

**Post-occupancy Evaluation of the Chicago Riverwalk
Final Report**

Ho Hsieh, Xuehan Li, Shui Wang, Yifei Wu

Client: Sasaki

Secondary client: Friends of the Chicago River

Advisor: Allen Burton, Victoria Campbell-Arvai, Mark Lindquist

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Abstract

This study focused on evaluating how Sasaki has implemented the design goals for the Chicago Riverwalk mainly from social and ecological perspectives. The Chicago Riverwalk is composed of six blocks. In order to establish new connections to the river and enrich people's life, each block was designed to provide diverse programs through changes in its shape and form. The Post-Occupancy Evaluation (POE) was conducted by mixed methods, including on-site survey, observation, expert interview and river sediment. The results indicate that goals in the theme of recreational and cultural were achieved very well. Goals in the theme of ecological may not be achieved as expected; however, people's perception of ecological environment especially the aesthetics of the terrestrial and floating wetland vegetation design was good. Finally, shortcomings of the design relative to the design goals and recommendation for future post-occupancy evaluation project are discussed.

1. Introduction

It is important to evaluate the success of landscapes to inform future design, however, most projects are not evaluated effectively in terms of whether and how well the design goals are being met despite the fact that many design goals are identified during the pre-design and design stages of a project (Landscape Performance Series (LPS), 2014). Post-Occupancy Evaluation (POE) functions to inform future design process and enhancing landscape performance based on the opinions from landscape architects who have done POE (LPS, 2014). Therefore, the client Sasaki, who has provided services across architecture, interior design, planning, landscape architecture, etc. over 60 years and completed various design projects with different focus, such as urban experience, campus, resilient system (Sasaki, n.d.), asked the team to conduct a POE for their Chicago Riverwalk project to help them understand whether the design goals were achieved and how their design strategy could be improved. Sasaki also hoped that the POE work the team did could work as a precedent for other design projects in their office. Over the last decade, the Chicago River has been developing with the Chicago Riverwalk project and offered lots of ecological, recreational and economic benefits for the city.

1.1 The Environment and History of the Chicago River

Since the early settlement, the main branch of the Chicago River has been development-focused. To satisfy commercial navigation, effluent disposal, and flood control, the Chicago River waterway was widened and deepened, its flow was reversed, and the river mouth was modified from 1816 to 1939 (LimnoTech 2010). Any realistic opportunity to undo these engineering would cause major social and economic impacts (LimnoTech 2010).

Before the intense urbanization and sewer system development, the Chicago Lake Plain was

mostly poorly drained and swampy (Chicago Public Library 2000, Illinois DNR 2000). The flow of the Chicago River waterway was reversed in order to diverge the polluted river water away from Lake Michigan to the Gulf of Mexico (IDNR 2000) (*Figure 1*). Before the reversal, the flow of the South and North Branch of the Chicago River converged at the Main Branch and flowed into Lake Michigan. In 1848, the Illinois-Michigan Canal was constructed to connect the South Branch of the Chicago River to the Mississippi River and finally to the Gulf of Mexico (IDNR 2000). To create the reversal of the water flow, pumps were operated at where the South Branch and the Illinois-Michigan Canal connected. The pumps create a constant flow that pulled the water from Lake Michigan to the South Branch (Egan, J.A. 1901). In order to accommodate the City's increasing sewage and commercial navigation needs, the Chicago Sanitary and Ship Canal (CSSC) was constructed in 1900 to replace the Illinois-Michigan Canal (IDNR 2000). The North Shore Channel was constructed in 1907 to aid the reversal (IDNR 2000).

There is very little information available regarding the evaluation of improving aquatic habitat in a highly constructed and modified waterways (LimnoTech, 2010). Most of the project along the Chicago River waterways were aiming at improving the recreational aspects or to stabilize river bank as of 2010 (LimnoTech 2010).

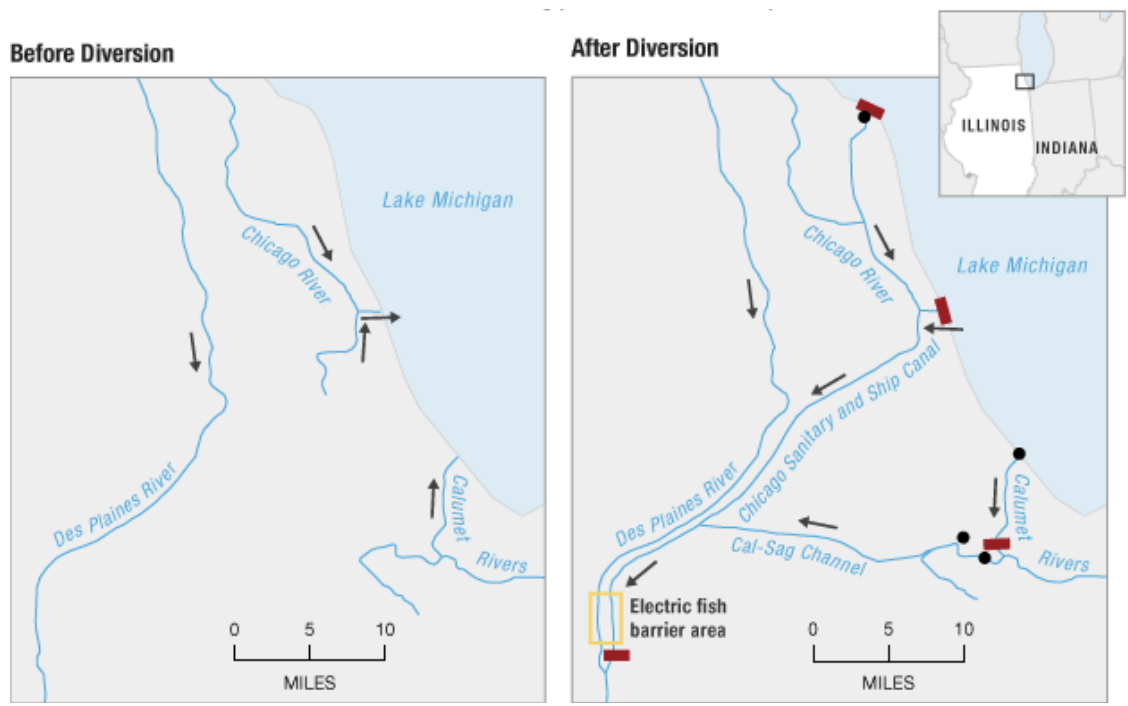


Figure 1: Chicago River Water flow (USGS)

1.2 The Chicago Riverwalk

In 1926, Daniel Burnham, an architect and urban planner, established Wacker Drive viaduct to increase the riverside promenades (Sasaki website, 2015). Over the last decade, the river has been developing (*Figure 2*) because of the Chicago Riverwalk, which adds more ecological,

recreational and economic benefits into Chicago (Sasaki website, 2015).

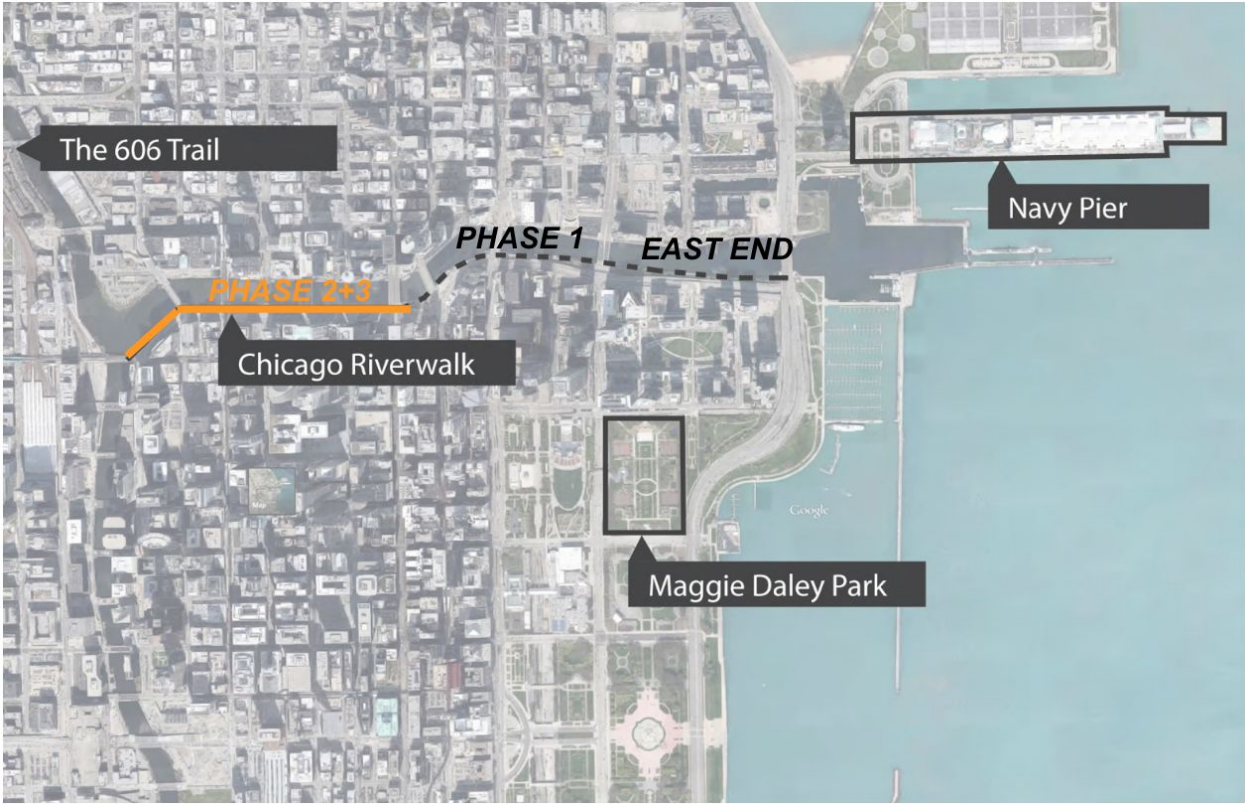


Figure 2: The location of Chicago Riverwalk (Sasaki's website)

1.3 Sasaki's Chicago Riverwalk

Sasaki's Chicago Riverwalk (Figure 3) along the main branch of the Chicago River offers a continuous under-bridge walkway and recreational amenity that connects the heart of downtown to the lakefront (Sasaki Associate. Inc. (Sasaki), 2011). Its construction started in 2011, of which the Marina Plaza, Cove, and River Theater block opened in June 2015 and the Swimming Hole, Jetty, and Boardwalk block opened in October 2016 (Sasaki Associate. Inc. (Sasaki, 2011).

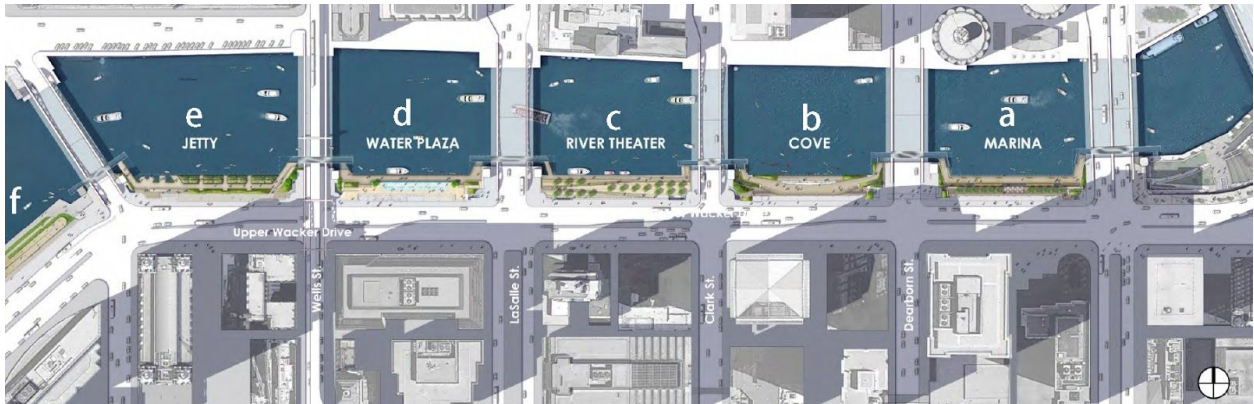


Figure 3: Phase 2 and Phase 3 of Chicago Riverwalk (Landscape Architecture Magazine Mar. 2017)

Sasaki's Chicago Riverwalk is composed of six blocks. In order to establish new connections to the river and enrich people's life, each block was designed to provide diverse programs through changes in its shape and form (Sasaki website). These blocks include: (Plate 1)



Plate 1: Six blocks (from left to right is a,b,c,d,e,f. And a,b,c,e are from Sasaki Website, d,f are from the team)

a. The Marina Plaza: It consists of restaurants and outdoor seatings to provide views of vibrant life on the river, including passing barges, patrols, water taxis, and sightseeing boats.

b. The Cove: It is the intermediate zone between land and water with concrete benches and beachgrasses. It provides physical connections to the water through Kayak rentals and docking for human-powered crafts .

c. The River Theater: It is a block-side amphitheater-like sculptural staircase linking Upper Wacker and the Riverwalk with an accessibility ramp. It offers pedestrian connectivity to the river's edge and seating with the greenery and shade by trees.

d. The Water Plaza: It is a space of water feature as splash pad for children and families to engage with water at the river's edge.

e. The Jetty: It consists of piers and floating wetland. It offers an interactive learning environment about the ecology of the river, including opportunities for fishing and identifying native plants. Fish LUNKERS, fish caisson/pole curtains, fish limnetic/pontoon curtains, submergent planting frames and the floating wetlands, were built at “the Jetty” section of the Chicago Riverwalk. Referenced primarily from a case of the Port of Rotterdam, Netherland and the fish hotel built by the Friends of the Chicago River, these constructed fish habitats and floating wetlands were designed to enrich the aquatic life (the sessile organisms, macroinvertebrates, and fish) in the heavily modified Chicago River and to provide a space for ecological experimentation and education (Sasaki, 2014, Paalvast et al, 2012, Friends of the Chicago River 2005).

f. The Riverbank: It is an accessible walkway access to Lake Street.

2. Methods

2.1 POE Conceptual Model

We referenced the post-occupancy evaluation framework established by Wolfgang Preiser in 2002 (*Figure 4*). The three evaluation phases of the project mainly corresponded to the “planning”, “conducting”, and “applying” processes in Preiser’s framework. Also, we inherited the use of objective evaluation methods and acknowledged the importance of quantitative methods emphasized by current landscape evaluation standards LPS.

Building on these previously developed framework, we further underscored the importance of understanding users’ perception in the post-occupancy evaluation of landscape design. Supplementing the secondary data analysis, observational study, and field eco-assessment, the use of surveys and interviews were utilized in the study. Also, we tried to bridge the often isolated portions of an evaluation. For instance, to connect the evaluation of safety to ecological benefits, we tried to understand if people were aware of the ecological benefits of a design and if this awareness affected their perception of safety in the landscape. Additionally, for the second goal of the project, we included recommendations part in the evaluation report as to inform “adaptive management” and to “support future project”. This part of the report highlighted missed opportunities and room for improvement in the evaluated design suggested by the analysis. Potential recommendations will be offered for the Chicago Riverwalk as well as future landscape projects with similar design goals. At last, for the third project goal, the team generated potential recommendations for future post-occupancy evaluation projects in Sasaki.

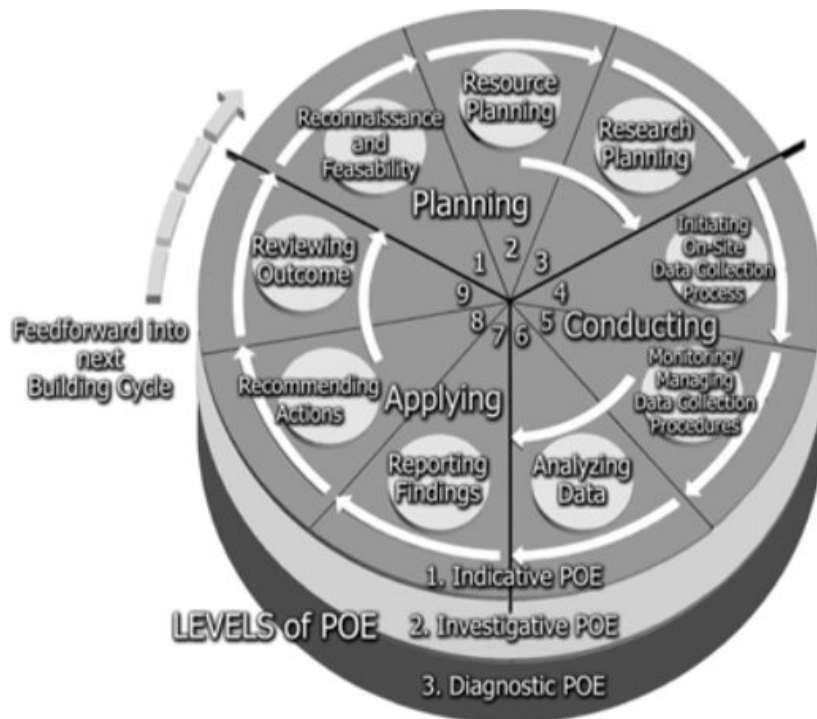


Figure 4: Post-occupancy evaluation framework (Preiser, 2002)

2.2 Research Area

In order to define research areas and develop a pertinent evaluation framework for the Chicago Riverwalk, we revisited the process by which the Sasaki Chicago River team developed the design goals. As stated in the Chicago Riverwalk 10% design report, volume 1, the Sasaki Chicago Riverwalk team defined four themes of concern -- economy, recreation, culture, and ecology, in which each theme includes four specific objectives, as the goals for the Chicago Riverwalk design by reviewing and analysing ideas and suggestions regarding to the specific section of the River from various agencies (Sasaki Associate. Inc. (Sasaki), 2011). To more deeply understand the context in which the objectives are generated and the specific meaning of each objective, the SEAS team carefully reviewed five available previous studies that are included in the documents referenced by the Sasaki Chicago Riverwalk team. The five previous studies are: Chicago River Master Plan from the Chicago Parks District (2002), the Chicago Riverwalk Agenda from the Mayor's Office (2005), the Action Plan for the Chicago River from the Friends of the Chicago River (2007), the Central Area Action Plan from the Department of Planning and Development (2009), and the Chicago Riverwalk Framework Plan from the Chicago Department of Zoning and Planning (with Skidmore, Owings & Merrill LLP) (2009). We then reconstructed the detailed description for each objective as to build a thorough scenario to develop appropriate evaluation criteria.

