

Creekfront activation: strategies for linear spaces and nature-based activities along
Wildcat Creek

by

Xing Huang

A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture and Regional & Community Planning
College of Architecture, Planning and Design

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Approved by:

Major Professor
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ABSTRACT

In recent decades, many cities have rediscovered and embraced riverfront development as an ecologic, economic, and social asset. The trend of more active and purposeful riverfront development may even be accelerating (Otto et al. 2004). However, creeks as smaller watershed features than rivers, are far more abundant, while being largely ignored and underused (Marsh 2010). Compared to rivers, smaller creeks are often more sinuous, more prone to flooding, overgrown with vegetation, and steep embankments often restrict physical creek access. Creeks are often not seen by the public, and as a result, are an underutilized community asset. In addition, with the increased popularity of sedentary online activity, outdoor nature-based activities are neglected. Many people may seldom encounter nature, especially along creeks which are rich in ecological diversity and can be a site for active recreation and education (Szczepanski 2006; Gruno and Gibbons 2020). Therefore, addressing how communities and designers can better utilize creeks for recreational and educational purposes is a topic worth discussing. This report explores the research question: “How can nature-based recreational and educational programs that are resilient to periodic flooding be developed along creeks that frequently flood while maintaining better creek accessibility?” Research methods included a review of the literature, compiling and analyzing precedents, and conducting projective design for two sites along Wildcat Creek in Manhattan, Kansas. The outcome is an activation guide for nature-based recreational and educational activities located along creekfronts which can be used by community groups, landowners, and designers.

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CREEKFRONT ACTIVATION

Strategies for linear spaces and nature-based
activities along Wildcat Creek

Xing Huang
Master's Report
2022

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A report submitted in partial fulfillment of the requirements for the degree:
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ABSTRACT

In recent decades, many cities have rediscovered and embraced riverfront development as an ecologic, economic, and social asset. The trend of more active and purposeful riverfront development may even be accelerating (Otto et al. 2004). However, creeks as smaller watershed features than rivers, are far more abundant, while being largely ignored and underused (Marsh 2010). Compared to rivers, smaller creeks are often more sinuous, more prone to flooding, overgrown with vegetation, and steep embankments often restrict physical creek access. Creeks are often not seen by the public, and as a result, are an underutilized community asset. In addition, with the increased popularity of sedentary online activity, outdoor nature-based activities are neglected. Many people may seldom encounter nature, especially along creeks which are rich in ecological diversity and can be a site for active recreation and education (Szczepanski 2006; Gruno and Gibbons 2020). Therefore, addressing how communities and designers can better utilize creeks for recreational and educational purposes is a topic worth discussing. This report explores the research question: “How can nature-based recreational and educational programs that are resilient to periodic flooding be developed along creeks that frequently flood while maintaining better creek accessibility?” Research methods included a review of the literature, compiling and analyzing precedents, and conducting projective design for two sites along Wildcat Creek in Manhattan, Kansas. The outcome is an activation guide for nature-based recreational and educational activities located along creekfronts which can be used by community groups, landowners, and designers.

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KEY TERMS

ACCESSIBILITY

A term to describe the opportunity to approach, enter, and interact. It also reflects the ease of travel between two points in space (Tasic et al. 2014).

CREEK

A term used to describe a smaller sized stream, although sometimes the terms creek and stream are used interchangeably. creek in this work refers to the watershed that does not exceed 30 m (98 feet) in width.

CREEKFRONT

A term used to describe an area where land meets a creek, it also refers to the edge of the creek.

NATURE-BASED EDUCATION

Nature-based education can also be referred to as nature-based environmental education, which is usually defined as a set of practices, tools, and programs used in nature to promote ecologically responsible attitudes, values, awareness, and knowledge that will enable people to actively protect environmental quality (Ardoin et al. 2020).

NATURE-BASED RECREATION

Nature-based recreation, also known as outdoor recreation, refers to activities that occur on natural surfaces or directly involve elements of nature, such as terrain, plants, wildlife, or water (Cordell 2008).



01

INTRODUCTION

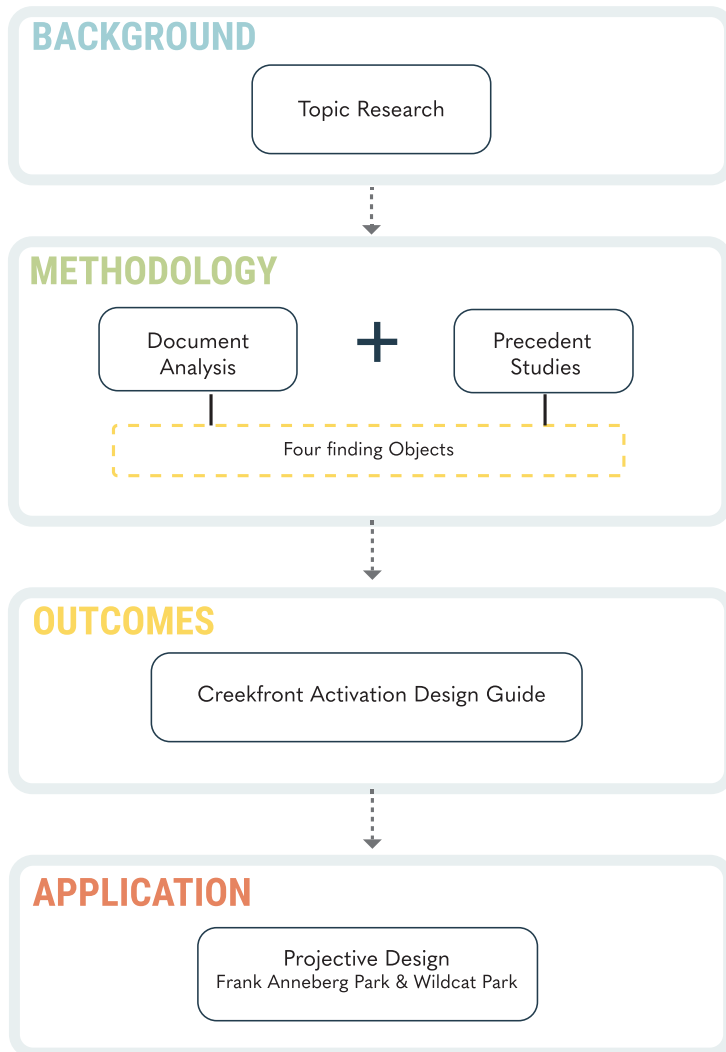


Figure 1.01
Visual report outline
(Huang 2022)

INTRODUCTION

For at least the last thirty years, many cities have rediscovered and redeveloped their rivers (Otto et al. 2004). This trend may even be accelerating (Otto et al. 2004). However, creeks are another watershed feature which lack comparable attention. Even though creeks are smaller than rivers, creeks are more abundant and can be found passing through or near most human settlements. Compared to rivers, development potential along creeks is far less researched and documented in the literature (Marsh 2010). Creeks present development challenges due to their flash flood potential, changing sinuosity and cross-section, steep embankments, thick bank vegetation, and restricted physical and visual access. Nevertheless, creeks can be a community asset if natural systems are respected, and development is carefully considered. Activating land frontage along creeks can be beneficial for the local economy, ecology, and residents (Otto et al. 2004). Supporting rich natural resources, creek frontage can serve as a natural playground for a wide variety of nature-based recreational activities and educational programs (Cordell 2008).

With the expansion of urbanization and the development of technology, people's desire to be exposed to nature and attendant opportunities are significantly reduced (Szczepanski 2006; Gruno and Gibbons 2020). Children are particularly affected by this phenomenon. There is evidence that school-aged children can accumulate more than seven hours per day of screen time across multiple media with TV serving as the most common screen type (Walsh et al. 2020; Uncapher et al. 2017), which leads to many negative impacts on their well-being and development. Children and adults can both benefit from increased contact with nature through nature-based recreational and educational activities. Creek frontage is an underutilized resource to support this activity and is the subject of this project and report.

DILEMMA

CENTRAL DILEMMA: Lack of access

As cities and the public realize the value and importance of rivers, more and more riverbanks are being rejuvenated, activated, and protected. However, on a comparative basis, creeks largely remain a neglected resource with limited access. Restrictive factors include a smaller size making them unnavigable, frequent bends contributing to course alterations, unstable and erosive banks, poor water quality, highly variable flow volumes, typical thick bank vegetation, less visibility, and private property restrictions and complicated adjacent land ownerships. In addition, pollution from runoff and times of low flow also discourage creek use. All these factors contribute to inaccessibility.

Access to creeks and frontages are necessary for successful urban spaces which benefit residents and visitors. By accessing, crossing, and using creeks, urban dwellers can enjoy more creek related educational and recreational activities. Creek access also enhances local identity and users experience a greater connection with nature that enhances their physical and mental health (Johnson 2019, May 2006). Place theory, which analyzes the human context in space, identifies accessibility which is the visual and physical connections of a place as one of the four factors that determine the quality of a place (Johnson 2019).

In the specific case of Wildcat Creek, its fronting lands are underused for recreational and educational purposes. Most of the land along Wildcat Creek outside of Manhattan is used for agriculture. Flowing eastward, once Wildcat Creek crosses Scenic Drive and enters Manhattan, land fronting the creek is a mixture of land uses: residential lots, a golf course, Manhattan parks, sports fields, water detention basins, and fragmented vacant green spaces. Most of land adjacent to Wildcat Creek resides in the Flood Hazard Zones (1% or 0.2% Annual Chance) (Bunger et al. 2013). The creek water level is also highly variable. According to data from USGS databases, the stage of Wildcat Creek at Manhattan Scenic Drive on August 31, 2021, was 2.8 ft

Figure 1.02
Creekfront access in
Frank Anneberg Park,
Manhattan, Kansas
(Huang, 2021)



(more typical), but there was a crest measured on July 15, 2021, which was 16.13 ft. just a month earlier. The flashy nature of creeks and high sediment loads also lead to Wildcat Creek banks which are steep and unstable. A large amount of vegetation exists along the creek edges which reduces soil erosion but can restrict flow by catching floating debris and exacerbating flooding. Overgrown vegetation also reduces creek visibility and accessibility. Multiple private land ownerships along the creek have also complicated assembling recreational trail corridors along the creek.

SECONDARY DILEMMA:

Lack of educational and recreational programming

As established in the background literature, many Americans spend inordinate amounts of time with electronic devices and have minimal contact with nature and the benefits it provides to mind and body. As a riparian habitat, Wildcat Creek offers a nature contact point for enjoyment, education, and recreation. However, due to limited access and disconnected open spaces along the creek, educational and recreational programming is currently lacking. Where would be the best locations for improved creek access points providing enhanced educational and recreational opportunities? What types of activities are envisioned? Who, or what groups, might originate and manage these activities?

RESEARCH QUESTION

How can nature-based recreational and educational programs that are resilient to flooding be developed along creeks that frequently flood while maintaining better accessibility?

SUPPORTING QUESTIONS

- How can experiential accessibility be better achieved along the creek?
- How does the design of nature-based activities affect creek bank protection strategies?
- How can creekfront areas be designed to offer visitors multiple options for gathering and entertaining, while supplying improved access to the creek?
- How can creek frontage which currently supports low usage be regenerated?
- How can creek floodplains incorporate multiple recreational and educational activities to activate the creekfront?
- How can the public be engaged with Wildcat Creek while maintaining habitat and hydrological function?
- What nature-based educational activities could a creek support?
- What recreational activities could a creek support?
- How can bank stabilization techniques protect steep and soft creek banks while permitting creek access and bank maintenance?

PROJECT OVERVIEW

This research project proposes design guidelines and nature-based activities for creekfront activation. To inform the development of creekfront areas for increased recreational and educational opportunities, the following resources will be reviewed: precedent studies, K-12 educational curricula, and recreational activity guides. Findings will be compiled as design guidelines which will inform projective design of two creekfront opportunity sites along Wildcat Creek in Manhattan, Kansas, including Frank Anneberg Park and Wildcat Park. The projective design demonstrates the application of the design guidelines and nature-based activities.

PROJECT GOALS

Develop a Creekfront activation guideline that government and landowners can use to inform the customization of their creekfront areas by applying nature-based activities.

Empower community members and landowners to activate creekfront areas by suggesting a step-by-step process, providing supporting examples, and outlining useful techniques, metrics, and resources.

Motivate the community, parents, and children to be closer to nature to encourage more participation in nature-based activities.

Provide resources for communities and landowners to best utilize creekfront areas to serve their needs and provide special economic benefits.



02

BACKGROUND

BACKGROUND

The background section of the report describes the knowledge of creekfront development and nature-based activities. The review of relevant literature assisted in understanding the importance of creekfront development and outdoor activities, and identified opportunities for future creekfront design by incorporating natural activities. Topic reviewed included: creek and creekfront, Wildcat Creek, the relationship between activity and space, nature-based activity, and nature-based education (Figure 2.01).

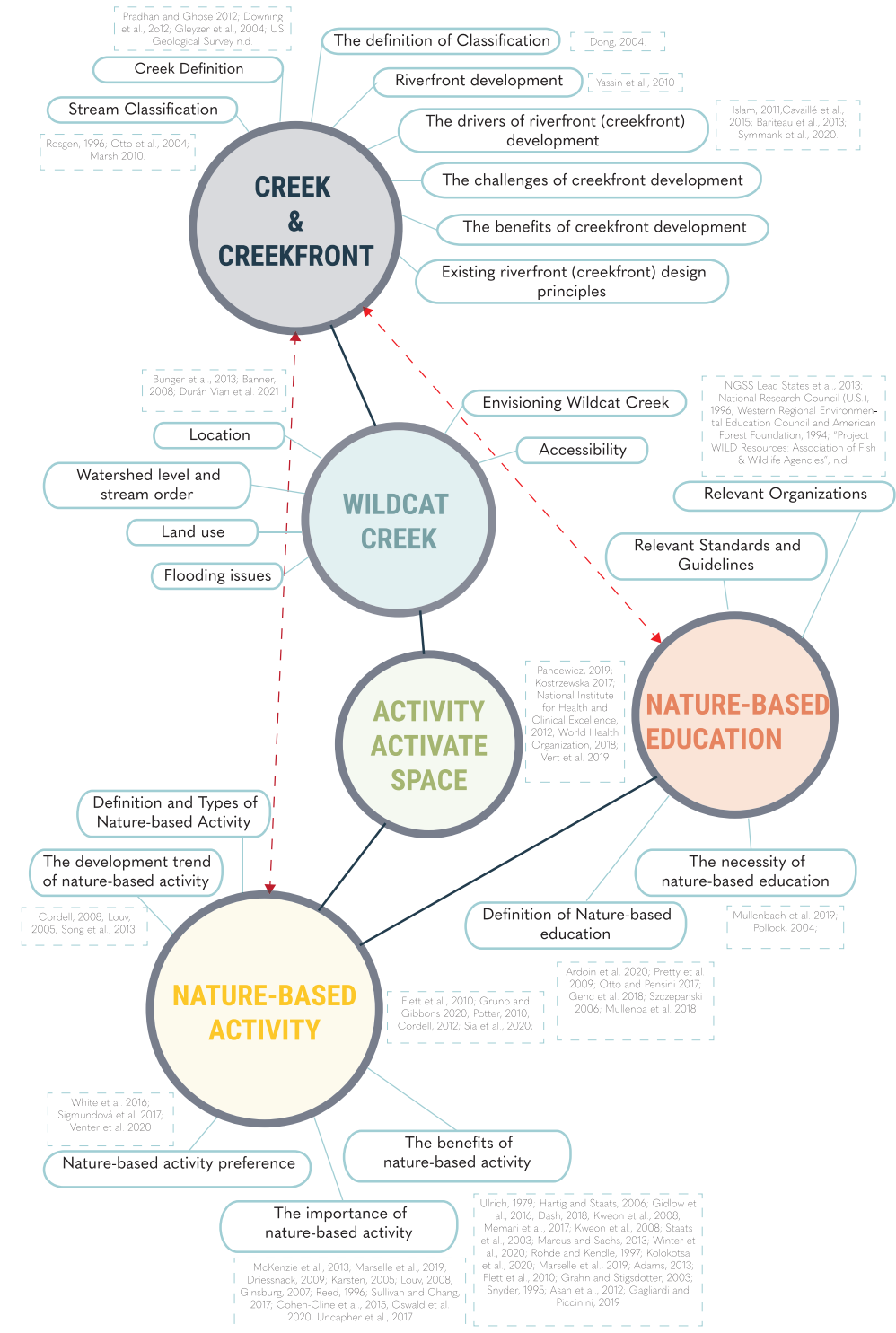


Figure 2.01
Literature map (Huang
2022)

CREEK AND CREEKFRONT

INTRODUCTION THE CREEK

Creek Definition

To accurately define a creek, it is necessary to understand what a watershed is and what order the watersheds follow, also known as the stream order.

Watershed

A watershed refers to the surface water that drains into a given stream, river, lake, or wetland (Otto et al. 2004). The movement of water through a watershed begins with rain, snowmelt, or groundwater that wells up to the surface (Otto et al. 2004). These surface waters move slowly over the ground and at some point, gather together to form minute threads of water (Marsh 2010). As these threads merge, rivulets form which erode soil and form small channels. Some of these rivulets merge to form larger channels, some of them form streams, and all of them merge to form larger streams (Marsh 2010). With each descent, these streams receive more runoff and groundwater discharge, eventually merging at the valley intersections. Large watersheds consist of several large rivers that ultimately empty into the oceans (Otto et al. 2004).

Streams that are joined together like the branches of a tree are known as drainage networks, and they are one of nature's most efficient ways of removing liquid water from the land (Marsh 2010). The drainage basin is the area from which water enters the drainage network, and, for a given set of geographical conditions, the size of the main channel and its flow increases with the size of the drainage basin (Marsh 2010).

Stream Orders

Networks in nature have a fundamental logic. The principle of stream orders defines that logic for drainage networks (Marsh 2010). Stream ordering creates a hierarchy of streamflow networks and classifies the system into identifiable orders (Pradhan and Ghose 2012; Downing et al. 2012). Among several stream ordering methods such as those of Horton (1945), Strahler (1952), Scheidegger (1965) and Shreve (1967), only the methods developed by Strahler and Shreve are widely used today (Pradhan and Ghose 2012; Gleyzer et al. 2004). In this work, the stream order developed by Strahler is used.

In Strahler's stream ordering system, all streams that have no tributaries are assigned an order of $K=1$. Continuing downstream, two (or more) streams of the same order K will form a stream with an order of $K+1$. There is no change in the downstream order of an order K stream when met with one of a lower order (Gleyzer et al. 2004). Figure 2.02 demonstrates a simple stream network with Strahler orders.

A stream segment's order depends on the order of its tributaries (Pradhan and Ghose 2012). The point of convergence is known as a junction, and streams are also referred to as links (Pradhan and Ghose 2012). The highest level in Strahler's stream order is 12, and the only river recorded at level 12 is the Amazon River, and one river recorded at level 11 is the Nile (Downing et al. 2012).

The exact width of a stream is determined by its discharge, slope, land use composition, and modification, along with its geomorphic history (Downing et al., 2012). Based on these features and the sequence of the rivers, Downing et al. (2012) collected and analyzed 400 streams from the published literature and were supplemented with original measurements of stream

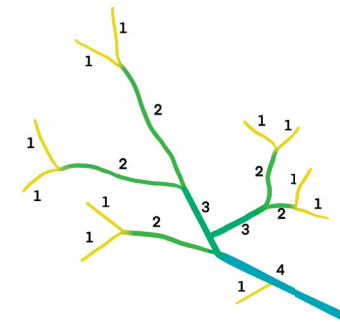


Figure 2.02
Stream Network with
Strahler Orders. (Huang
2021)

Order (m)	n _w	Mean length (km)	Total Length (km)	Width (m)	Area (km ²)
1	28,550,000	1.6	45,660,000	0.8	36,500
2	6,000,000	3.7	22,061,000	1.8	39,200
3	1,260,000	8.5	10,660,100	3.7	39,600
4	264,000	19.5	5,151,100	8.3	42,500
5	55,500	44.8	2,489,000	29.3	72,800
6	11,700	103.2	1,202,700	73.3	88,100
7	2,450	237.4	581,200	131.5	76,400
8	515	546.2	280,800	264.5	74,300
9	110	1,256.7	135,700	608.5	82,600
10	23	2,891.7	65,600	988.5	64,900
11	5	6,653.8	31,700	803.0	25,400
12	1	6,427.0	6,440	3,079.0	19,800

▲
Table 2.01
Stream order, number,
and mean length of
rivers and streams of
the world (Generated
from Downing et al.
2010 by Huang 2021)

width from satellite imagery, and found the relationship between the order and width of the streams. Downing et al. found out that the median width of a 1st order stream is 1.62 m, increasing exponentially with stream order (Downing et al. 2012). The mean width of streams and Strahler stream order present a positive growth relationship. Based on the similarity of river networks between regions and the reliability of physical rules governing the branching of river networks, Downing et al. analyzed the world's rivers as one branching river network. They estimated the global extent and size distribution of the world's water courses (see Table 2.01) from known ratios and conditions that the stream length of only one 12th order river in the world (the Amazon) is 6,487 km (Downing et al. 2012).

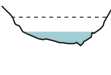
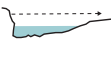
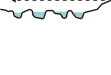
As shown in Table 2.01, first-order streams are the most numerous, and their width and length are relatively small. Indeed, the majority of American's river miles-more than 85 percent-are first-order through third-order streams, also known as headwater streams (Otto et al. 2004). A "headwater" is usually thought of as a small, swift, icy, and deeply shaded stream that flows down a steep, boulder-filled gorge (Otto et al. 2004). A headwater is an intermittent stream that flows briefly after snow melts or after a rain, but shrinks in dry weather, becoming a pool filled with water (Otto et al. 2004).

The words creek, river and stream are commonly used to represent a watershed based on its size in our daily lives. Although the current literature does not have a clear definition and standard to divide them, it is generally believed that creeks are the smallest of the three drainage types, with streams being in the middle, and rivers being the largest (US Geological Survey n.d). Based on Strahler's stream ordering and the study of Downing et al., **creek** in this work refers to the watershed that does not exceed 30 m (98 feet) in width.

Stream Classification

Stream classification helps to better understand design guidelines in the report and to implement creekfront design. Current river characteristics and configuration reflect current climate, lithology, deposition, and erosion history, in addition to the mediating effect of vegetation zones (Rosgen 1996). Since these factors change slowly, they set the basic template for the characteristics of the fluvial system (Rosgen 1996). The landforms and valley morphologies created by these processes occur over long time periods and vast distances. River morphology reflects not only past events, but also the streamflow and sediment regime determined by climate and form (Rosgen 1996). River morphology has three fundamental components: dimension, pattern, and profile, which act together to allow a river to be in balance with the prevailing energy gradients, sediment supplies, and sediment transport characteristics (Rosgen 1996).

Rosgen (1996) identified major stream classification based on the characteristics of valley types and landform, and the characteristics of channel cross-section, longitudinal profile, and planform features as measured and computed from collected field data (Rosgen 1996). Table 2.02 summarize the classification and main characteristics of major streams.

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/Soil Features	Cross Section View
Aa+	Very steep, deeply entrenched, debris transport, torrent streams	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools and waterfalls.	
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soil. Very stable if bedrock or boulder dominated channel	<1.4	<12	1.0 to 1.2	.04 to .01	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.	
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .029	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.	
C	Low gradient, meandering point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.	>2.2	>12	>1.2	<.02	Broad valleys w/terraces, in association with floodplain, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.	
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggregational processes, high bedload, and bank erosion.	
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly Variable	Highly Variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.	

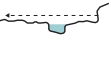
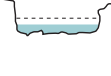
Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/Soil Features	Cross Section View
E	Low gradient meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.	
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.2	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.	
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.	



Table 2.02
General stream type
descriptions and
cross section views
(Generated from
Rosgen 1996 by Huang
2021)

In addition, even though rivers and creeks are both associated with watersheds, they still exhibit some features that distinguish them. The table 2.03 indicates the different between rivers and creeks.

INTRODUCTION TO CREEKFRONT

In this section, when introducing knowledge that is applicable to all watershed fronts, waterfront and riverfront are sometimes used as subjects instead of creekfront.

The definition of creekfront

A waterfront is generally defined as a zone of interaction between urban development and the water (Yassin et al. 2010). The term “waterfront” refers to the edge of the water in cities and towns of all sizes. The water body may be a river, lake, ocean, bay, creek, or canal (Yassin et al. 2010). Waterfront, or more widely known as riverfront, is defined in many ways. The urban riverfront is defined by Hussein as a dynamic area where cities engage their shorelines (Yassin et al. 2010). Dong (2004) defines a waterfront as a land fronting on water (Yassin et al. 2010). The term waterfront is sometimes substituted by several different words, such as city port, harbor front, riverside, river edge, and riverfront (Yassin et al. 2010).

A more detailed definition by Guo (1998), as cited in Dong (2004) and Yassin et al. (2010), describes the waterfront as an area where land meets water, approximately 200 to 300 meters away from the water and 1 to 2 kilometers away from the land site, as well as land within 20 minutes of walking distance. In addition, the waterfront area has a variety of interconnected features to create a focal point surrounding structural and nonstructural objects (Yassin et al. 2010). The special features, as shown in Table 2.04, of the waterfront area identified by Yassin et al. include dynamic area, habitat, nature defense, and pollution moderator (Yassin et al. 2010). Moreover, each riverfront area has its own geometry, including length, width, and water level, influenced by stream types, public infrastructure, landowner, and historical factors (Yassin et al. 2010).

For this work specification, “creekfront” describes an area where land meets first-order stream with width not to exceed 30 m (98 feet), approximately 200 to 300 meters away from the water and 1 to 2 kilometers away from the land site.

	River	Creek
Stream Order	12	1
Mean Length (km)	6427.0	1.6
Width (m)	3079.0	0.8
Amount	1	28,550,000
Sinuosity	Highly Variable, usually less meandering	Meandering
Flooding	Moderately stable	Highly often
Bank Stable	Highly Variable	laterally unstable with high bank erosion rates
Discharge	High volume	Low volume
Vegetation	Extensive richness	Relatively monotonous
Accessibility	Multi-access with open views	Natural barriers along the edges
Corridor	Well-developed	Underused
Land ownerships	Public, simple	Private, complicated

Table 2.03
The comparison of river and creek. (Huang 2021)

Riverfront development

It has been at least 30 years since towns and cities have renewed interest in their rivers, transforming abandoned industrial or derelict land into parks, homes, and offices (Otto et al. 2004). In fact, rivers have been a significant factor in urban settlements in North America for over four centuries (Otto et al. 2004). The history of riverfront development can be traced back to 2,000 BC (Yassin et al. 2010). Mann (1973) as cited in Yassin et al. (2010, p 6) indicates the historic milestone of urban riverfront development can be divided into six eras, as follows.

First Riverfront Settlement (2,000 BC-100 AD)

In the early days, transportation was mainly provided by the river for both travelers and goods. Even though the riverfront at the time was not an essential requirement for the city’s establishment, society continued to grow along its edge. The significance of initial connections between rivers and people was evident during this period of history (Yassin et al. 2010).

Middle Ages (100 AD – 1,600 AD)

Around that time, travelers who traveled along the river began to settle along the banks. The reason for colonizing along the riverbank may have been for safety reasons since the rest of the zone was covered in dense forest. Additionally, the river provided water for daily use and trading. Therefore, rivers became the primary determinant of city development (Yassin et al. 2010).

Renaissance (1,600 AD – 1,800 AD)
 During this period, the colony grew. The colony expanded by cutting down trees and clearing land. Thus, river-related businesses grew, and the river became a focal point. During this time, the river became of vital importance to the city’s development (Yassin et al. 2010).

Industrialization (1,800 AD – 1975)
 Small settlements developed into towns, and buildings were built along the rivers to facilitate trade. Many businesses began building structures on the riverbanks such as warehouses. Over time, rivers came to be perceived as public open space corridors. As a result, the riverfront area became a thriving business district (Yassin et al. 2010).

Decline of the Riverfront (1975 – 1990)
 The development of better transportation methods led to the decline of the riverfront. Roads and rail lines were constructed as a more convenient means of transportation. Due to better transportation, the river declined as a means of communication (Yassin et al. 2010). With the city turning its back on the river, the river was beginning to be neglected. It had become a back alley for the growing city. Together with the polluted river, early buildings and traditional settlements are still visible along the riverfront. This marks the beginning of the abandonment of riverfronts (Yassin et al. 2010).

Renewal of Riverfront (1990 – present day)
 Increasing research on rivers has led to people becoming aware of the importance of protecting river resources for urban development, and people’s demand for outdoor space has risen with the improvement of economic conditions, thus, cities have

Table 2.04
 Special characteristics of waterfront area
 (Generated from Yassin et al. 2010 by Huang 2021)

CHARACTERISTICS (FEATURES)	DESCRIPTION
DYNAMIC AREA	The Waterford zone is a dynamic area with constantly changing biological, chemical, and geological characteristics.
HABITAT	The waterfront has highly productive and biologically diverse ecosystems that benefit a wide variety of species by providing them with habitats.
NATURAL DEFENSE	Waterfront zone features such as mangrove forests provide an important natural defense against natural hazards (flooding, erosion, and storms).
POLLUTION MODERATOR	Water ecosystems may play a role in reducing the pollution effects from the land, for instance, by absorbing excess nutrients from sediments and human waste.

begun to revitalize the riverfront (Otto et al. 2004). Rediscovering rivers is a trend in cities today (Otto et al. 2004).

The drivers of riverfront (creekfront) development

Otto et al. (2004) indentifies three primary drivers that are influence riverfront development in urban areas today: 1) Water quality improvement and brownfield redevelopment, 2) A need for more park space and greenway, and 3) A growing interest in “green infrastructure” benefits (Otto et al. 2004).

Water quality improvements and brownfield revitalization

Since the 1950s, the federal government has been making some efforts, such as grants, to promote basic treatment of raw sewage before it is dumped into rivers and lakes (Otto et al. 2004). As well as the environmental movement of the 1960s, which resulted in the first Earth Day in 1970 (Otto et al. 2004). In 1972, Congress passed the Federal Water Pollution Control Act Amendments, which later became known as the Clean Water Act (Otto et al. 2004). In response to this Act, massive programs were developed to build wastewater treatment facilities, reduce raw sewage in rivers, and lead to redevelopment of rivers and riverfronts (Otto et al. 2004).

As urban rivers became cleaner in the 1980s, they were not just more aesthetically pleasing, but also healthier, enabling them to sustain a broader variety of fish, birds, and other wildlife (Otto et al. 2004). As a result of these improvements, the public was drawn to the water’s edge for walks, biking, fishing, and observing wildlife. Following the return of the people to the river, they expressed an increasing interest in preserving and restoring natural areas and wildlife habitat (Otto et al. 2004).

Desire for more park space and greenway

In many cities, riverfronts are being developed with open space, parks, and paths (Otto et al. 2004). As an example, Saint Paul, Minnesota, has developed a network of walkways and trails along a section of its downtown riverfront in conjunction with the restoration of the Harriet Island Historic Park (Otto et al. 2004).

Growing appreciation of “Green Infrastructure” Benefits

Over the past few decades, as more has been learned about the benefits of protecting natural resources, there has been a movement toward protecting natural river attributes and restoring harmed areas (Otto et al. 2004). Along with cleaning up past problems, cities are beginning to realize the importance of guarding against future harm, including obvious and inadvertent impacts (Otto et al. 2004). Federal, state, and local regulations began requiring protection of river water, structures, and functions. River protection is being incorporated into urban riverfront designs and construction (Otto et al. 2004).

The challenges of creekfront development

The potential of a creek as a development corridor is much less explored and documented in the literature in comparison with rivers because of the numerous challenges of creek development (Marsh 2010). Creeks present development challenges due to their flashy flood potential, changing sinuosity and cross-section, erodible soil, thick bank vegetation, restricted physical and visual access, poor water quality, community concern, and numerous landowners.

Community factors

The support for creek development is influenced by a number of community-related factors, such as: recognizing and considering the community's opinions about the development of sites, funding, materials, etc. (Whitehouse 2021). Lack of support from the community may hinder the development process and impact the development and use of the creek. Development along the creek can face serious legal problems, verbal conflicts, and vandalism (Whitehouse 2021). There is a negative correlation between the proximity of property to development and support (Whitehouse 2021). One example of trail development found by Brooks (2005) was landowners who owned property closer to trails reported more problems than those who owned property further away (Whitehouse 2021). It is logical to assume that trails are less supported where they are close to residences (Whitehouse 2021). The same logic could be applied to development along creekfronts.

Adjacent landowners factors

One of the biggest challenges of development along creeks is that many landowners will be involved. Take Wildcat Creek as an example. According to the Riley County GIS, there are 33 landowners on Wildcat Creek within the Manhattan boundary. These 33 landowners include the city of Manhattan. There are 10.1 miles of Wildcat Creek within the boundaries of Manhattan, of which the city of Manhattan accounts for only 15%, including the overlap with other owners, so 85% belongs to the other 32 private landowners. A more diverse group of landowners means more opinions, thus making adjustment more difficult.

Flooding

Flooding occurs when a channel cannot carry all the water it receives (Marsh 2010). Humans have experienced floods for thousands of years. Although our understanding of flooding has grown significantly over the past century or so, property damage and loss of life continue to increase (Marsh 2010). This trend is mostly due to population growth and a trend toward relocation to river valleys, coastal zones, the significant increase in non-permeable surfaces, and large cities throughout the developing world (Marsh 2010). Marsh (2010) notes that flooding is among the top environmental concerns in the United States. Over 7 percent of the United States lies within a 100-year floodplain, and these areas have been particularly appealing to rural and urban development (Marsh 2010). There were between 3.5 million and 5.5 million acres of floodplain land developed for urban use by 1980, including over 6,000 communities with populations over 2,500 (Marsh 2010). Development in the floodplain continues to expand at an annual rate of about 2 percent (Marsh 2010). Currently, vulnerable land uses are numerous, as evidenced by disasters like the recent Katrina flooding (Marsh 2010). Because of the terrain and riverbank structure, there is a high chance that a creek will flood, and its watershed area is frequently located in the flood zone, particularly the 1% Annual Chance Flood Hazard zone and Floodway.

Soil erosion

Soil erosion is one of the most serious issues related to land management that humanity must deal with today (Marsh 2010) and is also a common problem associated with creeks. Repeated flooding in a watershed erodes the riverbank and also damages wildlife habitats, farmland, buildings, roads, bridges, and other public places and private property (Islam 2008).

Sediment from soil erosion contaminates terrestrial and freshwater environments, such as woodlands, stream valleys, wetlands, and reservoirs, leading to habitat destruction and water quality degradation (Marsh 2010). Vegetation cover is the most important control on erosion for most soils (Marsh 2010). Erosion is inevitable when vegetation is disturbed or removed -irrespective of whether it is grass or trees (Marsh 2010).

The driving factors of the system are rainfall and runoff, whereas vegetation, soil texture, and slope are the resisting factors (Marsh 2010). Other factors affecting runoff erosion include rainfall intensity and frequency, slope and land management, and soil erodibility (Marsh 2010). The most erodible soil types

are loams, sands, and silts located on slopes without protection from plants (Marsh 2010). The effect of this condition is even worse if it is accompanied by heavy rainfall and no runoff controls. The loss of soil may be as high as 1 to 2 inches per year under these conditions (Marsh 2010). Marsh identifies four basic factors for soil erosion forecast: (1) vegetation, (2) soil type, (3) slope size and inclination, and (4) the frequency and intensity of rainfall (Marsh 2010).

Therefore, bank protection is a major ecological, landscape, urban planning, and engineering research topic. Most current bank erosion prevention structures are designed from a hard civil engineering perspective. In recent decades, bioengineering approaches have been developed (Cavaillé et al. 2015). Bank stabilization methods should be designed to fit field conditions. “Some stabilization concepts use synthetic or manufactured materials such as walls, mattresses, interlocking blocks and hexagonal structures and often involve multiple interventions on the riverbanks (Bariteau et al. 2013, 384).” Hardened bank stability techniques are a time-tested technology. These techniques need to be highly durable and easy to build. However, creating artificial banks by laying down steeply sloping fill composed of shot rock, a common bank protection method, will significantly reduce the potential for vegetation regrowth and limit access to water for both animals and humans (Bariteau et al. 2013). In recent decades, bioengineering methods have been developed which allow plants to be attached to the substrate with various devices to resist erosion. But in some cases, bioengineering methods will be limited to flattening slopes (Bariteau et al. 2013). Vegetation also sometimes fails to halt erosion if it is applied on treed clay or silt banks. In this case, bioengineering methods still require hard structures to be placed at the foot of the bank as well as major bank reshaping (Bariteau et al. 2013).

In addition, watersheds contain a variety of bank types. Bank types can be classified according to the following aspects: type of floodplain, land use classes, soil type, and denitrification levels. Floodplains can be categorized as active floodplain, or one of several land-use covers like forest, grassland, wetlands, water, farmland, urban areas, non-vegetated, and shore area. Floodplain soils can be of several types: regosol, brown soil, pseudogley, vega, gley, gley-tscheronsem, and peatlands (Symmank et al. 2020). Riverbank protection methods need to be applied and designed according to the location and the purpose of what is being achieved.

The benefits of riverfront (creekfront) development

The urban waterfront has experienced a renaissance in the past twenty years. A riverfront that was formerly a manufacturing and transportation hub is gradually becoming a natural area and filled with clean water (Otto et al. 2004). In urban riverfront areas, trails, plazas, parks, restaurants, shops, offices, recreational attractions, and other amenities are being built to draw residents, businesses, and visitors to the water (Otto et al. 2004). Riverfront revival has been shown to improve quality of life for residents, promote economic growth, and beautify downtowns (Otto et al. 2004). Otto et al. (2004) summarized in his book the following advantages of riverfront development:

- Improve water quality and reduce costs
 - Conserving open space is often the most cost-effective way to protect drinking water and other environmental resources (Otto et al. 2004). In contrast to spending money on the cleanup of polluted waters, this method of cleaning is cost-effective (Otto et al. 2004). As an example, wetlands can absorb between 20 and 60% of the heavy metal content in water, capture 80 to 90% of runoff sediment, and eliminate 70 to 90% of nitrogen entering from the air (Otto et al. 2004). As well, forests next to rivers can filter up to 90% of excess nitrogen runoff and 50% of excess phosphorous (Ecological Society of America 2003; Otto et al. 2004).
- Curb flood damage and lower the costs of flood control
 - Water damage in riverside communities continues to wreak havoc by taking lives and causing property damage, especially in places without regulations for floodplain development (Otto et al. 2004). Managing river ecosystems sustainably benefit not only property owners, but also the community in general (Otto et al. 2004). Preserving the natural state of rivers and streams can reduce the damage caused by flooding and erosion. Stream banks can be stabilized naturally with alternative approaches, wildlife habitats can be created, and an ecosystem can be more aesthetically pleasing with alternatives to engineered approaches (Otto et al. 2004).

- Decrease stormwater management costs
- Reduce sprawl and related infrastructure costs
- Revitalize the downtown riverfront with housing and business opportunities
- Provide jobs for residents in construction and commercial business
- Offer recreational opportunities, open space, and park amenities
 - Redevelopment of urban riverfronts opens up new recreational opportunities, such as walking and bicycling on greenways (Otto et al. 2004). The ease of access to public parks and open spaces is seen as a sign of a wealthy community and a way to attract businesses and residents (Otto et al. 2004).
- Raise property values and generate new tax revenues
- Attract state and federal funding, volunteers, and broad financial support (Otto et al. 2004).

Existing riverfront (creekfront) design principles

General Principles:

- Ecological goals and economic development goals are mutually beneficial
 - Healthy, functioning rivers are appealing and attractive to residents and businesses. An engaged public that enjoys riverfront features and activities also cares about the river's long-term health.
- Protect and restore natural river features and functions
- Regenerate the riverfront as a human realm
 - Good riverfront designs consider the needs of all neighborhoods, ages, and cultures in the community. They allow community members to experience the river up close.
- Compromises are necessary to achieve multiple objectives
- Make the process of planning and designing riverfronts broadly participatory (Otto et al. 2004)

Planning Principles:

- Demonstrate the characteristics of the city's unique relationships to the river
- Know the river ecosystem and plan for a scale larger than the riverfront
- Because rivers are dynamic, minimize new floodplain development
- Provide for public access, connections, and recreational uses
- Celebrate the river's environmental and cultural history (Otto et al. 2004)

Design Principles:

- Preserve natural river features and functions
- Buffer sensitive natural areas
- Restore riparian and in-stream habitats
- Use nonstructural alternatives to manage water resources
- Reduce hardscapes
- Manage stormwater on site and use nonstructural approaches
- Balance recreational and public access goals with river protection (Otto et al. 2004).

WILDCAT CREEK

INTRODUCTION OF WILDCAT CREEK

Location

Wildcat Creek flows towards Manhattan, Kansas, which is approximately 16 square miles in size. The 99-square mile Wildcat Creek watershed (Figure 2.03) lies between Tuttle Creek Reservoir located north of Manhattan on the Big Blue River, and the USACE Milford Reservoir along the Republican River (Bunger et al. 2013).

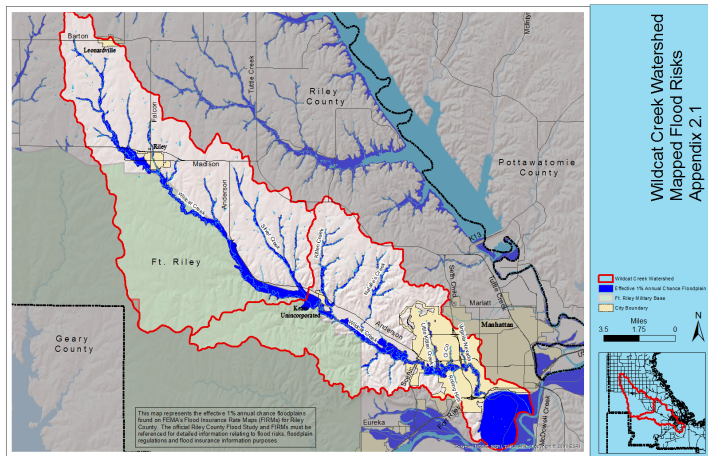


Figure 2.03
Wildcat Creek
Watershed (City of
Manhattan Kansas
2013)

Land use

According to Banner (2008), there were five land-use types included in Wildcat Creek watershed land, with permanent grass making up 55.61 percent of the land, cropland accounting for 18.84 percent, forest accounting for 14.56 percent, and development land accounting for only 10.68 percent.

Based on the zoning map for the City of Manhattan (The City of Manhattan Kansas 2018), the Wildcat Creek corridor includes nine zoning districts within the boundary of Manhattan Kansas, including R-3 - Multi-Family Residential, R - Single-Family Residential, R-2 - Two-Family Residential, PUD - Planned Unit Development, R-5 - Manufactured Home Park, C-5 - Highway Service Commercial, I-2 - Industrial Park, I-3 - Light Industrial, and Manhattan Parks. From the most to the least occupied area, R - Single Family has the most area, followed by Manhattan Parks, then PUD - Planned Unit Development and R-3 - Multi-Family Residential areas, then staggered R-5, R-3, I-3, C-5, and I-2.

Watershed level and stream order

First order stream with Hydrologic Unit Code (HUC) at

HUC 8: 10270101

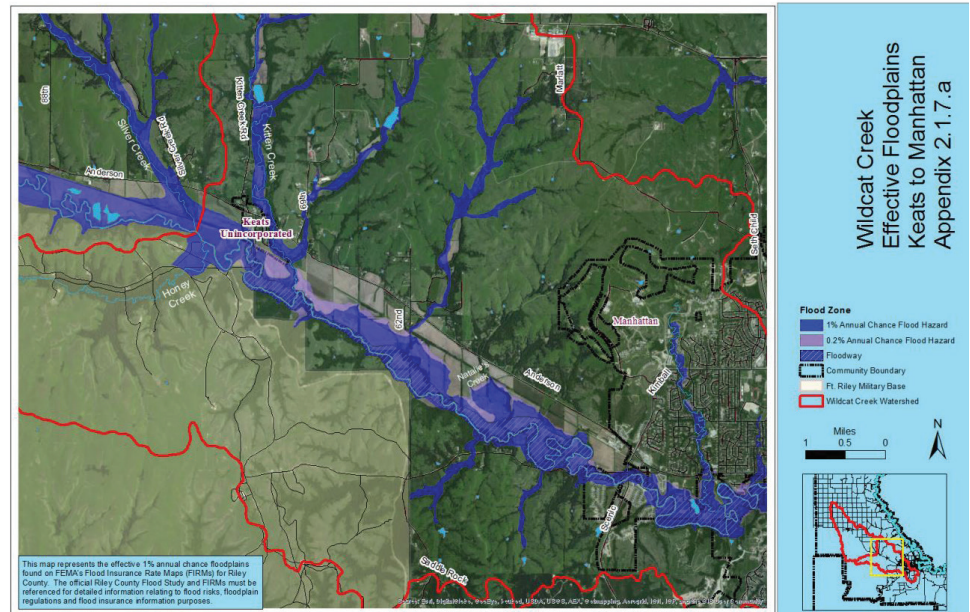
HUC 10: 02

HUC 12: 04, 05 (Banner 2008)

Wildcat Creek has a long history of flooding. Therefore, the City of Manhattan, Kansas published a Wildcat Creek Flooding Management Plan in 2013. The purpose of this plan was to “lessen the damaging effects of floods, maintain and enhance natural floodplain assets, and make effective use of water and related land resources within the floodplain (Bunger et al. 2013, 6).” In this document, the City of Manhattan details the flooding problem, flood data, land use, and development trends of each reach of Wildcat Creek. The Wildcat Creek Floodplain Management Plan shows that most of the creekfront areas along the Wildcat Creek are in the 1% or 0.2% Annual Chance Flood Hazard Zones. Most recently, Wildcat Creek flooding occurred on June 16, 2010, June 2, 2011, and September 2, 2018. Land parcels along the creek are composed of residential areas, parks, golf courses, and many fragmented open spaces.

030 | Background

Figure 2.05
Floodplains - Keats
to Manhattan (City of
Manhattan Kansas
2013)



Accessibility

Due to the physical characteristics of rivers, many cities realize that they should consider river planning and riverbank regeneration. Therefore, the publicization and entertainment of riverbanks have become more and more popular since the 1970s (Durán Vian et al. 2021). Accessibility to rivers has also improved.

However, accessibility of creeks which are smaller in scale compared to rivers lacks attention. Many creeks have problems with flooding, which also causes severe erosion of creek banks. For safety and ecological reasons, many cities have set up plant barriers along the creeks or used engineering techniques to protect the creek banks with stones or other artificial materials. These methods greatly reduce creek access. In addition, unlike rivers, the banks of creeks are often on private property, which also greatly reduces creek access due to trespass concerns.

Sections of wildcat creek be examined (Regional)

- Floodplains – Seth Child Road to Scenic Drive (Figure 2.04)
- Partial of Floodplains (Wildcat Park)- Keats-to-Manhattan (Figure 2.05)

Nodes on Wildcat Creek

This work will mainly focus on the two publicly accessible sites along the Wildcat Creek: Frank Anneberg Park and Wildcat Park (see Figure 2.06). These two sites are valued assets to the community, receive frequent use and have an abundance of vegetation. All the sites have the possibility of being connected directly to Wildcat Creek and provide access to downtown and to the neighborhood, but they currently lack both visual and physical access to the creek. Additionally, each of these sites has different types of stream bank profiles, which can be used as examples of creekfront design in different contexts. To provide guidance on how to apply the findings of this study, which is a design guideline about how to activate the creekfront by utilizing nature-based activities, projective design will be applied to these two sites.

