Classification** (visual distance standing at water’s edge)

- Shallow - Lake floor visible 15+ ft out from shoreline
- Gradual - Lake floor visible 10-14 ft out from shoreline
- Semi-steep - Lake floor visible 6-9 ft out from shoreline
- Steep - Lake floor visible 0-5 ft out from shoreline

**Vegetation Criteria** (for aquatic, emergent, and riparian)

- None - No vegetation present in this zone.
- Minimal - Vegetation is present in this zone, but it only covers a small portion of the shoreline.
- Semi-Dense - Approximately half of the total length of shoreline in this zone is vegetated.
- Dense - More than half of the total length of shoreline in this zone is vegetated.

**Visible Coarse Woody Debris Criteria**

- None - (0% coverage) No coarse woody debris is visible in this zone.
- Minimal - (25% coverage) Coarse woody debris is limited to small, submerged branches.
- Semi-Dense - (50% coverage) Coarse woody debris ranges from small to medium sized branches.
- Dense - (75% + coverage) Coarse woody debris is plentiful and ranges from small to large branches or partial trees varying in form.

Notes: 1) The goal of this analysis is to classify each zone’s visual severity of shoreline conditions and opportunities to further explore in the projective design. 2) Without a bathymetric map or detailed topography, or access to accurately measure water depths, visual estimations had to be made for shoreline slopes. 3) All graphic sections in this chapter are not to scale, but are proportional based on the overlay of site images. 4) All photographs that correlate with shoreline zones were taken by the author in Fall or Winter 2022 unless otherwise noted.

Shoreline Criteria for Zone 1

Average Degree of Shoreline Bank Erosion	● Tier 1 erosion (0-1 ft drop)
Typical Lake Bottom Slope (visual)	●●●●●●● Shallow
Immediate Shoreline Cover	●●●●●●●●●●●●● Mowed turf grass and gravel
Aquatic Vegetation	●●●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●●●● None
Visible Coarse Woody Debris	●●●●●●●●●●● Minimal (25% coverage)
Dock	●●●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●●●● Yes

Site Analysis

Zone 1

Summary

Zone 1 exhibits shoreline bank erosion up to one foot in height, accompanied by a shallow near shore lake bottom. The immediate shoreline is covered by manicured grass and exposed gravel. There are no signs of emergent or riparian vegetation. Additionally, there is minimal coarse woody debris to contribute to aquatic habitat. Zone 1 has three rock jetties that allow visitors to access deeper water. However, these jetties are not wheelchair accessible, limiting shoreline experiences for those with disabilities. Trees adjacent to the shoreline are in poor condition and are nearing replacement age.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to stabilize the shoreline.
- Maintain shoreline access points within vegetated buffers to provide variety for anglers and visitors.
- Re-finish rock jetties to allow for wheelchair accessibility.
- Connect campsites to the shoreline through the implementation of designated pedestrian trails.
- Strategically place small to large rocks and other natural and artificial Largemouth Bass habitat.
- Establish vegetated fiber rolls along eroded shoreline to reduce degradation.







Some trees near the shoreline are in poor condition.



There is manicured grass up to the water's edge.



There is opportunity to establish diverse aquatic habitat due to the shallow lake bottom.



The shoreline is very bleak in most places. A vegetated buffer would liven up the water's edge.



The majority of the shoreline in Zone 1 has a one-foot drop off due to erosion.

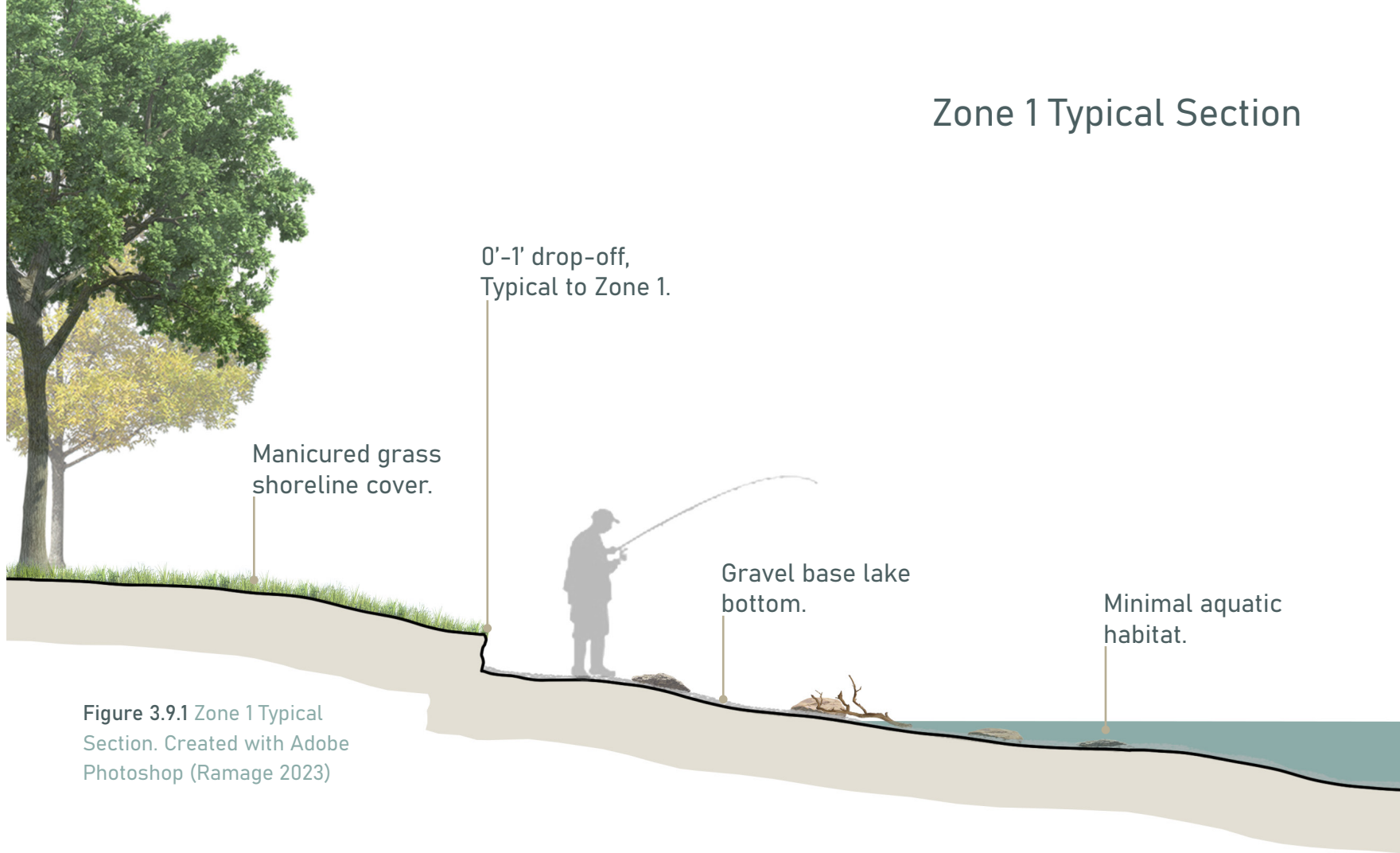


Figure 3.9.1 Zone 1 Typical Section. Created with Adobe Photoshop (Ramage 2023)



Shoreline Criteria for Zone 2

Average Degree of Shoreline Bank Erosion	● Tier 4 erosion (3+ ft drop)
Typical Lake Bottom Slope (visual)	●●●●●● Gradual
Immediate Shoreline Cover	●●●●●●●●●● Mowed turf grass
Aquatic Vegetation	●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●● None
Visible Coarse Woody Debris	●●●●●●●●●● Minimal (25% coverage)
Dock	●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●● No

Site Analysis

Zone 2

Summary

Zone 2 is unsafe as it exhibits shoreline bank erosion that exceeds three feet in height along the most severe stretch accompanied by a gradual near shore lake bottom. The immediate shoreline is covered by manicured grass. There are signs of gully formation beginning to occur. There are no signs of emergent vegetation, but there is riparian vegetation in the cove in this zone that shows signs of burn management. Additionally, there is minimal coarse woody debris to contribute to aquatic habitat. Zone 2 does not have any rock jetties.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to stabilize the shoreline.
- Maintain shoreline access points within vegetated buffers to provide variety for anglers and visitors.
- Design a retaining system that stabilizes the shoreline and allows for shoreline access.
- Connect campsites to the shoreline through the implementation of designated pedestrian trails.
- Strategically place small to large rocks and other natural and artificial Largemouth Bass habitat.







There is an unsafe dropoff to the water in this zone.



There are signs of erosion and gullies starting to form.



The cove in this zone is densely vegetated and shows signs of burn management.



The majority of the shoreline in this zone is severely degraded and has minimal aquatic habitat.



The lake floor is a gradual slope that drops off to deeper water about twelve feet from shore.

# Zone 2 Typical Section

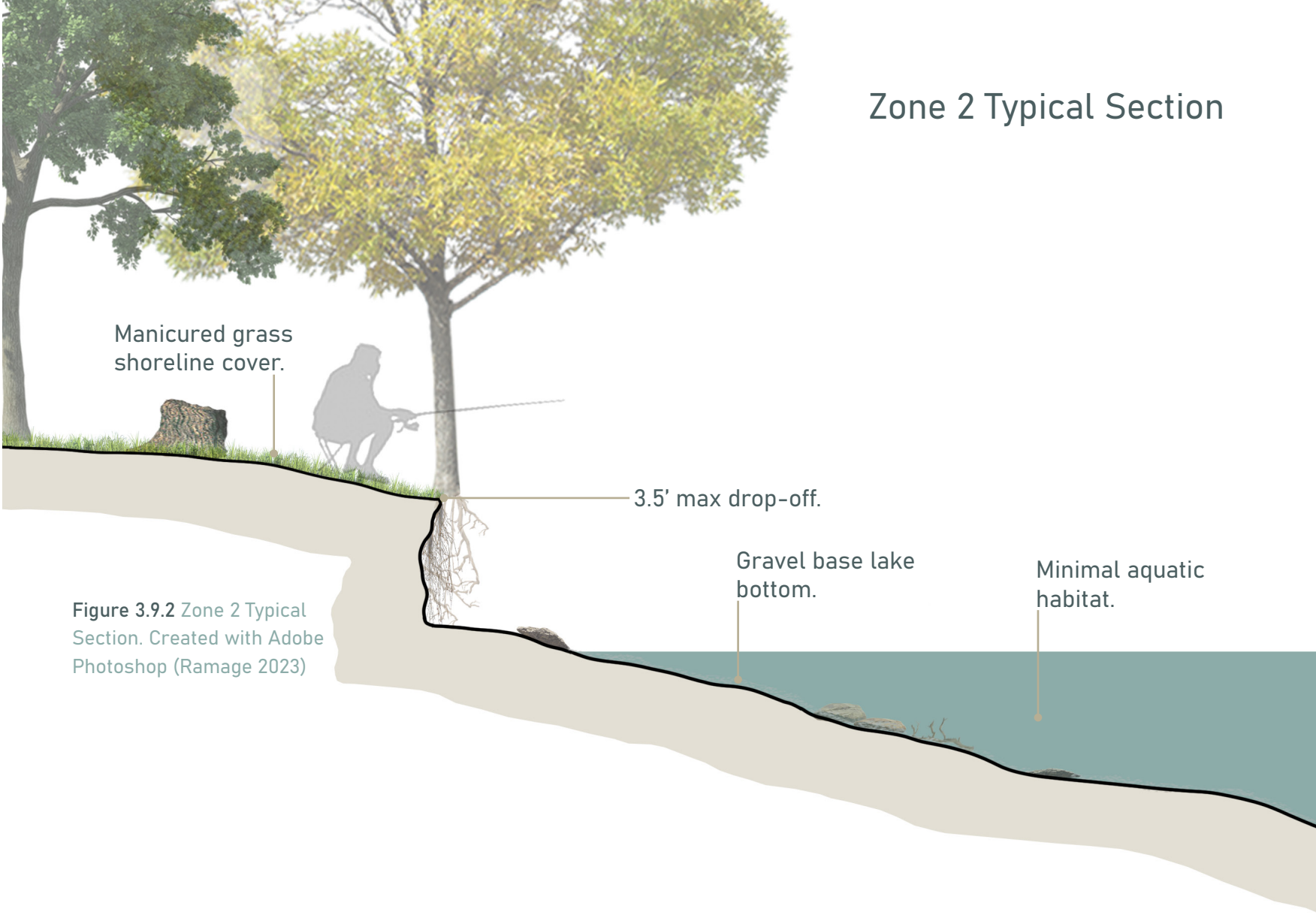


Figure 3.9.2 Zone 2 Typical Section. Created with Adobe Photoshop (Ramage 2023)



Shoreline Criteria for Zone 3

Average Degree of Shoreline Bank Erosion	● Tier 2 erosion ( 1-2 ft drop )
Typical Lake Bottom Slope (visual)	●●●●●●● Shallow
Immediate Shoreline Cover	●●●●●●●●●●●●● Mowed turf grass and gravel
Aquatic Vegetation	●●●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●●●● None
Visible Coarse Woody Debris	●●●●●●●●●●●●● Semi-dense (50% coverage)
Dock	●●●●●●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●●●●●●● Yes

Site Analysis

Zone 3

Summary

Zone 3 exhibits shoreline bank erosion up to two feet in height, accompanied by a shallow lake bottom. The immediate shoreline is covered by manicured grass and exposed gravel. There are no signs of emergent vegetation, but there is minimal established riparian vegetation. Additionally, there is dense coarse woody debris to contribute to aquatic habitat. Zone 3 has four rock jetties that allow visitors to access deeper water. However, these jetties are not wheelchair accessible, limiting shoreline experiences for those with disabilities. There are signs of beavers in Zone 3.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to stabilize the shoreline.
- Maintain shoreline access points within vegetated buffers to provide variety for anglers and visitors.
- Establish vegetated fiber rolls along eroded shoreline to reduce degradation.
- Connect campsites to the shoreline through the implementation of designated pedestrian trails.
- Place rocks to armor the shoreline from chronic wave action.
- Re-finish rock jetties to allow for wheelchair accessibility.







There is a variety of coarse woody debris in this zone.



There is evidence of beavers in this zone.



Beavers help contribute coarse woody debris in the littoral zone.



Manicured turf up to the water's edge does very little to stabilize the shoreline.



Coarse woody debris is present but is not accompanied by any other type of habitat structure other than rock jetties.

## Zone 3 Typical Section

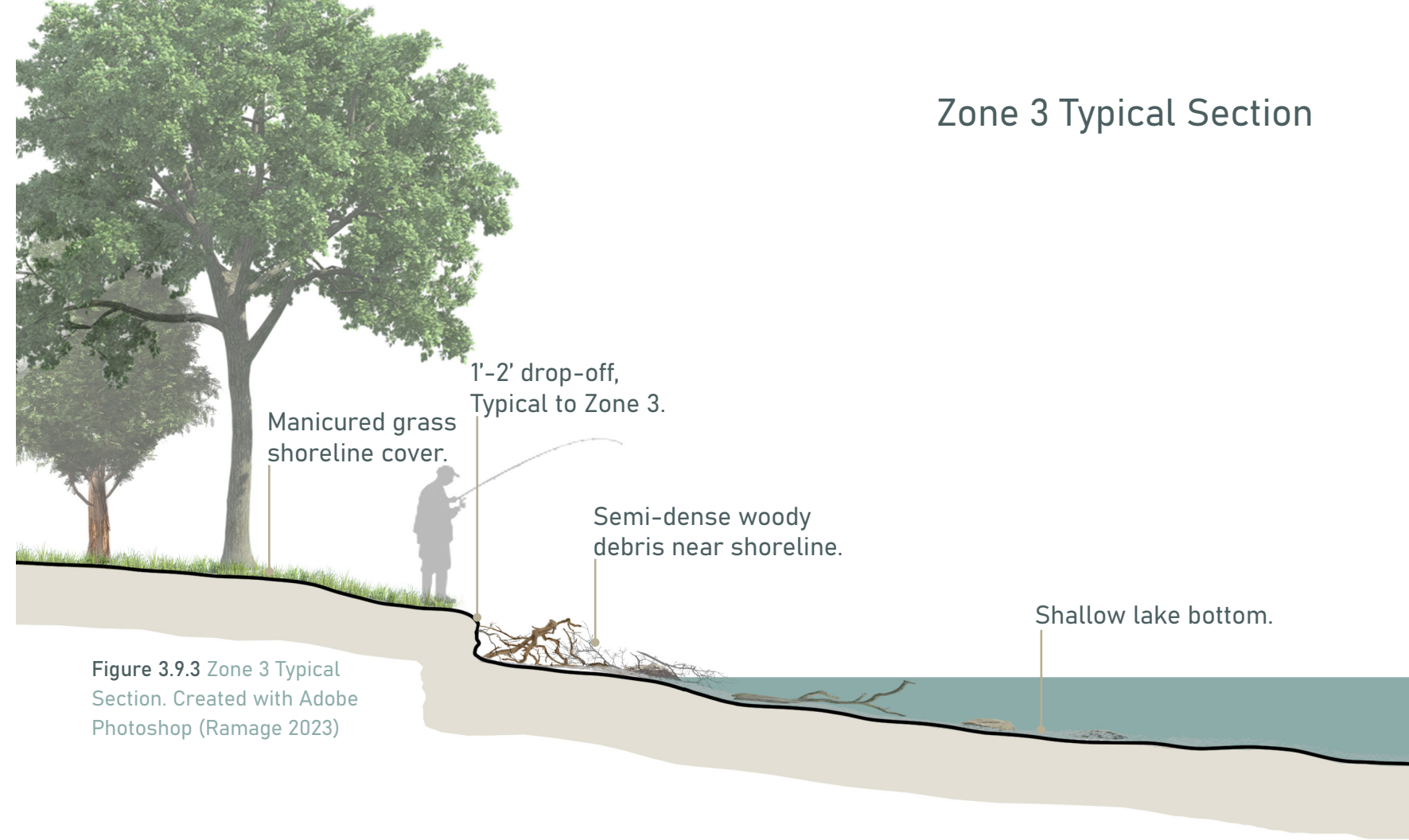


Figure 3.9.3 Zone 3 Typical Section. Created with Adobe Photoshop (Ramage 2023)



Shoreline Criteria for Zone 4

Average Degree of Shoreline Bank Erosion	● Tier 0 erosion (No significant signs)
Typical Lake Bottom Slope (visual)	●●●●●●● Shallow
Immediate Shoreline Cover	●●●●●●●●●●●●● Non-manicured vegetation
Aquatic Vegetation	●●●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●●●● Dense
Visible Coarse Woody Debris	●●●●●●●●●●●●● Semi-dense (50% coverage)
Dock	●●●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●●●● No

Site Analysis

Zone 4

Summary

Zone 4 does not show any signs of shoreline bank erosion and has a shallow lake bottom. The immediate shoreline is non-manicured vegetation. There are no signs of emergent vegetation, but there is dense established riparian vegetation. Additionally, there is semi-dense coarse woody debris to contribute to aquatic habitat. Zone 4 is affected by fluctuating water levels, temporarily experiencing low-water levels. One of the two main creek inlets of the lake are in Zone 4. No camping is allowed past this zone.

Opportunities to Explore in Projective Design

- Establish emergent, riparian and upland vegetation to broaden the shoreline buffer.
- Establish wetland conditions to cleanse water from the creek inlet and to provide habitat.
- Design wetland observation blind to allow for wildlife observation opportunities for visitors.
- Explore the feasibility of creating wildlife islands to diversify habitat and help keep nesting birds safe from predators.
- Connect accessible trail loop with a wetland boardwalk.







The image on the left shows Zone 4 prior to the low water level. In its naturally marshy state, there is an opportunity to establish wetlands to attract other types of wildlife like ducks, geese, frogs, and turtles. Additionally, establishing a diversity of wetland vegetation will help filter water as it enters the lake from the creek intermittently flowing into this zone. Rather than dredge out the sediments in this area, it is important to establish thriving wetlands on the site. Preserving some areas as mudflats can continue to provide important habitat to a variety of wildlife.



The western shore of Zone 4 is bluff-like and is densely vegetated.



There is an established vegetated buffer in this zone which is prohibited to camping.



The low water level shows the degree of sedimentation and opportunity for wetland development in this zone.

