BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-09 Subdocket C
CHICAGO AREA WATERWAYS SYSTEM	)	(Rulemaking- Water)
(CAWS) AND THE LOWER DES PLAINES	)	
RIVER: PROPOSED AMENDMENTS TO	)	
35 Ill. Adm. Code Parts 301, 302, 303 and 304	)	
(Recreational Use Designations)	)	

NOTICE OF FILING

To:

John Therriault, Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601

Marie Tipsord, Hearing Officer
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St, Suite 11-500
Chicago, IL 60601

Persons included on the attached
SERVICE LIST

Please take notice that on the 30th Day of June, 2011, I filed with the Office of the Clerk of the Illinois Pollution Control Board the attached **PRE-FILED TESTIMONY OF KIMBERLY RICE**, a copy of which is hereby served upon you.

Respectfully Submitted,

____

Jessica Dexter
Environmental Law and Policy Center
35 E. Wacker, Suite 1600
Chicago, IL 60601

DATED: June 30, 2011

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-09
CHICAGO AREA WATERWAY SYSTEM	)	(Rulemaking – Water)
AND THE LOWER DES PLAINES RIVER:	)	
PROPOSED AMENDMENTS TO 35 ILL.	)	
ADM. CODE PARTS 301, 302, 303, AND 304.	)	

Testimony of Kimberly Rice
June 29, 2011

Introduction

My name is Kimberly Bevan Rice and I am the policy and planning coordinator for Friends of the Chicago River (Friends), a nonprofit membership organization whose mission is to foster the vitality of the Chicago River for the plant, animal, and human communities that live within its watershed. Friends was founded in 1979 and our work spans the entire Chicago River system and surrounding watershed. The only organization dedicated solely to the river's improvement, Friends works in partnership with municipalities, businesses, community groups, schools, other nonprofits, government agencies and individuals through education and outreach, public policy and planning and on the ground projects that benefit the river. Friends has 5,000 members, volunteers and on-line advocates who work with us on an annual basis to improve the Chicago River.

The Chicago River is an evolving waterway. At one time considered a back alley for transporting raw sewage and waste, the Chicago River, thanks in part to the Clean Water Act and other advances, has experienced a renaissance that has brought with it a renewed vision of a healthy, thriving, natural, economic and recreational resource for all who live, work and play along its banks. Friends was founded to ensure that the Chicago River system becomes a natural, recreational and economic asset that is used, shared and loved by the people of the watershed. We have committed our work to furthering this ideal, but we are not alone. Government agencies, public and private entities, and volunteer groups have already invested billions of dollars in the river's revival and continue to do so presently, with plans for more investment into the future. We must protect these investments and work together to continue to improve the river, which is an enormous opportunity for river-based and river-edge business, new and improved open space, commercial operations and shipping, tourism, recreation community development and wildlife.

While I am not a fish habitat expert, as planning coordinator for Friends, I am aware of the great work being done by a whole host of other groups and agencies, both in partnership with Friends and independent of our projects. From new river-edge residential developments, restaurants, and paddling businesses to parks, paths and habitat projects that improve conditions for wildlife and fish, the Chicago River and the whole Chicago Area Waterway System (CAWS) is being embraced for its intrinsic and economic value.

Central to Friends' vision of a healthy river and a component of many projects throughout the CAWS is restoring habitat for fish. When referring to fish habitat restoration, I mean for example, projects that incorporate one or more of the following practices, though there are other options available, too (See Appendix A: *Improving Fish Habitat*):

- Stabilize and/or restore banks to prevent erosion and the release of silt that can be detrimental to fish habitats.
- Use of aquatic and upland vegetation to provide areas for shade, rest, feeding, spawning or hiding.
- Physical structures, such as logs or lunkers installed into the waterways to provide areas for rest, feeding, spawning or hiding

There are fish!

By the Metropolitan Water Reclamation District of Greater Chicago's (MWRDGC) own account, the number of fish species in the CAWS has significantly increased over the past 30-plus years. Thanks in large part to the MWRDGC's actions; the increases appear to correlate first with cessation of effluent chlorination from MWRDGC plants on the CAWS and the completion of the first 31 miles of the tunnel along the CAWS as part of the Tunnel and Reservoir Plan (TARP) in the mid-1980's. Another bump in numbers is noted most recently with the implementation of the SEPA stations in the mid-1990's, seeming to indicate that increasing dissolved oxygen had a positive effect on fish populations. (See, e.g., Exhibit 280 in this proceeding)

As their chart shows, the variety of fish species steadily increased from 10 to almost 70 over this time frame. This improvement deserves to be celebrated and continued through ongoing enhancement of fish habitat in all areas of the CAWS.

Additionally, the MWRDGC demonstrated further consideration on behalf of fish populations in the CAWS by releasing a feasibility study in November 2009 that addressed modification of the North Branch dam at River Park to allow for fish passage. The study recommended a Dutch Pool and Orifice type of fish passage (See Attachment A, pg. 87). The study noted improvements in water quality, specifically dissolved oxygen levels associated with dam modification (Attachment A, pgs. 2-3). This connectivity would allow fish from the CAWS to access additional higher quality habitat

SAMPLE PROJECTS

In addition to the MWRDGC's efforts, government agencies, public and private entities, and volunteer groups have been actively implementing and restoring quality fish habitat over the past decade.

Government Agencies

CITY OF CHICAGO

Visionary leaders from local municipalities and agencies envision the Chicago River and CAWS as a flourishing and healthy resource for people, wildlife and fish. The *Chicago River Agenda*, drawing on established data from the National Park Service, MWRDGC, the Chicago Department of Planning and Development, Chicago Park District, Friends, and others outlines the City of Chicago's support for increasing in-stream habitat to protect burgeoning fish populations (See Exhibit 276, pg. 19 in this proceeding).

Additionally, the *Chicago River Corridor Design Guidelines and Standards* recommends that among "the five goals of this plan are to… Restore and protect landscaping and natural habitats along the river, particularly fish habitat" (See Attachment B, pg. 1). To this end, the City has already implemented the following projects in the CAWS:

- North Side College Prep High School
- Lincoln Village Shopping Center
- 33rd Ward Yard
- Fleet Campus
- Julia C. Lathrop Homes – Friends led this project to create the Jimmy Thomas Nature Trail

CHICAGO PARK DISTRICT

The Chicago Park District has and continues to invest in the health of the Chicago River through completed and planned riverbank and habitat improvement projects. A sampling of these projects within the CAWS with the aforementioned considerations for fish habitat include:

- Completed
  - River Park
  - Clark Park
  - Ronan Park
  - Canal Origins
- In process or planned
  - Horner Park
  - Montgomery Ward Park (Erie, 511)
  - Ping Tom Park: North River Edge Development (See Exhibit 275 in this proceeding)
  - DuSable Park

Private Property/Businesses

Private landowners, developers, and businesses also have invested in fish habitat in the CAWS.

- The award-winning residential development, Fay's Point, in Blue Island embraced its location between the Cal-Sag Channel and Little Calumet River by restoring the wetland environment along its banks.

  > "The return of the natural shoreline has enhanced the ability of fish to find shelter and forage, with the underside of the floating docks offering food and cover, and the "bridge" ponds connecting the docks to shore act as shallow wetland nurseries for baby fish and amphibians" (See Attachment C, pg. 7).

- Redevelopment plans such as the award-winning Lake Riverdale Sustainable Master Plan incorporates expanded and enhanced habitat areas.
- WRD Environmental engineered and annually maintains another award-winning project, Friends' Chicago River Fish Hotel, a floating island planted with native vegetation to provide food and submerged cribs for shelter in the Main Stem of the Chicago River. (See Attachment D: *Images of habitat projects,* pg. 2)

Neighborhood Groups/Non-profits

- Riverbank Neighbors, an active community group on the North Branch of the Chicago River painstakingly restored their four-block section of riverbank by incorporating stabilization techniques, native vegetation and the installation of cedar wood fish lunkers to create fish habitat. (Attachment D, pg. 3)

FRIENDS OF THE CHICAGO RIVER

Friends has been involved in several other projects, including:

- The installation of experimental floating wetlands at the Diversey Turning Basin (Attachment D, pg. 4)
- Extensive riverbank restoration at Edgebrook Woods
- Upcoming restoration and habitat work at Kickapoo Woods.
- At present, Friends and the Illinois Department of Natural Resources (IDNR) are seeking $200,000 in funding for an in-stream habitat project designed for downtown Chicago. Intended to provide habitat in a built environment, the project uses recycled materials that can provide effective cover and protection for fish mimicking the characteristics of a natural bank. The linear system will be below water level and enhanced with woody debris and gravel to provide complex structures for fish and a food source for macroinvertebrates that will, in turn, become a food source for fish. The structure and its detail were developed by an IDNR scientist. (Attachment D, pgs. 5-6)

Conclusion

The CAWS teems with a variety of fish populations. Government agencies, private and public entities, and volunteer groups embrace a vision of healthy waterways offering quality fish habitat. From major municipal plans such as the *Chicago River Agenda* and the Lake Riverdale Sustainable Master Plan, to the efforts of neighbors spending their weekends crafting hand-made fish lunkers, the communities that border the CAWS exhibit their desire to protect fish and enhance their habitat. It is not only the fish that directly benefit from healthier waters and habitat, but so too do the birds such as cormorants, kingfishers, great blue herons, black-crowned night herons, and little green herons that I regularly see fishing along the shores of the CAWS, as well as birders, fishermen and any other person or critter that relies on the CAWS for sustenance or enjoyment.

Arguing the origins of each waterway does nothing to negate the presence of these fish. It does not matter whether or not a fish is living in a body of water created by people in the 20th century, one altered a century ago for other purposes, or if it is a waterway that has existed in its present form for the last millennia. We have gone from 10 species to 70. With such laudable progress, we should pause and take note, recognize our success, keep going and we *must not* stop now.

Thank you for your consideration.

Respectfully Submitted,

Kimberly B. Rice
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Chicago, IL 60604

Attachments

Attachment A: Waratuke, Andrew R., Jorge D. Abad, Christiana Barnas, and Marcelo H. Garcia. 2009. *Design and Modeling of a Combined Canoe Chute/Fish Passage for the North Branch Dam, Chicago, Illinois*. Sponsored by Metropolitan Water Reclamation District of Greater Chicago. University of Illinois at Urbana-Champaign. Under Contract: MWRDGC RPS #12.

Attachment B: City of Chicago. 2005 *Chicago River Corridor Design Guidelines and Standards.* Accessed online at http://www.cityofchicago.org/content/dam/city/depts/zlup/Sustainable_Development/Publications/Chicago_River_Plan_Design_Guidelines/ChicagoRiverGuidelines.pdf.

Attachment C: Fay's Point, LLC. Submission for 2010 Blue Ribbon Award.

Attachment D: Images of Habitat Projects from Friends' files.

1. Chicago River Fish Hotel
2. Riverbank Neighbors restoration and fish lunker project
3. Floating Islands at Diversey Turning Basin
4. Locations for planned Main Stem fish habitat
5. Design for planned Main Stem fish habitat

Attachment A

Design and Modeling of a Combined Canoe Chute/Fish Passage for the North Branch Dam, Chicago, Illinois

Andrew R Waratuke[a]
Jorge D Abad[b]
Christiana Barnas[c]
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[a]Research Engineer
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[c]Graduate Research Assistant
[d]Professor and Director, Ven Te Chow Hydrosystems Laboratory

November, 2009

ABSTRACT

The North Branch Dam on the Chicago River was built in the early 1900s to act as a grade control structure after completion of the North Shore Channel. A dual-use canoe chute/fishpassage has been proposed for the dam to restore biological connectivity between the upstream and downstream reaches while also providing increased recreational opportunities in the area.

An integrated canoe chute/fish passage design was recommended for the site. The canoe chute is comprised of four drop structures that provide a gradual transition between the upstream and downstream portions of the dam. The integrated technical fishway that has been recommended is of the style known as the Dutch Pool and Orifice fishway. This type of fishway has been proposed as a good alternative for the North Branch Dam site, more suitable to weaker-swimming fish species found in area streams than more traditionally used technical fishways such as the Denil.

A 1:20 scale physical model of the North Branch Chicago River system in the vicinity of the North Branch Dam was built in the Ven Te Chow Hydrosystems Laboratory of the University of Illinois' Department of Civil and Environmental Engineering. The purpose of the physical model, supplemented with computational fluid dynamics modeling, is to verify the safety of the proposed boat chute for the range of design flows while also providing insight into the effect the proposed structure will have on the overall flow patterns observed in the vicinity of the dam.

Modeling results indicate that the canoe chute should be safe for boater use for the full range of design discharges, with flows over the North Branch Dam ranging from 30 – 223 cfs. Before construction of the canoe chute/fishway several issues still need to be resolved that are outside the scope of this report. These issues include methods of limiting access to the canoe chute when discharges or downstream stages are outside of the proscribed safe range and adjustment of the spillway crest elevation external to the canoe chute/fish passage to limit discharges passing through the structure to limit the potential for extreme scour during large flow events.

ACKNOWLEDGEMENTS

This work was sponsored by the Metropolitan Water Reclamation District of Greater Chicago. The financial support provided is greatly acknowledged.

Mr. Joseph Schuessler, MWRD, provided comments throughout the development of the canoe chute/fishway design and during the early versions of this report

Survey data used to develop the bathymetry for both the physical and numerical modeling effort was provided by the Mr. Robert Walsh of the MWRD survey section. Stage and discharge data was provided by Mr. Kevin Johnson and Jim Dunker of the United States Geological Survey Illinois Water Science Center. Mr. Kevin Johnson and Alan Robl were also involved in the collection of ADCP field data in the vicinity of the dam that was used for calibration of the physical model.

The physical model was constructed by the machine shop of the Department of Civil and Environmental Engineering at the University of Illinois, supervised by Mr. Tim Prunkard. The hard work and expertise of the machine shop staff including, but not limited to, Mr. Chester Riggin, Charles Cook, Marc Killion, and Jamar Brown are gratefully acknowledged.

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1 INTRODUCTION

The Metropolitan Water Reclamation District of Greater Chicago (District) owns and maintains the dam located on the Upper North Branch of the Chicago River, immediately upstream of the junction with the North Shore Channel with the resulting confluence forming the Lower North Branch of the Chicago River. Adjacent riparian land and portions of the adjoining property are leased to North Park University and the Chicago Park District. In recent years the Chicago Park District has built river bank improvements including a canoe portage to the south of the North Branch Dam. The dam, known as the "waterfall" amongst park patrons, has become a popular fishing spot while providing a nice area to relax and enjoy nature.

In 2006, the Friends of the Chicago River (FOCR) approached the District regarding the possibility of installing a fish passage at the Dam. Separating the Upper North Branch from the Lower North Branch of the Chicago River, the dam presents a potential barrier to a connected biological community in that it does not allow for the passage of any fish species from the Lower North Branch or North Shore Channel into the Upper North Branch.

A study commissioned by the FOCR and performed by MWH Americas presented alternative designs for a possible fish passage to be located at the North Branch Dam. The purpose of the fish passage would be to restore biological connectivity between the various segments of the North Branch Chicago River system. The MWH report (MWH, 2006) presents two alternative fish passage designs: a Denil fishway that may be installed as an auxiliary structure onto the existing dam and a nature-like fishway in which the dam is removed completely and replaced with a pool and riffle system designed to maintain the existing stream grade, thereby minimizing the amount of streambed erosion that would be expected with dam removal.

During the course of evaluating the FOCR/MWH study, the District contacted the Department of Civil and Environmental Engineering (CEE) at the University of Illinois to solicit input. Citing a review of the literature that examined design recommendations and the effectiveness of fishways installed on low-gradient streams within the United States

(Caisley and Garcia, 1999), it was suggested that the installation of a dedicated fish passage at the North Branch Dam may not result in the anticipated increase in fish migration. This is largely due to the fact that there is little evidence suggesting that the fish species commonly found in Illinois streams will use more traditional fishway designs, which are often intended to attract and pass larger, stronger swimming species such as salmon and steelhead. Instead, it was suggested that a boat passage (or canoe chute) be installed at the dam with an integrated fish passage that could be used to increase recreational opportunities in the area while still providing an opportunity for fish passage and subsequent water-quality improvements while presumably minimizing the additional costs incurred.

It is likely that a combined canoe chute/fish-passage would provide the most overall benefit for the money. The structure would act to improve the biological connectivity of the North Branch Chicago River system by providing a means for the local fish communities to migrate upstream of the dam by utilizing the fish passage. The addition of several more flow cascades associated with the canoe chute drops are expected to increase dissolved oxygen levels in the vicinity of the dam, thereby resulting in an improvement in water quality. And finally, the construction of a canoe chute should provide increased recreational opportunities on the North Branch Chicago River system, thereby addressing several of the primary goals of FOCR:

> "...Friends has been working to improve the health of the Chicago River for the benefit of people and wildlife and by doing so, has laid the foundation for the river to be a beautiful, continuous, easily accessible corridor of open space in the Chicago region." (http://chicagoriver.org/about) – retrieved Sept 5, 2008

2 STUDY OBJECTIVES

The modification of low-head dams requires careful study to assess both the short-term and long-term impact that such endeavors might have on the river hydraulics and water quality (Armbruster and Garcia 1998). The North Branch Dam is no exception since this structure provides a control point for the drainage resulting from a highly urbanized watershed covering approximately 113 square miles (US Geological Survey, 2008). For instance, significant changes in the discharge characteristics of the dam could result in an increase in upstream flooding. The existing "waterfall' entrains substantial amounts of air which has a positive effect on dissolved oxygen levels in the North Branch of the Chicago River. In fact, the air entrained by the waterfall is the main reason why the fish congregate in close proximity to the dam, resulting in a popular fishing spot.

It is clear that a study of potential modifications to the North Branch Dam should not be limited to hydraulic and biological aspects but should also consider the impact of such modifications on the water quality of the waterway as well. When properly designed, a canoe chute in the North Branch Dam could also function as a fish passage and at the same time increase dissolved oxygen levels thus enhancing the water quality of the stream (Caisley et al. 1999). The possibility has provided the motivation for this research.

A preliminary design for the boat chute will be proposed and a hydraulic scale model will be built and tested in the Ven Te Chow Hydrosystems Laboratory of the Civil and Environmental Engineering Department at the University of Illinois at Urbana-Champaign. The boat chute will be designed and tested to cover a wide range of flow discharges. The goal is to verify that safe passage through the boat chute can achieved for flow rates ranging from 30 – 223 cfs, corresponding to a flow exceedance of 85% and 15%, respectively, for the flow-duration curve developed from the USGS' North Branch Chicago River at Albany Avenue gage. However, should it not be possible to maintain safe passage through the canoe chute for this entire range of flow discharges, the discharges at which safe passage can be maintained will be assessed.

Additionally, the discharge characteristics of the modified dam with the canoe chute/fish passage will be determined with the goal of maintaining pre-modification water-surface elevations upstream of the dam for all flow conditions. Flow measurements will also be conducted to determine the water velocities that can be expected in the canoe chute in order to assess the safety of the structure for boat passage, the potential for bed and/or bank erosion inside and external to the canoe chute, and to determine if flow velocities in the chute will be in a range that will be likely to allow the passage of the target fish species.