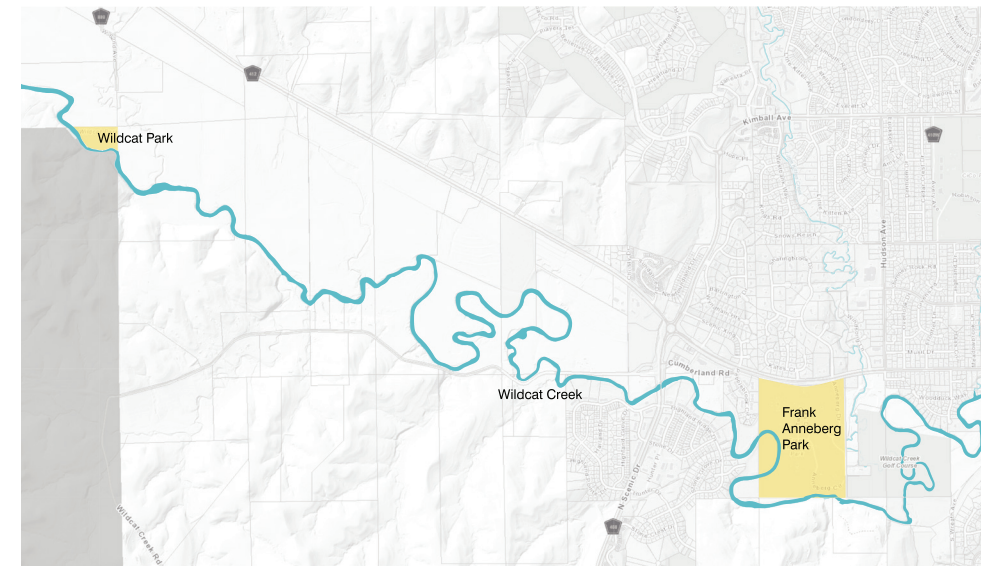


Figure 2.06
Two publicly accessible
along wildcat creek
(Huang 2021)

Envisioning Wildcat Creek

The City of Manhattan intends to enhance recreation and educational opportunities along Wildcat Creek. According to the city, a variety of recreation amenities exist along Wildcat Creek, but currently there is no direct connection via a recreation trail between these amenities. “In the mid-1970s creek bottom land that is south of the present-day Washington Square subdivision [vicinity of Anderson Ave and Garden Way], was dedicated to the City to extend a Wildcat Linear Trail. A portion of Wildcat Linear Trail exists west of Sunset Zoo – this appears to be the start of a concept to connect these recreation amenities together by extending and expanding the Linear Trail. This concept could be extended beyond the city limits to include Wildcat Park and Keats Park in Riley County, making this a regional park and trail network along Wildcat Creek (Bunger et al. 2013, 51).” The City of Manhattan wants to promote the creation of trails along the creek and connected open space areas, which not only expand recreation in the watershed, but also can preserve more open space in the floodplain to assist in alleviating flooding downstream and improve erosion and water quality (Bunger et al. 2013).

The last objective mentioned in the Wildcat Creek Floodplain Management is to preserve the cultural resources of Wildcat Creek. There is a plethora of culture resources in the Wildcat Creek watershed. “Artifacts from prehistoric nomadic tribes, American Indian tribes, the establishment of Fort Riley Military Reservation, and early settlers can be found in the watershed (Bunger et al. 2013, 51).” The Floodplain Management Plan (FMP) also shares some strategies to modify floodwaters. The strategies include stormwater detention, retention basins, levees, floodwalls, landforms, channel alterations, diversions, bypasses, and pump stations (Bunger et al. 2013).

The action section of the FMP indicates that the City of Manhattan intends to develop a recreational corridor along Wildcat Creek that could protect riparian resources and help maintain the floodway and floodplain as open space. This action will also improve Manhattan residents’ life quality and possibly create educational programs and products (Bunger et al. 2013).

ACTIVITIES ACTIVATE SPACE

Activity programming is a much-needed design strategy to improve the quality of a public space. The quality of public space has a direct impact on its own activation level and even the quality of urban life. From the perspective of users, the quality of public space here refers to its architecture, equipment, design, accessibility, and openness to the different needs of residents (Pancewicz 2019). From an objective point of view, the ecological quality of public space will also be considered in the overall quality of the space. The reason why activities can become an important strategy for activating and improving public spaces is because of their importance to people and their benefits. A study conducted in Poland indicates that activities, especially physical activities, provide people with pleasure and fun, health benefits, improvement of physical and mental condition, and the opportunities to meet new friends (Pancewicz 2019). Outdoor activity in nature is even more beneficial to societal quality and the physical and mental health of humans. Regular physical activity is positively associated with the prevention and treatment of non-communicable diseases like obesity, diabetes, cancer, cardiovascular diseases (CVD), as well as improved mental health and well-being (National Institute for Health and Clinical Excellence 2012; World Health Organization 2018; Vert et al. 2019).

In addition, through activities in public spaces in communities and cities, people can increase social cohesion, deepen neighborhood relations, and strengthen their identification with the place of residence (space and social significance) (Pancewicz 2019; Vert et al. 2019). However, public spaces in many cities lack access to abundant activity programs, so when a public space increases activity opportunities, users will also increase. A study on the renewal of riversides in Spanish cities showed that the users of river reconstruction areas increased by 25% after the intervention. One of the most notable methods of their intervention is to provide various activities programs and opportunities. This strategy creates attractive destinations for residents, and provides sports and social opportunities, so users increase (Vert et al. 2019). When a public space meets certain spatial and social conditions and needs, it will invite more people engaging the space willingly. Adding activity to space encourage people to integrate in the public space and lead to raising the quality of the space (Kostrzewska 2017). In this way, activities and programs activate the space by improving its quality and attracting more users.



◀
Figure 2.07
Hiking on a
mountaintop
(Huang 2018)

NATURE-BASED ACTIVITY

DEFINITION AND TYPES OF NATURE-BASED ACTIVITY

A widely accepted explanation about leisure was proposed by Godbey, which is “Living in relative freedom from the external compulsive forces of one’s culture and physical environment so as to be able to act ... in ways which are personally pleasing, intuitively worthwhile, and provide a basis for faith (Godbey 1985; Cordell 2012, 5).” Recreation is generally recognized as taking place during leisure time and being enjoyed for personal reasons (Cordell 2012). Nature-based recreation, also known as outdoor recreation, refers to activities that occur on natural surfaces or directly involve elements of nature, such as terrain, plants, wildlife, or water (Cordell 2008). Nature-based activity has different classifications according to different purposes, but in general it can be physically active and sedentary. In Cordell’s 2011 report on Outdoor Recreation Trends and Futures, he summarized nature-based recreation into the following categories:

- “Visiting recreation and historic sites—visiting the beach, visiting prehistoric sites, visiting historic sites, developed camping, swimming in lakes/ponds/etc., visiting waterside besides beach
- Viewing/photographing nature—viewing/photographing birds, viewing/photographing natural scenery, viewing/photographing other wildlife (besides birds), viewing/photographing wildflowers/trees/etc., viewing/photographing fish, visiting nature centers/etc., sightseeing, gathering mushrooms/berries/etc., taking tours or excursions on boats
- Backcountry activities—backpacking, day hiking, horseback riding on trails, mountain climbing, visiting a wilderness or primitive area, primitive camping, mountain biking, caving, rock climbing, orienteering
- Motorized activities—motorboating, off-highway vehicle driving, snowmobiling, using personal watercraft, waterskiing
- Hunting and fishing—anadromous fishing (salt-to-freshwater migratory fish, e.g., salmon), coldwater fishing, warmwater fishing, saltwater fishing, big game hunting, small game hunting, and migratory bird hunting
- Non-motor boating and diving—canoeing, kayaking, rafting, rowing, sailing, surfing, windsurfing, snorkeling, scuba diving
- Snow skiing and other winter activities—cross-country skiing, downhill skiing, snowboarding, snowshoeing, ice fishing (Cordell 2012, 5).”

There is also a classification that divides nature-based activity into two categories: Non-activity and Physically Active. “Non-activity” refers to pastimes that were less activity-intensive included spending time with animals, being outdoors in the fresh air, and enjoying the scenery (Flett et al. 2010). Spending time with animals included observing animals in nature, caring for domestic pets and tracking wild animals (Flett et al. 2010). In the survey conducted by Flett et al. (2010), the research participants indicated that this type of nature-based activity provides them the opportunity to be away from civilization and technology (phones, computer televisions), in unconfined space, and to escape.

“Physically Active,” as its name implies, this type of nature-based exercise requires a lot of physical energy. Physical Active nature-based activities include archery, biking, hiking, climbing, fishing, horseback riding, and interest in snow/ice activities such as snowboarding, snowshoeing, skating, skiing, sliding, making forts/snowmen, and ice-fishing et al. (Flett et al. 2010).

Another type of nature-based activity that has gained popularity in recent years is nature-based educational activities (Flett et al. 2010; Gruno and Gibbons 2020). Nature-based education appears to be a powerful tool for restoring people to their natural environment (Potter 2010; Gruno and Gibbons 2020). Nature-based educational activities provide participants with opportunities to engage with nature. Educators and other advocates can combine natural-based activities with many educational strategies to achieve educational significance (Flett et al. 2010). The most common strategies among them are combining interests, setting realistic challenges, and conducting task-oriented activities (Flett et al. 2010). The combination of natural-based activities and interests makes natural-based activities more appealing, and activity participants will be more engaged. Challenges and task-oriented goals make people look at their experiences in nature-based activities more positively. With the goal of enhancing a person’s engagement with outdoor exercise, participants could also incorporate tasks like photography, poetry, drawing, investigating different kinds of plant growth, and reflecting on their physical activity (Flett et al. 2010). Nature-based educational activities not only provide a great way to learn new skills and knowledge, but can also improve one’s self-confidence, social skills, leadership skills, mental health, resilience, and physical fitness (Flett et al. 2010; Gruno and Gibbons 2020).

The development trend of nature-based activity

The development and changes of nature-based activity can be traced back to the Great Depression and World War II. Early in the 19th century, as well as in earlier periods, most people in the United States lived an agrarian lifestyle in which they mainly worked outdoors, so they had little desire to go outside for leisure (Cordell 2012). However, the increase in wealth and population following the Great Depression and World War II has allowed outdoor recreation to become a more critical part of American lifestyles (Cordell 2008). More Americans are turning to manufacturing and other forms of indoor livelihoods which makes outdoor leisure activities more attractive. The transformation of work, leisure, and communication technology, along with the low gas prices, has allowed Americans to travel more and experience more outdoor activities (Cordell 2012). Recognizing and responding to this growing demand for leisure, the federal government established a committee in the 1950s and named it the Outdoor Recreation Resources Review Commission (ORRRC). The ORRRC was established in 1958 to examine current and future outdoor recreation trends (Cordell 2012). “As reported by ORRRC, the most popular summertime outdoor recreation activities in 1960 were, in order, driving for pleasure, swimming, walking, playing outdoor games or sports, sightseeing, picnicking, fishing, bicycling, attending outdoor sports events, boating, nature walks, and hunting. Also popular were camping, horseback riding, water skiing, hiking, and attending concerts or other outdoor events (Cordell 2008, 5).” The ORRRC’s second survey was in 1982, and the survey results on the most popular outdoor activities at that time were similar to those of twenty years ago.

However, by the year 2000, the trend of outdoor activities had undergone a great change. The most significant change since 2000 was the increase in the proportion of the total population participating in outdoor activities, and leisure walking was the most popular pastime (Cordell 2008). “In 1994–95, for example, 67 percent of the population participated in walking; by 2000, that rate had climbed to 83 percent, making it by far the most popular outdoor activity in America (Cordell 2008, 6).” There was a 4.4 percent increase in people who participated in one or more outdoor activities between 2000 and 2007. Furthermore, the total number of days of participation increased by approximately 25 percent between 67 billion and 84 billion. Among them, the number of days participating in outdoor recreational walks increased by nearly 14% (Cordell 2008). One interesting finding of

the National Survey on Recreation and the Environment (NSRE) initiated by ORRRC in 2000 is that although the number of people participating in outdoor activities has increased, some activities have increased, and others have decreased. In other words, research shows that although Americans' interest in nature and nature-based leisure activities has not declined, it has changed (Cordell 2008; Cordell 2012). According to the ORRRC, fishing and hunting seem to have declined in popularity over the past several years. Outdoor activities that are not physically challenging, such as watching, researching, and photographing birds and wild animals and other natural activities, are becoming increasingly popular (Cordell 2012). Cordell (2008; 2012) believes that Americans' interest in nature and nature-based leisure activities presents a very healthy trend. A similar idea was included in models developed for the 2010 Resources Planning Act (RPA).

Models developed for the 2010 Resources Planning Act (RPA) predict future recreation participation based on National Survey on Recreation and the Environment (NSRE) data and include nature-based recreation on all land and water ownerships (White et al. 2016). Model for outdoor recreation participation predicted 17 recreation activity composites by 2030, which are categorized into seven activity types: visiting developed sites, viewing and photographing nature, backcountry activities, motorized activities, hunting and fishing, nonmotorized winter activities, and nonmotorized water activities (White et al. 2016). Based on the model, the rate of participation in nature viewing and photography will increase by over 1 percent until 2030, while birding will increase by 4 percent (White et al. 2016). Backcountry activities such as hiking are projected to see an increase in participation of about 3 percent by 2030. Participant rates in nonmotorized winter activities are projected to increase by 6 to 7 percent by 2030, and the number of days spent on a nonmotorized winter activity is predicted to increase by almost 40 percent by 2030 (White et al. 2016). In contrast, motorized activities, hunting and fishing, and nonmotorized water activities are projected to decline by 2030 (White et al. 2016). Overall, most recreation activities are projected to grow between 2008 and 2030 according to the available data (White et al. 2016). Moreover, 1.6 million forest visits were recorded in Utah between 2007 and 2017, an increase of 2.6% on average annually (Smith and Miller 2020). The data also suggests that the use of parks and forested areas for outdoor recreation is increasing in Utah, as well as increased visits to public lands closest to urban areas (Smith and Miller 2020). The change of

participation rate in outdoor recreation is typically affected by population density, education level, the availability of private and public lands, and the effects of climate change including temperature increase and precipitation decrease (White et al. 2016). Outdoor recreation choices have changed over time as preferences, demographics, and recreation opportunities have changed. Generally, nature-based outdoor recreation participation has increased in the last decade, continuing a long-term trend (White et al. 2016). Despite numerous reports and data indicating that the number of people participating in nature-based activities in the United States is on the rise, many scholars and experts still believe that there is a decline in the access of people to nature. They indicate that as urban expansion and technological progress have pushed people away from natural environments, they spend more time using electronic devices and getting less time outdoors. Screen-based behaviors are some of the most popular forms of sedentary behavior among contemporary adolescents (Sigmundová et al. 2017). There are also some data to support this view. In the United States, less than 20% of adolescents report participating in recommended levels of aerobic and muscle-strengthening activities (Song et al. 2013). In addition to children, the opportunities for adults and the elderly to participate in nature are also greatly reduced.

However, the global response to the COVID-19 pandemic brought with it significant changes to human mobility patterns and working environments and even our relationship to nature (Naomi 2020; Venter et al. 2020). As research indicates the novel Coronavirus is more easily transmitted indoors than outdoors, people are realizing it's better to spend more time outside (Naomi 2020). Even when strict stay-at-home orders are enforced, many countries allow for and even encourage citizens to go for short walks in their neighborhoods (Naomi 2020). More people are connecting with nature than ever before (Naomi 2020).

The amount of outdoor recreational activity in Oslo municipality increased by 291% during lockdown dates during 2020 compared to the previous 3-year baseline (Venter et al. 2020). Among them, walking and cycling are pedestrian-related activities with the largest increase in lockdown activity (Venter et al. 2020). Data from Google mobility also shows a 19% increase in visits to parks and public green spaces (Venter et al. 2020) to support these aggregate increases in recreational activity (Venter et al. 2020). As a result of the epidemic, people are increasingly interested in nature-based activities and natural environments.

Nature-based activity preference

Young people and adults not only assured that they are interested in outdoor activities, but also suggested they prefer a variety of different types of activities (Flett et al. 2010). Some surveys and reports summarize the nature-based activity preference of youth and adults. As a group, youths prefer fairly competitive and challenging activities that can be done with friends. Additionally, youth also stated that they would like to be successful and enjoy controlling their own adventures (Flett et al. 2010). The preferences of youth in this regard are similar to the three critical factors-competence, autonomy, and relatedness- revealed in Deci and Ryan's theory of intrinsic motivation. In nature activities, the optimal experience (flow) can be much more motivating to younger people (Flett et al. 2010).

Contrary to the expectations of children, adults tend to prefer activities which are more cooperative, memorable, and enjoyable. Adults appreciate the restorative aspects of the outdoors (Flett et al. 2010). Moreover, the study summarizes barriers to outdoor activity that individuals feel and their dislikes towards it, including the following reasons:

- Safety concerns (i.e., dangerous animals, allergies, and lack of control)
- Extreme weather, especially extreme combinations of bad weather such as cold and wet
- Lack of comfort, including getting dirty
- Having no access to conveniences (television, computers.)
- Not enjoying the feeling of being active or sweating
- Inconvenience
- Lack of time (Flett et al. 2010)

The importance of nature-based activity

The development of cities and technological advances have changed the lifestyles and living conditions of people. Currently, more than half of the world's population lives within cities as a result of the rapid expansion of cities in recent years (McKenzie et al. 2013). While highly urbanized environments can be highly productive and convenient, they also contain more stressors that negatively affect health, such as higher temperatures, carbon emissions and pollution when compared to rural environments (Sia et al. 2020). Many studies have shown that the urban environment will increase the risk of poor mental health (McKenzie et al. 2013). A study analysis of anxiety in England proved that urban environments are generally associated with poorer mental health (McKenzie et al. 2013). In the United States and Europe, mental illness is becoming one of the most commonly occurring non-communicable diseases (Marselle et al. 2019). An estimated 20% of Americans and 27% of Europeans suffer from a mental illness in a given year (Marselle et al. 2019). The harm is outweighed by no benefits of it, either from a personal or social standpoint. From a social standpoint, the prevalence of mental disorders has led to increased economic burdens. Mental disorders are projected to be associated with a global economic burden of 6.0 trillion dollars by 2030 - more than the combined costs of cancer, diabetes, and respiratory diseases (Marselle et al. 2019). Therefore, it is particularly important to improve the mental health of city dwellers. Many studies have proven that exposure to nature has positive psychological impact, alleviating stress and mental fatigue and facilitating social ties that relieve loneliness (Sullivan and Chang 2017; Cohen-Cline et al. 2015). Nature-based activity that combines nature and activity can improve physical and mental health at the same time.

Furthermore, nature-deficit disorder is now being recognized as one of the most serious problems facing children today (Driessnack 2009). Childhood has moved indoors. In a recent study, children of today were labeled the backseat generation (Karsten 2005; Driessnack 2009). Cars escort the children to and from school, and to and from extracurricular activities (Driessnack 2009). They most often experience nature as they

travel in an automobile or watch nature DVDs projected directly on their car headrest screens (Louv 2008). In the current generation of children, digital media has become the most popular leisure activity for children and adolescents (Walsh et al. 2020). There is evidence that school-aged children can accumulate >7 hours per day of screen time for multiple media (Uncapher et al. 2017). In fact, this phenomenon is not unique to American youth, but can be observed globally (Uncapher et al. 2017). Many children can recognize cartoon images but not plant species. Even many children can define global warming and describe the impact of rainforest and deforestation in the Amazon River basin, but they don't know what plants grow in their backyards or which stormwater basins will be affected if they litter the streets outside their houses (Driessnack 2009). As Louv said, if the natural world is still hidden behind glass and can only be seen through windows or computer monitors, no child can really understand and benefit from nature (Louv 2008; Driessnack 2009). Direct experience with nature is slowly being replaced by indirect experience via electronic media and machinery for this new generation of children (Louv 2008). Additionally, Screen-based behaviors are some of the most popular forms of sedentary behavior among adolescents (Sigmundová et al. 2017). In many studies, sedentary time is considered to be associated with negative health outcomes, including impaired metabolic health, headaches, emotional distress, feeling low, irritability, anxiety, stomachaches, backaches, and other complaints (Walsh et al. 2020), and even influencing beliefs and behaviors (Mundy et al. 2020). However, the researchers have found, that increasing outdoor time is an effective means of reducing sedentary behavior and increasing physical activity and fitness in children (Gray et al. 2015). There is also preliminary evidence that green time - broadly defined as spending time in the outdoors or being exposed to the elements or content of nature - could buffer the effects of high screen time (Oswald et al. 2020). Nature may thus function as an upstream intervention to promote psychological well-being for children and adolescents in a high-tech era (Oswald et al. 2020).

The benefits of nature-based activity

Benefits on human physical health

A number of recent reports and studies have focused on the links between human health and participation in nature-based activities. Most of them pointed out that nature-based activities have a positive impact on human health. One of the greatest benefits associated with nature-based activity is its positive impact on physical health. Nature-based activities can positively affect the body mainly because nature interaction and physical activity both benefit the body. According to Cleland et al. (2008), time spent outdoors, level of moderate and vigorous physical activity, and body mass index were significantly related among elementary school children. Increasing physical activity reduces the incidence of overweight or obesity, which directly contributes to physical health (Kolokotsa et al. 2020).

As well as physical activity, access to forests and other natural areas is also proven to provide many direct physical benefits (Kolokotsa et al. 2020; Flett et al. 2010). There are reports that green spaces, such as green urban living rooms, green corridors, gardens, urban forests, etc., along with blue spaces such as rivers and lakes, can lead to better physical and psychological health, such as reduced risk of cardiovascular disease, improved pregnancy outcomes, and air quality improvements (Kolokotsa et al. 2020). Visits and contact with the natural environment also provide opportunities for relaxation and escape. This opportunity can help reduce blood pressure, heart rate, and muscle tension and strengthen the immune system by reducing

stress hormones and improving mood (Karjalainen et al. 2009; Winter et al. 2020; Flett et al. 2010). These impacts have potential benefits to prevent cancer and reduce the risk of fatal and non-fatal cardiovascular diseases (Flett et al. 2010; Kolokotsa et al. 2020). Kolokotsa et al. (2020) mentioned in the report that the subjects' heart rate, sympathetic nerve/parasympathetic nerve activity, and diastolic blood pressure improved in forest areas, and coastal scenery ranked first in terms of recovery. In addition, the report also mentioned that walking in the forest increases Natural Killer (NK) activity, number of NK cells, and levels of intracellular anti-cancer proteins, and that effect lasts at least seven days after the trip (Kolokotsa et al. 2020). Thus, while simply being in nature can improve health, being physically active in nature could provide even more health benefits.

Benefits on human mental health

Similar to the analysis and summary of the benefits of nature-based activity to participants, its positive impact on human mental health can also be attributed to the impact of natural and physical activity. Psychologically, contact with nature is well known to be beneficial to a person. Several investigations have found that exposure to nature landscape can significantly reduce stress compared to exposure to the urban landscape (Ulrich 1979). Nature landscapes can help people gain mental restoration during and after exertion. A controlled experiment invited participants to walk in the forest under high and low fatigue conditions. The results they received were that walking in the forest can efficiently bring mental restoration (Hartig and Staats 2006). In addition to green nature, exposure to water (or blue space) can also reduce stresses and mental fatigue, because the blue color is a soothing and calming color that can help lower heartbeat (Gidlow et al. 2016; Dash 2018).

There are three primary explanations of how nature landscapes affect stress and fatigue: Stress Reduction Theory, Attention Restoration Theory, and Prospect-refuge Theory (Kweon et al. 2008; Memari et al. 2017). Stress Reduction Theory was proposed by Ulrich, indicating the effective impact of nature on an individual's health (Memari et al. 2017, 105). Ulrich claims that natural landscapes restore human health by reducing stress. He believes that stress is a psychological, physiological, and behavior process, responding to a situation against one's health.

Nature scenes activate the parasympathetic nervous system to reduce stress by evoking feelings of mild to moderate interest, pleasure, and calmness (Memari et al. 2017, 105).

Attention Restoration Theory is also explained as Distraction Theory, which emphasizes the cognitive aspect of nature experience (Memari et al. 2017; Kweon et al. 2008). This theory categorizes attention into two types: “involuntary attention, where attention is captured by inherent or important stimuli, and voluntary or directed attention, where attention is directed by demanding cognitive processes (Memari et al. 2017, 105).”

Attention Restoration Theory proposes that prolonged use of directed attention can wear out a person’s ability to resist distractions. Studies found that people do not require reliance on directed attention in the natural environment, so that they can rest and recover the capacity to use directed attention in a green environment (Memari et al. 2017; Staats et al. 2003).

The Prospect-refuge Theory is based on an adaptive-evolutionary perspective, which is also known as the Environmental Aesthetic Theory proposed by geographer Jay Appleton (Marcus and Sachs 2013, 19). Appleton indicated that although most people are no longer hunter-gatherers, they still prefer and respond positively to natural elements and scenes that would have enabled their early ancestor’s survival. People regard the natural landscape as a refuge, and people who are ill or tired prefer a refuge (Marcus and Sachs 2013, 23).

Nature contact has been linked to cognitive benefits, such as improved focus, concentration, and working memory (Winter et al. 2020). “Rohde and Kendle have identified six benefits from contact with nature, including: reunion with and caring for nature; greater sense of identity and ownership of their country/land; feelings of integration versus isolation; stronger sense of possibility; empowerment and skill development; and restoration and relief from daily struggle (Rohde and Kendle 1997; Flett et al. 2010).”

Furthermore, physical movement and psychological directness have a positive relationship. Regardless of the environment, physical exercise will benefit human mental health (Kolokotsa et al. 2020). For example, Kolokotsa et al. (2009) proved that self-esteem, stress, and mood were improved significantly from pre-to post-runs (Kolokotsa et al. 2020). Some studies directly point out the benefits of nature-based activities. According to a study, people who participate in nature-based group walks are likely to recover from the after-effects of recent stressful events on their mental health (Marselle et al. 2019). The research also found group walks in nature reduce depression and positively affect mental well-being to a greater extent after at least one stressful life event (Marselle et al. 2019). There is growing recognition of the positive benefits of nature-based activity or nature-based recreation. Visiting natural settings and being outdoors are widely recognized as important for improving human mental health and physical health (Winter et al. 2020).

Benefits on environment

Nature-based activities are not only beneficial for people, but the setting of nature-based activities is also good for the environment. By participating in nature-based activities, people learn to value natural restoration, thus promoting ecologically responsible behaviors, such as restoring, caring for, and volunteering (Winter et al. 2020). Globally, climate change and other disturbing factors are affecting ecosystems. Environmental disturbances such as floods, droughts, wildfires, high temperatures, and invasive species caused by climate change that are often mentioned in textbooks and on television are affecting nearby nature in recent years (Winter et al. 2020). By going outdoors, engaging in active recreation, and visiting natural attractions, people have the chance to gain a better understanding of natural systems and place attachment as well as become more aware of what is happening concerning climate change (Winter et al. 2020). Increasing care and respect for nature is conducive to the sustainable and harmonious development of humans and nature (Winter et al. 2020).



Figure 2.08
A woman walking on
a paved hiking trail in
nature (Huang 2018)

Benefits on different groups of people

Children and Adolescents

Nowadays, children and adolescents are spending less time outside than children of the previous generation for various reasons (Adams 2013). This not only leads to relatively fewer opportunities for children and adolescents to contact nature, but also indirectly causes their lack of physical activities (Flett et al. 2010). Obesity has become an “epidemic” among contemporary American teenagers (Flett et al. 2010). An estimated 17% of youth ages 2 to 19 are affected by this “epidemic” of obesity (Flett et al. 2010). Many experts indicate that nature-based activities can increase children and adolescents’ opportunities for physical activity, thereby intervening in obesity (Flett et al. 2010). A traditional gym-like environment can be an attractive place for young people to perform activities, but nature may provide a more stimulating environment (Flett et al. 2010).

Moreover, interacting with nature can improve concentration, social behavior, and moral judgment, and become more self-disciplined for adolescents (Asah et al. 2012). In addition, participating in natural activities in childhood will increase the desire for natural activities in adulthood and encourage lifetime physical activity (Asah et al. 2012; Gruno and Gibbons 2020).

Nature-based activities also provide great opportunities for outdoor education. Outdoor education seems to be a very promising tool to reconnect individuals to their natural surroundings (Potter 2010) and improve their overall health. Literature in outdoor education has long heralded the positive outcomes of learning in nature: improved self-confidence, leadership ability, social skills, motivation, academic attainment, mental health, resilience, and increased physical activity (Gruno and Gibbons 2020).

Adults

For adults, nature-based activities are a good way to relieve stress, fatigue and anxiety. During recent decades, the impact of stress on humans is more significant, especially for adults (Grahm and Stigsdotter 2003, 1). A report indicates that “Nature’s impact on an individual’s stress involves not only a psychological response but also a physiological one since our body always changes with emotional stress (Snyder 1995, 13).” Many studies also prove that natural landscapes can help fatigued people gain restoration.



Figure 2.09
A family hiking down a
mountain trail (Huang
2018)

Seniors

For the elderly, nature can be used not only for relaxation, but more importantly, non-drug treatments that can be used for health purposes (Gagliardi and Piccinini 2019). In recent years, there has been an increase in research and reports on natural and elderly treatments, many of which report the broad benefits of nature-based activities, including reducing mortality and morbidity, as well as improving physical and mental health (Sia et al. 2020). Specifically, benefits of nature-based activities for the elderly include reduced diastolic blood pressure, heart rate, salivary cortisol, incidence of Type II diabetes and stroke, cardiovascular and all-cause mortality, as well as health-denoting associations with pregnancy outcomes, HRV, and HDL cholesterol, and self-reported improvements in health (Sia et al. 2020). A nature-based activity that is popular with older adults is gardening. It has been shown that gardening is conducive to overall health, fitness, flexibility, cognitive ability, and socialization (Sia et al. 2020). One treatment that relates to gardening is therapeutic horticulture (TH) (Sia et al. 2020). The process of therapeutic horticulture enhances participants' well-being by being involved in plants and plant-related activities (Sia et al. 2020). The study found that TH allows participants to maintain healthy sleep, mental health, and show better cognitive function over time (Sia et al. 2020). Generally, nature-based activities can be used as a treatment to cure the elderly, and they can also improve health and prevent diseases through daily participation.

NATURE-BASED EDUCATION

Definition of Nature-based education

Nature-based education can also be referred to as nature-based environmental education, which is usually defined as a set of practices, tools, and programs used in nature to promote ecologically responsible attitudes, values, awareness, and knowledge that will enable people to actively protect environmental quality (Ardoin et al. 2020). As more people pay attention to nature-based education, research has also risen, and there have been many variations on its definition. For example, Pretty et al. (2009) posits that nature-based education is a type of formal education that increases childrens' contact with nature. It provides children with an opportunity to become acquainted with nature in a green space. Green spaces are ideal environments for outdoor learning, which enhances children's connection to nature and improves their environmental knowledge (Pretty et al. 2009). Similarly, Edlund defines nature-based education as using outdoor settings to deliver curricular lessons (Edlund 2011; Genc et al. 2018). Otto and Pensini (2017) indicate that nature-based education that combines the acquisition of environmental knowledge with a connection to nature is proposed to increase eco-friendly behavior. The term "connection to nature" refers to a feeling of closeness with nature (Otto and Pensini 2017).

Although nature-based learning is described in various ways in the research literature, their similarities and differences can be identified. Nature-based learning and teaching emphasize connections between nature and education (Genc et al. 2018). Learning from the environment and nature enhances understanding across the curriculum and naturalizes the learning context (Genc et al. 2018). The combination of science, art, language, and social responsibility will add depth to each discipline and enhance our understanding of nature. Engagement and connection between students and their learning and world are core components of nature-based learning (Genc et al. 2018).

Moreover, nature-based teaching is a pedagogy based on sensory experience, which allows people to interact with nature and cultural phenomena directly based on the body, allowing people to use multiple senses (Szczepanski 2006). A distinctive



Figure 2.10
The shadow of playing
on a swing in the park
(Huang 2022)

feature of nature-based education is action-oriented learning, which emphasizes the development of knowledge and skills through active participation (Szczepanski 2006). A natural environment is viewed as both the learning context and learning subject (Szczepanski 2006). Nature-based education can also be seen as a form of learning. Learning in the natural and cultural environment goes beyond getting fresh air and exercising (Szczepanski 2006). With nature-based education, emotions, actions, and thoughts are interconnected (Szczepanski 2006).

Nature-based education has experienced significant growth for more than a decade, as seen through the growth of forest preschools, nature kindergartens, garden schools, and other ecocentric curricula (Mullenbach et al. 2019). This trend reflects an increasing interest in reaping the cognitive, emotional, mental, and physical health benefits of putting children "back into nature" (Nelson et al. 2018; Louv 2008), and encouraging better conservation of nature (Nelson et al. 2018). Nature-based preschools in the United States were first started at the New Canaan Nature Center in Connecticut in 1967, followed by the Massachusetts Audubon Arcadia Preschool in 1978 (Larimore 2016). This educational approach has experienced an increase in popularity since 2000. Approximately 20 preschools in the U.S. provide nature-based curriculum in 2012 (Larimore 2016).



Figure 2.11
An outdoor class
in a creek (Huang
2019)

The necessity of nature-based education

Nature-based education today is becoming an indispensable part of general education. The purpose of nature-based education is more than individual information transfer: It is to build and enhance knowledge, attitudes, and skills that enable individuals and communities to take positive action for the environment (Ardoin et al. 2020). Additionally, nature-based education facilitates links between actionable research findings and on-the-ground practices, thus enabling stakeholders to collaborate to address dynamic environmental issues over time (Ardoin et al. 2020). We can directly benefit the environment by providing nature-based environmental education (Ardoin et al. 2020).

Observations report only weak interrelationships between environmental knowledge and connection to nature (Otto and Pensini 2017). While most educational settings provide information about the environment, they seldom cultivate a connection with nature (Otto and Pensini 2017). Fortunately, studies point out that educational settings exist that are embedded in natural settings and can promote environmental knowledge and a connection to nature (Otto and Pensini 2017). Nature-based education enables students to acquire environmental knowledge and also foster their connection to nature by providing nature experiences and activities, as well as social relationships (Otto and Pensini 2017). Overall, nature-based environmental education is an effective teaching approach. By using this method, students build personal relationships with nature (Otto and Pensini 2017).

By taking advantage of the outdoor nature environment, students can develop critical thinking, creative inquiry, and problem-solving skills, fundamental life skills that enable them to evaluate world events (Pollock 2004; Pretty et al. 2009). Spending time in nature exposes children to challenges and risk, which can foster skills, resilience, and physical fitness (Mullenbach et al. 2019).

In modern cities, the densification of living spaces leads to a loss of green space, which is replaced by shopping centers, housing, roads, and multi-story car parks. It does not assist in promoting healthy factors in the interactions between humans and the environment (Szczepanski 2006). School environments in our society today also leave too few green areas for children to play and learn. Protective fences separate the individual from the environment and more movement-intensive learning environments (Szczepanski 2006). But nature-based education contains an opportunity for children and youth to escape the typical triangle of the home, the shopping center, and the school (Szczepanski 2006), and allow children to interact with their local environment with the purpose of learning about it (Mullenbach et al. 2019).

Relevant Standards and Guidelines

Next Generation Science Standards (NGSS)

The Next Generation Science Standards (NGSS) are based on a framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas developed by the National Research Council (NRC) (NGSS Lead States et al. 2013). Implementing the framework's vision has been documented in the form of performance expectations (PEs) which describe how students must demonstrate their level of skills. NGSS architecture was designed to provide teachers and curriculum and assessment developers with more information than the traditional one-line standard (NGSS Lead States et al. 2013).

The NGSS are standards, or goals, which define what students must know and be able to do; the standards do not dictate the techniques or methods of teaching (NGSS Lead States et al. 2013). The NGSS provides a new scientific standard to inspire and build interest in science, technology, engineering, and mathematics (STEM) in the United States (NGSS Lead States et al. 2013). This standard helps to set the correct expectations and goals, which provides the necessary basis for local decision-making on curriculum, assessment and teaching (NGSS Lead States et al. 2013).

National Science Education Standards

The purpose of National Science Education Standards can be expressed in a single phrase: Science standards for all students (National Research Council (U.S.) 1996). "The Standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science (National Research Council (U.S.) 1996)." Different students will learn in different ways, and students will acquire their understanding in different ways based on their interest, ability, and context. However, all students can develop the skills and knowledge described in the standards, even though some students go well beyond these levels (National Research Council (U.S.) 1996).

Project Learning Tree: Environmental Education Activity Guide: Pre K-8. Environmental Education Activity Guide

Project Learning Tree was recognized as one of the premier environmental education programs in the early 1970s (Western Regional Environmental Education Council and American Forest Foundation 1994). PLT is now used in all 50 U.S. states, U.S. territories, Canada, Japan, Mexico, Sweden, Finland, and Brazil. More than 60,000 educators attend workshops to learn how to use the program with young people every year in the United States (Western Regional Environmental Education Council and American Forest Foundation 1994). Through interdisciplinary, hands-on activities, PLT gives students opportunities to investigate environment issues and encourages them to take informed, responsible decisions (Western Regional Environmental Education Council and American Forest Foundation 1994). Through PLT, learners gain an understanding of our complex environment, enhance thinking skills and develop the ability to make informed decisions about environment issues (Western Regional Environmental Education Council and American Forest Foundation 1994).

The documents identify how WILD activities in the respective curriculum and activity guides correlate to NGSS Student Performance Expectations (PEs) includes:

- Project WILD (Fourth Edition) Correlations to NGSS Three Dimensions: DCI's, SEP's, and CCC's
- Project WILD Correlations to NGSS PEs (third edition correlations)
- Aquatic WILD Correlations to NGSS PEs
- Growing Up WILD Correlations to NGSS PEs

Relevant Organizations

Next Generation Science Standards (NGSS) lists more than a hundred organizations involved in science education, including but not limited to: universities, Afterschool Alliance, Alaska Science Education Consultants, American Association of Physics Teachers (AAPT), American Geological Institute (AGI), American Society of Engineering Education (ASEE), American Psychological Association (APA), National Association of Biology Teachers (NABT), National Association of Research in Science Teaching (NARST), National Earth Science Teachers Association (NESTA), National Middle Level Science Teachers Association (NMLSTA), et al. (NGSS Lead States et al. 2013).



03

METHODOLOGY

METHODOLOGY

The goal of the methodology was to show the research data collection and analysis process and purposes. This process answered the research question: How can nature-based recreation and education programs that are resilient to flooding be developed along creeks that frequently flood while maintaining better creek accessibility? To answer the question, the information and data collected were divided into four major categories: Access, Activity, Implementation, and Resiliency, as shown in Figure 3.01.

For collecting data and answering research questions, two methods were employed in this study, including document analysis and precedent studies. Data collected and analyzed from these methods were informed the development of the proposed design guideline for creekfront space with nature-based activities. The design guideline was applied to a project design for two publicly accessible areas along Wildcat Creek: Frank Anneberg Park and Wildcat Park in Manhattan, Kansas.

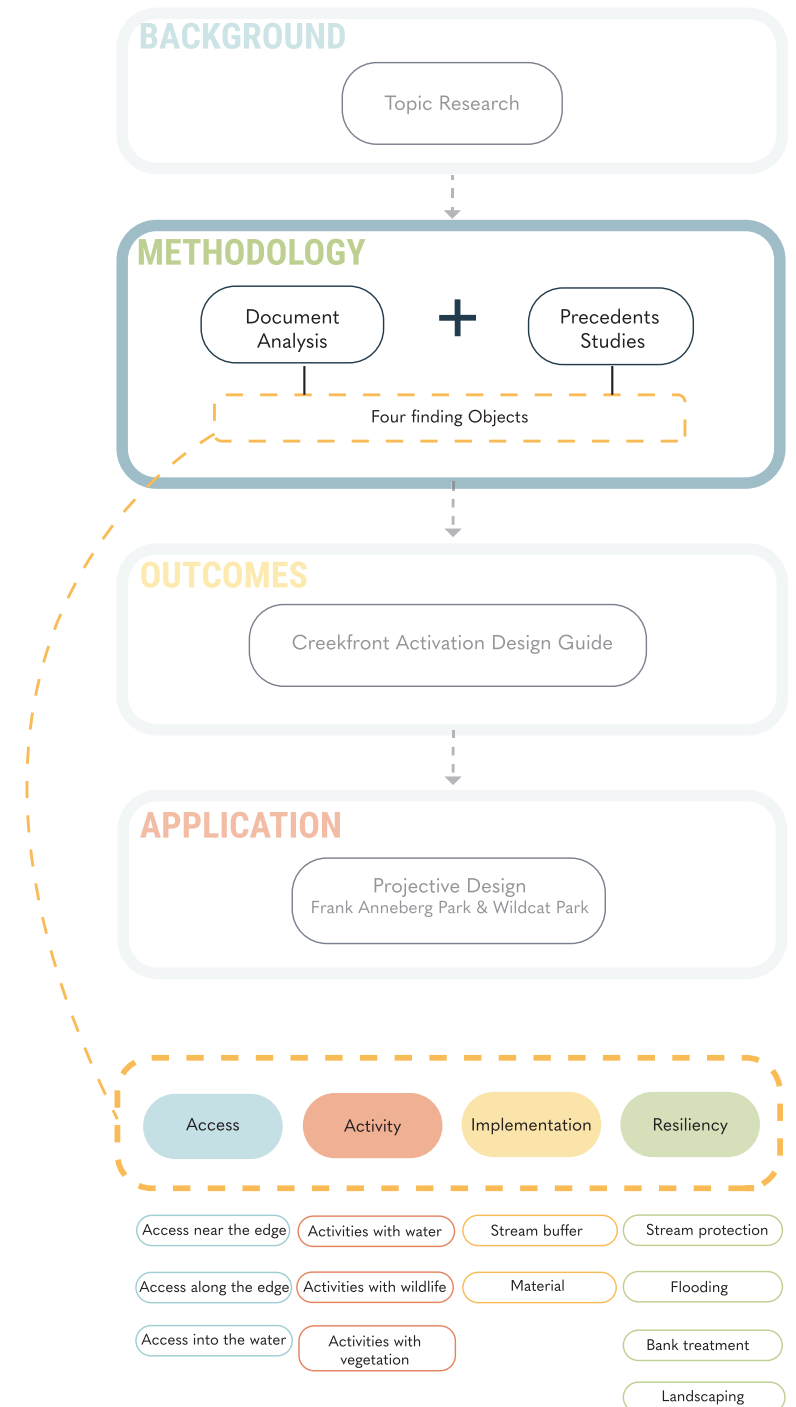


Figure 3.01
Project Overview
with methodology
highlighted and
four finding objects
(Huang 2021)

DOCUMENT ANALYSIS

Purpose

Documentary analyses were conducted to get an understanding of existing guidelines and standards related to creekfront space design and collecting design strategies and requirements. The selected documents covered design strategies and standards related to the principles of Access, Activity, Implementation, and Resiliency of creek frontage development. The information learned through the document analysis helped inform the development of proposed creekfront activation design guidelines.

Currently, very few waterfront design guidelines exist specifically for the creeks. No waterfront design guidelines link natural activities with activation of creek frontages. Therefore, the design guidelines selected for this review focus mostly on the general riverfront design, which has many strategies that are still applicable to the creek scale.

To understand how educational outdoor activities are combined with nature, the analyses of nature-based education program guides were conducted. Nature-based educational activities can be developed based on natural resources, so there are many nature-based activities that can be incorporated in creekfront areas which contain abundant natural resources.

Selected Criteria

Nine documents were selected for analysis and review, including four design guidelines, two design standards, and three nature-based activity guides. The four design guidelines cover strategies for access design, space design, and resilience treatment. Design guidelines include a general guideline, a regional guideline, and one on resilience. For the two design standards, one is a national standard, and the other is a regional standard. Due to the wide range of applications covered, the design guidance and design standard data and strategies are more complete and make the design guidance of this study more universally applicable.

Three Nature-based Activity Guideline documents were selected for review, including one that focuses on activities related to wildlife and general vegetation for K-12, one that focuses on aquatic wildlife and habitat, and one that focuses on plants for K-8. The activities in these three guidebooks are basically for K-12 children. These activities will not only be playable, but more importantly, they are educational.

Documents reviewed

- Existing Design Guidelines (Access, Resiliency)
 - *River, Space, Design Planning Strategies, Methods and Projects for Urban Rivers* by Martin Prominski et al. (2012)
 - *Chicago River Design Guidelines* by City of Chicago (2019)
 - *Stream Corridor Protection and Adaptive Management Manual* by Patti Banks Associates and Applied Ecological Services, Inc. (2006)
 - *A Guide to Riverfront Development: Connecting Communities to the Water* by Riverlife (2014)
- Existing Design Standards (Implementation)
 - *Aquatic Buffer Model Ordinance* by U.S. Environmental Protection Agency (EPA) (2002)
 - *Zoning and Development Code of the City of Kansas City, Missouri* by City of Kansas (2021)
- Existing Nature-based Activity Guides (Activity)
 - *Project Learning Tree: Pre-K-8. Environmental Education Activity Guide* by Western Regional Environmental Education Council and American Forest Foundation (1995)
 - *Project Wild: K-12 Curriculum & Activity Guide* by the Council for Environmental Education (2012)
 - *Aquatic Wild: K-12 Curriculum & Activity Guide* by the Council for Environmental Education (2016)

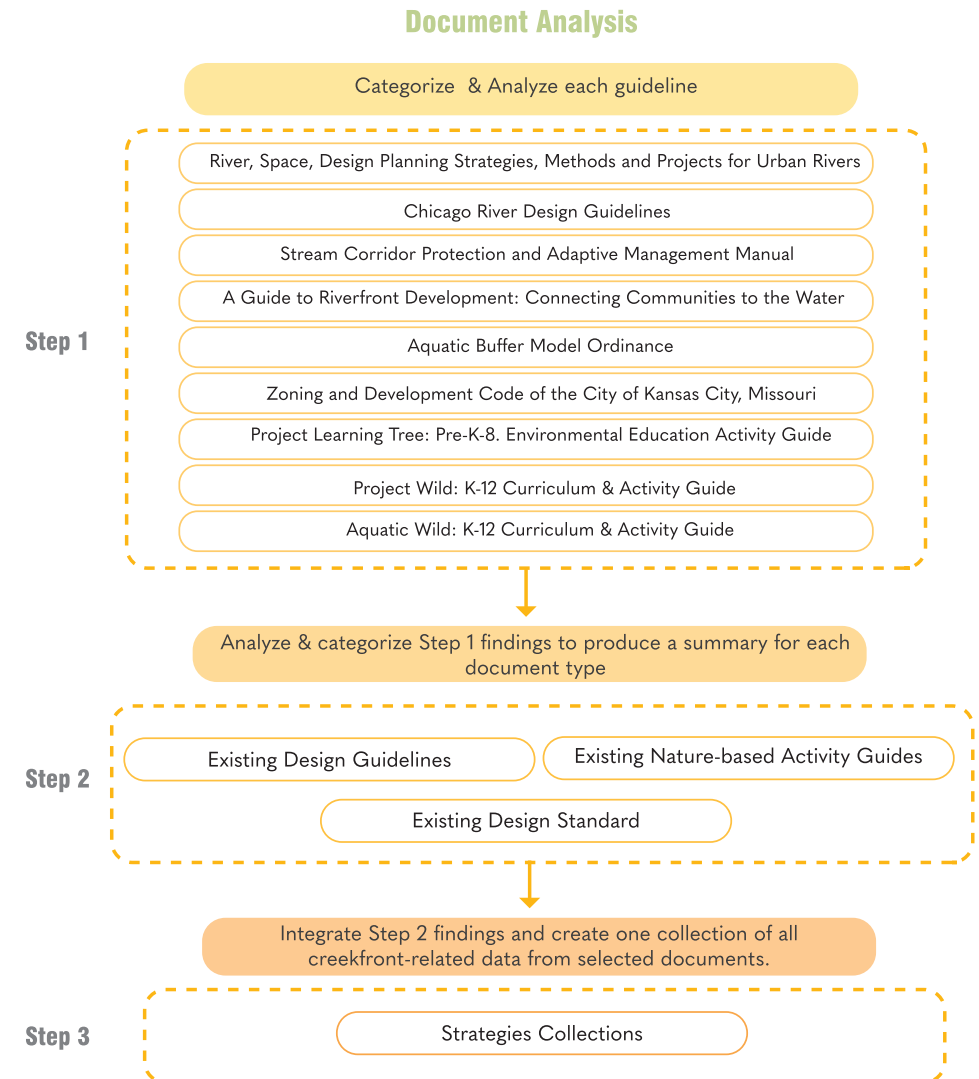


Figure 3.02
Document analysis
method overview (Huang
2021)

Procedure

Existing design guideline and nature-based activity documents were reviewed and summarized through a three-step classification and analysis process to synthesize design guidelines specific to creeks. The overall framework for the analysis and guidelines development was based on the four previously established principles: Access, Activity, Implementation, and Resiliency. As a test, the guidelines were then applied to two publicly accessible sites along Wildcat Creek. Using the guidelines, projective creekfront designs and recreational/educational activities and supporting amenities were proposed.