## Zone 4 Typical Section

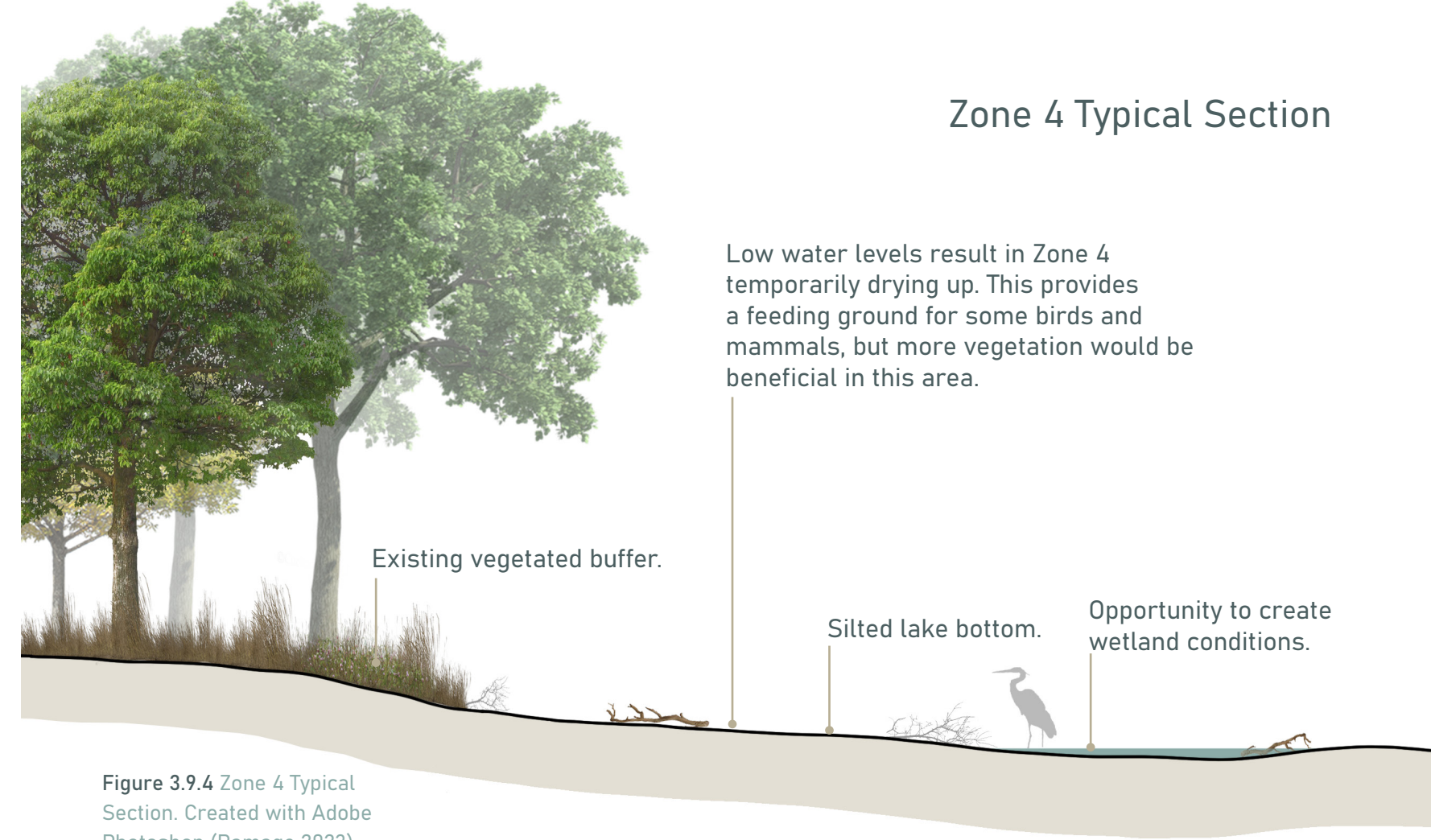


Figure 3.9.4 Zone 4 Typical Section. Created with Adobe Photoshop (Ramage 2023)



## Shoreline Criteria for Zone 5

Average Degree of Shoreline Bank Erosion	Tier 2 erosion (1-2 ft drop)
Typical Lake Bottom Slope (visual)	Gradual to semi-steep
Immediate Shoreline Cover	Manicured turf grass, rip rap, docks
Aquatic Vegetation	None visible due to winter freeze
Emergent Vegetation	None visible at the time of analysis
Riparian Vegetation	Minimal
Visible Coarse Woody Debris	None (0% coverage)
Dock	Yes
Rock Jetty	Yes

# Site Analysis

## Zone 5

## Summary

Zone 5 exhibits shoreline bank erosion up to two feet in height, accompanied by a gradual and semi-steep lake bottom (near docks and boat ramp). The immediate shoreline is covered by manicured grass, rip rap, and docks. There are no signs of emergent vegetation, but there is minimal established riparian vegetation. Additionally, there is dense coarse woody debris to contribute to aquatic habitat. Zone 5 has three rock jetties that are not wheelchair accessible, limiting shoreline experiences for those with disabilities. There are two wheelchair accessible docks in Zone 5 as well as a few ADA parking spaces.

## Opportunities to Explore in Projective Design

Establish littoral, emergent, riparian and upland vegetation to stabilize the shoreline.

Capitalize on docks as habitat structure by placing natural and artificial brush piles and littoral vegetation.



Maintain shoreline access points within vegetated buffer to provide variety for anglers and visitors.

Re-finish rock jetties to allow for wheelchair accessibility.





Some gravel roads in this zone are unnecessary and can be converted into a vegetated buffer.



There is an existing 40'x22' concrete pad in this zone that can support a gathering beneath a pavilion.



The intent for this area of Zone 5 is to improve the vegetated buffer, but maintain the shoreline how it is and let nature take its course.



The rock pier and boat ramp are severely dilapidated and are in need of repair.



There is ADA parking and accessible docks in Zone 5. There are opportunities in other zones to design more accommodating areas and experiences.

## Zone 5 Typical Section

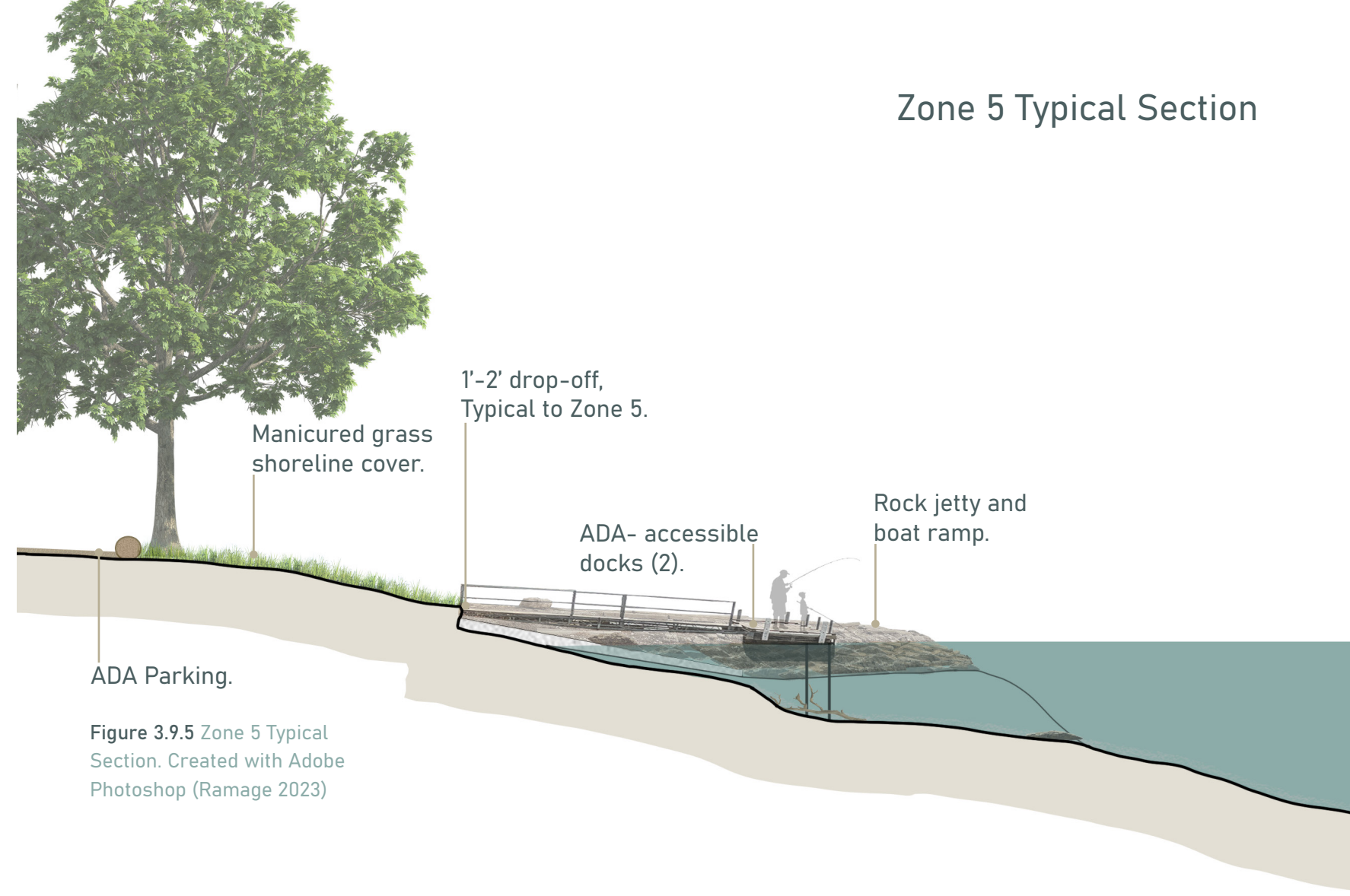


Figure 3.9.5 Zone 5 Typical Section. Created with Adobe Photoshop (Ramage 2023)



Shoreline Criteria for Zone 6

Average Degree of Shoreline Bank Erosion	● Tier 3 erosion (2-3 ft drop)
Typical Lake Bottom Slope (visual)	●●●●●●● Semi-steep
Immediate Shoreline Cover	●●●●●●●●●●●●● Mowed turf grass
Aquatic Vegetation	●●●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●●●● Minimal
Visible Coarse Woody Debris	●●●●●●●●●●●●● Semi-dense (50% coverage)
Dock	●●●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●●●● Yes

Site Analysis

Zone 6

Summary

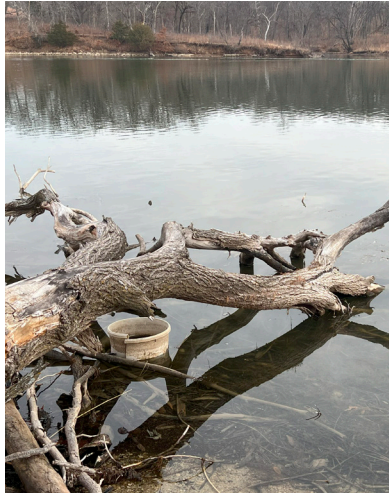
Zone 6 exhibits shoreline bank erosion up to three feet in height, and typically has a semi-steep lake bottom. The immediate shoreline is covered by manicured grass. There are no signs of emergent vegetation, and there is minimal established riparian vegetation. Additionally, there is semi-dense coarse woody debris to contribute to aquatic habitat. Zone 6 has four rock jetties that are not wheelchair accessible, limiting shoreline experiences far those with disabilities.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to stabilize the shoreline.
- Design a retaining system that stabilizes the shoreline and allows for shoreline access.
- Place rocks, trees, shrubs, and other vegetation to armor the shoreline from chronic wave action.
- Explore the possibility of implementing a swimming beach on the west side of Zone 6 in the cove.
- Plan for communal pavilions in Zone 6 to allow spaces for people to gather.
- Re-finish rock jetties to allow for wheelchair accessibility.







Large fallen trees are left along the shoreline to provide habitat, but there is a lack of diversity of habitat.



There are three existing 10'x14' concrete pads that can be used for picnic tables or new pavilions.



There are signs of burn management in the cove of Zone 6.

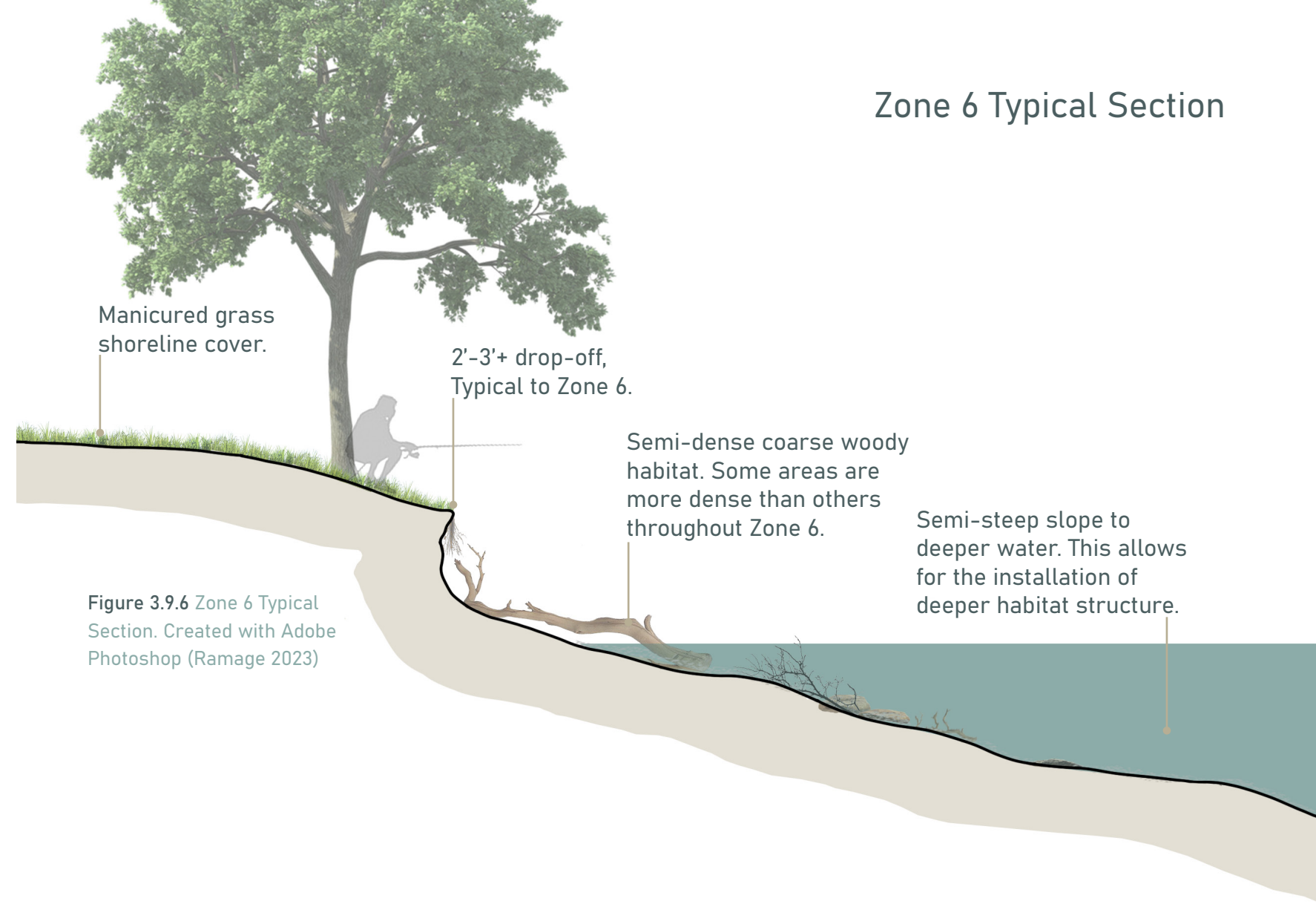


Trees like the one in the image above should be cut or trimmed when they are deemed a hazard and used as habitat structure around the lake.



This area of shoreline is a hazard to day-use visitors and needs to be reconstructed. In this instance, a tiered boulder wall with a vegetated buffer may be a suitable approach.

## Zone 6 Typical Section





Shoreline Criteria for Zone 7

Average Degree of Shoreline Bank Erosion	● Tier 0 erosion (No significant signs)
Typical Lake Bottom Slope (visual)	●●●●●●● Shallow
Immediate Shoreline Cover	●●●●●●●●●●●●● Mowed turf grass and non-manicured vegetation
Aquatic Vegetation	●●●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●●●● Dense
Visible Coarse Woody Debris	●●●●●●●●●●●● Dense (75%+ coverage)
Dock	●●●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●●●● No

Site Analysis

Zone 7

Summary

Zone 7 does not show any signs of shoreline bank erosion and has a shallow lake bottom. The immediate shoreline is covered partially by manicured grass and primarily non-manicured vegetation. There are no signs of emergent vegetation, but there is dense established riparian vegetation. Additionally, there is dense coarse woody debris to contribute to aquatic habitat. Zone 7 includes a primary creek inlet and this area of the lake has important wetland qualities. During site visits, most of Zone 7 was not accessible, therefore visual estimations were made at a distance from the edge of Zone 6.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to expand the wetland qualities.
- Design a wetland boardwalk to link hiking trails to a primary accessible path.
- Plan for a wetland observation blind to provide wildlife observation experiences for visitors.



Minimize trails throughout substantial areas of existing vegetation within and near this zone to avoid disturbance to wildlife (especially for birds and small mammals that build nests in the wetlands and nearby upland areas).



Existing dense woody debris and riparian vegetation reduces the amount rehabilitation treatments needed in Zone 7.



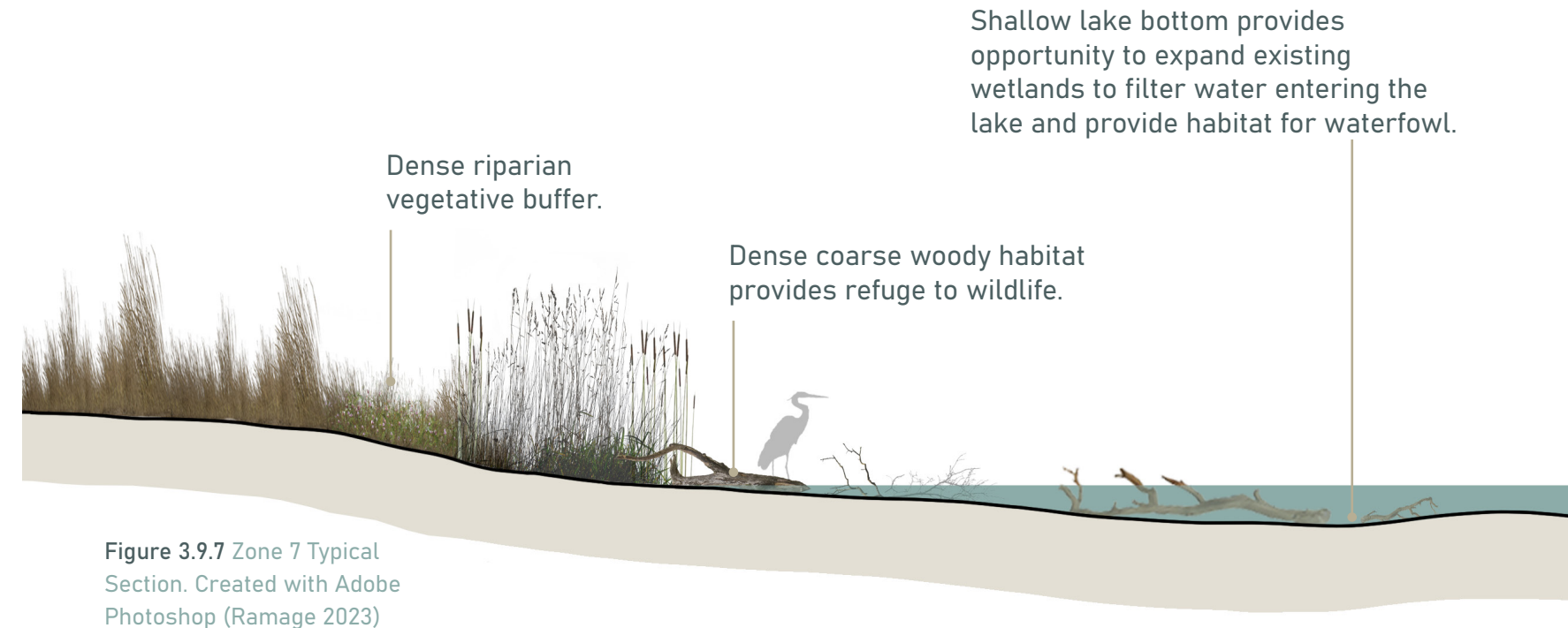
Although Zone 7 is not as silted as Zone 4, there are signs of sedimentation and shallow areas near the inlet likely due to erosion in the watershed.