3 SITE DESCRIPTION

3.1 North Branch Dam history

The North Branch Dam is located at the confluence of the Upper North Branch of the Chicago River and the North Shore Channel, in the Albany Park neighborhood of Chicago (Figure 3.1). Owned and maintained by the District, the dam is bordered on the north by a football stadium used by North Park University and on the South by River Park, operated by the Chicago Park District.

The North Branch Dam was originally built in 1910 as a grade control structure. The construction of the North Shore Channel and the subsequent straightening and dredging of the Lower North Branch resulted in a significant change in the channel bed elevation between the Upper North Branch and the Lower North Branch/North Shore Channel. The dam was built to maintain the channel bed elevation in the Upper North Branch, preventing excessive upstream erosion of the Upper North Branch and subsequent siltation in the lower North Branch (Hill, 2000).

Throughout the life of the dam, numerous improvements have been made to the dam's structure and the Upper North Branch channel. In the early 1940's a concrete lining was added to the channel of the Upper North Branch for approximately one mile upstream of the dam to combat increased flooding and channel erosion as well to prevent the formation of stagnant pools during periods of low water. Additionally, a cipoletti weir was installed during the same time period to prevent ponding from occurring behind the dam during times of low flow. Logs and other debris would frequently become jammed in this weir, so an additional wider notch was cut into the face of the dam in 1965 (Hill, 2000), resulting in the dam configuration that can be observed to this day (figure 3.2). In recent years the Chicago Park District has built additional river bank improvements including a canoe portage to the south of the dam.

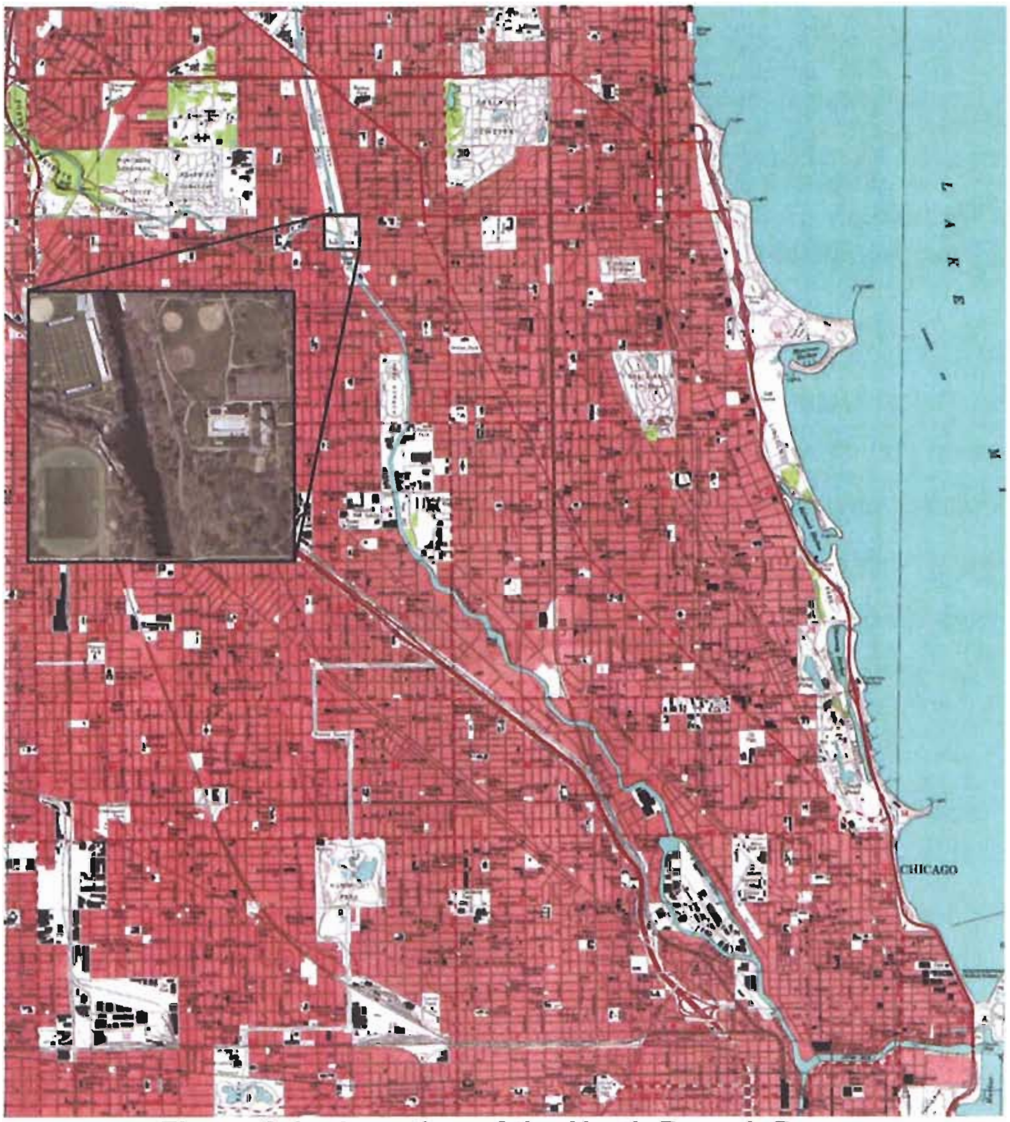


Figure 3.1 – Location of the North Branch Dam.

Figure 3.2 – Photograph of the North Branch Dam.
The photograph was taken from the junction of the North Shore Channel and the Lower North Branch.

3.2 Flow Data

3.2.1 Discharge Data

Flow-duration curves were developed for the North Branch system from daily discharge data collected at several nearby United States Geological Survey (USGS) surface-water gaging stations and from daily outflow data from the District's North Side Water Reclamation Plant (NSWRP), which on average accounts for approximately 77% of the flow in the North Shore Channel (as measured at Grand Avenue – USGS gage 05536118).

The flow duration curve for the Upper North Branch was developed exclusively from data available from USGS gaging station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL. Approved daily data is available from Oct 1, 1993 to Sept 30, 1998 and from Jun 24, 2000 to Sept 30, 2006. The flow-duration curve for the Upper North Branch is presented as Figure 3.3.

The flow duration curve for the North Shore Channel was developed from a combination of the flow measured at USGS station 05536101: North Shore Channel at Wilmette, IL which was active from Oct 1, 1999 to Sept 30, 2003 and the flow from the NSWRP, with data available from Jan 1, 1982 to Mar 31, 2008. The flow-duration curve could only be developed for the period of record in which the data from the North Shore Channel at Wilmette was operational.

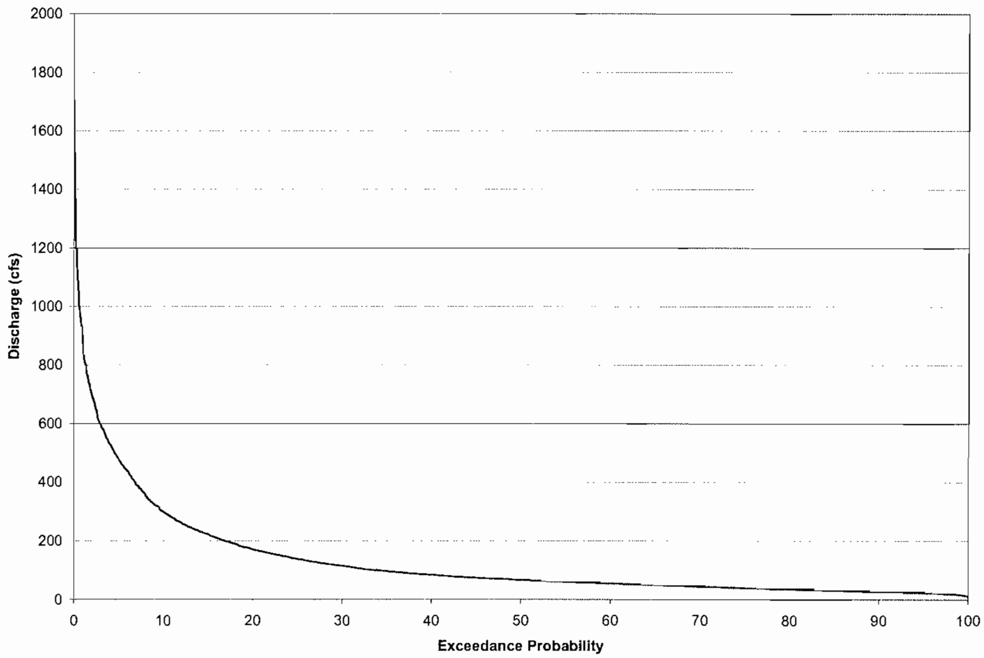


Figure 3.3 – Flow-duration curve for USGS gaging station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL.

(Based on approved stream flow record 10/1/1989 - 9/30/1998 & 6/23/2000 - 9/30/2006.)

In order to extend the period of record for the flow duration curve, it is possible to include flow data from the USGS gaging station 05536118: NB Chicago River at Grand Avenue at Chicago, IL which has a period of record from July 2, 2002 to Sept 30, 2007. Since there are no major ungaged in-flows between the junction of the Upper North Branch with the North Shore Channel and the USGS gage at Grand Avenue, it is possible to perform a regression analysis and extend the available data for the flow duration curve. The combined flows from the Albany Ave and Wilmette gages and the NSWRP are compared to the flow at Grand Ave and are presented in Figure 3.4. The regression equation is

$$Q_{\text{Grand Ave}} = 1.337Q_{\text{combined}} - 174.24 \qquad (1)$$

Using the inverse of this equation, it is possible to estimate the combined discharge from the North Shore Channel and the Upper North Branch. By subtracting out the flow from the Upper North Branch (Albany Ave gage), an estimation of the North Shore Channel flow from Oct 1, 2003 to Sept 30, 2007 can be determined (figure 3.5). The curves only vary by 9 cfs at 15% exceedance (2% difference) and 1 cfs at 85% exceedance (0.3 % difference). Therefore, either curve can be used with confidence. Flow data for selected exceedance values are summarized in table 3.1 for the Upper and Lower North Branch and North Shore Channel.

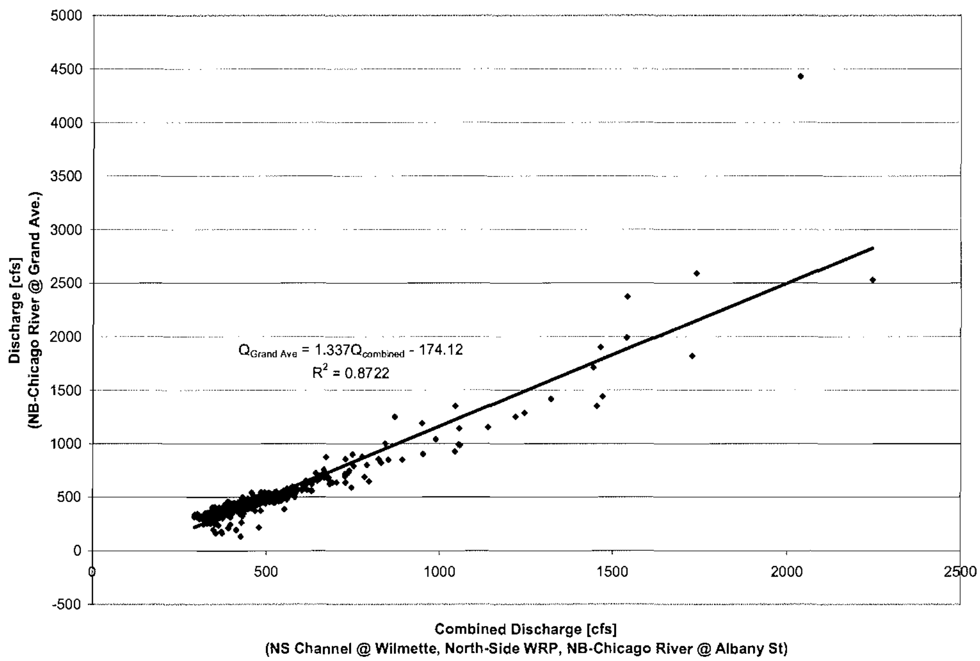


Figure 3.4 – Comparison of the combined gaged discharge upstream of the North Branch Dam to Grand Avenue.

The graph compares the combined gaged daily discharges from the gaging stations at Wilmette (USGS station 05536101) and Albany Ave (USGS station 05536105) and the published daily discharges from the North-Side WRP outfall (MWRDGC, 1999, 2007) to the gage at Grand Ave (USGS station 05536118).

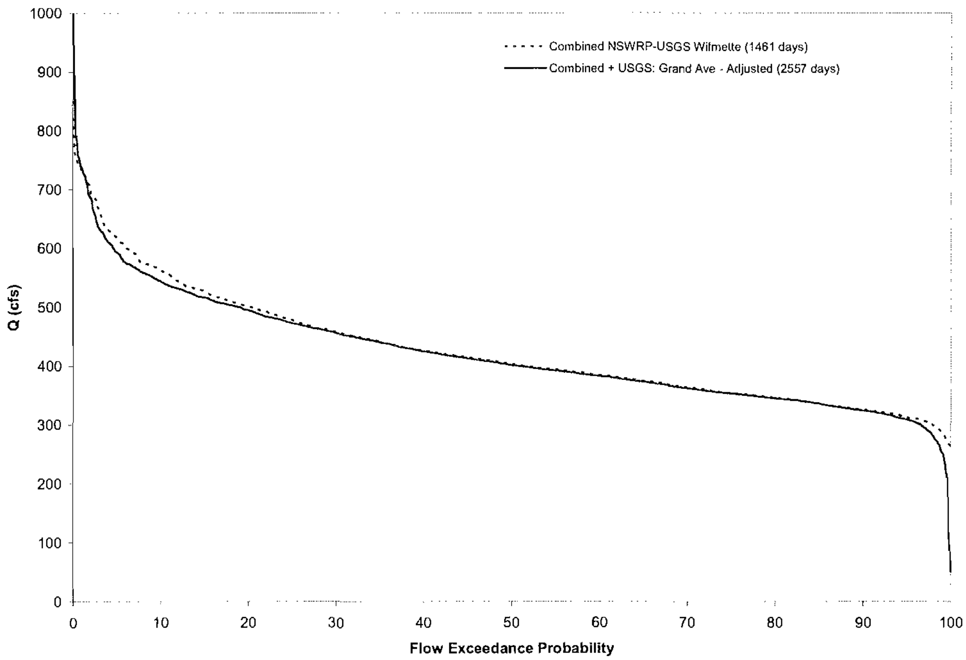


Figure 3.5 – Comparison of the flow duration curves below the North Branch Dam.

This graph compares the flow duration curve developed using the combined data from Wilmette (USGS station 05536101) and Albany Ave (USGS station 05536105) and the published daily discharges from the North-Side WRP outfall (MWRDGC, 1999, 2007) to the extended flow duration curve that includes the regressed data (using eq. 1) from the Grand Avenue gage (USGS Station 05536118).

Table 3.1 – Selected discharges for the Upper and Lower North Branch and North Shore Channel.

Exceedance Probability	Prototype Discharge (cfs)		
	Upper North Branch	North Shore Channel	Lower North Branch
95	22	312	334
85	30	336	366
75	39	354	393
65	49	374	423
55	60	394	454
45	74	415	489
35	98	441	539
25	141	478	619
15	228	526	754
5	476	909	1385

3.2.2 Stage data

Determining the water-surface stage of the UNB is a relatively straightforward procedure and may be done directly using the USGS's published rating curve for the Albany Avenue gage - this rating curve is presented as figure 3.6.

Determining an appropriate water surface elevation to apply to the North Shore Channel and the Lower North Branch is a more complicated endeavor. The Chicago River system below the North Branch Dam has three water-control locks (located in Wilmette on the North Shore Channel at Lake Michigan, in downtown Chicago on the main branch of the Chicago River at Lake Michigan, and in Lockport, upstream of the confluence of the Chicago Ship and Sanitary Canal and the Des Plaines River). The combination of these three locks allows the water level in the Chicago River system to be controlled precisely for navigation and storm-water management purposes. Due to this artificial control of the water levels in the Chicago River system, the development of a standard rating curve for the river below the North Branch Dam is not appropriate since it is possible for a gage height to be associated with a wide range of discharges, depending on how the locks are being operated.

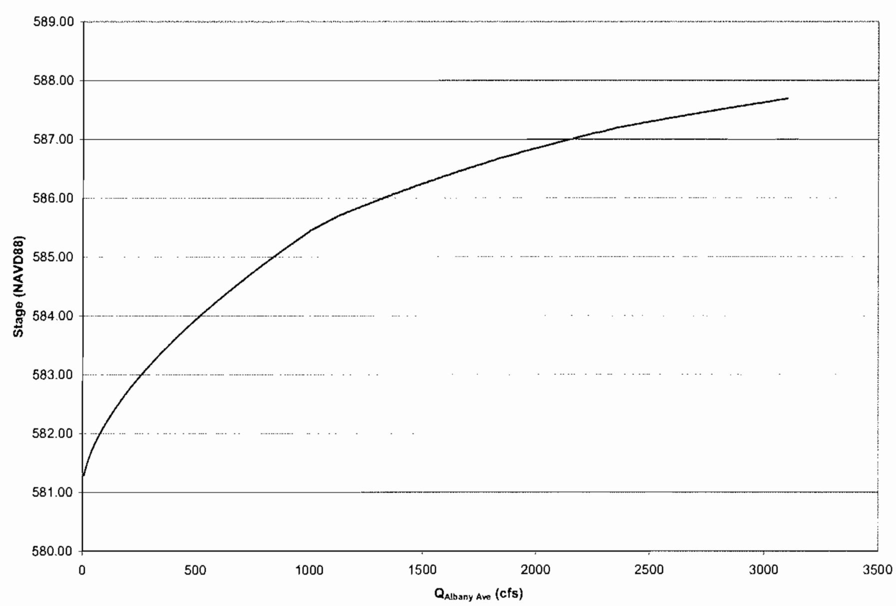


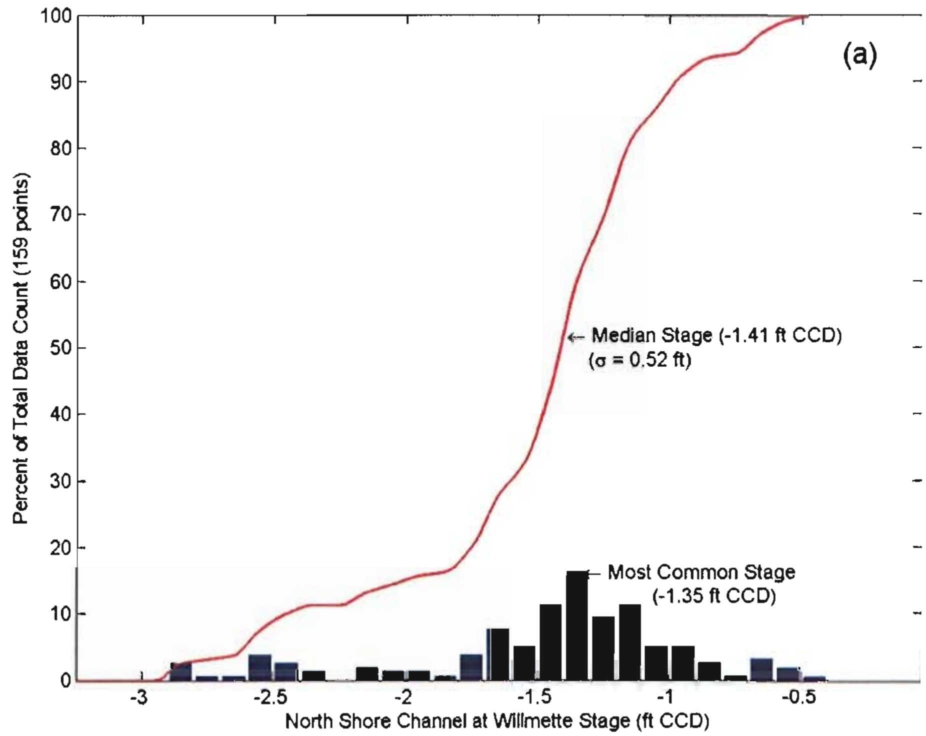
Figure 3.6 – USGS rating curve for station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL.