We focused on evaluating 11 of the 16 objectives across the four themes of the design (Table 1). 3 objectives in the economic theme (maximize leasable opportunities, activate space along the River, and support commercial boating activity) were excluded from the study considering

the composition of expertise of the team and time limitation, 1 objective in the cultural theme (embrace the site's history) and 1 objective in the ecological theme (use building sustainable strategies) were excluded from the study considering the composition of expertise of the team and time limitation.

Specific description and the evaluation methods for each of the 11 objectives are elaborated below (*Table 1*). Generally, with the thorough scenario in mind, we focused on answering the following general questions for each objective:

- 1) Is the objective being addressed? How do the objectives being implemented?
- 2) How do people perceive Chicago Riverwalk in terms of these stated objectives?
- 3) Is there any missed opportunity in the Riverwalk design?

Table 1: The three themes and 9 objectives that will be focused on for evaluation in the study

Theme	Objectives
Economic	Improve Perception of Safety
Recreational	Create a Continuous Public Walkway
	Increase Recreational Boat Activity
	Provide more Public River Uses
	Improve Vertical Circulation
Cultural	Create Diverse Gathering Spaces
	Celebrate the River's Uniqueness
	Enhance Community Life
Ecological	Restore Aquatic Habitat
	Cultivate Terrestrial Habitat
	Improve the Water Quality

For the economic, recreational, and cultural goals, on-site survey and observation were used for the evaluation. For ecological goals, three of them were selected for evaluation: Restore aquatic habitat, cultivate terrestrial habitat, and improve the water quality. No data exist to evaluate the "before" status as related to the vegetation design, floating wetlands, and constructed fish habitat. Therefore, the team chose to conduct expert interviews to understand their opinions on these elements of the overall design and their potential ecological benefits. The opinions of CRW visitors were also surveyed regarding the local environmental quality. An extensive literature review was conducted to ascertain if any water, sediment, or aquatic biota studies had been done on the Chicago River in the vicinity of the Chicago River Walk (CRW). Most studies

have been conducted by the City of Chicago's Metropolitan Water and Wastewater Reclamation District. Unfortunately, the river stations where they have collected data for decades are not adjacent to the CRW. The nearest river stations have revealed a relatively degraded aquatic ecosystem with chemically contaminated sediments. However, the water quality and fish species have been improving in the past few years due to improved wastewater treatment, capture of stormwater runoff, and the closing of Combined Sewer Overflows (CSOs). Sediments toxicity tests were used to better understand the current environmental quality Chicago River adjacent to the CRW.

So a "weight-of-evidence" (WoE) approach was used to evaluate whether the three ecological goals were attained due to the CRW design. The assessment methods comprising this WoE approach were: 1) Expert interviews, 2) Sediment toxicity tests, 3) Sediment toxic metals analyses, 4) Literature review, and 5) Visitor survey

2.3 On-site Survey

The on-site survey focused on types of visitors, activities of visitors and their perception about the Chicago Riverwalk. The survey, composed of a mix of 20 multiple choice (eg. What did you do (or plan to do) along the Chicago Riverwalk today?) and 5 open-ended questions (eg. In one sentence, can you tell me what you appreciate or enjoy most about the Chicago Riverwalk?), was conducted for adults (18 years or older) at the Chicago Riverwalk. The survey questionnaire is included in Appendix C. We employed intercept sampling to select participants to survey, e.g., intercepting people at the Chicago Riverwalk and asking them to participate in the survey. Each respondent was assigned a numbered paper questionnaire. The survey took about 10 minutes to complete. Y.W., S.W., X.L., and H.H. distributed and collected all surveys.

To better carry out the survey, we first developed a standard "recruitment script" that all team members used when recruiting participants. The recruitment script is included in Appendix A.

Then we conducted the survey at the Chicago Riverwalk for different periods of time within 5 days. (*Table 2*)

Table 2: Survey distribution time

Date	08/17/2017	08/18/2017	08/19/2017	08/20/2017	08/21/2017
Time	9 am - 1 pm	10 am - 2:30 pm	2:30 pm - 7 pm	10 am - 2:30 pm	2:30 pm - 7 pm

We distributed 60 surveys at each block along the Chicago Riverwalk as it was composed of six blocks and totally got back 354 valid surveys. (6 invalid surveys were eliminated since more than half questions were not filled).

After getting all surveys back, we summary statistics, i.e., means and frequencies, were calculated.

2.4 Observation

The observation focused on the number and peak time of visitors at the Chicago Riverwalk. The observations were conducted between 9 am to 5:30 pm from August 23rd (Tuesday) to August 29th (Monday) 2017. Basically, we counted for first 5 minutes of every 30 minutes for each block (eg: 9 am-9:05 am, 9:30 am-9:35 am, 10:00 am-10:05 am, etc.), recorded the number of people who entered, exited, passed in and stayed at the Riverwalk during that time. However, since block A and F are the beginning and the end of the riverwalk, people who passed in could be double counted as people who exited. Therefore, we only recorded the number of people who entered, passed in and stayed in block A and F to avoid this situation. (*Table 3*)

Table 3: Observation and counting protocol

BLOCK	ENTRY	EXIT	PASS_IN	STAY
A	People who enter from the road via stairs or another section of the Riverwalk into the block A within the first 5 minutes of every 30 minutes	--	People who enter from block B in the first 5 minutes of every 30 min. (People exit to road and other blocks of Riverwalk from block B)	People who have already been in the block A at the beginning of every 30 minutes
B-E	People enter from the road via stairs into each block within the first 5 minutes of every 30 minutes	People who exit to the road via stairs from each block within the first 5 minutes of every 30 minutes	People who enter from adjacent blocks into each block within the first 5 minutes of every 30 minutes	People who have already been in each block at the beginning of every 30 minutes
F	People who enter from the road via stairs into the block within the first 5 minutes of every 30 minutes	--	People who enter from block E in the first 5 minutes of every 30 minutes (People exit to road from the block F)	People who have already been in the block at the beginning of every 30 minutes

2.4.1 Variable

The following variables are used and calculated for the observation analysis: Entry, Exit, Pass by in, Pass by out and Stay.

2.4.2 Variable calculation

Block A (the Marina Plaza)

Assumptions (*Table 4*)

- 1) It is assumed that the population flow is stable in each of the 30-minute period. The ENTRY and PASS_IN flow of the 30-minute periods are estimated by multiplying the flow of the five-minute by six. The STAY of the 30-minutes period are assumed to remain the same as

that of the five-minute period.

- 2) Half of the ENTRY are from the road and the other half are from the neighboring Riverwalk designed by Ross Barney Architects.
- 3) Exit = ((people walk in from the Riverwalk of Ross Barney Architects) + (people walk in from block B))/2.
- 4) Pass by in (from the Riverwalk of Ross Barney Architects) = ((people walk in from block B)+(people enter from road))/2.
- 5) Pass by in (from block B) = ((people enter from road)+(people walk in from the Riverwalk of Ross Barney Architects))/2.

Table 4: Block A variable calculation

(every 30 min period)	Calculation
<i>Enter</i>	ENTER*6/2
<i>Exit</i>	ENTER*6/4 + PASS_IN *6/2
<i>Pass by in</i>	ENTER*6/2 + PASS_IN
<i>Pass by out</i>	ENTER*6*3/4 + PASS_IN/2
<i>Stay</i>	STAY

Block B (the Cove), C (the River Theater), D (the Water Plaza), E (the Jetty)

Assumption (Table 5):

It is assumed that the population flow is stable in each of the 30-minute period. The ENTRY, EXIT, and PASS_IN flow of the 30-minute periods are estimated by multiplying the flow of the five-minute by six. The STAY of the 30-minutes period are assumed to remain the same as that of the five-minute period.

Table 5: Block B/C/D/E variable calculation

(every 30min period)	Calculation
<i>Enter</i>	ENTER*6
<i>Exit</i>	EXIT*6
<i>Pass by in</i>	PASS_IN*6
<i>Pass by out</i>	$STAY_{t_{avg}} + ENTRY_t - EXIT_t + PASS_IN_t - STAY_{t+1}$ <ul style="list-style-type: none"> • Data point with negative values are removed from the rest of the analysis
<i>Stay</i>	STAY

Block F (the Riverbank)

Assumptions (Table 5):

- 1) The population flow is stable in each of the 30-minute period. The ENTRY, EXIT, and PASS_IN flow of the 30-minute periods are estimated by multiplying the flow of the five-minute by six. The STAY of the 30-minutes period are assumed to remain the same as that of the five-minute period.
- 2) Exit = people walk in block F from block E
- 3) Pass by out = people enter block F from road

Table 6: Block F variable calculation

(every 30 min period)	Calculation
<i>Enter</i>	ENTER*6
<i>Exit</i>	PASS_IN*6

<i>Pass by in</i>	PASS_IN*6
<i>Pass by out</i>	ENTER*6
<i>Stay</i>	STAY

2.4.3 Analysis calculation

- 1) Vertical circulation are analyzed by calculating the sum *Entry* of the entire Riverwalk and comparing the average *Entry* at each block.
- 2) For horizontal circulation, the average number of blocks where visitors walked through per visit is calculated by $(\text{sum of } Entry + \text{sum of } Pass\ by\ in) / (\text{sum of } Entry)$. In addition, the average of $(Pass\ by\ in + Pass\ by\ out)$ at each block are calculated and compared.
- 3) For visitors' staying behavior, the average number of people stayed are analyzed by different time periods and different blocks. The average length of time people spent at the Riverwalk and at each block are also analyzed. The time spent by block are calculated by $x / (Exit + Pass\ by\ out)$ where $x = \text{average number of people staying} = Stay + (Entry + Pass\ by\ in - Exit - Pass\ by\ out) / 30$. The average time spent at the Riverwalk is calculated by summing up the time spent by block weighed by the number of people staying.
- 4) All observation analysis were conducted using R 3.4.3.

2.5 Expert interview

Six experts and organizations who advocate the Chicago River and of which the members use the Chicago River were selected for interview through internet searching. Snowball sampling was used to search for additional relevant interview subjects. Specifically, the interviewees were asked whether there are any other individuals or groups they would recommend we speak with about the Chicago Riverwalk area of the river. The interviews were semi-structured and contained questions regarding the experts' opinions on the environmental health and recreational opportunities of the Chicago River near the Chicago Riverwalk, the degradation of the Chicago River, previous ecological restoration or water quality improvement projects, potential ecological and water quality improvement strategies and the Chicago Riverwalk designed and constructed by the Sasaki Associate, Inc. (see Appendix X for the interview guideline). The interviews were conducted via phone or video call from August 2017 through January 2018. The recorded interviews were transcribed and qualitative analysis were conducted using NVivo 11.1.1.

2.6 River Sediment toxicity and metals contamination

2.6.1 Overview

All toxicity and physicochemical analyses were conducted in the Burton Ecotoxicology Research Laboratory at the School for Environment and Sustainability at the University of Michigan. Chicago River sediment testing was conducted to better understand the environmental quality of the Chicago River. Contaminated sediments can degrade the overall quality of a waterway, as they contaminate the benthic organisms living on the sediment and any fish that feed on them. When the sediments are resuspended they may also contaminate the water column and organisms residing there (Burton 1992; EPA, 2000; MWRD, 2013). Metals such as copper, lead,

nickel, and zinc are common contaminants in urban sediments, as they are used in many products, such as galvanized materials, tires, paint, brake pads, and in all municipal wastewaters and stormwater runoff (Burton and Pitt 2002). Metals tend to bind to silt and clay and settle onto bottom sediments in slow moving waters. There is a proportional relationship between water and sediment chemical concentration depending on various factors such as water hardness, pH and grain size etc. (Di Toro et al., 1990, 1991). Contaminated sediment not only pose a risk to the benthic species by direct exposure, but also negatively affect other aquatic organisms by bioaccumulation in the food chain and exposure to organisms in the overlying water (Burton 1992).

2.6.2 Sediment sampling

Sediment collections were October 20, 2017 with the assistance of the Metropolitan Water Reclamation District (MWRD) of Greater Chicago. One-liter bottles of sediment were collected from the Chicago River at four Ambient Water Quality Monitoring (AWQM) stations: station 74 (located at lakeshore), 100 (located in the vicinity of the Chicago Riverwalk), 46 (located at the upper/northern stream of the Chicago River), 39 (located at the down/southern stream of the Chicago River) (MAP). (*Plate 2*)

A Petite Ponar Peterson was used to collect the sediment sample. The samples were handled and stored following the EPA methods (EPA, 2000). An underwater camera was used to observe fish around and below the floating wetlands at The Jetty block of the Riverwalk. (*Plate 2*)

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Plate 2: Water Sampling Process in August 2017 (from team)

2.6.3 Chemical analyses

Sediment samples were analyzed for trace metals (Cr, Cu, Fe, Mn, Ni, and Zn) using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) following digestion. Metal concentration results were interpreted using the Screening Quick Reference Tables (SQuiRTs) for inorganic chemicals in freshwater sediment (Buchman, 2008). The SQuiRT lists multiple sediment concentration thresholds for determining if sediments are likely to be toxic. The toxicity of metal concentrations above sediment thresholds referred to as Probable Effects Concentrations (PEC) and Threshold Effects Concentrations (TEC) suggest adverse benthic effects are likely or possible, respectively (*Table 22*) (MacDonald et al., 2000).

2.6.4 Toxicity testing

Hyaella azteca (7 day survival) was used for evaluation of sediment toxicity. *H. azteca* is a commonly used toxicity testing organism because of its sensitivity to sediment contamination and recommended by the USEPA (USEPA 2000). The survival rate of *H. azteca* is assumed to be positively correlated to the abundance of amphipods in the field and negatively correlated to the percent tolerant taxa and metal contamination. Two replicates were used for each sediment sample. Two control/reference tests (water only) were also conducted. The dissolved oxygen (DO) concentration, pH, and temperature for the replicates and controls were recorded

(Table 7).

Table 7: The screening levels for inorganic in freshwater sediment in SQuiRTs (Buchman, 2008).