The first step of the analysis was to summarize each selected document according to the spatial types and strategies presented. Each document has its own classification scheme and priorities, so this step presents the full range of strategies collected.

Progressing to the second step, results from the initial summarization were distilled into the three categories: Existing Design Guidelines, Existing Design Standards, and Existing Nature-based Activity Guides. Strategies were culled to only include those elements applicable to the scale and character of creeks.

Step three involves integrating all the guidelines and strategies from the three document categories that were summarized in step two, and finally creating a single synthesized collection with four sections of all creekfront-related strategies, requirements, and suggestions.

Step 1

Existing Design Guidelines Review

River, Space, Design Planning Strategies, Methods and Projects for Urban Rivers (2012) by Martin Prominski et al.

The book *River, Space, Design Strategies* was written by landscape architect Martin Prominski. As a guidebook and reference for those who work in the field of urban river spaces, this book provides a systematic and transferrable overview of the wide variety of design possibilities for urban river spaces. There are a series of innovative strategies and corresponding design tools and practice examples presented in this book for designers and individuals who want to design rivers, all of which provide inspiration and strategies for riverfront space design. For this guideline, the procedure consists of identifying access strategies, ecological strategies, and the methods of implementation incorporated in each proposed river space design strategy.

Chicago River Design Guidelines (2019) by City of Chicago

The Chicago River Design Guidelines were organized by the City of Chicago based on early river design guidelines for the development of the city's riverbanks. Although the Chicago River design guideline was written for the Chicago River, the design strategies contained in this document and the Chicago River development case study are very exemplary, and a few of the strategies can be summed up and applied more broadly. For the purposes of analyzing and compiling this guideline, the first step was to review all the strategies proposed, and then classify them according to the four categories of access, activity, resilience, and implementation. The strategies described in the diagram were transferred and displayed in the unified graphic style in this report.

Stream Corridor Protection and Adaptive Management Manual (2006) by Patti Banks Associates and Applied Ecological Services, Inc.

The *Stream Corridor Protection and Adaptive Management Manual* provides information and guidance to assist city staff, developers, and private property owners in preserving and maintaining streams throughout Kansas City. Designed to help buffer restoration and recreation in the future, this manual provides general maintenance practices, restoration measures, and vegetation management guidance. Since land use has a profound effect on streams and available management options, management guidance is organized by general land use (urban, transitional, agricultural, and undisturbed lands). There is a short-, medium-, and long-term management recommendation in each land use discussion. The study of this design guide was focused on three stream types (urban streams, traditional streams, non-developable streams) that are more applicable to creeks.

A Guide to Riverfront Development: Connecting Communities to the Water (2014) by Riverlife

Riverlife, a nonprofit organization formed in 1999 to lead a community vision for the development of Pittsburgh's downtown riverfronts, proposed this riverfront design guideline in 2014. As a resource, this document aims to assist property owners, planners, developers, public agencies, and nonprofit organizations who wish to maximize opportunities and the value of riverfront assets. The design strategies applicable to creeks in this guideline include access, resilience, and implementation which were incorporated into an abridged summary of all the design guideline finding strategies.

Existing Design Standards

Aquatic Buffer Model Ordinance (2002) by U.S. Environmental Protection Agency (EPA)

The Aquatic Buffer Model Ordinance was organized by the U.S. Environmental Protection Agency (EPA) with the purpose of proposing language and technical guidance to aid in creating the most effective stream buffer zones. Information in this document informed the implementation data and strategies. The review of this document was mainly focused on Section VI: Design Standards for Forest Buffers. The goal of the Aquatic Buffer Model Ordinance review was to identify the stream buffer size, stream buffer adjustment methods, and land use of each buffer zone.

Zoning and Development Code of the City of Kansas City, Missouri (2021) by City of Kansas City

The Zoning and Development Code of Kansas City, Missouri was written by Kansas City planning staff according to the City Charter or pursuant to the specific terms of the ordinance enacting said amendment. Zoning and development regulations may be applied to all developments, public or private, within the territorial limits of Kansas City, Missouri. The review was focused on the 88-415 Stream Buffer section which is under the Development Standards (400 Series) chapter. The Stream Buffer section was used to identify the stream buffer size, scope and applications of the buffer zones, and land use within each buffer zone.

Existing Nature-based Activity Guides

Project Learning Tree: Pre-K-8. Environmental Education Activity Guide (1995) by Western Regional Environmental Education Council and American Forest Foundation

Project Learning Tree: Pre K-8 Environmental Education Activity Guide was designed by educators to help children learn how to think about the environment. Project Learning Tree (PLT) is a comprehensive environmental education curriculum which not just about trees but also about the entire environment: land, air, and water. The guide can be used by educators, youth groups, and by parents with their children, as well as museums and nature centers. This document outlines various nature-related activities for children, both indoors and outdoors. Review of this guide aimed to identify nature-based educational activities that can be applied to creek frontage and the creek itself. Activities were chosen using the following criteria.

- Activity should be conducted outdoors
- Activity should allow children to integrate with the environment
- Activity should be applicable to the creekfront and creek

Project Wild: K-12 Curriculum & Activity Guide (2012) by the Council for Environmental Education

The *Project Wild: K-12 Curriculum & Activity Guide* was designed and created by Project WILD, a conservation and environmental education program dedicated to wildlife and habitat. Educators of all kinds can use these guides to teach about people, wildlife, and the environment. This document was applied the same activity criteria to select activities.

Aquatic Wild: K-12 Curriculum & Activity Guide (2016) by the Council for Environmental Education

The *Aquatic Wild: K-12 Curriculum & Activity Guide* was also organized by Project WILD. This guide is also designed to be available to formal and non-formal educators. The activities in this guide are more related to water. The criteria below were also used to help filter and identify potential actions for creekfront design.

Step 2

In the second step of analysis and classification, each of the three document types was subjected to its own classification standards since it contains different content. The Existing Design Guidelines category covered very comprehensive content, and its summary included three parts: Access, Implementation, and Resiliency. The Existing Design Standards category needed only a combination of information from the two documents of the previous analysis step. The information gathered from existing design standards related to implementation information. For the Nature-based Activity Guides category, a collection of the activity findings from three guides were compiled.

Step 3

The last step of document analysis classified and analyzed the outcomes from the previous two steps and produced a comprehensive information collection. This collection had four main categories: Access, Activity, Implementation, Resiliency.

Application

Findings from the document analysis were represented in the Findings chapter. These findings also helped inform the Creekfront activation design guideline. The Creekfront activation design guideline also applied the findings from the document analysis.

PRECEDENT STUDIES

Purpose

Precedent studies were used to identify information in constructed design examples on various sites, particularly streamfronts. Analyzing and categorizing precedents and identifying information related to specific design elements and strategies informed the creekfront activation design guidelines. The information gained through the precedent studies also assisted in understanding how the four main categories of information mentioned in Figure 3.01 were integrated into one design.

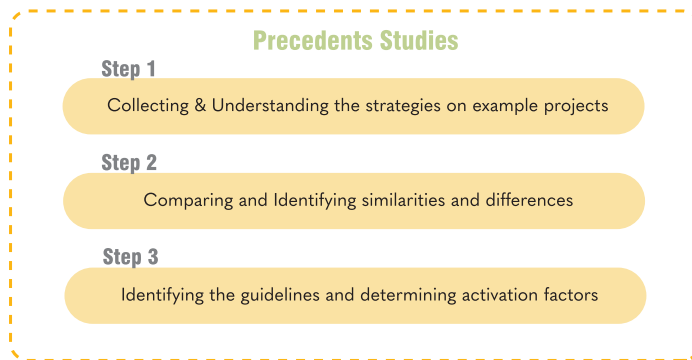


Figure 3.03
Precedent studies
method overview (Huang
2021)

Precedent Analysis

Examples of good riverfront design projects were selected that met predefined criteria. Each of the selected projects addressed at least one of four objectives: access, activity, implementation, and resilience; and projects should have successfully activated the spaces. The precedents range from riverside promenades to small urban streams, which allowed the outcomes of the study to be more comprehensive, as to enrich the content of the creekfront activation design guidelines.

The next step of the precedent analysis was to understand and collect the design strategies applied to the example projects. The design strategies mainly focused on the four objectives mentioned above. In this step, the access strategies were illustrated by text and graphical representations.

Following collecting and understanding the precedents, the information from the previous step were compared to identify the similarities and differences among the design strategies advanced by the precedents. The last step was to identify the guidelines of access, activity, implementation, and resiliency that derive from precedents. The activation factors related to these four objects were determined in this step. These findings contributed to the development of the creekfront activation design guidelines.

Selection Criteria

Despite differences in size, location, and activity, all the design precedents met the following criteria:

1. Project is completed and constructed
2. Incorporates access to the water or water edge
3. Provides space or programs for nature-basic activities
4. Design can be replicated in other similar sites

Findings Organization

The content was organized in the following way to standardize the findings:

- Project name
- Location
- Project size
- Design Approach
 - Access
 - Activity program
 - Implementation
 - Resiliency

Precedents Included:

- Puyangjiang River Corridor, Zhejiang, China
- Buffalo Bayou Park, Houston, TX
- Cheonggyecheon Stream Restoration Project, Seoul, South Korea
- Revitalizing Kazan's Prime Waterfront, Kazan, Russia
- Meadow Creek Stream Restoration, Charlottesville, VA
- Xi'an Juehe River Fanchuan Park, Xi'an, China
- Baakenpark, Hamburg, Germany
- Boneyard Creek Restoration, Champaign, IL
- Johnson Habitat Park, Denver, CO
- Riverfront Fort Wayne, Fort Wayne, IN
- Sioux Falls Downtown River Greenway, Sioux Falls, SD
- Pavilion on the riverbank of Ljubljana River, Ljubljana, Slovenia

04

FINDINGS

FINDINGS

DOCUMENT ANALYSIS
9 Documents

-
- Access design strategies categories
- Nature-based Activities categories & Guide
- Nature-based Activities detail categories
- Buffer zone and setback implementation summarization
- Dimensions and materials for access and furnishings
- General stream corridor management strategies based on time frame
- Landscape zones and plant selection categories
- Typical stream ecological issues and corresponding resilient treatments
- Resiliency strategies and treatment categories



PRECEDENT STUDIES
12 Precedents

- Brief overviews of each precedent
- Access design strategies categories
- Outdoor recreation activities categories
- The relationship between outdoor recreational activity and locations
- Implementation strategies and suggested materials summarization
-
-
-
-
-
-
- Resiliency strategies summarization

FINDINGS

In this chapter, findings from the study’s research methodology: document analysis and precedent studies are presented. Each method’s findings are divided into four sections for the four objects. The strategies of four objects derived from these findings were used to develop and inform the Creekfront design guidelines and to shape the projected designs along Wildcat Creek. The four objects are Access, Activity, Implementation, and Resiliency.

DOCUMENT ANALYSIS

After reviewing the nine existing guideline documents, the strategies and principles from each were synthesized and grouped into four sections of similar ideas based on four objects. The Access section includes the access design strategies identified in the guidelines. The activity section consists of a collection of nature-based educational and recreational activities suitable for creekfront locations. Within the Implementation section, the suggested implementation strategies and principles are outlined, including the minimum standards for buffer zones, setbacks, materials, and sizes for access and furnishings. The Resilience section includes a list of typical creekfront issues and responses.

◀ Figure 4.01
Chapter 4 finding
overview (Huang 2022)

ACCESS

The results of the document analysis identified 18 creekfront access design strategies. For a better understanding of these strategies, they are grouped into three categories based on the locations where they may be applicable (see Figure 4.02). Each design strategy was accompanied by a list of the relevant resilience treatments, which are found in the resilience section, and potential activities.

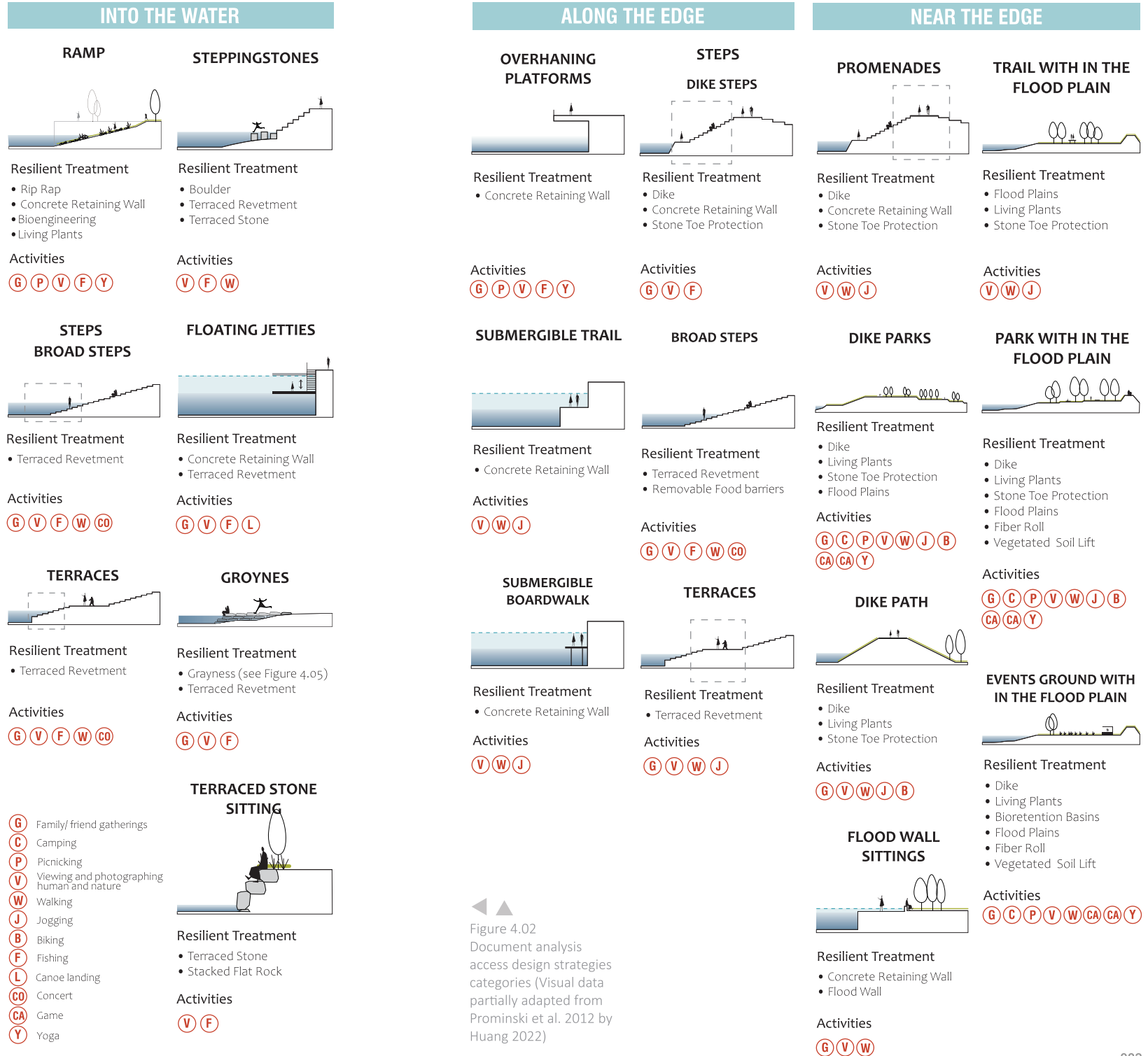


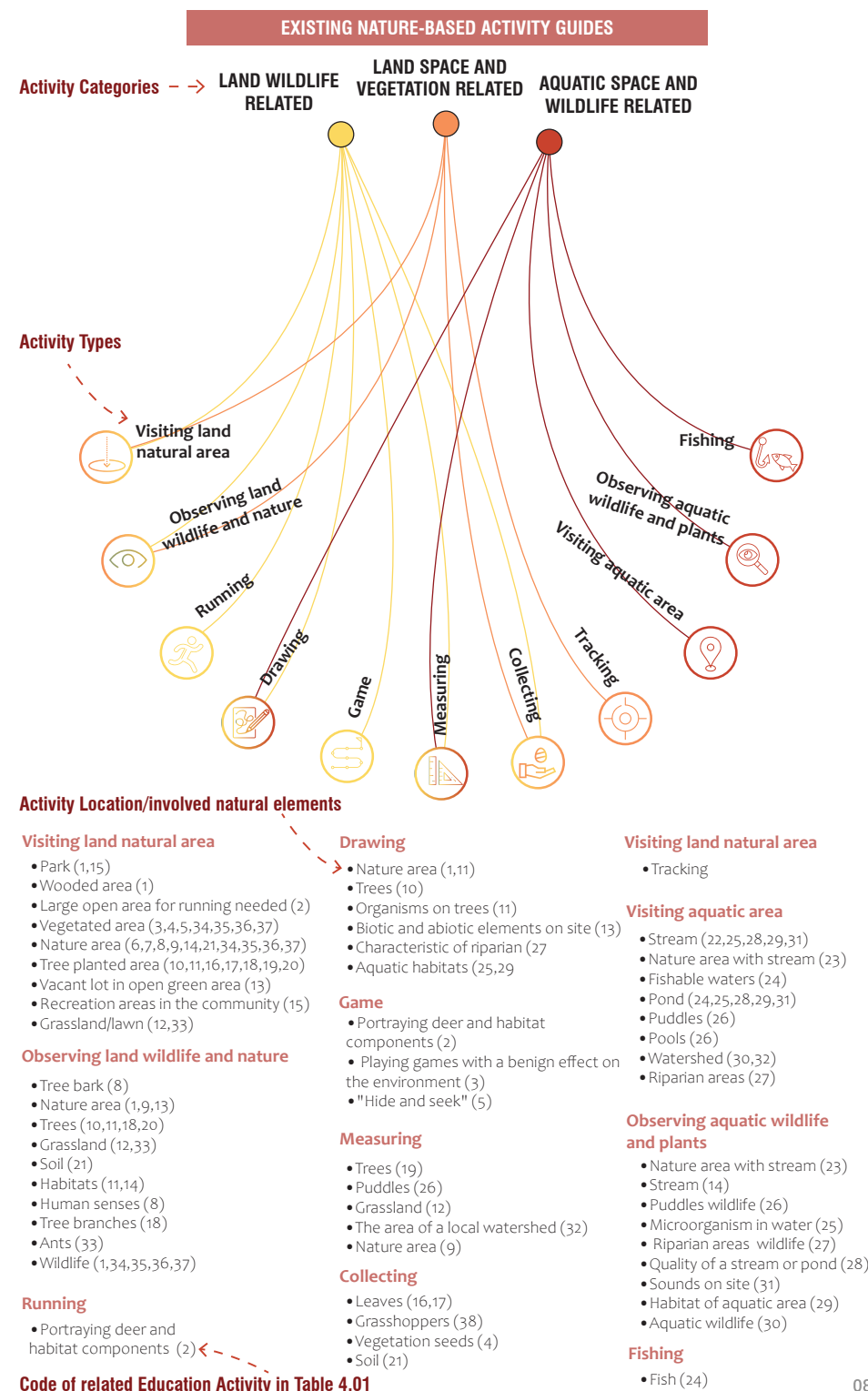
Figure 4.02
Document analysis
access design strategies
categories (Visual data
partially adapted from
Prominski et al. 2012 by
Huang 2022)

ACTIVITY

Following the review of three existing nature-based activity guides, 38 applicable educational activities intended to apply outdoors and engage with nature were identified and grouped into three main categories based on location, natural elements that can be interacted with, and the objects of the activity. The characteristics of these 38 activities allowed 11 activity types to be identified. The relationship between them and the three categories of activities is presented in Figure 4.03. In the diagram, the subtype of each activity type is also displayed, and the code of each activity indicates the relationship between activity types and activities. The collection table (Table 4.01) summarizes 38 creekfront applicable activities from existing nature-based activity guides, along with their code, name, education grade level, introduction, and sources. The three main activity categories and types that were determined were then utilized to inform the proposed design guidelines.

Besides nature-based educational activities, 13 outdoor recreational activities that can be conducted at the creekfront have also been identified from document analysis, including walking, jogging, running, bicycling, roller-skating, in-line skating, and skateboarding, viewing/photographing humans, viewing/photographing nature scenery, fishing, family/friend gatherings, swimming, and floating.

Figure 4.03
Document analysis
nature-based activities
categories (Huang 2022)



Nature materials	Code	Activity Name	Grade level	Objectives	Details (Guideline and page)
Land space and vegetation related	1	Drawing on nature	Grades 5-8	Generalizing that wildlife and other animals are an important inspiration for art and science	Project wild 285
	2	Oh Dear!	Grades 5-8	Portraying deer and habitat components in a physical activity to recognize the fluctuations in wildlife and ecosystem	Project wild 36
	3	Playing lightly on the Earth	Pre-K, Grades K-4	Looking for evidence of games that harm the environment and then inventing and playing games with a benign effect on the environment	Project wild 432
	4	Seed need	Grades 5-8	Evaluating the importance of wildlife as contributors to ecological systems using the example of seed dispersal	Project wild 98
	5	Thicket Game	Pre-K, Grades K-4	Identifying the importance of adaptation to animals by playing "predator" and "prey" game	Project wild 114
	6	Urban nature search	Grades 5-8	Generalizing that each habitat has characteristic life forms	Project wild 70
	7	Habitrekking	Grades K-4	Identifying the similar basic needs, share environment, and similar environmental issue between human and wildlife	Project wild 79
	8	Peppermint around	Grade K-6	Smell and taste, identifying the importance of the sense of smell in daily life	Project learning tree 7
	9	Planet of plenty	Grade 4-6	identifying the importance of biological diversity	Project learning tree 24
	10	Adopt a tree	Grade 3-8	studying the characteristics of a tree	Project learning tree 65
	11	Trees as habitats	Grade 3-8	Learning trees as home for other organisms	Project learning tree 70
	12	Air plants	Grade 3-6	Exploring the relationship between the amount of oxygen produced by plants and the amount of oxygen used by humans	Project learning tree 85
	13	Are vacant lots vacant?	Grade 4-8	examining and describe ecological relationships between biotic and abiotic elements on site	Project learning tree 153
	14	Field, forest, and stream	Grade 4-8	Measuring and comparing components in three different ecosystems	Project learning tree 156
	15	I'd like to visit a place where	Grade 4-8	exploring the importance of parks and open space	Project learning tree 188
	16	To be a tree	Grade Prek-4	Identifying structures of a tree	Project learning tree 219
	17	Looking at leaves	Grades K-4	Learning leaf structure among different trees	Project learning tree 228
	18	Bursting buds	Grade K-6	learning the function of buds	Project learning tree 232
	19	How big is your tree?	Grades 3-8	learning the methods to measure trees	Project learning tree 239
	20	Name that tree	Grades 2-8	Identifying characteristics of tree species	Project learning tree 247
	21	Soil stories	Grades 5-8	examine different soils	Project learning tree 252

▲▲
Table 4.01
Document analysis
nature-based activities
detail categories (Huang
2022)

Nature materials	Code	Activity Name	Grade level	Objectives	Details (Guideline and page)
Aquatic space and wildlife related	22	Blue Ribbon Niche	Grades 3-5, Grades 6-8	identify different organisms that live in riparian areas	Aquatic wild 94
	23	Edge of Home	Grades 3-5, Grades 6-8	Identifying the characteristics of ecotones, or transitional zones, between two wildlife habitats	Aquatic wild 119
	24	Gone Fishing!	Grades 6-8, Grades 9-12	Studying on fish and fish habitat	Aquatic wild 272
	25	Micro Odyssey	Grades 3-5, Grades 6-8	identify microorganisms in water	Aquatic wild 91
	26	Puddle Wonders!	Grades 6-8	measure, record the puddle, and examine wildlife using the puddles	Aquatic wild 166
	27	Apiarian Retreat	Grades 3-5	Studying habitat characteristics of riparian areas and identifying the importance of riparian areas to wildlife and humans	Aquatic wild 175
	28	Water Canaries	Grades 6-8, Grades 9-12	investigates a stream or pond, identify aquatic organisms, assess the relative environmental quality of a stream or pond	Aquatic wild 63
	29	Water Plant Art	Grades k-2, Grades 3-5	create artworks showing aquatic habitats	Aquatic wild 72
	30	Water Safari	Grades k-2	field investigation to discover wildlife and water sources	Aquatic wild 37
	31	Water Wings	Grades 3-5, Grades 6-8	visit stream, pond, lake, river, or beach, record sounds on site	Aquatic wild 160
	32	Watershed	Grades 6-8, Grades 9-12	measure the area of a local watershed	Aquatic wild 196
	33	Ants on a Twig	Grades 5-8	Observing and demonstrating ant behavior and identifying similarities and differences in basic need of ants and humans	Project wild 88
Land wildlife related	34	Environmental Barometer	Pre-K, Grades K-4	Obverting and counting wildlife in an area to considering ways in which the presence of wildlife can be seen as an indicator of environmental quality	Project wild 77
	35	Microtel Treasure Hunt	Grades 5-8	discovering that humans and wildlife share environment and recognizing that humans do not exclusive use of environments	Project wild 82
	36	Tracks!	Grades 5-8	Identifying common animal tracks	Project wild 30
	37	Wildlife is everywhere!	Grades K-4	Comparing human and wildlife habitats and realizing that wildlife is around the world	Project wild 51
	38	Grasshopper gravity	Grades K-4	Generalizing that wildlife ranges from small to large organisms and exists in a variety of forms	Project wild 4

*Project Wild: Project Wild: K-12 Curriculum & Activity Guide (2012) by the Council for Environmental Education

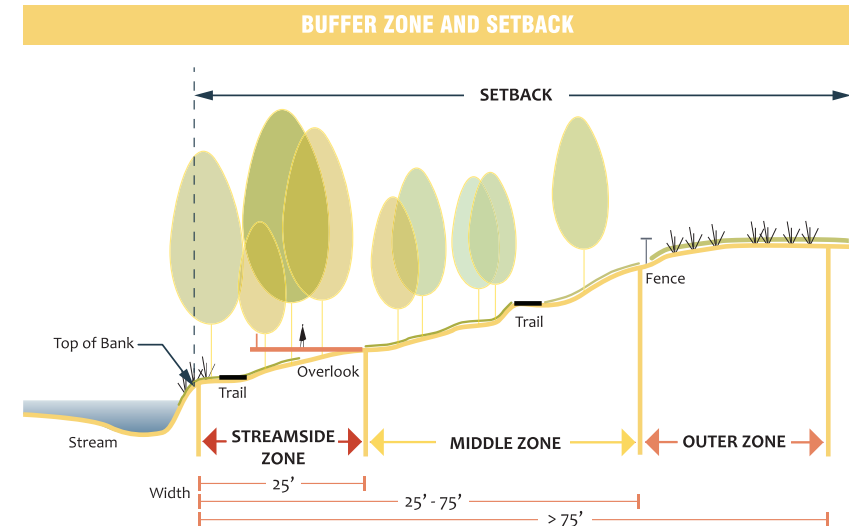
*Aquatic Wild: Project Wild: K-12 Curriculum & Activity Guide (2016) by the Council for Environmental Education

*Project Learning Tree: Pre K-8. Environmental Education Activity Guide (1995) by Western Regional Environmental Education Council and American Forest Foundation

IMPLEMENTATION

As a method for protecting stream stability, quality, habitat, infrastructure, and flood protection, stream buffers (setbacks) are required. Analysis of existing design standards identified the design suggestion and requirement for stream buffers provided by the City of Kansas City and U.S. Environmental Protection Agency (EPA), and other four existing design guideline documents. Table 4.02 presents a collection of buffer design requirement withdrawals from documents, including the width of the buffer zone, functions, and allowed uses in each buffer zone. Buffer zone requirements may vary slightly from region to region, however, the requirements listed in Table 4.02 are highly indicative. The implementation principles of setbacks are also summarized in Table 4.02, which shows minimum setbacks for creekfront design and permitted improvements.

Table 4.02
Buffer zone and setback
summarization (Huang
2022, data from the City
of Kansas City 2021, U.S.
Environmental
Protection Agency (EPA)
2002, and City of Chicago
2012)



CHARACTERISTICS	STREAMSIDE ZONE	MIDDLE ZONE	OUTER ZONE
Buffer widths	Extends 25 feet landward from the edge of stream	extends 25 to 75 feet from the stream	Extends landward 75 feet from the outer edge of the middle zone
Functions	Protecting the physical and ecological integrity of the stream.	Protects key components of the stream with mature vegetation adapted to the area and establishes a buffer zone between uplands and stream banks.	Prevents encroachment of the stream buffer and filters run-off from residential and commercial development
Allowed use	- Flood control structures - Footpaths - Road crossings, where permitted - vegetation management - streambank stabilization - approved road, trail, and utility crossings - stormwater outfalls - Approved stream access for fishing and wildlife viewing and trail overlook areas	- Any activity allowed in the streamside zone - paved and unpaved recreational trails for hiking and biking. - underground utility corridors that are fully vegetated and designed in accordance requirements - Stormwater management facilities - Recreational uses - Limited tree clearing	- Any activity allowed in the streamside and middle zones - Stormwater management - Best Management Practices (BMP) maintenance - Property owners may establish the maximum outer zone with no more than 40% to 50% of the outer zone area may be disturbed, and the first 25 feet with no-build area.
SETBACK			
Dimensions	Measured horizontally from the top of the bank, rather than from the water's edge		
Minimum setback	The minimum setback along creek varies from 30 linear feet to 60 linear feet		
Function	Stormwater management, stabilizing creekbanks, water quality improvements, habitat improvement, Creekside aesthetics and providing naturalistic landscaping and public access.		
Permitted Improvements or structures	- Paved or unpaved walkways. - Stormwater best management practices (BMPs). - Shade structures such as arbors, trellises, or pavilions. - Public gathering spaces and other creekfront landing amenities. - Site furnishings including, but not limited to, benches, light fixtures, drinking fountains, bike racks, signage. - Fences and walls		
Content	- Buffer zones - Planted with native vegetation		

A collection of construction sizes and materials for three types of access and two categories of site furnishings was generated after reviewing the documents (see Figure 4.04). Implementation detail suggestion for access categorized by path use, including pedestrian/biking trails, running trails, and multi-use paths. For each of the path types, there is a recommended construction dimensions, but the materials can be used for all types of access. The site furnishings were divided into two groups: lighting and others, since lighting construction differs significantly from that of other site furnishings.

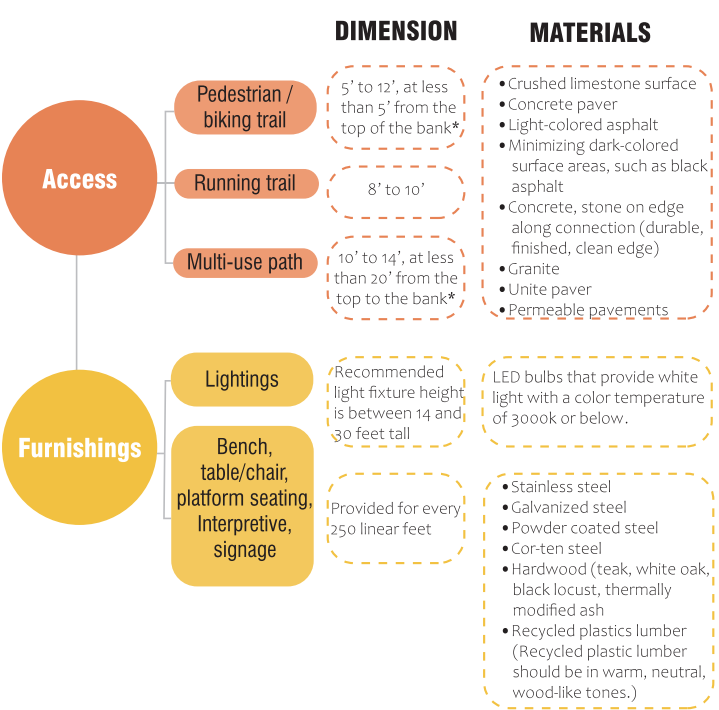


Figure 4.04
Dimensions and materials for access and furnishings (Huang 2022, data from City of Chicago 2012 and Riverlife 2014)

*The minimum setback distance of this access design within the "Streamside Zone"

RESILIENCY

Findings from the documents relevant to resiliency were synthesized and grouped into three parts based on related themes and are presented in this section. In the resiliency section, the first part is about management strategies for stream corridors according to time frame as shown in Table 4. 03. Following this section, there is a table (Table 4. 04) which presents plant zones along the creek edge. The third part provides a summary of the important ecological issues related to creeks as well as resilience strategies and treatments for these issues. Twenty-six resilient treatments were identified from the findings and are divided into six categories which address five ecological issues, including sedimentation, erosion, flooding, poor water quality, and simple habitat.

Table 4.03
General stream corridor management strategies based on time frame (Generated from Patti Banks Associates and Applied Ecological Services, Inc. 2006 by Huang 2022)

MANAGING THE STREAM CORRIDORS BASED ON TIME FRAME	
Time Frame	Protection Strategy
Short Term (Preservation)	Set aside stream buffer
	Prohibit dumping
	No storage or use of pesticides or heavy equipment
	Inspect condition (bank stability, erosion, vegetative cover)
	Remove trash
Medium Term (Enhancement)	Identify erosion damage
	Properly align and design road and infrastructure crossing
	Repair unstable banks
	Remove exotic or invasive vegetation
	Remove debris and fill
Long Term (Re-creation)	Restore native vegetation
	Establish vegetative buffers
	Stabilize hydrology and streambed

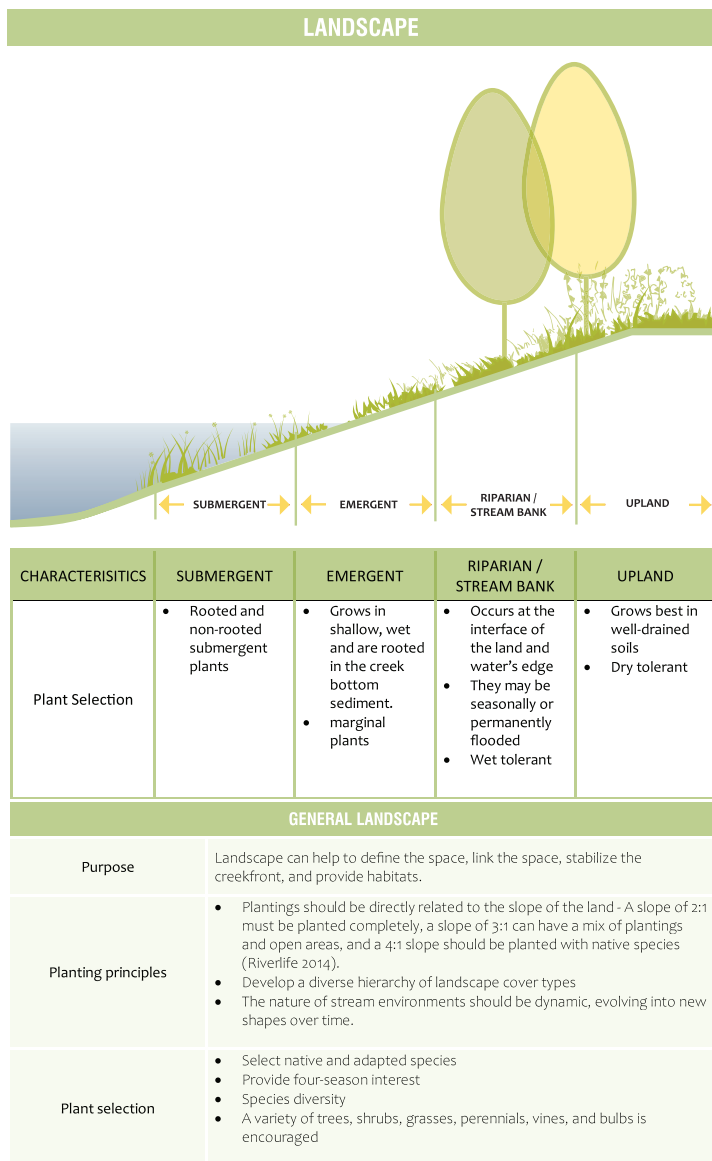
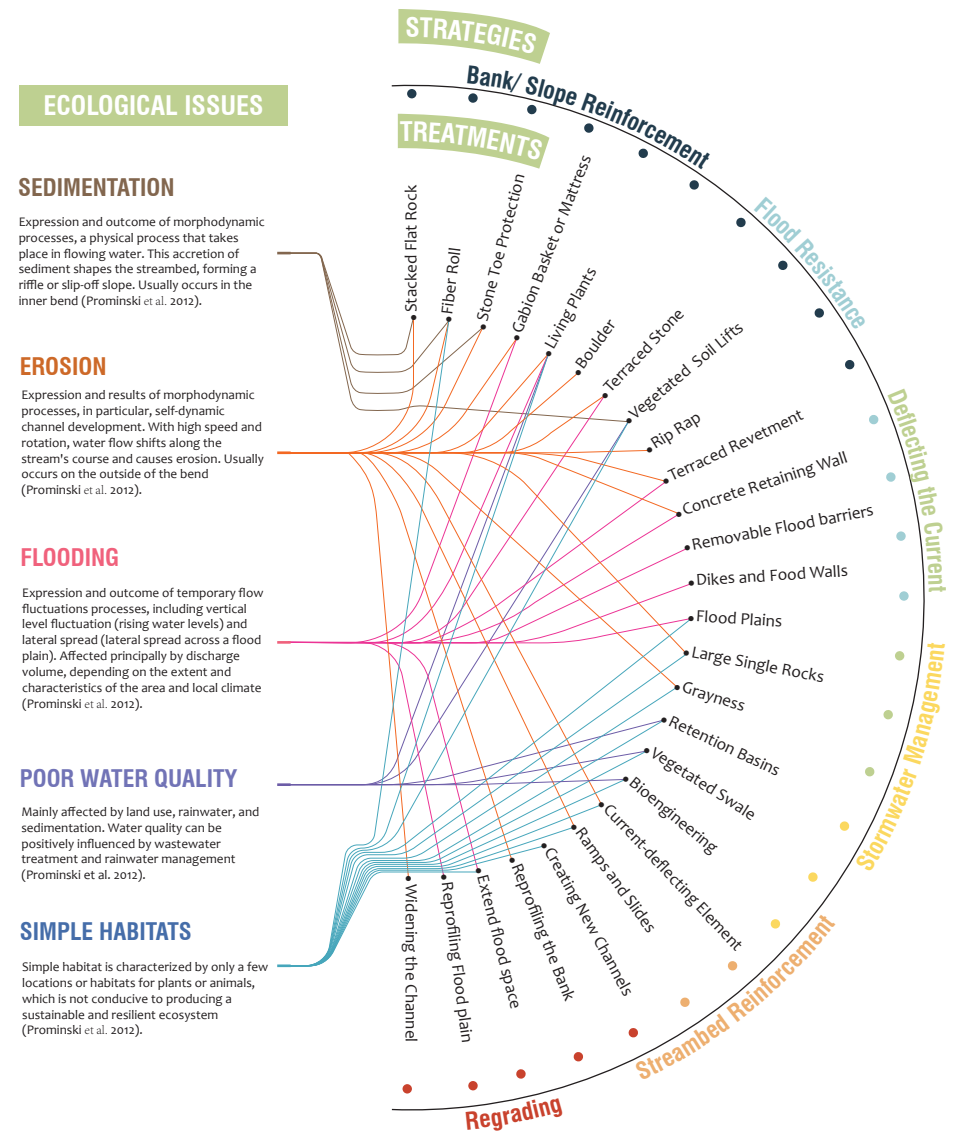


Table 4.04
Document analysis
landscape zones and
plant selection categories
(Huang 2022, data from
City of Chicago 2012 and
Riverlife 2014)

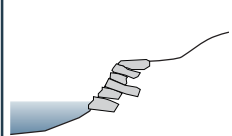
Figure 4.05
Typical stream ecological
issues and corresponding
resilient treatments
(Huang 2022)



- Fiber Roll** An erosion-prevention device consisting of a cylinder of nonwoven fiber produced from coconut husks and wrapped in a woven rope or mesh of coconut fibers installed along the streambank toe. (City of Chicago 2019).
- Gabion** Rectangular wire baskets filled with stones to protect embankments from erosion (Prominski et al. 2012).
- Vegetated Soil Lifts** A bank protection method involves fabric wraps around soil layers containing native plants that are seeded and planted (City of Chicago 2019).
- Rip Rap** A layer of angular stones installed on the streambank serves as an erosion-prevention measure (City of Chicago 2019)
- Grayness** A structure constructed at right angles to the stream bank with stone, concrete, or wood to decrease the negative impact of water flow on the bank by diverting the current away from the bank. (Prominski et al. 2012).
- Retention Basins** A basin or reservoir that temporarily stores water to reduce peak discharges (Prominski et al. 2012).
- Vegetated Swale** A vegetated sunken or marshy area which slows down stormwater flow and removes soil particles through buffer zones (Riverlife 2014).
- Bioengineering** The construction methods or materials allow replicating the natural system quality and capabilities of organic matter (Riverlife 2014).
- Terraced Revetment** A bank reinforcement method, commonly made of stone and constructed as steps or seats providing a place to rest or linger directly on the waterside (Prominski et al. 2012).

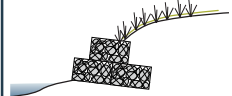
RESILIENCY STRATEGIES AND TREATMENT

Bank/ Slope Reinforcement



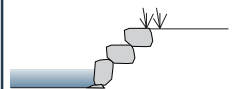
Stacked Flat Rock

- Stabilize the bank
- Reducing erosion and sedimentation



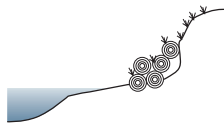
Gabion Basket or Mattress

- Stabilize the bank
- Controlling the erosion and scouring of land
- Reducing flood damage



Terraced Stone

- Stabilize the bank
- Reducing erosion
- Providing habitats



Fiber Roll

- Stabilize the bank
- Reducing erosion
- Enhancing habitats and create diverse biotopes



Living Plants

- Stabilize the bank
- Resistant to flooding
- Filtrate the runoff
- Increasing species diversity



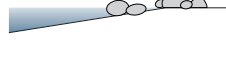
Vegetated Soil Lift

- Stabilize the bank
- Reduce eroding and subsequent settlement
- Increasing vegetation species
- Provide a suitable slope



Stone Toe Protection

- Stabilize the bank
- Reducing erosion and sediment
- Protecting the bank from constantly changing water flows



Boulder

- Stabilize the bank
- Minimize erosion



Rip Rap

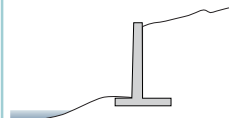
- Stabilize the bank
- Protecting against erosion



Terraced Revetment

- Stabilize the bank
- Reducing erosion
- Manage floods resulting from daily fluctuations in vertical water levels

Flood Resistance



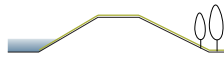
Concrete Retaining Wall

- Providing flood protection at the cutting edge
- Stabilize the bank
- Preventing soil erosion



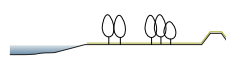
Removable Flood barriers

- Creating flooding tolerant access



Dikes and Flood Walls

- React to the lateral spread of the water
- Providing flood protection



Flood Plains

- Respond to the lateral spread of the water
- Respond to the lateral spread of the water

Deflecting the Current



Large Single Rocks

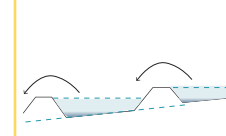
- Diving the current from the banks toward the center to reduce erosion and sedimentation
- Creating diverse biotopes and habitats



Grayness

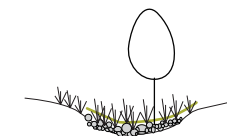
RESILIENCY STRATEGIES AND TREATMENT

Stormwater Management



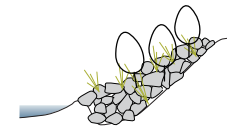
Retention Basins

- Controlling the discharge volume of stream when water level rises
- Reducing soil erosion
- Cleaning runoff



Vegetated Swale

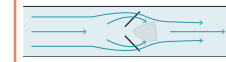
- Slow flow of stormwater
- Removing soil particles to improve water quality
- Increasing habitats



Bioengineering

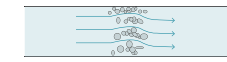
- Reproducing the natural system quality and capabilities of organic matter.
- Enabling the self-healing capabilities of nature

Streambed Reinforcement



Current-deflecting Element

- Increasing flow rates in sections of a watercourse to concentrate current carriers off bed material and decrease sedimentation
- Offering special habitat



Ramps and Slides

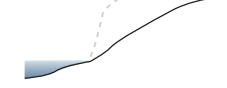
- Offering a diverse habitat
- Restoring the natural hydraulic process
- Making a stream passable by reshaping its bed

Regrading



Creating New Channels

- Increasing structural diversity in streams by building parallel channels or dividing them
- Increasing habitat
- Reestablishing natural morphodynamic processes of stream



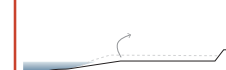
Reprofilling the Bank

- Reducing bank slope to minimize or eliminate soil erosion
- Steep slopes are suggested to re-grade to a minimum 3:1 (horizontal to vertical) slope



Extend flood space

- Providing more space responding later spread of the water (flooding)
- Increase habitat diversity



Reprofilling Flood plain

- Regrade the flood plain with more gentle sloping banks to enhance both ecological value and accessibility
- Enhance nature habitats



Widening the Channel

- Increasing floodwater discharge capacity
- Reducing water flow in this section
- Facilitating the motion of sediment shifting processes by increasing the variation of the watercourse



Figure 4.06
Document analysis
resiliency strategies
and treatment
categories (Visual data
partially generated
from Prominski et al.
2012 by Huang 2022)

PRECEDENT STUDIES

Findings from the precedent studies indicate a series of potential design strategies relating to access, activity, implementation, and resiliency to activate creekfront spaces. The precedent studies helped inform the structure and content of design guidelines for creekfront spaces.

The study of precedents provides information on constructed waterfront projects. Analyzing the strategies and design of access, activities, programs, implementation, and resiliency that applied in these projects provides inspiration of design in Wildcat Creek waterfront design and developed guideline for general creekfront design. The findings were categorized into four sections and each section has tables or diagrams to illustrate the analysis findings of that topic related to the precedents.