In order to overcome this complication, a statistical approach was taken to determine the downstream rating curve. Using 15-minute gaging data, the stages measured at Wilmette and Grand Avenue were combined based upon the corresponding flow rate at Albany Avenue and grouped together into 10 flow ranges (corresponding to Albany Avenue flow exceedances of 0-10%, 10-20%, 20-30%, etc). For a given flow range, the probability distribution of stages at Wilmette and Grand Avenue were determined and the median and most common (mode) stages were determined, as well as the standard deviation of the distribution. Example distributions for the 50-60% flow exceedance range for the Grand Avenue and Wilmette gages are presented in figure 3.7.

To determine the water surface elevation at the location of the North Branch dam, the simplified assumption was made that the water surface has a constant slope between the Wilmette and Grand Avenue gages. Then, given that the North Branch dam is located approximately equidistant from these two gages (11.8 km along the stream centerline from each), the averages of the median water-surface elevations at Grand Avenue and Wilmette were used as the water surface elevations below the North Branch dam. The downstream stages are summarized in table 3.2 and presented graphically in figure 3.8.

Table 3.2 – Calculated stages downstream of the North Branch Dam.

Albany exceedance	Albany flow range (cfs)	Median Grand Ave stage (ft NAVD88)	Std deviation Grand Ave Stage (ft)	Median Wilmette stage (ft NAVD88)	Std deviation Wilmette Stage (ft)	Stage below NB dam (ft NAVD88)	Std deviation of stage below NB dam (ft)
100-90%	298.5-1990	577.25	0.21	577.65	0.36	577.45	0.59
90-80%	170.5-298.5	577.25	0.26	577.65	0.32	577.45	0.54
80-70%	114.5-170.5	577.25	0.21	577.65	0.43	577.45	0.71
70-60%	83.5-114.5	577.15	0.23	577.75	0.45	577.45	0.74
60-50%	66.5-83.5	577.25	0.24	577.85	0.52	577.55	0.86
50-40%	54.5-66.5	577.25	0.25	577.85	0.62	577.55	1.04
40-30%	44.5-54.5	577.25	0.28	578.25	0.54	577.75	0.88
30-20%	34.5-44.5	577.15	0.27	578.25	0.47	577.70	0.77
20-10%	26.5-34.5	577.15	0.30	578.15	0.49	577.65	0.80
10-0%	11-26.5	577.15	0.64	578.45	0.94	577.80	1.55



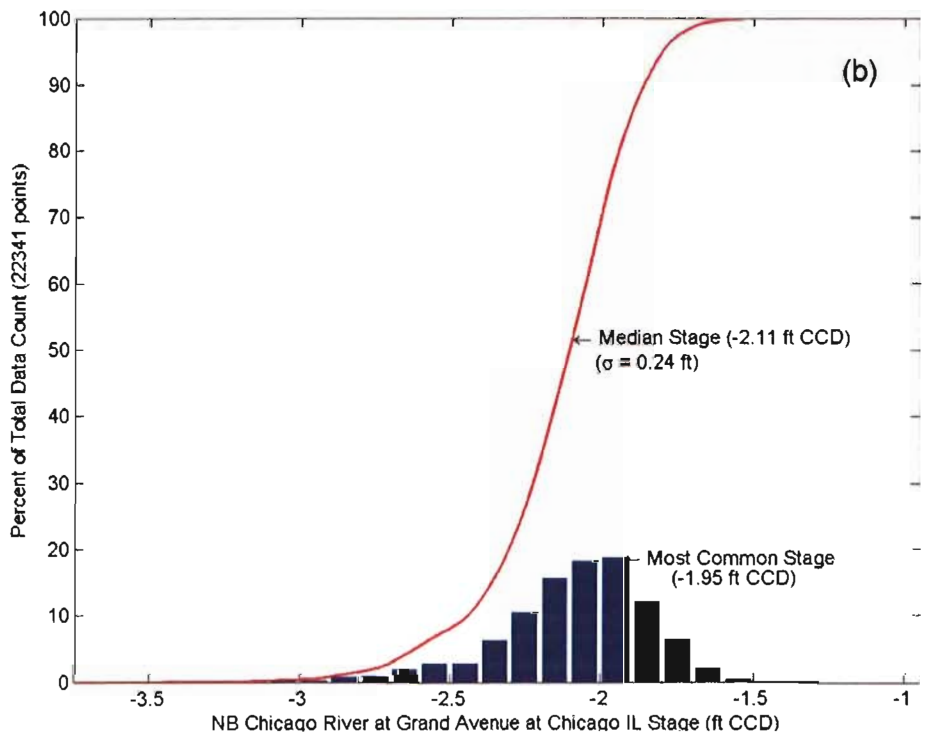


Figure 3.7 – Stage histograms and cumulative probability distributions for the Wilmette and Grand Avenue gages.

The datapoints for these distributions are a subset of the gage data that occur during the same 15-minute time interval as a 50-60% exceedance flow event measured at the North Branch Chicago River at Albany Ave. gage.

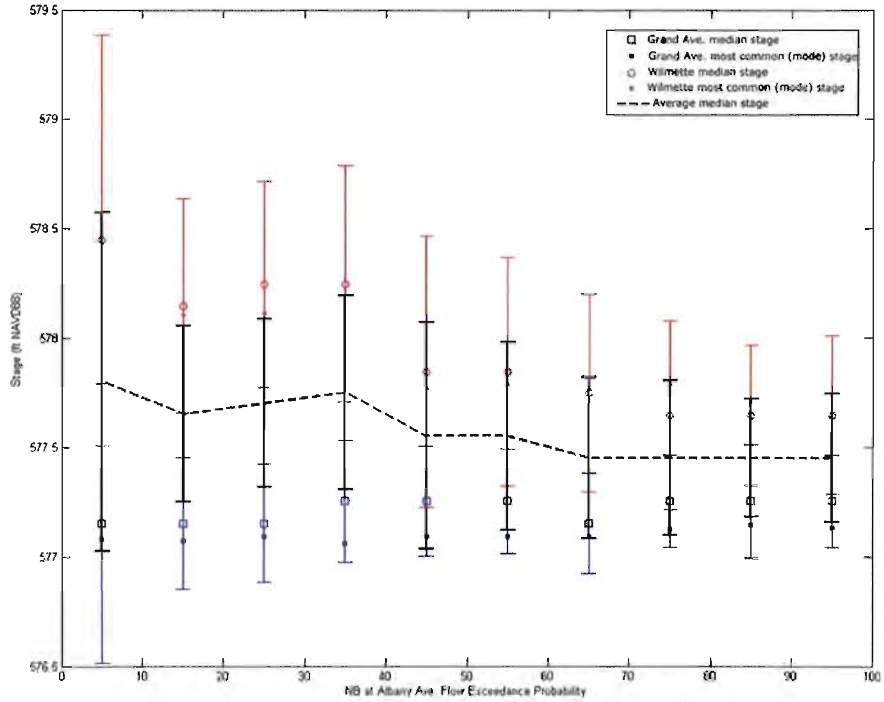


Figure 3.8 – Calculated stage downstream of the North Branch Dam for various discharge exceedances at Albany Avenue.

Also presented in this figure are the median stage and standard deviations of the stages the USGS Wilmette and Grand Avenue gaging stations – USGS station numbers 05536101 & 05536118) (Note: error bars represent 1 standard deviation).

4 STUDY DESCRIPTION

4.1 Physical Model Construction

A geometrically undistorted 1:20 scale physical model of the North Branch Chicago River reach in the vicinity of the North Branch dam was constructed in the Ven Te Chow Hydrosystems Laboratory (VTCHL) of the University of Illinois at Urbana-Champaign's Department of Civil and Environmental Engineering. The physical model included the Upper North Branch of the Chicago River approximately 50 meters upstream of the existing dam, the North Shore Channel approximately 80 meters upstream of the confluence with the North Branch, and the Lower North Branch of the Chicago River approximately 80 meters downstream of the confluence (the model extents are shown overlaying the aerial photograph of the site in figure 4.1). Over bank topographical and in-channel bathymetrical survey data was provided by the District.

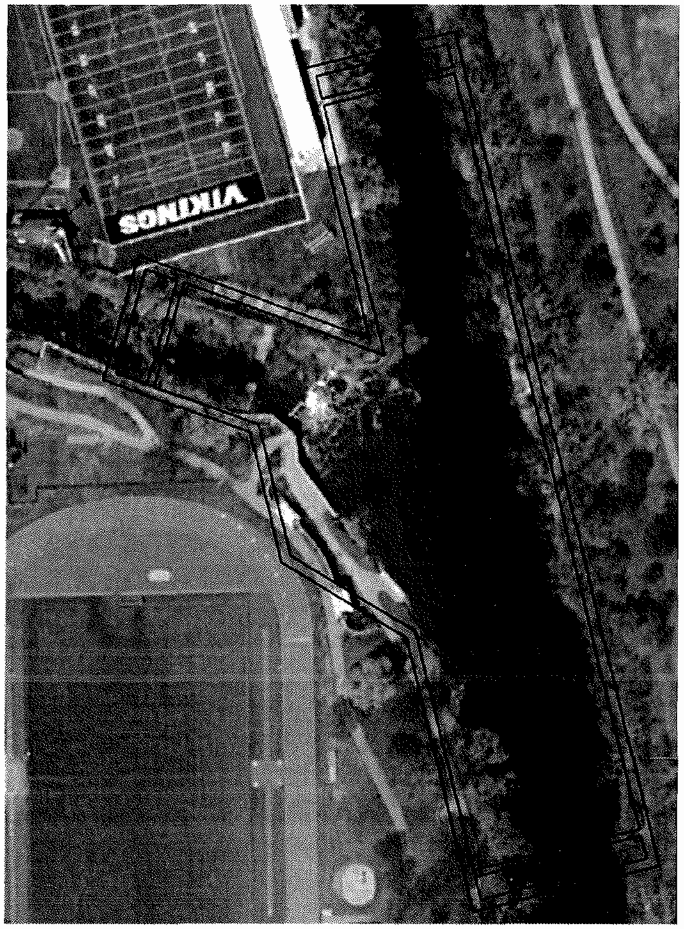


Figure 4.1 – Extents of the physical model referenced to an aerial photograph of the NB dam site.

The physical model was comprised of a 36-inch tall by 6-inch thick reinforced concrete basin designed to contain the model geometry. Inside the modeling basin, a wooden deck was built out of 2x10 dimensional lumber and ¾-inch plywood to support the cross-section templates and the final concrete cap (figure 4.2(a) & (b)). PVC cross-sections were then attached to the top of the plywood decking at the correct location to provide a basis for the channel geometry. The model was finally capped with a thin layer of concrete, forming the final channel geometry (figure4.2(c)).

Water was supplied to the model via PVC pipe connected to the VTCHL's constant head tank. An 8-in pipe was used for the provided flow to two individually metered and valved PVC lines that supplied water to the upstream model extents of the North Shore Channel and Upper North Branch (a 4-inch line and a 3-inch line, respectively). These branch lines each terminated in perforated pipe manifolds recessed in 18-in wide reservoirs at the upstream ends of the model. At the downstream end of the LNB, water was collected in a third 18-in wide reservoir and routed via a metered and valved 8-in PVC pipe into the laboratory's re-circulating water-supply channel. Water level in the model was set and controlled using mass continuity. Inflow was set slightly higher or lower than the outflow, causing water levels to increase or decrease as required until the desired water level was reached, at which time the inflow was set to match outflow, maintaining a constant water level for the duration of a test.

Figure 4.2 – Photograph of the physical model construction.
Photograph shows (a) Interior support structure (b) PVC templates installed in model (c) completed physical model in the Ven Te Chow Hydrosystems Laboratory.

4.2 Physical Model Scaling

The physical model was designed using an undistorted geometric similarity and operated using the Froude similarity law. Geometric similarity requires all physical dimensions in the prototype structure be scaled equally in the model. Geometric length ratios are given by

$$L_r = L_p/L_m \quad (2)$$

where L_r is the length ratio, and L_m and L_p are length dimensions in the model and prototype, respectively. Based on experience and the laboratory space available, the length ratio chose for the model study is 20:1. The free-surface flow in the present study is dominated by gravitational and inertial forces. Therefore, the ratio of gravitational to inertial forces, the Froude number, F, must be the same in both the model and prototype to satisfy dynamic similarity. The Froude ratio, F_r, is represented by

$$F_r = F_p/F_m = 1 \quad (3)$$

where

$$F_m = V_m/(gL_m)^{0.5} \quad (4)$$

and

$$F_p = V_p/(gL_p)^{0.5} \quad (5)$$

V_m and V_p are the model and prototype velocities, respectively; g is the gravitational acceleration; and L_m and L_p are length dimensions in the model and prototype, respectively. Equations (6), (7), and (8) give the scale ratios for velocity, V, discharge, Q, and time, T, for a length ratio of 20,

$$V_r = V_p/V_m = L_r^{0.5} = 4.47 \quad (6)$$

$$Q_r = V_rL_r^2 = L_r^{0.5}\, L_r^2 = L_r^{2.5} = 1789 \quad (7)$$

and

$$T_r = L_r/V_r = L_r/L_r^{0.5} = L_r^{0.5} = 4.47 \quad (8)$$

The time ratio and the velocity ratio are 4.47. This means that even though the water velocities in the model are slower, events actually occur faster. The discharge ratio is 1788. A flow of 223 cfs (a flow exceedance of 15% on the Upper North Branch) in the prototype scales to a discharge of 0.12 cfs in the model.

It is realized that fluid inertia and gravity are not the only quantities which influence the fluid mechanics of the modeled system. Fluid viscosity, though small for water, can have a profound effect on a flow field through the modification of the boundary layer formation and zones of separation. To model for this, it would require holding the Reynolds number, $R = VL/v$ (where v = the kinematic viscosity) the same between the model and the prototype. Since water is the fluid in both the model and the prototype ($v_r = 1$), Reynolds similarity would require $V_r = 1/L_r$ – however, Froude similarity requires that $V_r = L_r^{0.5}$. This result implies that it is impossible to have exact simultaneous Froude and Reynolds similarity without changing the fluid between the model and prototype. The practice in hydraulic engineering is to ensure that the Reynolds number in the model is still sufficiently large so that boundary layer formation and zones of separation, if any, are still correctly represented. For L_r = 20 the ratio for the Reynolds number (model-to-prototype) is

$$R_r = V_r L_r / v_r = L_r^{1.5} = 89$$

so that the Reynolds number in the model is reduced from that in the prototype by a factor of about 89.

For the present case, the largest potential scale effects are going to be expected at low flows where the Reynolds number is expected to be the smallest (due to smaller discharges and corresponding flow velocities within the channel). For the 85% flow exceedance discharge of 30 cfs in the Upper North Branch, the Reynolds number for the approach flow to the dam will be on the order of 5 x 104 and after scaling will be on the order of 104 which is at the accepted limit for fully turbulent flow of 900 (when the Reynolds number is based upon flow depth or hydraulic radius). However, at the drop structures themselves the Reynolds number is expected to be higher, on the order of 105, making the model scale Reynolds number on the order of 10^4. The Reynolds number for the flow in the North Shore Channel upstream of the dam will be on the order of 3.5×10^5 (scaling to 6×10^4) and the Reynolds number of the Lower North Branch is 2.8×10^5 (scaling to 4.8×10^4). Therefore, scaling effects due to the Reynolds number should be negligible for the model study.

4.3 Physical Model Data Collection

Two types of data were collected in the physical model: quantitative (consisting of velocity and water-surface measurements) and qualitative (consisting of visual – video and still image) data.

4.3.1 Stage Measurements

Stage data was collected using a series of lory point gauges mounted on aluminum beams spanning the physical model basin (figure 4.3). The precision of these point gauges is 0.001 ft (0.3 mm). At each section in which water-surface measurements were collected, a reference point was surveyed onto the model and used as an elevation datum. Measurement sections and the subsequent reference points for each are indicated for the existing dam configuration (figure 4.4(a)) and for the canoe-chute/fish-passage configuration (figure 4.4(b)).

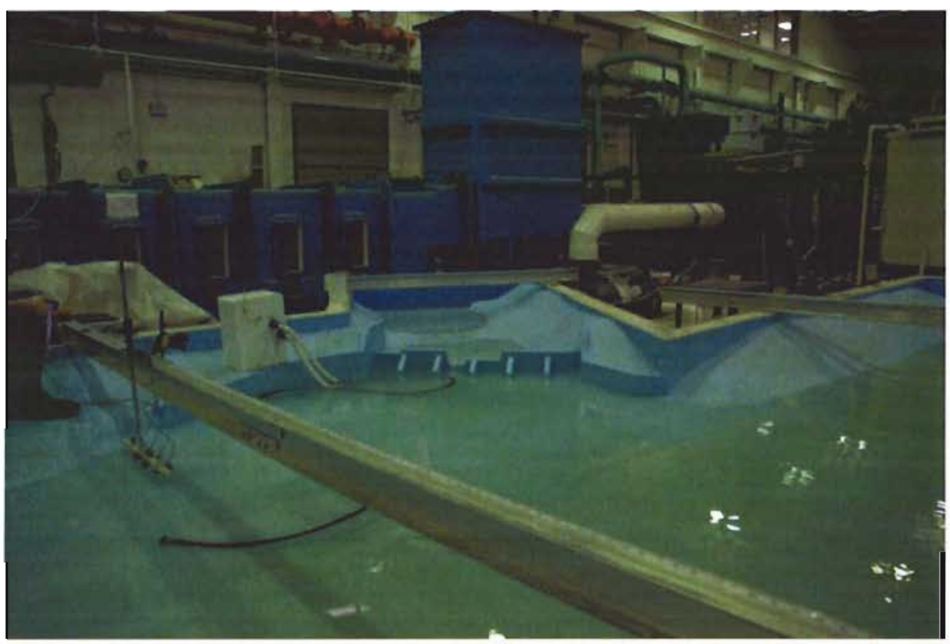


Figure 4.3 – Photograph of the measurement apparatus used during physical model testing.