Screening benchmark		
Background	N/A	The concentration below which toxicity was rarely observed and tolerable by most benthic species
ARCS <i>H. azteca</i> TEL	Assessment and Remediation of Contaminated Sediment <i>H. Azteca</i> Threshold Effect Level	
TEC	Threshold Effect Concentration	
TEL	Threshold Concentration Level	
LEL	Lowest Effect Level	
PEC	Probable Effect Concentration	The concentration above which toxicity was frequently observed and harmful to most benthic species
PEL	Probable Effect Level	
SEL	Severe Effect Level	
UET	Upper Effects Threshold	

3. Results

3.1 Survey

3.1.1 General information

1) Arrival time

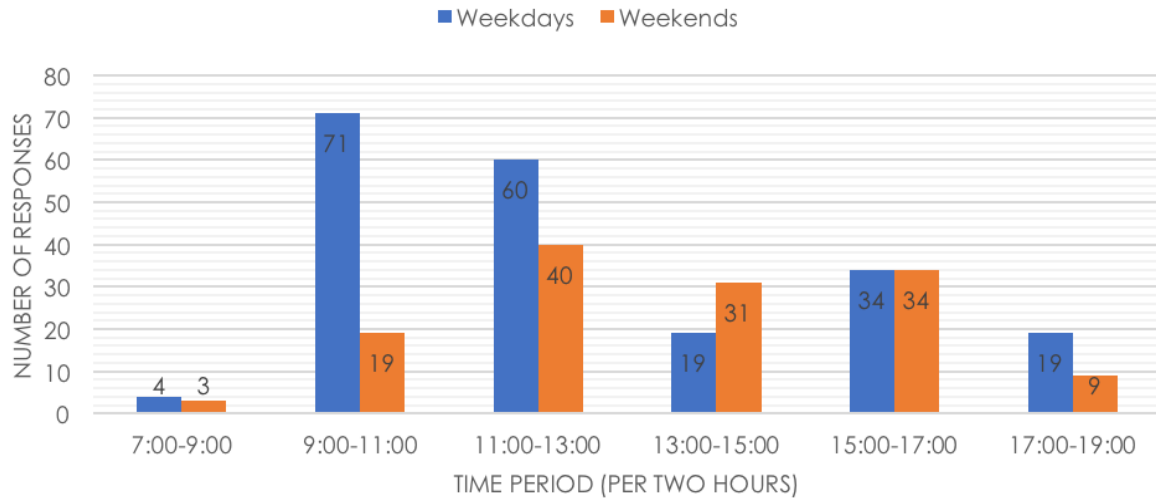


Figure 5: Arrival Time

We found that on weekdays, from 7am to 9am, very few people arrived at the Chicago Riverwalk, however, the number of people then reached to the peak from 9am to 11am. This time period was the routine time commuting to work. It seemed that people preferred to walk through the Chicago Riverwalk when commuting instead of walking along the road. While on weekends, from 7am to 9am, still very few people arrived, the number of people then did not reach to the peak until 11am. (Figure 5)

2) Frequency

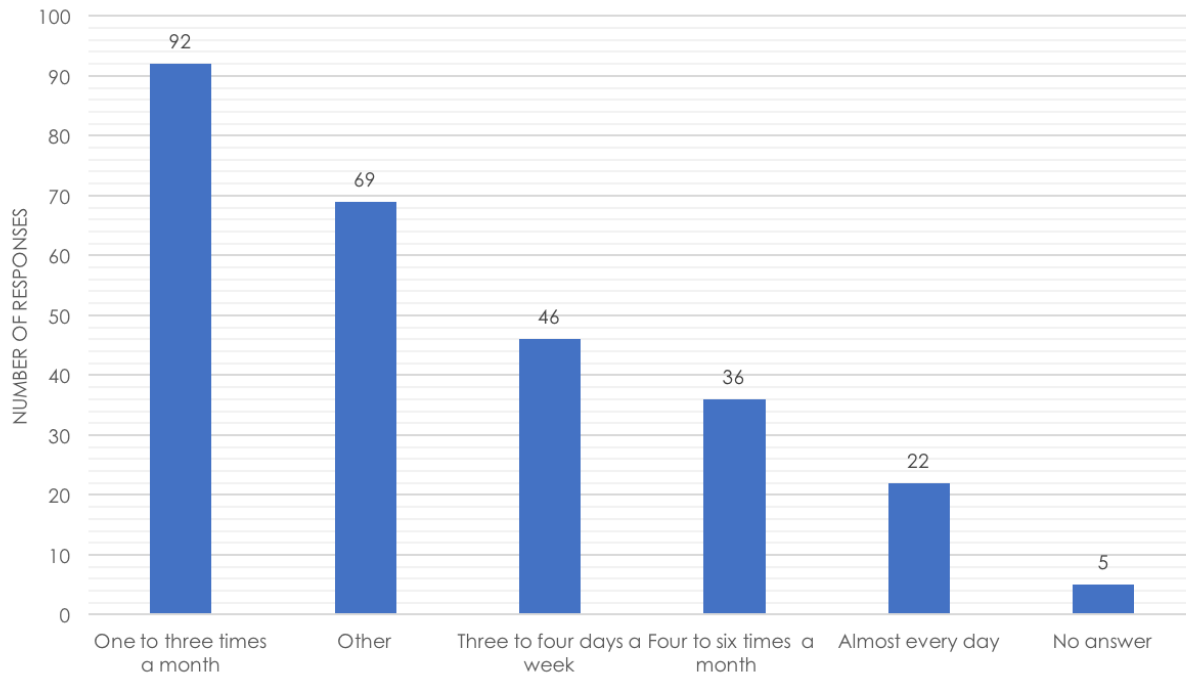


Figure 6: Frequency

For 24% (84/353) respondents who was not at the Chicago Riverwalk for the first time, most of them visited the Chicago Riverwalk one to three a month. And “other” contained answers of couple times a year from less than 1 to 6 times. (Figure 6)

3) Visitor types

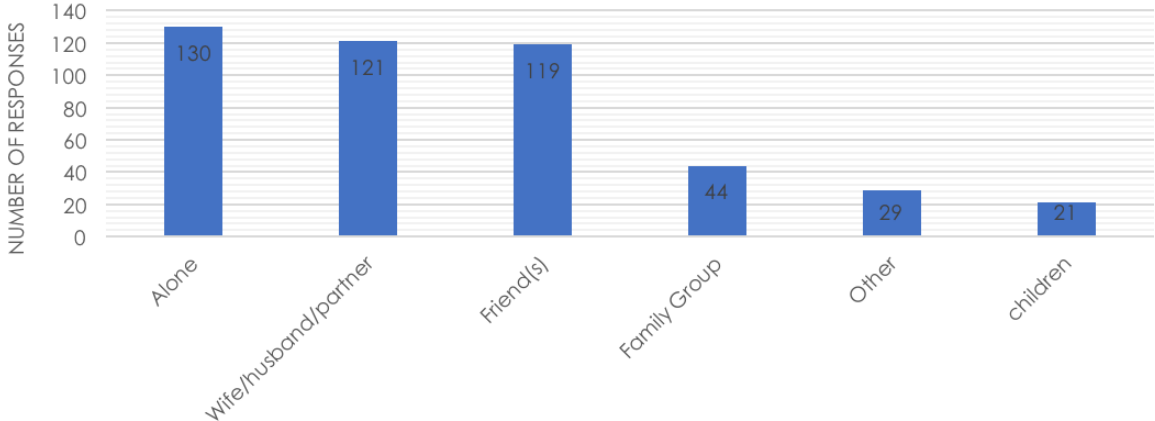


Figure 7: Visitor types

Typically, the majority of respondents visited the Chicago Riverwalk alone or with wife/husband/partner or with friends. Many respondents visited the Chicago Riverwalk with family group or children. Among the respondents who choose others, a few respondents mentioned that they visited the Chicago Riverwalk with co-workers, 7 respondents were with dog, 4 respondents were in school group and 1 respondent was in the tour group. (Figure 7)

4) Activities along the Riverwalk

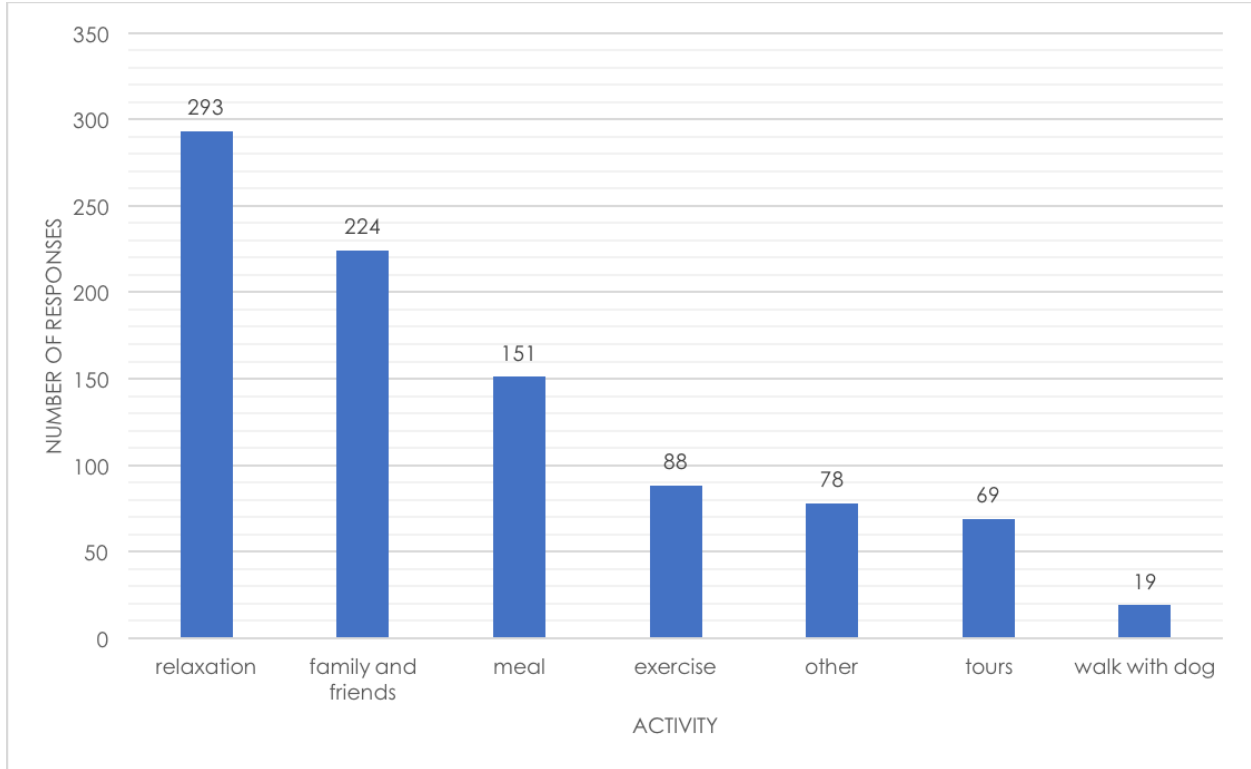


Figure 8: Activities

In general, respondents relaxed, spent time with family and friends and had meal along the Chicago Riverwalk. Other activities contained going to work or home, fishing, reading, photographing and kayaking. (Figure 8)

Table 8: Activities

	Spring (139)	Fall (139)	Winter (90)
Get to work (commute)	x (4)	x (3)	x (5)
Fishing	x (1)		
Teaching		x (1)	
Relax (sitting by the river, people watching, reading, music)	x (42)	x (47)	x (18)
Meals and drinks	x (28)	x (27)	x (9)
Exercise (Cycling, walking, running, walking pets)	x (86)	x (88)	x (55)
Sightseeing	x (5)	x (2)	x (2)
Photography	x (2)	x (2)	x (2)
Game		x (1)	x (1)
October/pumpkin patch		x (1)	
Water taxi	x (1)	x (1)	x (1)

Christmas lights stopping			x (3)
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Since we only did the survey in summer, we also designed the question to ask about the activities during spring/fall/winter. For these seasonal activities, exercise, meals and drinks, and relaxation were the most three popular activities during the year. (Table 8)

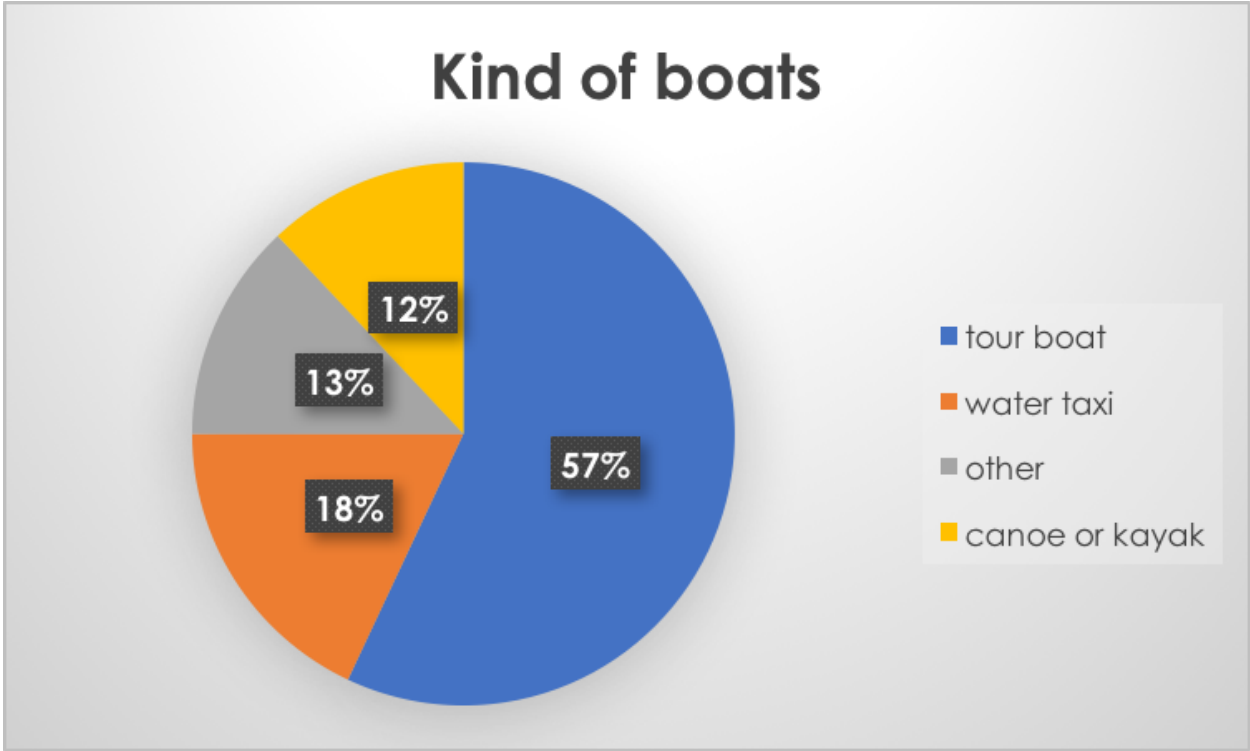


Figure 9: Boat activities

We also looked at the specific kinds of boats people would like to use. For 50% (171/349) respondents who had boat in the vicinity of the Chicago Riverwalk, the majority of respondents wanted to take tour boats. Some respondents also mentioned other boat types like Yacht, personal boats and power boats. Also, most respondents (145/171) took part in boating for one to three times. Only few respondents (8/171) took part in boating for more than 6 times. (Figure 8)

For the fishing activity, only a few respondents (6/346) had fished there. Three of them fished almost everyday, two respondents fished once to three times a month and one respondent fished four to six times a month. The answers to open-ended question "What do you typically catch?" were carp, catfish, bluegill, yellow perch, white perch, bullheads, large mat bass, Bass, Pinfish, invasive goby, European Bass. Two respondents wanted to consume what they caught due to no pollution, however, three responses did not want to do so because of the dirty and not healthy water quality. One response mentioned they only caught fish and released them.

5) Gathering Spaces Perspective

Table 9: Frequency of visiting/using six blocks

	Marina (n=244)	Cove (n=246)	River theater (n=246)	Water plaza (n=243)	Jetty (n=244)	Riverbank (n=244)
Never/Rarely	82(33.6%)	59(23.0%)	76(30.9%)	99(40.8%)	99(40.6%)	108(44.3%)
Little	59(24.2%)	61(24.8%)	54(21.0%)	54(22.2%)	59(24.2%)	52(21.3%)
Occasionally	46(18.9%)	64(26.0%)	47(19.0%)	46(18.9%)	42(17.2%)	37(15.2%)
Often	32(13.1%)	42(17.1%)	43(17.5%)	25(10.3%)	25(10.2%)	23(9.4%)
Very often	25(10.2%)	20(8.1%)	26(10.6%)	19(7.8%)	19(7.8%)	24(9.8%)

We investigated the frequency of visiting/using each of the following places in the Chicago Riverwalk to get the preference of six blocks from the respondents. We excluded those who visited this place for the first time. Then for each block, we got 244, 246, 246, 243, 244, 244 effective answers respectively. For Marina and River theater, one third respondents visited here never/rarely, a quarter respondents visited here little; For Cove, a quarter respondents visited here never/rarely, a quarter respondents visited here little, a quarter respondents visit here occasionally; For Jetty and Riverbank, two-fifths respondents visit here never/rarely, a quarter respondents show visit here little. (*Table 9*)

Table 10: Gathering Spaces

	Green/natural areas (n=337)	Sitting areas (n=342)	Restaurants/bars (n=276)
Far too little	16(4.7%)	4(1.2%)	6(2.2%)
Too little	107(31.8%)	31(9.1%)	68(24.6%)
About right	208(61.7%)	300(87.7%)	186(67.4%)
Too much	3(0.9%)	5(1.4%)	16(5.8%)
Far too much	3(0.9%)	2(0.6%)	0(0.00%)

In terms of how people feel about the amount of green/natural areas, sitting areas and restaurants/bars in the Chicago Riverwalk, we got 337, 342, 276 effective answers respectively for each part. More than half answers showed the amount of green/natural areas was about right, but still one third answered showed the amount of green/natural areas was too little; The majority of answers showed the amount of sitting areas was about right; More than half answers showed the amount of restaurants/bars was about right, but still a quarter answers showed the amount of restaurants/bars was too little. (*Table 10*)