Puyangjiang River Corridor

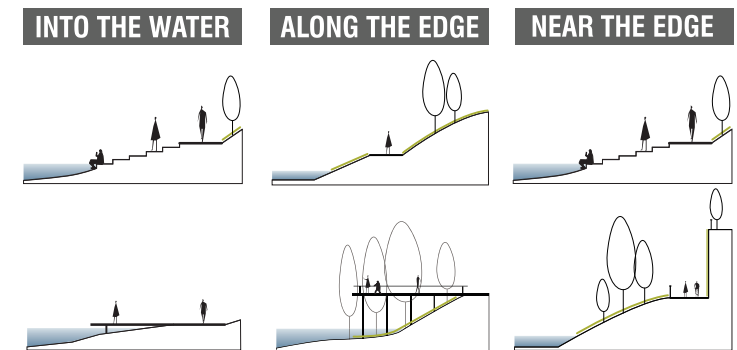
Zhejiang, China

The Puyangjiang River and its tributaries in Pujiang, a small town in eastern China, have become heavily polluted, waterways have been channelized, and riverbeds have been turned into sand quarries due to swift industrial development in the past 40 years. The Puyangjiang River Corridor renovation project, developed by the Turenscape design team and the local government, adopted three strategies to enhance and restore the Puyangjiang River Corridor, which has been severely degraded by development. Restoration strategies include 1) ecological restoration, 2) preservation and integration of existing resources, and 3) establishment of connections and activities (Turenscape. 2019).

In this project, concrete on the riverbank was replaced with plants; the existing vegetation was protected; several programs were added in harmony, and bridges, trails, and bicycle trails were installed to connect communities on both sides. Various riverside designs and trails along the bank activate the riverbank and reconnect people to nature (Turenscape. 2019).

For more information, visit <https://www.turenscape.com/en/home/index.html>

Figure 4. 07
Access strategies of
Puyangjiang River
Corridor project (Huang
2022)



Size 10 mile long, 485 acres, 60-390 feet wide

Designer Turenscape

- Activities**
- Visiting developed Site: Family/friends gathering
 - Viewing and photographing nature: Viewing/photographing bridges, Viewing/photographing nature scenery
 - Backcountry activities: Jogging, Walking, Biking
 - Fishing
 - Non-motorized water activities: Swimming, Floating

Buffalo Bayou Park

Houston, TX

Buffalo Bayou Park used to be an engineered turf drainage corridor with a long flooding history. With reconstruction, this derelict drainage basin hidden beneath a tangle of highway infrastructure transformed into a resilient urban green park. Using channel stabilization techniques, the design enhances the bayou's natural meanders while increasing its resilience to flooding. Planting strategy reduced mowed turf by half, removed non-native and invasive species, and replaced them with riparian reforestation areas with historic species compositions and naturalized meadows featuring native plants. The strategies help stabilize the landscape, create new habitats, add aesthetic value, minimize maintenance costs, and curb bank erosion as well as water pollution (SWA Group n.d.; Aman 2019).

The 160-acre public space has been completely renovated, deploying a comprehensive program of urban ecological services and increasing pedestrian access. Over 15 miles of pedestrian trails and bike paths were added as well as 4 new bridges to enhance connectivity and opportunities for the surrounding neighborhoods. Along with continuous multi-access, Buffalo Bayou Park now offers flexible activity and event spaces, and various elements built to withstand the natural, periodic flooding of the bayou. Buffalo Bayou withstood three significant floods and avoided an estimated \$2 million in damages from Hurricane Harvey (SWA Group n.d.; Aman 2019).

For more information, visit <https://rb.gy/pcb2mc>



Figure 4.08
An aerial view of Buffalo Bayou Park, Houston, TX (Google Earth Pro 2022)

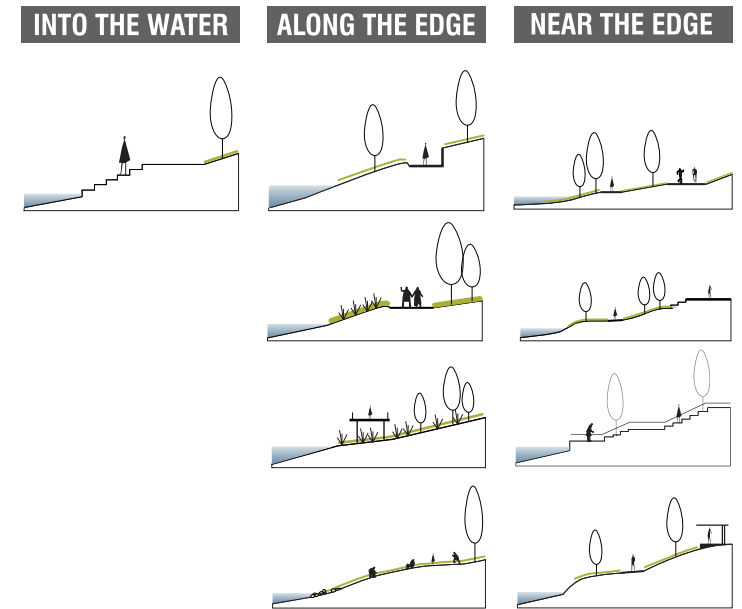


Figure 4.09
Access strategies of Buffalo Bayou Park (Huang 2022)

Size 160 acres; 2.3 miles long

Designer SWA Group

- Activities**
- Visiting developed Site: Family/friends gathering, Picnicking
 - Viewing and photographing nature: Viewing/photographing bridges, Viewing/photographing nature scenery
 - Backcountry activities: Jogging, Walking, Biking
 - Motorized activities: Motorboating
 - Nonmotorized water activities: Swimming, Floating
 - Urban recreation activity: Game, Concert
 - Sports: Volleyball, Yoga

Cheonggyecheon Stream Restoration Project

South Korea, Seoul

The elevated highway and the road that covered Cheonggyecheon Stream were the arteries of urban transport. Due to the increase in land prices and the stagnation of development caused by the transformation of the economic structure of Seoul, the living quality and economy of the old Seoul downtown had declined (Seoul Solution 2011).

Also, the elevated highway and the concrete deck of the bridge covering Cheonggyecheon had safety issues at the time as well. Consequently, the Seoul government demolished parts of the elevated highway and the concrete bridge deck covering the stream. The Cheonggyecheon Restoration Project removed an elevated highway and exposed the Cheonggyecheon Stream. This resulted in 3.6 miles of green corridors for pedestrians, bicyclists, and wildlife, while also contributing to economic growth (Robinson 2011). 22 bridges (12 pedestrian, 10 for automobiles and pedestrians) were added to increase the connectivity of north-south linkages. In 29 different locations, willow swamps, shallows, and marshes were constructed, providing habitat for fish, amphibians, insects, and birds. Water-level-changing terraced walls provide access as levels fluctuate, create seasonal interest as surfaces submerge and re-emerge, and protect the city from flooding (Robinson 2011). Implementing this downtown waterfront project enhances the quality of life for residents, improves the environment, restores the historical value of the river, and stimulates the economy of the region.

For more information, visit <https://rb.gy/krvhbj>



Figure 4.10
Concrete pedestrian
path and Stairs in
Cheonggyecheon Stream
bank (Google Earth Pro
2022)

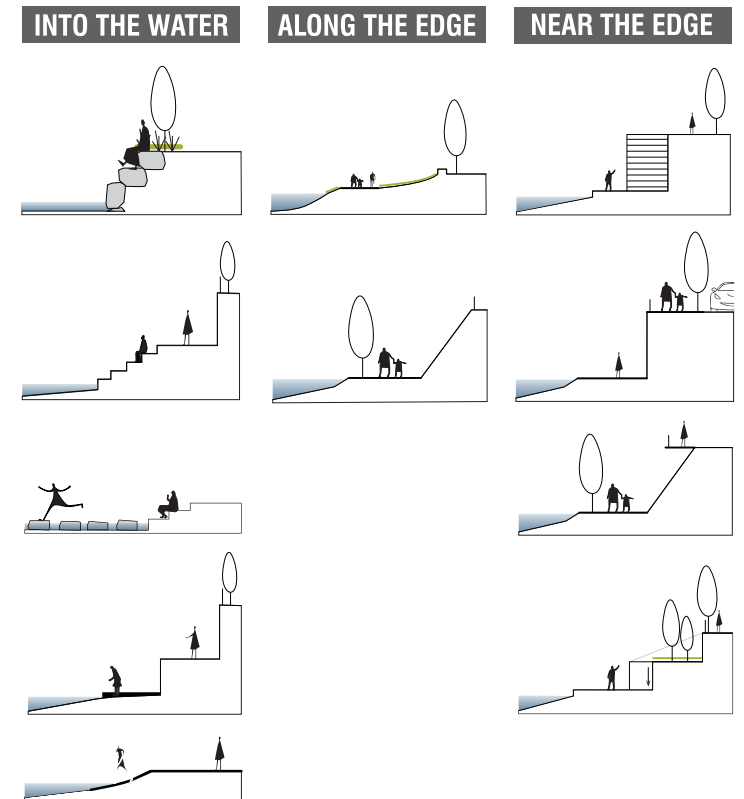


Figure 4.11
Access strategies of
Cheonggyecheon Stream
Restoration Project
(Huang 2022)

Size ~100 acres 3.6 miles (5.84 km) long

Designer SeoAhn Total Landscape

- Activities**
- Visiting developed Site: Family/friends gathering
 - Viewing and photographing nature: Viewing/photographing bridges, Viewing/photographing nature scenery
 - Backcountry activities: Jogging, Walking, Biking
 - Urban recreation activity: Movie, Concert

Revitalizing Kazan's Prime Waterfront

Kazan, Russia

Kazan lies on the north and east shorelines of Lower Kaban Lake, which is Russia's sixth-largest city. By dumping waste in Kaban Lake for 700 years, the city was separated from its waterfront, resulting in the loss of both cultural vitality and ecological amenities. Due to high-speed roadways, private properties, and overgrown groves on abandoned brownfields, residents lack access to Kaban lake. Turenscape won the project through a national competition completed in 2015 (Turenscape 2019). Several platforms and boardwalks are built beyond the concrete embankment to give residents and visitors easier access to the waterfront. Moreover, ramps and stairs are also used to connect pedestrian paths and places that float above the lake with those on the ground. On the lake's shore, walkways, bicycle paths, and rest and activity areas have been constructed, allowing for the hosting of rich cultural and sports events. Water remediation buffer zones established along the lakeshore not only catch surface runoff from several ditches, but also provide education and entertainment. Kazan's waterfront has currently been reclaimed with ecological health, cultural vitality, and reconnected with residents and the city (Turenscape 2019).

For more information, visit <https://www.turenscape.com/en/project/detail/4655.html>



Figure 4.12
Boardwalk in Kazan's
prime waterfront (Google
Earth Pro 2022)

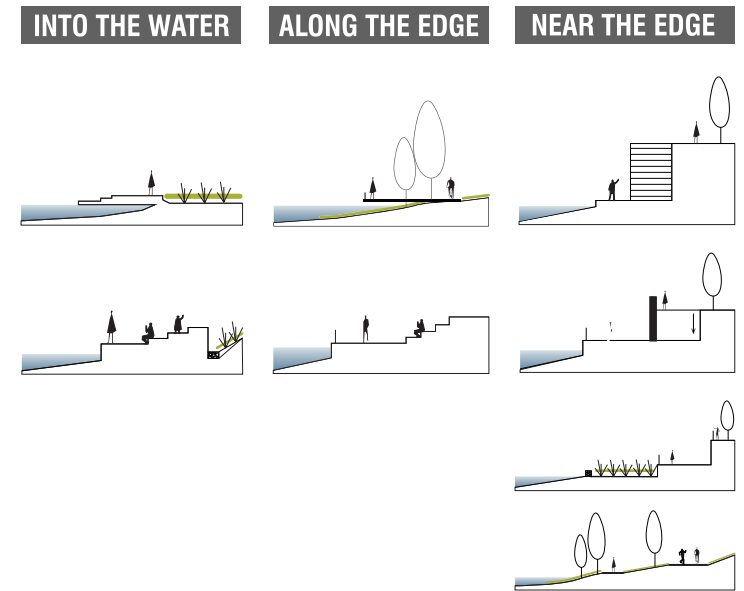


Figure 4.13
Access strategies of
Kazan's prime waterfront
(Huang 2022)

Size a shoreline of 1.4 miles, an area of about 74 acres

Designer Turenscape

- Activities**
- Visiting developed Site: Family/friends gathering
 - Viewing and photographing nature: Viewing/photographing nature scenery
 - Backcountry activities: Jogging, Walking, Biking
 - Fishing
 - Nonmotorized water activities: Swimming, Floating
 - Urban recreation activity: Movie, Concert

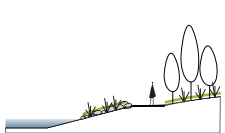
Meadow Creek Stream Restoration

Charlottesville, VA

Meadow Creek is the major waterway in Charlottesville, Virginia. As a result of excessive sedimentation resulting from uncontrolled stormwater runoff, Meadow Creek deteriorated, and it was listed as an “impaired waterway” by the Virginia Department of Environment and Conservation Quality. In order to restore the stream system and improve water quality, as well as improve aquatic habitat and aesthetics, a significant stream restoration program was conducted in 2012 (The City of Charlottesville 2013). Using a “natural channel design” approach, a dynamically stable meandering pattern was established, and the stream was reconnected to its floodplain and stability. The approach reduced stream bank erosion and sedimentation. It restores diverse aquatic habitats and improves streamside forest habitats by creating a self-sustaining stream system (Cho 2014). This project preserved 1.5 miles of dirt trail that is part of the 20-mile long Rivanna Trail, a National Recreation Trail and a Virginia Birding and Wildlife Trail, as well as 72 acres of land as new conservation easements, of which 40 acres are new public parkland (Cho 2014).

For more information, visit <https://rb.gy/dlpvxve>

ALONG THE EDGE



NEAR THE EDGE

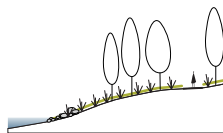


Figure 4.14
Access strategies of
Meadow Creek Stream
(Huang 2022)



Figure 4.15
Plan View of Meadow
Creek Stream (Google
Earth Pro 2022)



Figure 4.16
View of Meadow Creek
Stream from a crossing
bridge (Google Earth Pro
2022)

Size 1.4 linear miles long, 72 acres easement

Designer Vanasse Hangen Brustlin, Inc

Activities

- Viewing and photographing nature: Viewing/photographing bridges, Viewing/photographing nature scenery
- Backcountry activities: Jogging, Walking, Biking

Xi'an Juehe River Fanchuan Park

Xi'an, China

Juehe River Fanchuan Park is an urban park integrating ecological restoration, natural sightseeing, leisure and entertainment, and humanistic experience (Turenscape 2021). The park is located in the middle of the Juehe river, a narrow and short branch of Chang'an's Eight Rivers. Xi'an has undergone rapid development, resulting in a lot of urban construction waste. As a result, the Juehe river, located in low-lying terrain, has become a favorite place for pile-up soil. Dumping of construction waste and soil changed the river channel, making the river less connected and making the bank difficult for plants to grow, which resulted in poor access to the site and river. To resolve the site problem, the design team designed a trestle-type hydrophilic shore, which created a new river for the local residents and provided a place for recreation and entertainment (Turenscape 2021; Landscape Album 2021). The trestle-type hydrophilic shore was achieved by smoothing the bank of the river, planting plants on the construction wasteland, re-planning the circulation, adding hydrophilic facilities, and increasing activity programs (Turenscape 2021; Landscape Album 2021).

For more information, visit <https://www.turenscape.com/en/project/detail/4718.html>

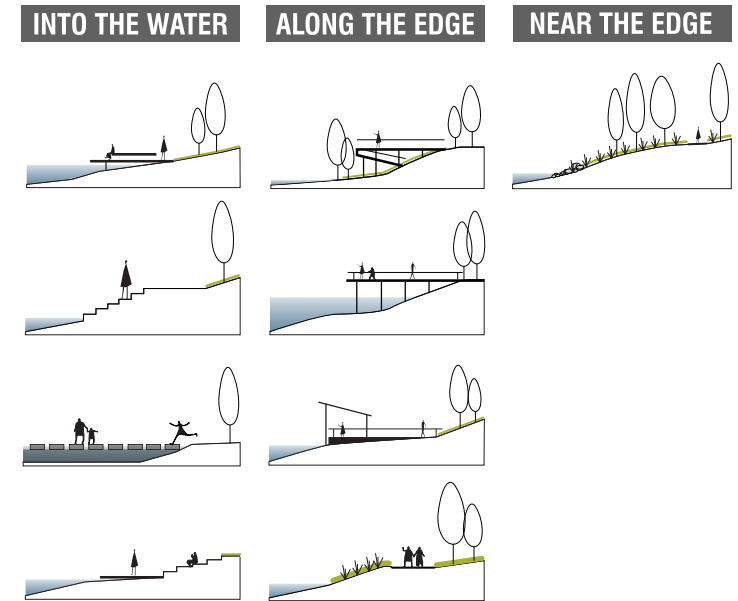


Figure 4.17
Access strategies of Xi'an
Juehe River Fanchuan
Park (Huang 2022)

Size 41.02 acres

Designer Turenscape

Activities

- Visiting developed Site: Family/friends gathering, Picnicking, Camping
- Viewing and photographing nature: Viewing/photographing bridges, Viewing/photographing nature scenery
- Backcountry activities: Climbing, Jogging, Walking, Biking
- Fishing
- Nonmotorized water activities: Swimming
- Urban recreation activity: Concert
- Sports: Table tennis, Basketball, Badminton

Baakenpark

Hamburg, Germany

Since 2015, Baakenpark has been the green heart of eastern HafenCity. Baakenpark is a 12.35-acre artificial peninsula of sand with spectacular topography and linear edges, steel banks, stone promenades, and stone walls. Throughout Baakenpark, there are three plateaus of different heights set on the waterfront, which not only provide flood protection, but also provide various functions and places (Landezine 2019).

The western plateau is dominated by sport and recreation areas. The wooden sofa on the western plateau provides a relaxing place to sit or lie down while enjoying the scenery. Playing fields made of artificial turf can be used for leisure and school activities. The middle level plateau is located on the northern embankment and offers a playground and sunbathing area with a gallery of banks. The central plateau features seating areas and a platform, giving people a chance to enjoy panoramic views of the harbor basin and host small events. The eastern plateau is the highest point in the peninsula at 15 meters (45 feet). Its steep slopes drop sharply on three sides, like a pyramid. On the flat slope of the hill is a staircase that leads to a viewing platform. The Himmelsberg offers the best views of Hamburg harbor and is the highlight of the Himmelsberg. Because of its height and its location, this part is quieter and more isolated (Landezine 2019). Baakenpark provides visitors with various recreation and sport opportunities and increases access for both pedestrians and cyclists from surrounding areas. The unique topography integrates activity programs with flood protection function while enhancing shoreline aesthetics.

For more information, visit <https://atelier-loidl.de/en/baakenpark-hamburg>



Figure 4.18
Aerial view of Baakenpark
from the overlook
platform (Google Earth
Pro 2022)

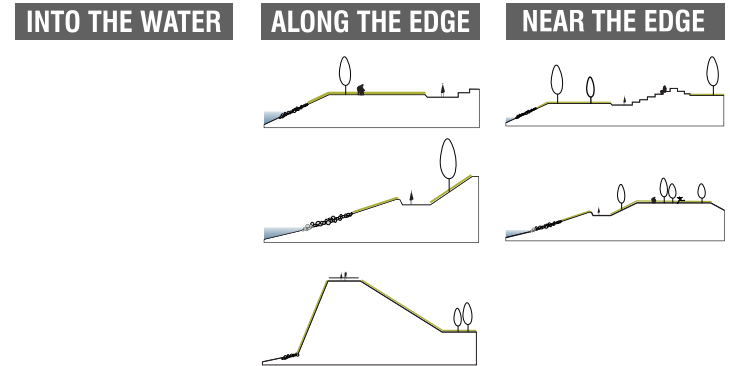


Figure 4.19
Access strategies of
Baakenpark (Huang 2022)

Size 12.35 Acres

Designer Atelier LOIDL

- Activities**
- Visiting developed Site: Family/friends gathering, Picnicking
 - Viewing and photographing nature: Viewing/photographing bridges, Viewing/photographing nature scenery
 - Backcountry activities: Jogging, Walking, Biking
 - Urban recreation activity: Game
 - Sports: Basketball, Football

Boneyard Creek Restoration: Scott Park and the Second Street Detention Basin

Champaign, IL

Scott Park and the Second Street Detention Basin design is Phase two of the overall Boneyard Creek restoration plan. The entire plan is part of a seven-phase effort to provide 100-year flood protection along Boneyard Creek, a highly channelized and engineered waterway suffering from poor water quality and flooding issues (Kim 2013; Hitchcock Design Group 2018). By using natural stone terraces, Boneyard Creek Improvement Plan restored the original waterway's curvilinear alignment and controlled erosion. As a result, stormwater holding capacity and detention capacity were improved to support future development, while allowing for extra recreation and enjoyment spaces. Along the creek, improvements include pedestrian pathways, overlooks, plazas, gateways, streetscapes, parking, and bridges. The project also connects downtown and the university through open space, winding trails, and a wide pedestrian promenade (Kim 2013; Hitchcock Design Group 2018).

For more information, visit <https://rb.gy/y8xfil>



Figure 4.20
Fountain in Scott Park
that allows climbing and
access to water (Google
Earth Pro 2022)

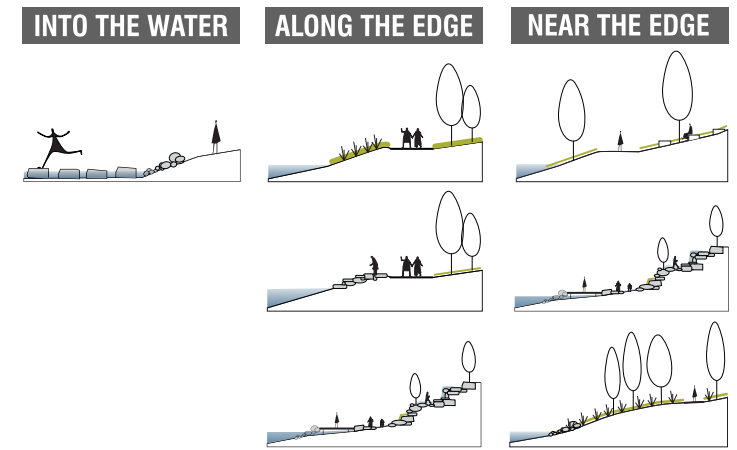


Figure 4.21
Access strategies of Scott
Park with Boneyard Creek
(Huang 2022)

Size 10 acres

Designer Hitchcock Design Group

- Activities**
- Visiting developed Site: Family/friends gathering
 - Viewing and photographing nature: Viewing/photographing nature scenery
 - Backcountry activities: Climbing, Jogging, Walking, Biking
 - Urban recreation activity: Concert

Johnson Habitat Park

Denver, CO

Johnson Habitat Park is a premier environmental education center located adjacent to South Platte River. This park was a collaborative effort between the design team, the City and County of Denver, the Greenway Foundation, The Trust for Public Land, the community, and many non-profit organizations. With the establishment of Johnson Habitat Park, not only did kids and families have a place to go outside for educational and recreational activities, but it also restored riverbanks, wetlands, and contaminated land. Regional trails in the park link the different programs of the park and provide greater accessibility from the city to the river (DHM Design 2016).

For more information, visit <https://rb.gy/tkijpe>



Figure 4.22
View of the boulders at
Johnson Habitat Park
from driveway (Google
Earth Pro 2022)

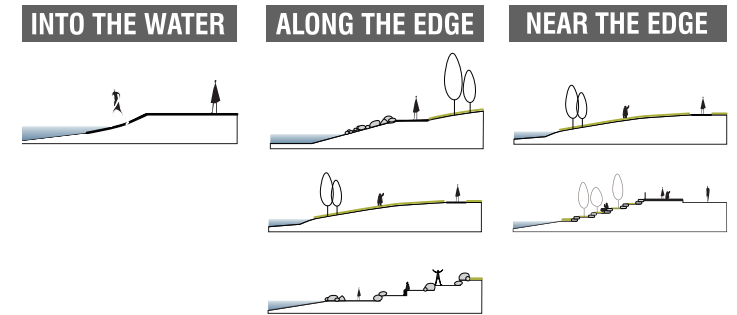


Figure 4.23
Access strategies of
Johnson Habitat Park
(Huang 2022)

Size 8.76 acres

Designer DHM Design

Activities

- Visiting developed Site: Family/friends gathering, Picnicking, Camping
- Viewing and photographing nature: Viewing/photographing nature scenery
- Backcountry activities: Climbing, Jogging, Walking, Biking
- Fishing
- Nonmotorized water activities: Floating

Riverfront Fort Wayne

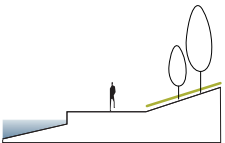
Fort Wayne, IN

The Riverfront Fort Wayne is a three-phase renovation project that aims to enhance access to Fort Wayne's St. Mary's River and improve the quality of life in Fort Wayne. Phase 1 of the riverfront improvement was designed by Lamar Johnson Collaboration (LJC). In Phase I of the project, a waterfront promenade and urban plaza were created, creating a dynamic new destination for entertainment that is connected to the CBD, surrounding neighborhoods, and the vast River Greenway Trails (The LJC n.d.). Phase 2 of Riverfront renovation adds public open space stretches along the north side of the St. Mary's River from Clinton Street to Harrison Street and from the historic Wells Street Bridge to Ewing Street (RFW 2021).

Wayne Tree Canopy Trail is the third phase in the Riverfront Fort Wayne renovation project. The Tree Canopy Trail gracefully weaves through existing trees on the north bank of the St. Mary's River between Harrison Street and the Historic Wells Street Bridge. Five different waterfront designs and rich social interaction and recreation programs have greatly increased the accessibility and playability around the St. Mary's River. With access to the riverfront elevated 20 feet above ground, pedestrians can walk along the riverfront trail while enjoying incredible views of downtown Fort Wayne to the south (HOCH Associates n.d.).

For more information, visit <https://rb.gy/hu1tkn>

ALONG THE EDGE



NEAR THE EDGE

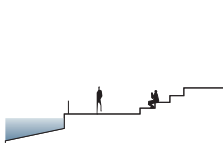
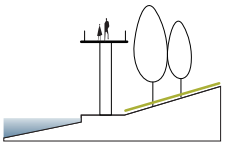
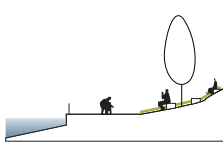


Figure 4.24
Access strategies of Fort
Wayne Riverfront (Huang
2022)



Figure 4.25
View of the St. Mary's
River from Promenade
Park and the view of
Wayne Tree Canopy Trail
across the river (Google
Earth Pro 2022)

Size 7.73 Acres

Designer Lamar Johnson Collaborative, HOCH Associates

Activities

- Visiting developed Site: Family/friends gathering, Picnicking
- Viewing and photographing nature: Viewing/photographing nature scenery
- Backcountry activities: Jogging, Walking, Biking
- Urban recreation activity: Game, Movie, Concert

Sioux Falls Downtown River Greenway

Sioux Falls, SD

Sioux Falls bike trails and greenways were established in 1975 following the completion of the original greenway master plan. Confluence provided the city in 2004 with an update to the existing Greenway and Riverfront Master Plan that incorporated upper and lower trails with public gathering areas around the river and made it more accessible for pedestrians and bicyclists (Confluence n.d.; James 2015). Currently, the first and second phases of the project are complete, and the third phase is underway. The project advances the Downtown Sioux Falls bike trail and greenway system, provides rich recreational opportunities, and stimulates economic development along the Sioux River corridor (Confluence n.d.; James 2015). The project's first phase included the construction of an urban riverwalk, a pedestrian bridge, and an amphitheater. Second phase includes an interactive water feature in a new plaza and more access points to the greenway. In phase three, the trail will be extended along the riverbanks (James 2015). With the Sioux Falls Downtown River Greenway, river access and outdoor recreational and educational activities are enhanced.

For more information, visit <https://rb.gy/nazgmg>

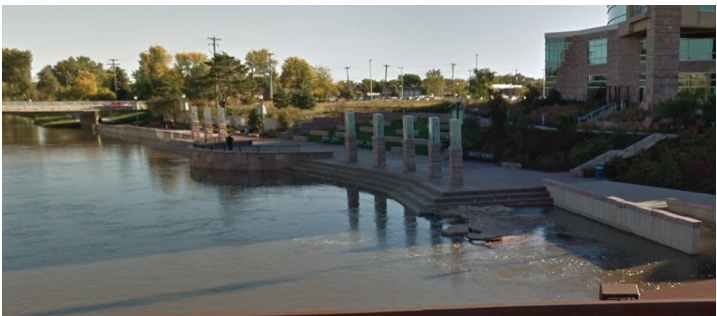


Figure 4.26
Multi-use paths, ramps,
and amphitheater in
Sioux Falls Downtown
riverfront (Google Earth
Pro 2022)

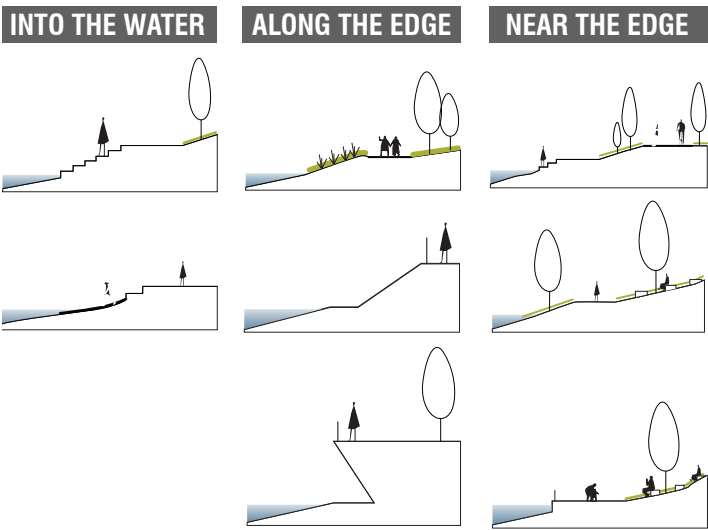


Figure 4.27
Access strategies of Sioux
Falls Downtown riverfront
(Huang 2022)

Size	3.4 acres
Designer	Confluence
Activities	• Visiting developed Site: Family/friends gathering, Picnicking, Camping • Viewing and photographing nature: Viewing/photographing nature scenery • Backcountry activities: Archery, Horseback riding, Jogging, Walking, Biking • Motorized activities: Motorboating • Fishing • Nonmotorized water activities: Floating • Urban recreation activity: Concert

Pavilion on the riverbank of Ljubljancia River

Ljubljana, Slovenia

The pavilion on the Petkovšek embankment is a spatial intervention installation, which was initially constructed in 2007 as a temporary public space and was reconstructed in 2014. The pavilion was designed to activate the amenities around the river, which is physically and programmatically separate from the city ground floor, as well as investigate visitors' reactions through concrete examples. The re-assessment led to the installation being very popular among patients and visitors to the nearby hospital, which lacked any riverside lounges for relaxing. The pavilion was built in accordance with the site's terrain, employing a montage construction strategy, characterized by six steel curve beams made up of several specific elements - the bench, the fence, the platform, and the roof (BB ARHITEKTI. n.d.). This installation provides people with a gathering space with a river view while breaking the wall between river and city.

ALONG THE EDGE

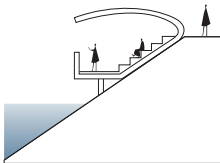


Figure 4.28
Access strategy on
Ljubljancia Riverbank
(Huang 2022)

For more information, visit <https://rb.gy/lserln>

Size	0.025 Acres
Designer	Confluence BB ARHITEKTI
Activities	- Visiting developed Site: Family/friends gathering - Viewing and photographing nature: Viewing/photographing nature scenery

ACCESS

By collecting and analyzing the precedents, 68 access design strategies were identified and categorized into 12 design types and three main access strategies. The three main access strategies are access along the edge, access near the edge, and access into the water. There are 12 types of access design, including trail, overlook, platform, open lawn, pedestrian bridge, amphitheater, plaza, stairs, ramps, decks, steppingstones, and sittings. As a result, 27 access designs (7 types) offer access along the edge, 25 designs (8 types) provide access near the edge, and 16 designs (6 types) allow access into the water (Figure 4.30).



Figure 4.29
Categorization and
summary of access
strategies (Huang 2022)

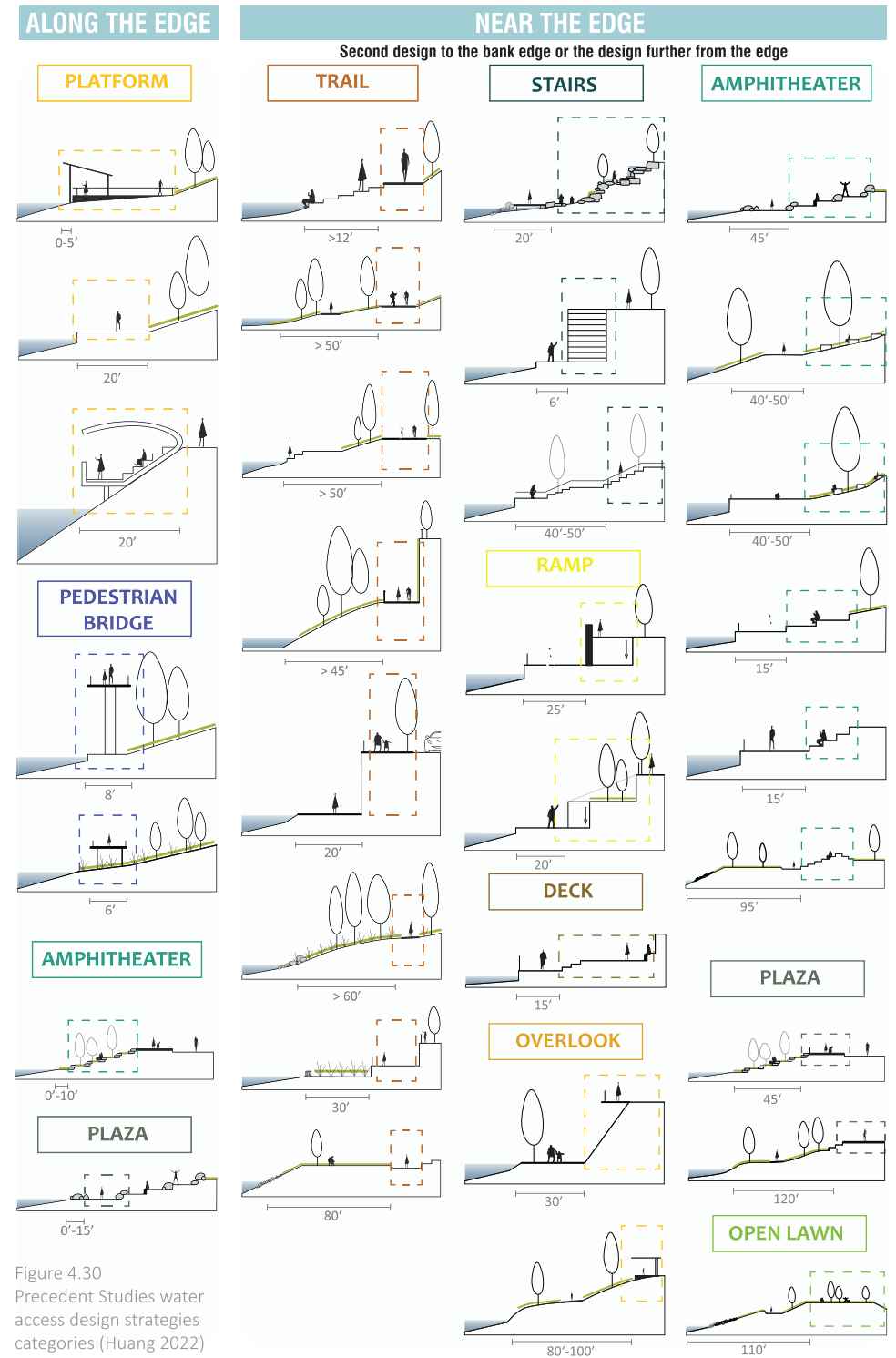
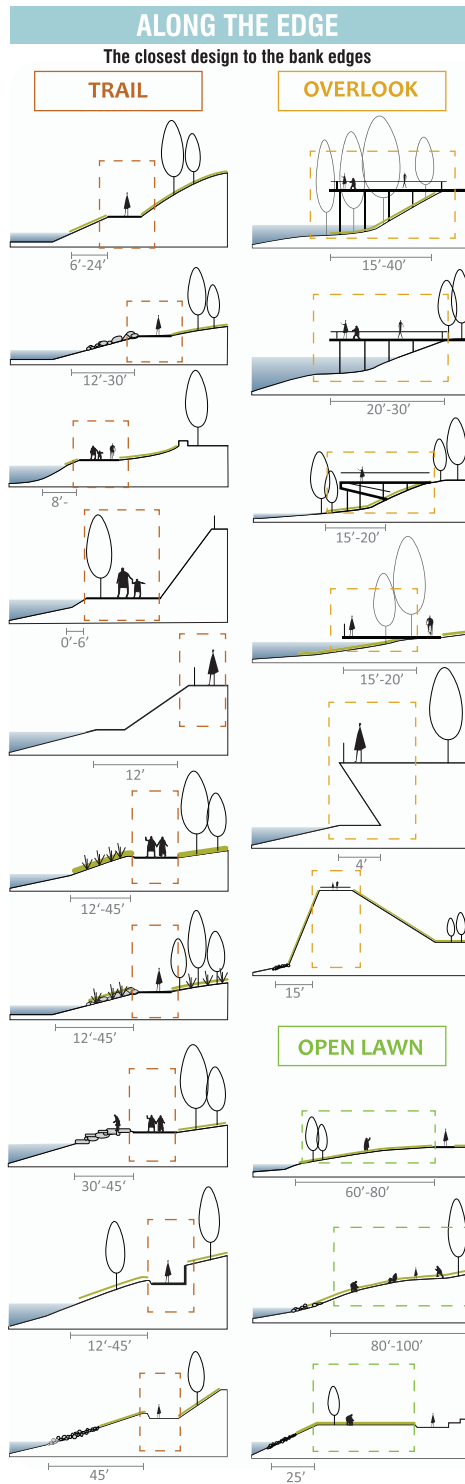
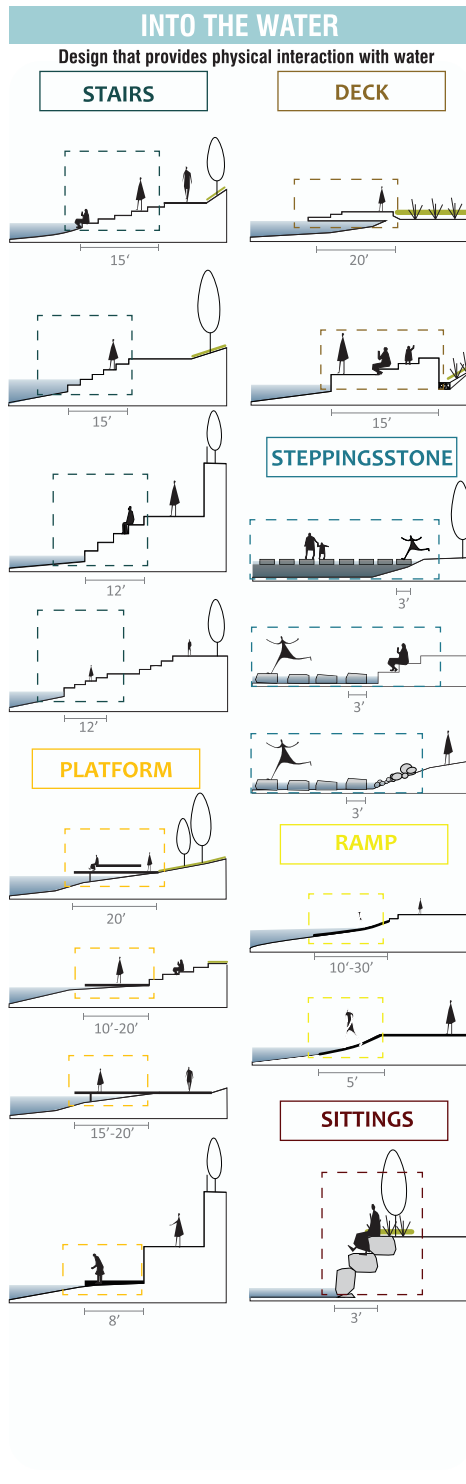


Figure 4.30
Precedent Studies water
access design strategies
categories (Huang 2022)

ACTIVITIES

In order to understand what activities could apply to creekfront space, the activities in each precedent were categorized based on the types of outdoor recreation activities identified by the outdoor recreation activity prediction model developed for the 2010 Resources Planning Act (RPA). Combining the prediction model and 12 precedent waterfront projects, 24 outdoor recreation activities were identified and categorized into eight activity types.

Among the 12 selected precedent projects, Viewing/photographing nature scenery was the most adopted activity. Backcountry activities were the most popular type of activity, with three activities applied in 11 precedent projects.

The recreation activity types are applied the most in the 12 selected projects are Viewing and photographing nature, especially Jogging/running, Hiking/walking, and Biking. 11 out of 12 precedent projects had all three activities. Another activity adopted by 11 precedent projects is Family/friends Gathering which belongs to Visiting developed Site activity type (Figure 4.31).

Additionally, the findings of the precedent studies were gathered and analyzed to summarize 19 human activity-related program locations. In applying these program locations, the site will be able to engage in interrelated activities. Figure 4.32 depicts the relationship between 17 activity locations and 24 activities taken from the precedents. These human activity-related program locations were as follows:

Activity locations

- Pedestrian trails
- Biking trails
- Pedestrian bridge
- Multi-use path
- Platform
- Children playground
- Pool
- Stream
- Amphitheater
- Open lawn
- Deck
- Sport field
- Gathering garden
- Plaza
- Sitings
- Overlook
- Stairs
- Steppingstones
- Ramp

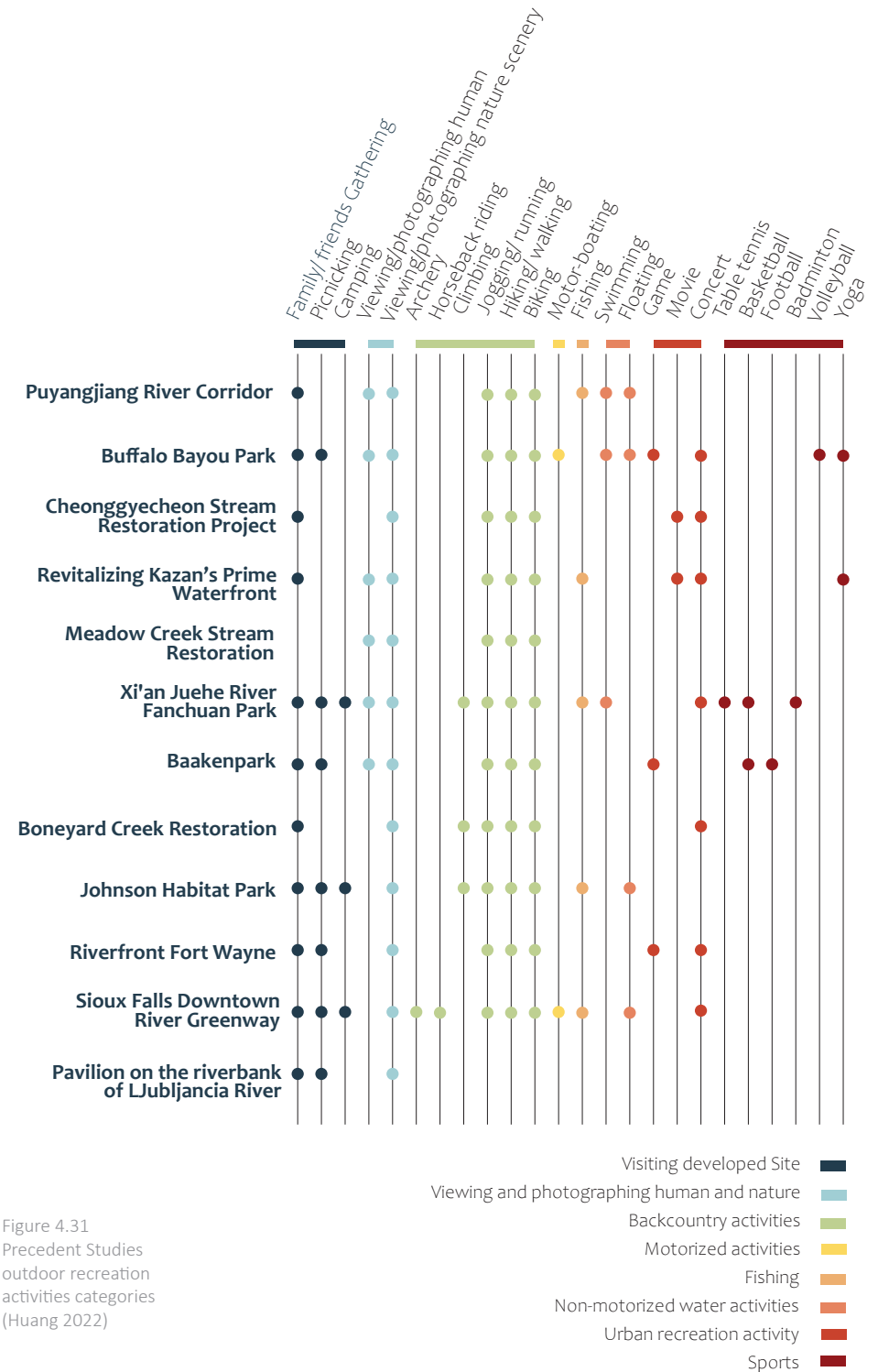


Figure 4.31
Precedent Studies
outdoor recreation
activities categories
(Huang 2022)

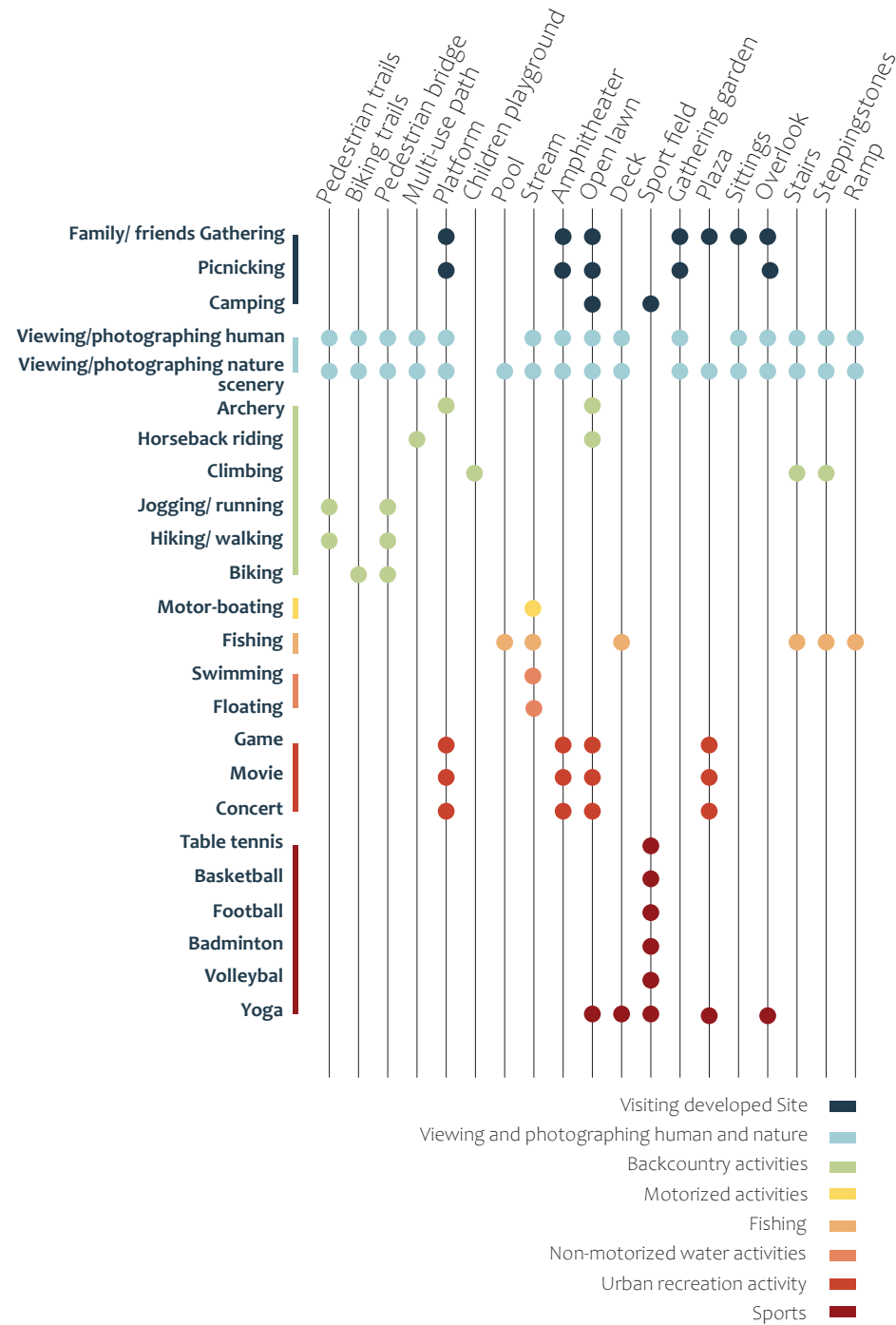


Figure 4.32
The relationship between outdoor recreational activity and applicable locations from precedent studies (Huang 2022)

IMPLEMENTATION

As a result of analyzing precedents, 9 implementation strategies that could be applied to creekfront design were identified, which are categorized into 6 primary categories as shown in Table 4.05. Moreover, 15 materials that can be utilized to construct creekfront spaces were identified. Although the geolocation of precedents is vastly different, the materials used for waterfront spaces remain similar. Geolocation differences in precedents led to variations in subcategory types of material. As an example, the precedent in Sioux Falls, SD and the precedent in Denver, CO both utilized stone material, but they both selected their local stone, such as Sioux quartzite. In most of the precedents, local materials are the primary choice. Further research revealed many more implementation strategies and materials possibilities, and Table 4.05 displays only findings from 12 precedents.