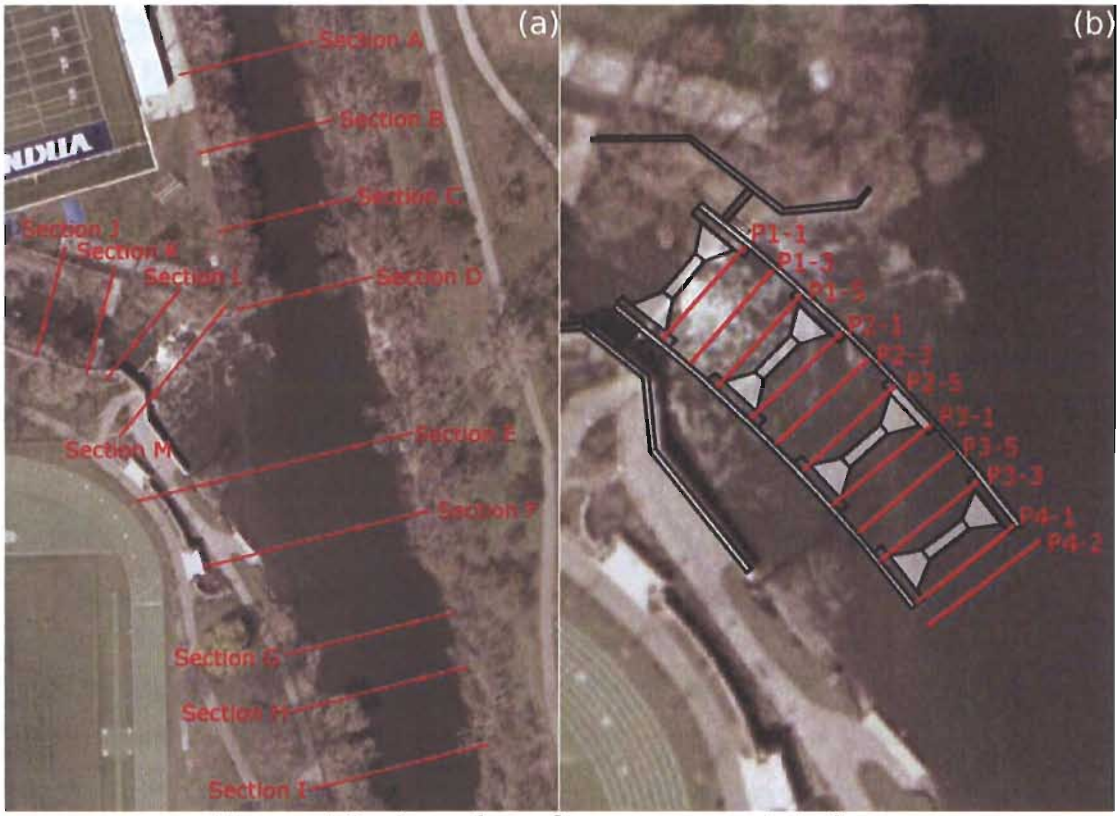


Figure 4.4 – Location of measurement stations.
Measurement locations are indicated for (a) the existing dam configuration and (b) the proposed canoe chute/fish passage configuration.

4.3.2 Velocity Measurements

Velocity data was collected using two instruments.

A Nortek Vectrino was used to collect high-resolution 3-dimensional point velocities. The Vectrino calculates three-dimensional water velocities within a specified sampling volume by measuring the frequency shift of a series of sonic pulses emitted from the probe. The pulses reflect off particles suspended in the water column and return to the probe with a Doppler frequency shift that can be directly related to the water velocity. The focal distance of the Vectrino is 5-cm, meaning that the reported water velocities occur within a sampling volume 5-cm from the probes tip. Due to the shallow depths that were anticipated during the model study, a side looking probe was used (figure 4.5). This configuration allowed for flow velocities to be measured very near the bottom and near the top of the water-column since it is possible to use the side-looking probe with the top two receiving prongs of of the water and still resolve a two-dimensional flow field. In these cases, however, it was necessary to neglect the "z", or vertical component of velocity.

Figure 4.5 – Nortek Vectrino with a side-looking probe configuration.

An Ultrasonic Velocity Profiler-DUO (UVP), manufactured by Met-Flow SA of Lausanne, Switzerland was used to collect two-dimensional flow velocities along a vertical profile at various cross sections in the model. Similar to the ADV, the UVP emits ultrasonic pulses that reflect off seeding particles suspended in the water column and calculates the velocity based on the measured Doppler-shift frequency of the reflected pulse. The UVP is capable of determining the location of the seeding material in the water column (and therefore the location of the velocity measurement) by determining the length of time it takes for the emitted ultrasonic pulse to travel to the seeding material and back to the probe. If the interval between individual pulses is long enough for a pulse to travel to the bottom of the channel and back it becomes possible to determine an "instantaneous" velocity profile for the entire depth. The UVP is only capable of determining a true one-dimensional velocity parallel with the axis of the transducer. However, it the transducer is placed at an angle to the primary flow direction, the one-dimensional signal can be resolved to give a two component velocity (figure 4.6)

Four UVP probes were mounted side-by-side on a point gauge that could be lowered such that the probes sat just below the water surface. The four probes collected data one at a time sequentially. Each probe recorded data for a period of 1-2 minutes (determined by the level of turbulence observed in the flow – more highly turbulent flow was anticipated to take a longer period of time to reach a stable mean value). At a given cross section, the UVP measurements were taken at equally spaced locations across the channel width to get a representation of velocities across the entire cross-section. The time-series profiles were then averaged (after filtering to remove velocity spikes) to determine the flow profile.

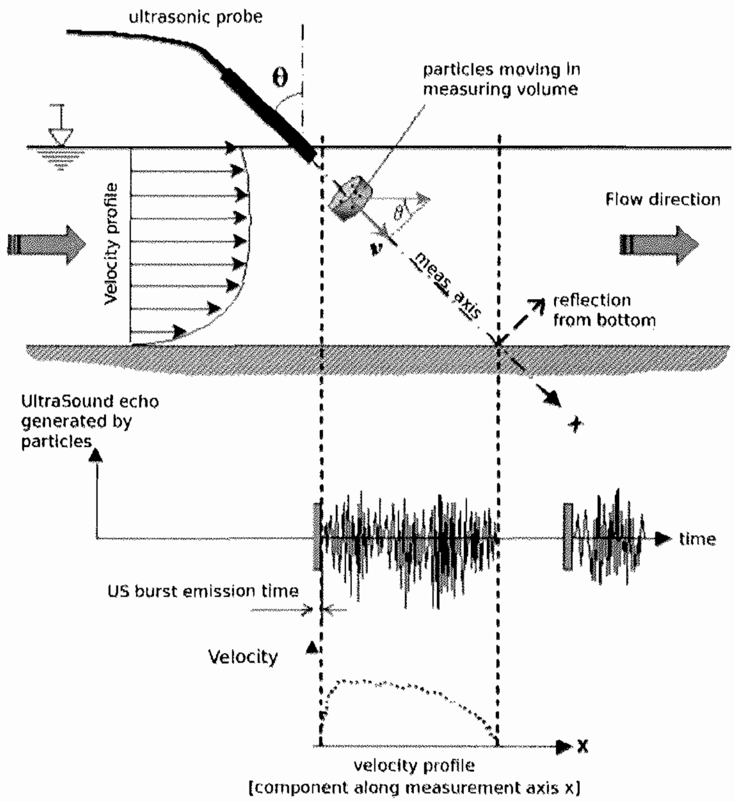


Figure 4.6 – Principle of operation for the MetFlow UVP (MetFlow, 2002).

During the course of data analysis, it was determined that the VTCHL water supply did not contain enough natural seeding to ensure reliable flow measurements with either the UVP or the Vectrino. This deficiency in seeding resulted in substantial noise in the velocity signal that would often overwhelm the true velocity signal, resulting in inaccurate velocity measurements.

Several alternatives were tried to increase the level of seeding in the flow. The first alternative was the addition of small hollow glass spheres to the flow (traditionally used to increase seeding for ADV measurements). There were several problems with this alternative. First, it was difficult to add the seeding to the flow in such a manner that it became evenly distributed throughout the water column. The seeding tended to pass by the measurement section in "plumes" that could be easily swept away by the flow, especially at higher discharges. Second, due to the length of time it took to measure a single cross-section (on the order of 1-2 hours) a significant quantity of seeding material would need to be added to the flow to ensure acceptable measurements throughout the cross section. The addition of a large quantity of seeding to the flow presented a problem because the North Branch Dam model shares a common, re-circulating water supply with other facilities in the VTCHL that could be adversely affected by the addition of a large mass of foreign particles.

A review of the literature indicated that the introduction of micro-bubbles into the flow has been successfully used to provide seeding for measurement using the UVP (Meile et al., 2008). Meile et al. had used electrolysis to produce hydrogen bubbles that would act as seeding in the flow - due to safety concerns the use of electrolysis for the physical model study was not considered practical. However, it was determined that bubbles created by the commercially available AS-MK III "Micro-Nano Bubble Generator" manufactured by Asupu Company, Ltd., would serve as a suitable seeding material for both the UVP and Vectrino probes.

After some experimentation in the lab with the appropriate technique, the following methodology was used to seed the model. The bubble generator was set up to withdraw water from the upstream end of the model and, after adding the micro-bubbles, the water was re-introduced to the flow approximately 10-15 feet upstream of the measurement section by way of a perforated rubber hose. It was important to place the hose close enough to the measurement section to ensure that all of the micro-bubbles did not dissolve into the water column, thereby eliminating the source of seeding, while at the same time placing the hose far enough from the measurement section to ensure that there was sufficient time for the bubbles to disperse uniformly through the water column and to make sure that the hose itself did not alter the flow profile.

4.3.3 Flow Visualization

Flow visualization exercises were completed with the aid of dye and/or confetti. Flow visualization videos were collected for the 15, 55, and 85 percent exceedance discharges and were used together with the velocity measurements to determine the predominant flow patterns in the vicinity of the Dam.

4.4 CFD Model and Computational Setup

A three-dimensional computational fluid dynamics (CFD) model (FLOW-3D, Flow Science 2008) that solves the Navier-Stokes equations together with a model for turbulence (RNG, Yakhot and Smith, 1992), and an interface capturing method (VOF, Hirt and Nichols 1981) was used to determine the flow the flow characteristics in the vicinity of the North Branch Dam. The FLOW-3D software package has been previously used by VTCHL staff for a number of projects associated with river restoration and hydraulics (Rodriguez et al, 2004; Abad and Garcia, 2005; Abad et al. 2008).

The use of CFD modeling in addition to the scale physical model was done for several reasons. It would be impractical to measure in the physical model with the resolution that is achievable with the CFD model. It was impossible to measure at some locations in the model due to limitations in the measurement techniques used, making CFD modeling one of the only ways to collect information on the flow fields in this location. Additionally, because the CFD modeling was performed on the prototype scale system, it was expected that it would not suffer from the scale effects that were likely to be present in the physical model study. This was especially important when examining flow turbulence and dissipation (one of the most important parameters for successful operation of the fish-passage). Dissipation of turbulent kinetic energy is ultimately controlled by the fluid viscosity and is therefore heavily effected by Reynold's number based scale effects. As discussed in a previous section of this report, it is impossible to have perfect Reynold's number similarity while using Froude-based scale factors. Therefore, use of a CFD model is likely to provide a much better estimate of turbulence and dissipation than is achievable with the physical model.

The modeled computational domain for the FLOW-3D modeling effort is approximately the same as was used for the physical model study and used the same survey and bathymetry data. As observed in Figure 4.7, the computational domain has a reach that extends into the Upper North Branch, a reach extending upstream into the North Shore Channel and a reach downstream of the junction into the Lower North Branch; therefore suitable boundary conditions at these three boundaries are required. The upstream boundary condition for the Upper North Branch was determined from a 1-D HEC-RAS model of the upstream reach assuming critical depth at the dam. The HEC-RAS model was calibrated using the USGS Albany Avenue gaging station. As discussed in §3.2.2, the Chicago River system downstream of the North Branch dam is completely controlled by the operation of lock and dam structures located in Wilmette, the Chicago Harbor, and in Lockport. FLOW-3D model runs were begun before the analysis presented in §3.2.2 had been completed and because the Chicago River system is maintained at a relatively constant stage, a single depth was used for the FLOW-3D modeling independent of modeled discharge. This stage was determined from the USGS gaging station 05536123 Chicago River at Columbus Drive at Chicago, IL and was 577.32 ft NAVD88, which is slightly lower than the updated median stage estimate of 577.45-577.80 ft NAVD.

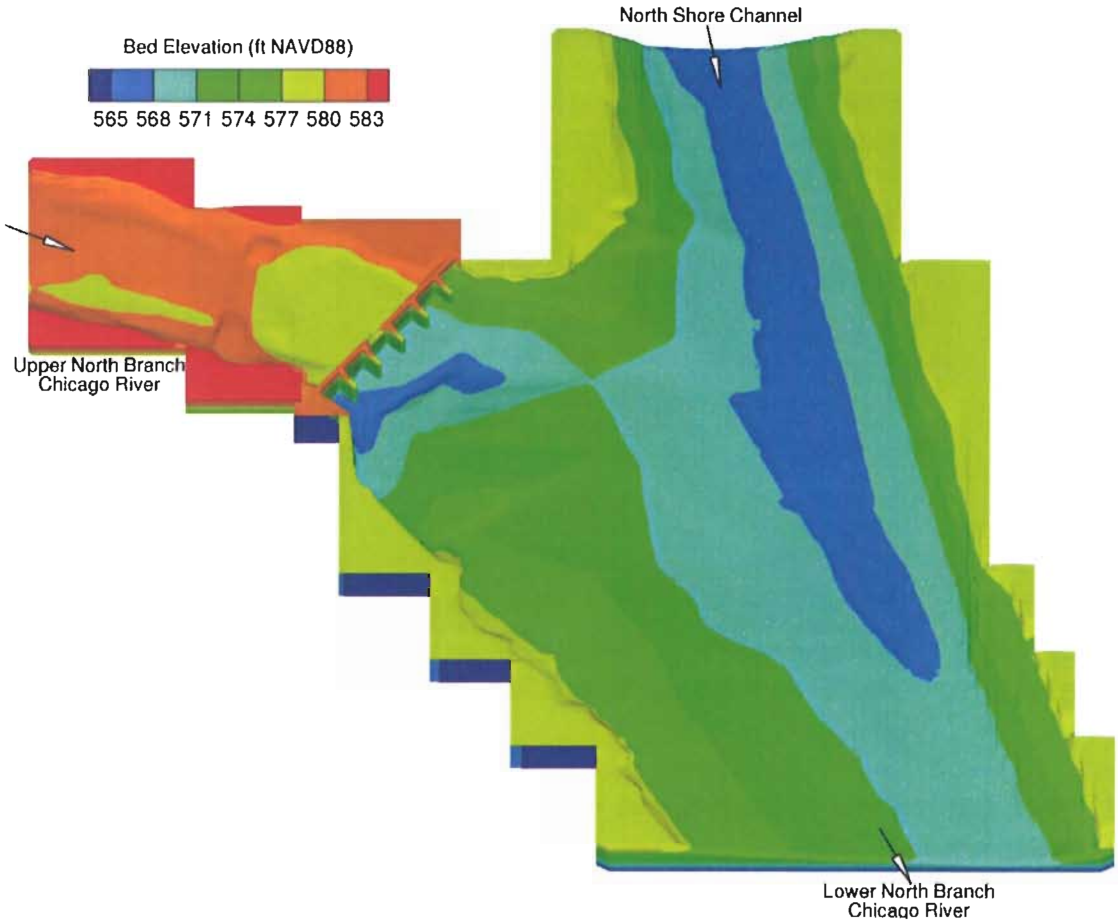


Figure 4.7 – Representation of the computational domain used for FLOW-3D modeling of the existing dam configuration.

The modeling was performed using 10 linked-type multiblocks. Bed elevation is in feet NAVD88.

5 MODELING OF THE EXISTING DAM CONFIGURATION

5.1 Physical Model Calibration

Model calibration was performed in two stages, one to verify that flow patterns in the North Shore Channel and Lower North Branch are reasonable, and the other to verify that the rating curve developed by the physically modeled dam is consistent with the prototype. Figure 5.1 identifies relevant measurement locations.

Figure 5.1 – Measurement locations used for physical model calibration.
Red points are ADCP field measurement coordinates.

5.1.1 Field Calibration – North Shore Channel and Lower North Branch Chicago River Flow Patterns

On August 26, 2008, a set of two discharge measurements were performed using a boat mounted acoustic doppler current profiler (ADCP). One set of measurements was performed on the North Shore Channel approximately 250 ft north of the confluence with the North Branch Chicago River (corresponding to Section A in figure 5.1), the other set of measurements was performed on the Lower North Branch of the Chicago River approximately 300 ft downstream of the dam (Section G). A total of 8 transects were collected for each set of discharge measurements. The total measured discharge was approximately 458 cfs in the North Shore Channel and 480 in the Lower North Branch resulting in total discharge from the Upper North Branch of 22 cfs, which matched the reported daily discharge at USGS gaging station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL for the time period in which the field measurements were collected.

An inverse distance weighting scheme was used to average the results from the 8 individual ADCP transects that made up a discharge measurement. The stream-wise velocity component of the averaged profile is presented in figure 5.2(a) & (c).

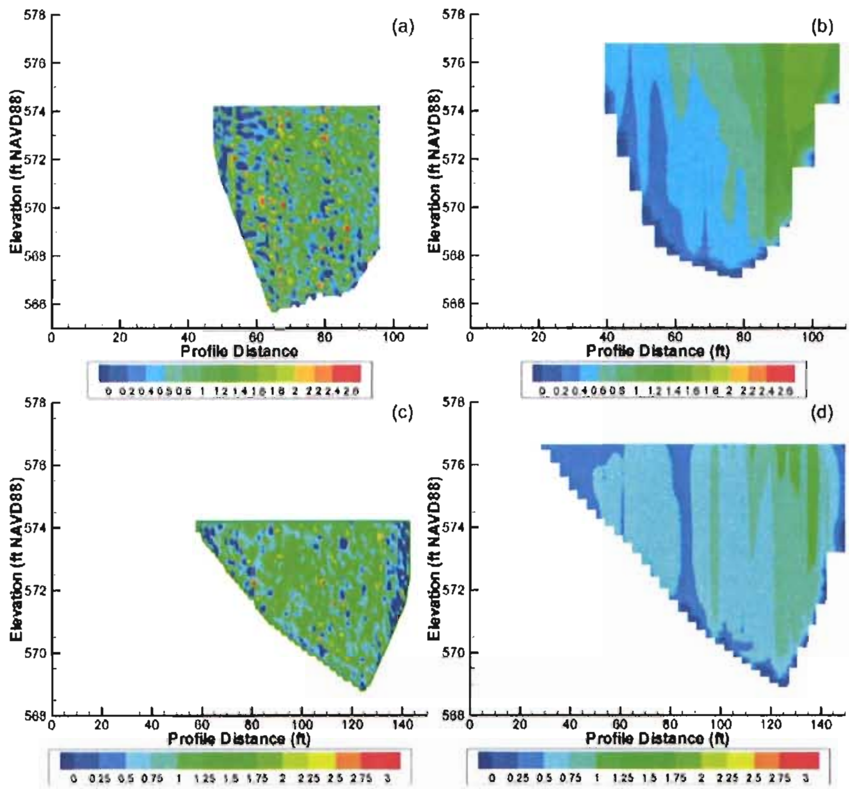


Figure 5.2 – Comparison of ADCP measurement and model UVP measurements for the NSC and Lower NB.