6) Safety

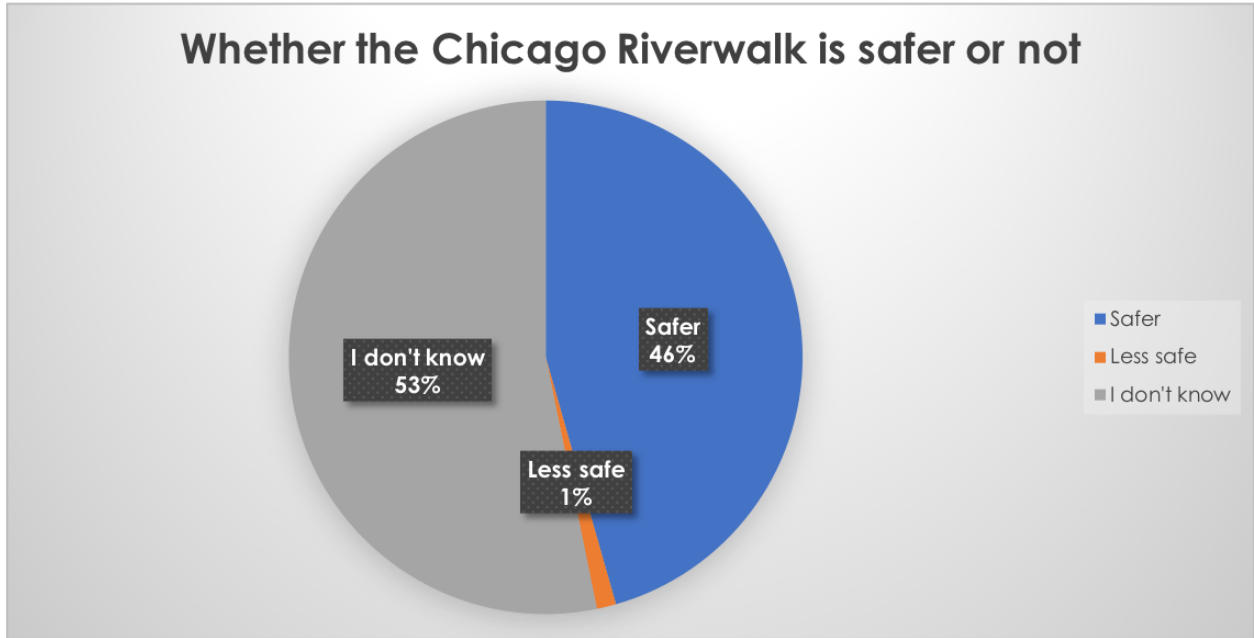


Figure 10: Safety

More than half of respondents (53%) had no idea whether the Chicago Riverwalk was safe or not, and almost half of respondents (46%) thought the Chicago Riverwalk was safer. (*Figure 10*)

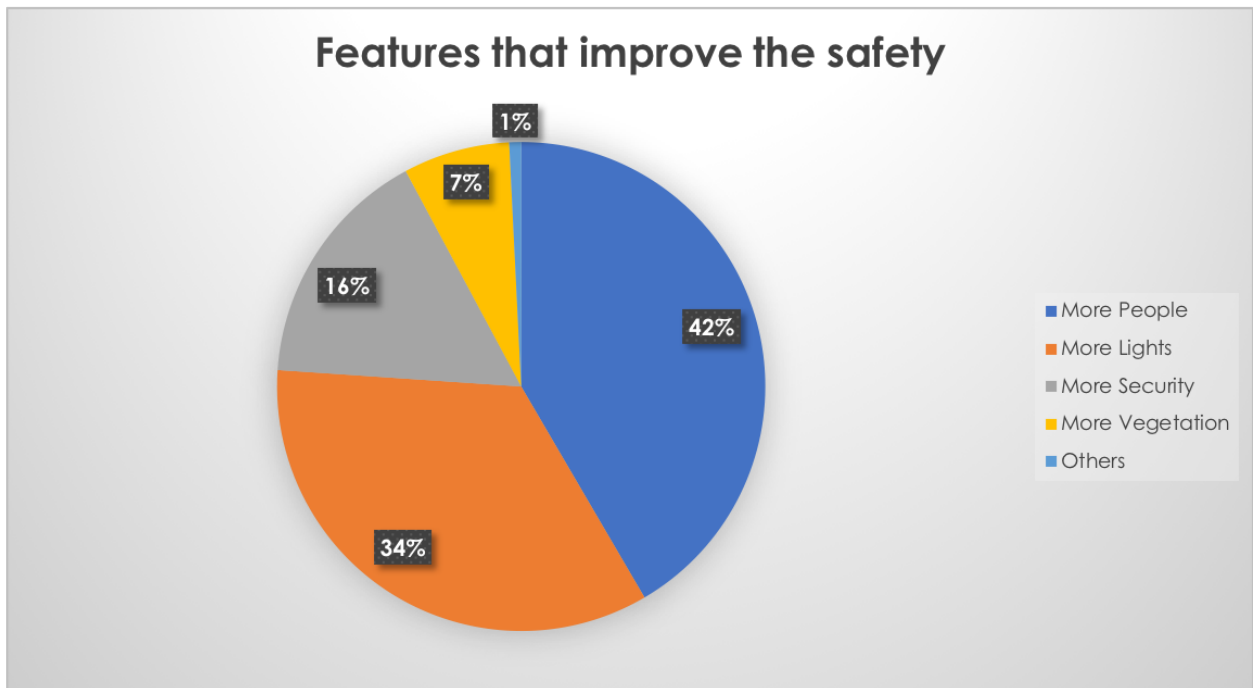


Figure 11: Features that improve the safety

When asked what features improved the safety, respondents ranked the option of more people (42%) first, followed by more lights (34%), more security (16%), more vegetation (7%) and others (1%).(Figure 11)

Table 11: Safety

	not at all satisfied	a little	somewhat	quite a bit	very satisfied
During the day (n=349)	2 (0.57%)	5 (1.43%)	25 (7.16%)	150 (42.98%)	167 (47.85%)
At night (n=170)	2 (1.18%)	5 (2.94%)	50 (29.41%)	72 (42.35%)	41 (24.12%)

We also asked respondents about how satisfied they were with the Chicago Riverwalk in terms of safety for walking during the day and at night. Most respondents were either very satisfied or quite a bit satisfied with the Chicago Riverwalk in terms of safety for walking during the day. About two-thirds respondents (66.47%) were either very or quite a bit satisfied with the Chicago Riverwalk in terms of safety for walking at night. About 30% respondents were somewhat satisfied with it. (Table 11)

7) People's perception of ecological environment

Table 12: People's perception of ecological environment

	not important	slightly important	moderately important	important	very important
Floating wetland (n=156)	13 (8.33%)	21 (13.46%)	50 (32.05%)	45 (28.85%)	27 (17.31%)
The diversity of plants (n=305)	10 (3.28%)	43 (14.10%)	100 (32.79%)	97 (31.80%)	55 (18.03%)
Health of the Chicago River(n=346)	17 (4.91%)	37 (10.69%)	96 (27.75%)	101 (29.19%)	95 (27.5%)

According to respondents who noticed the floating wetland, almost 80% of them thought the floating wetland was moderately or even more important to their enjoyment of the Chicago Riverwalk, and less than 10% of them thought the floating wetland was not important; According to respondents who liked the diversity of plants, over 80% of them thought the diversity of plants (i.e. trees, shrubs, grasses and flowers) was important to their enjoyment of the Chicago Riverwalk, and very few people thought the diversity of plants was not important; More than 80% respondents thought the health of the Chicago River was important to their enjoyment of the Chicago Riverwalk, and very few people thought the health of the Chicago River was not important. (Table 12)

Table 13: People's perception of water quality

	strongly agree	somewhat agree	somewhat disagree	strongly disagree	don't know
If the Chicago River was in good health (n=344)	55 (15.99%)	139 (40.41%)	68 (19.77%)	28 (8.14%)	54 (15.70%)

In addition, we also asked respondents to what degree they agreed the opinion that Chicago River was in good health. The option of somewhat agree (40.41%) ranked first, followed by strongly agreed (15.99%), somewhat disagreed (19.77%), don't know (15.70%) and strongly disagreed (8.14%). (*Table 13*)

8) Uniqueness of Riverwalk

In terms of the perspectives of uniqueness, we designed the open-ended question: "What is unique about the Chicago Riverwalk?" The respondents could provide a few examples. The answers were categorized into seven themes. We identified the themes and analyzed each category. The description of themes and examples of the answers from the respondents are as follows:

Walkway: The characteristics of walkway in terms of walking experiences from people.

Eg. "Ease of walking once on it. Very friendly, walkable, clean, nice walk. It gives me a more walk to work. Very well kept, large and planned. The length."

Context: The surrounding environment and location benefits.

Eg. "In Chicago, the combination of the buildings +nature. In the middle of skyscrapers. Oasis within a downtown environment. Easy accessible to loop."

Nature: Physical features as opposed to humans or human creations.

Eg. "Clean water, River in a large downtown.plants, beautiful flowers, The color of the lake, natural habitat, sounds, smells"

Features: The characteristics of Riverwalk itself.

Eg. "People. Each block is very different, annual different unique scenes. Makes great use of something unexpected, many city rivers don't have this at all. Views. Beauty."

Experiences: The activities occurred here.

Eg. "Lots of places to sit, a variety of places to spend time (restaurants, bars, boats) Tours/entertainment or some activities (The fishing. the party. Lights. Water taxi.) The businesses along it. Sitting and drinking nearby water. More opportunity to enjoy the riverwalk."

Emotional benefits: People derive from their visit to the Riverwalk.

Eg. "Beautiful. Nice. Well-constructed, Relaxing, quiet, So big, endearing, clean, Lively, more active, open, positive."

Disadvantages: Something that people are dissatisfied with the Riverwalk.

Eg. "Size, traffic, Dirty water, busier."

Others:

Eg. "Everything. Have not been to many."

We also looked at the similar places reminded by the respondents. Most of them mentioned San Antonio, Milwaukee, which is a popular riverwalk. (Table 14)

Table 14: Similar places

US	NY	New York	waterfront areas. Buffalo, Boardwalks in NY, Highline, The walks around Manhattan (7)
		Boston	waterfront areas, Weinberg (4)
	PA	Pittsburgh	Riverwalk, River walks in other cities (s/a Pittsburgh), Southside Pittsburgh (4)
	IL	Chicago	The lakefront and north side beaches Navy Pier, Museum Campus, Millenium Park Area (New area)
		Naperville	Naperville riverwalk (4)
	OH	Cincinnati	The Serpentine Walk, the banks (3)
	CA	San Francisco	Pier, Embarcadero San (2)
	TX	San Antonio	San Antonio, Milwaukee (39)
		Austin	Austin Riverwalk(3)
IN	Indianapolis	Indianapolis riverwalk (5)	
CANADA		Vancouver	Vancouver, BC (3)
EUROPE		Spain	Valencia, Spain riverwalk; Madrid rio in Spain (3)
		France	Paris / Seine / Paris canal st martin (6)
		Italy	Along tiber river in Rome; Portland: Larsad(vistula river) (2)
		Austria	Danube river in Vienna, Rivers running through Salzburg (2)
UK		London	The Thames - London, River thames, south bank, London (5)
SINGAPORE			Clarke Quay(3)

9) Effect of community life

For the effect of the Chicago Riverwalk, we designed the open-ended questions to ask the respondents to tell what they like and dislike about the Chicago Riverwalk. Based on the answers about what they like, we categorized them into six themes, identify the themes and analyze each category. The description of themes and examples of the answers from the respondents are as follows:

Walkway: The characteristics of walkway in terms of walking experiences from people.
 Eg. Continuous uninterrupted way through city for pedestrians. No auto traffic. Easy access.
 Length.

Context: The surrounding environment and location benefits.
 Eg. Proximity to Michigan Ave and loop. Architecture design. The location. Being outside along water. Oasis in urban area.

Nature: Physical features as opposed to humans or human creations.
 Eg. Sights and sounds. Fresh air. Clean water. Plants / vegetation. Closer to water. The river (gives me a break from city life). The breeze. Green space.

Features: The characteristics of Riverwalk itself.
 Eg. Beauty (It is beautiful in the sense that it is like a park among so much concrete and glass; beauty of nature with Chicago Architecture; vibrant). Light at night. The view.

Experiences: The activities occurred there.
 Eg. A space where people can do many activities, such as exercise, walk dogs, run, eat lunch, take photos, sightseeing and explore Chicago. People / People watching. The sitting area (by water). Bars / Restaurants. Architecture boats. More recreational spaces for the city. Public space. The fishing. Relaxation (with friends). Beer / Wine (with friends). The entertainment.

Emotional benefits: People derive from their visit to the Riverwalk.
 Eg. Quiet, serene, tranquility. Calm (environment, city). Peacefulness. Elegant aesthetically. Community feeling.

10) Others

Table 15: What people dislike about the Chicago Riverwalk

In one sentence, can you tell me what you dislike about the Chicago Riverwalk? (N=276)	
Description	Number
Nothing they dislike	100
Dislike the dirty water (litters/garbage/pollution in river) or the river can be cleaner	24
Dislike the smell, either from the river or boat	22
Dislike the crowded, there's too many people sometimes	22
Dislike the noise, either from traffic (cars, trains, boats) or construction	10
The number of restaurants/cafes/bars or food/drink options are not enough	9
Dislike too much concrete or need more green space	7

Seats are not enough	4
Worried about the safety	4
Dislike bikes	3
No opinion	2
Others	69

For the answers of what they dislike, half of the responses showed there was nothing they dislike. (Table 15)

Table 16: What people would like to add about the Chicago Riverwalk

In one sentence, Is there anything else you would like to add about the Riverwalk? (N=201)	
Description	Number
There's nothing to add or it is already beautiful and great	123
Add more restaurants/bars or food/drink options	15
Want the Riverwalk be longer or have one on the other side	11
Add green space or floating garden	10
Add more events (floating museum, art event, community event, concert)	5
Add additional restroom	4
Add sitting area	3
Not sure	1
Others (each have their individual opinions that can not be combined)	29

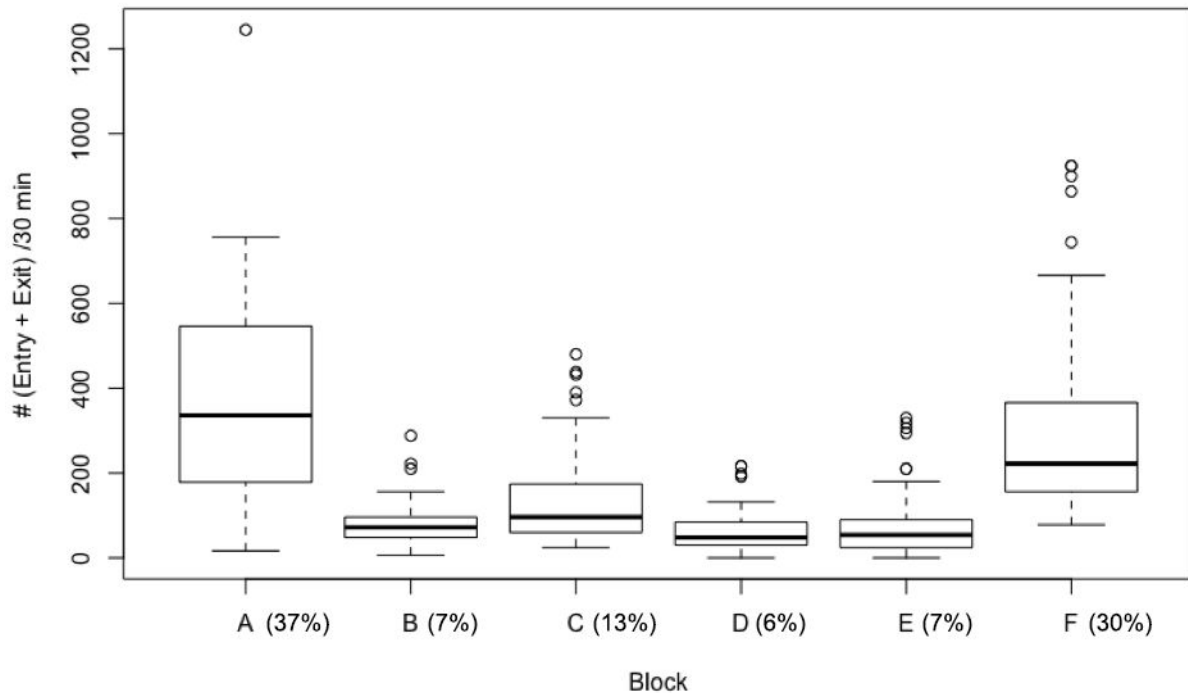
Based on the table, almost 60% respondents thought that there was nothing to add or Chicago Riverwalk was already beautiful and great. Some even want to develop the riverwalk or establish new one on the other side. (Table 16)

3.2 Observation

During the observing period, 55,554 visits to the Riverwalk were estimated. On average, people walked through 4.3 blocks per visit and stayed at the Riverwalk for 6.7 minutes per visit.