IMPLEMENTATION			
IMPLEMENTATION STRATEGIES	Vertical element setting location	Hardscape items such as retaining walls should be placed parallel to water flow.	
		Building walls to support bedrock elevations	
	Flooding resilience object material	Lighting poles near water could be constructed of concrete to better withstand flooding.	
	Footpath setting location	Footpaths set at a height of 12 feet allow visual access to water and eliminate silt collection after flooding.	
		A concrete walkway along the bank could be five feet wide	
	Bank protection materials and system	A vegetated soil lift with BioD-Block system all along the bank protects against flooding.	
MATERIALS	Bank width-depth ratio	Bank width-depth ratio ranges could be considered from 8.2 to 38.3.	
	Construction method	Montage construction is a method to implement structure along the bank that consists of a number of different materials and one main supporting beam or structural element.	
		Native Plants	Waterproof Wood
		Corten Steel	Stone
		Scrap Iron	Aluminum
		Bricks	Crusher Fines
		Permeable Concrete	Fiber Reinforce Plastic (FRP)
			Plastic
			Boulder
			Steel
			Bamboo
			Composite Materials

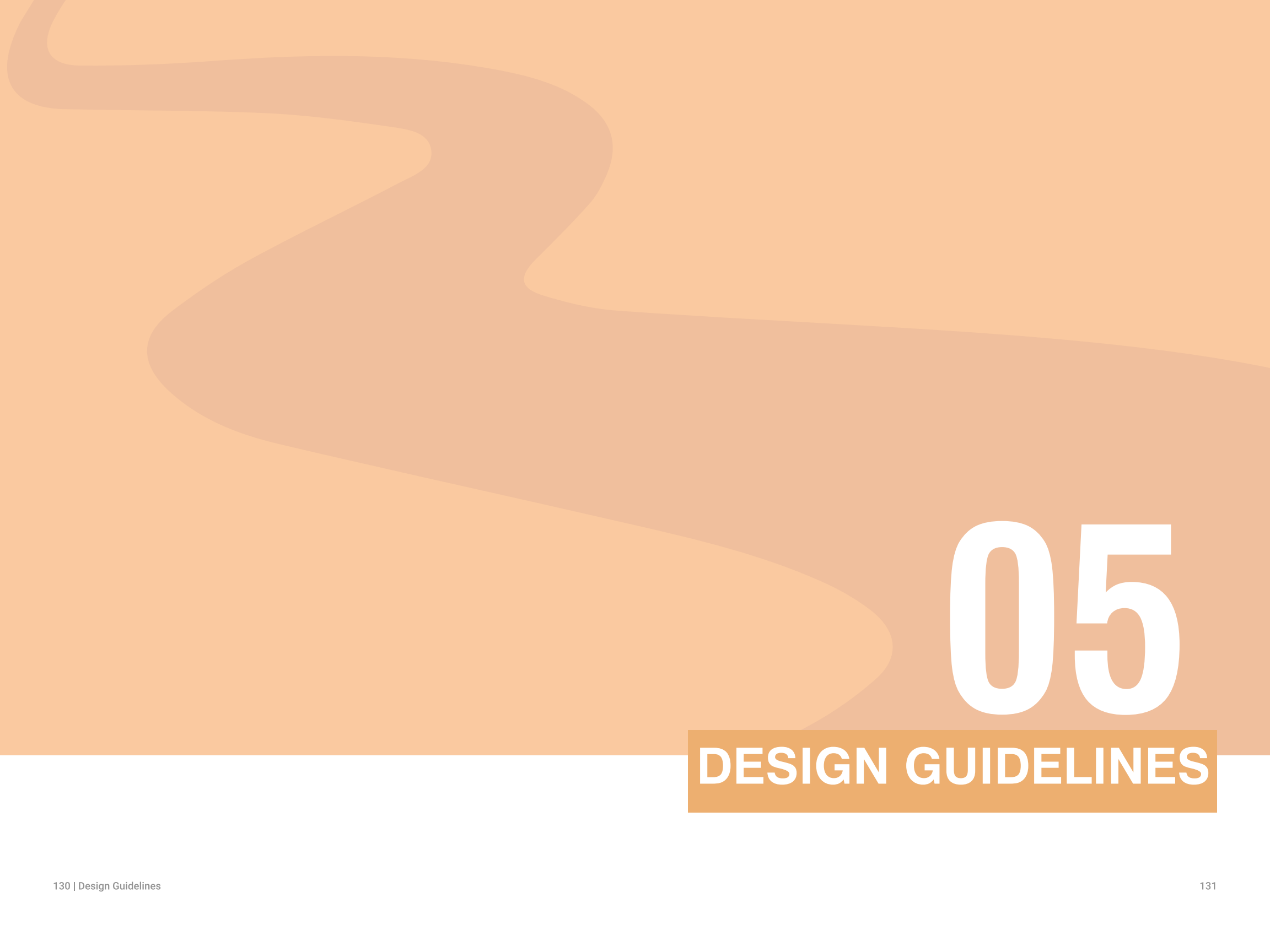
Table 4.05
Precedent studies implementation strategies categories (Huang 2022)

RESILIENCY

Through analyzing and comparing, 30 resilient strategies were withdrawn from the precedent studies and categorized into 9 primary strategies, including replacing, restoring, repairing, increasing, reducing, placing, installing, applying, and adding. These strategies would help inform the proposed design guidelines and the design for the projective design along Wildcat Creek.

Table 4.06
Precedent studies
resiliency strategies
categories (Huang 2022)

RESILIENCY STRATGIES	
Replacing	- Replacing the concrete of the bank with native vegetation transforms them into flood-adaptive Green Sponges. - Replacing some mowed turf with a naturalized meadow to stabilize the landscape - Replacing invasive species with local species to stabilize the bank
Restoring	- Restoring natural vegetation on banks to capture and divert surface flows and build biologically active areas. - Restoring connectivity between waterways
Repairing	Repairing the streamline to enhance the biodiversity of animals and plants
Increasing	- Increasing the sinuosity of the stream channel by utilize channel stabilization techniques to make it more flood resistant. - Diversifying elevation of slopes provide a variety of experiences and provide flood resistance
Reducing	- Reducing the steep height of the banks to reconnect the stream with its floodplain. - Reducing the bank slope to make the bank more resilient.
Placing	- Placing silt benches on the inner bends of the channel geometry to allow the silt to collect naturally in low-flow areas, making maintenance easier - Placing site furnishings, plants, and walkways in strategic locations to withstand the natural flooding - Placing the high-water switches allowing cut off the power during floods - Placing green space lower than the road to collect road water effectively - Placing hardscape items such as retaining walls parallel to the flow of water in order to prevent turbulence, debris impact, and silt deposition.
Installing	- Installing coir lifts and live staking at selected locations to prevent erosion and slope failure. - Installing gabion on the bank to withstand flooding and erosion. - Installing concrete light poles to resist the impacts of floating debris - Installing engineered soils with fiber turf as reinforcement under lawn areas to stabilize the soil, improve weight distribution, avoid compaction.
Applying	- Applying wide stone promenades along the linear edge to respond to flooding - Applying a rainwater collection ditch on the road and use it for landscape irrigation - Applying a hydrodynamic profile on the concrete columns on pedestrian and bike bridges can minimize turbulence of water during flood events. - Applying pools and riffles in meanders to aerate and slow the stream flow - Applying bio-retention swales and basins to enhance water quality
Adding	- Adding terraced vertical walls to provide visitor's access - Adding considerable amounts of new vegetation to improve streambank stability, restore native forest habitats, and filter runoff. - Adding maintenance routes to enable silt removal equipment - Adding a weir to create a lake - Adding rain gardens and bioswales adjacent to constructed areas - Adding plants to soften walls that were necessary to construct sloped walkways



05

DESIGN GUIDELINES

DESIGN GUIDELINES

This chapter presents the creekfront activation design guidelines, including the operation process, design suggestions, and design strategies. The creekfront activation guidelines are exemplified in Chapter 6 of the projective design for the creekfront in two locations along the Wildcat Creek in Manhattan, Kansas: Anneberg Park and Wildcat Park.

PURPOSE

As smaller watershed features, creeks are far more abundant, but are largely underused and ignored (Marsh 2010). Their position crosses developed and untouched areas, remaining so common they are often overlooked, with only occasional flooding revealing their presence. Since creeks are often sinuous, more likely to flood, overgrown with vegetation, and have steep embankments, physical access to them is generally limited. Thus, creeks are often hidden from public view and underutilized community assets. With development strategies, creekfront areas can be activated to bring benefit to local economies, ecology, and residents (Otto et al. 2004). With its associated natural resources, creek frontage can provide a natural playground for a variety of nature-based recreational activities and educational programs (Cordell 2008). The creekfront activation design guide is intended as a resource for communities considering development along creekfronts. In developing the creekfront design guide, a step-by-step participatory process is to create site-specific activation design strategies and provide recommendations for their implementation.

WHAT IS THE CREEKFRONT ACTIVATION DESIGN GUIDE?

The Creekfront Activation Design Guide is a six-step design facilitation guide that teaches the community how to develop their own site-specific designs using proposed processes and design strategies. This guide provides a series of creekfront treatment recommendations based on the different site conditions and general instructions for implementation and maintenance. The sequence of actions outlined in the guide can be followed step-by-step to create a comprehensive creekfront development with access to the edge, near the edge, and into the water. For each treatment, there will be corresponding activities, locations, implementation strategies, and resiliency strategies. Users can develop appropriate design solutions according to their needs and site conditions by combining different position design strategies in a flexible manner.

WHO CAN USE THE CREEKFRONT ACTIVATION DESIGN GUIDE?

This guide is intended to be used by designers, private owners, organizations, and governments that own creekfront properties or wish to enhance the creekfront spaces by incorporating various designs that support nature-based activities. The Creekfront Design Guide does not require extensive design experience, as long as there is a creek and adjacent land along the creek.

WHY THE CREEKFRONT ACTIVATION DESIGN GUIDE?

The Creekfront Design Guide offers a process for creek frontage design with design solutions and suggestions. The guide may also provide inspiration for other creekfront design initiatives. There are a few situations where the Creekfront Design Guide could help, including:

- An existing creekfront space with no physical and visual access
- An existing creekfront area is bordered by vegetation and underused.
- An existing creek edge that is not accessible and with a steep slope
- An existing creekfront area lacks activity opportunities
- A creekfront park with low usage that wants to attract more visitors
- A private landowner wishes to utilize creekfront areas more and add more activity space

HOW TO USE THIS GUIDE?

The Creekfront Design Guide consists of six steps: (1) Analyze the site, (2) Identify suitable design type, (3) Choose the design treatment, (4) Arrange the design treatment, (5) Construct the design, and (6) Maintain the design. Each step is one section. Follow this guide step-by-step just as following a recipe to cook a dish, adding ingredients according to preference taste, combining them, and ultimately creating meal (see Figure 5.01).

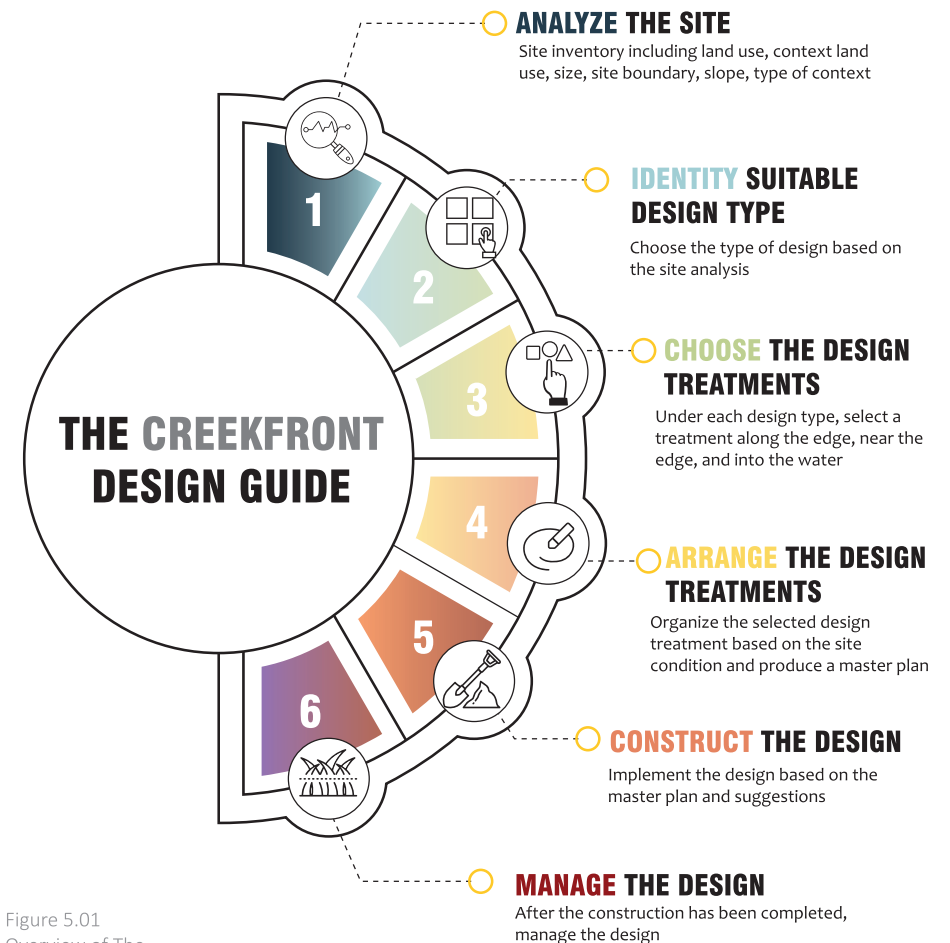
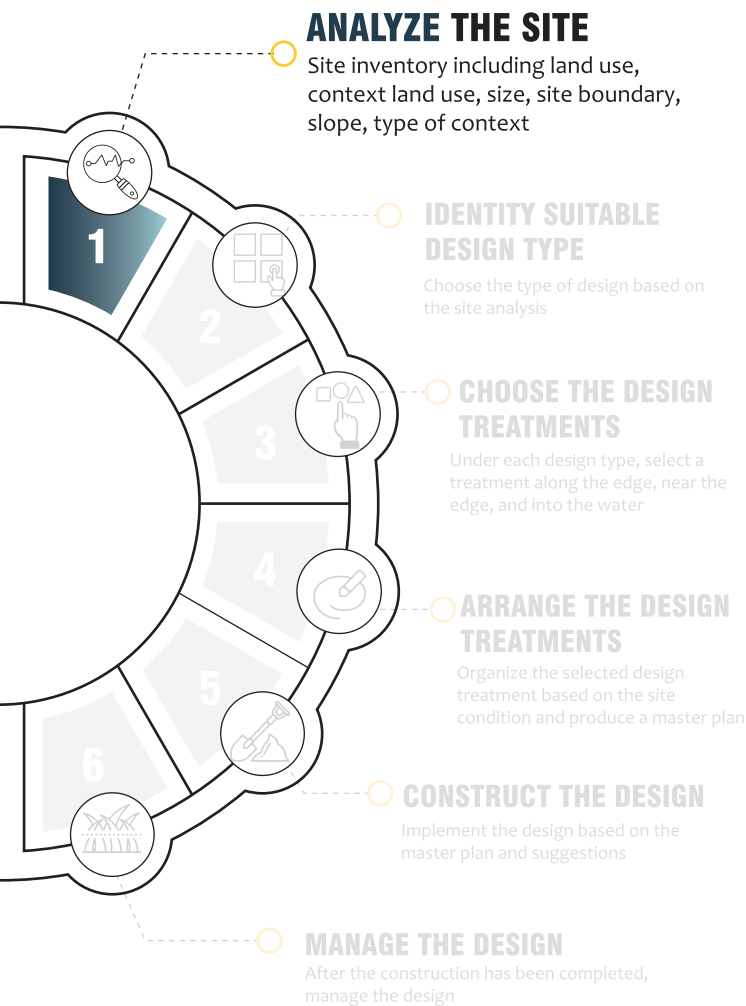


Figure 5.01
Overview of The
Creekfront Design Guide
(Huang 2022)



01. Analyze the site

To begin renovating or improving a creekfront space, the Creekfront Design Guide recommends first understanding and analyzing the creekfront space. There are ten aspects of the site that need to be identified: site location, dimensions, land use, context, existing creek access, activities, circulations, topography, ecological issues, and landscaping. The site inventory guide form (Table 5.01) serves as a guide and checklist for the evaluation of the existing conditions of the creekfront site in order to create a better understanding of the site and to prepare for the next step of identifying appropriate design types. The section also provides basic information to fill out the inventory table.

Site Dimensions

Site dimensions refer to the size and area of the creekfront development project. The site should be measured from the middle of the creek or over the creek to the farthest boundary of the site within which development is permitted. For measuring the area or distance, use the area measure tool in Google Earth (<http://earth.google.com>).

Site Context

Site context is referred to as properties found around the project site, including adjacent and nearby areas. To analyze surrounding areas, observe their development degree, materials, land use, buffer zone areas, and usage. An area with a high proportion of artificial materials such as bricks and concrete may be considered developed, or a place with fewer or no artificial materials and structures may be considered undeveloped. A buffer zone is an area where environmental improvement or protection can take place. Usually, measure from the creek's edge to the nearest buildings or densely populated areas. In terms of usage rate, if the project site is a public space, it refers to the number of people who use it, and if it is a private space, it refers to the frequency of use.

Figure 5.02
An overview of The
Creekfront Design
Guide with a focus on
step one (Huang 2022)

Existing Creek Access

The creek access refers to both physical and visual opportunities for people to interact with the creek. These may occur along the creek edge, near the creek edge, or within the creek.

Activities

For activities, identify what activities are now available on the project site. The following common creekfront activities list provides some ideas and examples.

Visiting developed site

- Family/friends gatherings
- Picnicking
- Camping

Viewing and photographing human and nature

- View/photographing human
- View/photographing nature scenery

Backcountry activities

- Horseback riding
- Climbing
- Jogging/ running
- Hiking/ walking
- Biking

Sports

- Table tennis
- Basketball
- Badminton
- Volleyball
- Yoga

Non-motorized water activities

- Swimming
- Floating

Motorized activities

- Motor-boating

Urban recreation activities Fishing

- Game
- Movie
- Concert

Other

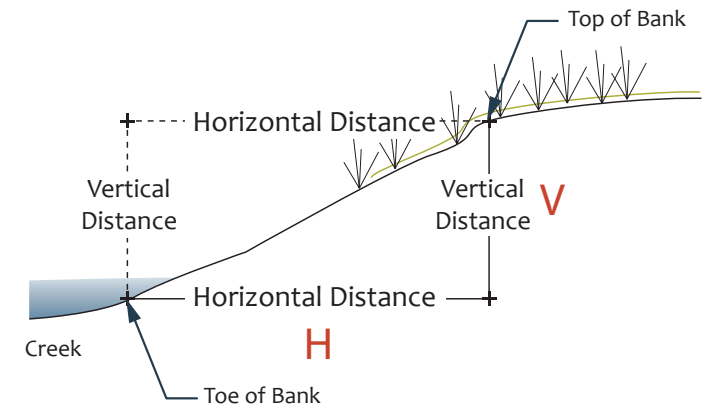
Circulation Routes

It is necessary to identify the existing circulation on site. By using Google Earth, locate a plan view of the site and determine pedestrian circulation patterns. Circulation types will vary depending upon its use and material, such as pedestrian walkways, biking paths, jogging paths, hiking paths, multi-use paths, boardwalks, concrete paths, etc.

Topography

An easy way to understand topography is to consider it as a profile and shape of the land surface. It may be too complicated for people without an architecture or landscape architecture design background to prepare a topography map, but it is relatively easy to determine the slope of the creekbank. A slope is a measure of the steepness of the ground. It is usually expressed in percentages. A slope of 0% indicates that the terrain is flat, a slope of 0-10% indicates that it is sloping, a slope of 10-30% indicates that the terrain is steep, and a slope of over 30% indicates that the terrain is very steep. To calculate the slope percentage of a slope, measure the distance vertically (height) from the top of the slope to the bottom and the horizontal distance from the toe of the slope to the parallel spot of bank top (see Figure 5.03). Measure distances can be conducted on site or by using Google Earth Pro.

Figure 5.03
Calculation and
measurement of bank
slopes (Huang 2022)



$$\text{Slope Percent} = (\text{Vertical Distance} / \text{Horizontal Distance}) \times 100\%$$

$$\text{Slope Percent} = (V+H) \times 100\%$$

Ecological Issues

The most common ecological issues associated with creeks are erosion, sedimentation, flooding, poor water quality, and simple habitat. Depending on the situation, there may be some treatments on site that will address these issues, such as flood walls, rip rap, and retentions. Considering the current ecological issues and their corresponding treatments is of particular importance as they have a great impact on the creekfront design.

Landscaping

It is also important to become familiar with the plants on site. Study the site plants by counting the tree species on site, as well as checking if there are any plants growing along the creek bank. Phone app such as “Picture this” can be used to identify the plant species on site. Identifying invasive landscape species is intended to inform where vegetation will be removed when designing and implementing the project. Removing invasive species accurately contributes to sustainability of the site and reduces damage to well-developed existing habitats.

Potential Connections

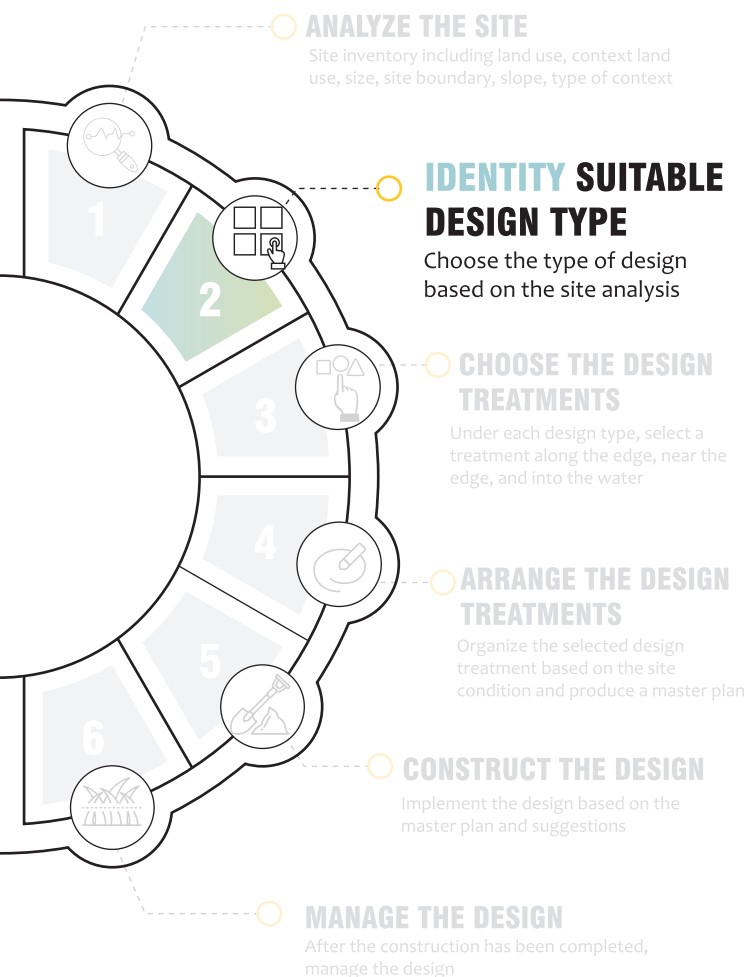
While setting up a boundary around the site, be aware that the site does not exist on its own. Its development is integrally related to the nearby development, especially when the site is located adjacent to a creek. Therefore, analyzing existing, under-construction, or planned connection opportunities around the site is also part of the site analysis. While connections need not be built immediately, reserve the locations for the future connection when arranging the selective designs. For example, if there is a pedestrian trail along the creekfront near the site, plan how to connect to it or reserve a place for future connections.



Table 5.01
Site inventory guide form
(Huang 2022)

SITE INVENTORY

Site Location (Boundaries)		
Site Dimensions (Size)		
Site Context ***		
Development Degree	☐ Developed	☐ Undeveloped
Materials	☐ Largely Paved	☐ Largely Vegetated
Land Use	☐ Residential / Playground	☐ Nature park
	☐ Street/Business Area	☐ Farmland ☐ Other
Buffer Zone	☐ Fewer buffer zones	☐ Plenty buffer zones
Usage	☐ High Usage	☐ Low Usage
Existing Creek Access***		
Physical access	☐ Along the edge	☐ Near the edge
	☐ Into the water	☐ No
Visual access	☐ Yes (Where)	☐ No
Activities***		
Circulation Routes		
Types	☐ Yes (Type: i.e. walkways) ☐ No	
Locations	☐ Prepare a map/plan	
Topography		
Site Topography	☐ Topography Map (for designer)	
Bank Slope	☐ General Sloping	☐ Steep ☐ Very Steep
	☐ Flat	
Ecological Issues *		
Types	☐ Yes (Erosion, Sedimentation, Poor water quality, Flooding, simple habitats, other)	
	☐ No	
Treatments (if any)		
Creekside Vegetation		
Plants Species (Using APP for help)	☐ Dominant Species ()	
	☐ Invasive Species (where)	
Potential Connections		
Existing & Future Surrounding elements	☐ Trails ☐ Parks ☐ Schools ☐ Zoo ☐ Plaza/Squares	
	☐ Public Transportations ☐ Communities	



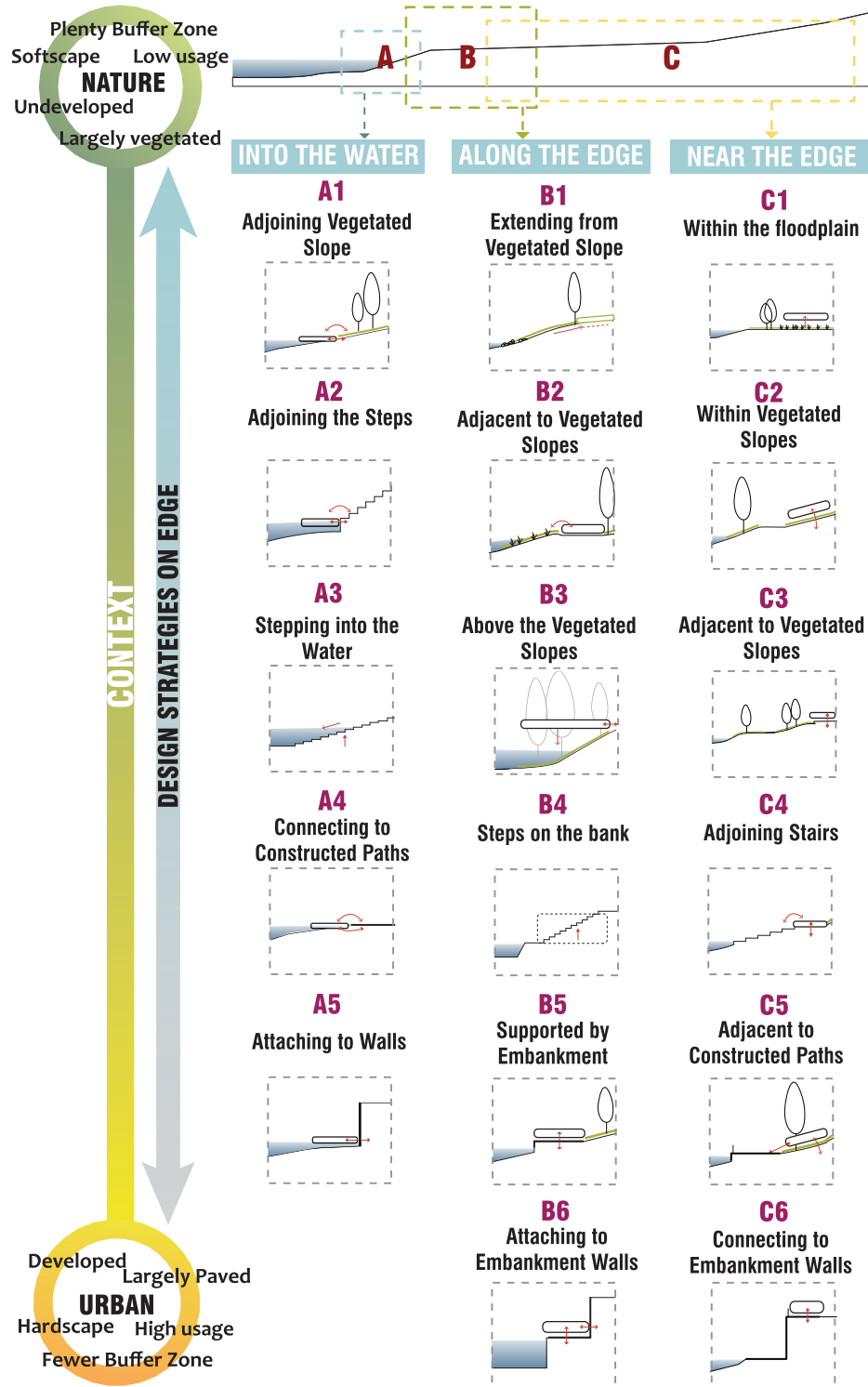
02. Identity suitable design type

Following completion of the previous step, a better understanding of the creekfront property is documented. Now identify the design types that will work best for the site. This section allows selection of the design types from Figure 5.05 based upon the characteristics of the site context gathered in the previous step.

A total of 17 design types is illustrated in Figure 5.05, which can be applied to three creekfront areas. The design types are arranged from left to right according to available locations, and the further to the left, the closer to the creek. According to the degree of hardscape participation, the design types are also arranged from top to bottom, and the further down the part, the more hardscape is involved and the more suited the site to the urban context. Select design types based on the keywords associated with the site context. When choosing design types, choose whichever side includes more context keywords. If context keywords appear half-way on either side, select the design types in the middle.

Moreover, this section provides catalogs (Figure 5.06 to Figure 5.08) of design treatments which are organized by design type. This can serve as a guide to help find design treatments in the next section. Within the following section, more information regarding each design treatment will facilitate choosing designs that suits the site and designer preferences.

◀
Figure 5.04
An overview of The
Creekfront Design Guide
with a focus on step two
(Huang 2022)



A CATALOGUE OF DESIGN TREATMENTS IN SECTION 3

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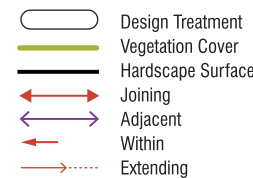
INTO THE WATER

Design that provides physical interaction with water

Design Type Code & Name	Design type diagram	Design treatments	Page
A1 Adjoining Vegetated Slope		A1.1 Open Platform A1.2 Groynes A1.3 Stepping Stones	152
A2 Adjoining the Steps		A2.1 Open Platform A2.2 Stepping Stones A2.3 Hardscape Ramp	152
A3 Stepping into the Water		A3.1 Settable Steps A3.2 Long Steps A3.3 Terraced Steps	153
A4 Connecting to Constructed Paths		A4.1 Hardscape Ramp A4.2 Open Platform A4.3 Terraced stone Sitting A4.4 Deck	154
A5 Attaching to Walls		A5.1 Open Platform A5.2 Floating Jetties A5.3 Vegetated ramp	155

Figure 5.05
Catalog of creekfront
design types arranged by
site context (Huang 2022)

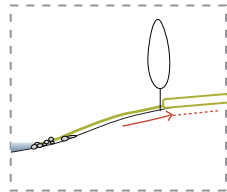
Figure 5.06
Catalog of creekfront
design types for access to
water (Huang 2022)



ALONG THE EDGE

The closest design to the bank edges

B



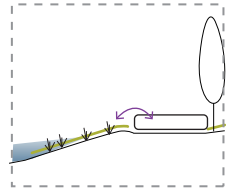
B1

Extending from Vegetated Slope

- B1.1 Open Sloped Lawn
- B1.2 Open Flat Lawn

Page

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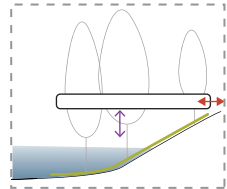
B2

Adjacent to Vegetated Slopes

- B2.1 Pedestrian Trail and mowed grass slope
- B2.2 Pedestrian Trail and natural vegetation slope
- B2.3 Pedestrian Bridge
- B2.4 Overlook
- B2.5 Dike Path

Page

157



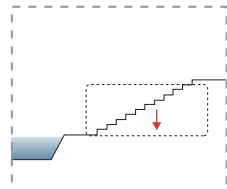
B3

Above the Vegetated Slopes

- B3.1 Overlook
- B3.2 Fenced Platform

Page

158



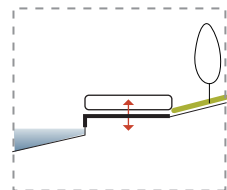
B4

Steps on the bank

- B4.1 Stairs
- B4.2 Terraces
- B4.3 Amphitheater

Page

159



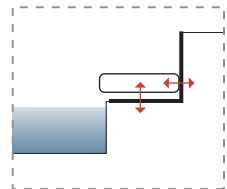
B5

Supported by Embankment

- B5.1 Promenades
- B5.2 Pedestrian Bridge
- B5.3 Platform
- B5.4 Plaza

Page

160



B6

Attaching to Embankment Walls

- B6.1 Trails
- B6.2 Overlook
- B6.3 Pedestrian Bridge
- B6.4 Pavilion

Page

161

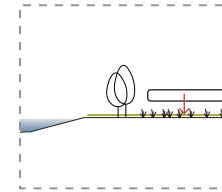
Figure 5.07
Catalog of creekfront
design types applicable
along the water's edge
(Huang 2022)

Figure 5.08
Catalog of creekfront
design types applicable
near the water's edge
(Huang 2022)

C

NEAR THE EDGE

Second design to the bank edge or the design further from the edge



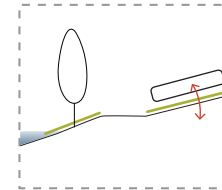
C1

Within the floodplain

- C1.1 Park
- C1.2 Event grounds
- C1.3 Trail

Page

163



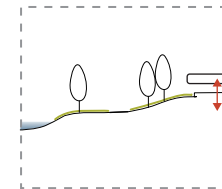
C2

Within Vegetated Slopes

- C2.1 Park
- C2.2 Amphitheater
- C2.3 Overlook

Page

163



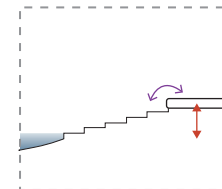
C3

Adjacent to Vegetated Slopes

- C3.1 Trail
- C3.2 Plaza
- C3.3 Amphitheater

Page

164



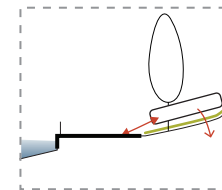
C4

Adjoining Stairs

- C4.1 Stairs
- C4.2 Plaza
- C4.3 Trail

Page

165



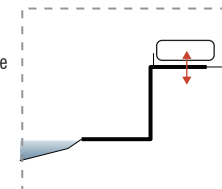
C5

Adjacent to Constructed Paths

- C5.1 Amphitheater
- C5.2 Deck
- C5.3 Flood Wall Sitting

Page

166



C6

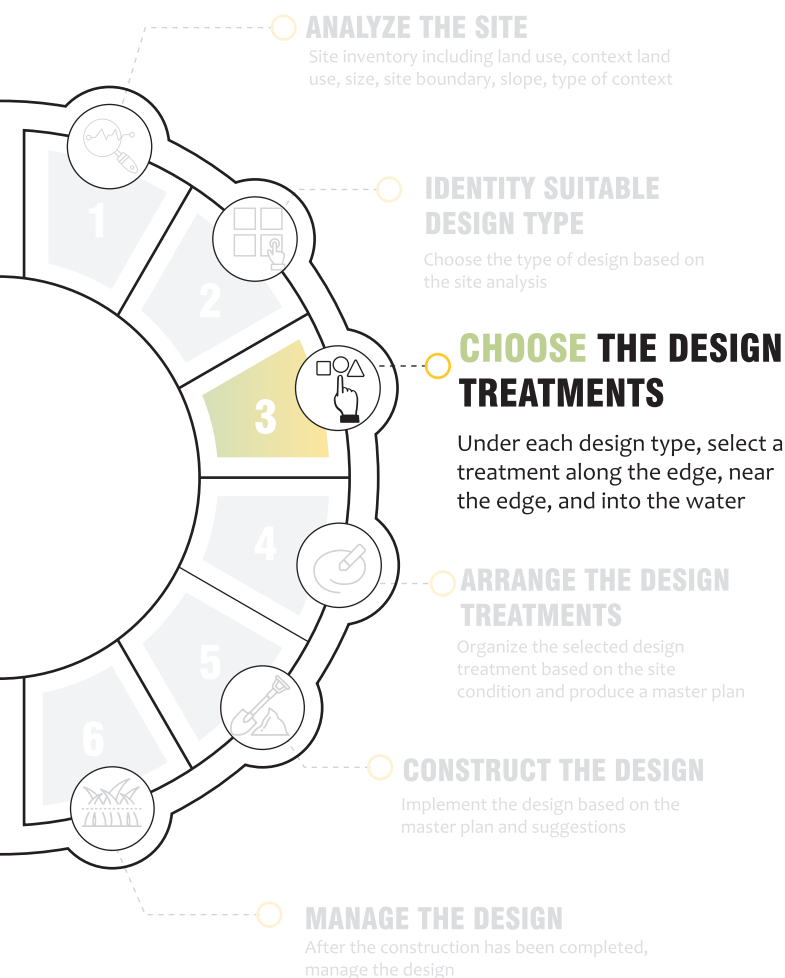
Connecting to Embankment Walls

- C6.1 Ramp
- C6.2 Stairs
- C6.3 Overlook
- C6.4 Trail

Page

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03. Choose the design treatments

In this section, a more comprehensive collection of design treatments is presented. This collection is arranged in the same manner as the catalogs in the previous section. Design treatments consist of an example section diagram, accompanying recreational activities and educational activities, relevant ecological strategies, recommended slope range for implementation, and suggested materials. Moreover, the homepage of each design location displays a diagram that summarizes the properties of all design types included in that collection. The property diagram provides an overview and comparison of each of the design types, and includes five amenities: playability, accessibility, sustainability, flood adaptability, and biodiversity.

After selecting the appropriate design types in the previous step, select one or more designs from each treatment type. Choose a design treatment based on what activities are desired. The treatments provide different types of activities, as well as their capability to resist flooding. After a thorough evaluation, pursue one or more treatments in different locations. A list of introductions to ecological strategies can be found in Chapter 4, Figure 4.06: Document analysis resiliency strategies and treatment categories on page 94. To learn more information about the educational activities, go to Figure 4.03: Document analysis nature-based activities categories on page 85.