(a) ADCP field measurements at Section A (b) UVP model measurements at Section C (note: end effects from the model make UVP measurements at Section A invalid – Section C has a similar cross section and was felt to be valid for comparison), (c) ADCP field measurements at Section G, (d) and UVP model measurements at Section G. Profile distance is from an arbitrary point on the right-hand bank.

The UVP was used to measure the stream-wise flow velocity in the model. The location corresponding to Section A in the physical model was approximately 1.5 feet from the water-supply reservoir. This resulted in some very pronounced end effects being measured in the model, most noticeably an area of reverse flow near the right-hand bank. It was felt that it would be reasonable to compare the flow profiles measured in the model at Section C to those collected in the field since the end effects appear to have largely dissipated at this location in the model for the target discharge and there are no major changes in the bathymetry between Sections A and C. This data is presented as figure 5.2(b). The UVP data collected in the model corresponding to Section G is figure 5.2(d).

The field measurements agree reasonably well with the model measurements at these two locations. Flow velocities are generally a little bit higher in the field measurements, but the overall magnitude of the flow velocities is similar. Also, both the field and model measurements show a general increase in flow velocity near the left-hand bank, indicating a concentration of the flow in this area. A visual comparison of the flow passing over the dam is presented in figure 5.3 with the field and model photographs appearing quite similar.

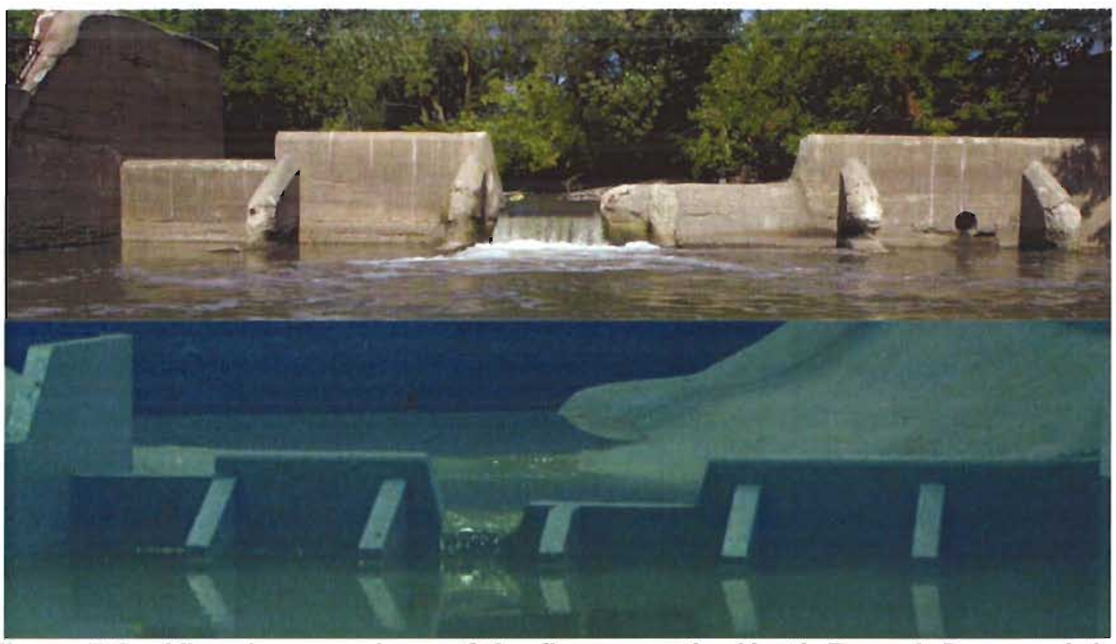


Figure 5.3 – Visual comparison of the flow over the North Branch Dam and the model for the same scaled flow condition.

The flow rate pictured is the field calibration discharge of $Q_{Upper\ North\ Branch}$ = 22 cfs, and $Q_{North\ Shore\ Channel}$ = 458 cfs.

5.1.2 Verification of the North Branch dam rating curve

Figure 5.4 presents a comparison between the published USGS rating curve for station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL (retrieved online 5/15/2008, rating ID 3, processed 6/8/2004) and the rating curve measured in the model at Section J. The maximum difference in stage is on the order of 2.5 inches, indicating very good agreement.

Immediately upstream of the dam, there is a submerged concrete walkway that appears to act as the primary flow control structure at low flows (figure 5.5). In order to determine the role this walkway plays in determining the measured rating curve, measurements were made in the model at Section L, and compared to those collected at section J (figure 5.6 – sections as indicated in figure 5.1). From these data, it is apparent that this walkway acts to control the stage for discharges less than approximately 550 cfs. This result may prove important during the design phase of the canoe chute/fishway study when determining the roll a change in the spillway discharge characteristics will have on upstream stages.

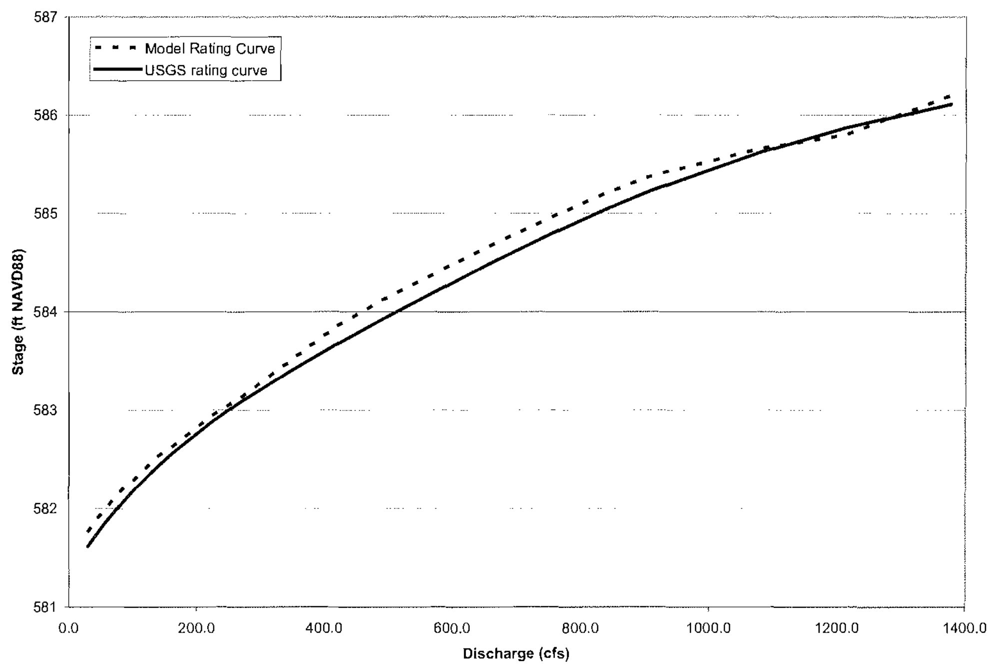


Figure 5.4 – Comparison of the published USGS rating curve for station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL and the model generated rating curve at Section J.

Maximum prototype difference is on the order of 3 inches.

Figure 5.5 – Submerged concrete walkway immediately upstream of the North Branch Dam.

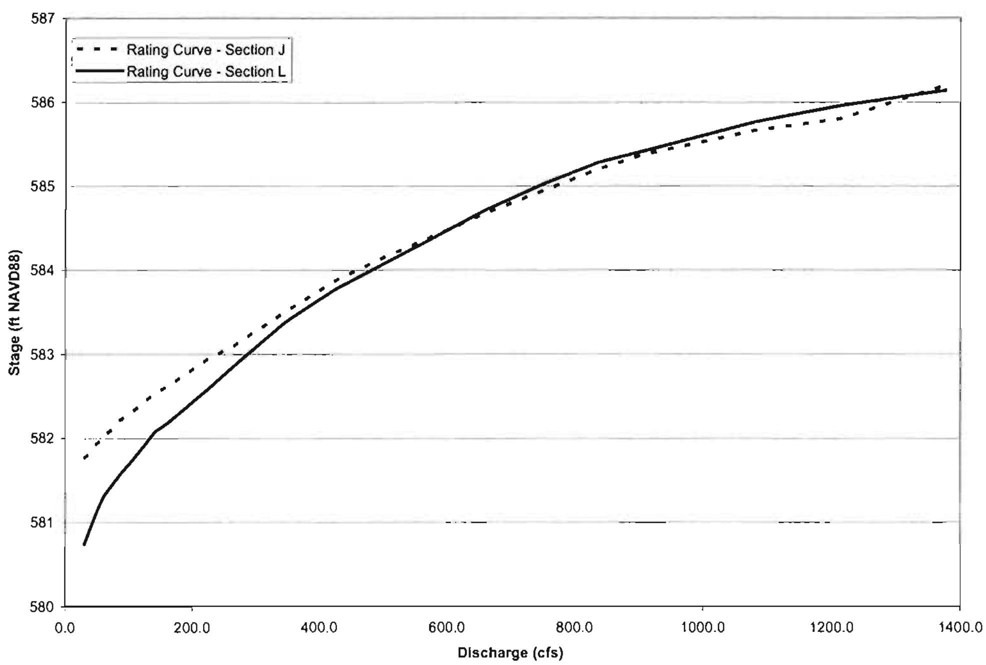


Figure 5.6 – Comparison of rating curves upstream and downstream of the submerged concrete walkway (measurement sections J and L).

5.2 Numerical Model of the Existing Dam

Figure 5.7 shows the water surface elevations determined by the FLOW-3D model for both the 85% and 15% exceedance discharges. The water-surface elevation is nearly constant for both the North Shore Channel and Lower North Branch as can be expected from the regulated nature Chicago River system. The water-surface elevation in the Upper North Branch changes according to the backwater effects exerted by the dam and the submerged walkway. For the 85% exceedance discharge, it can be seen from figure 5.7(a) that the water surface control is the submerged walkway discussed in the previous section of this report and shown in figure 5.5. It can also be determined that the control for the 15% exceedance flow (figure 5.7(b)) is the dam itself, which is in agreement with the results from the physical model.

Figure 5.8 shows the velocity distribution for both design discharges at different elevations (z=572.1 and 576.5 ft NAVD88). Due to the interaction of flows from the North Shore Channel and Upper North Branch, there are regions of horizontal recirculation, especially near the downstream part of the dam. The junction serves to expand the flows from the North Shore Channel, thereby reducing velocities in this region for both design discharges. Downstream of the junction, the velocities increase until they are approximately the same magnitude as observed in the North Shore Channel upstream of the junction. This recovery of the velocity magnitude is a good indication that the modeled domain should be sufficiently large to model the existing dam configuration and any future canoe chute/fishway implementation without experiencing any undue boundary effects.

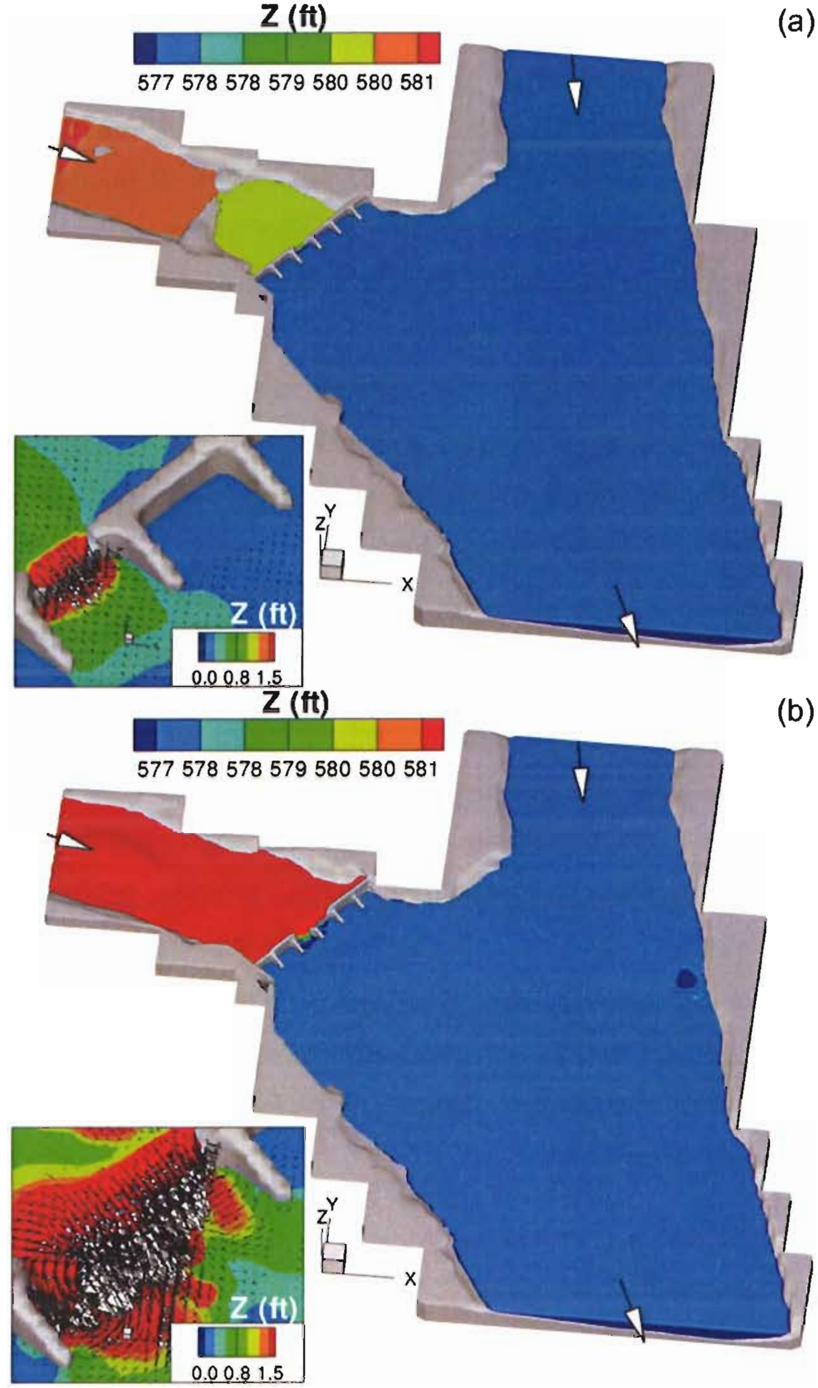


Figure 5.7 – Calculated FLOW-3D water surface elevations.

Results are for (a) 85% exceedance and (b) 15% exceedance design discharges

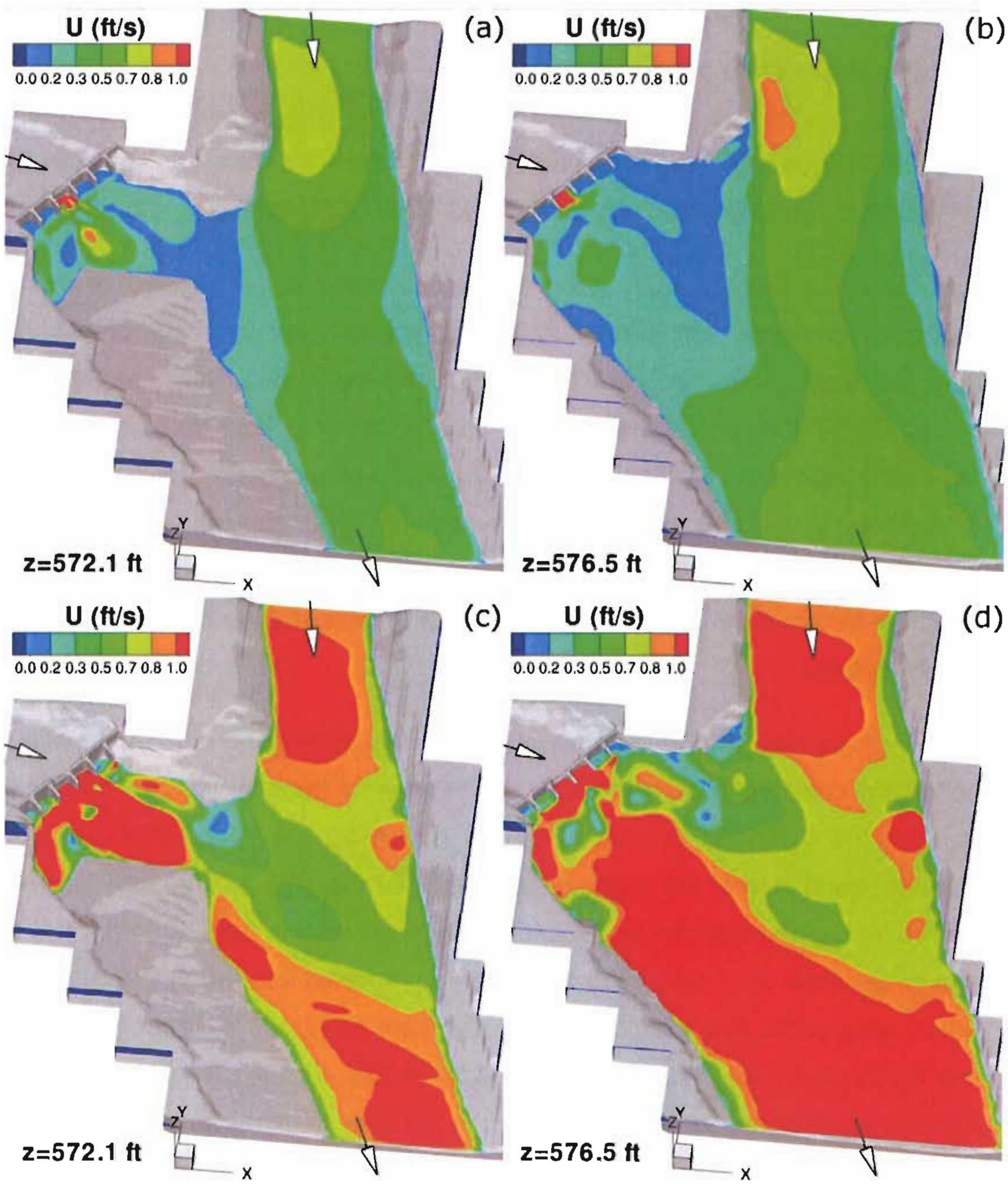


Figure 5.8 – FLOW-3D CFD model results showing the Velocity magnitude for both design discharges at different elevations.
(a), (b)85% exceedance and (c), (d) 15% exceedance

5.3 Characterization of flow in the Lower North Branch/North Shore Channel

5.3.1 Flow Velocity Measurements

Depth-averaged velocity vectors for the 15%, 55%, and 85% exceedance discharges are presented in figures 5.9, 5.10, and 5.11, respectively. This data was compiled from the UVP and Vectrino measurements and the FLOW-3D CFD model.

It can be seen that there is fairly good agreement between the measurements and computational techniques with a few notable exceptions. As discussed previously in §5.1, there are some pronounced end effects that develop in the physical model. These end effects exhibit themselves through an area of reverse flow that occurs at the entrance to the model for the North Shore Channel and are most pronounced in the velocity vectors collected for measurement section "A". This zone of reverse flow has largely dissipated by section "C" and while still present, is much less pronounced and the agreement between the physical model measurements and the numerical modeling results is acceptable.