3.2.1 Vertical accessibility

In all blocks, most vertical entries and exits of the Riverwalk occurred at block A, C and F. The wide stairs at block C might contribute to its higher vertical accessibility compared to the neighboring D and B. (Figure 12)



(% = vertical circulation per block / total vertical circulation)
 Figure 12: Number of people who entry/exit per 30 minutes

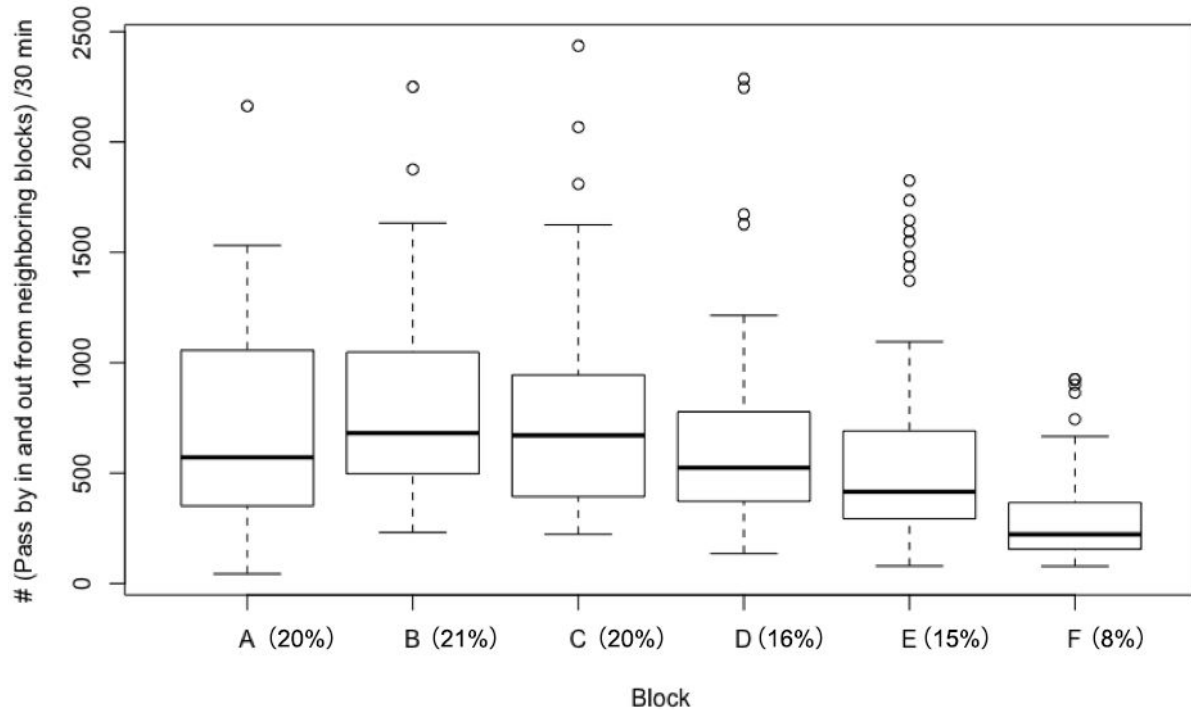
3.2.2 Horizontal circulation

All blocks are used as horizontal walkway. (Figure 13) And ANOVA result (Table 16) is: B C A > D E F; A D > E F; D E > F.

Table 17: Horizontal ANOVA

	Estimate	Std. Error	t value	Pr(> t)
BLOCK A	720.43	36.80	19.576	< 2e-16 ***
BLOCK B	795.93	38.29	20.787	< 2e-16 ***
BLOCK C	748.00	38.29	19.536	< 2e-16 ***
BLOCK D	626.42	38.29	16.360	< 2e-16 ***
BLOCK E	553.93	38.09	14.541	< 2e-16 ***
BLOCK F	285.85	36.63	7.804	2.71e-14 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1



(% = Horizontal circulation per block / total horizontal circulation)
 Figure 13: Number of people who pass in/out from adjacent blocks per 30 minutes

3.2.3 Staying behaviour (single block & multiple blocks)

Block A had most people staying (111 people) for the longest time (5 minutes). Block B and C had averagely 56 and 52 people staying for 3 and 4 minutes. On average, there are 14 people staying in block E for 1 minute. Block D and F had the least people staying (6 and 5 people respectively) for the shortest time (about half minute).

1) Number of people staying by block (Figure 14)

ANOVA result (Table 18) is: A > BC > E > DF.

Table 18: Horizontal ANOVA

	Estimate	Std. Error	t value	Pr(> t)
BLOCK A	111.429	5.424	20.545	< 2e-16 ***
BLOCK B	56.052	5.643	9.933	< 2e-16 ***
BLOCK C	52.309	5.643	9.270	< 2e-16 ***
BLOCK D	6.392	5.643	1.133	0.2578
BLOCK E	13.776	5.614	2.454	0.0144 *
BLOCK F	4.925	5.398	0.912	0.3620

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

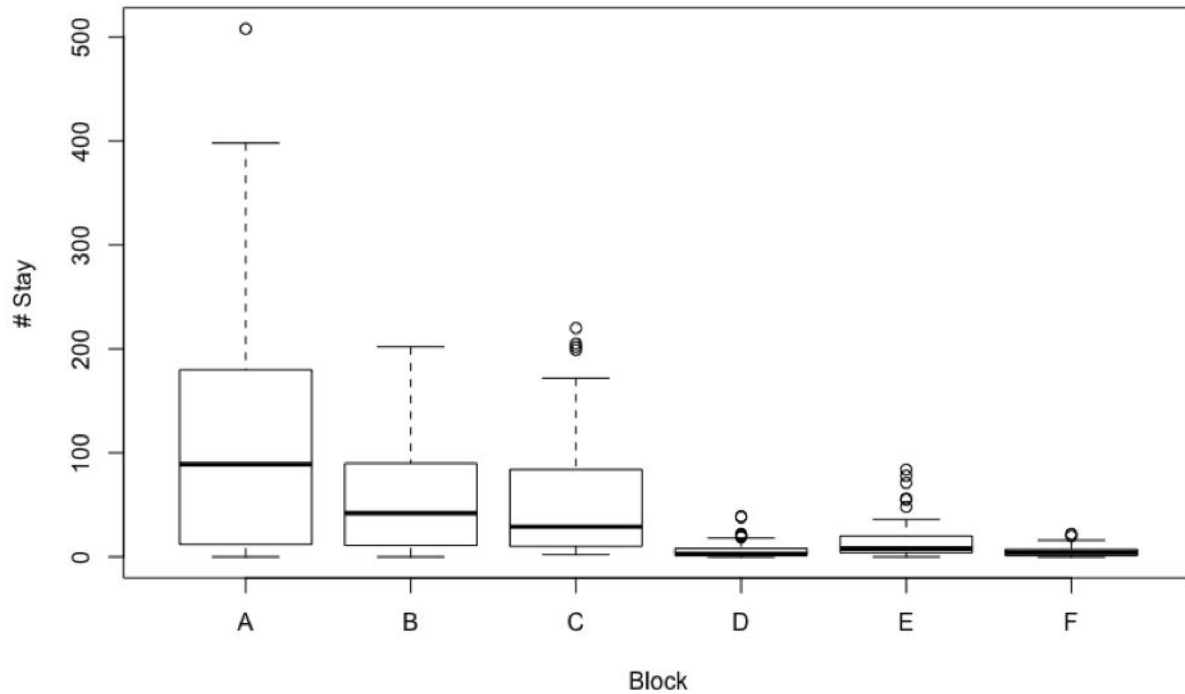


Figure 14: Number of people staying by block

2) Length of stay by block are calculated by $x / (\text{Exit} + \text{Pass by out})$ (Figure 15)
ANOVA result (Table 19) is: A > C B > E F D.

Table 19: Time ANOVA

	Estimate	Std. Error	t value	Pr(> t)
BLOCK A	5.3407	0.2767	19.302	< 2e-16 ***
BLOCK B	3.4188	0.2879	11.876	< 2e-16 ***
BLOCK C	3.6808	0.2879	12.786	< 2e-16 ***
BLOCK D	0.5201	0.2879	1.807	0.0713
BLOCK E	1.1972	0.2864	4.180	3.35e-05 ***
BLOCK F	0.6617	0.2754	2.403	0.0166 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

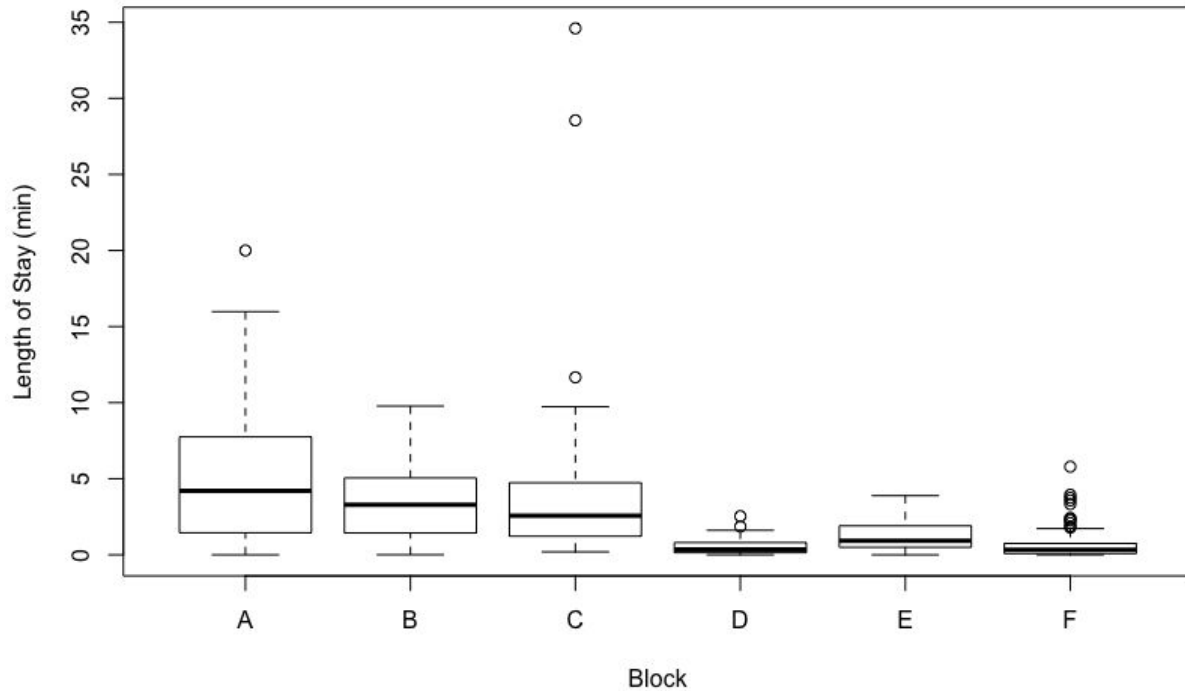


Figure 15: Time spent by block

3) Temporal analysis (8/26,27 are weekend, 8/27,29 are rainy)

Staying behavior by single block (*Figure 16*). And the analysis for each block is included in Appendix B.

Block A and B are more popular after noon on Friday, Saturday and Sunday as the peak number in Block A and B were 245 and 198 on Friday (8/25/2017), 508 and 186 on Saturday (8/26/2017), 298 and 202 on Sunday(8/27/2017). In addition, Block C and E are more popular during lunch time (12:00-13:00) on weekdays (Monday-Friday) as we can see there was a prominent vertex falling in between 12:00 and 13:00 on weekdays, which represented a sharp increase in the number of people staying in Block C and E.

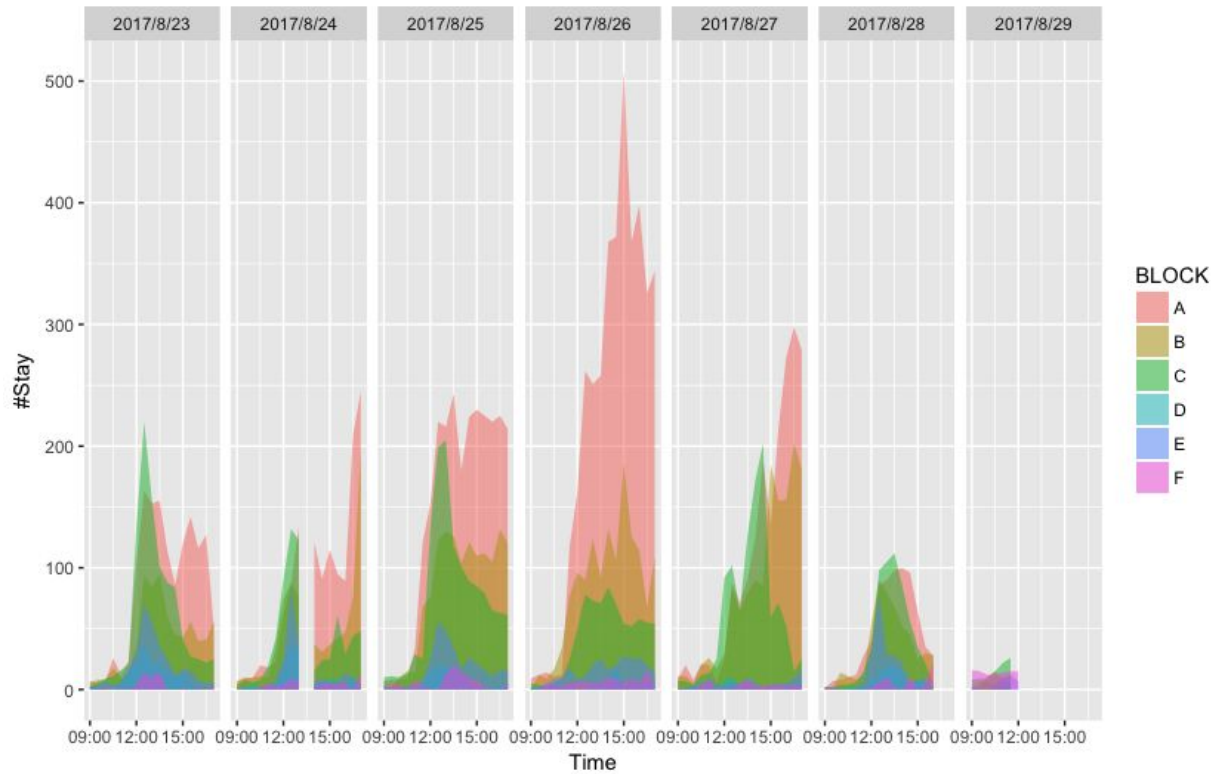


Figure 16: Visitors' behavior at the Riverwalk (non-stacked)

4) Staying behavior of the entire Riverwalk (multiple blocks):

More people stayed at the Riverwalk on Friday to Sunday than Monday to Thursday as the number of people staying in each block on Friday to Sunday are far more than those on Monday to Thursday.

From Friday to Sunday, the Riverwalk was most popular in the afternoon with a peak of 780 people staying at 15:00 on Saturday (8/26/2017). From Monday to Friday, the Riverwalk was popular at lunch time (12:00–13:00) with a peak of 600 at 12:00 on Wednesday (8/23/2017). (Figure 17)

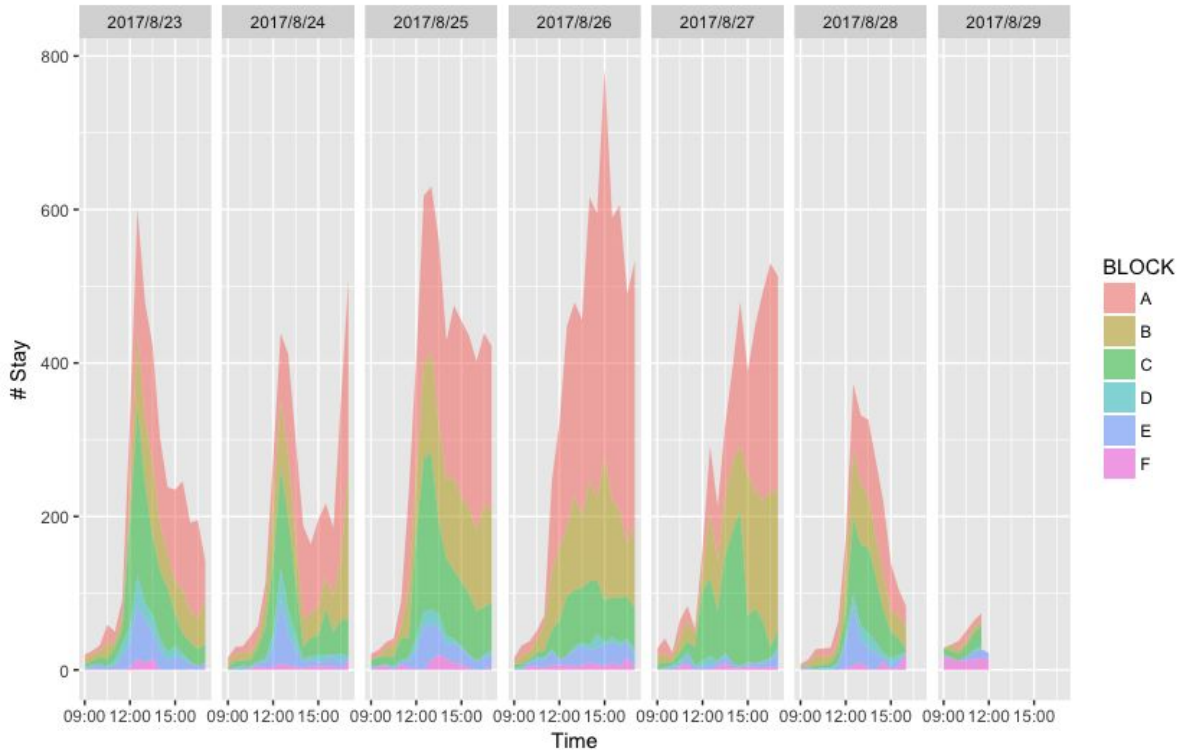


Figure 17: Visitors' behavior at the Riverwalk (non-stacked)

3.3 Expert interview

The most mentioned themes in the expert interviews were the aesthetics of the Riverwalk, the Riverwalk's ability to bring people close to the water, and the educational benefits of the Riverwalk.