Zone 7 is one of the two main creek inlets into the lake. The Kansas Department of Wildlife and Parks designated land to the north of the shoreline as a special events area (implied/assumed, but not confirmed, as the area for occasional youth hunts), and it is under lock and gate. However, the riparian wetland conditions in this zone can be expanded to provide unique user experiences. This is a crucial link for the creation of a trail loop around the lake for users to enjoy. This zone is heavily vegetated with riparian, woodland, and upland tallgrass conditions, which provides opportunity for wildlife observation. For wildlife conservation purposes, keeping good portions of this area off-limits to people is wise.



The eastern shoreline of Zone 7 is heavily wooded. This is beneficial to the stability of the shoreline.

## Zone 7 Typical Section



Shoreline Criteria for Zone 8

Average Degree of Shoreline Bank Erosion	● Tier 2 erosion (1-2 ft drop)
Typical Lake Bottom Slope (visual)	●●●●●●● Shallow
Immediate Shoreline Cover	●●●●●●●●●●●●● Non-manicured vegetation
Aquatic Vegetation	●●●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●●●● Dense
Visible Coarse Woody Debris	●●●●●●●●●● Minimal (25% coverage)
Dock	●●●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●●●● No

Site Analysis

Zone 8

Summary

Zone 8 exhibits shoreline bank erosion up to two feet in height, and typically has a shallow lake bottom. The immediate shoreline is covered by manicured grass. There are no signs of emergent vegetation, but there is dense riparian vegetation. There is minimal coarse woody debris to contribute to aquatic habitat. During site visits, only the southern third of Zone 8 was accessible. I did not access the area past the cove near the middle of the zone. Therefore, in addition to visual observations from Zone 6, assumptions had to be made that the same shoreline characteristics exist in the central and northern area of Zone 8.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to stabilize the shoreline.
- Establish vegetated fiber rolls along eroded shoreline to reduce degradation.
- Place rocks and native willow cuttings to armor the shoreline from chronic wave action.

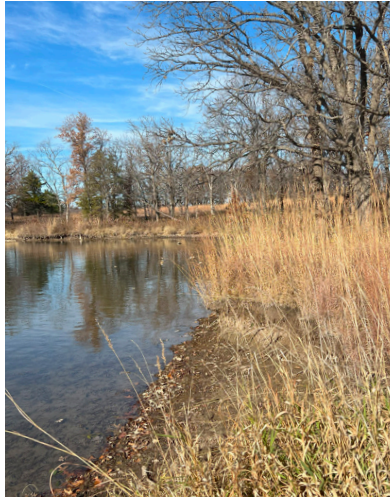


- Design secondary trails that branch off from the primary hiking trail to allow access to designated shoreline access points to minimize trampling.
- Explore the need for dredging specific areas in the southern part of Zone 8 to provide deeper aquatic habitat. Do not dredge in the central and northern parts of the zone.





Native tallgrass and rocks at the water's edge stabilize the soil and minimize sedimentation.



There are erosive drop-offs at the water's edge. Fiber rolls would help reduce erosion.



Wooded areas have more established riparian plants with fewer grasses and forbs.

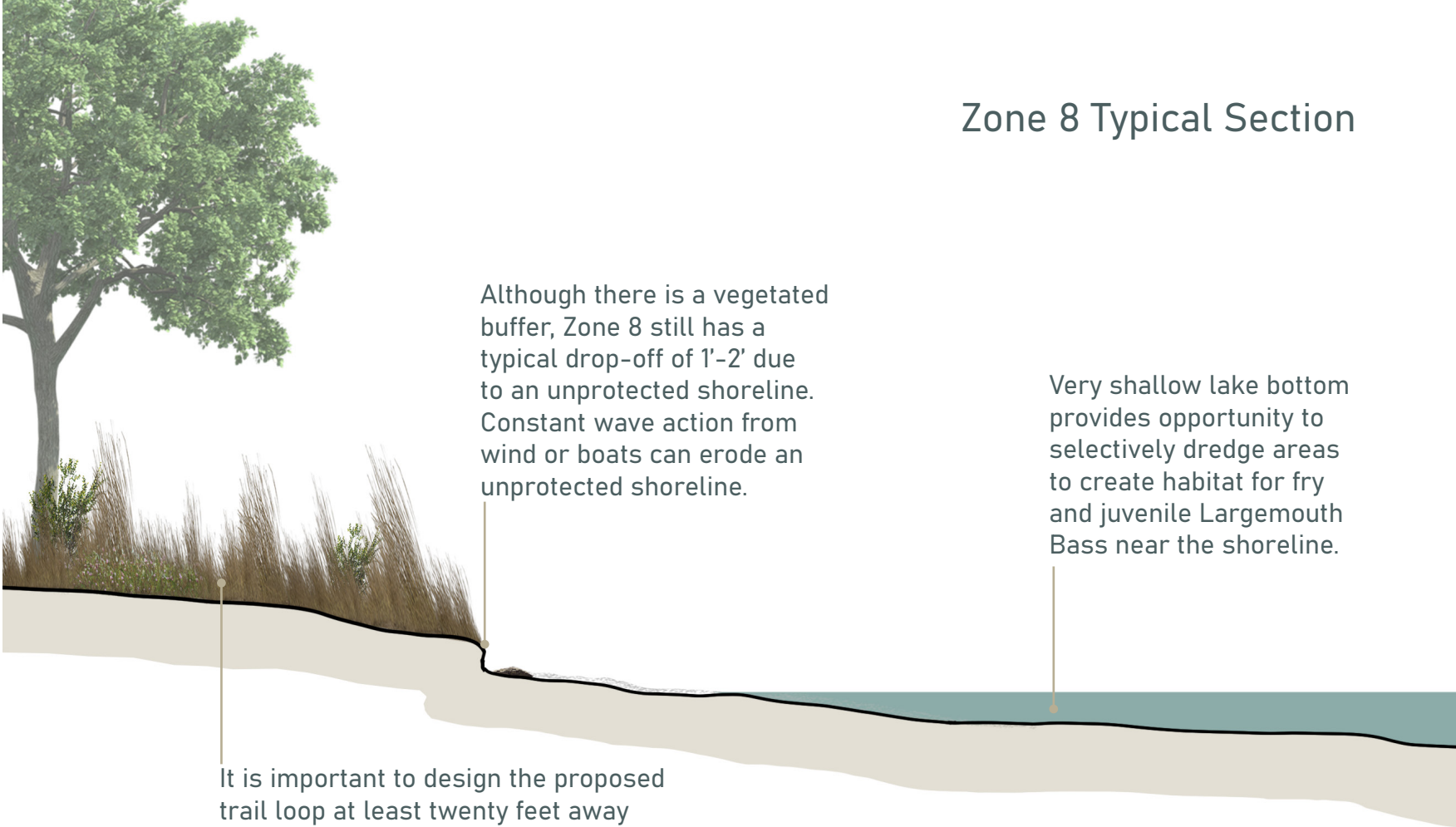


The lake bottom is very shallow in Zone 8. Dredging in selective areas would allow for opportunities to establish habitat, especially for juvenile Largemouth Bass.



There is a lack of rocks and structural habitat diversity along the shoreline in Zone 8.

# Zone 8 Typical Section



Although there is a vegetated buffer, Zone 8 still has a typical drop-off of 1'-2' due to an unprotected shoreline. Constant wave action from wind or boats can erode an unprotected shoreline.

Very shallow lake bottom provides opportunity to selectively dredge areas to create habitat for fry and juvenile Largemouth Bass near the shoreline.

It is important to design the proposed trail loop at least twenty feet away from the vegetated buffer (if grading allows) to prevent excess trampling of shoreline cover.

Figure 3.9.8 Zone 8 Typical Section. Created with Adobe Photoshop (Ramage 2023)



Shoreline Criteria for Zone 9

Average Degree of Shoreline Bank Erosion	● Tier 0 erosion (No significant signs)
Typical Lake Bottom Slope (visual)	●●●●●● Steep
Immediate Shoreline Cover	●●●●●●●●●● Rip rap and non-manicured vegetation
Aquatic Vegetation	●●●●●●●●●●●●●● None visible due to winter freeze
Emergent Vegetation	●●●●●●●●●●●●●● None visible at the time of analysis
Riparian Vegetation	●●●●●●●●●●●●●● None
Visible Coarse Woody Debris	●●●●●●●●●● Minimal (25% coverage)
Dock	●●●●●●●●●●●●●●●●●● No
Rock Jetty	●●●●●●●●●●●●●●●●●● No

Site Analysis

Zone 9

Summary

Zone 9 does not show any signs of shoreline bank erosion and has a steep near shore lake bottom. The immediate shoreline is covered by rip rap and non-manicured vegetation. There are no signs of emergent or riparian vegetation. There is minimal coarse woody debris to contribute to aquatic habitat. There is informal access to the water’s edge if visitors choose to traverse down the rock-faced slope. There are saplings and woody shrubs that need to be cut and killed to prevent structural damage to the dam.

Opportunities to Explore in Projective Design

- Establish littoral, emergent, riparian and upland vegetation to improve shoreline habitat.
- Make the crest of the dam wheelchair accessible to link the ADA loop trail to the east side of the lake.
- Establish deeper aquatic habitat by placing artificial brush piles for Largemouth Bass.



- Maintain informal shoreline access points along the dam to provide a variety of fishing and observation opportunities for anglers and others.
- Do not allow trees and large shrubs to grow on the dam to help maintain its structural integrity. This may require clipping and spot-treating woody plants with a safe, appropriate herbicide.



The dam is armored with large rocks and established tallgrasses. The lake bottom drops off quickly from the face of the dam to deeper water.



There are tree saplings establishing on the dam that need to be removed before they create issues and compromise the dam's structural integrity (Nebraska Department of Natural Resources n.d.). The design intent for the projective design regarding the dam is to establish an accessible trail along the crest to allow people of all abilities to experience the east side of the lake. Additionally, there are existing areas that allow people to get to the water's edge along the dam, which will remain available to site users in the projective design. Structural diversity in aquatic habitat will be important to establish along the area of the dam to provide multi-seasonal habitat for Largemouth Bass.

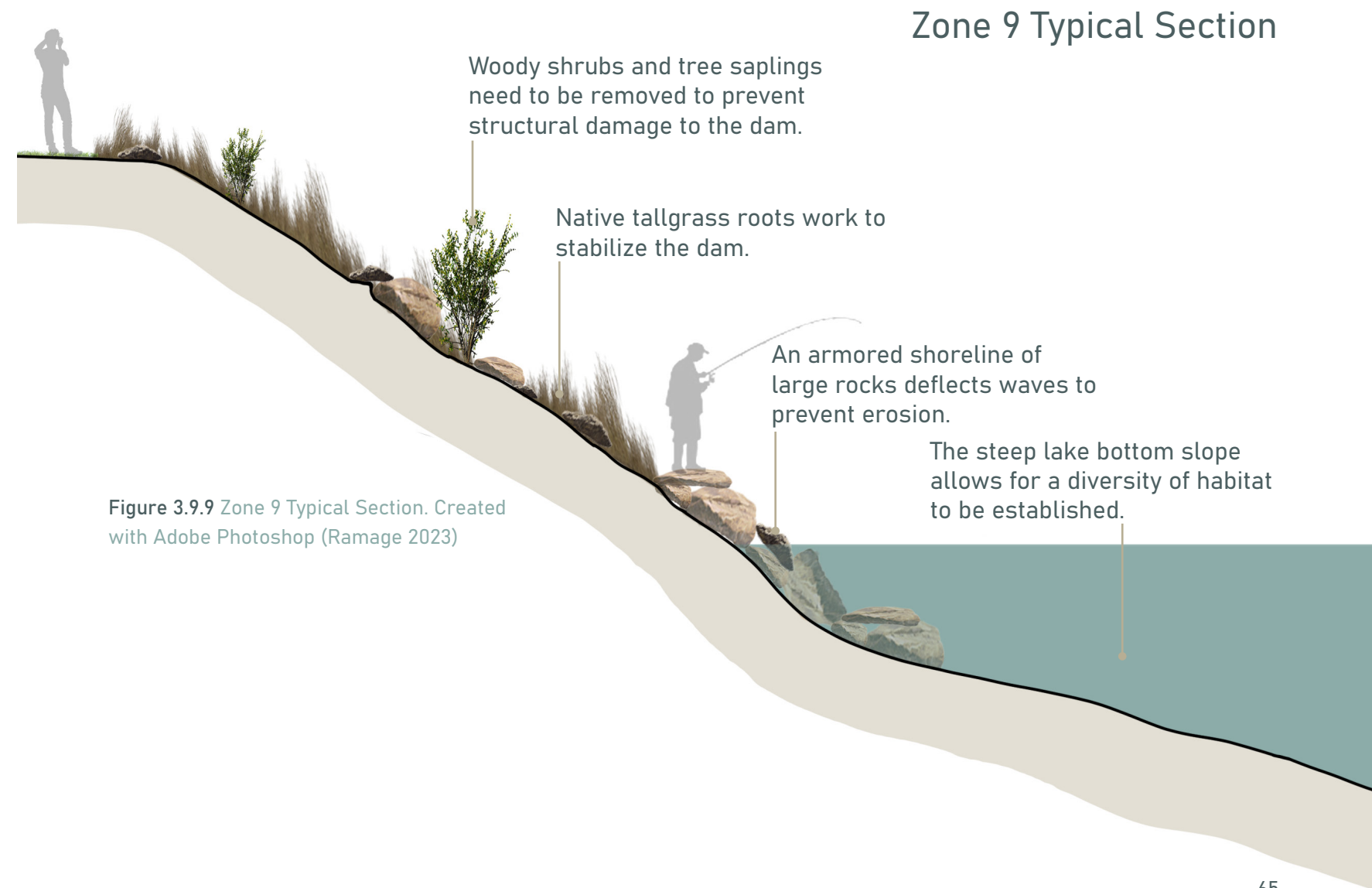


Figure 3.9.9 Zone 9 Typical Section. Created with Adobe Photoshop (Ramage 2023)



# Site Analysis

## Summary

Only three of the nine zones (4, 7, & 9) currently have no signs of erosion. Therefore, roughly two-thirds of the shorelines of Pottawatomie State Lake No. 2 are in need of rehabilitation. There is great opportunity to establish vegetated buffers to enhance shoreline habitat, stabilize the bank, and provide a variety of user experiences.

Zone 2 and Zone 6 are the two zones in severe need of intervention due to the safety concern of drop offs of three or more feet to the water. These zones will need more complex treatments of soil retaining systems that still allow safe access to the water's edge.

The remaining zones (1, 3, 5, & 8) exhibit similar characteristics to each other having one to two feet of erosion that can be approached with simpler treatments such as vegetated fiber rolls and rocks to armor the shoreline from erosive wave action.

Overall, this analysis proves that Pottawatomie State Lake No. 2 has a clear need for shoreline rehabilitation to improve aquatic habitat for Largemouth Bass, pedestrian safety, and recreational opportunities for site visitors.



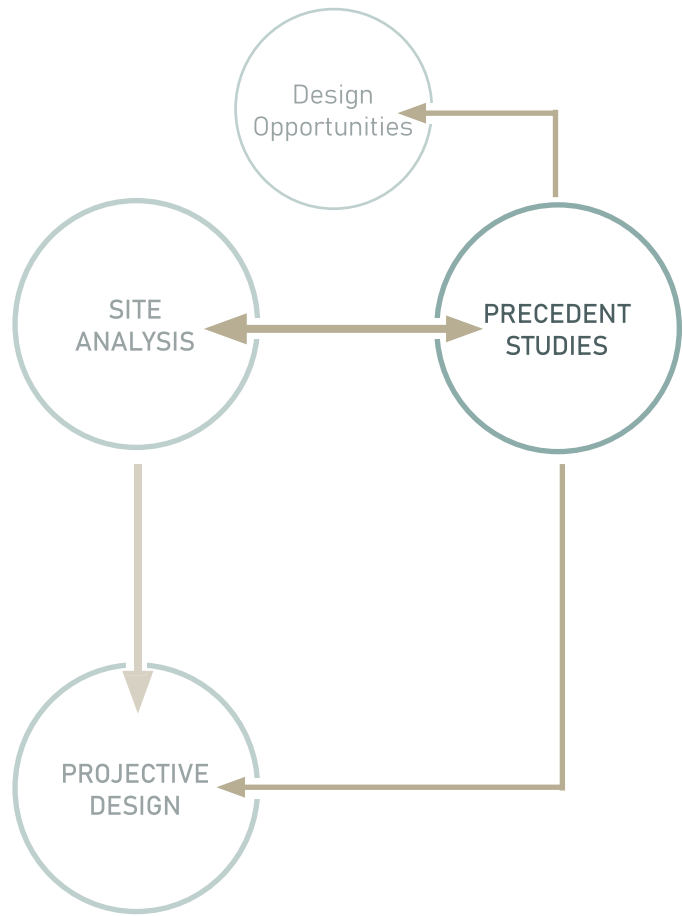
Figure 3.10 Largemouth Bass  
Splash at Pottawatomie State  
Lake No. 2 (Ramage 2023)

# CHAPTER 4

## PRECEDENT STUDIES

PRECEDENT STUDIES

When conducting precedent studies, I searched for good examples of shoreline vegetation and naturalized shorelines, trail systems, camping accommodations, fishing access, and day use facilities to conduct a strong foundation of ideas to inform the projective design thinking and decision-making. For each study, I identified which design interventions the project focuses on the most (fishing, camping, hiking, day-use, shoreline vegetation), gathered images and carefully considered the inspiration and ideas that directly translated to the projective design. The precedent studies provided the foundation about how to design vegetated buffers, a variety of trails, and to also provide a variety of new user experiences (wildlife observation, swimming, playground, and accessibility to deeper water). Research from the literature review and ideas gleaned from precedent studies highlighted design opportunities to explore through the projective design process. Additionally, site visits, analysis maps and sections, and aerial imagery were used to identify opportunities for site improvements and the need for deeper connections between user needs, the needs of wildlife, and the opportunities for increased ecological awareness, learning, respect, and environmental stewardship at Pottawatomie State Lake No. 2.