◀
Figure 5.09
An overview of The
Creekfront Design Guide
with a focus on step three
(Huang 2022)

A

INTO THE WATER

Design that provides physical interaction with water

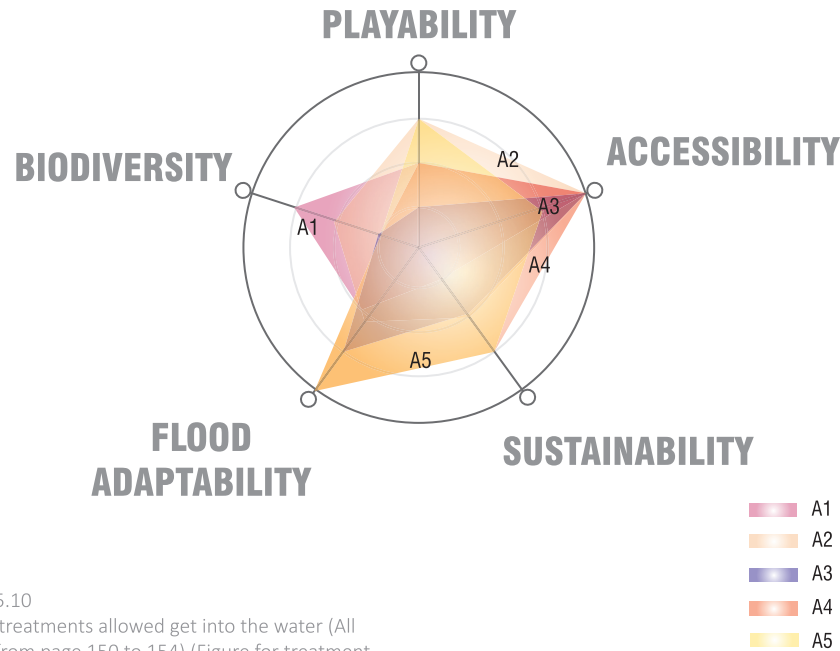
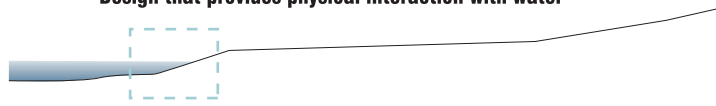
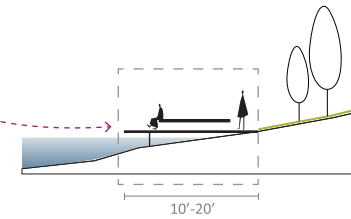
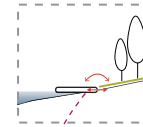


Figure 5.10
Design treatments allowed get into the water (All
Figure from page 150 to 154) (Figure for treatment
A2.2, A3.2, A5.3 originally generated by Prominski et
al. 2012 and regenerated by Huang 2022)

A1 Adjoining Vegetated Slope

A1.1 Open Platform

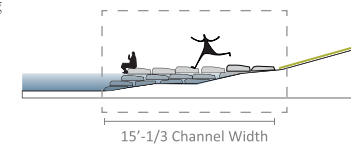


Activities Involved	G P V F L Y
Relevant Ecological Strategies	- Reprofiling the Bank - Living Plants
Slope	< 10%
Materials	- Wood - PVC

Recreational Activities

- G Family/ friend gatherings
- C Camping
- P Picnicking
- V Viewing and photographing human and nature
- W Walking
- J Jogging
- B Biking
- F Fishing
- L Canoe landing
- CO Concert
- CA Game
- Y Yoga
- S Sports

A1.2 Groynes

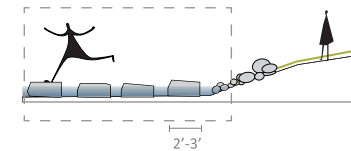


Activities Involved	G V F W
Relevant Ecological Strategies	- Reprofiling the Bank - Living Plants - Grassiness
Slope	< 10%
Materials	Stones

Educational Activities

- OA Observing aquatic wildlife and habitat
- OL Observing land wildlife and nature
- D Drawing
- G Game for learning
- M Measuring
- C Collecting

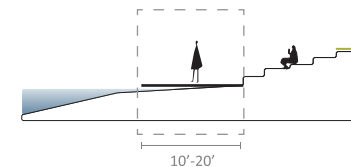
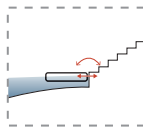
A1.3 Stepping Stones



Activities Involved	W V F
Relevant Ecological Strategies	- Reprofiling the Bank - Stone Toe Protection
Slope	< 5%
Materials	Stone

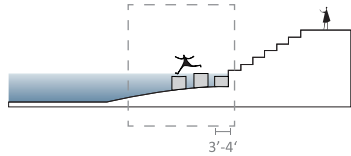
A2 Adjoining the Steps

A2.1 Open Platform



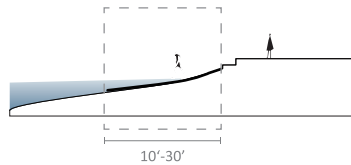
Activities Involved	G P V F L Y
Relevant Ecological Strategies	- Reprofiling the Bank - Terraced Revetment
Slope	< 5 %
Materials	- Wood - PVC - Concrete

A2.2 Stepping Stones



Activities Involved	V F OA
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment • Boulder
Slope	< 10%
Materials	• Stone

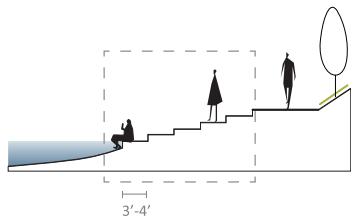
A2.3 Hardscape Ramp



Activities Involved	V F OA
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment
Slope	< 8%
Materials	• Concrete • Stone

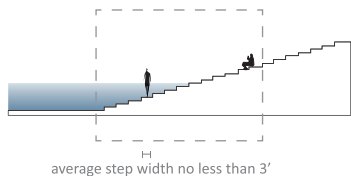
A3 Stepping into the Water

A3.1 Settable Steps

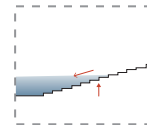


Activities Involved	G V F OA
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment
Slope	< 30%
Materials	• Concrete • Stone

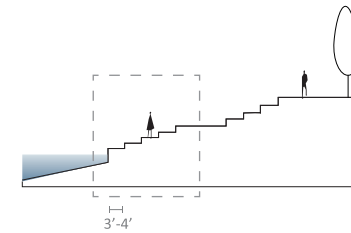
A3.2 Long Steps



Activities Involved	G V F OA
Relevant Ecological Strategies	• Reprofilling the Bank • Living Plants
Slope	< 30%
Materials	• Concrete • Stone



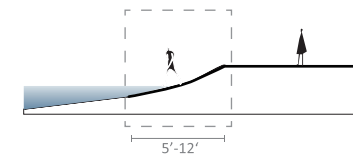
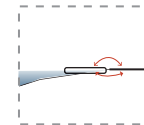
A3.3 Terraced Steps



Activities Involved	G V F OA
Relevant Ecological Strategies	• Reprofilling the Bank • Living Plants
Slope	< 30%
Materials	• Concrete • Stone

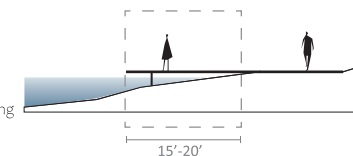
A4 Connecting to Constructed Paths

A4.1 Hardscape Ramp



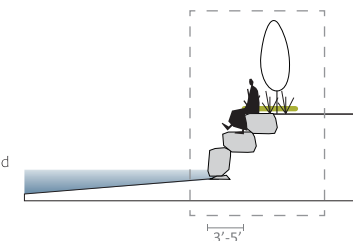
Activities Involved	G V F OA
Relevant Ecological Strategies	• Reprofilling the Bank
Slope	< 8%
Materials	• Concrete • Stone

A4.2 Open Platform



Activities Involved	G P V F L Y OA D
Relevant Ecological Strategies	• Stone Toe Protection
Slope	< 10%
Materials	• Concrete • Wood

A4.3 Terraced stone Sitting



Activities Involved	V F OA
Relevant Ecological Strategies	• Stacked Flat Rock • Terraced Revetment
Slope	< 50%
Materials	• Stone

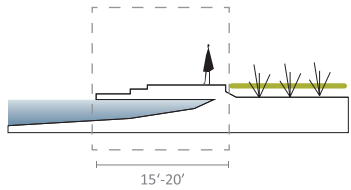
Recreational Activities

- G** Family/ friend gatherings
- C** Camping
- P** Picnicking
- V** Viewing and photographing human and nature
- W** Walking
- J** Jogging
- B** Biking
- F** Fishing
- L** Canoe landing
- CO** Concert
- CA** Game
- Y** Yoga
- S** Sports

Educational Activities

- OA** Observing aquatic wildlife and habitat
- OL** Observing land wildlife and nature
- D** Drawing
- G** Game for leaning
- M** Measuring
- C** Collecting

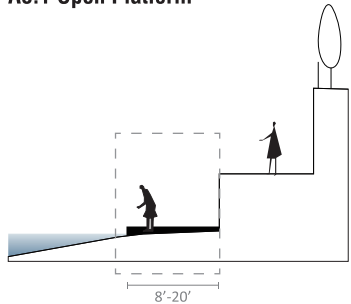
A4.4 Deck



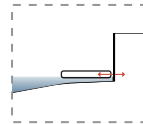
Activities Involved	G V F OA
Relevant Ecological Strategies	• Bioretention Basins • Boulder
Slope	< 5 %
Materials	• Wood • PVC

A5 Attaching to Walls

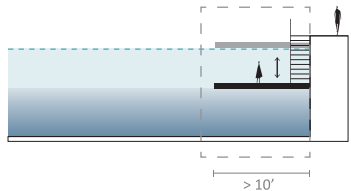
A5.1 Open Platform



Activities Involved	G P V F L OA D
Relevant Ecological Strategies	• Retaining Wall
Slope	> 25 %
Materials	• Concrete • Stone

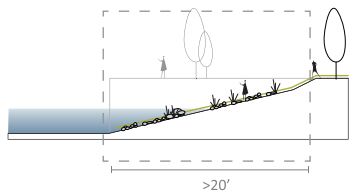


A5.2 Floating Jetties



Activities Involved	G V F OA
Relevant Ecological Strategies	• Retaining Wall • Terraced Revetment
Slope	> 25
Materials	• Wood • PVC

A5.3 Vegetated ramp



Activities Involved	G V F OA
Relevant Ecological Strategies	• Reprofiling the Bank • Retaining Wall • Living Plants
Slope	< 30 %
Materials	• Native Plants • Stone

Recreational Activities

- G** Family/ friend gatherings
- C** Camping
- P** Picnicking
- V** Viewing and photographing human and nature
- W** Walking
- J** Jogging
- B** Biking
- F** Fishing
- L** Canoe landing
- CO** Concert
- CA** Game
- Y** Yoga
- S** Sports

Educational Activities

- OA** Observing aquatic wildlife and habitat
- OL** Observing land wildlife and nature
- D** Drawing
- G** Game for learning
- M** Measuring
- C** Collecting

B

ALONG THE EDGE

The closest design to the bank edges

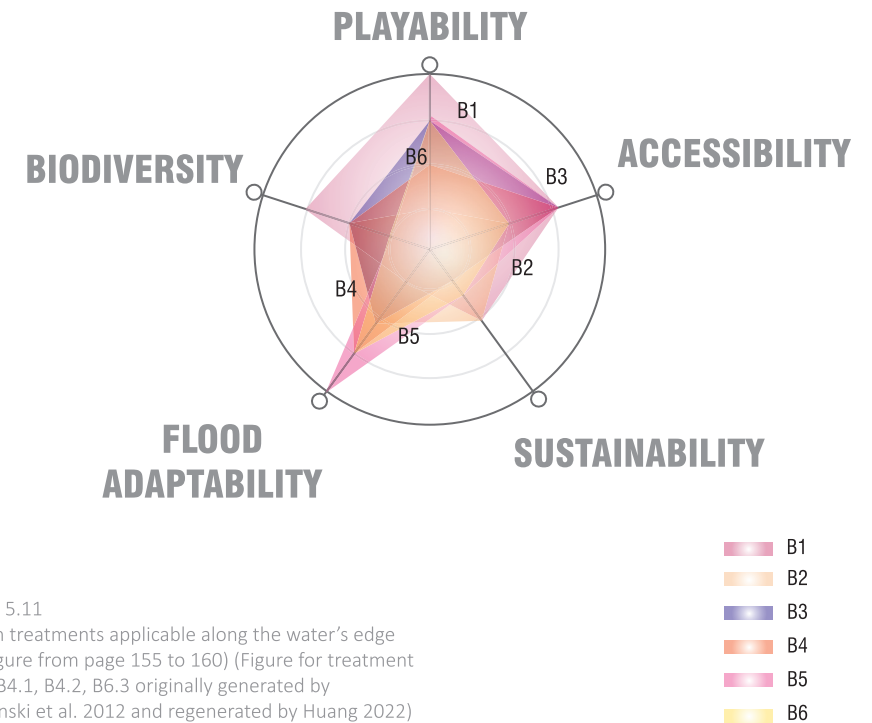
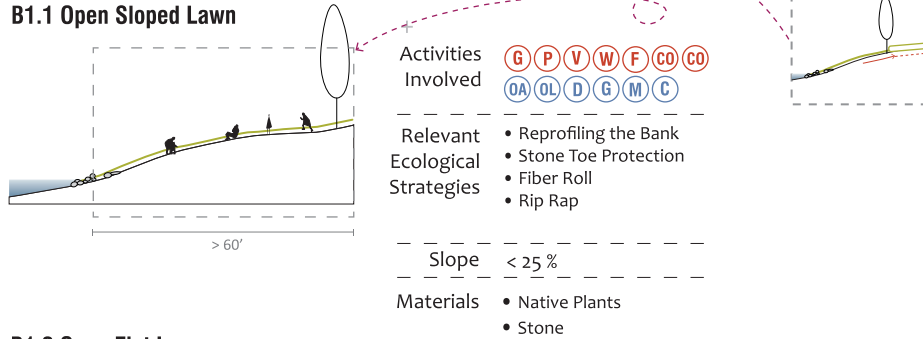


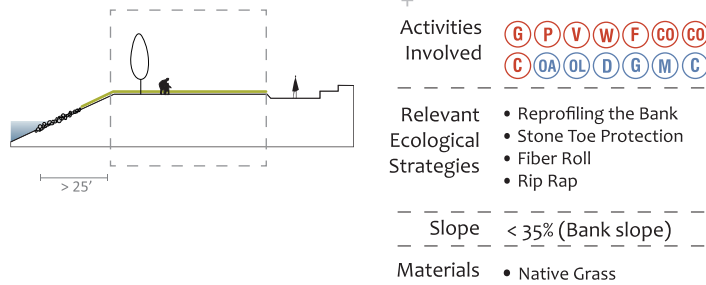
Figure 5.11
Design treatments applicable along the water's edge
(All Figure from page 155 to 160) (Figure for treatment B2.5, B4.1, B4.2, B6.3 originally generated by Prominski et al. 2012 and regenerated by Huang 2022)

B1 Extending from Vegetated Slope

B1.1 Open Sloped Lawn

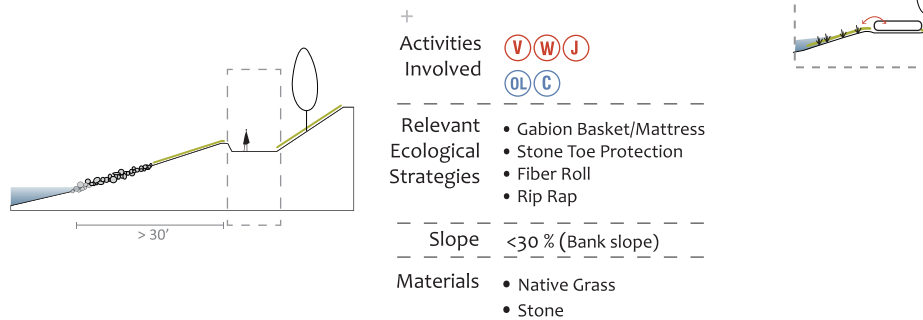


B1.2 Open Flat Lawn

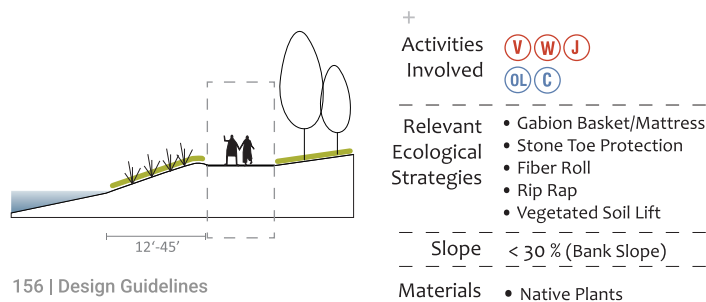


B2 Adjacent to Vegetated Slopes

B2.1 Pedestrian Trail and mowed grass slope



B2.2 Pedestrian Trail and natural vegetation slope



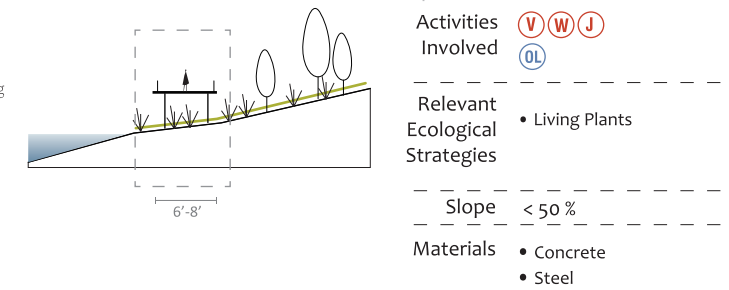
Recreational Activities

- G** Family/ friend gatherings
- C** Camping
- P** Picnicking
- V** Viewing and photographing human and nature
- W** Walking
- J** Jogging
- B** Biking
- F** Fishing
- L** Canoe landing
- CO** Concert
- CA** Game
- Y** Yoga
- S** Sports

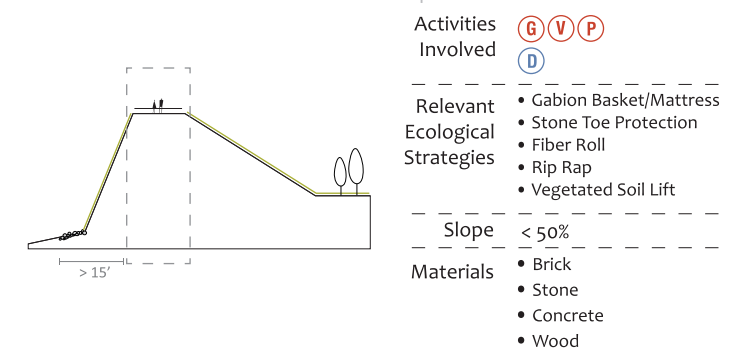
Educational Activities

- OA** Observing aquatic wildlife and habitat
- OL** Observing land wildlife and nature
- D** Drawing
- G** Game for learning
- M** Measuring
- C** Collecting

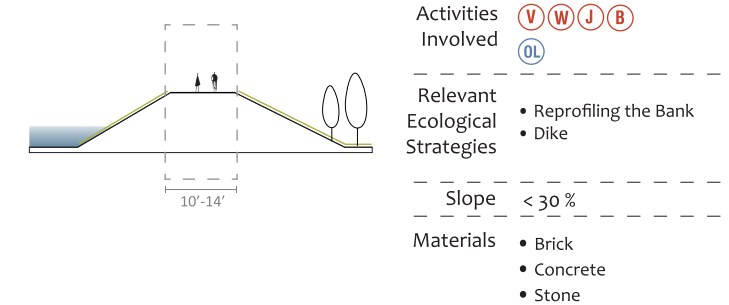
B2.3 Pedestrian Bridge



B2.4 Overlook

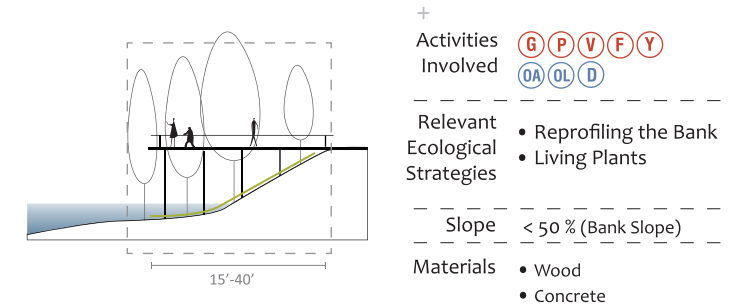


B2.5 Dike Path

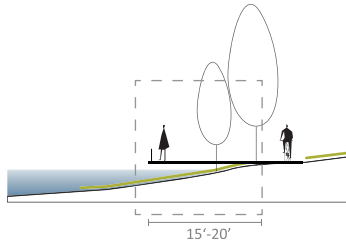


B3 Above the Vegetated Slopes

B3.1 Overlook



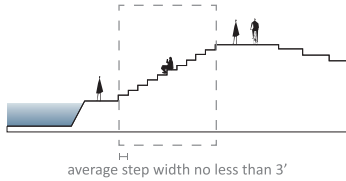
B3.2 Fenced Platform



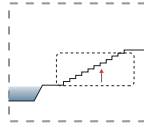
Activities Involved	G P V F OA D
Relevant Ecological Strategies	• Reprofilling the Bank • Boulder • Living Plants
Slope	< 10 %
Materials	• Wood • Concrete

B4 Steps on the bank

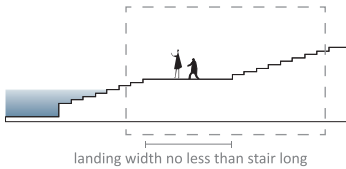
B4.1 Stairs



Activities Involved	G V W OA
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment
Slope	50~100 % (Stairs)
Materials	• Concrete • Stone • Wood

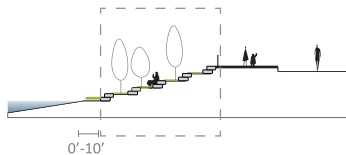


B4.2 Terraces



Activities Involved	G V W J OA
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment
Slope	50~100 % (Stairs)
Materials	• Concrete • Stone

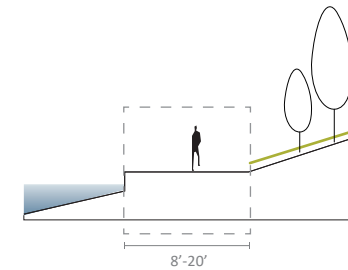
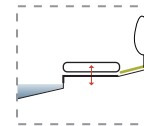
B4.3 Amphitheater



Activities Involved	G V F OA OL C
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment • Gabion Basket/Mattress
Slope	50~100 % (Stairs)
Materials	• Native Plants • Stone

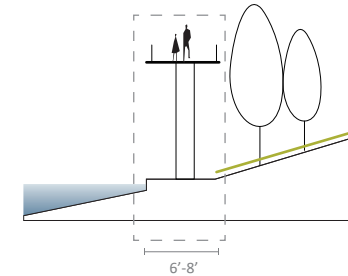
B5 Supported by Embankment

B5.1 Promenades



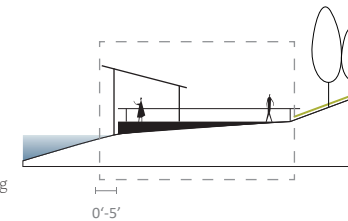
Activities Involved	V W B L J F OA
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	< 10 % (Bank slope)
Materials	• Concrete • Stone

B5.2 Pedestrian Bridge



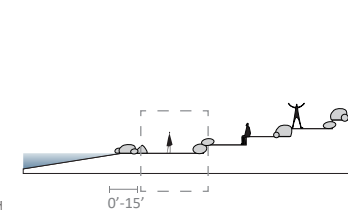
Activities Involved	V W OL
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	< 10 % (Bank slope)
Materials	• Concrete • Wood • Steel

B5.3 Platform



Activities Involved	G P V F W OA OL D
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	< 30 %
Materials	• Concrete • Steel • Wood

B5.4 Plaza



Activities Involved	G P V W CO CA Y OA D G M
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall • Boulder
Slope	< 5 %
Materials	• Concrete • Stone • Brick

Recreational Activities

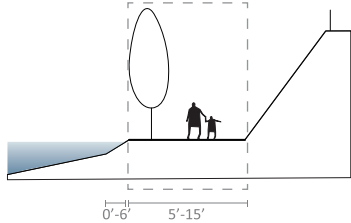
- G** Family/ friend gatherings
- C** Camping
- P** Picnicking
- V** Viewing and photographing human and nature
- W** Walking
- J** Jogging
- B** Biking
- F** Fishing
- L** Canoe landing
- CO** Concert
- CA** Game
- Y** Yoga
- S** Sports

Educational Activities

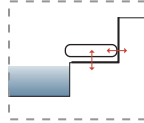
- OA** Observing aquatic wildlife and habitat
- OL** Observing land wildlife and nature
- D** Drawing
- G** Game for learning
- M** Measuring
- C** Collecting

B6 Attaching to Embankment Walls

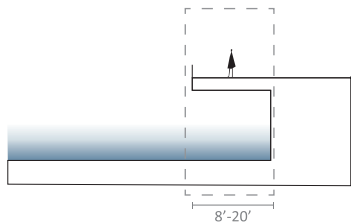
B6.1 Trails



Activities Involved	V W J B F OA
Relevant Ecological Strategies	- Reprofiling the Bank - Retaining Wall - Gabion Basket/Mattress
Slope	< 5 %
Materials	- Concrete - Stone

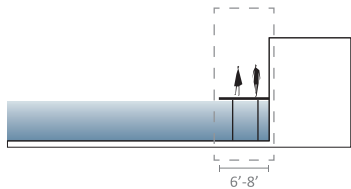


B6.2 Overlook



Activities Involved	V P W J B OA D
Relevant Ecological Strategies	Retaining Wall
Slope	< 5 %
Materials	- Concrete - Wood

B6.3 Pedestrian Bridge



Activities Involved	V W OA
Relevant Ecological Strategies	Retaining Wall
Slope	< 3 %
Materials	- Native Plants - Stone

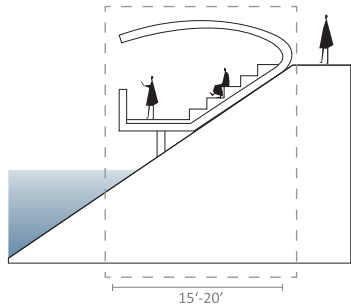
Recreational Activities

- (G) Family/ friend gatherings
- (C) Camping
- (P) Picnicking
- (V) Viewing and photographing human and nature
- (W) Walking
- (J) Jogging
- (B) Biking
- (F) Fishing
- (L) Canoe landing
- (CO) Concert
- (CA) Game
- (Y) Yoga
- (S) Sports

Educational Activities

- (OA) Observing aquatic wildlife and habitat
- (OL) Observing land wildlife and nature
- (D) Drawing
- (G) Game for learning
- (M) Measuring
- (C) Collecting

B6.4 Pavilion



Activities Involved	G P V OA D
Relevant Ecological Strategies	Retaining Wall
Slope	< 60 % (Bank Slope)
Materials	- Steel - Wood

C

NEAR THE EDGE

Second design to the bank edge or the design further from the edge

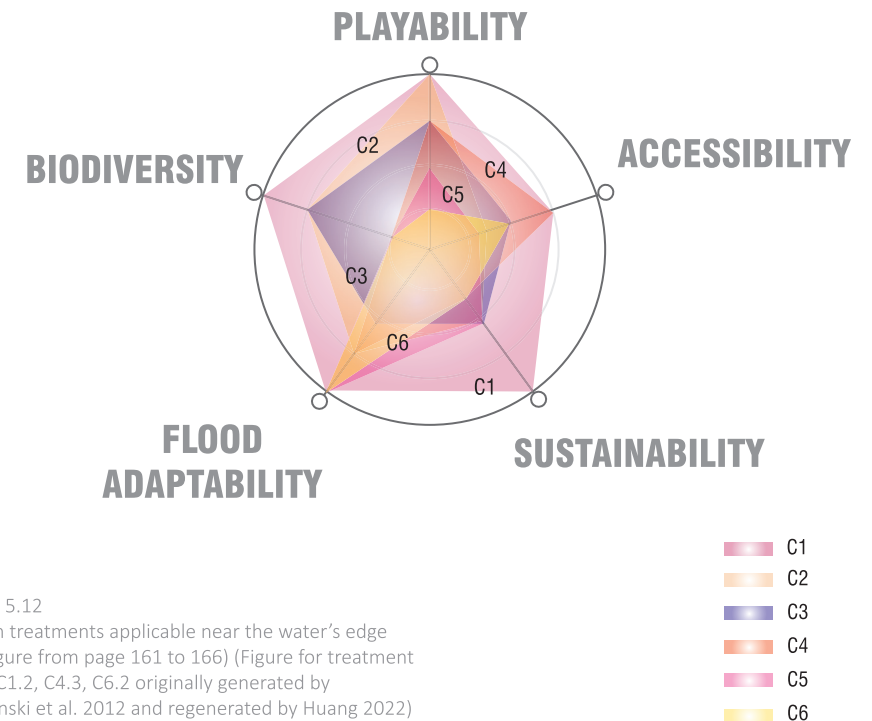
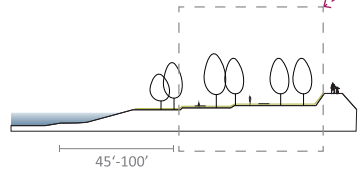


Figure 5.12

Design treatments applicable near the water's edge (All Figure from page 161 to 166) (Figure for treatment C1.1, C1.2, C4.3, C6.2 originally generated by Prominski et al. 2012 and regenerated by Huang 2022)

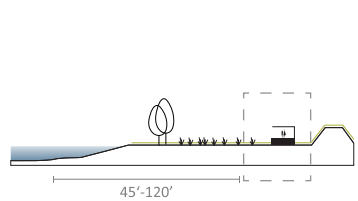
C1 Within the floodplain

C1.1 Park



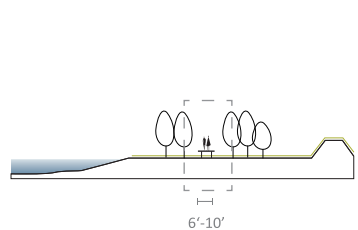
Activities Involved	G C P V W J B CA Y S OL D G C M
Relevant Ecological Strategies	- Reprofiling Land - Flood Plains - Living Plants
Slope	< 10%
Materials	- Native Plants - Concrete

C1.2 Event grounds



Activities Involved	G C V W CA Y OL D G
Relevant Ecological Strategies	- Reprofiling Land - Flood Plains - Living Plants
Slope	< 10 %
Materials	- Brick - Concrete

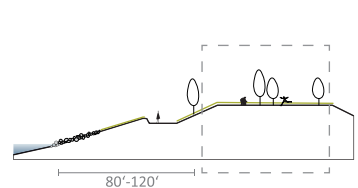
C1.3 Trail



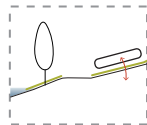
Activities Involved	V W J OL
Relevant Ecological Strategies	- Flood Plains - Living Plants
Slope	< 10 %
Materials	- Concrete - Steel - Wood

C2 Within Vegetated Slopes

C2.1 Park



Activities Involved	G C P V W J B CA Y S OL D G C M
Relevant Ecological Strategies	- Gabion Basket/Mattress - Stone Toe Protection - Living Plants - Fiber Roll
Slope	< 10 %
Materials	- Native Plants - Stone - Brick - Light-colored asphalt



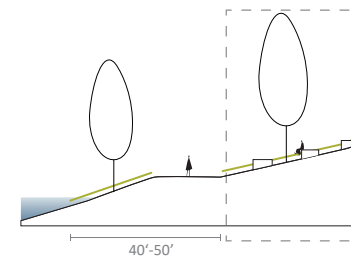
Recreational Activities

- G Family/ friend gatherings
- C Camping
- P Picnicking
- V Viewing and photographing human and nature
- W Walking
- J Jogging
- B Biking
- F Fishing
- L Canoe landing
- CO Concert
- CA Game
- Y Yoga
- S Sports

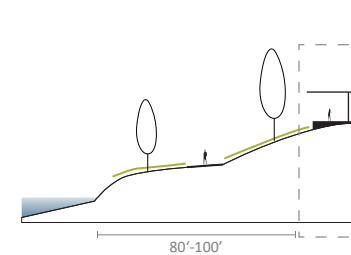
Educational Activities

- OA Observing aquatic wildlife and habitat
- OL Observing land wildlife and nature
- D Drawing
- G Game for leaning
- M Measuring
- C Collecting

C2.2 Amphitheater



C2.3 Overlook

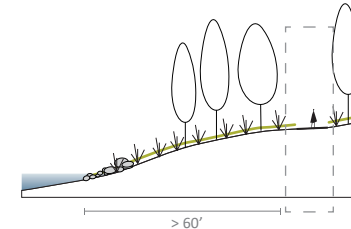


Activities Involved	G P V CO OL D C G
Relevant Ecological Strategies	- Reprofiling - Living Plants - Stone Toe Protection - Fiber Roll
Slope	< 25%
Materials	- Concrete - Stone - Wood

Activities Involved	G P V CO Y OL D C G
Relevant Ecological Strategies	- Reprofiling - Living Plants - Stone Toe Protection - Fiber Roll
Slope	< 30 %
Materials	- Native Plants - Stone

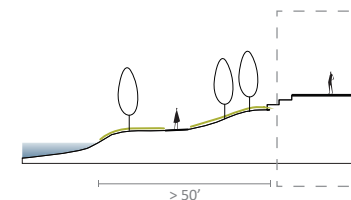
C3 Adjacent to Vegetated Slopes

C3.1 Trail



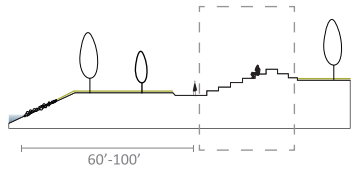
Activities Involved	V W J OL C
Relevant Ecological Strategies	- Reprofiling the Bank - Stone Toe Protection - Living Plants
Slope	< 50 %
Materials	- Concrete - Brick

C3.2 Plaza



Activities Involved	G C P V W CO CA Y OL D G
Relevant Ecological Strategies	- Rip Rap - Stone Toe Protection - Living Plants - Fiber Roll
Slope	< 30 %
Materials	- Concrete - Brick - Light-colored asphalt

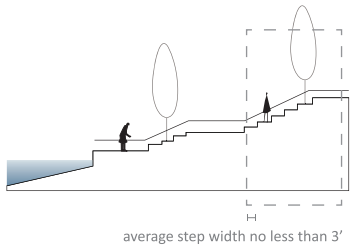
C3.3 Amphitheater



Activities Involved	G P V CO CA OL D G
Relevant Ecological Strategies	• Vegetated Soil Lift • Stone Toe Protection • Living Plants • Fiber Roll • Gabion Basket/Mattress
Slope	50~100 % (Stairs)
Materials	• Concrete • Stone • Wood

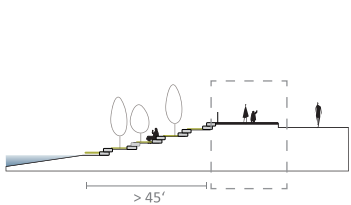
C4 Adjoining Stairs

C4.1 Stairs



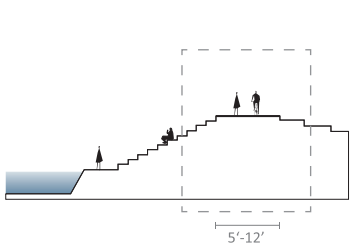
Activities Involved	V W OA G
Relevant Ecological Strategies	• Terraced Revetment • Reprofilling Land
Slope	50~100 % (Stairs)
Materials	• Concrete • Stone

C4.2 Plaza



Activities Involved	G P V W CO CA Y OL D G
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment • Vegetated Soil Lift • Fiber Roll • Gabion Basket/Mattress
Slope	50~100 % (Stairs)
Materials	• Concrete • Stone • Brick

C4.3 Trail



Activities Involved	V W J B M
Relevant Ecological Strategies	• Reprofilling the Bank • Terraced Revetment • Living Plants
Slope	50~100 % (Stairs)
Materials	• Native Plants • Stone • Brick

Recreational Activities

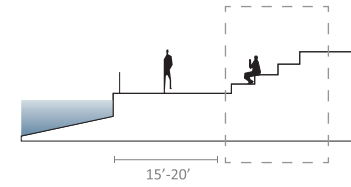
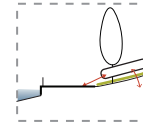
- G** Family/ friend gatherings
- C** Camping
- P** Picnicking
- V** Viewing and photographing human and nature
- W** Walking
- J** Jogging
- B** Biking
- F** Fishing
- L** Canoe landing
- CO** Concert
- CA** Game
- Y** Yoga
- S** Sports

Educational Activities

- OA** Observing aquatic wildlife and habitat
- OL** Observing land wildlife and nature
- D** Drawing
- G** Game for learning
- M** Measuring
- C** Collecting

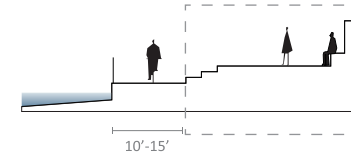
C5 Adjacent to Constructed Paths

C5.1 Amphitheater



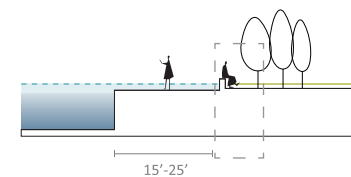
Activities Involved	G P V W CO CA D
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	50~100 % (Stairs)
Materials	• Concrete • Stone

C5.2 Deck



Activities Involved	G P V W CO CA Y D
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	< 5 %
Materials	• Wood • Stone

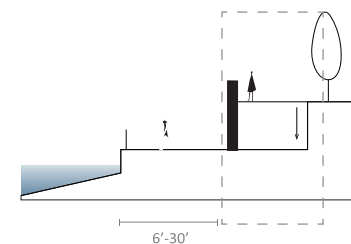
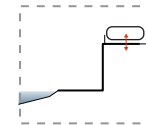
C5.3 Flood Wall Sitting



Activities Involved	G V OL D
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	< 5 %
Materials	• Concrete

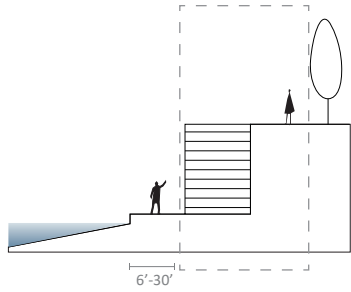
C6 Connecting to Embankment Walls

C6.1 Ramp



Activities Involved	V W J B G
Relevant Ecological Strategies	• Reprofilling the Bank • Retaining Wall
Slope	< 8 % (Ramp)
Materials	• Concrete • Stone • Light-colored asphalt

C6.2 Stairs



+	Activities Involved	V W
Relevant Ecological Strategies	• Retaining Wall	
Slope	50~100 % (Stairs)	
Materials	• Wood • Stone • Concrete	

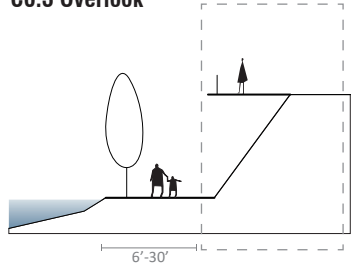
Recreational Activities

- (G) Family/ friend gatherings
- (C) Camping
- (P) Picnicking
- (V) Viewing and photographing human and nature
- (W) Walking
- (J) Jogging
- (B) Biking
- (F) Fishing
- (L) Canoe landing
- (CO) Concert
- (CA) Game
- (Y) Yoga
- (S) Sports

Educational Activities

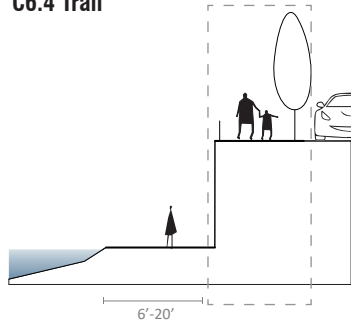
- (QA) Observing aquatic wildlife and habitat
- (QL) Observing land wildlife and nature
- (D) Drawing
- (G) Game for learning
- (M) Measuring
- (C) Collecting

C6.3 Overlook



+	Activities Involved	G V Y D
Relevant Ecological Strategies	• Retaining Wall	
Slope	< 5 %	
Materials	• Native Plants • Stone	

C6.4 Trail



+	Activities Involved	G V W J B C
Relevant Ecological Strategies	• Retaining Wall	
Slope	< 5 %	
Materials	• Wood • Stone • Concrete • Light-colored asphalt	

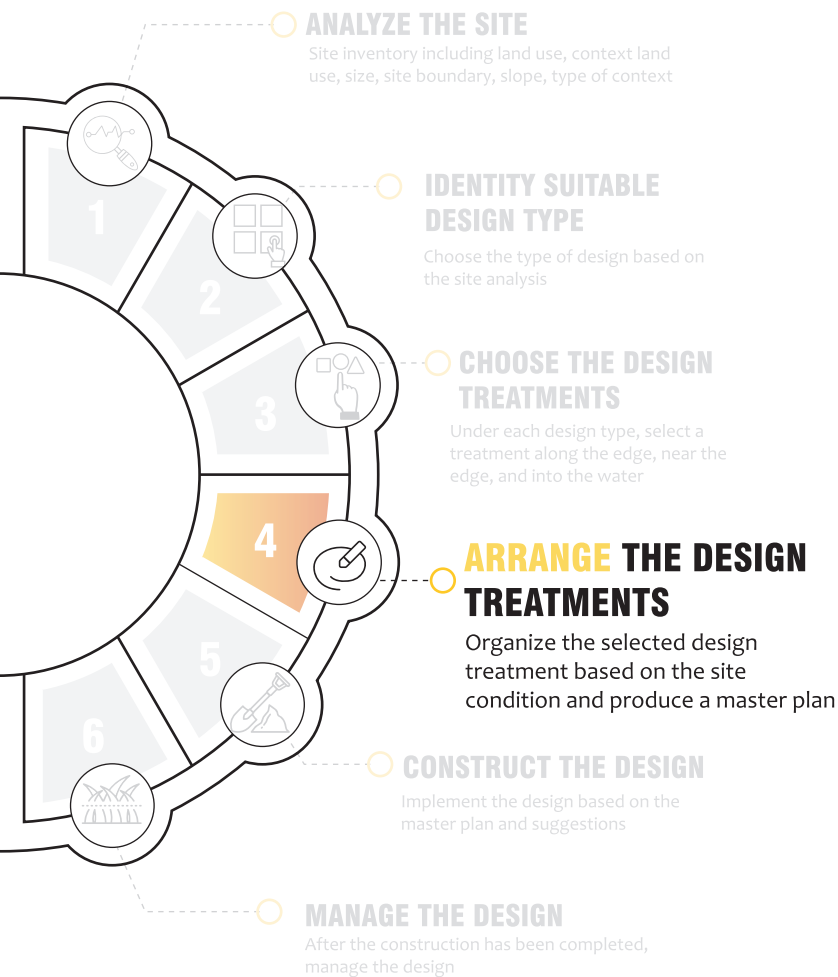


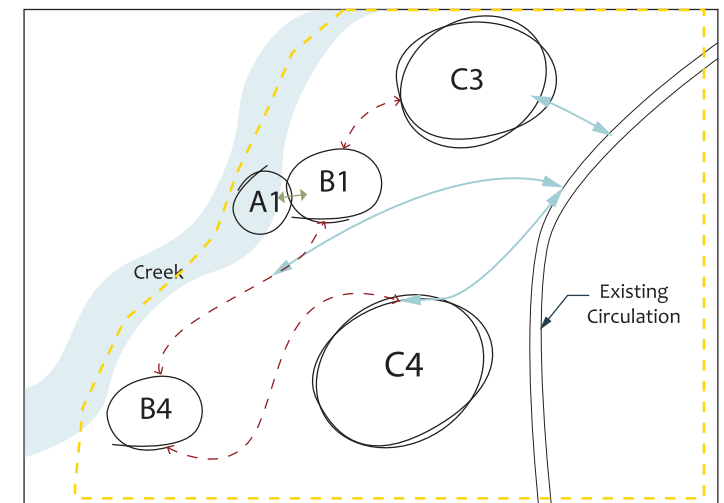
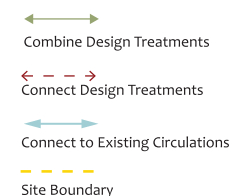
Figure 5.13
An overview of The Creekfront Design Guide with a focus on step four (Huang 2022)

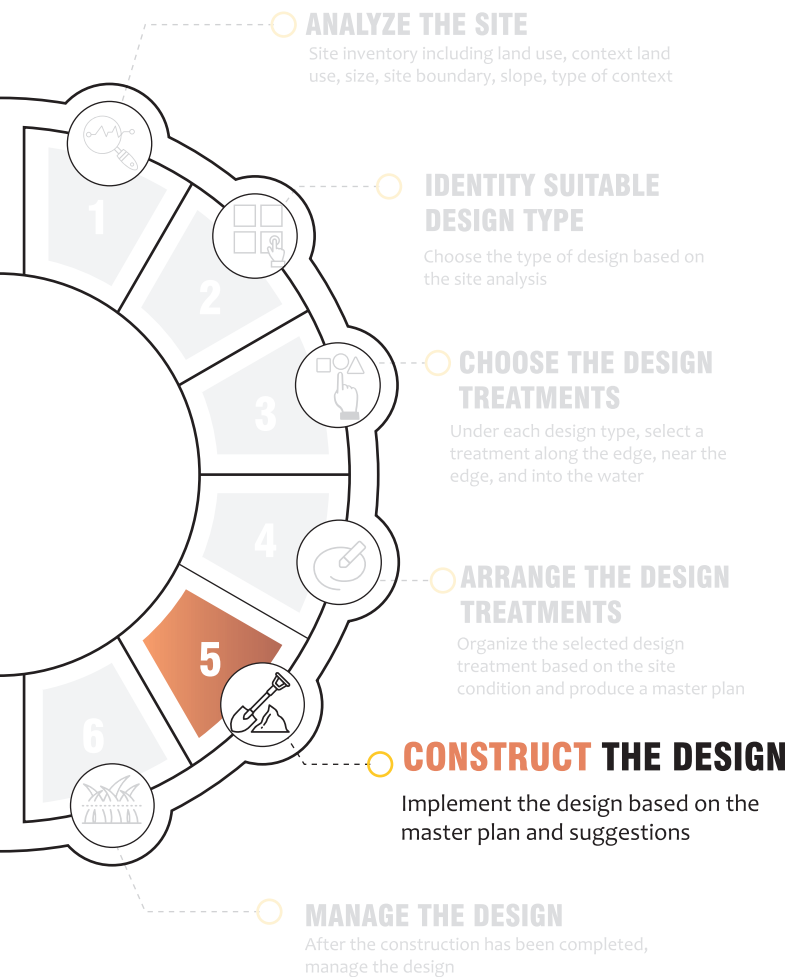
04. Arrange the design treatments

Once design elements are selected that provide the desired activities that can be applied to the creekfront site, combine the chosen options and arrange them on the site. Use the plan view image or map of the site obtained from Google Earth in the first step site inventory as a base. Next, plan out a design treatment based on existing conditions which incorporate existing circulations and programs more easily. Listed below are some principles of design treatment to assist in developing the master plan. Fig. 5.14 illustrates an example of how design treatments might be arranged on site.

1. Attempt to set aside more buffer zones and increase setback distances
2. Disperse event areas and functions throughout the site in order to activate the entire site
3. Treatments that are applied into the water (A types) can be combined with treatments that are applied along the edge (B types).
4. If the bank is steep and unstable, it is recommended to choose design strategies that can provide visual access near the edge (C type) as well as some access along the edge with no structures constructed along the edge.
5. Establish a connection with the existing circulation system

Figure 5.14.
An example to arrange selected design treatments (Huang 2022)





05. Construct the design

Figure 5.15
An overview of The Creekfront Design Guide with a focus on step five (Huang 2022)

Having defined the preferred design strategy and determining how to integrate the strategy with the existing site conditions is the Fifth Step towards implementing the design of the creekfront space. By incorporating the suggestions and standards available in this section, designers will be able to start making construction drawings and details; non-designers, they will be able to refine design, making coordination with the construction team easier and more efficient. This section provides construction-related dimensions and advice regarding setbacks, buffer zones, trails (paths), site furnishings, and landscaping (see Table 5.02).

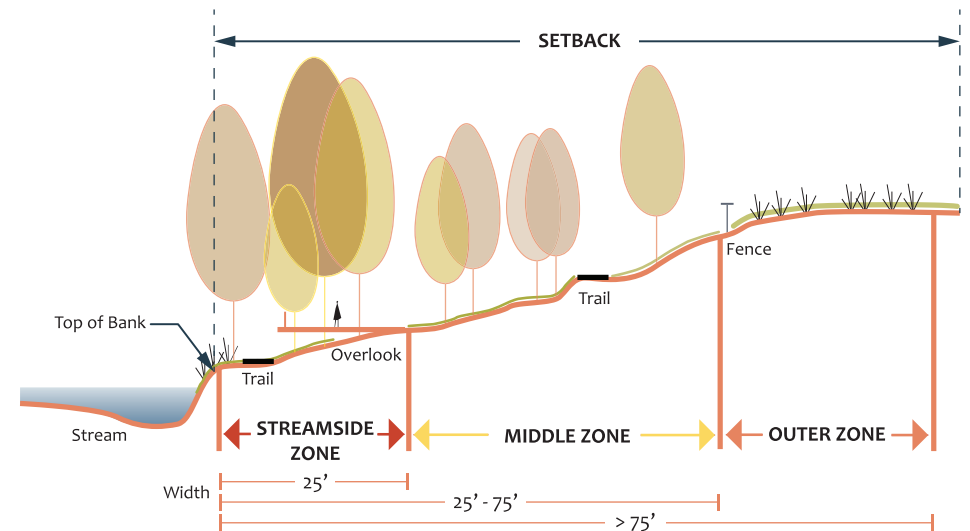


Figure 5.16
An illustration of the buffer zones and setback (Huang 2022)

Setback	
Dimensions	- Minimum setback for any vertical structures is 60 feet - More than 60 feet is highly recommended
Permitted Improvements or structures (within 60')	- Paved or unpaved walkways. - Stormwater best management practices (BMPs). - Shade structures such as arbors, trellises, or pavilions. - Public gathering spaces and other creekfront landing amenities. - Site furnishings including, but not limited to, benches, light fixtures, drinking fountains, bike racks, signage. - Fences and walls
Buffer Zones (see Figure 5.16)	
Streamside Zone	Dimensions - Extends 25 feet landward from the edge of stream Allowed use - Flood control structures, Footpaths, Road crossings, vegetation management, streambank stabilization, approved road, trail, and utility crossings, stormwater outfalls, Approved stream access for fishing and wildlife viewing and trail overlook areas
Middle Zone	Dimensions - extends 25 to 75 feet from the stream Allowed use - Any activity allowed in the streamside zone, paved and unpaved recreational trails for hiking and biking, underground utility corridors that are fully vegetated and designed in accordance requirements, Stormwater management facilities, Recreational uses, Limited tree clearing
Outer Zone	- Extends landward 75 feet from the outer edge of the middle zone Allowed use - Any activity allowed in the streamside and middle zones, Stormwater management, Best Management Practices (BMP) maintenance
Trail	
Pedestrian/ Biking Trail	5' to 12', at least 10' from the top of the bank (with slope less than 30% or retaining wall)
Running Trail	8' to 10'
Multi-use Path	10' to 14', at least 60' from the top of the bank
General Suggestions	- Regrade the terrain if it is too steep to install trails Materials - Crushed limestone surface, Concrete paver, Light-colored asphalt, minimizing dark-colored surface areas, such as black asphalt, Concrete, stone on edge along connection (durable, finished, clean edge), Granite, Unite paver, Permeable pavements

Furnishings	
Lightings	- Recommended light fixture height is between 14 and 30 feet tall - LED bulbs that provide white light with a color temperature of 3000k or below - Lighting poles near water could be constructed of concrete to better withstand flooding.
Other	- Bench, table/chair, platform seating, Interpretive, signage - The recommendation is to install every 250 linear feet - Placing site furnishings parallel to water flow is recommended. - Materials – Stainless steel, Corten steel, Hardwood, Recycled plastic lumber
Landscaping	
Planting principles	- Planting should be based on the slope of the land - Slopes over 30% should be planted with plants that don't need regular maintenance - Develop a diverse hierarchy of landscape cover types - The nature of stream environments should be dynamic, evolving into new shapes over time
Plant selection	- Select native and adapted species - Provide four-season interest - Species diversity - A variety of trees, shrubs, grasses, perennials, vines, and bulbs is encouraged - Remove invasive species and replaced with native species



Table 5.02
Implementation
suggestions for creekfront
designs (Huang 2022,
data from setback from
City of Chicago 2012 and
Riverlife 2014, the City
of Kansas City 2021, and
U.S. Environmental
Protection Agency (EPA)
2002)

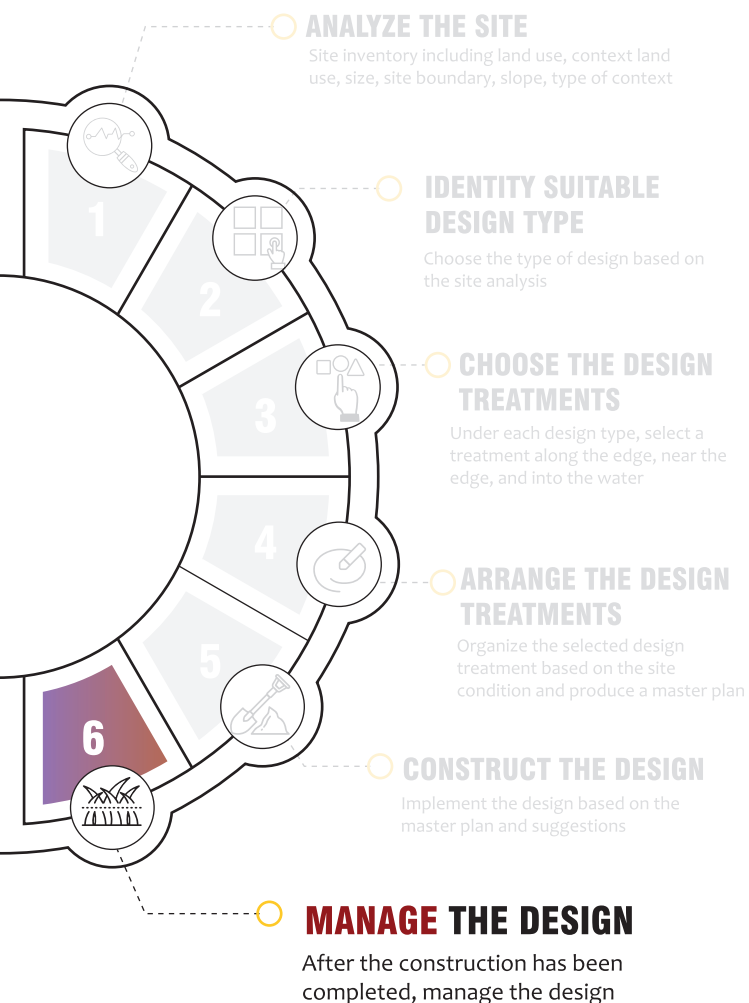


Figure 5.17
An overview of The Creekfront Design Guide with a focus on step six (Huang 2022)

06. Manage the design

Managing the creekfront space is also a vital component of activating the creekfront. Unlike the previous five steps, managing the site is most time-consuming. Site management is an ongoing process that requires continuous involvement. Nature, such as rivers, creeks, and landscapes, are dynamic and change over time. Thus, in order to preserve the design as long as possible, either maintain it as is, or make it adaptable to natural dynamic changes. In the following table, some management methods are listed according to their length of duration: short-term, medium-term, and long-term. In general, the longer the duration of the management method, the higher the requirements for the preliminary design. Therefore, during the design process, it is important to consider the future management and the space that can be allocated for its implementation (see Table 5.03).