Downstream of the dam, the measurement techniques show good agreement with the exception of the cross-section immediately downstream of the dam (section "E"). At this cross-section, the velocities developed by the FLOW-3D modeling effort are higher along the right-hand side of the channel, especially for the 15% exceedance discharge (figure 5.11). This difference can be explained due to an error in the TIN generation that was used to generate the bathymetry that was incorporated into the FLOW-3D model. The vertical wing walls that extend out from the dam represent a discontinuity in the TIN. This discontinuity was not handled correctly in this area resulting in several TIN elements that sloped from the channel bottom to the over-bank elevation, resulting in a significant, artificial shallowing of the channel bottom. This shallowing then resulted in a significant increase in velocity in this area as the discharge forced through a much shallower than that actually exists. This error in the bathymetry was not discovered until the FLOW-3D model had been running for a period of several weeks and given that the effects of the shallowing appear to have completely dissipated by the next measurement section (Section "G"), it was not felt that it was necessary to correct the bathymetry and re-run the model.

Immediately in front of the dam all of the measurement techniques show good agreement. The area in front of the dam shows a large increase in flow in the vicinity of the cipoletti weir, which is as would be expected due to the flow over the dam. On either side of this high outward flow, there are zones of reverse flow where the water re-circulates back toward the dam. An examination of the three-dimensional non-depth averaged vectors in this area (figures 5.12) shows that the majority of the flow occurs near the channel bottom, implying that the water passing over the weir plunges to the channel bottom and is then directed outward into the junction. The maximum velocities in this area are approximately 5.8 ft/s and 6.2 ft/s as determined from the FLOW-3D model and the Vectrino measurements, respectively, for the 15% exceedance discharge.

The generally good agreement between the FLOW-3D model and physical model in front of and downstream of the dam are a good indication that the observed end effects, while an unfortunate result of space limitations in the lab, are largely dissipated by the time the flow reaches the junction and should not heavily influence the results obtained for the canoe chute modeling.

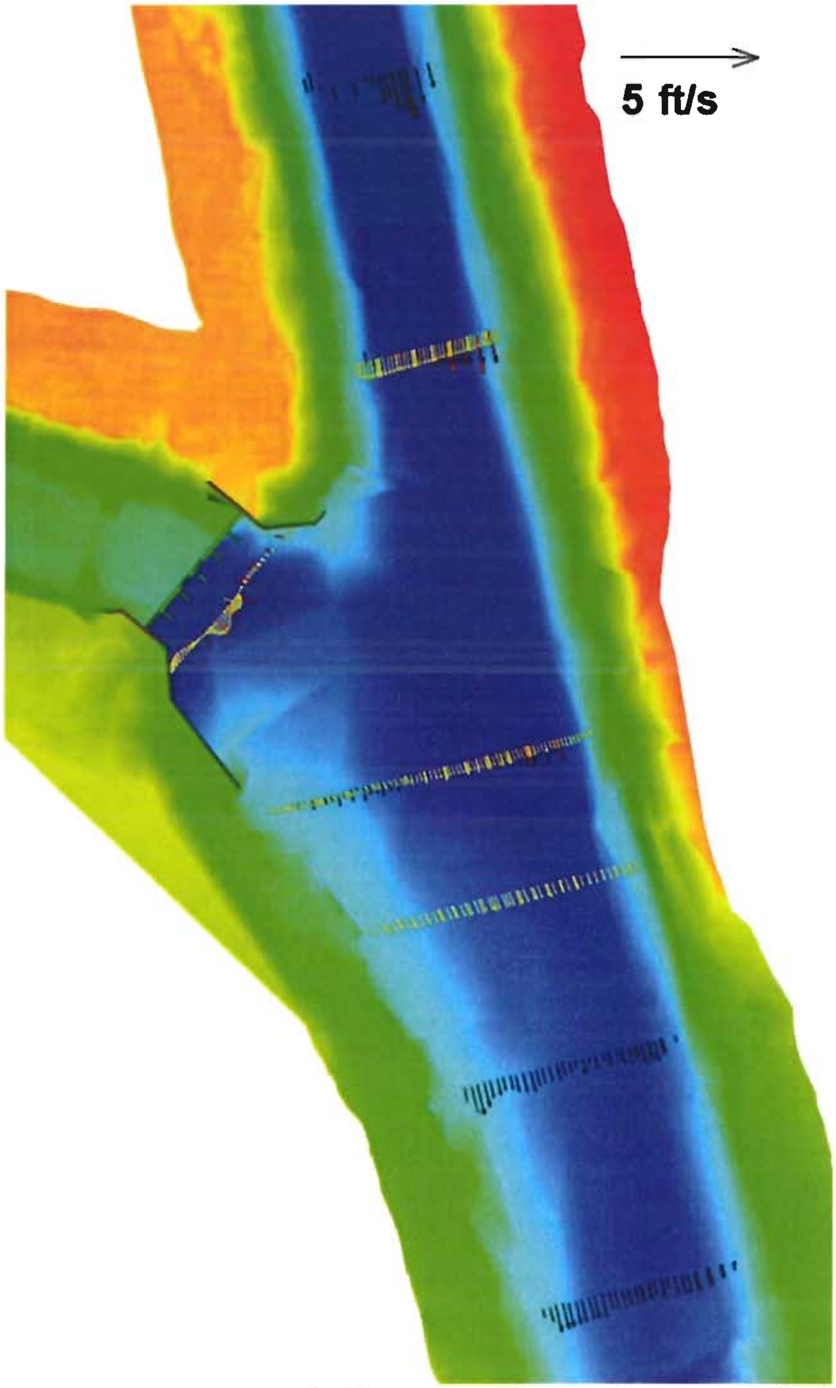


Figure 5.9 – Comparison of depth averaged velocity vectors for the 85% exceedance discharge.

Yellow vectors represent FLOW-3D modeling results, red vectors are measurements made with the Nortek Vectrino and black vectors are measurement made with the MetFlow UVP.

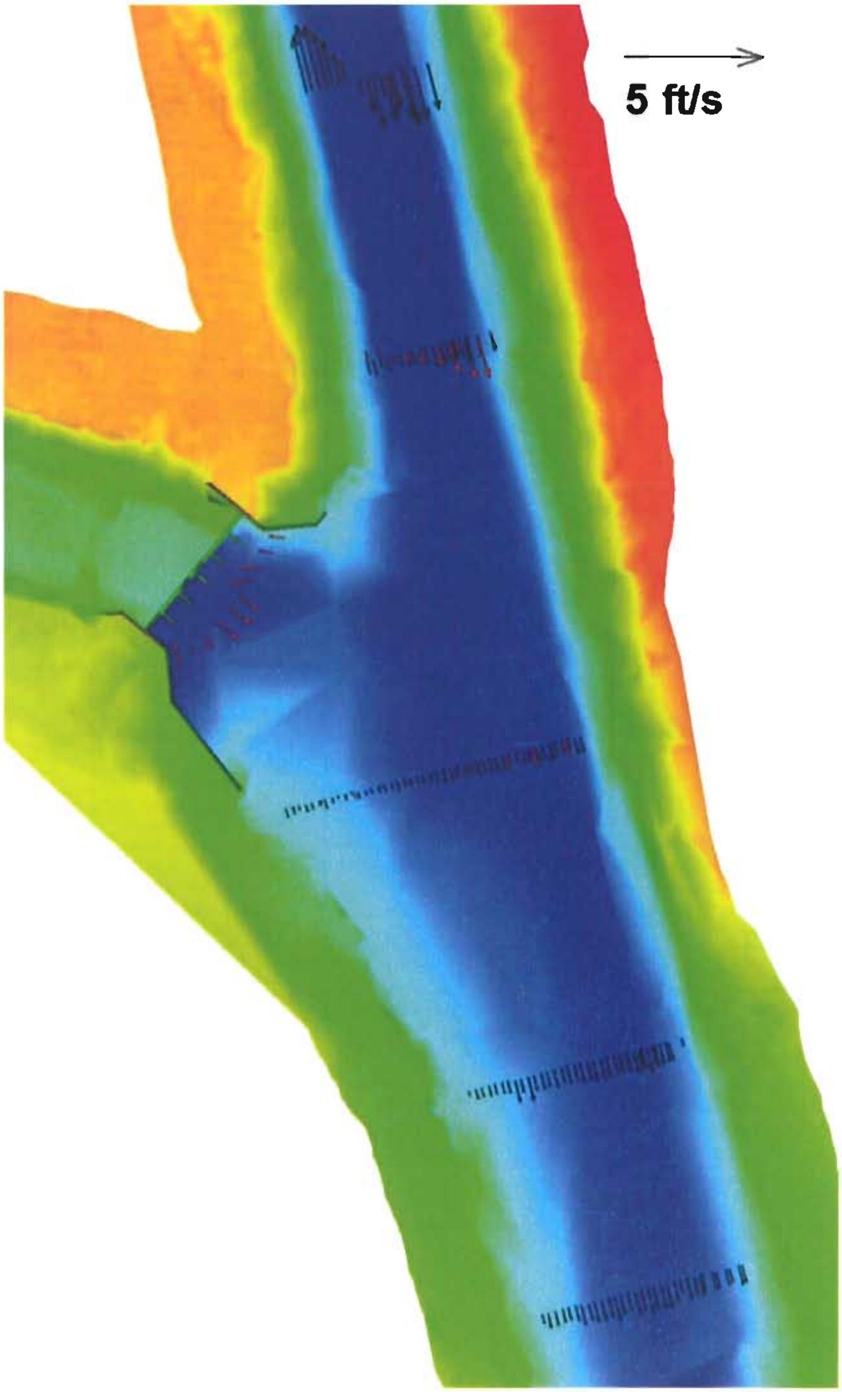


Figure 5.10 – Comparison of depth averaged velocity vectors for the 55% exceedance discharge.

Red vectors are measurements made with the Nortek Vectrino and black vectors are measurement made with the MetFlow UVP.

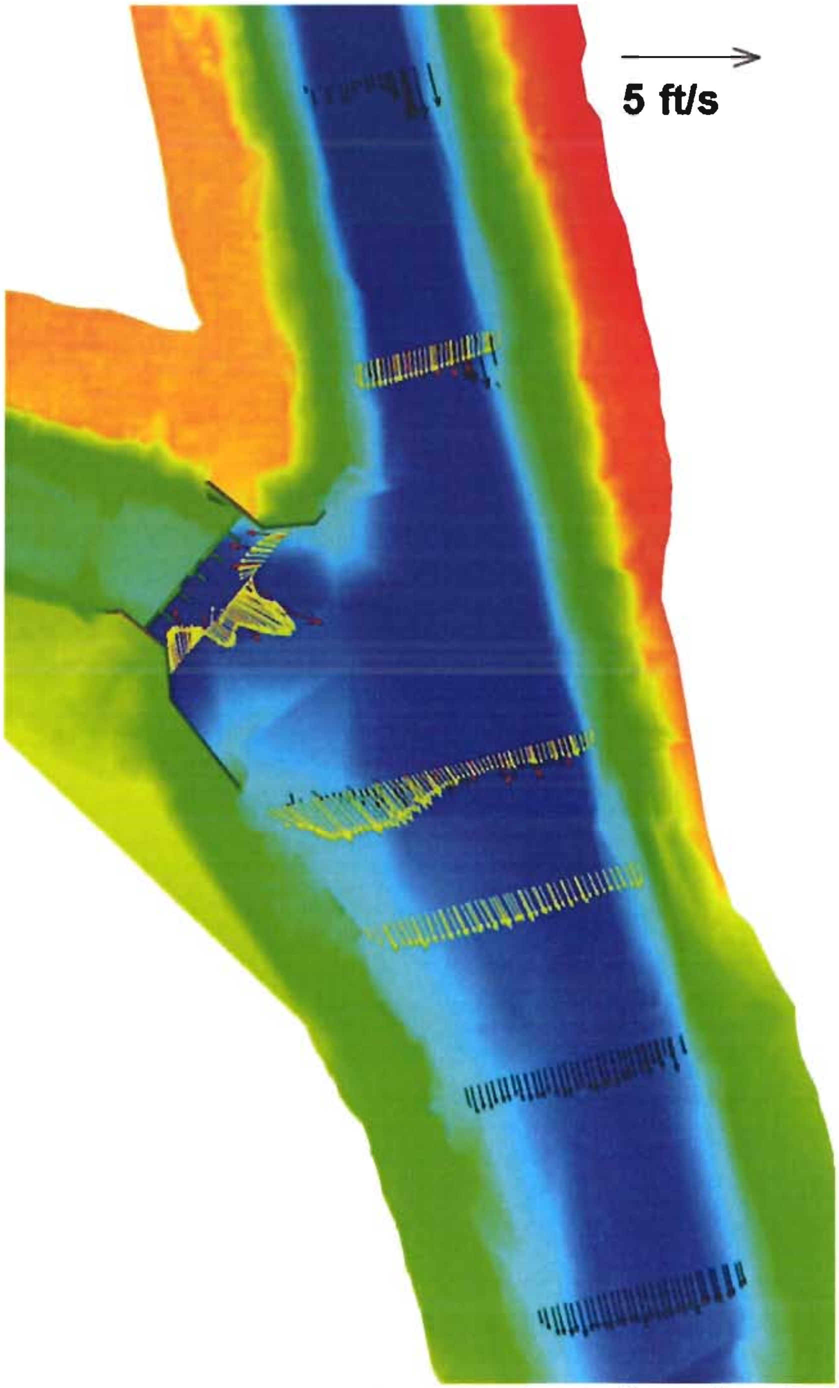


Figure 5.11 – Comparison of depth averaged velocity vectors for the 15% exceedance discharge.

Yellow vectors represent FLOW-3D modeling results, red vectors are measurements made with the Nortek Vectrino and black vectors are measurement made with the MetFlow UVP.

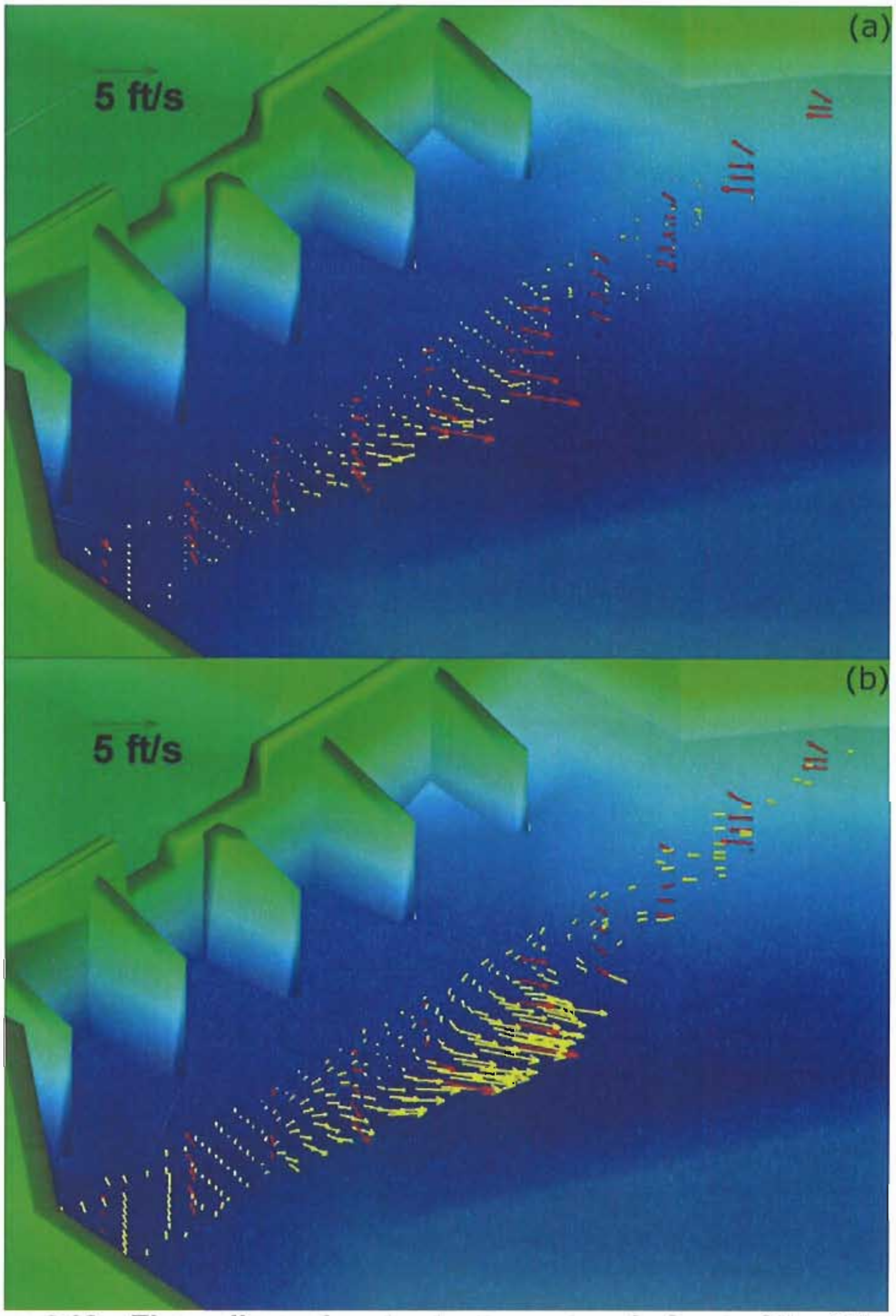


Figure 5.12 – Three dimensional velocity vectors in front of the NB dam. *Vectors have been plotted for the (a)85% exceedance discharge (Q_{UNB} = 30 cfs, Q_{NSC} = 336 cfs, Q_{LNB} = 366 cfs) (b)15% exceedance discharge (Q_{UNB} = 228 cfs, Q_{NSC} = 526 cfs, Q_{LNB} = 754 cfs), Yellow vectors represent FLOW-3D modeling results and red vectors are measurements made with the Nortek Vectrino.*

5.3.2 Flow Visualization

Flow visualization exercises were completed for the 15%, 55% and 85% discharges to supplement the velocity measurements and aid in the determination of overall flow patterns within the North Branch system. A general discussion of the observed flow patterns follows.

Water passing over the dam plunges to the bottom of the channel, is deflected and then travels out from the dam with a small lateral component, as shown for the 85% exceedance discharge in figure 5.13. Figure 5.14 shows the evolution of dye injected onto the water surface immediately in front of the dam. As can be seen in this figure, the water moves with the highest velocity immediately in front of the discharge point of the dam, in this case the cipoletti weir location. This water is advected away from the dam face and initiates two large-scale recirculation zones, one on either side of the discharge point.

Figure 5.13 – Dye injection upstream of the spillway for the 85% exceedance discharge.

The primary notable difference as flow rate is increased is that the strength of the recirculation cells that are present is increased. Figures 5.15 and 5.16 show the time evolution of dye injected downstream of the junction for the 85% exceedance discharge and the 15% exceedance discharge, respectively. It can be seen that the majority of the flow velocity is along the left hand bank of the North Shore Channel/Lower North

Branch. In the case of the 15% exceedance the recirculation zone initiated by flow passing over the dam is strong enough that it entrains some water from downstream of the junction and draws it back toward the dam (figures 5.16 (c)-(d)), while this area is relatively still for the 85% exceedance discharge (figure 5.16 (a) & (b)).