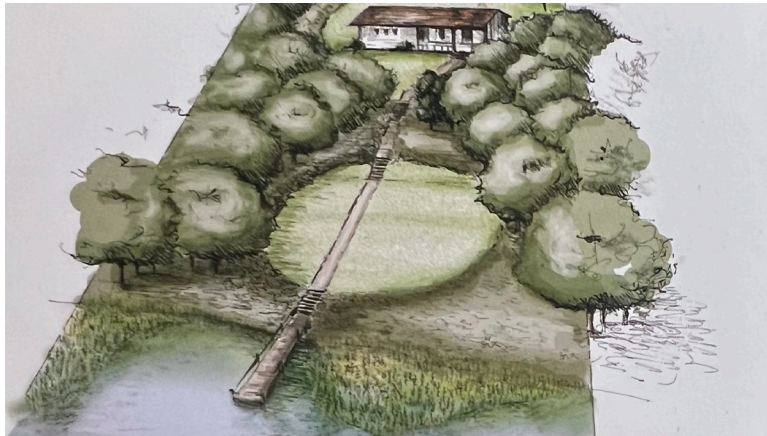
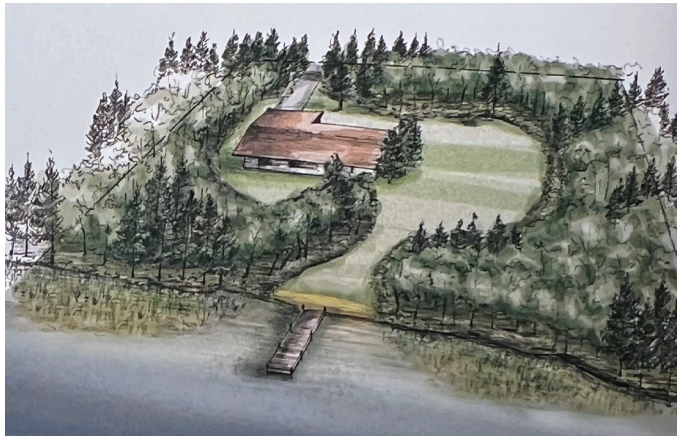
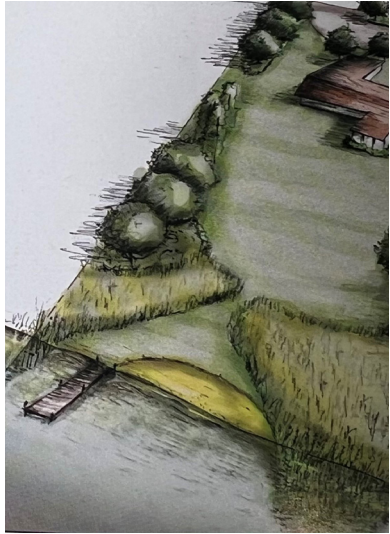


PRECEDENT STUDY INSPIRATION TABLE

Table 2 Precedent Study Interventions and Inspiration (Ramage 2023)

Project	Design Interventions and Inspiration						
	Trail System	Naturalized Shoreline	ADA Accessibility	Camping	Fishing/ Aquatic Habitat	Day Use Facilities	Programming
Lakescaping for Wildlife and Water Quality (pg. 48-53)		Plant Layout, Buffer design, Shoreline Access					
South Manistique Lake Watt-Stamper Park, Curtis, MI		Establish Vegetation, Plant Layout					
Shaw Nature Reserve, St. Louis, MO	Nature Trail, Wildlife Observation, Wetland Boardwalk	Native Vegetation, Plant Communities					Educational Signage, Nature Play
Walnut Creek Lake and Recreation Area, Papillion, NE	Trail Loop	70% of land is Native Prairie	Paved Trail Loop, ADA Fishing Pier	Tent Camping	ADA Pier and Docks, Fish are Stocked and Managed by NGPC	Shelters, Play ground	Youth Primitive Camping, No Wake Boating
Duck Creek Recreation Area, Peru, NE	Nature Trail	Vegetation Density	ADA Pier	Tent Camping	Coarse Woody Habitat	Play ground, Shelter	Swimming beach, No Wake Boating





## LAKESCAPING FOR WILDLIFE AND WATER QUALITY (PG. 48-53) (HENDERSON, DINDORF, AND ROZUMALSKI 1999)

### Inspiration for projective design

Consider the various forms of vegetated buffers to provide unique and sensory engaging shoreline experiences.

Imagine the houses as campsites and consider the forms it could take in the projective design.

Establish new trees along the shoreline to provide shade for site users and to cool the water along the shoreline.

Docks are an effective way to provide artificial habitat structure and to allow access to deeper water for site users.

Provide for visual and sensory progression and/or mystery as views to a lake are disclosed in different ways related to site context (landform slope, vegetation, orientation, and so forth).

This precedent, although not a specific built project, is a collection of ideas that could be implemented into the projected design. The diagrams in this book are tailored to lakefront homeowners, but the ideas can be translated directly to my site, especially in areas of camping and shoreline access points. There are several diagrams that depict different ways to incorporate native vegetative buffers that also allow people to access the water's edge in specific places where it is best to do so. These ideas will be useful in areas between the rock jetties to still allow anglers to cast into the water.

A balance of a vegetated buffer, shoreline access points, and trails will be an important aspect of the projective design.





Emergent vegetation is established to enhance aquatic habitat.



Fiber rolls and burlap netting are installed to initiate shoreline stabilization.



Riparian vegetation is planted within the burlap netting to prevent invasive vegetation from becoming established.



The vegetated buffer is protected by a wooden fence to minimize trampling.



The vegetated buffer has select areas that allow for shoreline access.

## SOUTH MANISTIQUE LAKE, WATT-STAMPER PARK, CURTIS, MICHIGAN

### Inspiration for projective design

Install fiber rolls along shorelines that have erosion drop offs up to two feet.

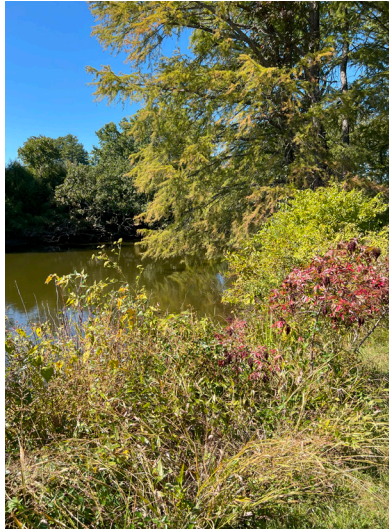
Place barrier fence, or other effective barriers near shoreline access points, to designate areas where people can go. Additionally, this will help maintenance crews determine where to mow.

Use a combination of rocks, fiber rolls, and desired vegetation planted within burlap netting to protect the shoreline and discourage undesirable vegetative competition and invasive species from sprouting in disturbed and re-vegetated areas.

This project is one of nine shoreline demonstration sites that were completed during a Certified Natural Shoreline Professional training for the Michigan Natural Shoreline Partnership. The South Manistique Lake demonstration site was completed in 2012. This stretch of shoreline was rehabilitated with fiber rolls, burlap netting, native vegetation, and various sizes of rocks and sediment. The fiber rolls were placed at the toe of the slope and fastened with wooden stakes to keep them in place. The burlap netting was wrapped under the fiber rolls and laid onto the re-graded shoreline to prevent further erosion. The burlap netting was cut in specific places to allow for native plants and live stakes to be planted. There was not a formal planting plan for the site, but rather planted randomly using native grasses, sedges, rushes, and flowering plants. On the bottom side of the fiber rolls, various sizes of rocks were placed to provide further stabilization and to dampen the erosive action of the waves. Additionally, there were zones of shoreline that are still allow access down to the water that are bordered by log fences to help maintain the vegetation. Over time, as sediment was captured by the rocks and vegetation, new aquatic vegetation started to emerge in the project site and the plated vegetation filled in to create an effective buffer (Michigan Natural Shoreline Partnership n.d.).

(Left) **Figures 4.2.1 – 4.2.5** South Manistique Lake Watt-Stamper Park Demonstration Site Images (Michigan Natural Shoreline Partnership n.d.)





The shorelines exhibit variety of riparian vegetation.



The wetland boardwalk allows visitors direct access to the water's edge and wildlife interaction. This provides a unique experience for people of all abilities.



Trees adjacent to the water's edge contribute to aquatic habitat by providing shade and structural habitat.

Figures 4.3.1 – 4.3.4 Shaw Nature Reserve site images (Ramage 2023)



Wildlife observation blinds are an appealing amenity that allows visitors to interact with nature.

Figure 4.3.5 Wildlife Observation Blind. Missouri Botanical Garden, Shaw Nature Reserve n.d.

## SHAW NATURE RESERVE, ST. LOUIS, MISSOURI

### Inspiration for projective design

Design wetland boardwalks in Zones 4 and 7 to provide a variety of experiences along the loop trail.

Observation blinds, especially in Zones 4 and 7 will provide opportunities for site users to observe wildlife that will inhabit established wetlands.

It is important to provide physical access to the water's edge, and also unique visual access.

A September 2022 class field trip I attended to Shaw Nature Reserve provided a range of examples of how trails can be implemented into a natural setting. Using concepts and ideas discovered at Shaw Nature Reserve for the projective design will allow me to effectively design a trail system that connects each programmatic element. At the reserve, the wetland boardwalk stood out to me as a very interesting design element to get users to interact with the water's edge without impacting established vegetation. Additionally, the observation blinds were a great addition in the wetlands because it allowed users to observe wildlife through a telescope, while being "hidden." Implementing elements like this in the projective design will provide more programmatic elements to better serve families who enjoy the park. The reserve also had great examples of how trails can be used within prairie and woodlands, which are present at the projective design site. The prairie trails offered mowed paths while the woodland trails were often compacted soil or gravel. A combination of materiality, difficulty, and accessibility will be important when implementing trails into the projective design.



(Top three images) Figures 4.4.1–4.4.3 Walnut Creek Recreation Area site images (Ramage 2023)



There are mown paths to the water's edge.



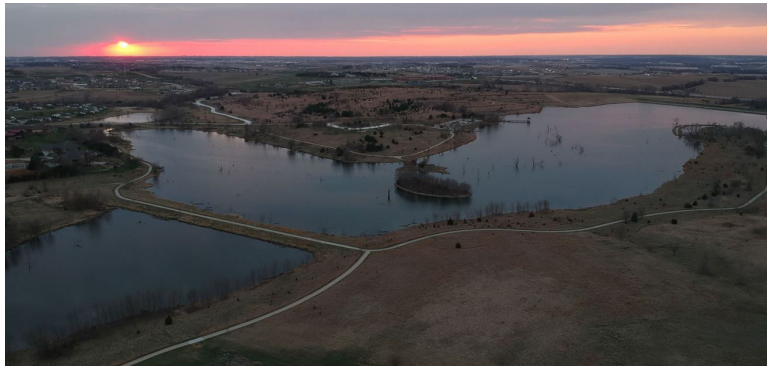
ADA trails are set within vegetated buffers.



ADA trails have mown strips on either side to prevent overgrowth.



In highly trafficked areas, shorelines are armored with rocks and vegetated buffers.



The ADA loop trail provides visitors of all abilities to enjoy the park and its amenities.

(Left and Above) Figures 4.4.4 – 4.4.5 Walnut Creek Recreation Area (City of Papillion n.d.)

## WALNUT CREEK LAKE AND RECREATION AREA, PAPIILLION, NEBRASKA

### Inspiration for projective design

Design an accessible trail system and provide more hiking trails the park.

Walnut Creek Lake is a similar size to Pottawatomie State Lake No. 2. Since Walnut Creek has a paved trail across the dam, then Pottawatomie State Lake No. 2 should also be eligible for pavement across the dam.

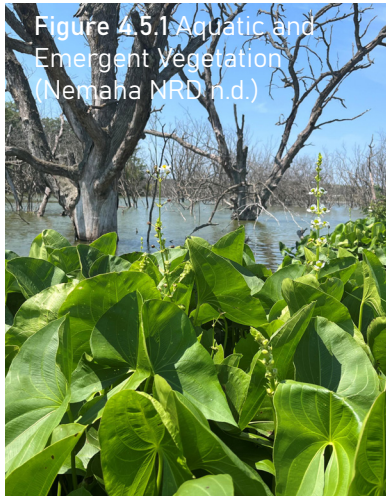
Establish native prairie with a variety of wildflowers in open areas to make the park more ecologically diverse.

Designing islands in the wetlands serve as wildlife refuge and provide dynamic observation opportunities for site users.

Ensure that the projective design includes a vegetated and armored shoreline near any proposed or existing docks to discourage trampling of the shoreline.

Walnut Creek Lake and Recreation Area is a 405-acre mixed use park with a 105-acre lake. The property includes a 3.1-mile hiking trail loop, 5 miles of bike trail, playground, four pavilions, a dog park, ADA accessible fishing pier, boat ramp, and RV and tent campsites. Additionally, 70% of the property has been maintained as native Nebraska prairie (City of Papillion n.d.). This park exhibits several areas of healthy, naturalized shorelines. The lake is well maintained by the Nebraska Game and Parks Commission through the stocking of bass, catfish, bluegill, crappie, and sunfish. This allows for year-round fishing. Walnut Creek Lake and Recreation Area is a pack in, pack out facility, which means there is no trash service offered in the park. Visitors are responsible for removing any trash they have, making them responsible for the cleanliness of the park (City of Papillion n.d.).

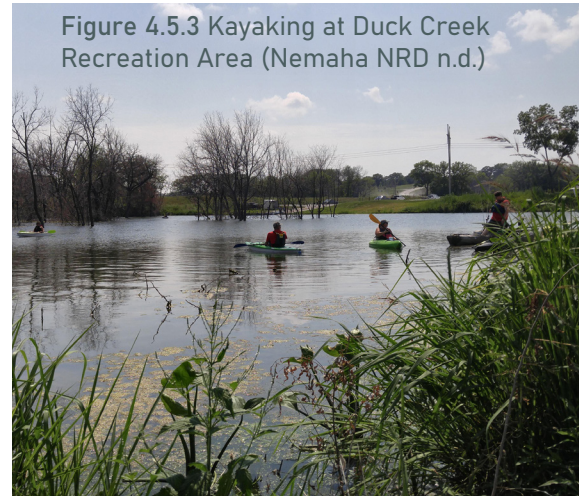




Aquatic and emergent vegetation is established to enhance shoreline habitat.



The swimming beach is an amenity that the whole family can enjoy.



The lake is no-wake boating, which allows great opportunity for kayaking.



Although the roads are gravel, there are concrete ADA parking and accessible paths at the lake.



The accessible jetty allows for a variety of users to access deeper water.

## Duck Creek Recreation Area, Peru, Nebraska

### Inspiration for projective design

Design a small swimming beach in a shallow cove to provide an additional amenity to the park.

Stabilize shorelines by planting diverse vegetated buffers. Include vertical layering of vegetation to provide shade where needed or desired along shorelines.

Duck Creek has a variety of shorelines that serve different recreational purposes ranging from wooded campsites to pedestrian trails.

Convert all existing rock jetties to accessible jetties. Connect them with an accessible trail system.

Duck Creek Lake is similar in size to Pottawatomie State lake No. 2. Since Duck Creek supports a swimming beach, then Pottawatomie State Lake No. 2 should be able to do so as well.

Duck Creek Recreation Area is located near Peru, Nebraska and was recently opened in 2018. The lake is 62 acres within the overall 200-acre site. The site has tent and RV camping, nature trails, playgrounds, picnic shelters, restroom facilities, and a swimming beach. The park also provides ample open space for other activities or large gatherings (Nemaha NRD n.d.). Duck Creek is an excellent example of how small lakes can have numerous programmatic elements without feeling too crowded. This lake has a fair amount of aquatic and emergent vegetation and shoreline structure, which benefits the fish population and shoreline anglers.



# CHAPTER 5

## PROJECTIVE DESIGN





Figure 5 | Great Blue Heron  
(Ramage 2023)

# PROGRAMMING

Existing programming will not be removed, but improved upon with the addition of proposed programmatic elements across the site. The precedent studies inspired the inception of programmatic elements into the projective design based on the site having suitable opportunities to explore in the design process.

## EXISTING PROGRAMMING

- FISHING
- BOATING
- KAYAKING
- TENT CAMPING
- PICNICKING
- ADA - ACCESSIBLE DOCKS (2)



## PROPOSED PROGRAMMING

- WETLAND BOARDWALK
- WILDLIFE OBSERVATION BLINDS
- LAKE OVERLOOK
- SWIMMING BEACH
- DAY-USE PAVILIONS
- NATURE PLAYGROUND
- NATURALIZED SHORELINES
- ADA AND HIKING TRAILS
- ACCESSIBLE ROCK JETTIES



# DESIGN GUIDELINES

## VEGETATION

### Shoreline planting

Littoral zone – the area below the waterline that is too deep for emergent vegetation (1–4 ft deep) (Caflisch et al. 2021). Ideal zone for aquatic vegetation, rocks, wood, and manmade structure to provide multi-seasonal habitat for Largemouth Bass.

Emergent zone – the part of the bank slope that is in less than twelve inches of water. This area is most suitable for native emergent aquatic plants such as rushes and arrowhead (Sagittaria) (Caflisch et al. 2021).

Riparian zone – the part of the bank slope that is typically above water level but can become inundated during heavy rain events. “The deep, extensive root structure of native grasses, shrubs, and trees prevents erosion and undercutting of banks” (Tennessee Valley Authority 2008, 2).

Upland zone – the driest zone because the slope forces water to run downhill. The water level of the lake does not reach this level, so the plants in this zone need to be drought tolerant. Native perennials and grasses are best for this zone, although shrubs and trees can also be important as they help cool habitats along the water's edge and create structural diversity (Caflisch et al. 2021).

Vegetated buffers will work to clean campsite runoff to improve the water quality of the lake, especially along the shorelines for fish.

Pottawatomie State Lake No. 2 has a plethora of rock jetties that allow people to access deeper water. Between those jetties are large spans of manicured grass with degraded shorelines. To maintain access between the jetties, vegetation should be planted in a form of a buffer with paths leading to the water's edge, minimizing the amount of mowed lawn. Refer to precedent study – Lakescaping for Wildlife and Water Quality (Henderson, Dindorf, and Rozumalski 1999) for visual representation.

The foundation of research from the literature review in combination with the design opportunities derived from precedent studies and site analysis inspired design guidelines that serve as a foundation for the projective design process.

## TRAILS

### Access Around the Lake

It is important to provide a variety of trails to accommodate for a variety of users. Trail users include people with walking disabilities, walkers, hikers, trail runners, endurance athletes, etc. Each of these user groups desire a variety of qualities and difficulties in a trail (Havel 2009).

An interconnected trail system would provide users with exposure to various ecosystem types, wildlife observation opportunities, and a possible educational trail within the site.

There is currently minimal access on the east side of the lake but designing a trail system that allows users to access that side would be a great addition to the hiking amenity.

The implementation of a trail system provides an opportunity to link all programmatic elements on the site together with the benefits of naturalized shorelines.

### Shoreline Access Points

Designated paths along the shoreline, to the rock jetties, and to the water's edge will minimize trampling.

Design ADA accessible piers to allow people of all abilities to experience all that these lakeside features have to offer.

### Observation

At the Shaw Nature Reserve, the wetland boardwalk is a unique design element that provides opportunities for users to interact with the water's edge without impacting established vegetation. Additionally, the observation blinds are a great addition to the wetlands because it allows users to observe wildlife through a telescope.

The creation of an interconnected trail loop system would provide users with exposure various ecosystem types, wildlife observation opportunities, and a possible educational trail within the site.



# DESIGN GUIDELINES

## CAMPING

### Tent Pads

Tent pads are an effective sustainable camping best management practice (BMP) that work to delineate spaces where campers can set up tents and their belongings (Marion et al. 2020).

Tent pads can be lined with rocks, logs, or treated lumber depending on the desired aesthetic (Marion et al. 2020).

### Introducing Native Plants to Campsites

The implementation of native vegetation to create buffers will work to create more designated spaces within the campsite, which would provide campers with a sense of more privacy and connection to nature. Creating an ecologically diverse campsite with direct visual and physical access to the shoreline will better connect campers to the rest of the site as a whole and provide a better user experience.

### Fire Pits

Fire pits pose a challenge to implementing native vegetation because there is a greater chance of accidental spread of fire. Thus, the following actions are needed:

All fires should be burned in fire rings that are clear of built structures or flammable material within twenty-five feet (Beresford 2022).

Low hanging branches should be pruned to assure overhead trees do not get damaged.

### Vehicular Access to Campsites

Designated campsites are designed to minimize trampling by vehicles and pedestrians.

Remove unnecessary vehicular paths and replace with vegetated buffer or campsite.

## FISHING

### Accessibility

Re-finish rock jetties to allow for accessibility around all parts of the lake.

Accessible paths around parts of the lake will increase the opportunities for anglers of all abilities.

### Natural and Artificial Habitat Structure Placement

Aquatic plants, such as hardstem bulrush, create habitat for spawning fishes because they provide cover, shade, and produce oxygen in the water (Reed and Pereira 2009).

If there is coarse woody habitat near shorelines, bass will likely be in less than six feet of water and utilize the woody structure as cover (Ahrenstorff et al. 2008).

In areas where woody debris cannot be naturally dropped in the littoral zone (the area below the waterline that is too deep for emergent vegetation), the placement of artificial brush piles ranging in depths from zero to 20 feet of water is a recommended strategy in creating year-round habitat for Largemouth Bass and their prey.

Artificial brush piles can be in the form of recycled Christmas trees or cut cedars, fallen branches, or sticks arranged to form brush piles.

Largemouth Bass prefer spawning habitat that is in depths of one to four feet that provides a combination of aquatic vegetation, woody debris, sand, gravel, and large rocks (Bennett 1971; Bolding et al. 2001).

Largemouth Bass prefer nesting near physical structure because it increases mating, hatching, and nesting success” (Sass 2009, 6).

Juvenile bass tend to relate to habitats that provide dense cover of aquatic vegetation (water lilies and pondweed), woody debris, and fine gravel (Pegg et al 2015).

A healthy and diverse shoreline that is composed of biotic and abiotic elements is vital for the health and success of the fish population in an impoundment.