Table 20: The themes and example quotes from the expert interviews.

Theme	Example quotes
Aesthetics	<p>"aesthetically it's really beautiful"</p> <p>"The beautiful view of Chicago City"</p> <p>"[the floating wetlands] brings in sort of that natural environment to a very built environment Riverwalk"</p>
Bring people to the water	<p>"a great example of a revitalization of an urban river system"</p> <p>"encourages people to think about, ..., where else can I go along the river"</p> <p>"help us advance the conversation....other stretches of our rivers that we want people to see and realize this is an additional asset"</p> <p>"a wonderful symbol of the attention and the investment"</p>

	<p>“even for the locals...get introduced to rivers and really can see it in a whole new light”</p>
Educational	<p>[floating wetland] “a wonderful addition...to the river to remind us what a natural riverfront habitat would look like”</p> <p>“an easy way to understand the resources”</p> <p>“a wonderful measure to which were more improving water quality”</p> <p>“...getting more people to relate to the river, have that relationship, and appreciate it, and enjoy it, and therefore pick up their trash and make sure that they’re being an active participant in helping restore...”</p> <p>“open people’s eye to the assets and benefits from having an accessible and a clean and healthy and thriving river front system”</p> <p>“if people use it more...they have the feeling that we have to clean it out more”</p> <p>“an indirect help to improve the water quality”</p> <p>“[for the planting design] whether or not people understand the role of natives. I don’t know”</p>
Ecological	<p>“those plantings are more aesthetic”</p> <p>“I don't think they have significant impact on the ecology of the river”</p> <p>“I think that design is a great idea. Anything that incorporate the native species...the ecosystems have these organisms...the species living over there.”</p> <p>“any time we can incorporate native plants native species into an environment it's generally a very positive thing”</p>

3.4 River sediment analysis

The metal concentrations in the sediment also indicated they were severely contaminated, based on exceedances of several thresholds. Cr at the main branch exceeded PEC, PEL, SEL, and UET, while at the north branch exceed the PEL. All sediments had Cu higher than PEC, SEL, and UET while the north branch sample also exceeded PEL. For Zn all sediments had values higher than PEC and PEL; the main and north branch also exceeded the UET. Mn in the main branch and the lake shore samples were lower than most screening benchmarks; however Mn does not tend to be toxic. For samples at all locations[AB1], the concentrations of Fe and Ni were higher than the benchmarks indicating tolerable to benthic species (eg. TEC, TEL, and LEL) while lower than those indicating harmful (eg. SEL and UET) (Buchman, 2008) (Table. 21).

Table 21: The metal digestion of river sediment at the four stations using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

	Sediment Metal Digestion (per billion dry weight)*					
	Cr	Cu	Fe (%)	Mn	Ni	Zn
Lake Shore	66,000	^178,000	2.09	439,000	22,000	^466,000
Main Branch	^116,000	^191,000	1.90	348,000	35,000	^572,000
North Branch	^92,000	^230,000	3.32	553,000	32,000	^775,000
South Branch	68,000	^195,000	2.14	414,000	25,000	^506,000
Average	86,000	^198,000	2.36	439,000	29,000	^580,000

*All values are represented as per billion dry weight unless specified

^ values that exceed one or more SQuiRT benchmarks indicating toxicity

For the *H. azteca* 7-day exposure, averagely, the survival rates are 35%, 25%, 20%, 10% for the station at Lakeshore, Main Branch, North Branch, and South Branch, respectively (Table 22). These are acutely toxic levels suggesting the sediments are severely contaminated with chemicals.

Table 22: The 7 d *H. azteca* exposure toxicity evaluation results

Chicago Riverwalk Sediments 7 d *H. azteca* exposure

Replicates	Date	DO (mg/L)	pH	Temperature (C)	Survival of <i>H. azteca</i> alive
Lake Shore a	4 Jan 18	5.42	7.76	22.8	100%
Lake Shore b	4 Jan 18	5.30	7.72	22.6	100%
Main Branch a	4 Jan 18	5.14	7.63	22.1	100%
Main Branch b	4 Jan 18	5.34	7.61	21.6	100%
North Branch a	4 Jan 18	4.82	7.46	22.0	100%
North Branch b	4 Jan 18	5.20	7.50	22.1	100%
South Branch a	4 Jan 18	5.00	7.63	21.9	100%
South Branch b	4 Jan 18	5.15	7.61	22.1	100%
Lake Shore a	11 Jan 18	5.08	6.84	21.6	20%
Lake Shore b	11 Jan 18	5.04	7.20	21.4	50%
Main Branch a	11 Jan 18	4.65	7.27	21.3	10%
Main Branch b	11 Jan 18	4.56	7.26	21.3	40%
North Branch a	11 Jan 18	3.72	7.36	21.3	30%
North Branch b	11 Jan 18	4.55	7.48	21.4	10%
South Branch a	11 Jan 18	4.67	7.51	21.5	20%
South Branch b	11 Jan 18	5.00	7.52	21.5	0%
Reference a (water only)	11.Jan.18	5.11	7.21	21.4	10
Reference b (water only)	11.Jan.18	5.14	7.23	21.4	10

4. Discussion

The results are discussed in relation to the design goals across the four themes that we focused on.

4.1 Economic

Improve the Perception of Safety

From the survey, we found that most people felt safe when walking along the Chicago Riverwalk both during the day and night (*Table 12*). Overall, they were satisfied with the Chicago Riverwalk in terms of safety. When it came to the question whether the Chicago Riverwalk was safer or not compared to two years ago (before the construction of the Chicago Riverwalk),

more than half of respondents had no idea about it, because some respondents may only visit here after its construction (*Figure 10*). They did not know what happened before the construction of the Chicago Riverwalk. Compared the amount person who thought the Chicago Riverwalk was safer (46%) with those who thought was less safe (1%), we thought that the Chicago Riverwalk improved the perception of safety. Besides, the most compelling feature that improved the sense of safety to respondents was more people, followed by more lights (*Figure 11*). That being said, the popularity of the Chicago Riverwalk and its design of lighting had a large impact on improving the sense of safety to people.

4.2 Cultural

4.2.1 Create Diverse Gathering Spaces

There are several gathering spaces at the Chicago Riverwalk, including green/natural area, sitting area and restaurants/bars. From the survey (*Table 10*), we figured out that more than half of respondents felt the amount of those gathering spaces were enough and they were able to find lots of space to sit and spend time at the Riverwalk. About 10% to one-third of respondents wanted more gathering space, very few people thought there were too much gather space. But overall, the Chicago Riverwalk has diverse gathering spaces for people to sit, eat or have a rest.

From the observation, we found that the Marina Plaza had most people staying (111 people) for the longest time (5 minutes). (*Figure 14 and Figure 15*) The Cove and the River Theater had averagely 56 and 52 people staying for 3 and 4 minutes. The Water Plaza and the Riverbank had the least people staying for the shortest time (about half minute). We thought the Marina Plaza was the place where more people prefer to visit and stay due to its most restaurants and sitting areas compared to other blocks, which provided more opportunities for people to sit and stay. The Cove had some restaurants in addition to a few seating areas and the River Theater had very big and obvious stairs, which contributed to their attractiveness to people as people were able to sit and gather there for a long time. However, the Water Plaza had only a few seating areas and the Riverbank had almost no formal seating areas led to their least attractiveness. Thus, we thought creating diverse gathering spaces is a good way to attract people.

4.2.2 Celebrate the River's Uniqueness

Since it was difficult to quantify the uniqueness of the Chicago Riverwalk, we decided to use an open-ended question to figure out how people think about the uniqueness. We found that the majority of respondents realized and described the uniqueness of the Chicago Riverwalk, whose answers were categorized and summarized as follows: Walkway - The characteristics of walkway in terms of walking experiences from people; Context - The surrounding environment and location benefits; Nature - Physical features as opposed to humans or human creations; Features - The characteristics of Riverwalk itself; Experiences - The activities occurred here; Emotional benefits - People derive from their visit to the Riverwalk. Moreover, from other questions in the survey, respondents also mentioned some special activities that impressed them a lot, such as October/pumpkin patch and Christmas lights stopping. All these aspects have made the Chicago Riverwalk unique and attractive.

However, some respondents still thought the Chicago Riverwalk was similar to other places they had ever been to. Among those places, San Antonio Riverwalk, a city park and a continuous walkway along the banks of the San Antonio River, ranked first. (Table X) In our opinion, the walkway and context of these two riverwalk may be similar, but the nature, features and experiences still differentiated the Chicago Riverwalk from the San Antonio Riverwalk.

4.2.3 Enhance community life

From the survey, we found that respondents had positive attitudes toward the effect of the Chicago Riverwalk on community life. They thought the Chicago Riverwalk was a continuous uninterrupted way for pedestrians, which was essential to connect the communities. It was easy to get access without auto traffic. In addition, the lighting at night was also attractive and beautiful. This public space created a peaceful oasis in the urban area by providing recreational activities nearby the River, such as relaxation, spending time with families and friends, exercise, walking dogs, dining, taking photos, sightseeing, fishing and boating (Plate 3). Among them, relaxation, spending time with families and friends, and exercise were the most frequent activities people would like to do (Figure 8, Table 8). We believe, all these activities enriched the life and increased the connection between urban areas and the Chicago River.

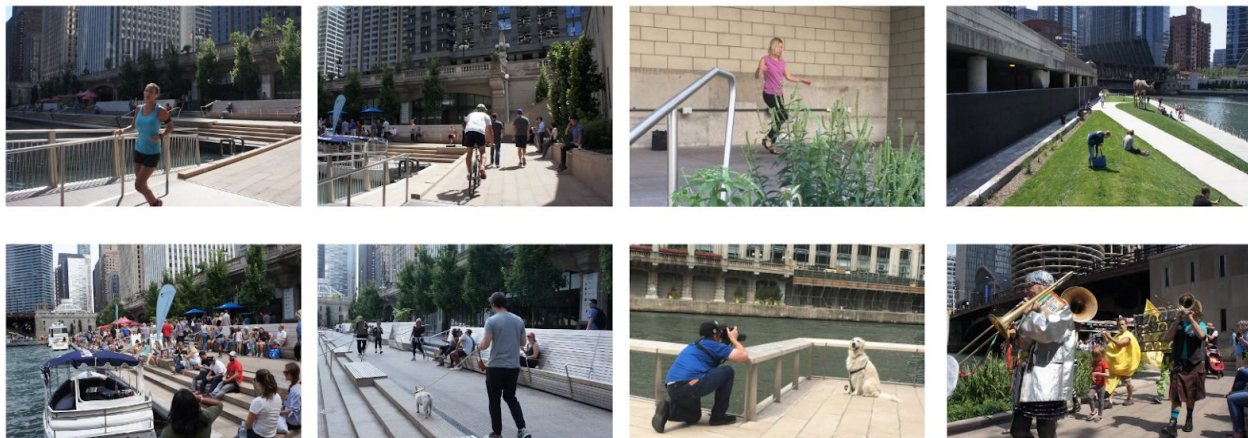


Plate 3: Activities along the Riverwalk in August 2017 (from team)

We also found that more people stayed at the Riverwalk on weekends than weekdays, which might due to the working hour (Figure 23). So from Monday through Thursday, the Riverwalk was popular at lunch time. However, from Friday to Sunday, the Riverwalk was most popular in the afternoon.

4.2.4 Improve Vertical Circulation

From the observation (Figure 12), we could see that the Marina Plaza had most vertical entries and exits of the Riverwalk, followed by the Riverbank and the River Theater. Since the Marina Plaza and the Riverbank were the beginning and the end of the Riverwalk, people might tend to enter or exit the Riverwalk in these two blocks. And wide and obvious wide stairs in the River Theater potentially contributed to its higher vertical accessibility.

In the survey, we asked respondents whether the Riverwalk provided enough access for people with mobility issue. Unfortunately, 40% respondents had no idea whether the Riverwalk provided enough access for people with disabilities and only one-third respondents thought the Riverwalk provided enough access. Since respondents mostly were people without disabilities, they might not notice or even just ignore the design for disability at the Riverwalk as they do not have that need. So we were not able to confirm if the Riverwalk provided enough access for people with disabilities, but we could see Riverwalk do provide some ramps for disabled people in the River Theater and the Riverbank through observation.

4.3 Recreational

4.3.1 Create a Continuous Public Walkway

From the site plan (Figure 24), we could easily see the connectivity between blocks as there is no interruption or obstacle along the Riverwalk and people could easily pass by from the Marina Plaza to the Riverbank.



Figure 24: Site Plan (From Sasaki 2011-0523 CRW Design Report - Vol 1 Full Bleed)

From the observation, we could see a lot of people passing by blocks continuously, either jogging, running or walking a dog, which means the Riverwalk has created a continuous public walkway. Besides, people were estimated to walk through 4.3 blocks per visit averagely through the observation. In other words, people did not come to the Riverwalk merely for one specific block, instead, they came and passed by several blocks, also reflecting the continuity of the Riverwalk as well.

From one of the open-ended questions in the survey that what you appreciate or enjoy most about the Riverwalk, we found that most respondents spoke highly of the walkway at Riverwalk. Because they thought the walkway was continuous, uninterrupted and without auto traffic, which offered people a great walking experience along the river. In general, the Chicago Riverwalk created a continuous public walkway for people.

4.3.2 Increase Recreational Boat Activity

From the survey, we found that about half of respondents took part in boat activities in the vicinity of the Chicago Riverwalk. Among these people, most of them took tour boats, some of

them took water taxi and canoe/kayak. Other boat types like Yacht, personal boats and power boats were also mentioned. (Figure 9)

In addition, most respondents took part in boat activities one to three times a year and only few respondents did so over six times a year, which we thought matched the fact that most respondents took tour boats and recreational boat activities were seasonal and rarely took in winter. During the field trip in summer, we did see many boats, especially at weekends. So we thought there were various recreational boat activities happening in the Chicago river, especially in summer.

4.3.3 Provide more public River use

From the survey, we found that most people took tour boats, which could be regarded as the top river use of the public. There were diverse boat types in the river, such as Yacht, personal boats, water taxi, and power boats. During the field trip, we also noticed some special boats, especially at weekends. These boats encouraged the public water transportation to connect the urban area. One of the other public river use was fishing. Unfortunately, even the Chicago Riverwalk provided many places for people to go fishing (i.e. decks in many blocks), only a few people fished there. We thought it might be due to the poor water quality and noise from the surrounding.

Also, we noticed another public river use while doing observation, that was, Floating Museum (Plate 4). It was a floating platform in August for robust, free, interactive public arts and culture programming. Abundant seating area (just facing the museum) in the River Theater exactly provided people with convenience to enjoy the art and museum.



Plate 4: Floating Museum in August 2017 (from team)

4.4 Ecological

The habitat improvement report of the Chicago Area Waterway System Habitat Evaluation and Improvement Study by LimoTech is the most comprehensive report available about the physical and biological impairments and the improvement potential of the Chicago area waterways (2010). Based on this report, the riparian land of the Chicago River is highly developed urban nature and the riparian land was assumed to be infeasible to alter or use for habitat improvement due to the potential high economic and social costs. In addition, 97% of the Chicago River banks are consisted of vertical walls, which the removal of it would largely affect the riparian land. Because of these characteristics, it is stated in the report to be infeasible to improve the bank structure and the amount of macrophyte, overhanging vegetation, and the bank pocket areas in the Chicago River main branch. The potential to improve the habitat on the Chicago River main branch is extremely limited as compared to other branches of the waterway system.

Our results of sediment testing suggests all sediments are highly contaminated near the CRW, based on their acute toxicity and metal threshold exceedances. This means the waterway cannot be high quality without these contaminated sediments being removed. However, desirable fish species have been increasingly observed in this section of the Chicago River, such as largemouth and smallmouth bass, bluegill bream, crappie, and sunfish. The improved water quality has allowed more sensitive fish species to pass through and feed in this area of the river, with a close proximity to Lake Michigan through the upstream Lock system. One aim of the floating wetlands and constructed fish habitats is to draw fish population and other aquatic organisms to the Chicago River by creating artificial habitats and food sources. However, our results suggest the sediment quality at the Chicago River main branch could pose an ecological risk and prevent them from reproducing in this area of the river. Additionally, our team observed City employees collecting dead fish around the floating wetlands on a daily basis (Figure. X). We recommended further investigation on whether the designs benefit the development of healthy aquatic populations or serve as an “attractive nuisance” whereby fish are drawn to the structures and then exposed to contaminated sediments. The sediment survey was only a limited reconnaissance. Understanding the role of contaminated sediments versus the beneficial impact of the floating wetlands and fish habitat will require more in-depth studies.