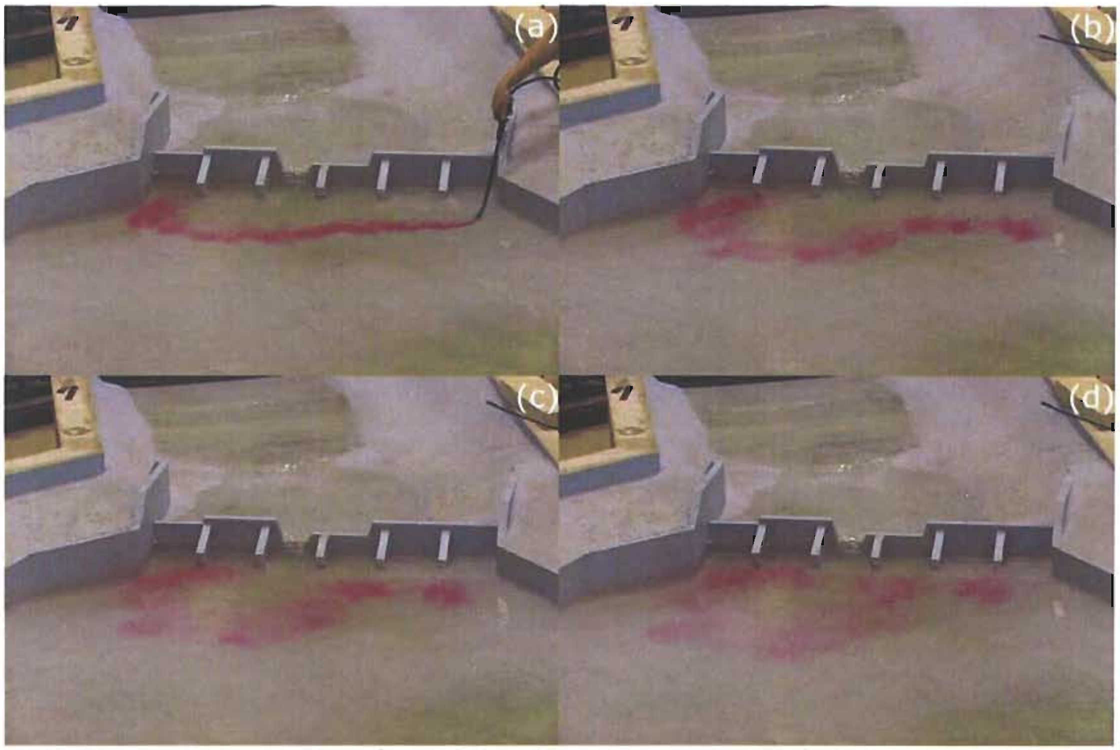


Figure 5.14 – Evolution of dye injection downstream of the dam for the 85% exceedance discharge.

The model scale time interval is approximately 2.5 seconds between frames.

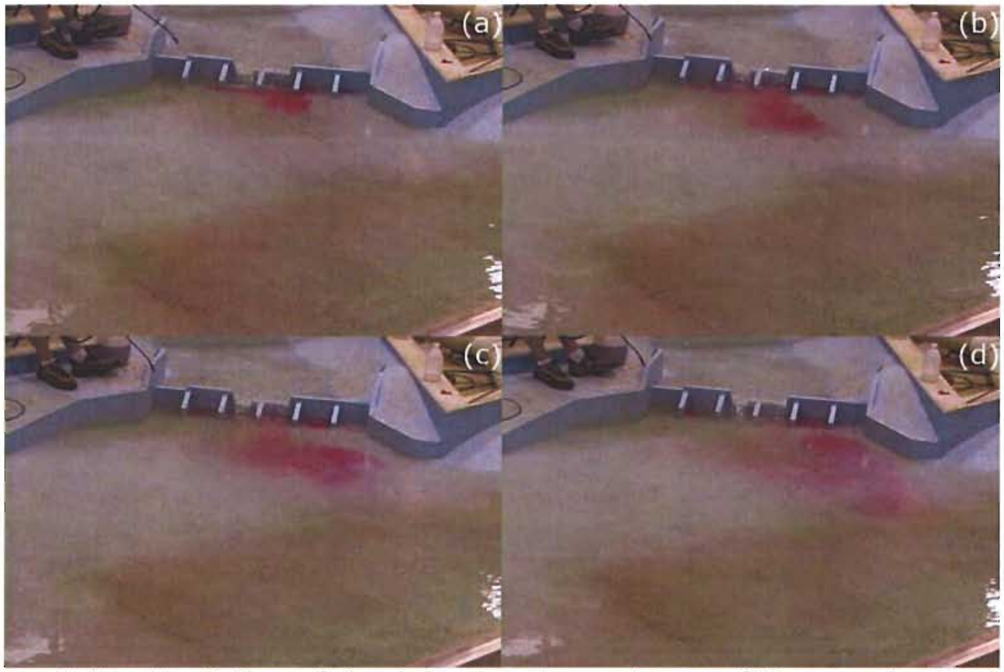


Figure 5.15 – Evolution of dye injection downstream of the dam for the 15% exceedance discharge.
The model scale time interval is approximately 2.5 seconds between frames).

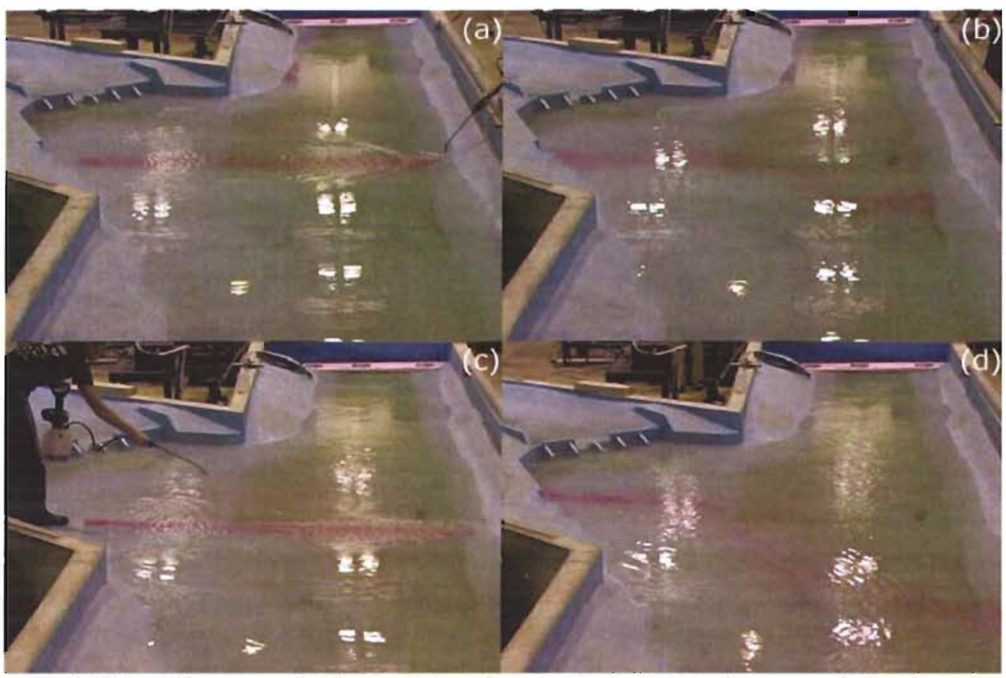


Figure 5.16 – Time evolution of dye injuected downstream of the junction.
(a), (b) the 85% exceedance discharge and (c), (d) the 15% exceedance discharge.

5.4 Influence of Lower North Branch/North Shore Channel stages upon flood stages upstream of the North Branch dam

In light of the flooding event that occurred upstream of the North Branch dam during September, 2008, it was considered useful to determine the role of tailwater conditions in the Lower North Branch and North Shore Channel in influencing stages upstream of the dam.

Because the physical model was designed to operate within a much smaller flow regime than the one seen during the September flood event, it was not possible to model the maximum flows. During that period, the maximum discharge measured at the Grand Avenue gage (05536118 NB Chicago River at Grand Avenue at Chicago, IL) was 9600 cfs and the maximum flow at station 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL was outside of the published rating curve, indicating flows greater than 3100 cfs and most likely in the range of 3800 cfs (Richard Lanyon, email to author, Aug 18, 2009). Therefore, it was necessary to examine the influence of the tailwater elevation on stages upstream of the dam at much smaller discharges that could be handled in the model while still obtaining useful information. To achieve this goal, three different discharges were run over the North Branch Dam: 476, 821, and 1200 cfs, while holding the discharge in the Lower North Branch constant at 415 cfs and varying the tailwater elevation. An additional measurement was made with flow rates of 476 cfs and 909 cfs in the Upper and Lower North Branches, respectively to determine the influence of flow velocity within the Lower North Branch and North Shore Channel on the results.

It can been seen from figure 5.17 that for tailwater elevations below about 582 ft (NAVD88), the rating upstream of the dam is unaffected regardless of flow. After the tailwater reaches this stage, there is a transition region where the tailwater begins to affect the upstream stage, but the dam is not completely submerged. Complete submergence and the resulting 1:1 correlation between the upstream and downstream stages occurs when the tailwater elevation reaches 587 ft NAVD88.

It can also be seen that the flow rate in the Lower North Branch and North Shore Channel do not appear to have a great effect on the stages that are observed upstream of the dam. From figure 5.17, it can be seen that there is no discernable difference in the curves developed for a discharge of 476 cfs in Upper North Branch and discharges of 415 and 909 cfs in the lower North Branch. This indicates that the effect of flow velocities downstream of the dam have an negligible effect on the rating curve of the Upper North Branch, at least for the flows examined. It is possible that significantly higher flows such as those seen during the September 2008 flood event (on the order of 10000 cfs as measured at Grand Avenue) may have an effect on the rating at the dam, though this is considered unlikely and is impossible to test given discharge rates available to the physical model.

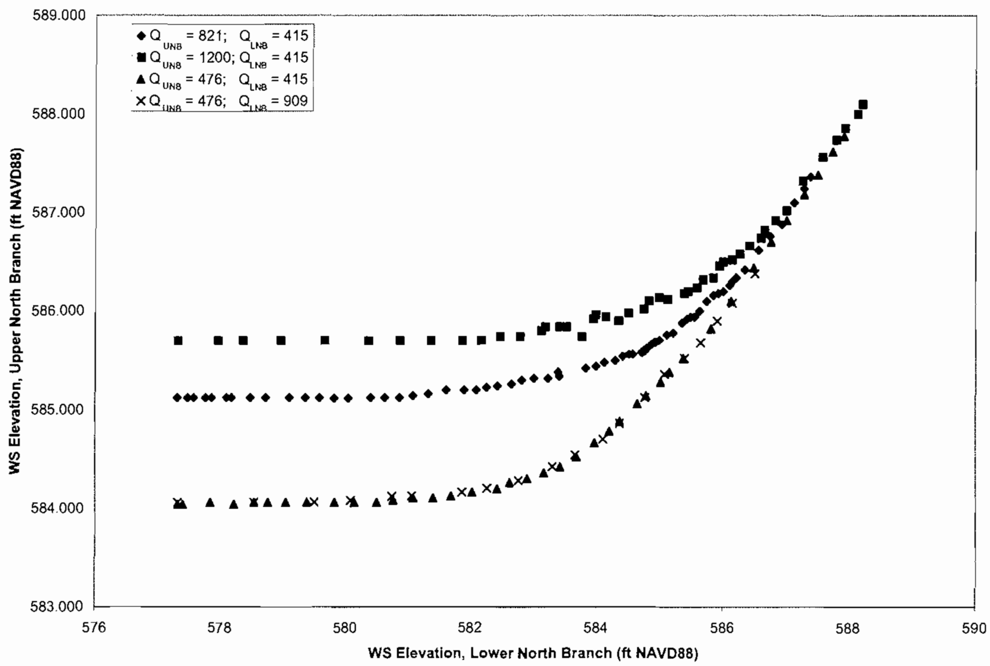


Figure 5.17 – Head-water vs tailwater elevations for the North Branch dam.

Examining the water-surface elevation hydrographs for the September 2008 flood event (figure 5.18), stages in the Lower North Branch (as recorded at Grand Ave) reached a maximum elevation of 582.64 and quickly subsided. This peak stage coupled with the previously discussed results indicates that the backwater conditions that existed during this event most likely had only a minor effect on the stages measured upstream of the dam at the peak backwater stage, but in general, the effects should have been negligible.

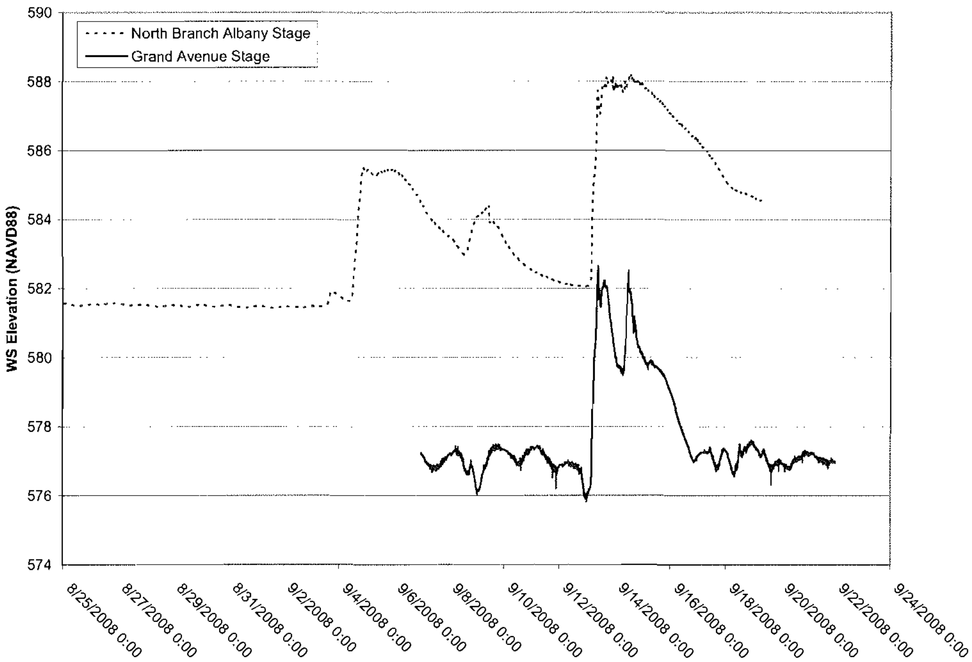


Figure 5.18 – Gaging data for the September 2008 flood.
15-minute water-surface elevations collected for station 05536118 NB Chicago River at Grand Avenue at Chicago, IL and 05536105: North Branch Chicago River at Albany Avenue at Chicago, IL, (personal communication).

6 GENERAL DESIGN CONSIDERATIONS

The primary consideration when designing a canoe chute is boater safety (Caisley and Garcia, 1999; Caisley et al, 1999). The canoe chute should be free of obstacles or sharp edges that could damage the boat or injure a boater, the canoe chute should be wide enough to allow a boat to pass freely through the drops in the event that the boat become turned and is forced though the drop sideways, the degree of difficulty and height of the drops should be suited to the expected skill of the boater, the depth of the pools should be deep enough to allow a boater to safely escape an overturned vessel without injuring themselves on the bottom, and most importantly, the hydraulic jumps that are formed in the downstream pool of each drop should be of a type that are known to be generally safe for boaters.

When considering a fish passage design, the most important consideration is whether the flow conditions within the drop are such that the fish passage can and will be used by the target fish species. Probably the most important consideration when designing a fish passage are the flow velocities that occur. If flow velocities are too large, it may be difficult for weaker swimming fish to traverse the fishway. Also, turbulence levels in the fishway must be considered. If turbulent intensities become too large, it is possible that some of the smaller fish species may have difficulty orientating themselves within the flow. Additionally, the entrainment of large air bubbles may interfere with the fishes' respiration (Rodrıguez et al, 2006). Finally, the fish passage must be located so that it will attract fish to the entrance of the fish passage. Caisley and Garcia (1999) provide a discussion of the important design considerations when locating the fish passage.

6.1 Canoe Chute Design Description

Taggart et al. (1984) describes the types of hydraulic jumps that are known to be dangerous to boaters. These include submerged jumps, jumps with reverse surface currents (circulating back toward the drop), and drops with large, rapid changes in water surface elevation. Although these types of jumps are often found in natural waterways, Taggart points out that they tend to be much more dangerous in man-made boat chutes due to the uniformity of the drop structure across the width of the boat chute – the irregularity of the drops in a natural waterway are more likely to present escape paths to the side of the current. Because of this, dangerous hydraulic jumps should be avoided at all costs in a man-made boat chute.

Taggart recommends that the jump should be in the wave and transitional stage of the B-jump as described by Moore and Morgan (1959). Moore and Morgan describe three types of hydraulic jump that can occur when flow passes over an abrupt drop: the A-jump in which the drop structure is submerged and the jump forms upstream of the drop, the wave jump in which an undular wave forms at the surface of the flow downstream of the drop, and the B-jump in which a well defined hydraulic jump occurs downstream of the drop. The authors also describe what they term the "minimum jump B," which is essentially a transition region between the wave and B-jumps (figure 6.1).

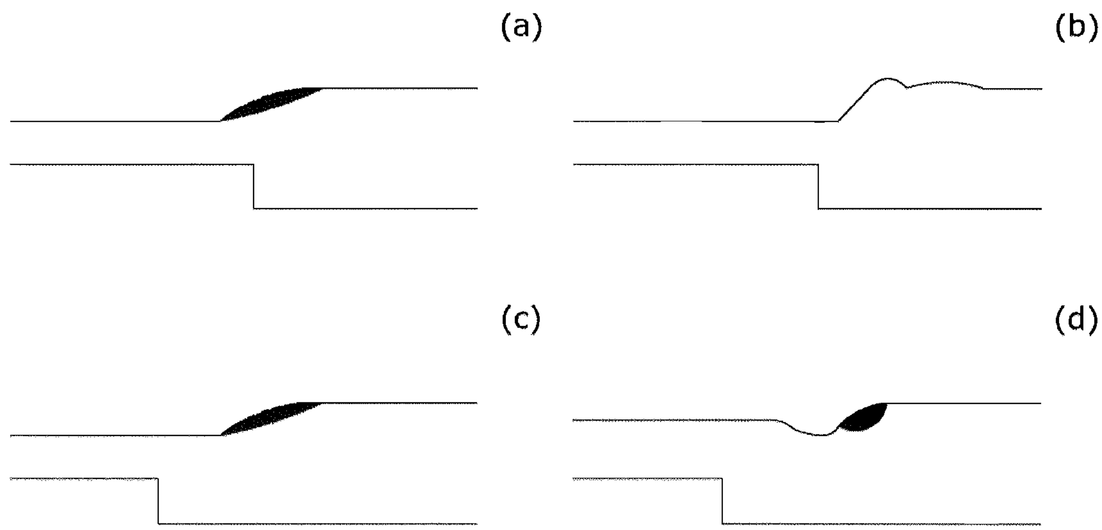


Figure 6.1 – Jump types as described by Moore and Morgan (1959).
(a) A-jump, (b) Wave jump, (c) B-jump, (d) minimum B-jump.

The type of jump that is formed at the downstream end of an abrupt drop is highly dependant upon the tailwater elevations and backwater conditions in the pool, and therefore is greatly affected by the length of the downstream pool between drops. Caisley et al. (1999) have developed a set of guidelines designed to aid in the design of canoe chutes for low-head structures similar to the North Branch dam.