# PARK ROADS TO REMAIN AND TO BE REMOVED



# PEDESTRIAN TRAIL EXPERIENCES

Figure 5.3.1 Accessible Trail  
(Ramage 2023)



Accessible Trail

Figure 5.3.2 Gravel Trail  
(Ramage 2023)



Gravel Trail

Figure 5.3.3 Mown Trail  
(Ramage 2022)



Mown Trail

Figure 5.3.4 Boardwalk  
(Ramage 2022)



Boardwalk

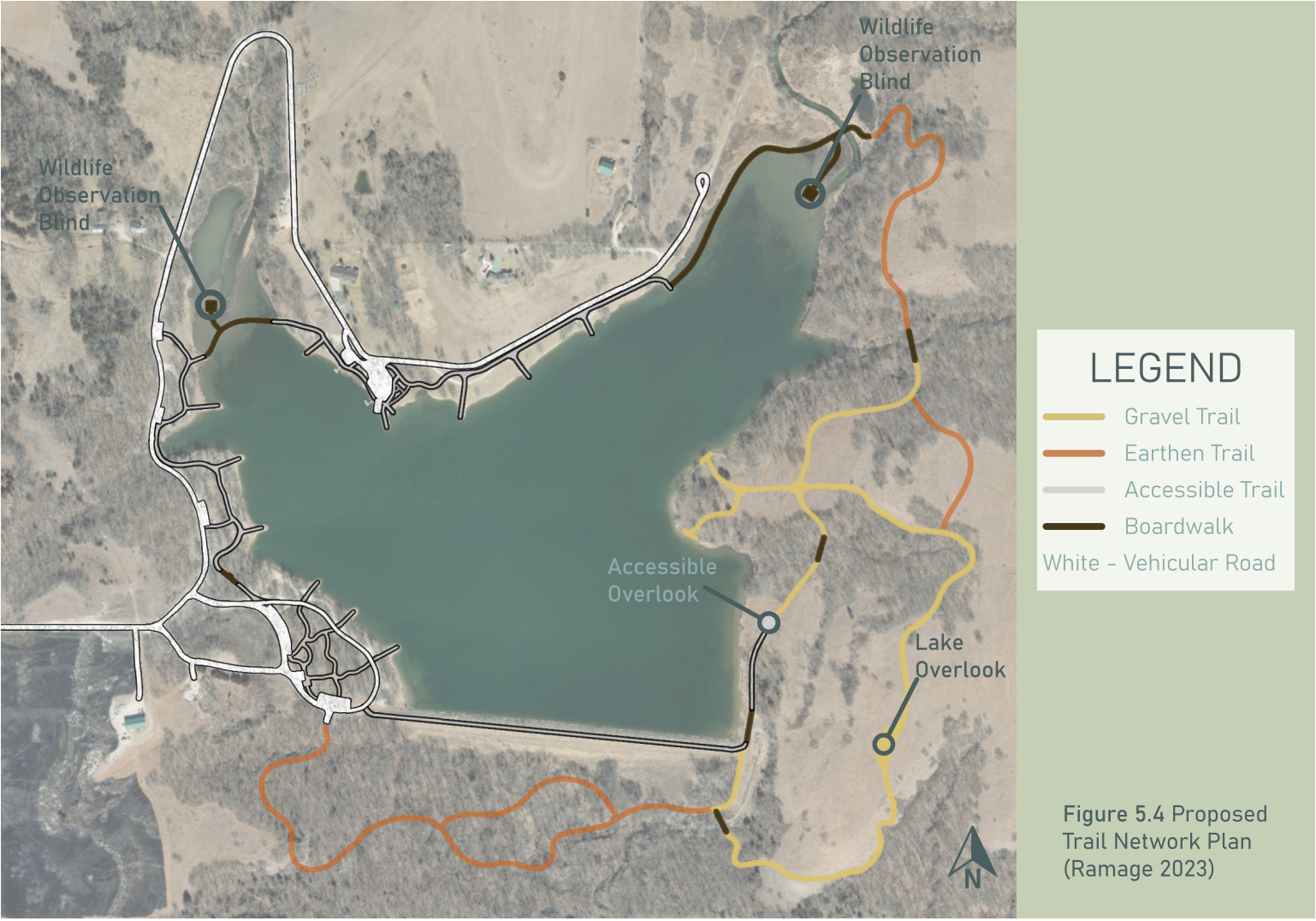
Figure 5.3.5 Earthen Trail  
(Ramage 2022)



Earthen Trail



PROPOSED PRIMARY TRAIL NETWORK

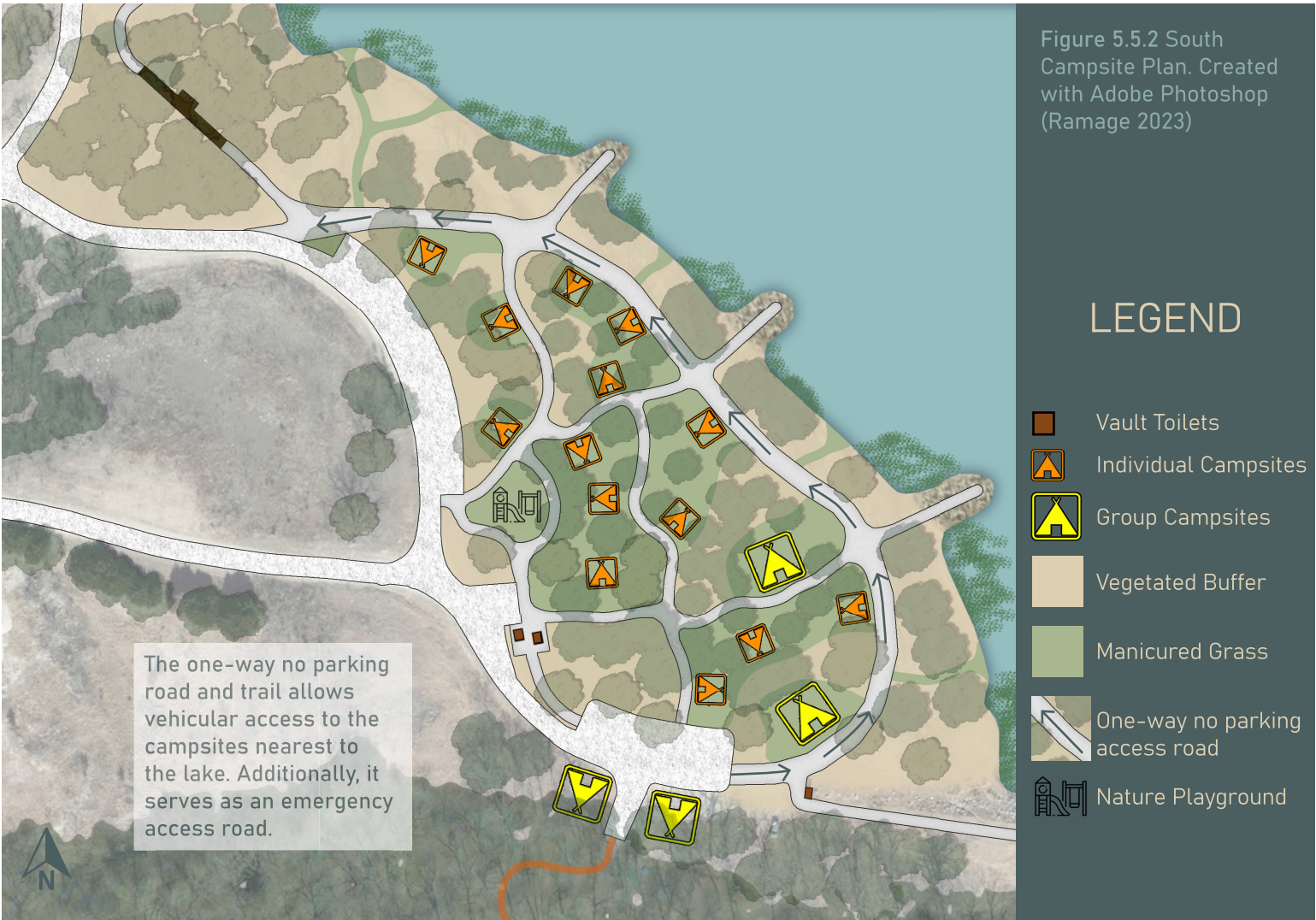




CAMPSITE CONTEXT MAP



SOUTH CAMPSITE PLAN





# CENTRAL CAMPSITE PLAN



# NORTH CAMPSITE PLAN





# INDIVIDUAL TENT CAMPSITE CONCEPT

Figure 5.5.5 Individual Tent Campsite Photomontage.  
Created with Adobe Photoshop (Ramage 2023)



# GROUP TENT CAMPSITE CONCEPT

Figure 5.5.6 Group Tent Campsite Photomontage.  
Created with Adobe Photoshop (Ramage 2023)

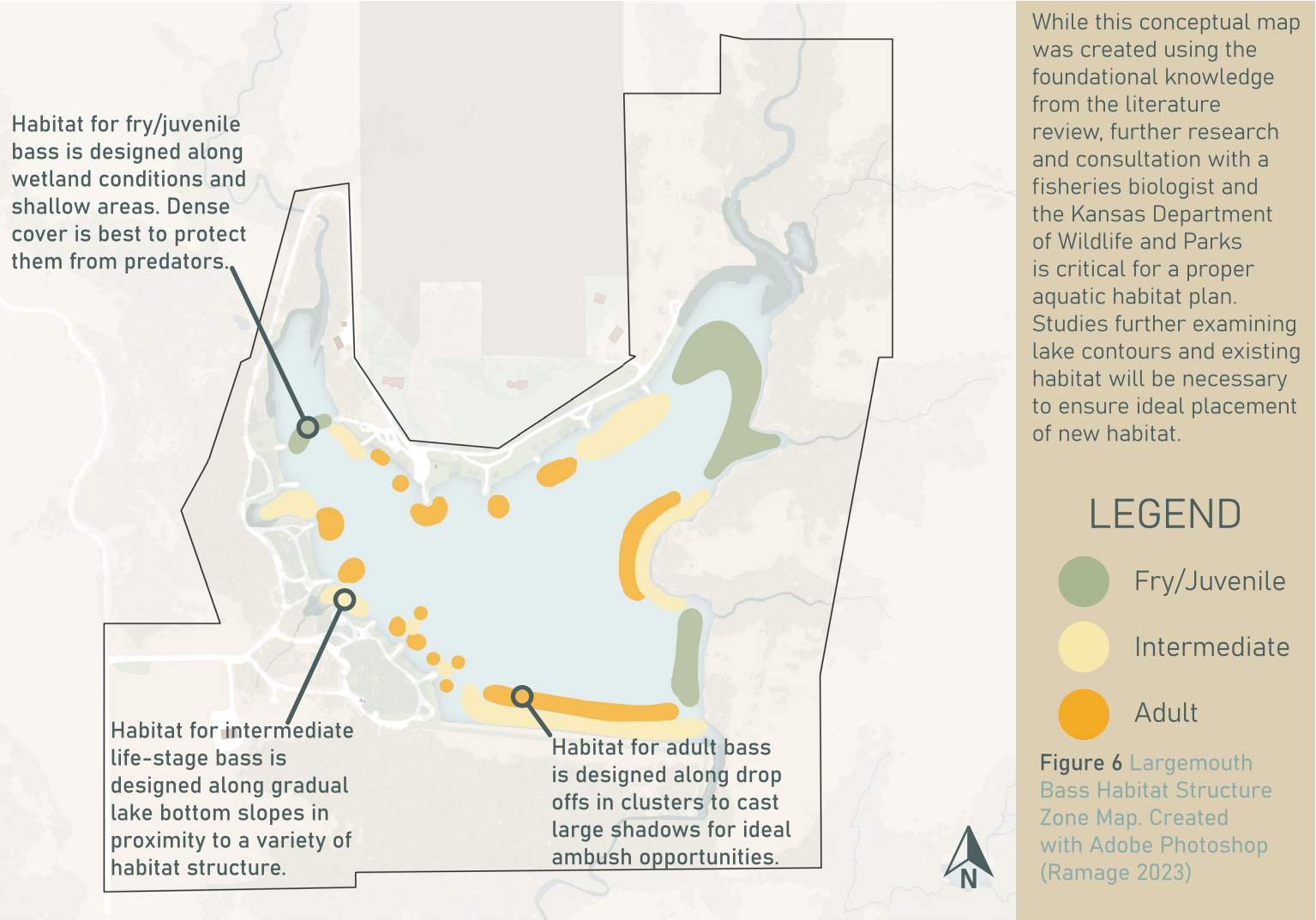




# HABITAT STRUCTURE FOR LIFE STAGES OF LARGEMOUTH BASS

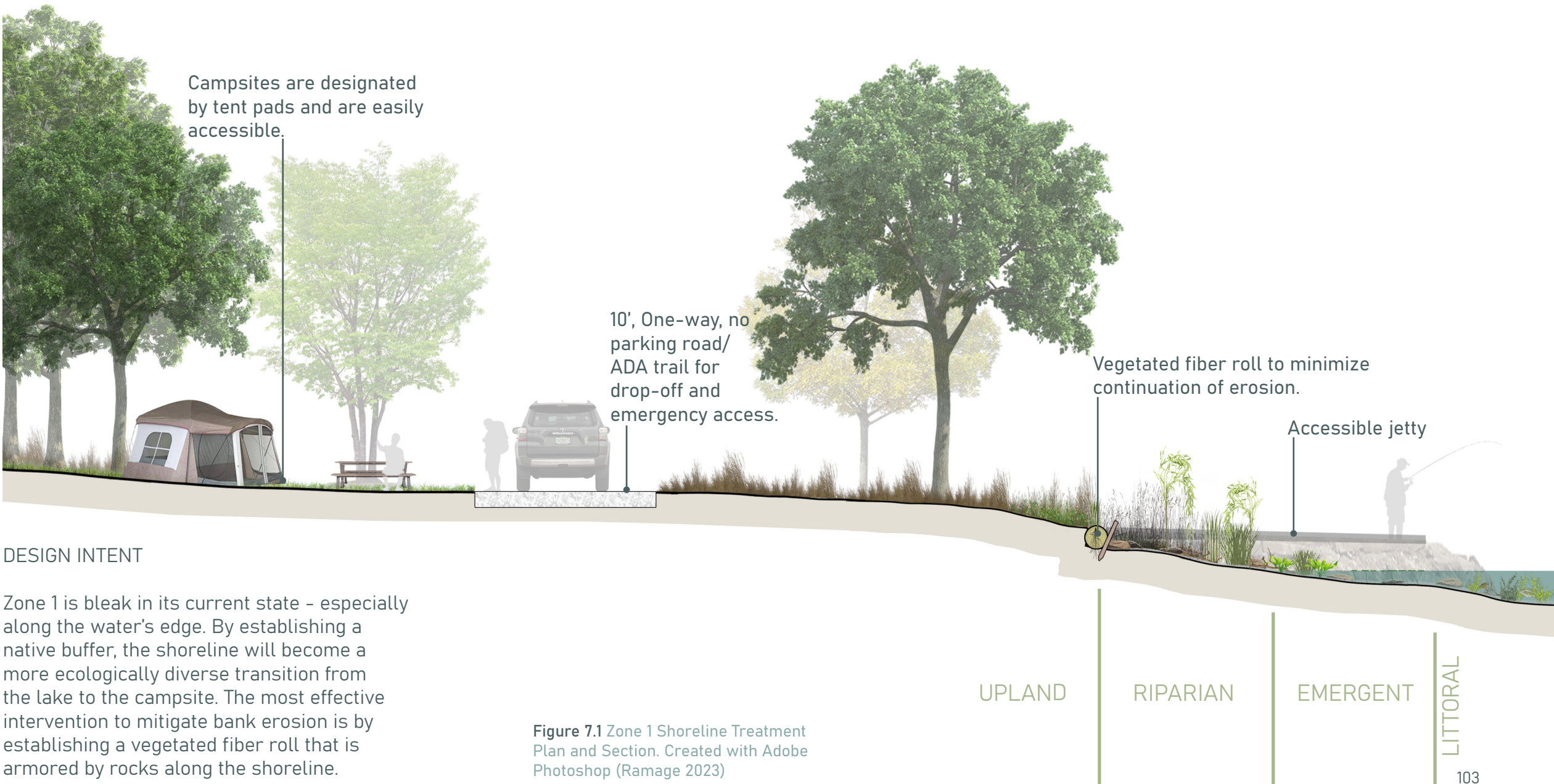
<div><div>Fry / Juvenile</div><div>Natural Habitat</div><div>Dense aquatic vegetation Rock piles with tight spaces Stands of rushes and sedges</div><div>Artificial Habitat</div><div>Mesh cubes made from low and high-density polyethylene (safe for water) that allow fry to take cover.</div><div>*Do not use PVC due to the leaching of chemicals over time.</div></div>	<div><div>Intermediate</div><div>Natural Habitat</div><div>Aquatic vegetation Rock piles Sunken branches and logs Small brush piles Sunken evergreens</div><div>Artificial Habitat</div><div>Small artificial brush piles made from low and high-density polyethylene.</div><div>Docks</div><div>*Artificial habitat does not need replaced since it does not decompose like natural structure.</div></div>	<div><div>Adult</div><div>Natural Habitat</div><div>Aquatic vegetation Rock piles / boulders Sunken branches, logs, trees Large brush piles Sunken evergreens</div><div>Artificial Habitat</div><div>Large artificial brush piles made from low and high-density polyethylene that cast large shadows.</div><div>Docks</div><div>*Artificial habitat costs money whereas natural structure can typically be sourced for minimal costs.</div></div>
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# LARGEMOUTH BASS HABITAT STRUCTURE ZONES



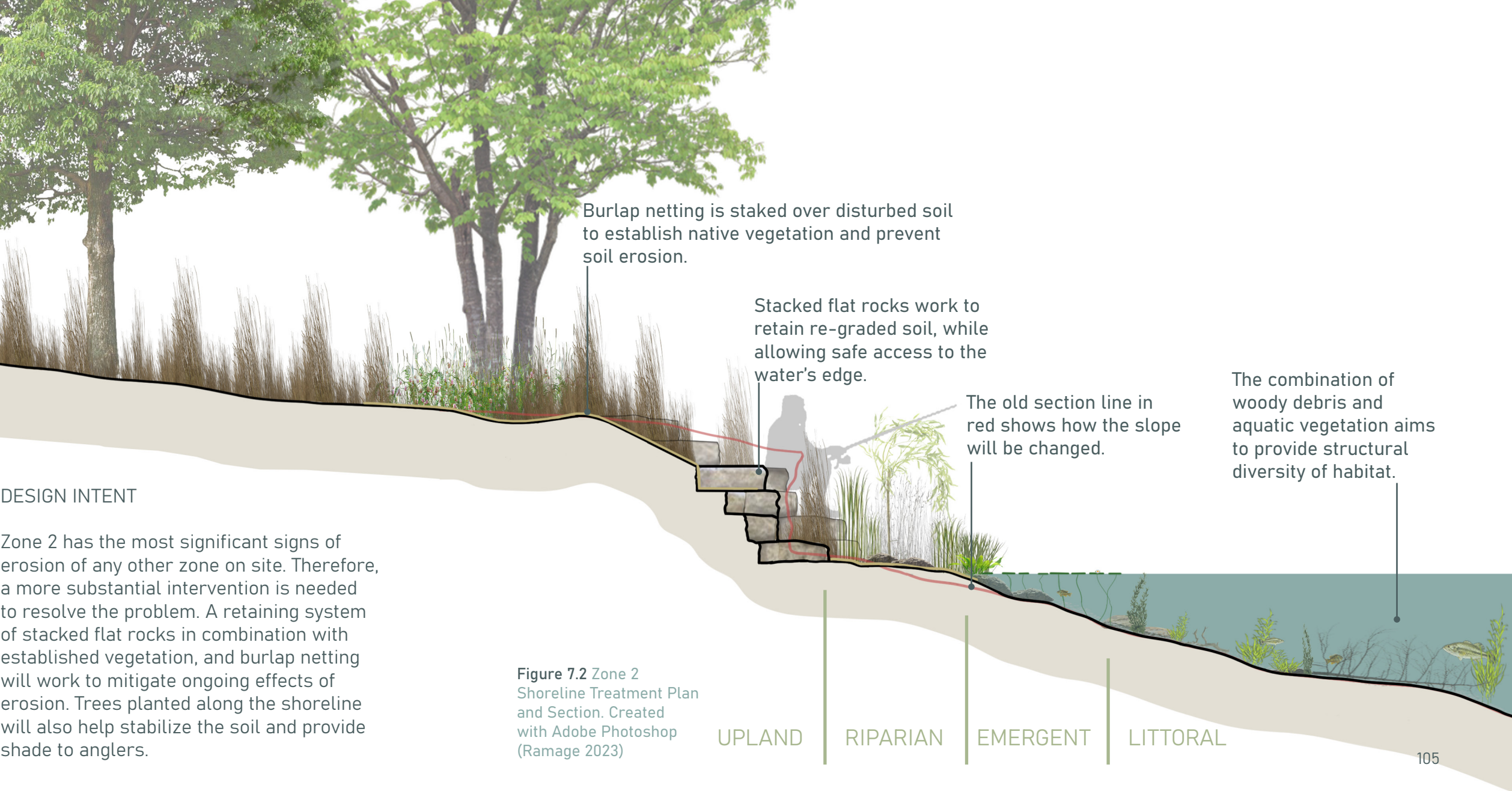


ZONE 1 SHORELINE TREATMENT





# ZONE 2 SHORELINE TREATMENT



## DESIGN INTENT

Zone 2 has the most significant signs of erosion of any other zone on site. Therefore, a more substantial intervention is needed to resolve the problem. A retaining system of stacked flat rocks in combination with established vegetation, and burlap netting will work to mitigate ongoing effects of erosion. Trees planted along the shoreline will also help stabilize the soil and provide shade to anglers.