All interviewed experts agree that the Chicago Riverwalk is aesthetically impressive and have educational benefits. The Riverwalk is itself beautiful and provides a great view of the Chicago City. Its great accessibility encourages people to see and appreciate the Chicago River in a new way. In addition, when people get closer and know more about the river, they might care more about its water quality and ecological health. The responses of the our survey suggest that people did enjoy the diverse ecological designs at the Riverwalk. Almost half of the respondents (46%) noticed the floating wetlands on the Jetty and of those who noticed the wetlands, about 78% of them indicated the wetlands were somewhat important to their enjoyment at the Riverwalk. In addition, over 80% of the respondents appreciated the diversity of the plants on the Riverwalk and indicated this diverse vegetation is one of the reasons they like the Riverwalk. Over 84% of the respondents thought the health of the Chicago River was important for their

enjoyment at the Riverwalk. Interestingly, over half (56.4%) of the respondents believed the Chicago River was in good health, which conflicts with the sediment toxicity results. This optimistic responses may be due to the improving river quality contributed by the stormwater management in recent years.

For the ecological design, the interviewed experts mostly think incorporating native plant species is a generally great idea while significant ecological benefits might be limited because of the highly engineered waterway and the pollution of the water. The native planting and floating wetlands could act as a symbol to remind people the characteristics of a natural riverfront. The experts pointed out that more educational signage about the ecological health of the river and how the ecological designs work could be a potential improvement.

One important need for any potential habitat improvement study along the Chicago River is the collection of biotic data for ecological impact assessment. Although some artificial structures aiming at habitat improvement are being constructed on the Chicago River, little information is available for ecological evaluations. Examples of projects include the linker boxes constructed in 2003 for the Weed Street project on the North Branch and the Cueono Pass project on the South Branch as well as the Friends of the Chicago River's "fish hotel", which is the inspiration of the floating wetlands on the Riverwalk (LimnoTech, 2010). As of 2010, no project on the Chicago area waterways was identified to collect biotic samples and empirically measure its ecological impact (LimnoTech 2010).

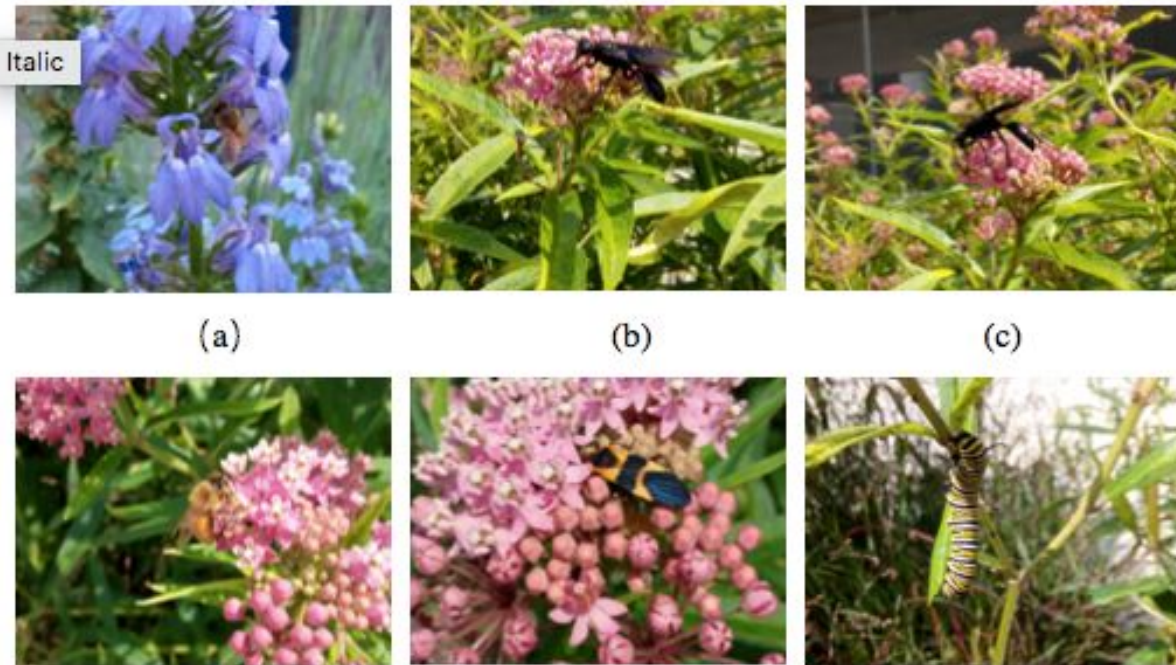
Citizen science and engagement programs could be an approach for both educational purposes and for data collection and monitoring of the ecological design of the Chicago Riverwalk. The floating garden project of the Urban Rivers on the North Branch of the Chicago River was the only project identified by the team that has some ongoing biotic data collection (Urban Rivers, n.d.). The floating gardens of the Urban Rivers were first installed in June 2017 inspired by Joshua Yellin's research about artificial fish islands on the Chicago River (2014). Volunteer groups (River Ranger) are organized to record the plant health and wildlife sightings around the floating gardens (Urban Rivers, n.d.). In addition, the Urban Rivers partner with the Metropolitan Water Reclamation District to collect fish data around the floating garden (Urban Rivers, n.d.). The team recommends that for Sasaki's future projects or any landscape design team to consider partnering with ecological consulting agencies or environmental NGOs for the design, monitoring, and data collection of the ecological benefits both during and after the design process.



(a)

(b)

Plate 5: The floating wetlands in May 2017 (a) and August 2017 (b). (from team)



Italic

(a)

(b)

(c)

(d)

(e)

(f)

Plate 6: The observation of insects on the terrestrial plantation in August 2017. (from team)



Plate 7: The observation of terrestrial plantation in August 2017. (from team)

4.5 Limitations

The result from the survey and observation were both limited to time as we only distributed the survey and observed in August.

In terms of survey, undercoverage bias occurs because we just select respondents randomly, not representative. We did not make sure that the percentage of the different groups of sample correspond to the percentage of the groups of populations. For example, we did not consider respondents with disabilities especially, possibly add another choice that if respondents are people with or without disabilities regarding to the question of "whether the Riverwalk provided enough access for people with mobility issue". And some individuals chosen for the sample only completed part of the survey, which causes the nonresponse bias that results in the different amount of answers for each questions. And the tendency of survey respondents to answer questions in a manner that will be viewed favorably by others. For example, it can take the form of over-reporting "good" or under-reporting "bad,". The tendency poses a serious problem with conducting research with self-reports, especially questionnaires. This social desirability bias interferes with the interpretation of average tendencies as well as individual difference. In addition, we do not use statistical test to see if the independent variables are significant associated with the dependent variables.

In terms of observation, we come to observe with prior knowledge and subjective feelings about what we studied, in other words, there is the tendency to see what we expect to see or what we want to see. Because of these conscious or unconscious prejudices, the results might have bias. To reduce the observation bias, we designed the protocol before the experiment and took turns to observe blocks. In addition, since we count the number manually, the results we got might not accurate. When analyzing the observation data, we made several assumptions which might not be very accurate.

5. Conclusion

5.1 Goals achievement

Table 23: Goals achievement

Theme	Objectives	Level
Economic	Improve Perception of Safety	Good
Recreational	Create a Continuous Public Walkway	Very good
	Increase Recreational Boat Activity	Good
	Provide more Public River Uses	Very good
	Improve Vertical Circulation	Good
Cultural	Create Diverse Gathering Spaces	Good
	Celebrate the River's Uniqueness	Very good
	Enhance Community Life	Very good
Ecological	Restore Aquatic Habitat	Neutral
	Cultivate Terrestrial Habitat	Neutral
	Improve the Water Quality	Poor

After summarizing all the results from on-site survey, observation, expert interviews and river sediments test, we decided to use “Very good, Good, Neutral, Poor and Very poor” to evaluate 11 goals that we focused on. Overall, we thought goals in the theme of recreational and cultural were achieved very well. From the data we got, goals in the theme of ecological may not be achieved very well, but from the answers of on-site survey, we found people’s perception of ecological environment was good. Moreover, since the Chicago Riverwalk has only been built for a few years, the influence of ecological environment may not reflect totally, further researches are still needed for evaluating goals in the theme of ecological more accurately. (Table 23)

5.2 Recommendations

Even if most people thought there was nothing need to be added to the Chicago Riverwalk since it was already beautiful, some people still had diverse dislikes toward Riverwalk (Table 15). The most mentioned problems were the crowdedness, noise and the bad smell from the Chicago River, which ought to be improved by strategies in the future. People wanted to add more green spaces, restaurants and restrooms (Table 16). They also hoped to develop the riverwalk or establish another new one on the other side. But overall, we could say that most people were satisfied with the Chicago Riverwalk.

Acknowledgement

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Reference

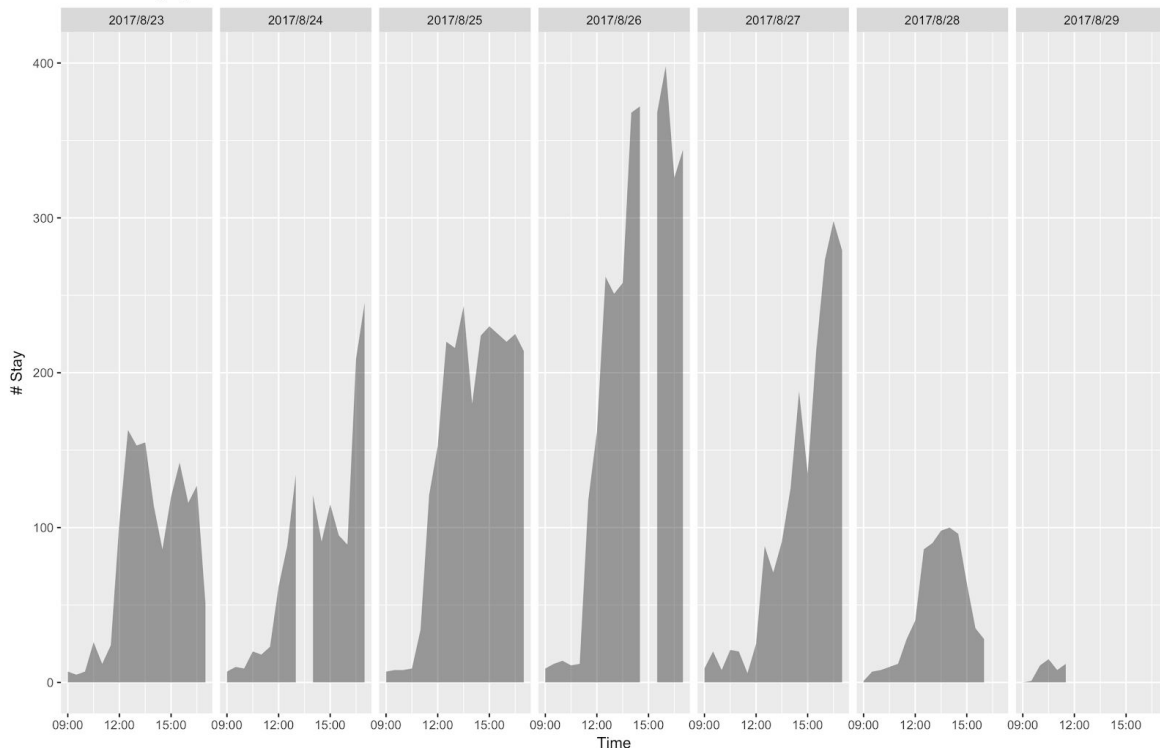
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Appendix

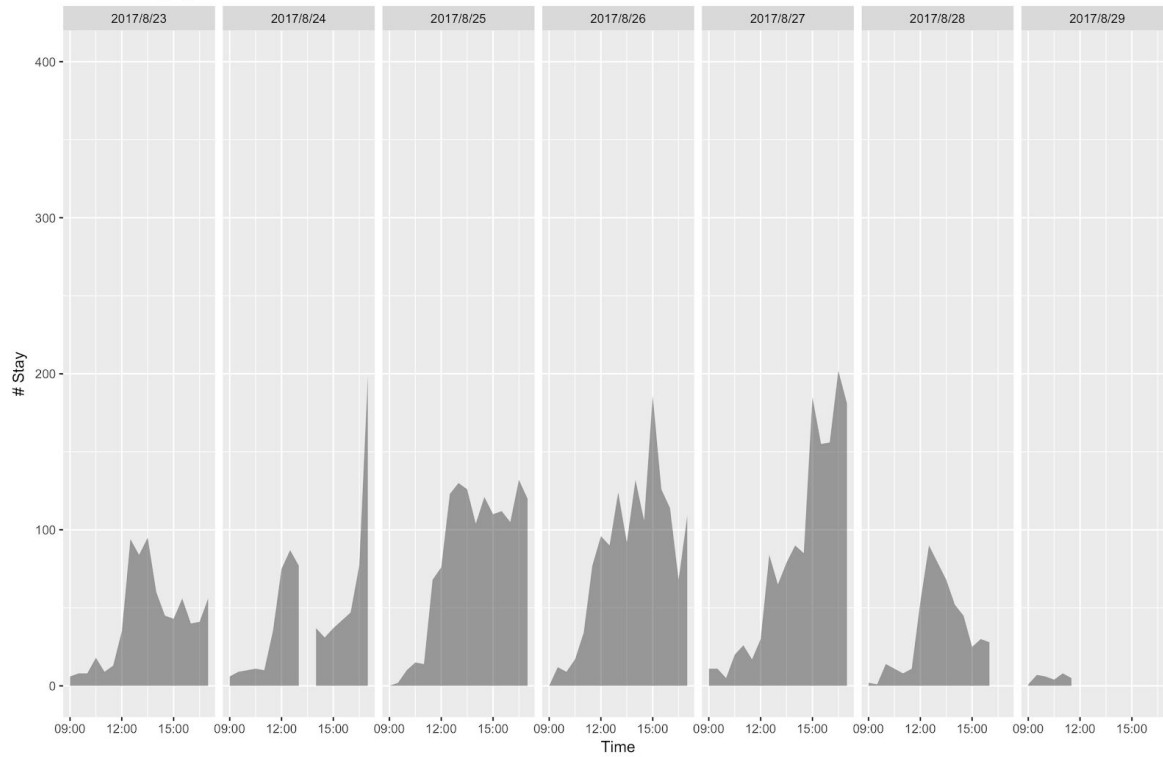
Appendix A: Recruitment script

Hi there, my name is _____, I am a graduate student in the School for Environment and Sustainability (formerly SNRE) at the University of Michigan, and would like to conduct a survey about your views on the Chicago Riverwalk (there are no right or wrong answers). The survey should take no more than 15 minutes of your time. We are conducting this survey to understand how the Riverwalk performs and functions for our master's project (Post-occupancy Evaluation of Chicago Riverwalk); your responses will not be shared with anyone outside of the project. We will not collect any personally identifying information from you, and your responses will remain anonymous. You will not be identified in any publication from this study. The questionnaire will be destroyed once the analysis is complete. If you have any questions or concerns, please contact us through chicagoriverwalk17@umich.edu

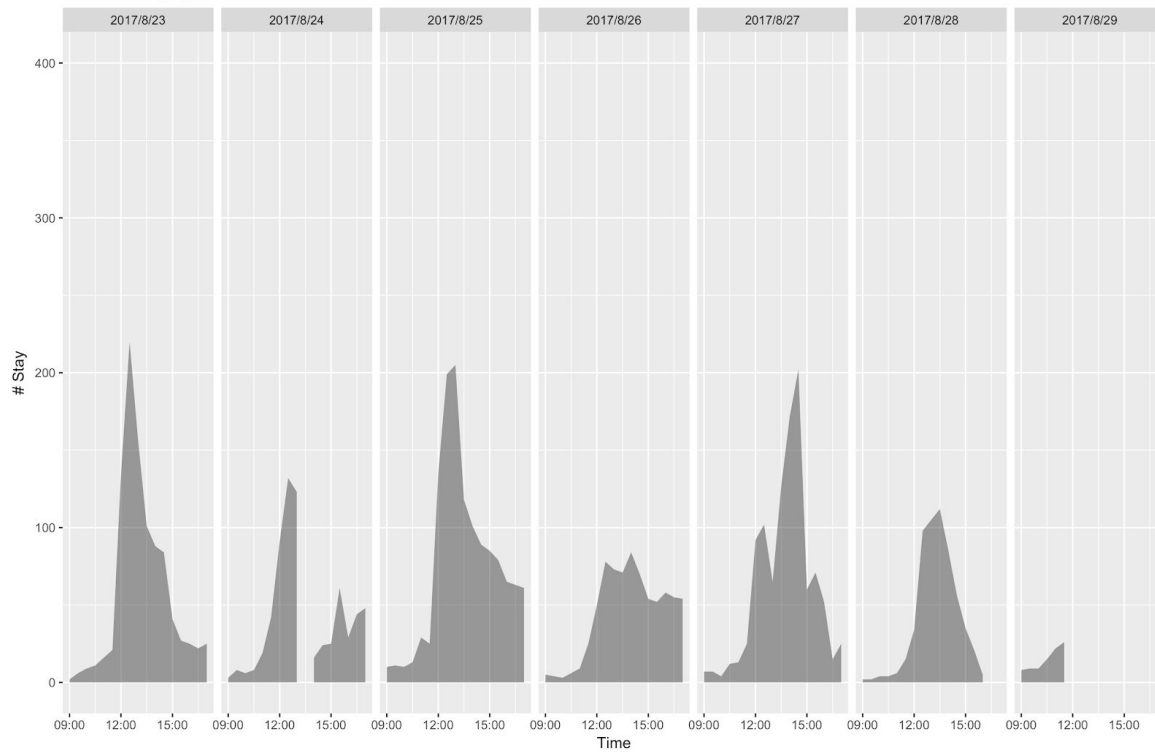
Appendix B: Visitors' staying behavior for each block