Table 5.03 General stream corridor management strategies based on time frame (Generated from Patti Banks Associates and Applied Ecological Services, Inc. 2006 by Huang 2022)

MANAGING CREEKFRONT SPACES BASED ON TIME FRAME	
Time Frame	Managing Strategy
Short Term (Preservation)	Set aside stream buffer
	Prohibit dumping
	No storage or use of pesticides or heavy equipment
	Inspect condition (back stability, erosion, vegetative cover)
	Remove trash
Medium Term (Enhancement/Restoration)	Identify erosion damage
	Properly align and design road and infrastructure crossing
	Repair unstable banks
	Remove exotic or invasive vegetation
	Remove debris and fill
Long Term (Re-Creation)	Restore native vegetation
	Remove debris and mud from paved surfaces after flood events
	Establish vegetative buffers
	Stabilize hydrology and streambed



06

SITE APPLICATIONS

SITE APPLICATION

The purpose of this chapter is to present two projective plans for creekfront design in two areas of Wildcat Creek in Manhattan, Kansas (see Figure 6.01), and demonstrate the application of the Creekfront Activation Design Guide from Chapter 5. The projective design sites were selected in two different locations along Wildcat Creek to provide different design context applications. The two projective designs incorporated the proposed design process outlined in the design guide. This process began with the site analysis followed by design solution selections and design arrangement. The main goal of these two creekfront designs was to provide greater access to the creek and to provide recreational and educational opportunities for the community. Each design site had its own set of design goals, which varied according to its site conditions.

Due to time constraints, the results of the projective designs are conceptual and consist of site inventory diagrams, a master plan, process diagram, axonometric sections of each access design, and conceptual perspectives. Graphics are used alongside the checklist form and written descriptions of inventory, design selection process, and design conceptualization. The projective designs provide examples for only the first three steps on the Creekfront Activation Design Guide. As well as considering design ideas and arranging design, consideration was given to implementation and maintenance according to the site conditions.

Figure 6.01
The locations of two projective designs along Wildcat Creek (Huang 2022, data source: GIS Viewer; Clark 2012)

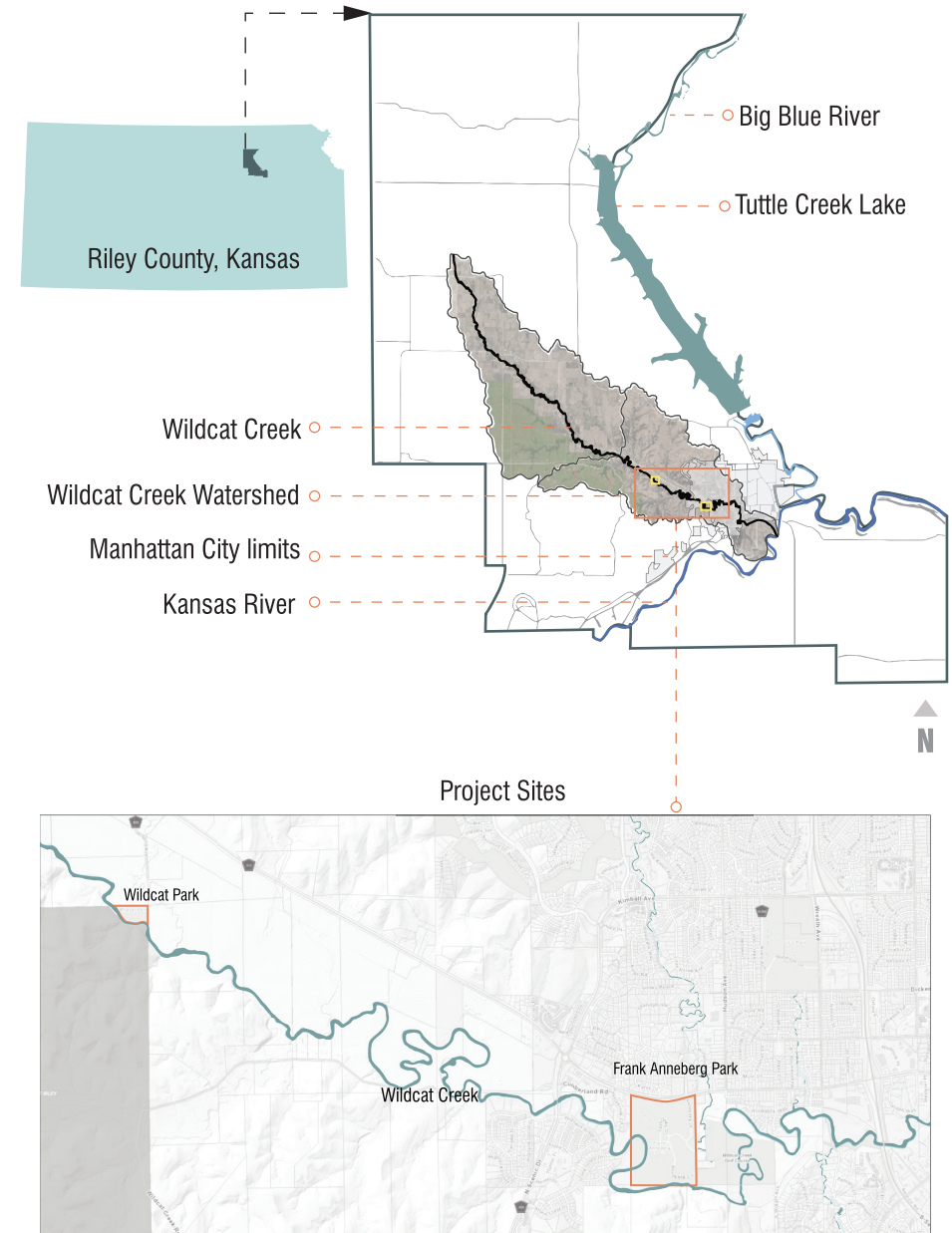




Figure 6.02
Existing plan view of
Frank Anneberg Park
(Huang 2022)

Frank Anneberg Park

The projective design at Frank Anneberg Park in Manhattan, Kansas, provides an application example of the Creekfront Activation Design Guide in a relatively developed site context. Floods have occurred frequently at the site since it is located in a floodway. The park is semi-surrounded by Wildcat Creek but due to a heavy vegetative barrier, park visitors have little access to the creek except for two pedestrian bridges, one of which is still reserved for private use. Some park users may not even be aware that Wildcat Creek runs adjacent to the park. Therefore, Frank Anneberg Park is a typical creekfront site with the potential to connect directly to Wildcat Creek and offer a wider range of recreational opportunities.

SITE ANALYSIS

Location and Context

Frank Anneberg Park is located on the western perimeter of Manhattan, Kansas, within the Wildcat Creek watershed area. The 25 acres of creek front areas were selected from a park site of 104 acres, with a distance of 350 feet between the creek edge and the site boundary (Figure 6.05). Frank Anneberg Park is a well-established park located in a low-density residential area adjacent to a golf course and a high-density residential community. Thus, the site context of Frank Anneberg Park is more developed, highly used, and contains a variety of hardscapes as well as designed softscapes (Figure 6.03). Although there is a mix of urban and natural surroundings, the areas near the creek are mostly natural. Therefore, when I select design types in the next steps, I select those that are coded in the middle or first alphabetical order.



Figure 6.03
Context of Frank
Anneberg Park (Huang
2022; Google Earth Pro
2022)

Figure 6.04
Frank Anneberg Park site
photograph (Huang 2021)

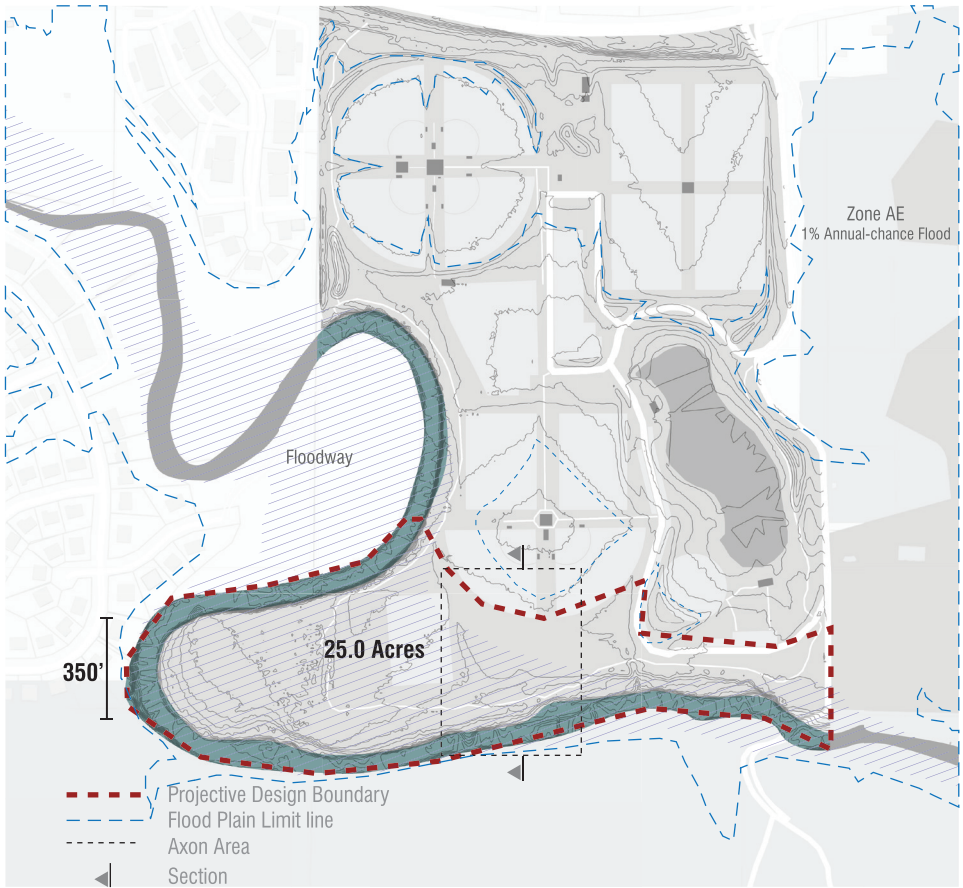


Figure 6.05
Frank Anneberg Site Map
(Huang 2022, adapted
form Google Earth Pro
2022)

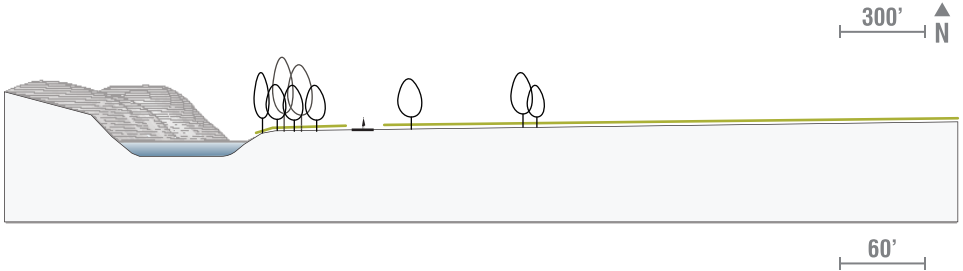
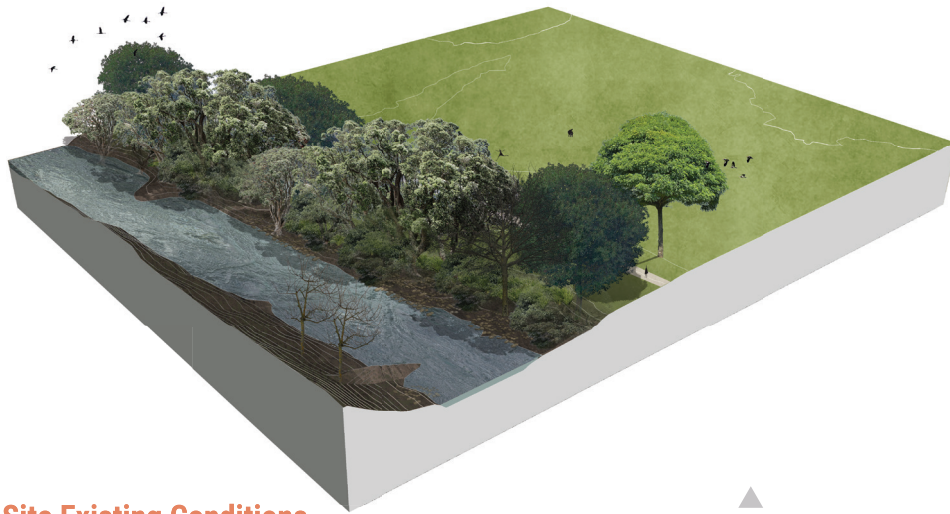


Figure 6.06
Frank Anneberg Park
Section (Huang 2022)



Site Existing Conditions

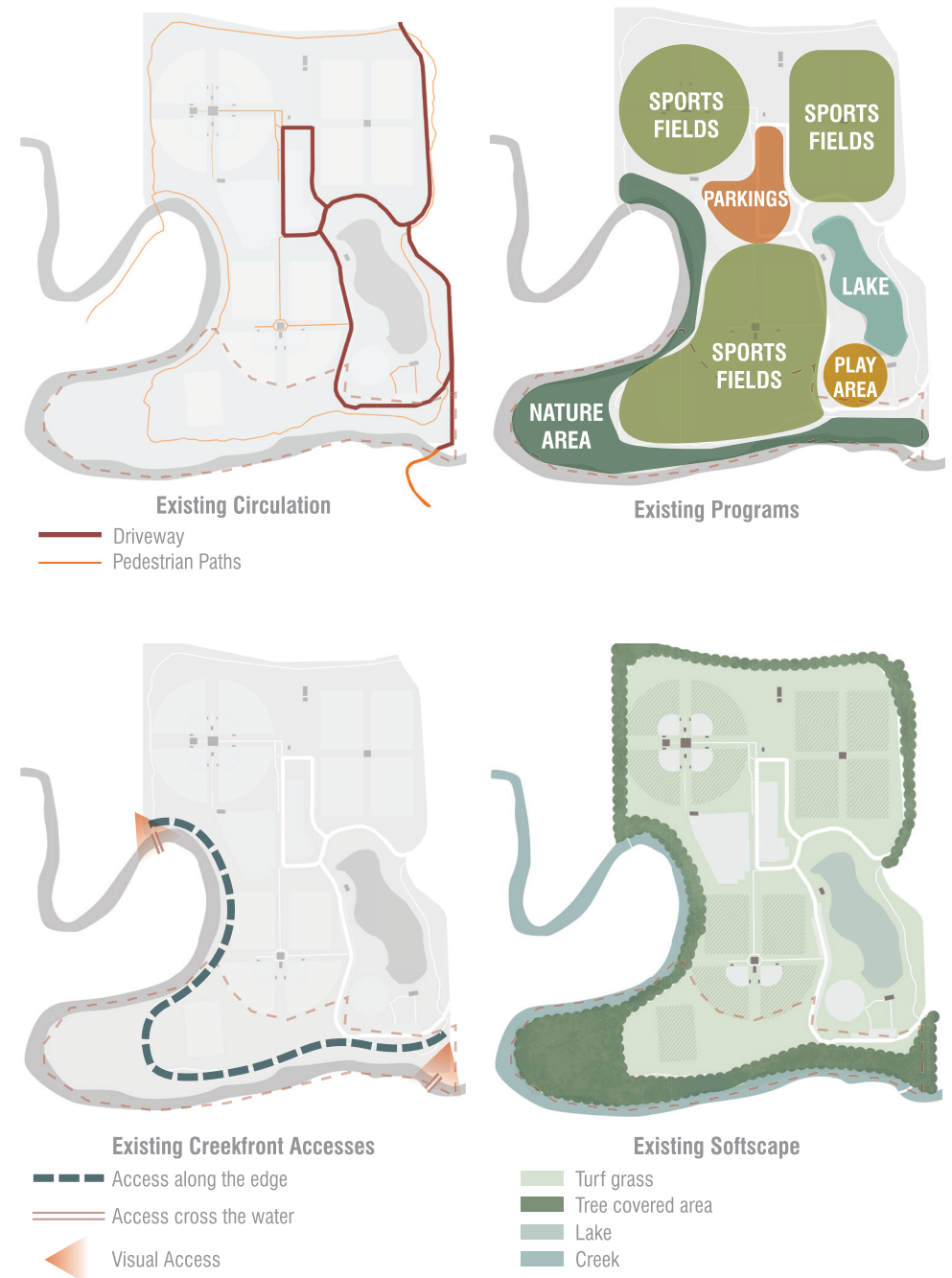
There are two types of circulation in Frank Anneberg Park: pedestrian trail and driveway. A pedestrian trail loops the park, providing users with opportunities to walk and run (Figure 6.08). The pedestrian trail runs near a creek edge and connects two creek crossing bridges. This trail, however, does not provide direct access to the creek, either physically or visually. The creek can only be viewed from the crossing bridges, and other areas are obscured by vegetation.

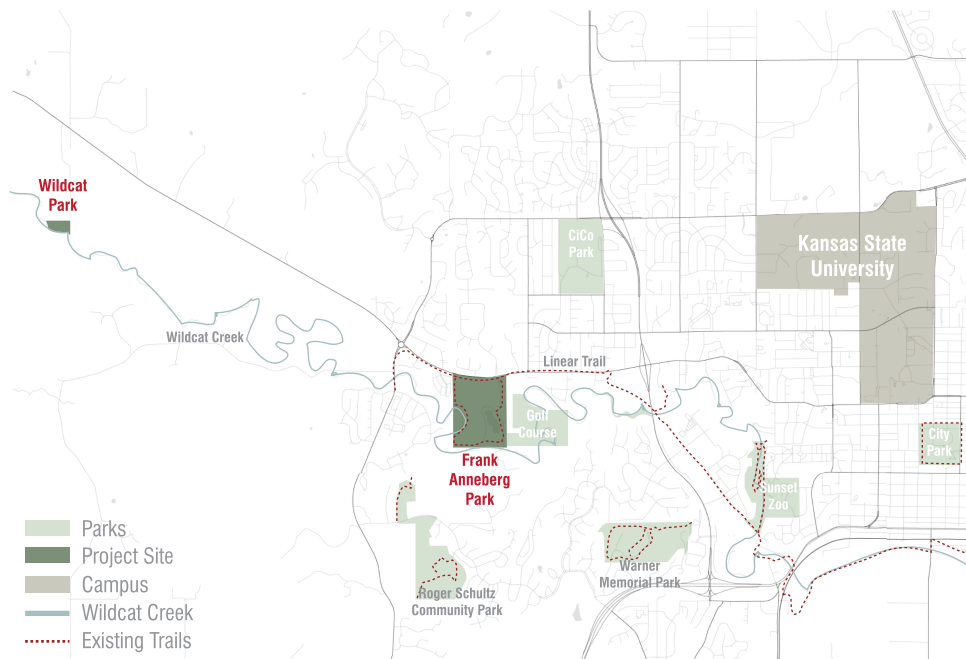
In addition to circulation, Frank Anneberg Park also has 13 turf sports fields, including a soccer field within the project boundary. The park includes a lake and a playground where people can fish and children can play. Natural resources are abundant in the park, including many plant species and wildlife species. On the southwest corner of the park, there is a forest with the potential to be a great educational resource.

Due to the park's location within a floodway, there is a possibility of periodic flooding. Vegetation barriers and long-distance setbacks are currently being used to combat flooding. It is important to note that because of the characteristics of the creek, there is also the possibility of erosion and sedimentation. Furthermore, the calculated slope of the bank in the project site is approximately 30-50%; whereas the slope of the bank in Figure 6.06 is 47.6%. The creek bank at the project site is very steep.

▲ Figure 6.07
View of part of Frank
Anneberg Park and
Wildcat Creek (Huang
2022)

▶ Figure 6.08
Site inventory Diagram
of Frank Anneberg Park
(Huang 2022)





Potential Connections

Based on the site analysis, it was discovered that there were some existing connections and potential opportunities for future connections with the creekfront design of Frank Anneberg Park and surrounding (Figure 6.09). The existing pedestrian trail in Frank Anneberg Park is connected to the linear trail, the longest pedestrian trail in Manhattan, providing access to a wide range of activities and recreational opportunities. Considering Wildcat Park and Frank Anneberg Park are separated along Wildcat Creek, there is an opportunity to establish a connection in the future, such as a trail along the creek on the south side of Frank Anneberg Park. Accordingly, the connection with the linear trail will be maintained as much as possible, and a connection with Wildcat Park will also be considered during the design process.

▲ Figure 6.09
Potential connections
of Frank Anneberg Park
(Huang 2022, image base
generated from Snazzy
Maps)

► Figure 6.10
Frank Anneberg Park Site
Inventory Checklist Form
(Huang 2022)

SITE INVENTORY - Frank Anneberg Park

Site Location (Boundaries)	3801 Anderson Ave, Manhattan, KS (Boundaries see Figure 6.05)		
Site Dimensions (Size)	About 25 Acres, horizontal distance from creek to boundary is 350'		
Site Context ***			
Development Degree	☒ Developed	☐ Undeveloped	
Materials	☐ Largely Paved	☒ Medium paved	☐ Largely Vegetated
Land Use	☒ Residential / Playground	☐ Nature park	
	☐ Street/Business Area	☐ Farmland	☐ Other
Buffer Zone	☐ Fewer buffer zones	☒ Plenty buffer zones	
Usage	☒ High Usage	☐ Low Usage	
Existing Creek Access***			
Physical access (see Figure 6.08)	☐ Along the edge	☒ Near the edge	
	☒ Into the water (private access)	☐ No	
Visual access	☒ Yes (Cross Bridges)	☐ No	
Activities***	Recreational Activities: Family/ friend gatherings, Picnicking, Viewing and photographing human and nature, Walking, Jogging, Biking, Fishing, Game, Yoga, Sports Educational Activities: Observing aquatic/land wildlife and habitat, Drawing, Game for learning, Collecting		
Circulation Routes			
Types	☒ Yes (Type: Walkway, Driveway)	☐ No	
Locations	☒ Prepare a map/plan (see Figure 6.08)		
Topography			
Site Topography	☒ Topography Map (see Figure 6.05)		
Bank Slope	☐ General Sloping	☐ Steep	☒ Very Steep
	☐ Flat		
Ecological Issues *			
Types	☒ Yes (Erosion, Sedimentation, Poor water quality, Flooding, simple habitats, other)		
	☐ No		
Treatments (if any)	Flooding: Tree Barriers		
Creekside Vegetation			
Plants Species	☒ Dominant Species (Ash tree, Oak tree, Maple tree, Sycamore)		
	☐ Invasive Species (where)		
Potential Connections			
Existing & Future	☒ Trails	☐ Parks	☐ Schools
Surrounding elements	☐ Public Transportations	☒ Communities	☐ Plaza/Squares
	☐ Zoo		
	☐ Other		

DESIGN TYPES AND TREATMENTS SELECTION – Frank Anneberg Park



Figure 6.11
Design type selection
for Frank Anneberg Park
(Huang 2022)

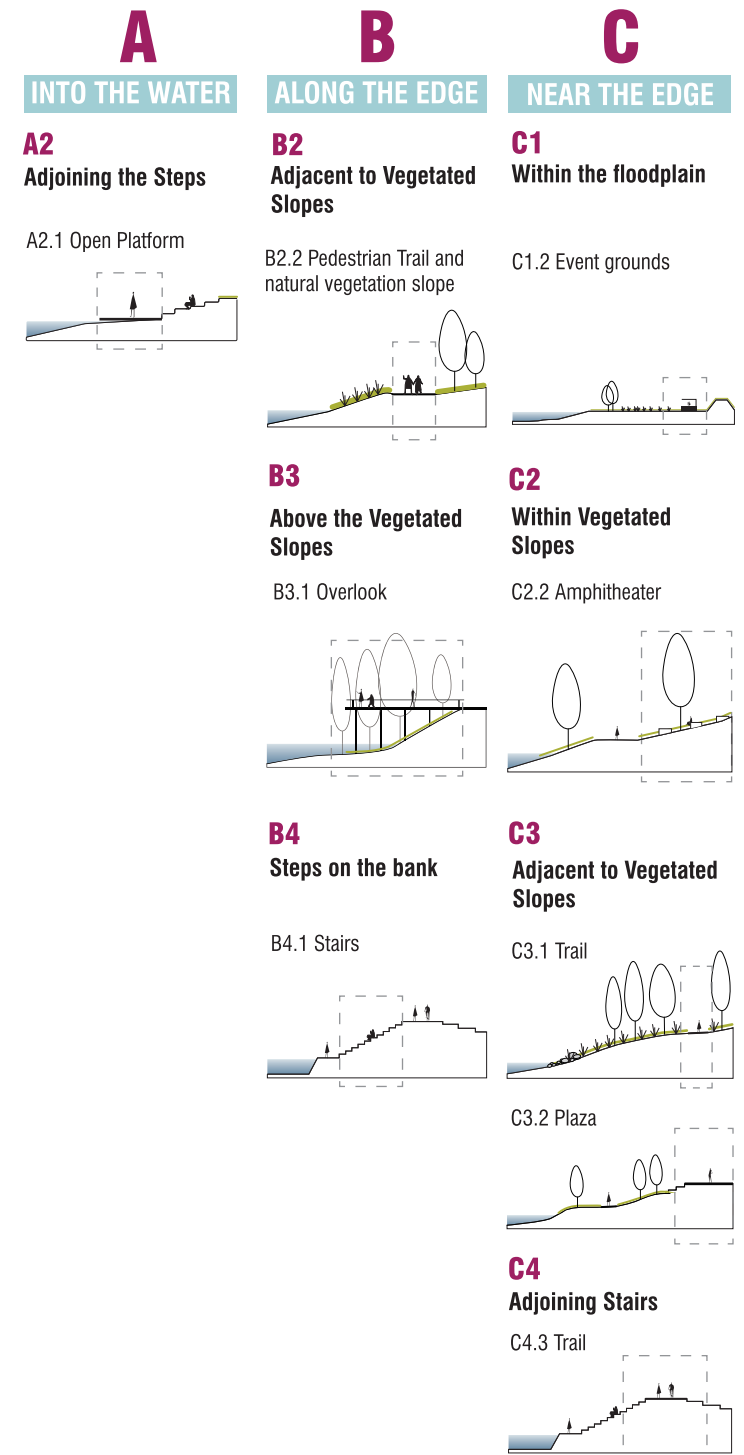


Figure 6.12
Design treatment
selection for Frank
Anneberg Park (Huang
2022)

Following the design guidelines proposed in chapter 5, suitable design types that could be applied in different locations were selected. Site analysis indicates that Frank Anneberg Park sits within a high-density residential area and a natural area, however, the natural areas are slightly more than paved. Therefore, the design types in the middle of the catalog were selected, including A2, B2, B3, B4, C1, C2, C3, C4. Using the design type as a guide for the search, one or more treatments were selected from each treatment type (Figure 6.12). The selection of design treatments was mainly based on the activities offered by the treatment and its design.

DESIGN ARRANGEMENTS

Nine design treatments were selected, and they were arranged based on topography, existing design, and the designer's preferences. Landing treatments such as platform, overlook, and amphitheater are scattered across the site and connected by connection treatments such as trails along the creek. The diagram of Frank Anneberg Park treatments arrangement (Figure 6.13) shows the arrangement and locations of selected design treatments on the site.

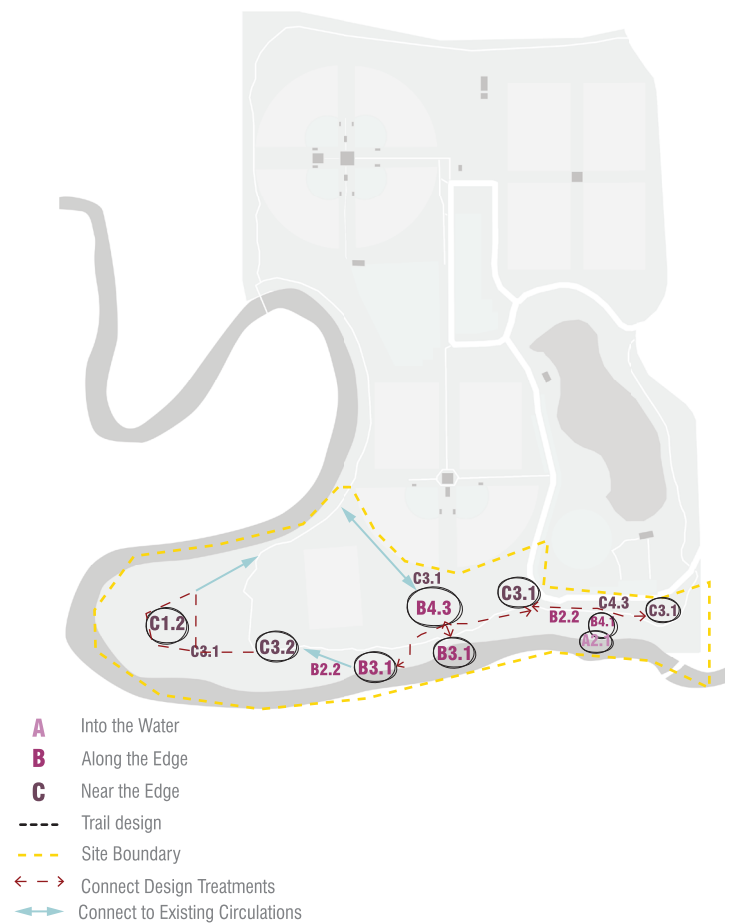


Figure 6.13
Design treatments
arrangement for Frank
Anneberg Park (Huang
2022)

Frank Anneberg Park Master Plan



Figure 6.14
Proposed Frank Anneberg
Park Creekfront Area
Master Plan (Huang 2022,
adapted from Google
Earth Pro 2022)

Recreational Activities

- G** Family/ friend gatherings
- P** Picnicking
- V** Viewing and photographing human and nature
- W** Walking
- J** Jogging
- B** Biking
- F** Fishing
- CO** Concert
- CA** Game
- Y** Yoga
- S** Sports

Educational Activities

- OA** Observing aquatic wildlife and habitat
- OL** Observing land wildlife and nature
- D** Drawing
- G** Game for leaning
- M** Measuring
- C** Collecting

Figure 6.15
Frank Anneberg Park
Existing aerial imagery
and context (Google
Earth Pro 2022)



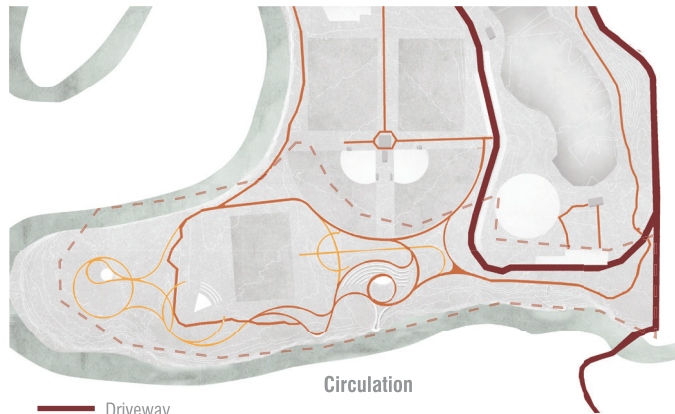
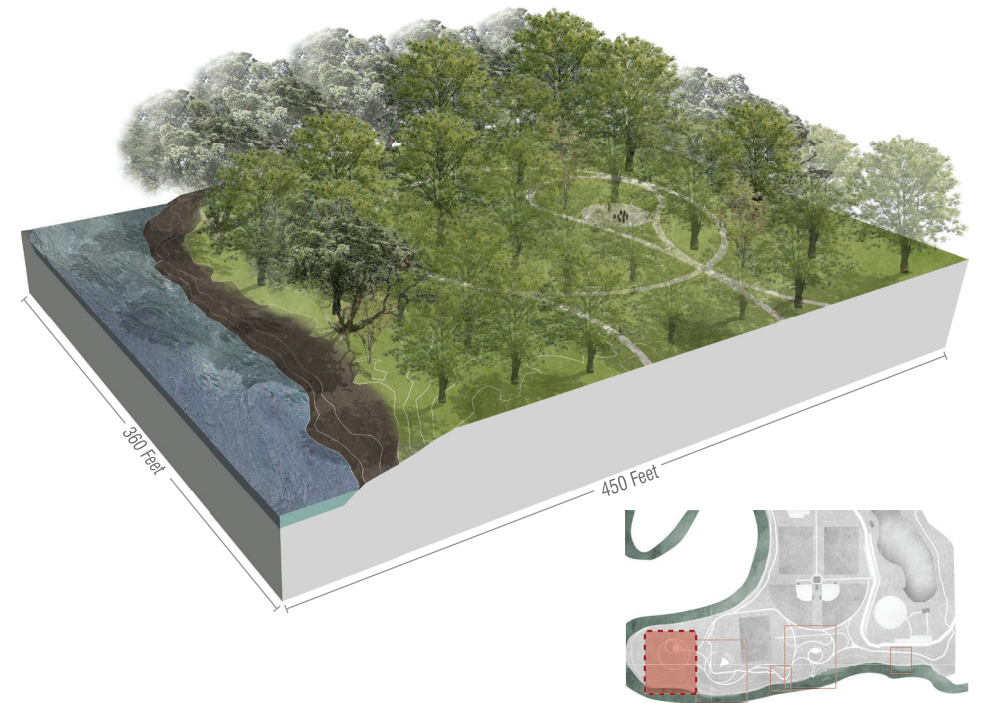


Figure 6.16
Diagram of Proposed
Frank Anneberg Park
design (Huang 2022)



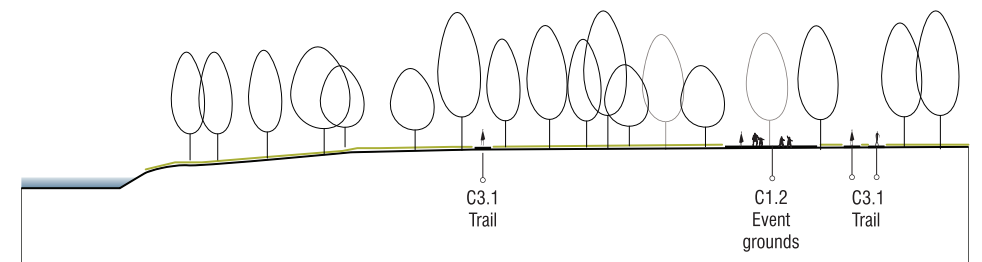
Figure 6.17
Trail in the western
corner forest of Frank
Anneberg Park, showing
by axon view, location key
map and section (Huang
2022)



Frank Anneberg Park Design Details

As shown in the post-design analysis diagram in Figure 6.16, the creekfront of Frank Anneberg Park increases the circulation of different hierarchies, adding three more ways to access the creek, while also retaining a large number of existing plants.

Figure 6.17 illustrates the design of the west area of the site. This area boasts the greatest number of plant resources in the site, which also makes it a great location for educational purposes. For this area, a trail and event grounds were added, allowing it to be used for outdoor education. The area is available for educators to lead children on educational excursions. Alternatively, this can also serve as a semi-enclosed space for creation and rest.



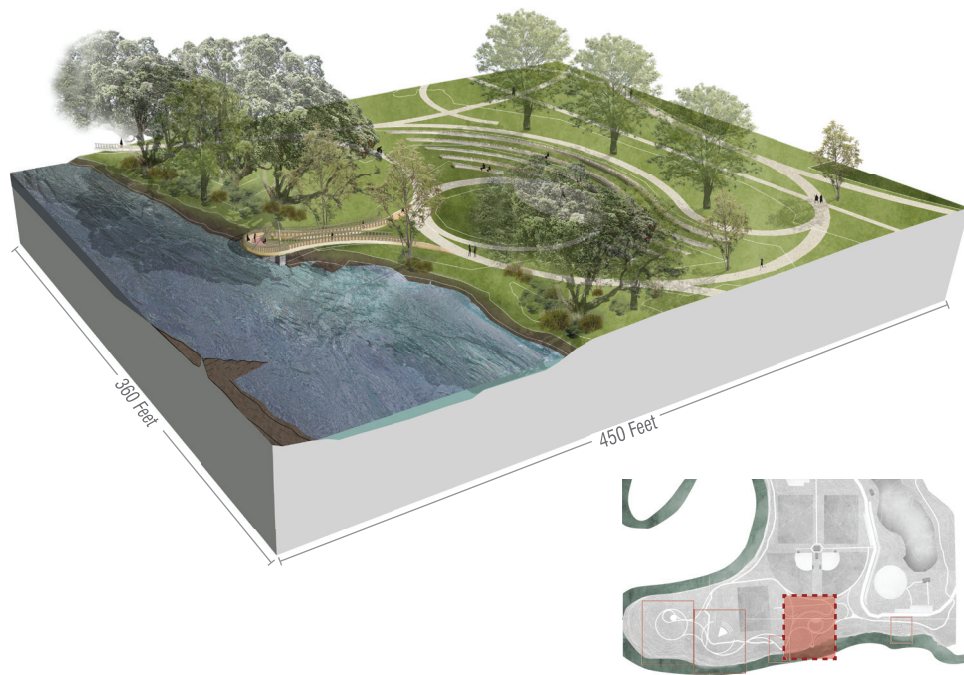


Figure 6.18 depicts the design of the central portion of the site. A drawbridge-style overlook platform and an amphitheater are provided in this area. A lawn amphitheater can be used for outdoor entertainment events such as concerts, which is a pleasant gathering place. Views of the creek are available from the top of the amphitheater. The overlook platform is connected to the creekfront trail that extends above the creek. From this position, visitors can observe the entire creek and its changes.

Figure 6.18
Amphitheater and overlook platform in the center part of Frank Anneberg Park, showing by axon view, location key map and section (Huang, 2022)

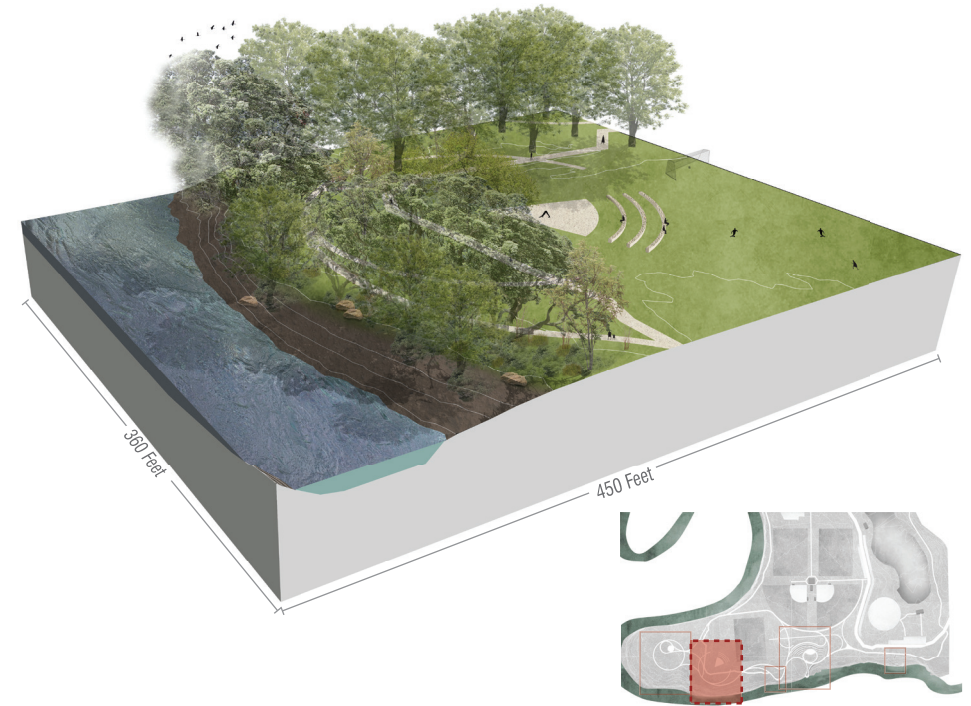
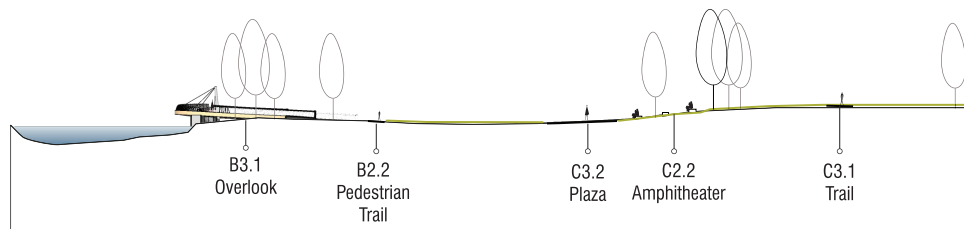
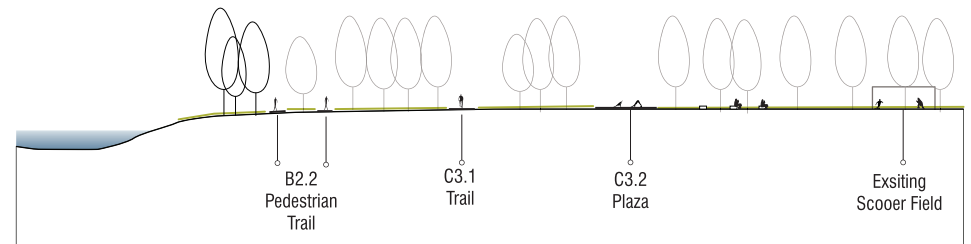
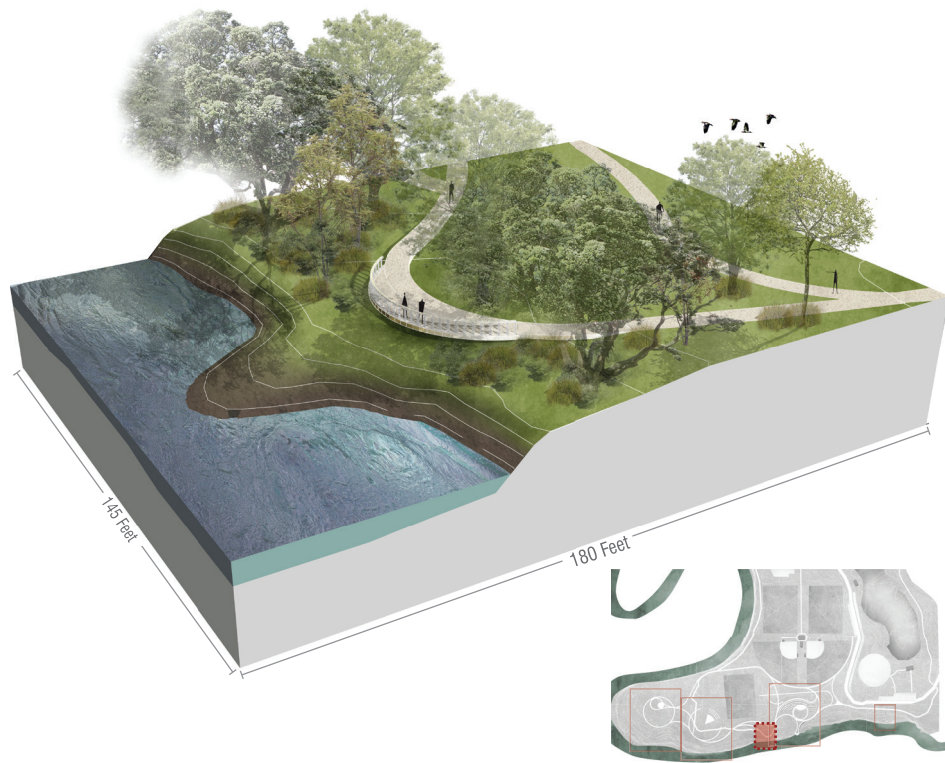


Figure 6.19
Scalloped plaza and sitting next to soccer field, showing by axon view, location key map and section (Huang 2022)

As shown on the diagram on this page (Figure 6.19), the soccer field has remained, and a sector plaza and seating were added. Using the plaza for yoga and seats under the shade of the trees offer a nice option for gathering and relaxing.





The diagram on this page (Figure 6.20) illustrates another design for an overlook platform at Frank Anneberg Park. This is a corner platform on the creekfront trail. Unlike another overlook platform (Figure 6.18), it does not extend above the creek, but it still can provide a landing place for people to observe the creek.