Figure 7.2 Zone 2 Shoreline Treatment Plan and Section. Created with Adobe Photoshop (Ramage 2023)



# ZONE 3 SHORELINE TREATMENT



## DESIGN INTENT

Zone 3 has similar existing characteristics as zone 1. Therefore, design interventions will be similar to mitigate erosion and to diversify the vegetation and habitat structure along the shoreline. By staking vegetated fiber rolls along the erosive drop-offs, runoff water will be slowed as it enters the lake. Additionally, rocks and emergent vegetation will reduce and chronic wave action that could be the cause of the initial erosion. Rocks, emergent vegetation, coarse woody debris, and aquatic plants work to establish diverse habitat for Largemouth Bass and their prey.

In addition to accessible jetties, mown paths to the water's edge allows access for anglers. This is especially important during the summer months where several people could be at the lake, all looking for a spot to cast a line.

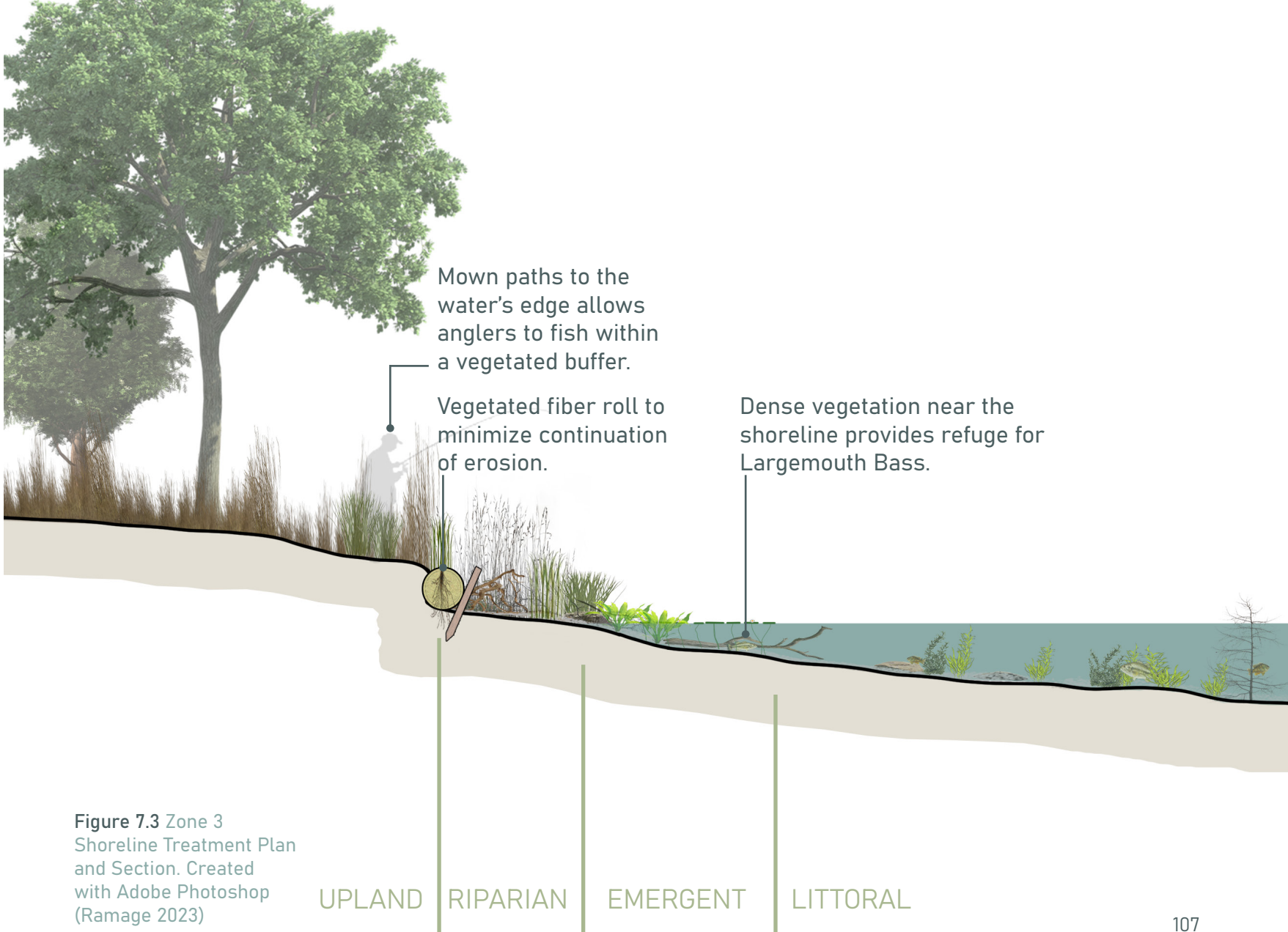


Figure 7.3 Zone 3  
Shoreline Treatment Plan  
and Section. Created  
with Adobe Photoshop  
(Ramage 2023)



# ZONE 4 SHORELINE TREATMENT



## DESIGN INTENT

Zone 4 has one of the two main creek inlets of Pottawatomie State Lake No. 2. With a large area of agricultural land in the watershed, there are signs of sedimentation. However, this provides great opportunity to establish a wetland to filter any sediments entering from the inlet. Through the creation of wetlands, there will likely be an increase of waterfowl in the park. To capitalize on this, a wildlife observation blind will be connected through the accessible trail system by a wetland boardwalk. The observation blind provides unique opportunities for site users. Inspiration for the implementation of the observation blind came from the Shaw Nature Reserve and other wildlife viewing areas.

There is currently no pedestrian connection from the west side of the lake to the northern shores near the boat ramp. There is only a gravel road that goes around the park to access that area. To increase the pedestrian connection, a boardwalk is designed to cross the wetland by linking two accessible jetties together. The boardwalk must be set at a higher elevation than the outflow of the lake.



Figure 7.4.1 Philadelphia University students design, construct wildlife viewing blind. Higher Education Tribune, 2016.



Figure 7.4.2 Boardwalk bird blind Midland Texas I-20 Wildlife Preserve. Trip Advisor n.d.

## WILDLIFE OBSERVATION BLIND CONCEPT

The two images to the left are examples of the aesthetic and functionality of the proposed observation blind. The intent is to provide wheelchair accessibility from the boardwalk to the observation blinds. Water-tolerant trees such as willows or birches will be planted near the blind to make the blind appear more “natural”.

Figure 7.4.3 (see pages 110-111) shows the Zone 4 Shoreline Treatment Section.



ZONE 4 SHORELINE TREATMENT

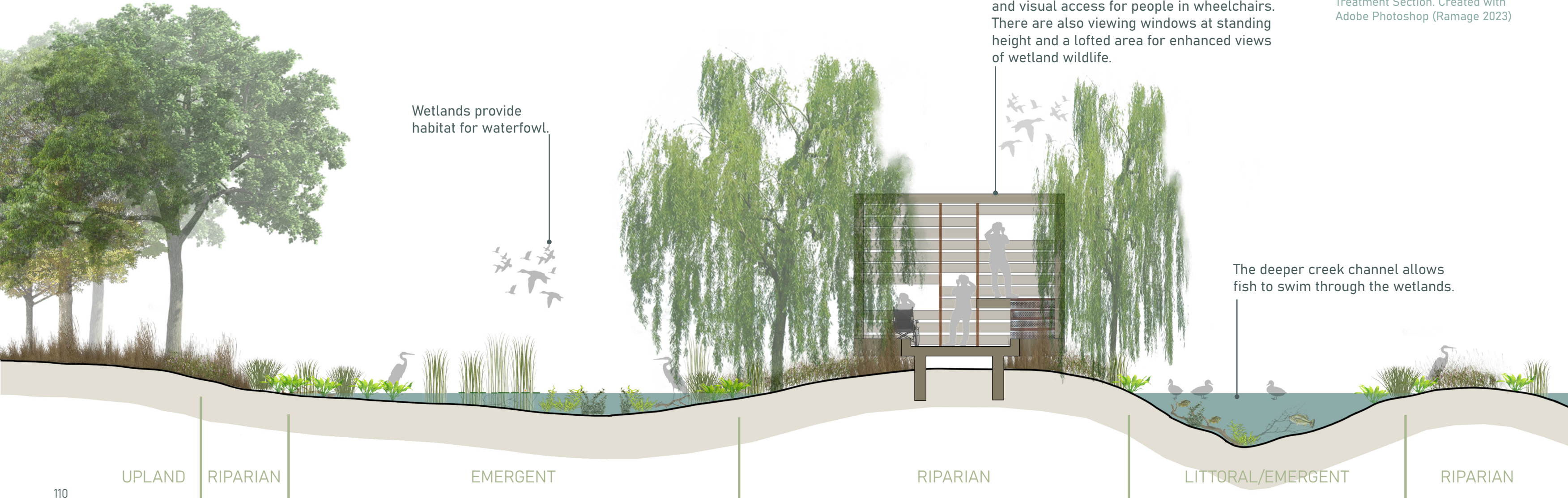


Figure 7.4.3 Zone 4 Shoreline Treatment Section. Created with Adobe Photoshop (Ramage 2023)

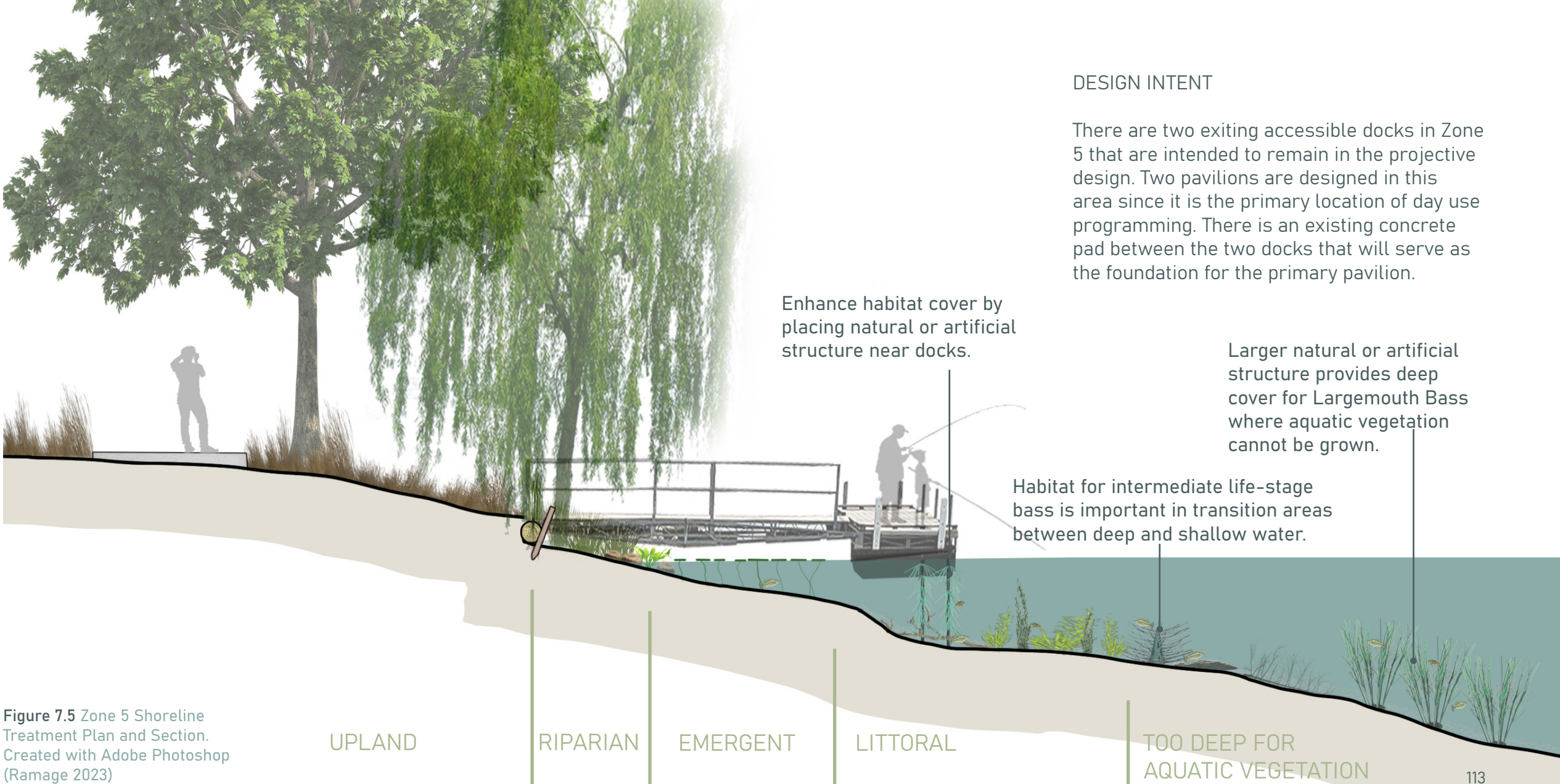


# ZONE 5 SHORELINE TREATMENT



## DESIGN INTENT

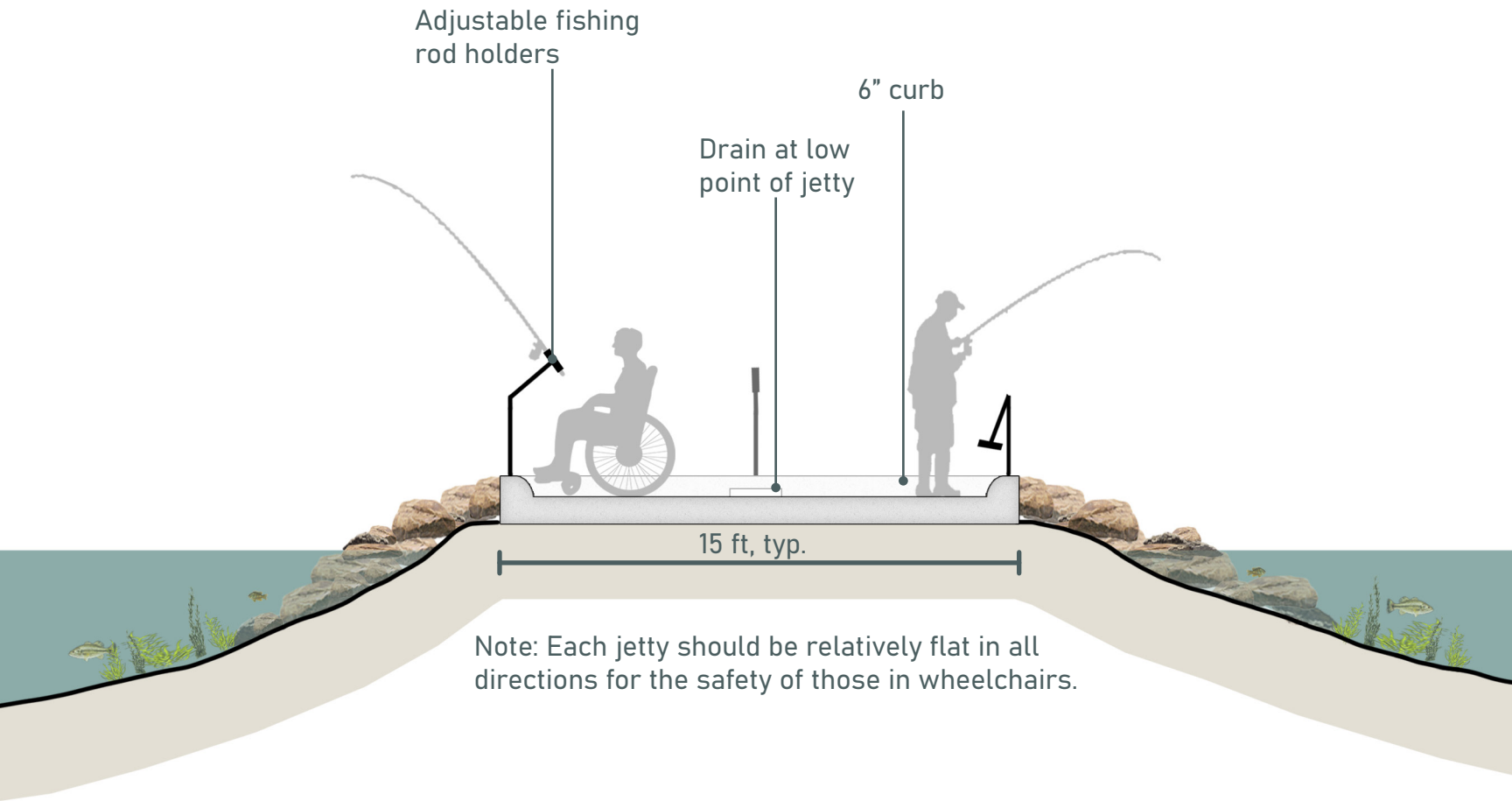
There are two exiting accessible docks in Zone 5 that are intended to remain in the projective design. Two pavilions are designed in this area since it is the primary location of day use programming. There is an existing concrete pad between the two docks that will serve as the foundation for the primary pavilion.