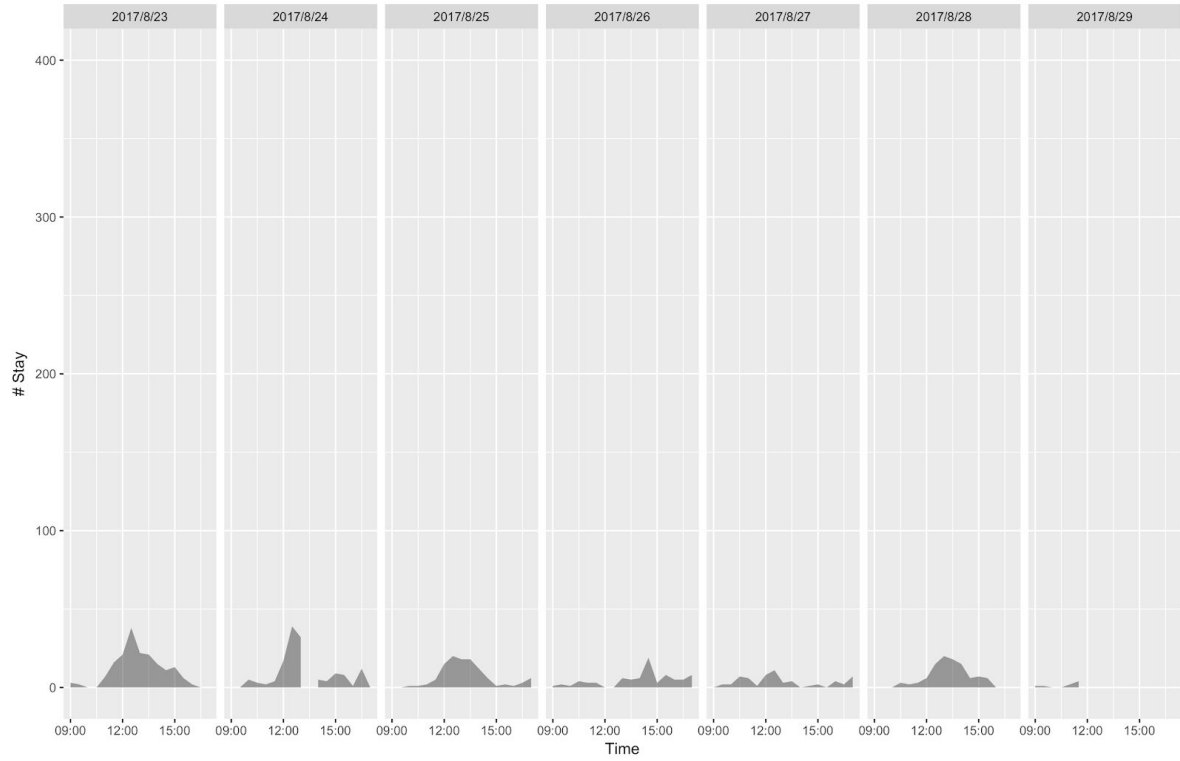
Visitors' behavior in block A



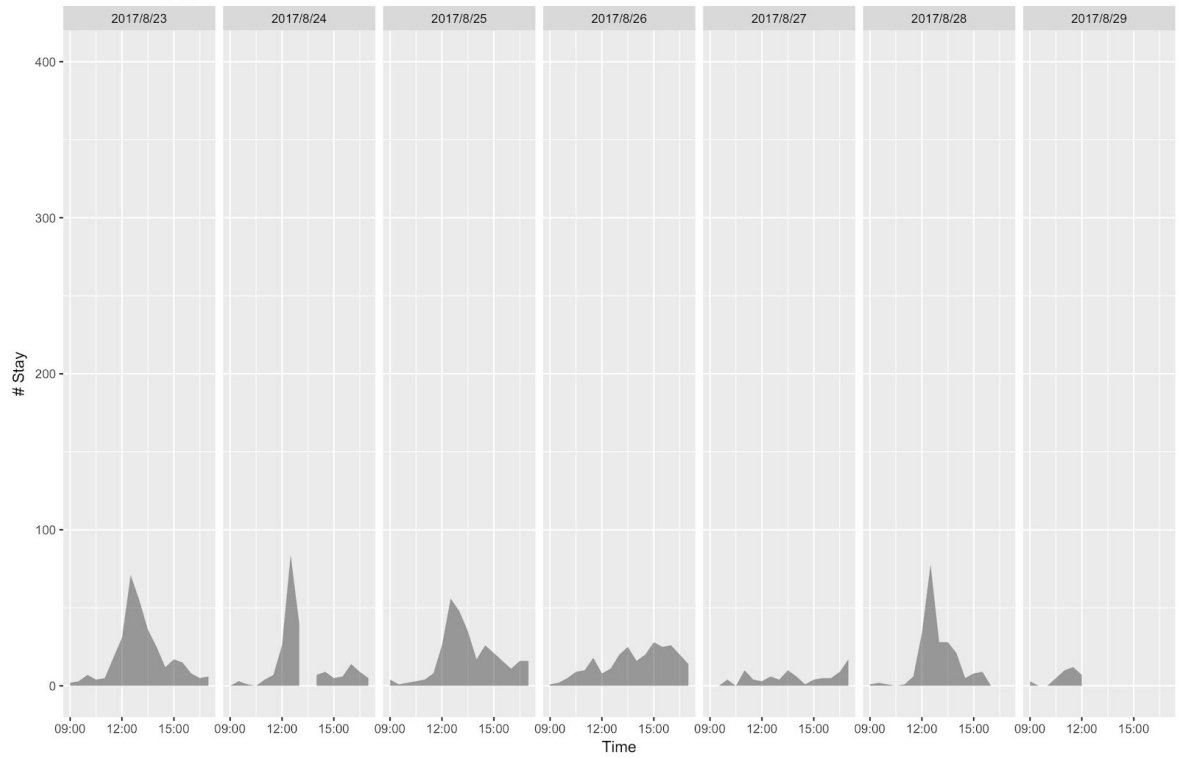
Visitors' behavior in block B



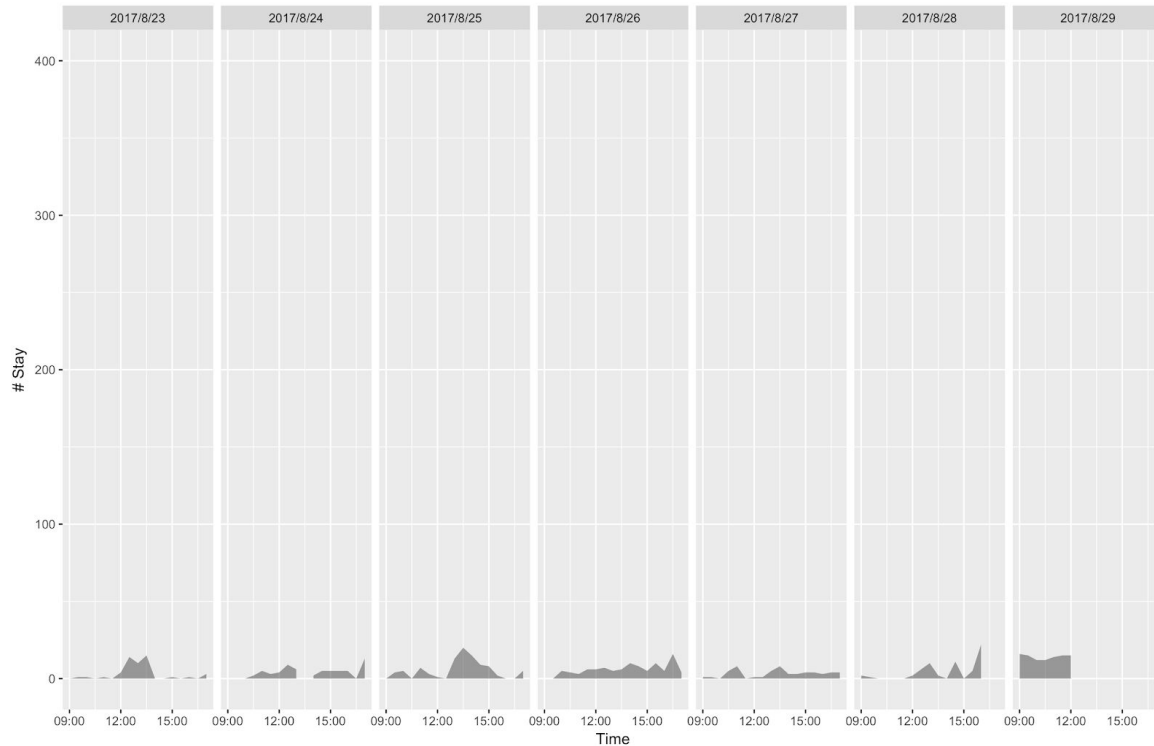
Visitors' behavior in block C



Visitors' behavior in block D



Visitors' behavior in block E



Visitors' behavior in block F

Appendix C: Survey

Thank-you for taking part in our survey. Your responses will remain anonymous, and you are free to stop taking the survey at any time. Please return the survey to us when you have completed it.

For the questions without "check all that apply", you only need to select one of the response options.

CHICAGO RIVERWALK SURVEY

Gender (Male, female, prefer not to say) _____

Age (in years) _____

City (please indicate state as well. If from outside the US, please indicate what country as well) _____

1. What time did you arrive at the Chicago Riverwalk today?

_____ ()A.M. ()P.M.

2. Are you typically with others when you visit the Chicago Riverwalk? (check all that apply)

A. Alone B. Wife/husband/partner C. Children D. Friend(s) E. Family Group F. School Group G. Tour Group H. Dog(s) I. Other_____

3. What did you do (or plan to do) along the Chicago Riverwalk today? (check all that apply)

A. Relaxation B. Spend time with family or friends C. Walk your dog D. Tours E. Exercise F. Have a meal G. Other _____

In addition to what you did today, what are some other things you have done in the Chicago Riverwalk? (check all that apply)

A. Relaxation B. Spend time with family or friends C. Walk your dog D. Tours E. Exercise F. Have a meal G. Other _____

4. Is this your first time visiting the Chicago Riverwalk?

A. Yes B. No

If no, how often do you visit the Chicago Riverwalk?

A. one to three times a month B. four to six times a month C. Three to four days a week D. Almost every day E. Other _____

5. Do you come here during other seasons (spring/fall/winter)?

A. Yes B. No

If yes, please **list the activities** you engage in during spring / fall /winter:

Spring

Fall

Winter

6. Do you fish here?

A. Yes B. No

If yes, **how often do you fish here?**

A. This is the first time B. once to three times a month C. four to six times a month D. Three to four days a week E. Almost every day

If yes, **what do you typically catch?**

Will you consume what you catch? Why or why not?

If no, have you ever seen anyone fishing here?

7. Have you ever boated in the vicinity of the Chicago Riverwalk?

A. Yes B. No

If yes, **what kind of boat?** (check all that apply)

A. canoe or kayak B. tour boats C. water taxis D. Others_____

If yes, **how many times in a year do you take part in boating in the vicinity of the Chicago Riverwalk?**

- A. 1-3 times B. 4-6 times C. More than 6 times

8. Do you plan to pay (or have you paid) for any goods or services along the Chicago Riverwalk?

- A. Yes B. No

If yes, **where?** (check all that apply)

- A. water taxi B. tour boats C. boat docking D. restaurant/bars E. Other _____

And how much are you typically spend per visit ?

- A. less than \$5.00 B. \$5.01 to \$10.00 C. \$10.01-\$20.00 D. more than \$20.00

9. How long do you typically spend along the Chicago Riverwalk?

- A. Less than 10 minutes B. 10 minutes – 30 minutes C. 31 minutes – 60 minutes
D. More than 60 minutes

10. How often do you visit/use each of the following places in the Chicago Riverwalk?

(See the photos below and Fill the number **in each blank**.)

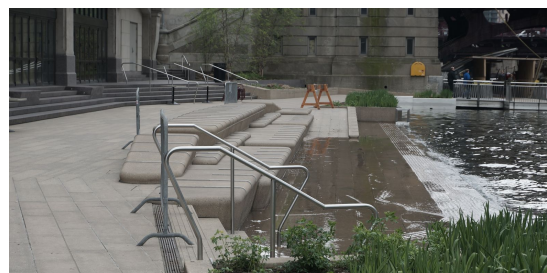


**This is the overall location map. (Photos provided only for illustrative purposes are not exactly what looks like now)*

1 = never or rarely, 2 = a little, 3 = occasionally, 4 = often, 5 = very often

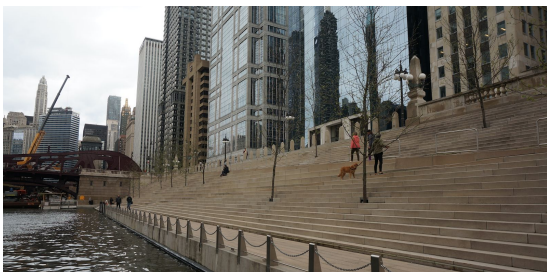


Marina Plaza (e.g. sitting area) _____



b. Cove (e.g. sitting area) _____

a.



c. River Theater (e.g. stairs) _____
fountain) _____



d. Water Plaza (e.g.



e. Jetty (e.g. floating wetland & decks) _____ f. Riverbank (e.g. boardwalk) _____

11. Thinking about your nearby environment, how do you feel about the amount of the following in the Chicago Riverwalk? (Please circle the response)

Green/natural areas (e.g., grass, trees, flower planters)

1 = far too little, 2 = too little, 3 = about right, 4 = too much, 5 = far too much

Sitting areas (e.g., benches, stairs)

1 = far too little, 2 = too little, 3 = about right, 4 = too much, 5 = far too much

Restaurants/Bars

1 = far too little, 2 = too little, 3 = about right, 4 = too much, 5 = far too much

12. How satisfied are you to access to the Riverwalk?

1 = not at all satisfied, 2 = a little, 3 = somewhat, 4 = quite a bit, 5 = very satisfied

13. For people with mobility issues, do you think the Riverwalk do enough accessing to the River? (e.g., providing wheelchair access)

A. Yes B. No C. I don't know

14. How satisfied are you with the Chicago Riverwalk in terms of safety for walking during the day?

1 = not at all satisfied, 2 = a little, 3 = somewhat, 4 = quite a bit, 5 = very satisfied

15. Have you been the Chicago Riverwalk at night?

A. Yes B. No

If yes, **how satisfied are you with the Chicago Riverwalk in terms of safety for walking at night?**

1 = not at all satisfied, 2 = a little, 3 = somewhat, 4 = quite a bit, 5 = very satisfied

16. Compared to two years ago (before the construction of the Chicago Riverwalk), do you feel that Chicago Riverwalk is safer?

A. Safer B. Less safe C. Don't know

If you feel that the Chicago Riverwalk is more safe, what features have improved the safety for you?

A. More lights B. More people C. More security D. More vegetation E. Other _____

17. Do you notice/are you aware of the floating wetland?

A. Yes B. No

If yes, **does the floating wetland play a role in your enjoyment of the Chicago Riverwalk?**

1 = not important, 2 = slightly important, 3 = moderately important, 4 = important, 5 = very important

18. Do you like the diversity (different kinds) of plants? (i.e., trees, shrubs, grasses and flowers) at the Chicago Riverwalk?

A. Yes B. No

If Yes, **does the variety of plants play a role in your enjoyment of the Chicago Riverwalk?**

1 = not important, 2 = slightly important, 3 = moderately important, 4 = important, 5 = very important

19. Are there other natural features that attract you to the Chicago Riverwalk?

Please specify: _____

20. Is the Chicago River in good health?

A. Strongly Agree B. Somewhat Agree C. Somewhat Disagree D. Strongly Disagree
E. Don't Know

21. Does the health of the Chicago River play a role in your enjoyment of the Chicago Riverwalk?

1 = not important, 2 = slightly important, 3 = moderately important, 4 = important, 5 = very important

22. Is the Chicago Riverwalk similar to other places you have been?

A. Yes B. No

If no, **what is unique about the Chicago Riverwalk?**

If yes, **what place does the Chicago Riverwalk remind you of?**

23. In one sentence, can you tell me what you appreciate or enjoy most about the Chicago Riverwalk?

24. In one sentence, can you tell me what you dislike about the Chicago Riverwalk?

25. Is there anything else you would like to add about the Chicago Riverwalk?

Thank-you for taking part in our survey! Please return the survey to our team.