Figure 6.20
Overlook Platform and pedestrian trail, showing by axon view, location key map and section (Huang 2022)

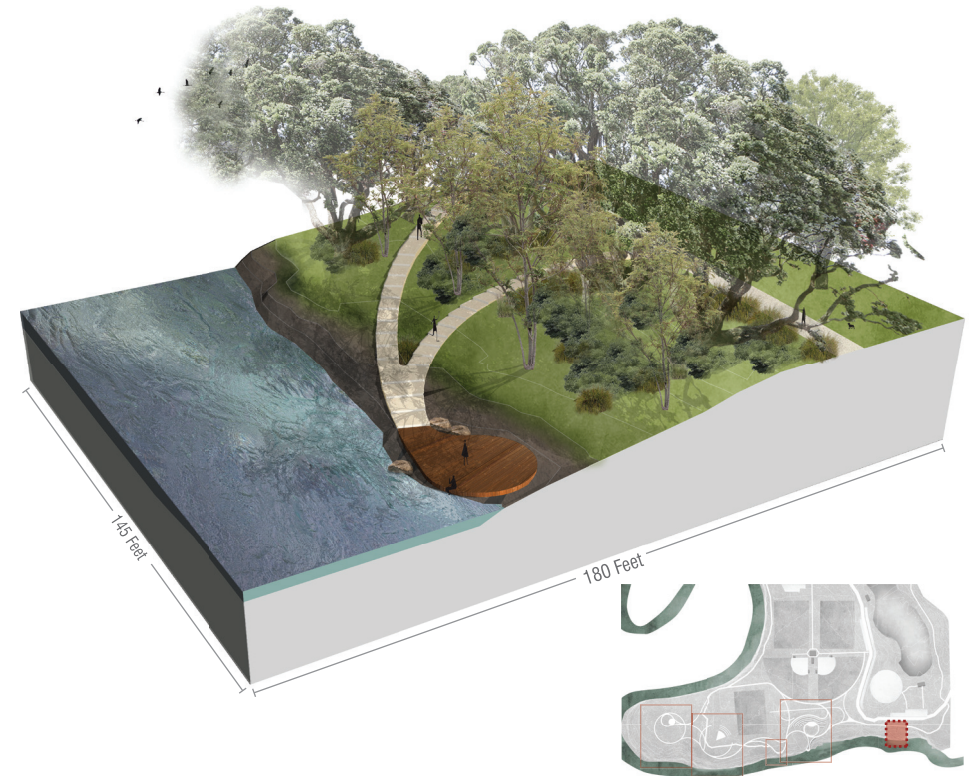
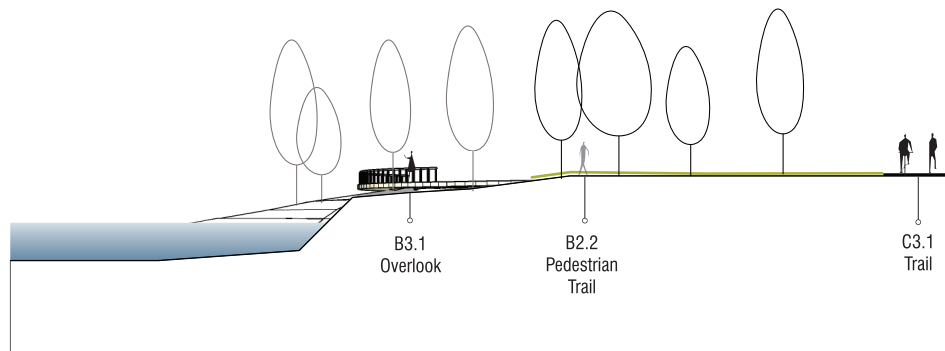


Figure 6.21
Into-water platform and stairs, showing by axon view, location key map and section (Huang 2022)

Figure 6.21 presents the only into-water design in Frank Anneberg Park. This design incorporates an open platform that is connected to the creekfront trail by stairs. With this design, visitors have the opportunity to interact with Wildcat Creek up close. During a flood, the design is submerged and not usable, but it can be quickly cleaned up and reused afterward.

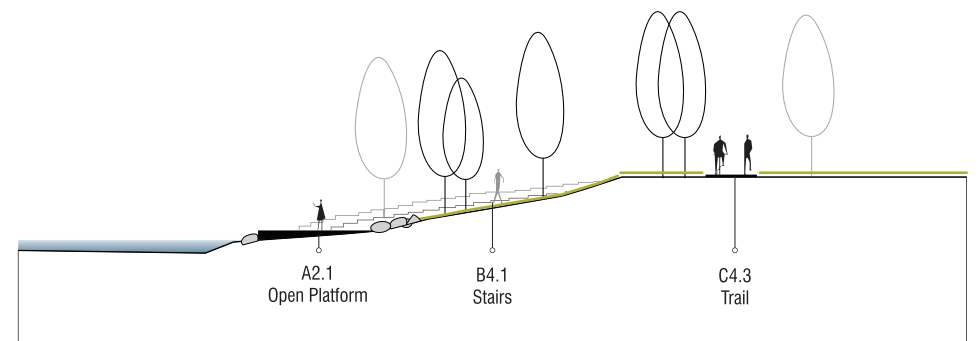




Figure 6.22
Frank Anneberg Park
Creekfront Design
perspective (Huang 2022)

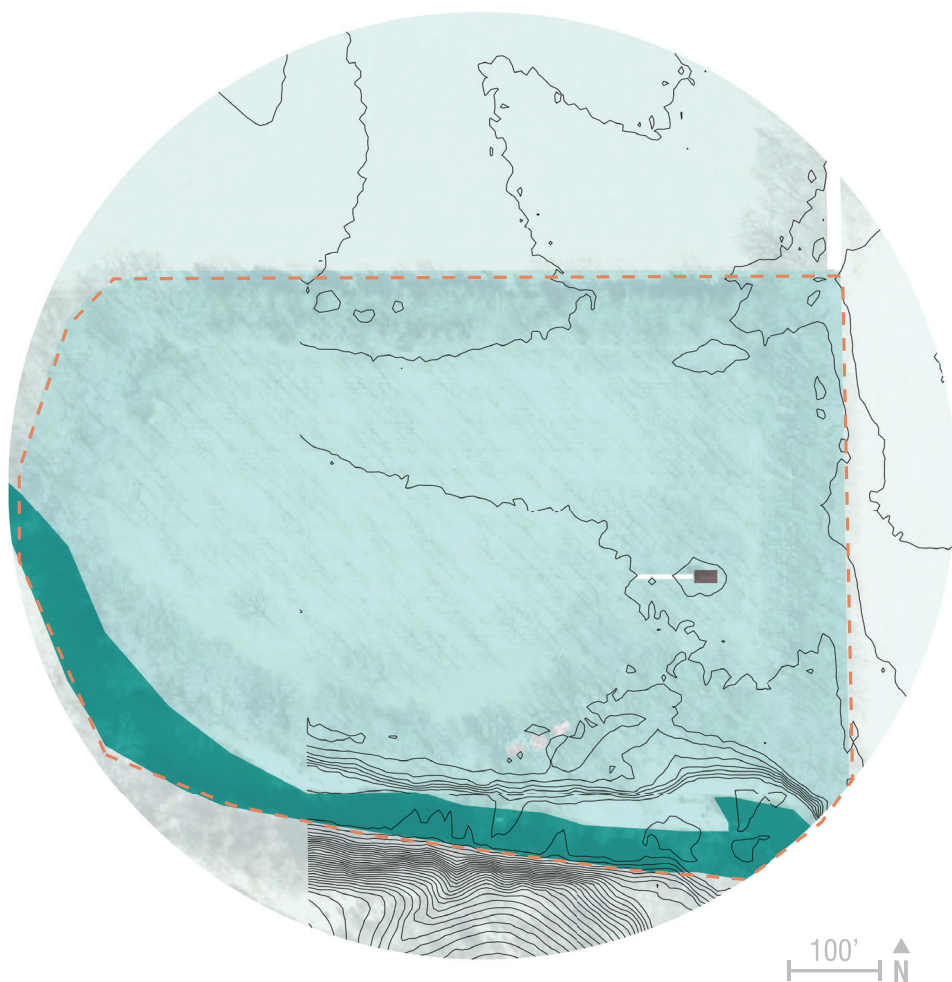


Figure 6.23
Existing plan view of
Wildcat Park (Huang
2022)

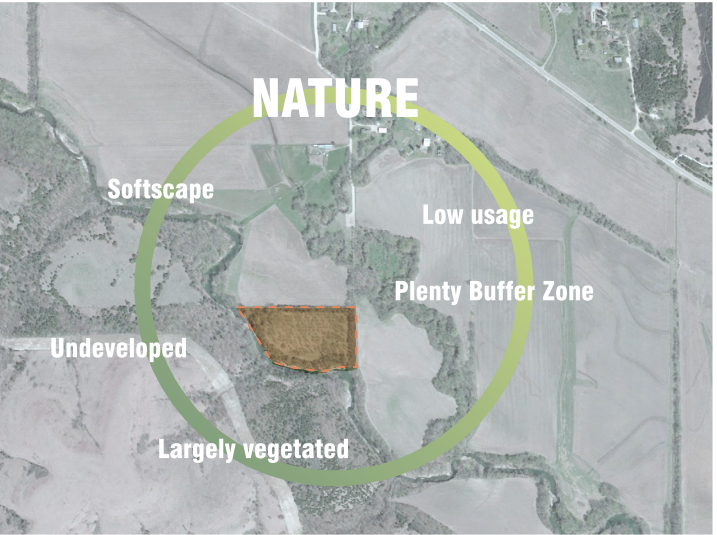
Wildcat Park

The projective design at Wildcat Park near Manhattan, Kansas, provides an application example of the Creekfront Design Guide in a natural site context. Wildcat Park is also located within the Wildcat Creek floodway and is subject to extensive flooding. The park is almost fully vegetated with only one physical natural access to get into the creek. The abundant vegetation and undeveloped state of Wildcat Park makes it an ideal example of how to activate undeveloped creekfront areas.

SITE ANALYSIS

Location and Context

Wildcat Park is a natural park located along Wildcat Creek, approximately 15 minutes from downtown Manhattan. The project site in Wildcat Park is 8.10 acres with a distance of 480 feet between the creek edge and the site boundary (Figure 6.26). Wildcat Park is most vegetated and surrounded by undeveloped nature areas (Figure 6.24). Considering Wildcat Park’s natural context, the design types tend to be mostly natural types.



1000' N

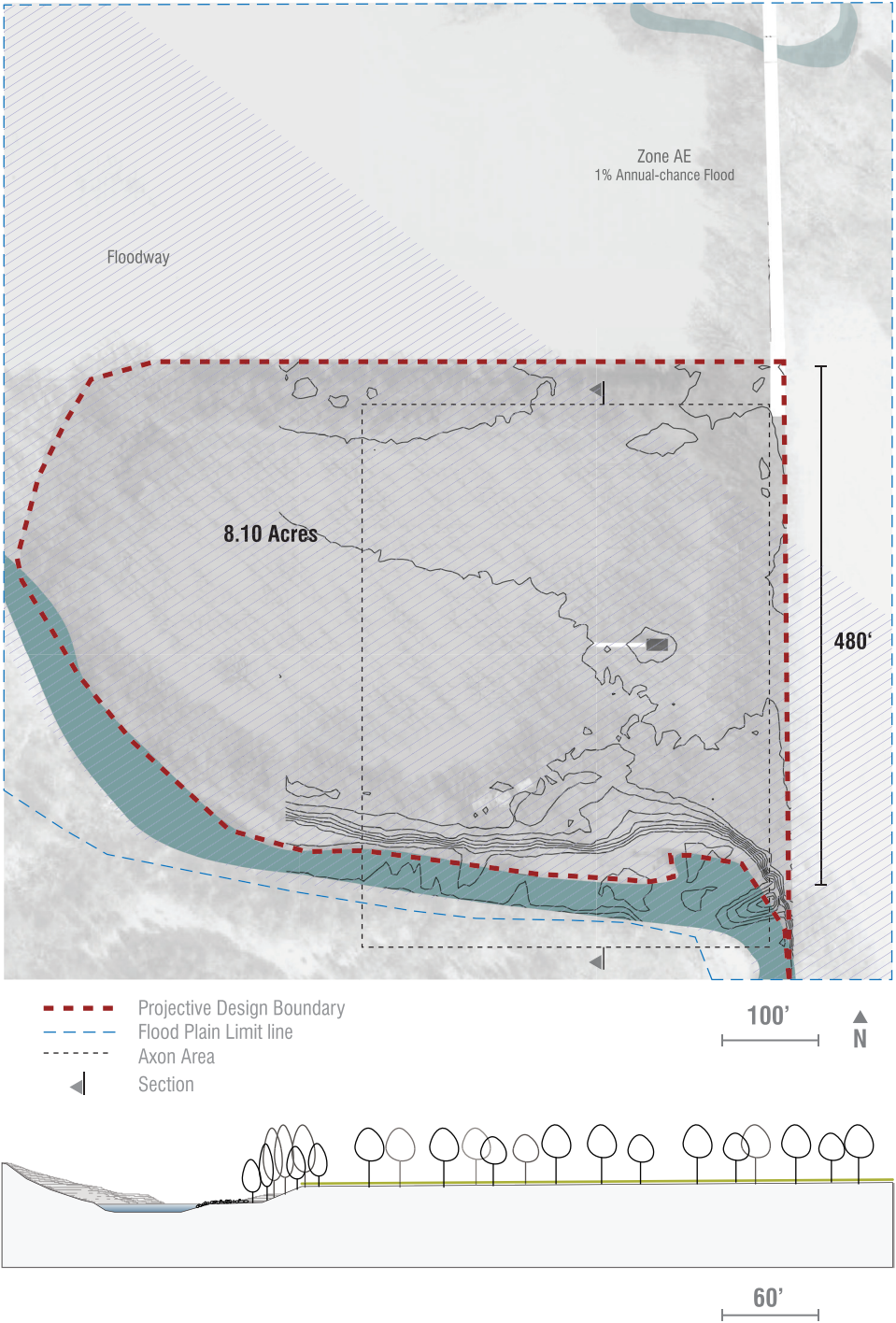


Figure 6.25
Wildcat Park site
photograph (Huang 2021)

Figure 6.24
Context of Wildcat Park
(Adapted from Google
Earth Pro 2022)

Figure 6.26
Wildcat Park Site Map
(Huang 2022, adapted
form Google Earth Pro
2022)

Figure 6.27
Wildcat Park Section
(Huang 2022)



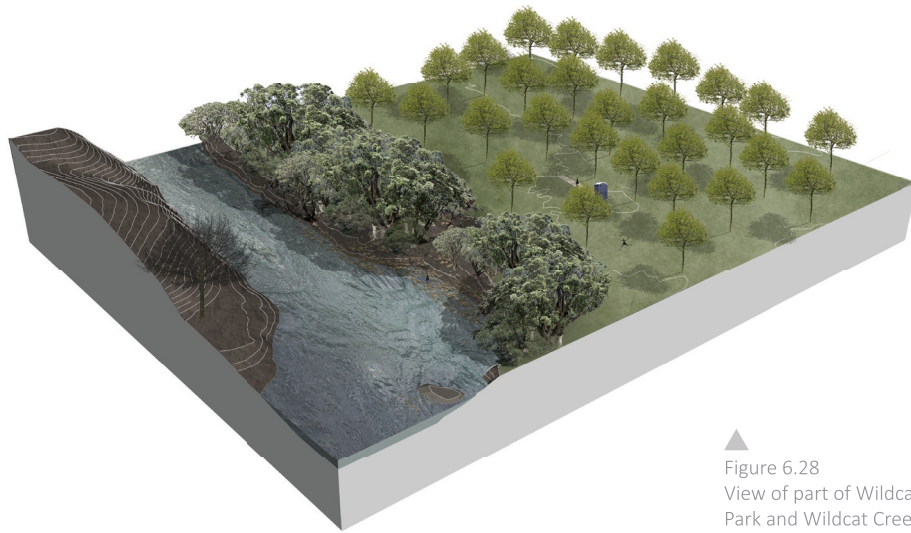


Figure 6.28
View of part of Wildcat
Park and Wildcat Creek
(Huang 2022)

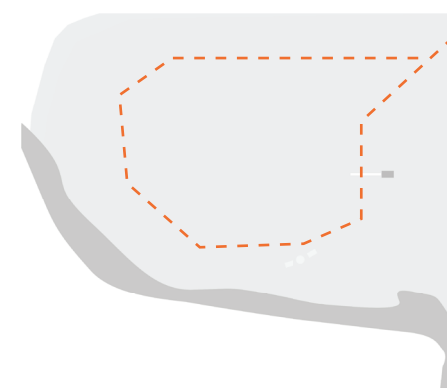
Site Existing Conditions

The project site has no clearly defined circulation, only a single gravel path connecting parking to the site, as shown in Figure 6.29. Besides, all vehicles are prohibited from entering Wildcat Park. From the park, one can hardly see the creek except for walking down an unpaved ramp slope to access the water, which is steep and not accessible to all individuals.

The planted ground and largely tree canopy of Wildcat Park make it an ideal spot for camping and picnicking. There are also restrooms and fire rings for people who intend to picnic and camp here. With a dense vegetation barrier and tall trees planted in the middle, the site offers many opportunities for recreational and educational activities.

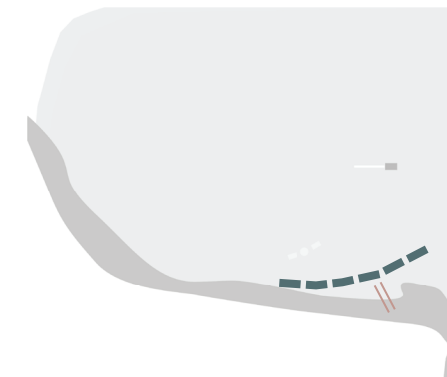
The creekbank is slowly eroding due to the water flow. Many trees on the bank are now obscuring. To reduce the negative impact of fast-flowing water on the bank, pebbles and boulders are placed on the toe of the bank. The slope of the bank on site is very steep, and some of the spots show a slope of more than 60%. The bank slope of the section shown in Figure 6.27 is 39%.

Figure 6.29
Site inventory Diagram
of Wildcat Park (Huang
2022)



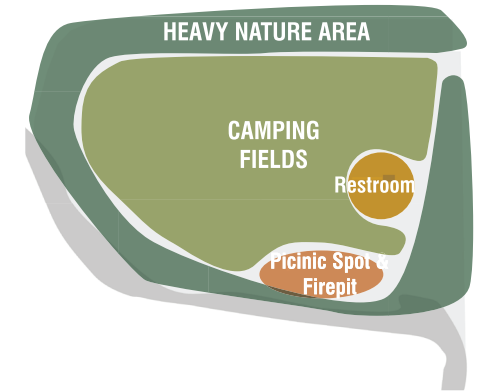
Existing Circulation

- Defined Circulation
- - - Pedestrian Circulation
(No Defined Circulation)

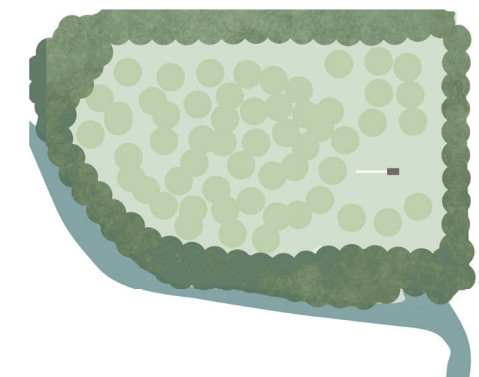


Existing Creekfront Accesses

- - - Access along the edge
- Access cross the water

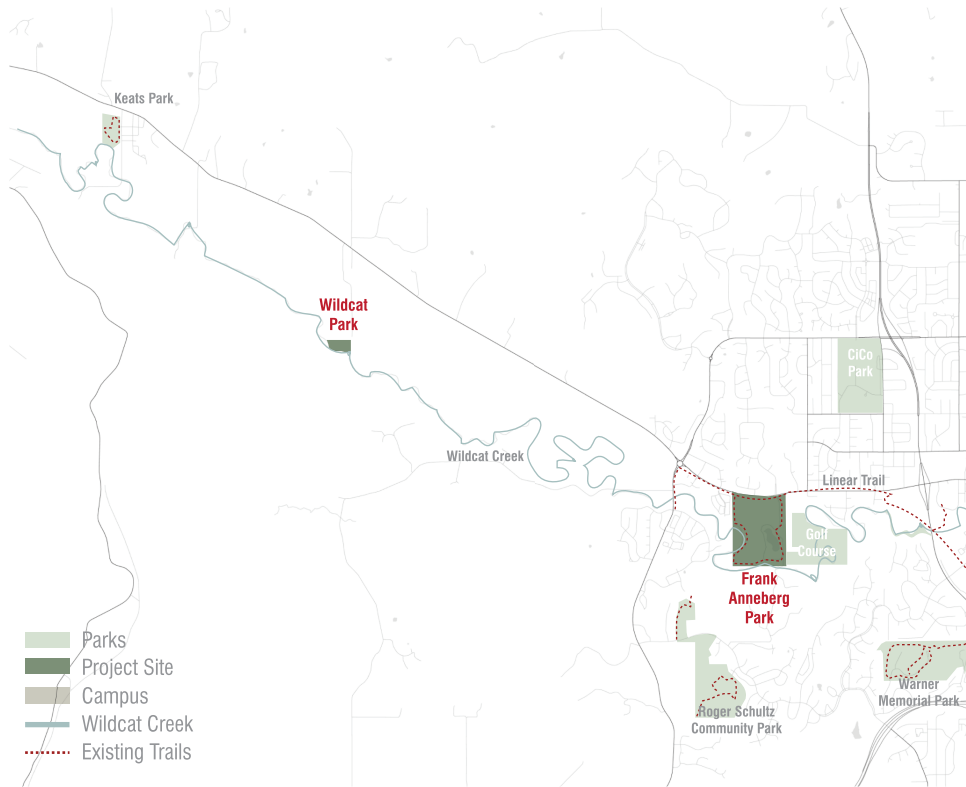


Existing Programs



Existing Softscape

- Turf grass
- Trees
- Tree covered area
- Creek



Potential Connections

The site analysis of Wildcat Park reveals that there are no existing connections between Wildcat Park and its surrounding areas. However, the location of Wildcat Creek indicates that it has potential links to other parks along Wildcat Creek. As shown in Figure 6.30, Keats Park, Wildcat Park and Frank Anneberg Park are all adjacent to Wildcat creek, so a connection could be established between these three parks. The design of Wildcat Park will take into consideration the establishment of a trail that runs along the creek.

▲ Figure 6.30
Potential connections
of Wildcat Park (Huang
2022, image base
generated from Snazzy
Maps)

▶ Figure 6.31
Wildcat Park Site
Inventory Checklist Form
(Huang 2022)

SITE INVENTORY - Wildcat Park

Site Location (Boundaries)		2019-2025 W 62nd Ave, Manhattan, KS (Boundaries see Figure 6.26)	
Site Dimensions (Size)		About 8.10 Acres, horizontal distance from creek to boundary is 480'	
Site Context ***			
Development Degree	☐ Developed	☒ Undeveloped	
Materials	☐ Largely Paved	☒ Largely Vegetated	
Land Use	☐ Residential / Playground	☒ Nature park	
	☐ Street/Business Area	☐ Farmland	☐ Other
Buffer Zone	☐ Fewer buffer zones	☒ Plenty buffer zones	
Usage	☐ High Usage	☒ Low Usage	
Existing Creek Access***			
Physical access (see Figure 6.29)	☐ Along the edge	☒ Near the edge	
	☒ Into the water	☐ No	
Visual access	☐ Yes _____ (Where) _____	☒ No	
Activities***	Recreational Activities: Family/ friend gatherings, Picnicking, Camping, Viewing and photographing human and nature, Walking, Game, Yoga, Educational Activities: Observing aquatic/land wildlife and habitat, Drawing, Game for leaning, Collecting		
Circulation Routes			
Types	☐ Yes _____	☒ No	
Locations	☒ Prepare a map/plan (see Figure 6.29)		
Topography			
Site Topography	☒ Topography Map (see Figure 6.26)		
Bank Slope	☐ General Sloping	☐ Steep	☒ Very Steep
	☐ Flat		
Ecological Issues *			
Types	☒ Yes (Erosion, Sedimentation, Poor water quality, Flooding, simple habitats, other)		
	☐ No		
Treatments (if any)	Erosion: Boulders, Pebbles		
Creekside Vegetation			
Plants Species (Using APP for help)	☒ Dominant Species (Ash tree, Oak tree)		
	☐ Invasive Species (where)		
Potential Connections			
Existing & Future Surrounding elements	☒ Trails ☐ Parks ☐ Schools ☐ Zoo ☐ Plaza/Squares		
	☐ Public Transportations ☐ Communities ☐ Other		

DESIGN TYPES AND TREATMENTS SELECTION – Wildcat Park



Figure 6.32
Design type selection
for Wildcat Park (Huang
2022)

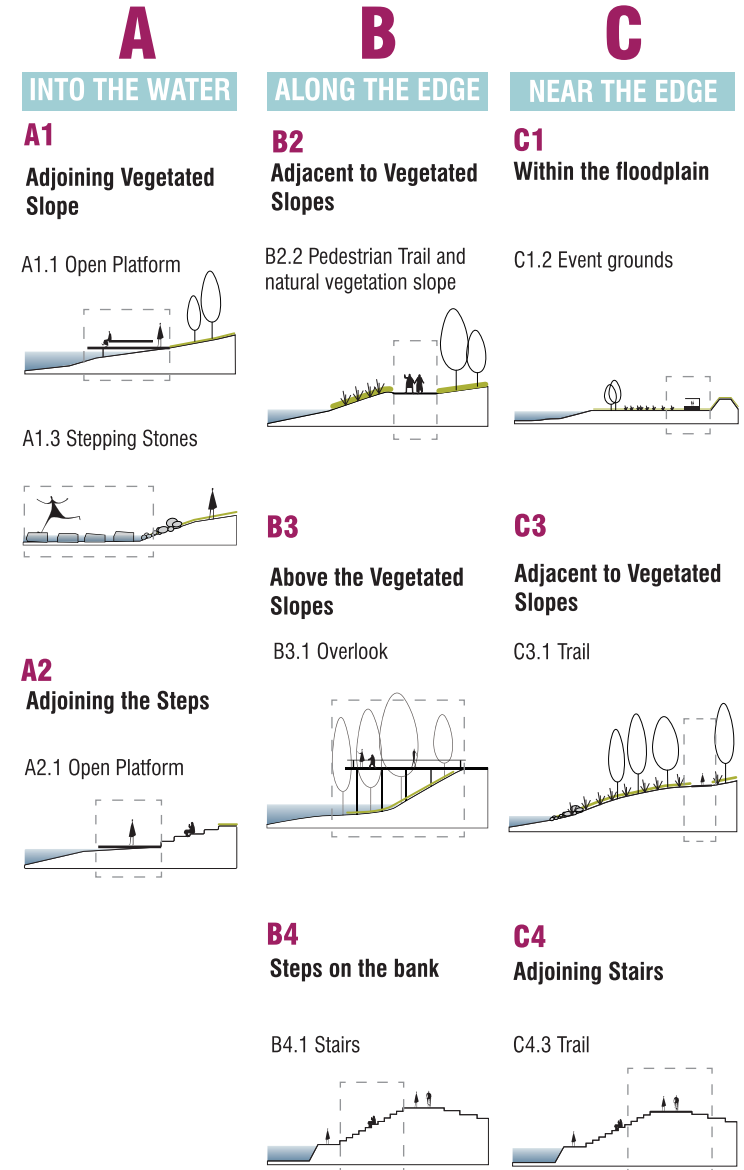


Figure 6.33
Design treatment
selection for Wildcat Park
(Huang 2022)

According to the guidelines in chapter 5, design types were selected which could be applied in different locations after analyzing the site. Analyses of the site indicate that Wildcat Park is situated in an area of underdeveloped nature. Therefore, all of the design types used in Wildcat Park are inclined toward natural types, and they are A1, A2, B2, B3, B4, C1, C3, C4. From each treatment type, at least one treatment was selected (Figure 6.33) using the design type as a guide. In the selection of design treatments, activities offered by the treatment and its design were the primary considerations.

DESIGN ARRANGEMENTS

Nine design treatments were chosen, and they were arranged based on topography, existing design, and the designer's preferences. Landing treatments such as open platforms and overlook platforms are scattered across the site. These are connected by connection treatments such as trails along the creek. The diagram of the treatment arrangement for Wildcat Park (Figure 6.34) illustrates the positions and placements of selected design treatments on the site.



Figure 6.34
Design treatments
arrangement for Wildcat
Park (Huang 2022)



Figure 6.35
Proposed Wildcat Park
Creekfront Area Master
Plan (Huang 2022,
adapted from Google
Earth Pro 2022)

Recreational Activities

- G Family/friend gatherings
- C Camping
- P Picnicking
- V Viewing and photographing human and nature
- W Walking
- J Jogging
- B Biking
- CA Game
- Y Yoga

Educational Activities

- OA Observing aquatic wildlife and habitat
- OL Observing land wildlife and nature
- D Drawing
- G Game for learning
- M Measuring
- C Collecting

Figure 6.36
Wildcat Park Existing
aerial imagery and
context (Google Earth Pro
2022)



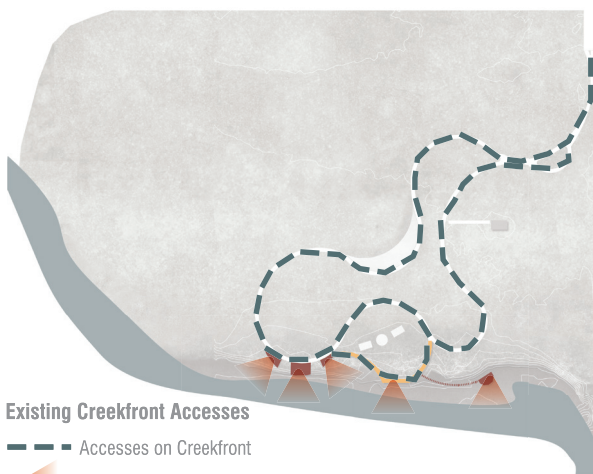
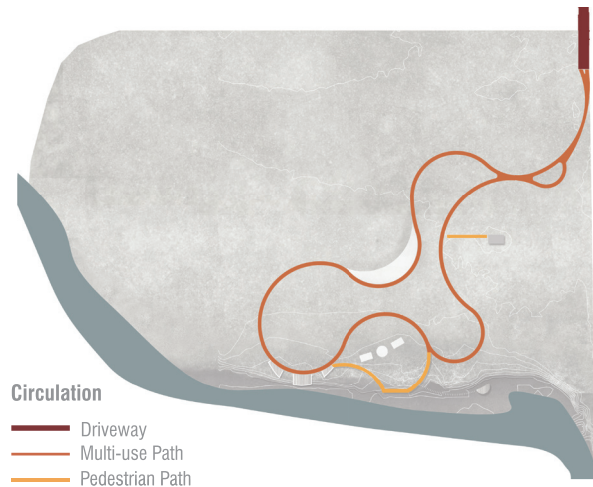
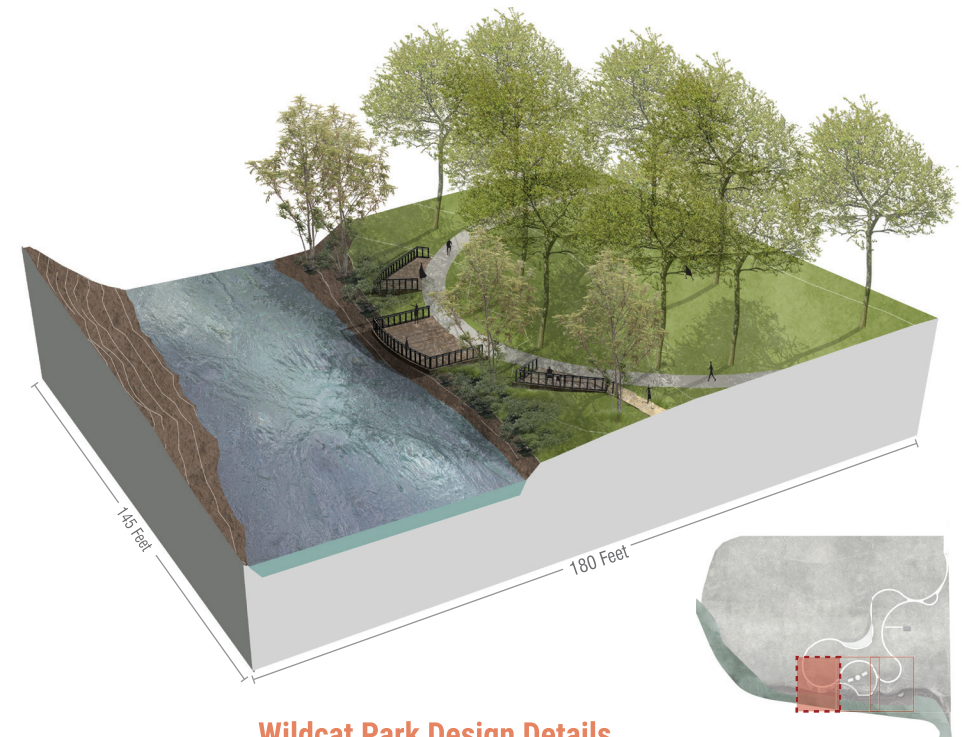


Figure 6.37
Diagram of Proposed
Wildcat Park design
(Huang 2022)



Wildcat Park Design Details

In the post-design analysis diagram in Figure 6.37, it can be seen that more paved trails were added to Wildcat Park, as well as three additional means of accessing the creek while retaining a large number of existing plants.

The diagram on this page depicts the three overlook platforms connected to the trail (Figure 6.38). The intention of this design is to provide visual access for visitors to Wildcat Creek. Along with the original camping capabilities of Wildcat Creek, this platform can be utilized for picnics and gatherings.

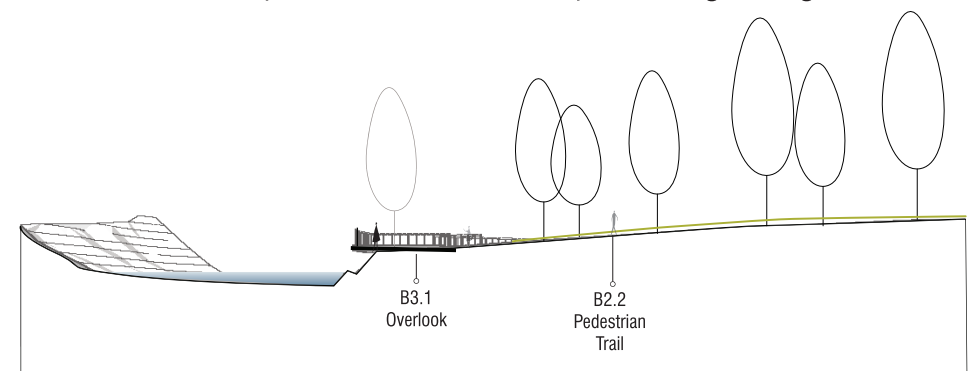


Figure 6.38
Three Overlook Platform
and pedestrian trail,
showing by axon view,
location key map and
section (Huang 2022)

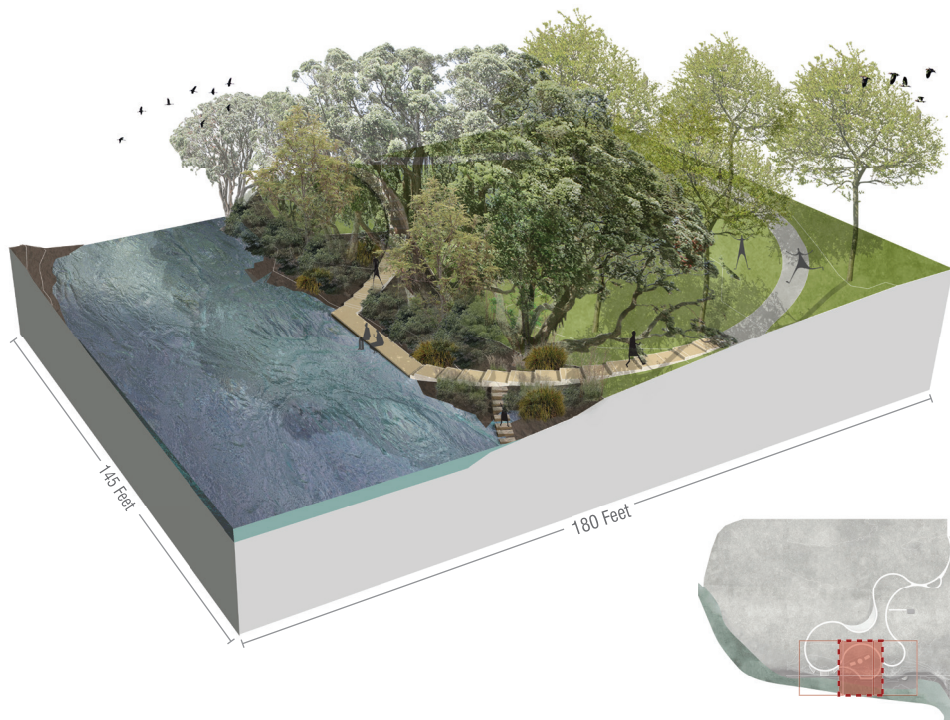


Figure 6.39 shows a design of an open platform that connects to stairs on both edges. This platform allows visitors to sit along the edge and play with water. Instead of the steep slope of the original project site which was unpaved, stone stairs will offer better accessibility.

Figure 6.39
Open platform and stairs connecting to trail, showing by axon view, location key map and section (Huang 2022)

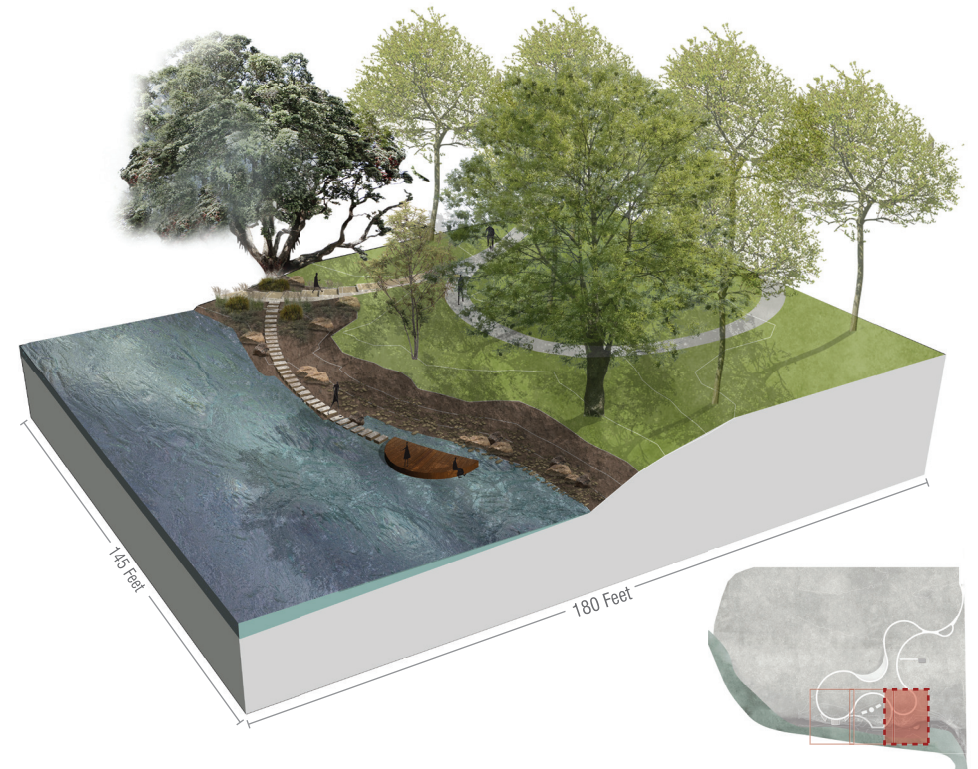
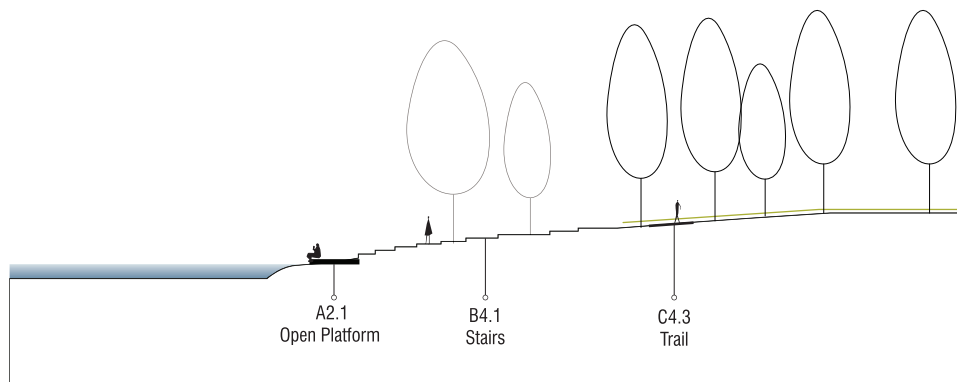


Figure 6.40
Into-water platform and steppingstones, showing by axon view, location key map and section (Huang 2022)

Figure 6.40 illustrates a platform and steppingstones that connect to stairs. This platform provides visitors with a greater amount of space compared to another one, which provides an opportunity for a picnic or a lie-down. During the unflooding period, educators could also bring their students here to observe and learn about aquatic habitat. Several boulders have been placed to help protect the bank from water erosion.

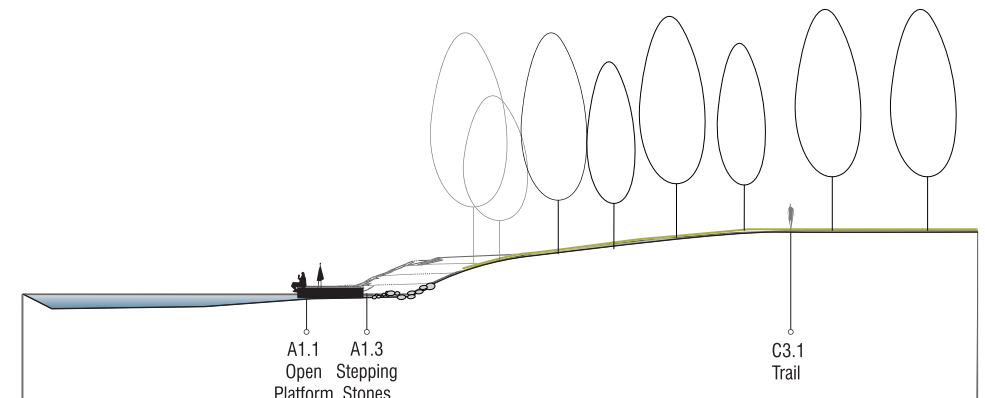




Figure 6.41
Wildcat Park Creekfront
Design perspective
(Huang 2022)



07

CONCLUSION

CONCLUSION

As an important component of the natural environment, creeks play a much more significant role than is generally recognized. The impact of creeks on human life and the natural environment has always been significant. Compared to rivers, creeks are more widespread and more numerous, but they are subject to a greater amount of development restrictions, which contributes to their poor accessibility. And this also shows the importance of creek and creekfront development. Consequently, it is important to develop creeks and creekfronts. Further, human closeness to nature and a need for outdoor activities contribute to the development of outdoor spaces. Thus, this report explores how to combine nature-based activities in order to activate the important creekfront area.

Through a study of existing literature, design guidelines, and precedent projects, overlapping information related to creek and nature-based activities was identified, and connections and patterns between outdoor nature-based activities and design were discovered. Combining these findings with information from the literature regarding the problems faced by creekfront and the history of creekfront development produced a design guide for activating creekfront areas with nature-based activities as a key factor.

A program will be accompanied by corresponding activities, whether they are recreational or educational. In organizing site-adaptable access design treatments that satisfy different use functions while integrating environmental resilient strategies, a creekfront design can be realized with nature-based functions programs as well as flood resistance.

The primary outcome of the study was the creekfront activation design guide, informing designers and communities of implementable, participatory, and inspiring creekfront design related information. The creekfront activation design guide was intended to summarize research findings and provided an introduction to developing creekfront areas, as well as to draw public attention to the creek and the creekfront. While this guide was well-informed by literature reviews, precedent studies, and two projected design applications, it could be further enhanced by peer review and real-life application.



APPENDICES

APPENDICES - A

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APPENDICES - B

Glossary

Accessibility A term to describe the opportunity to approach, enter, and interact. It also reflects the ease of travel between two points in space. (Tasic et al. 2014)

Alluvium "Any material deposited by running water; the soil material of floodplains and alluvial fans." (Marsh 2010, 484)

Bioengineering The construction methods or materials allow replicating the natural system quality and capabilities of organic matter (Riverlife 2014).

Buffer "The zone around the perimeter of a wetland or lake use activities are limited in order to protect the water features." (Marsh 2010, 485)

Creek A term used to describe a smaller sized stream, although sometimes the terms creek and stream are used interchangeably. creek in this work refers to the watershed that does not exceed 30 m (98 feet) in width.

Creekfront A term used to describe an area where land meets a creek, it also refers to the edge of the creek.

Discharge "The rate of waterflow in a stream channel; measured as the volume of water passing through a cross-section of a stream per unit of time, commonly expressed as cubic feet (or meters) per second." (Marsh 2010, 486)

Drainage basin The drainage basin is the area from which water enters the drainage network, and, for a given set of geographical conditions, the size of the main channel and its flow increases with the size of the drainage basin (Marsh 2010).

Erosion "The removal of rock debris by an agency such as moving water, wind, or glacier, generally, the sculpting or wearing down of the land by erosional agents." (Marsh 2010, 487)

Fiber Roll An erosion-prevention device consisting of a cylinder of nonwoven fiber produced from coconut husks and wrapped in a woven rope or mesh of coconut fibers installed along the streambank toe. (City of Chicago 2019).

Gabion Rectangular wire baskets filled with stones to protect embankments from erosion (Prominski et al. 2012).

Grayness A structure constructed at right angles to the stream bank with stone, concrete, or wood to decrease the negative impact of water flow on the bank by diverting the current away from the bank. (Prominski et al. 2012).

Land use "The human activities that characterize an area, for example, agricultural, industrial, and residential." (Marsh 2010, 489)

Nature-based Education Nature-based education can also be referred to as nature-based environmental education, which is usually defined as a set of practices, tools, and programs used in nature to promote ecologically responsible attitudes, values, awareness, and knowledge that will enable people to actively protect environmental quality (Ardoin et al. 2020).

Nature-based Recreation Nature-based recreation, also known as outdoor recreation, refers to activities that occur on natural surfaces or directly involve elements of nature, such as terrain, plants, wildlife, or water (Cordell 2008).

Resiliency Resiliency is the ability to overcome adversity (Marselle et al. 2019). Sometimes it can also be understood as adaptive capacity.

Retention Basins A basin or reservoir that temporarily stores water to reduce peak discharges (Prominski et al. 2012).

Rip Rap A layer of angular stones installed on the streambank serves as an erosion-prevention measure (City of Chicago 2019)

Riparian "A reference to the environment along the banks of stream; often more broadly applied to the larger lowland corridor on the stream valley floor." (Marsh 2010, 493)

Riverbank "Sides of a river, the transitional area between watercourse and foreland." (Prominski et al. 2012, 293)

Riverbed "Bottom of the river, ground over which the water flows." (Prominski et al. 2012, 293)

Setback "A term used in site planning to indicate the critical distance that a structure or facility should be separated from an edge." (Marsh 2010, 494)

Sinuosity "A measure of the curviness of a stream channel; the ratio of channel length to the length of the meander belt axis." (Marsh 2010, 494)

Stream order "The relative position, or rank, of a stream in a drainage network. Stream without tributaries, usually the small ones, are first-order; streams with two or more first-order tributaries are second-order, and so on." (Marsh 2010, 495)

Terraced Revetment A bank reinforcement method, commonly made of stone and constructed as steps or seats providing a place to rest or linger directly on the waterside (Prominski et al. 2012).

Vegetated Soil Lifts A bank protection method involves fabric wraps around soil layers containing native plants that are seeded and planted (City of Chicago 2019).

Vegetated Swale A vegetated sunken or marshy area which slows down stormwater flow and removes soil particles through buffer zones (Riverlife 2014).

Watershed A watershed refers to the surface water that drains into a given stream, river, lake, or wetland (Otto 2004).

Wetland "A term generally applied to an area where the ground is permanently wet or wet most of the years and is occupied by water-loving (or tolerant) vegetation." (Marsh 2010, 497)