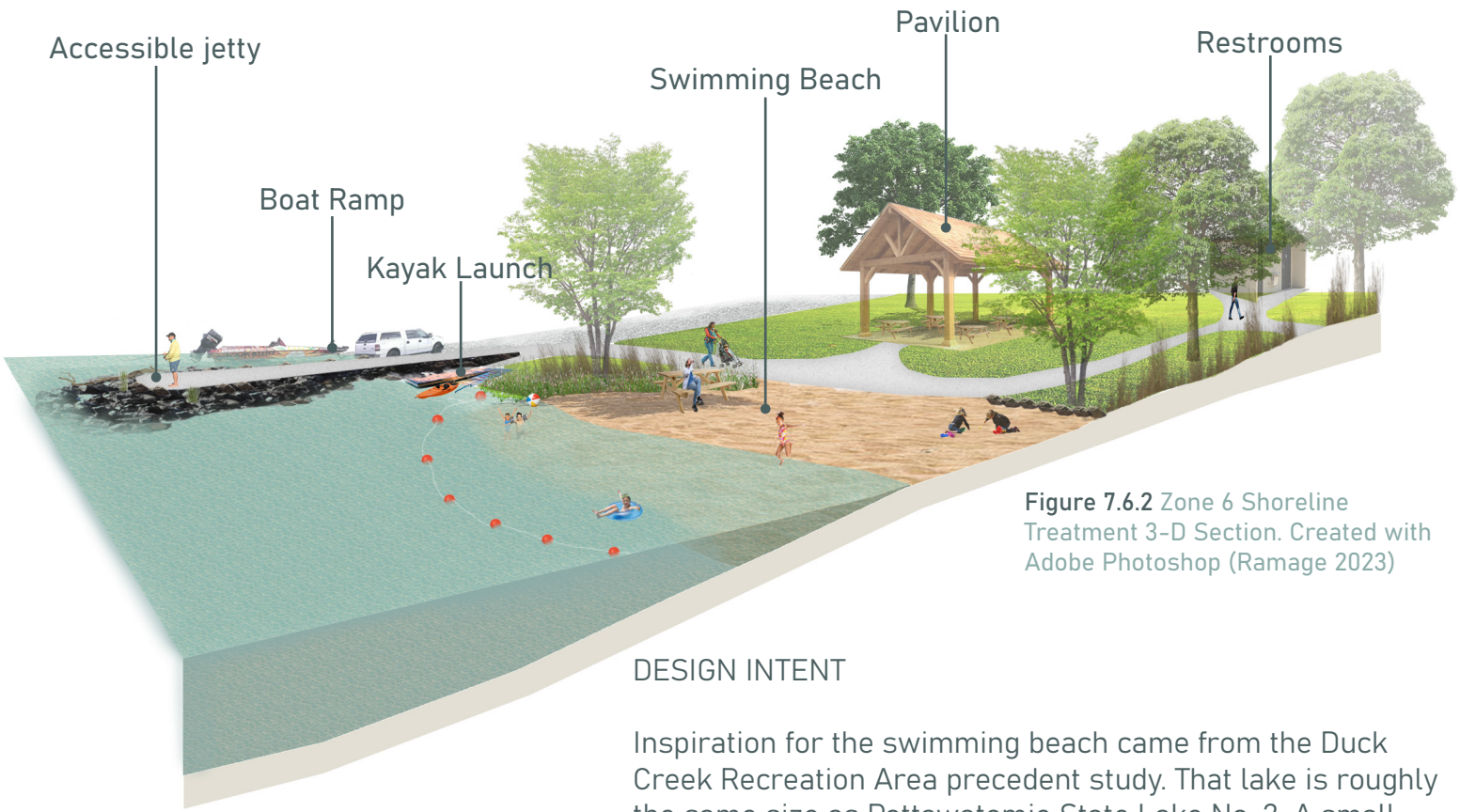


# Typical Accessible Rock Jetty

Figure 7.6.1 Typical Accessible Rock Jetty Section. Created with Adobe Photoshop (Ramage 2023)



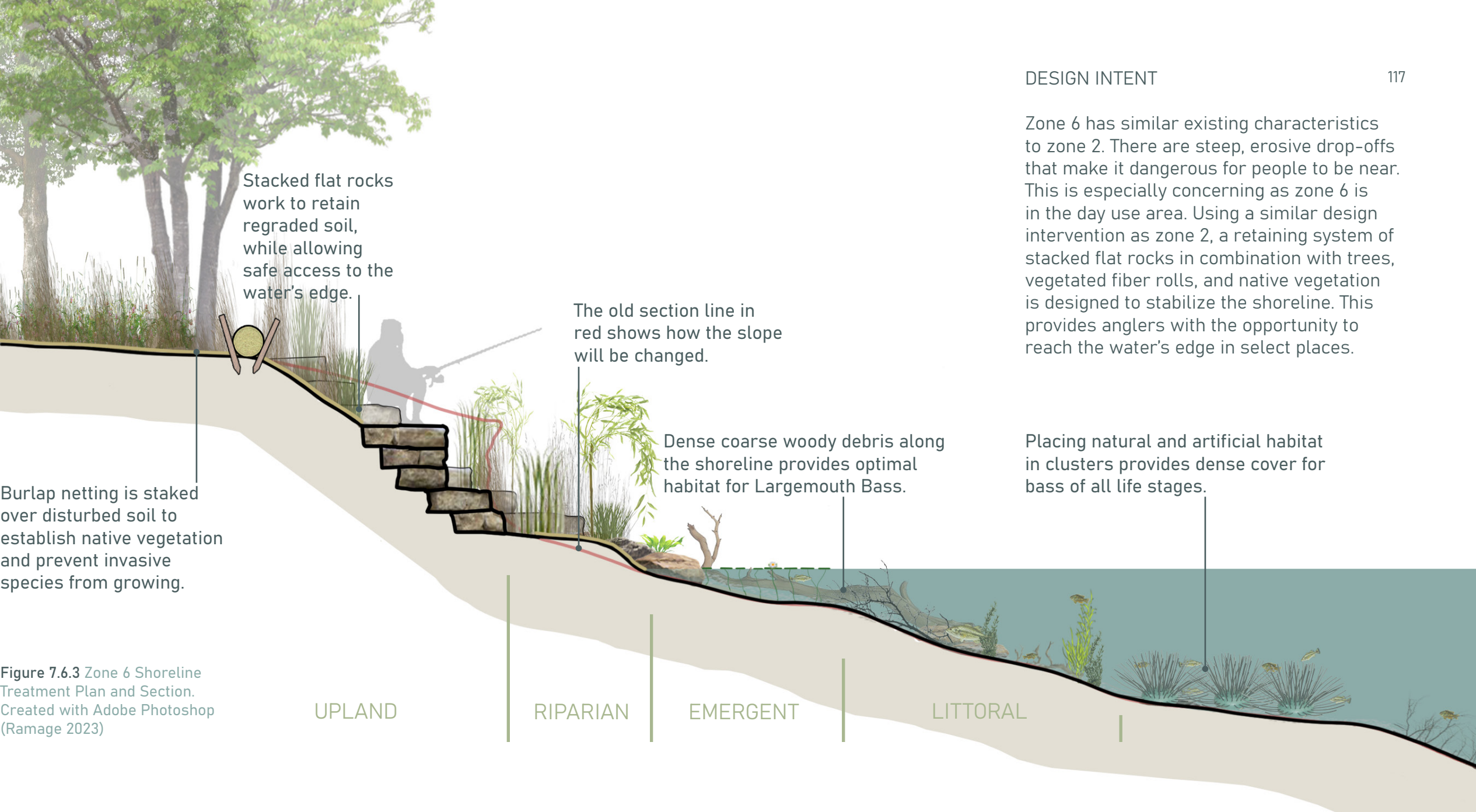
# ZONE 6 SHORELINE TREATMENT



## DESIGN INTENT

Inspiration for the swimming beach came from the Duck Creek Recreation Area precedent study. That lake is roughly the same size as Pottawatomie State Lake No. 2. A small swimming beach would provide a variety of opportunities for families to enjoy. Locating it near the primary parking, restrooms, and a pavilion is ideal for site visitors.

# ZONE 6 SHORELINE TREATMENT



**Figure 7.6.3** Zone 6 Shoreline Treatment Plan and Section. Created with Adobe Photoshop (Ramage 2023)

## DESIGN INTENT

Zone 6 has similar existing characteristics to zone 2. There are steep, erosive drop-offs that make it dangerous for people to be near. This is especially concerning as zone 6 is in the day use area. Using a similar design intervention as zone 2, a retaining system of stacked flat rocks in combination with trees, vegetated fiber rolls, and native vegetation is designed to stabilize the shoreline. This provides anglers with the opportunity to reach the water's edge in select places.



# ZONE 7 SHORELINE TREATMENT



## DESIGN INTENT

Zone 7 is the other primary creek inlet of Pottawatomie State Lake No. 2. Similar to zone 4, zone 7 has signs of sedimentation possibly due to agricultural land in the watershed. By capitalizing on the opportunity for wetlands, a second wildlife observation blind is designed to provide more opportunities for site visitors. Additionally, the boardwalk in this zone provides access to the hiking trails on the east side of the lake.

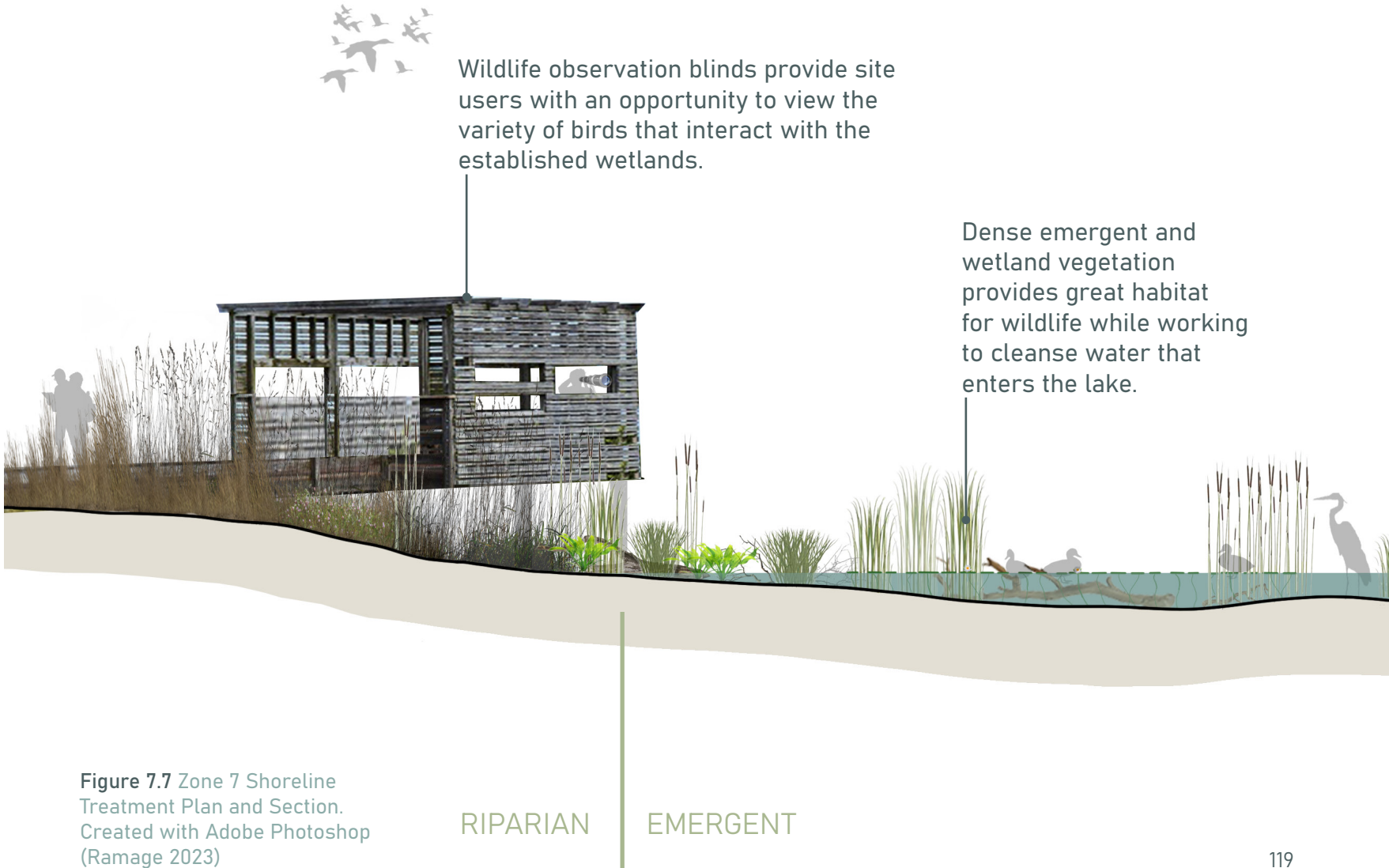


Figure 7.7 Zone 7 Shoreline Treatment Plan and Section. Created with Adobe Photoshop (Ramage 2023)

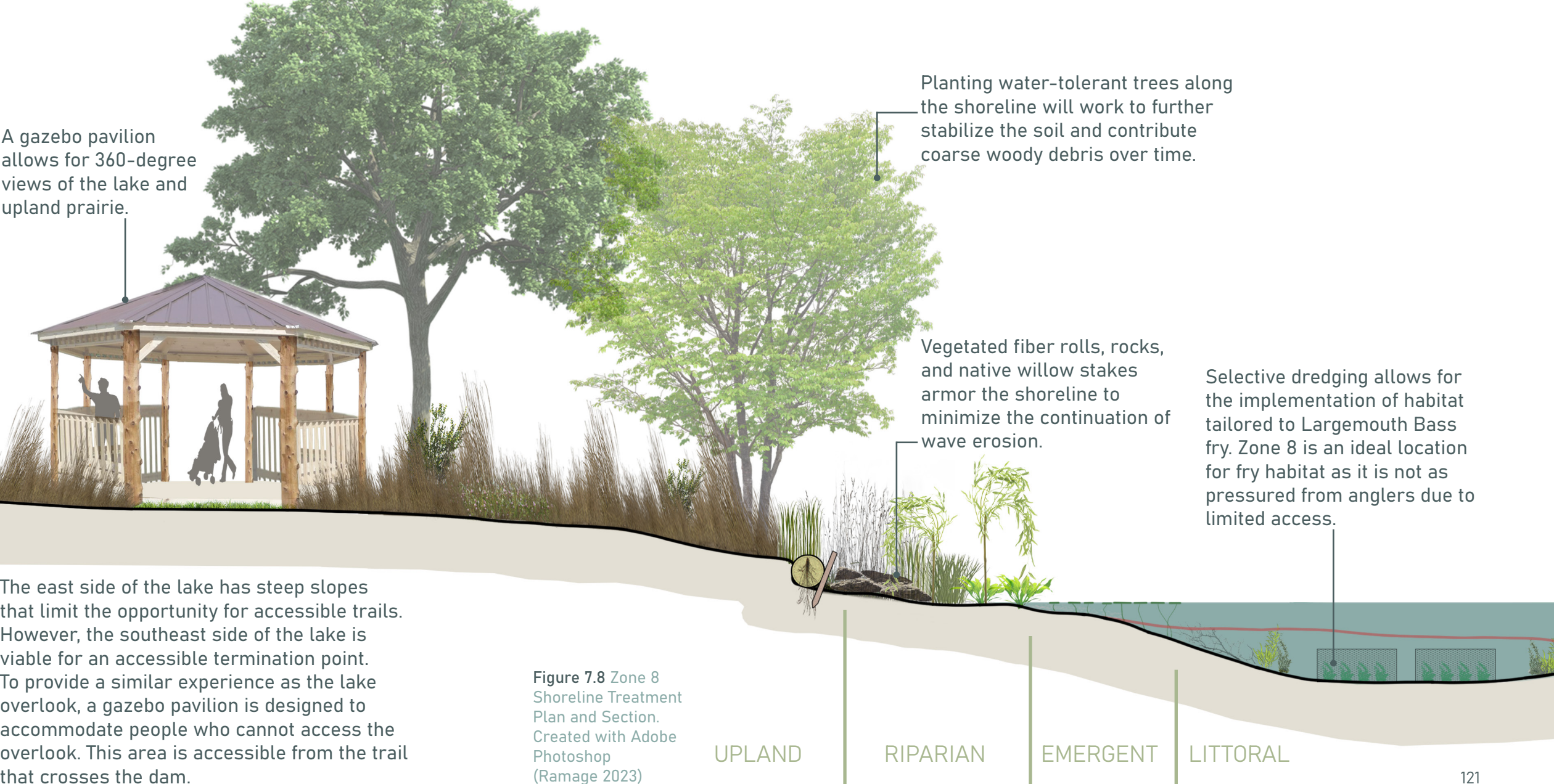


# ZONE 8 SHORELINE TREATMENT



A gazebo pavilion allows for 360-degree views of the lake and upland prairie.

The east side of the lake has steep slopes that limit the opportunity for accessible trails. However, the southeast side of the lake is viable for an accessible termination point. To provide a similar experience as the lake overlook, a gazebo pavilion is designed to accommodate people who cannot access the overlook. This area is accessible from the trail that crosses the dam.





# ZONE 9 SHORELINE TREATMENT



Figure 7.9.1 Accessible Trail Across Dam. Created with Adobe Photoshop (Ramage 2023)

## DESIGN INTENT

Drawing inspiration from the Walnut Creek Lake and Recreation Area precedent study (shown in the image below), an accessible trail that crosses the dam is a crucial link for pedestrians and programmatic elements. The dam at Walnut Creek is roughly the same size as the dam at Pottawatomie State Lake No. 2. Therefore, the dam should be able to withstand the extra infrastructure. Working with engineers would be crucial if this concept were to move forward within the Kansas Department of Wildlife and Parks.



Figure 7.9.2 Walnut Creek Dam (Ramage 2023)

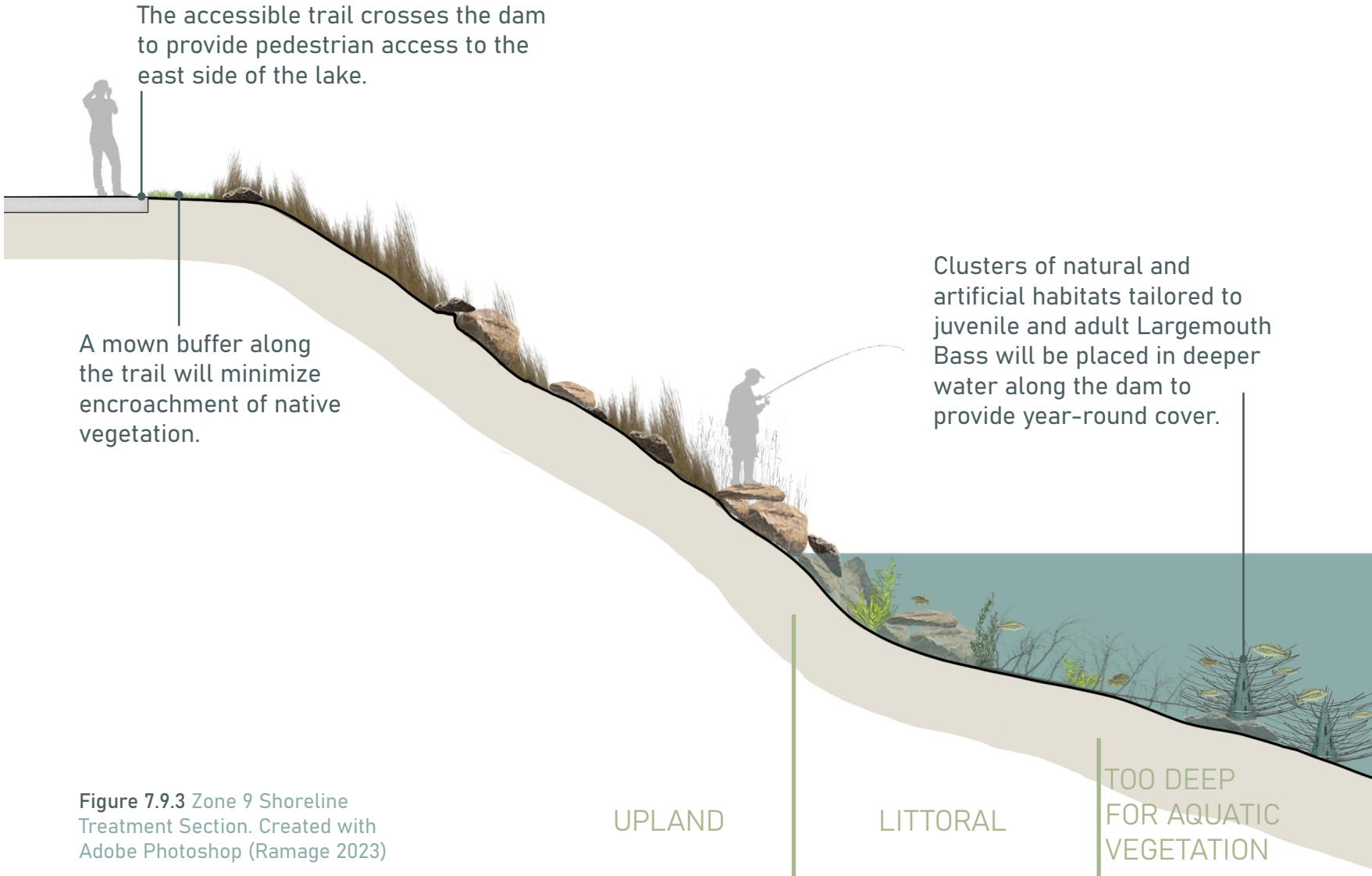


Figure 7.9.3 Zone 9 Shoreline Treatment Section. Created with Adobe Photoshop (Ramage 2023)





Figure 8 Pottawatomie State Lake  
No. 2 site image (Ramage 2023)

# PROJECTIVE DESIGN SUMMARY

2.23 Miles of Hiking Trails	1 Kayak Launch
1.67 Miles of Accessible Trails	4 Pavilions (including 2 overlooks)
0.35 Miles of Wetland Boardwalk	Swimming Beach
2 Wildlife Observation Blinds	7 Group Tent Campsites
2 Accessible Docks	25 Individual Tent Pads
12 Accessible Rock Jetties	317,400 sq ft of Proposed Wetlands
1 Boat Ramp	185,600 sq ft of Vegetated Buffer (replaces turf grass)
	1.13 Miles of Rehabilitated Shoreline



## PROJECT PRIORITIES

The project priorities are broken into eight objectives for the rehabilitation of Pottawatomie State Lake No. 2 with objective number 1 being the highest priority. Objectives 1-4 should be completed in the order that is listed, but objectives 5-8 can be implemented in any order decision-makers see fit. Furthermore, objectives 5-8 are not all deemed necessary for rehabilitation, but provide diverse opportunities for site users and should each be considered for implementation if the budget allows.

1. Address shoreline erosion and establish vegetated buffers
  - Zones 2 and 6 – Highest need for design intervention.
  - Zones 1, 3 and 5 – Second priority for design intervention
  - Zones 4, 7, 8, and 9 – Last shoreline zones in need of design intervention, but the implementation of wetlands is very important.
2. Collaborate with Kansas Department of Parks and Wildlife and fisheries biologists to assess ideal locations for natural and artificial aquatic habitat for Largemouth Bass.
3. Remove and implement any road infrastructure that was proposed to allow for the development of accessible trails in the camping and day use zones.
4. Implement accessible rock jetties, repair boat ramp, implement kayak launch.
5. Implement tent pads and campsite amenities.
6. Implement proposed hiking trails and boardwalks.
7. Implement wildlife observation blinds and overlooks.
8. Implement proposed swimming beach and pavilions.

## WHAT ARE THE NEXT STEPS?

Completing a bathymetric scan of Pottawatomie State Lake No. 2 is crucial for future implementation of aquatic habitat. Collaboration between engineers, landscape architects, fisheries biologists, and the Kansas Department of Wildlife and Parks is necessary for any progression of the ideas and concepts proposed in this report. While this report aimed to fill the gaps between human recreation and ecological functionality of recreational lakes, there is much more to be researched, especially in the field, including analyzing shoreline performance and resiliency over time. If Pottawatomie State Lake No. 2 is rehabilitated with the interventions proposed in this report, it would be a great candidate for field research for decades to come. Additional research to build upon this report could be completed by graduate students or professionals focusing on other fish species at this lake and others — with the possibility of examining less common or even endangered species. On the social and behavioral side, more in-depth research on human interactions with shorelines and recreational amenities could be conducted to continue building on ideas and recommendations discussed in this report.

# PROJECT LIMITATIONS

All site visits to Pottawatomie State Lake No. 2 and analysis were completed over the wintertime, resulting in an underrepresentation of littoral and emergent vegetation. Further analysis should be completed during the spring and summer months to accurately inventory existing vegetation. Several assumptions had to be made due to the lack of ability to speak or otherwise communicate with representatives from the Kansas Department of Parks and Wildlife. Clear communication is important for the progression of this proposal. With limited resources pertaining to topography and bathymetry, many visual estimations had to be made in order to assess the shoreline, lake bottom, and upland conditions. Ideally, more accurate analysis would be completed to progress in the development of the park. Lastly, the projective design is only in the conceptual phase. A continuation of research and design development with professionals is needed to move forward with many of the ideas presented in this report.

# CONCLUSION

Pottawatomie State Lake No. 2 is in great need of shoreline rehabilitation to improve the overall health and longevity of the lake for future generations to enjoy. Through research and the design process, the interventions proposed in this report would mitigate the effects of shoreline erosion while capitalizing on the opportunities to improve pedestrian and vehicular circulation, programmatic opportunities, and habitat for Largemouth Bass and their prey.

It is time that we balance our recreational desires with the rehabilitation of the freshwater ecosystems we have impacted for hundreds of years. The research conducted in this report can be used for other recreational lakes in need of rehabilitation. Hopefully one day Pottawatomie State Lake No. 2 can be used as an example for future design, construction, or retrofitting of recreational lakes throughout the Flint Hills and the Midwest.



# Works Cited

Ahrenstorff, Tyler D., Matthew R. Helmus, and Greg G. Sass. 2008. "The Influence of Littoral Zone Coarse Woody Habitat on Home Range Size, Spatial Distribution, and Feeding Ecology of Largemouth Bass (*Micropterus Salmoides*).” Springer Science+Business Media B.V., 223-233. doi: 10.1007/s10750-008-9660-1.

Bennett, George W. 1971. *Management of Lakes and Ponds*. 2nd ed. New York: Van Nostrand Reinhold Company.

Beresford, Sam. 2022. "How Far Should Garden Be from Fire Pit?" Hoe and Rake. July 29, 2022. <https://www.hoeandrake.com/how-far-should-garden-be-from-fire-pit/>.

Bolding, Bruce, Scott Bonar, and Marc Divens. 2001. "*Use of Artificial Structure to Enhance Freshwater Sportfish Communities in Lakes, Ponds and Reservoirs: A Literature Review*." Olympia, Washington: Washington State Dept. of Fish and Wildlife, Inland Fish Investigations, Science Division.

Caflisch, Mary, Cathy Reas Foster, Sarah A. White, and Katie Callahan. 2021. "Shorescaping Freshwater Shorelines." Home & Garden Information Center. Accessed October 5, 2022. <https://hgic.clemson.edu/factsheet/shorescaping-freshwater-shorelines/>.

Chapman, Jacqueline M., Catherine L. Proulx, Maxime A.N. Veilleux, Caroline Levert, Shireen Bliss, Marie-Eve Andre, Nicolas W.R. Lapointe, and Steven J. Cook. 2014. "Clear as Mud: A Meta-Analysis on the Effects of Freshwater Fish and the Effectiveness of Sediment-Control Measures." *Water Research* 56: 190-202. doi: 10.1016/j.watres.2014.02.047.

City of Papillion. n.d. "Walnut Creek Recreation Area." Papillion, NE. Accessed October 24, 2022. <https://www.papillion.org/facilities/facility/details/Walnut-Creek-Recreation-Area-14>.

Dibble, Eric D, and S.L. Harrel. 1997. "Largemouth Bass Diets in Two Aquatic Plant Communities." *Journal of aquatic plant management*, 35 (2): 74-78.

Dirks, Harrison P. 2020. "A Framework for Reservoir Restoration in The Midwest." Technical Report, Kansas State University.

Gabelhouse Jr., Donald W., Ruchard L. Hager, and Harold E. Klaassen. 1982. *Producing Fish and Wildlife From Kansas Ponds. Kansas Fish and Game Commission*.

Havel, Richard. 2009. "Sustainable Trail Development: A Guide to Designing and Constructing Native-Surface Trails." Town of Castle Rock, Parks & Recreation Department. <https://www.crgov.com/DocumentCenter/View/1430/Sustainable-Trail-Development-Guidelines-PDF>.

Henderson, Carrol L., Carolyn J. Dindorf, and Fred J. Rozumalski. 1999. *Lakescaping for Wildlife and Water Quality*. State of Minnesota, Department of Natural Resources.

Juracek, Kyle E. 2015. "The Aging of America's Reservoirs: In-Reservoir and Downstream Physical Changes and Habitat Implications," *Journal of the American Water Resources Association* (JAWRA) 51, 1: 168-184. doi: 10.1111/jawr.12238.

Kansas Department of Wildlife and Parks. n.d. "Pottawatomie No. 2 Fishing information." Accessed October 5, 2022. <https://ksoutdoors.com/Fishing/Where-to-Fish-in-Kansas/Fishing-Locations-Public-Waters/Northeast-Region/Pottawatomie-No.-2>.

King, S., D. Osmond, J. Smith, M. Burchell, M. Dukes, R. Evans, S. Knies, and S. Kunickis. 2016. "Effects of Riparian Buffer Vegetation and Width: A 12-Year Longitudinal Study," *Journal of environmental quality* 45, 4: 1243-1251. doi: 10.2134/jeq2015.06.0321.

Kirkeeng, Chance. 2017. "Effects of a Large-Scale Habitat Enhancement Project on Largemouth Bass Behavior, Feeding, and Growth in Grand Lake, Texas." Dissertation, ProQuest Dissertations Publishing.

Marion, Jeffrey L., Jeremy Wimpey, Johanna Arredondo, and Fletcher Meadema. 2020. Sustainable Camping "Best Management Practices." DOI U.S. Geological Survey, Virginia Tech Field Unit. Final Research Report to the DOI, National Park Service, Appalachian Trail Park Office, and the Appalachian Trail Conservancy, Harpers Ferry, WV. 57 p.

Michigan Natural Shoreline Partnership. n.d. "Demonstration Sites." Michigan Natural Shoreline Partnership. Accessed October 24, 2022. <https://www.shorelinepartnership.org/demonstration-sites.html>.

Muenz, Tara K., Stephen W. Golladay, George Vellidis, And Lora L. Smith. 2006. "Stream Buffer Effectiveness in an Agriculturally Influenced Area, Southwestern Georgia: Responses of Water Quality, Macroinvertebrates, and Amphibians." *Journal of Environmental Quality* 35 (5): 1924-1938. doi:10.2134/jeq2005.0456.

Nebraska Department of Natural Resources (NeDNR). n.d. "Common Problems at Dams - Trees Department of Natural Resources." Accessed October 11, 2022. <https://dnr.nebraska.gov/dam-safety/trees>.

Nemaha NRD. n.d. "Duck Creek Recreation Area | Nemaha Natural Resources District." Accessed October 24, 2022. <https://www.nemahanrd.org/recreation/duck-creek-recreation-area>.

Pegg, Mark A., Kevin L. Pope, Larkin A. Powell, Kelly C. Turek, Jonathan J. Spurgeon, Nathaniel T. Stewart, Nick P. Hogberg, and Mark T. Porath. 2015. "Reservoir Rehabilitations: Seeking the Fountain of Youth." *Fisheries (Bethesda)* 40 (4): 177–181. doi: 10.1080/03632415.2015.1017635.

Reed, Jeffery, and Donald Pereira. 2009. "Relationships Between Shoreline Development and Nest Site Selection by Black Crappie and Largemouth Bass," *North American journal of fisheries management* 29, 4: 943–948. doi: 10.1577/M06–234.1.

Sass, Greg G. 2009. "Coarse Woody Debris in Lakes and Streams." <https://doi.org/10.1016/B978-012370626-3.00221-0>.

Severson, John P. 2007. "Wetland Habitat Enhancement and Shoreline Stabilization Using Riprap Breakwaters on Kinkaid Lake in Southern Illinois." Dissertation, ProQuest Dissertations Publishing.

Tennessee Valley Authority (TVA). 2008. *Benefits of Riparian Zones That Use Native Plants*. Knoxville, Tennessee: Tennessee Valley Authority.

Zhu, Jiaying. 2012. "Criteria for Aquatic Planting Design in Ecological Redevelopment of Urban Riverfronts." Technical Report, Kansas State University.



# Appendix A

## Suggested Plant Palette

# Littoral Zone Primary Plant Suggestions

The littoral zone is the area below the waterline that is too deep for emergent vegetation. This zone is one to four feet deep or more if the water is clear. This allows sunlight to penetrate through, which is the ideal place to have native aquatic plants (Caflisch et al. 2021). Aquatic plant growth needs to be closely monitored and managed to prevent overgrowth that could lead to depletion of oxygen and possible fish kill.

Common Name	Scientific Name	Form/size	Notes
Pond Lily	<i>Nymphaeaceae</i>	rooted, floating, 6-8" diameter	Large coverage can limit oxygen in the water
American Pondweed	<i>Potamogeton nodosus</i>	rooted, long, jointed stems (up to 6 ft in length), submerged and floating leaves	Provides aquatic habitat for fish as well as food for waterfowl
Coontail	<i>Ceratophyllum demersum</i>	rootless, dark, straight, flat leaves (1/2" in length) on branches and off-shoots up to 11 ft long. "Christmas tree"-like form	Provides dense habitat and food for fry-juvenile fish
Naiad	<i>Najas spp.</i>	rooted, narrow, finely toothed-leaves, varies in size and form	Very important waterfowl food. Establish in moderation to prevent overgrowth

# Emergent Zone Primary Plant Suggestions

The emergent zone is the part of the bank slope that is in less than twelve inches of water. This area is most suitable for native emergent aquatic plants such as rushes and arrowhead (Sagittaria) (Caflisch et al. 2021).

Common Name	Scientific Name	Form/size	Notes
Arrowhead	<i>Sagittaria latifolia</i>	Up to 4 ft tall with long stalks and leaves. White or pink flowers	Great food source for waterfowl and other animals
Hardstem Bulrush	<i>Schoenoplectus acutus</i>	Slender stems 3-10 ft in height, compact flower with gray-brown spikelets	Provides habitat for birds and mammals, and spawning habitat for fishes. Filters contaminants and sediments
Water Sedge	<i>Carex aquatilis</i>	Waxy leaves and smooth stem, grows to height of 8-20" tall with 3-7 spikelets. Flowers May-August	Provides habitat for waterfowl and other birds, as well as cover for small fish.
Sweet Flag	<i>Acorus calamus</i>	Rush or sedge up to 2.5 ft in height, sword-shaped leaves	Can grow in up to 9" of water, used for erosion control
Shreve's Iris	<i>Iris virginica var. shrevei</i>	Sword-shaped limp leaves and stem up to 3 ft tall, blooms blue flowers in May	Toxic to domestic animals, use in areas away from day-use and camping.



# Riparian Zone Primary Plant Suggestions - Trees and Shrubs

The riparian zone is the part of the bank slope that is typically above water level but can become inundated during heavy rain events. The soil in the riparian zone is almost always saturated, except during very dry periods (Caflisch et al. 2021).

Common Name	Scientific Name	Form/size	Notes
Buttonbush	<i>Cephalanthus occidentalis</i>	Large multi-stemmed shrub to small tree growing up to 18 ft in height in ideal conditions. Fragrant flowers	Stabilizes shorelines, used as a food source by several species of birds and attracting to pollinators
Red Twig Dogwood	<i>Cornus sericea</i>	Deciduous shrub up to 9 ft tall, red stems, and showy white flowers	Provides multi-seasonal visual interest and combats soil erosion
Black Chokeberry	<i>Aronia melanocarpa</i>	Small-medium shrub up to 8 ft in height, multi-stemmed, white flowers and black fruit	Attractive shrub for the water's edge, provides food source to native birds
River Locust (False Indigo)	<i>Amorpha fruticosa</i>	Multi stemmed shrub reaching heights of 16+ ft	Used for erosion control
River Birch	<i>Betula nigra</i>	Spreading crown and drooping branches, reaches heights of 30 to 40 ft	Fast growing, multi-seasonal interest, stabilizes soil to combat erosion
Black Willow	<i>Salix nigra</i>	Medium tree growing up to 25-40 ft or more in ideal conditions	Plant by container or live stake, fat-growing to quickly stabilize soil
Eastern Cottonwood	<i>Populus deltoides</i>	Large tree up to 50-80 ft in height	Extensive root system stabilizes soil

# Riparian Zone Primary Plant Suggestions - Grasses and Perennials

The riparian zone is the part of the bank slope that is typically above water level but can become inundated during heavy rain events. The soil in the riparian zone is almost always saturated, except during very dry periods (Caflisch et al. 2021).

Common Name	Scientific Name	Form/size	Notes
Water Parsnip	<i>Sium suave</i>	Perennial up to 6 ft in height with showy white flowers	Thrives in wet soils and provides root structure to stabilize shoreline
Allegheny Monkey Flower	<i>Mimulus ringens</i>	Perennial up to 3 ft in height with showy purple flowers in late summer	Establishes by self-seeding and rhizomes, ideal for establishing riparian shorelines
Joe Pye Weed	<i>Eutrochium purpureum</i>	Tall perennial up to 7 ft in height with showy, fragrant pink flowers	Attracts pollinators and contributes to soil stability
Northern Sea Oats	<i>Chasmanthium latifolium</i>	Showy grass up to 5 ft in height, broad leaves with nodding seed head	Shade tolerant, self-seeding
Virginia Wild Rye	<i>Elymus virginicus</i>	Bunch grass up to 4 ft in height, showy nodding spikes, flat leaves	Self-seeding, used for erosion control
Fox Sedge	<i>Carex vulpinoidea</i>	Clump sedge up to 3 ft in height, narrow leaves	Prefers moist soil near streams or ponds

# Upland Zone Primary Plant Suggestions - Trees and Shrubs

The upland zone of a vegetated shoreline is the driest zone because the slope forces water to run downhill. The water level of the lake does not reach this level, so the plants in this zone need to be drought tolerant. Shrubs and trees are important as they help cool habitats along the water's edge and create structural diversity (Caflisch et al. 2021).

Common Name	Scientific Name	Form/size	Notes
Bur Oak	<i>Quercus macrocarpa</i>	Large deciduous tree up to 80 ft in height, rounded crown, leathery leaves, large acorns	Shade, habitat and food source to wildlife, extensive root system to stabilize soil
Swamp White Oak	<i>Quercus bicolor</i>	Medium deciduous tree up to 60 ft in height, broad, rounded crown, medium to wet soil preference	Plant in gradual transition areas adjacent to riparian or wetland zones, attracts birds
Basswood	<i>Tilia americana</i>	Large deciduous tree up to 80 ft in height, ovate-rounded crown, medium water preference	Shade tree, drought tolerant, showy flowers
Black Hickory	<i>Carya ovata</i>	Large deciduous tree up to 90 ft in height in ideal conditions, taproot, showy, edible fruit	Food and habitat to wildlife, important part of oak-hickory woodlands
Smooth Sumac	<i>Rhus glabra</i>	Large shrub, 9 to 20 ft in height, red fall color,	Prefers well-drained slopes, spreads quickly to stabilize soil, habitat to upland wildlife
American Plum	<i>Prunus americana</i>	Large shrub up to 15 ft in height, fragrant blooms	Excellent wildlife plant, forms a thicket over time
Choke Cherry	<i>Prunus virginiana</i>	Large shrub or tree up to 30 ft in height, white flowers	Provides habitat to native wildlife

# Upland Zone Primary Plant Suggestions - Grasses and Perennials

The upland zone of a vegetated shoreline is the driest zone because the slope forces water to run downhill. The water level of the lake does not reach this level, so the plants in this zone need to be drought tolerant. Native perennials and grasses are best for this zone (Caflisch et al. 2021).

Common Name	Scientific Name	Form/size	Notes
Big Bluestem	<i>Andropogon gerardii</i>	Native tallgrass up to 6 ft in height, flat leaves, tight, extensive root system	Stabilizes soil, good for erosion control
Little Bluestem	<i>Schyzachyrium scoparium</i>	Native tallgrass up to 3 ft in height, clump forming, purplish in color	Tight roots stabilize soil, great for dry slopes
Switchgrass	<i>Panicum virgatum</i>	Native tallgrass up to 6 ft in height, tolerates range of soils, columnar form	Self-seeding, attracts birds, used in a variety of scenarios including along shorelines
Indian Grass	<i>Sorghastrum nutans</i>	Native tallgrass up to 5 ft in height, copper-colored seed heads, very showy	Rhizomatous roots, ideal for soil stabilization
Black-eyed Susan	<i>Rudbeckia hirta</i>	Perennial up to 3 ft in height, showy golden flower, prefers mesic soil	Self-seeding, attracts birds and pollinators, seasonal interest
Purple Coneflower	<i>Echinaceae purpurea</i>	Perennial up to 5 ft in height, purplish pink flower, dry to mesic soil	Self-seeding, attracts birds and pollinators, seasonal interest
Great Blue Lobelia	<i>Lobelia siphilitica</i>	Perennial up to 3 ft in height, showy blue flower, refers mesic to wet soil	Thrives near ponds or streams



# Sources Used for Suggested Primary Plants

<https://www.solitudelakemanagement.com/blog/6-aquatic-plants-in-lakes-across-the-midwest/>

<https://extension.psu.edu/naiad#:~:text=Value%20and%20Concern%20to%20the%20Pond%201%20Naiad,fish%20kills%20when%20it%20dies%20in%20the%20fall.>

<https://www.missouribotanicalgarden.org/PlantFinder>

<https://mortonarb.org>

<https://extension.usu.edu/rangeplants/grasses-and-grasslikes/water-sedge>

Henderson, Carrol L., Carolyn J. Dindorf, and Fred J. Rozumalski. 1999. *Lakescaping for Wildlife and Water Quality*. State of Minnesota, Department of Natural Resources.

# Additional Sources for Native Plants

Kansas Grasses and Wildflowers (<https://www.kswildflower.org/>)

The USDA Plants Database (<https://plants.usda.gov/home>)

Crit Site Prairie & Wetland Nursery (<https://www.critsite.com/>)

Taylor Creek Restoration Nurseries (<https://www.taylorcreeknurseries.com/>)

Lady Bird Johnson Wildflower Center (<https://www.wildflower.org/plants-main>)