The preliminary canoe chute designed was based on the procedure and recommendations established in Caisley et al (1999). Some relevant safety characteristics that are suggested by Caisley et al and are incorporated into the design are discussed below.

- The maximum change in water-surface elevation upstream to downstream of the drop should be on the order of 1-1.5 ft (0.305 – 0.457 m).
- The width of the drop weir should be wide enough to allow room for a canoe or kayak to pass through over the drop safely without becoming trapped in the event that the boat becomes turned sideways. As per the recommendation in Caisley et al (1999), a width of 20 feet has been incorporated into the design.

- The pools should be deep enough to allow a boater to right themselves or escape from their boats without injuring themselves on the bottom in the even that the boat capsizes.

Additionally, the following design elements have been incorporated into the chute layout:

- A nominal pool length of 40 feet and pool width of 42 feet has been set.
- Contraction and expansion baffles are located coincident to each weir with an angle of the contraction of 60 degrees with respect to the flow centerline.
- The upstream-most weir is aligned with the existing dam spillway with subsequent weirs gradually re-aligning in a southern direction so that the downstream-most weir is perpendicular to the southern wing wall of the existing dam. This was done to minimize amount that the canoe chute encroaches upon the primary channel for the NSC and Lower NB. The radius of curvature of the canoe chute centerline is 667-ft.
- The total chute length along the centerline is approximately 150 ft
- An open area is maintained to the north of the canoe chute to allow continued usage of the secondary overflow weir located on the right hand (south) side of the existing dam (when looking downstream). An additional open area is maintained to the north of the canoe chute to allow an unimpeded flow path in the event that the dam overtops or to allow for the construction of an additional overflow weir on the northern portion of the existing dam.

A schematic of the preliminary canoe chute design is presented in figure 6.2. Preliminary design calculations (based on the procedure established in Caisley et al, 1999) are presented in Appendix A.

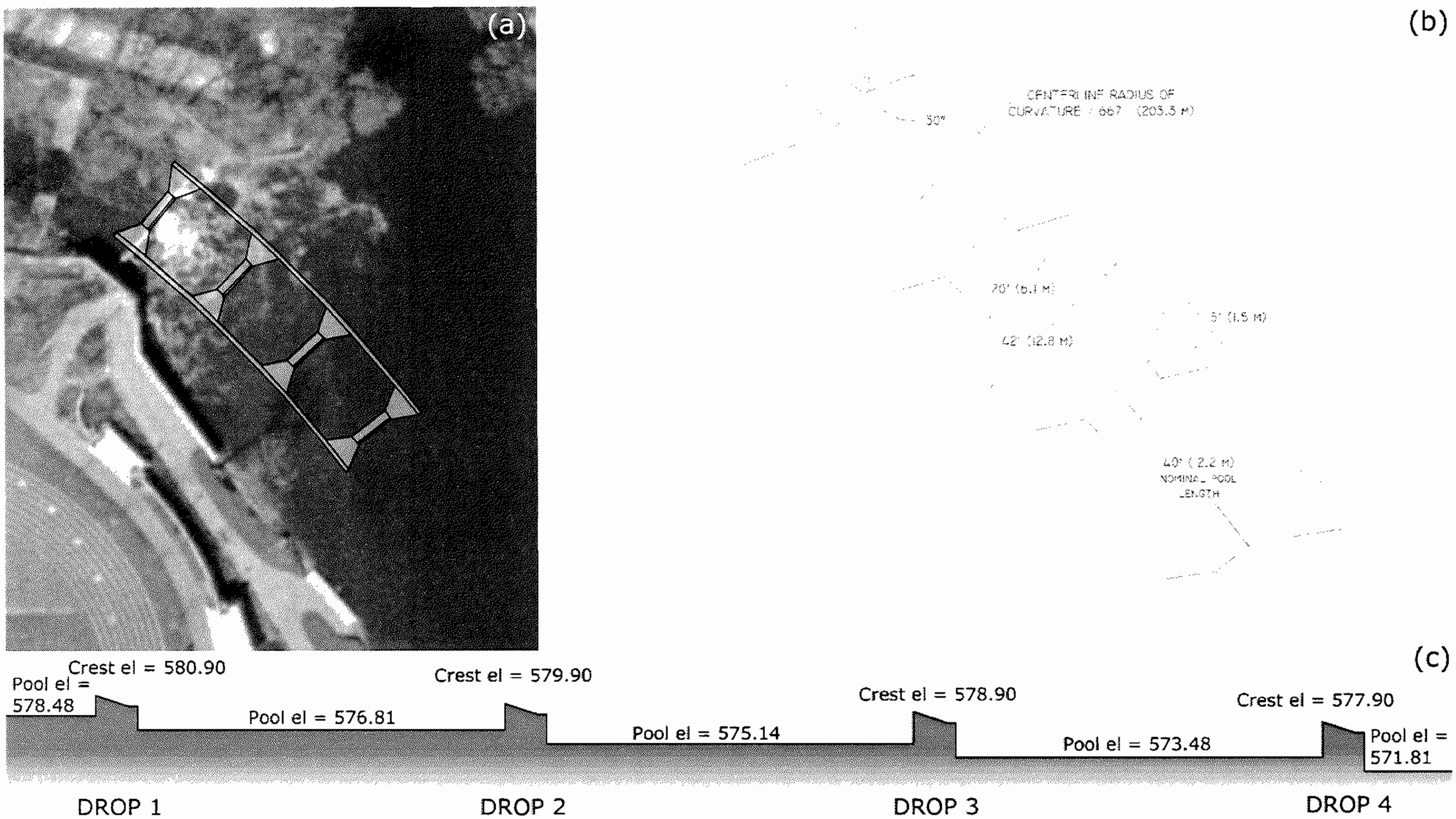


Figure 6.2 – Preliminary proposed canoe chute design.

(a) Proposed location of the North Branch dam canoe chute and fishway. (b) Basic canoe chute dimensions (c) Profile view of the proposed canoe chute (elevations are in ft NAVD88). The elevation of the downstream end of each drop is 1.3 ft below the crest elevation.

An additional consideration when designing a canoe chute is the minimum depth of flow over the drops that would be required to prevent a boat from becoming hung-up. A common assumption made by canoe manufacturers is that the depth of the boat below the water-surface will be on the order of 4-inches (10 cm) at the rated maximum loading capacity. This number is fairly prevalent in the industry as indicated by the common specification of the boat width at the 4-inch water line. While this depth is a good rule of thumb for the absolute minimum water depth required, it should be noted that this depth can increase or decrease based on whether the canoe is loaded above or below its rated capacity.

6.2 Fishway Design Description

It is unlikely that any of the fish present in the Chicago River system will be capable of traversing the canoe chute drop structures directly. Therefore it will be necessary to incorporate a dedicated technical fish passage in the design of the canoe chute. There are two primary alternatives for adding a fish passage to the structure of the canoe chute. The first alternative is to integrate the fishway directly into the design of the canoe chute and segment the fishway so that the design drop for each fishway segment is the same as the drop for the canoe chute. For this alternative, there can be either one or two fishway runs (at the outside edge of either or both contraction baffles). The second alternative is to have the fishway attached to the exterior wall of the canoe chute. For this alternative, the canoe chute would be hydraulically separate from the canoe chute (figure 6.3).

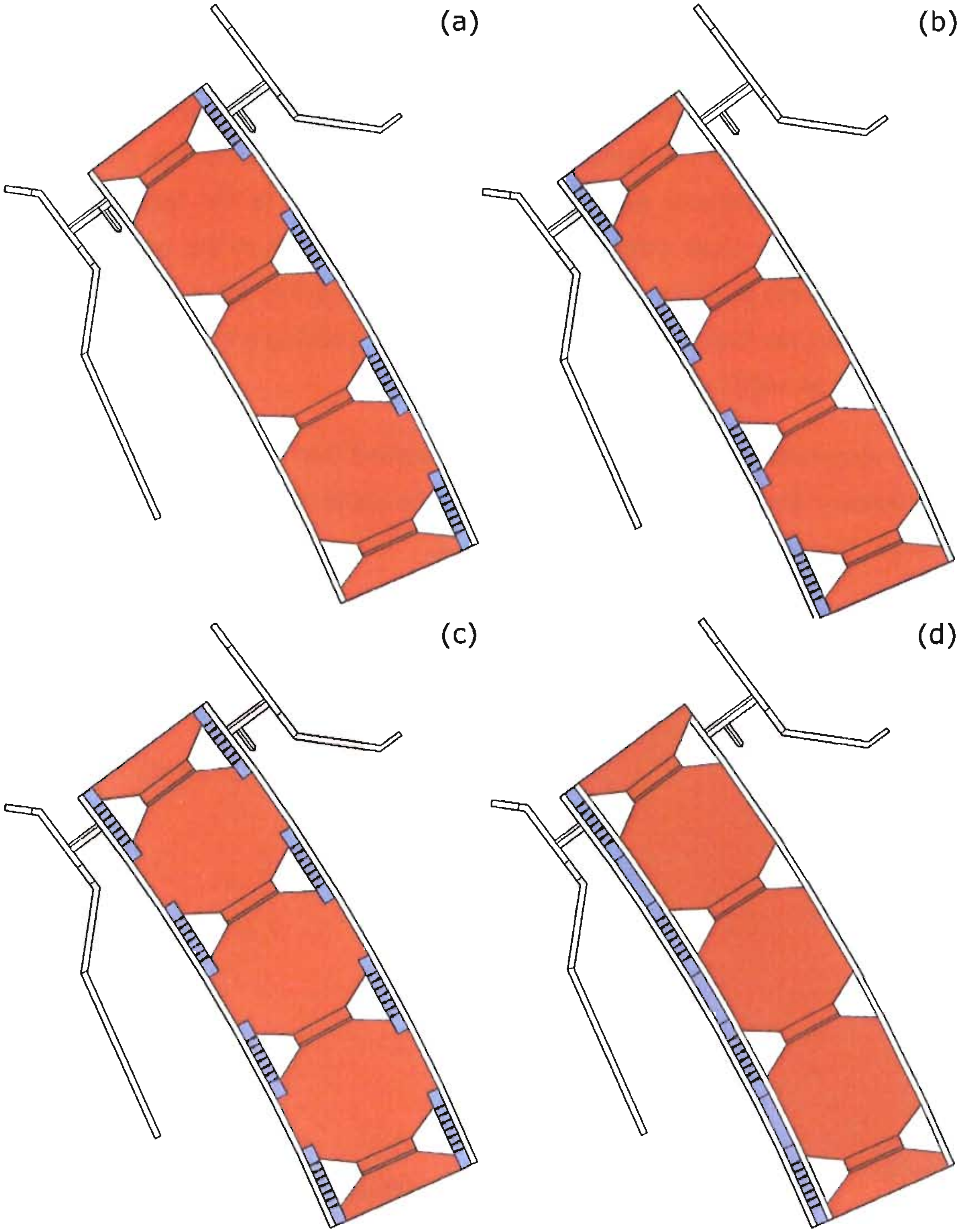


Figure 6.3 – Integration of the canoe chute and fishway design.
(a) with the fishway sharing pools and the fishway on the left side, (b) right side, or (c) both sides of the canoe chute. (d) The fishway hydraulically separate from the canoe chute. (Note: Fishway is shaded in blue, the canoe chute in red.)

Each of the alternative fishway configurations has pros and cons that must be considered. The integrated fishway has the benefit that the canoe chute pools can also serve as resting pools for the fishway. Additionally, the aerated flow from the canoe chute and the position of the fishway at the edge of the expanding flow on the side of the canoe chute's hydraulic jump may help to guide fish to the fishway entrance. However, due to the close proximity of the fishway channels to the boat chute drop, care must be taken to make sure that it will not be possible for a boat to enter the fishway and become trapped (this can be prevented by adding a trash screen or pilings at the entrance to each fishway run).

Based on discussions with District staff, it was decided that the two fishway alternative with the fishway directly incorporated into the canoe chute design would be examined in more detail. This layout is presented in figure 6.4.

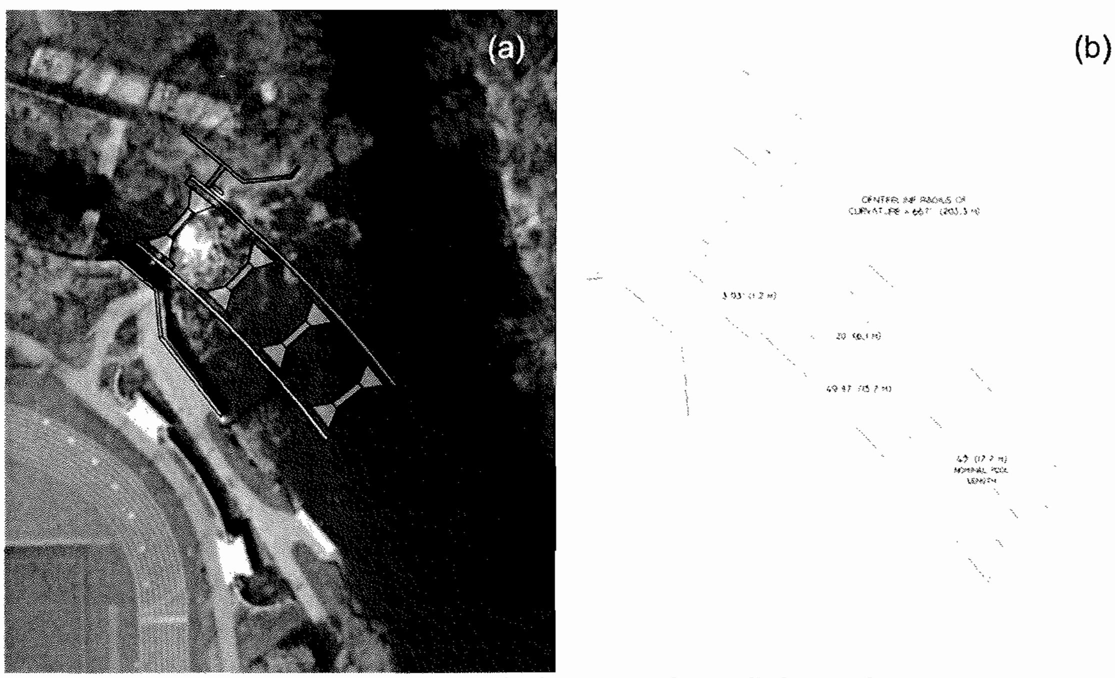


Figure 6.4 – Recommended canoe-chute fishway layout.

A standard Denil fishway or a Dutch Pool and Orifice (modified "DeWit") fishway appear to be good options for installation in the proposed North Branch dam canoe chute/fishway. Although there is much more in the literature about the hydraulic behavior and performance of the Denil fishway (Katopodis et al, 1997; Kamula and

Barthel, 2000; Bunt et al, 1999; Bunt, 2001; Odeh, 2003), the Dutch Pool and Orifice fishway (described in detail in Boiten and Dommerholt, 2006) would seem to be a better alternative for the North Branch dam fishway than the Denil fishway originally recommended by MWH in the preliminary analysis conducted for the FOCR.

The Dutch Pool and Orifice fishway is essentially a vertical slot fishway in which the top of the slot is enclosed to form a rectangular orifice. These orifices are offset from one baffle to the next so that the flow is forced through a sinuous path, thereby increasing head losses in the fishway and providing areas of relatively low velocity for fish to rest.

A significant benefit of the Dutch Pool and Orifice fishway for the North Branch dam location is that it draws significantly less flow for a given headwater elevation than a comparably sized Denil fishway (see figure 6.5 and calculation examples in Appendix B). Additionally, the discharge through the Dutch Pool fishway is not as heavily dependant on upstream water depth as is the Denil fishway and should maintain a relatively constant discharge (and velocity through the orifices) for almost all expected operating conditions.

For a given headwater condition, the mean velocity through the baffle opening (total discharge/projected opening area) for a Denil fishway is slightly lower than for the Dutch Pool and Orifice fishway (figure 6.6). However, it was noted by Odeh (2003) that the velocities in the upstream-most portion of the Denil fishway are about 50% higher than they are in the rest of the fishway (figure 6.7(a)). In contrast, velocities though the Dutch Pool and Orifice fishway remain relatively constant throughout the fishway and do not vary depending upon the longitudinal location along the fishway (Boiten and Dommerholt, 2006 – figure 6.7(b)). This is an important consideration when dealing with the weaker swimming fish species that would most likely use the North Branch dam fishway. The fact that the velocity increase in the Denil fishway occurs at the upstream-most portion of the fishway is relevant because this would be the location in the fishway where the fish are most likely to be fatigued – therefore, it is safe to assume that the increase in velocities here are most likely to negatively affect weaker swimming fish. It has been noted that successful use of a Denil fishway by smallmouth bass (a target species as determined by FOCR and MWH (MWH, 2006)), is affected by the maximum water velocity found in the fishway, with an exponential decline in usage relative to water velocity (Bunt et al, 1999). It can be assumed that a similar relationship can be found for other species as well and that a general lack of fishway use by non-anadromous fish can be partially attributable to the high water-velocities generally found in most fishways.

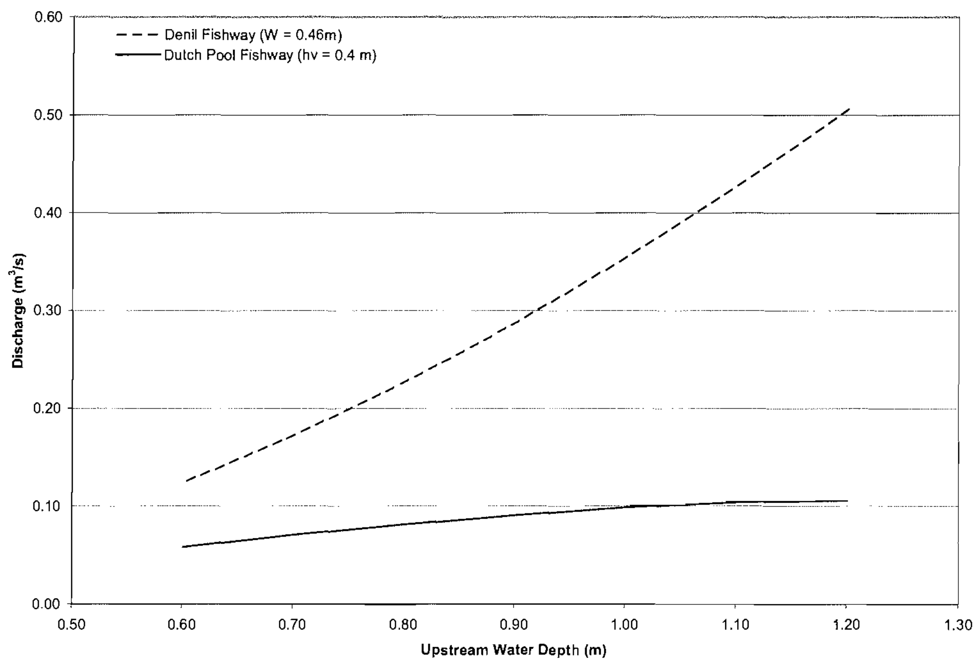


Figure 6.5 – Comparison of Discharges though the standard Denil and Dutch Pool and Orifice fishway.

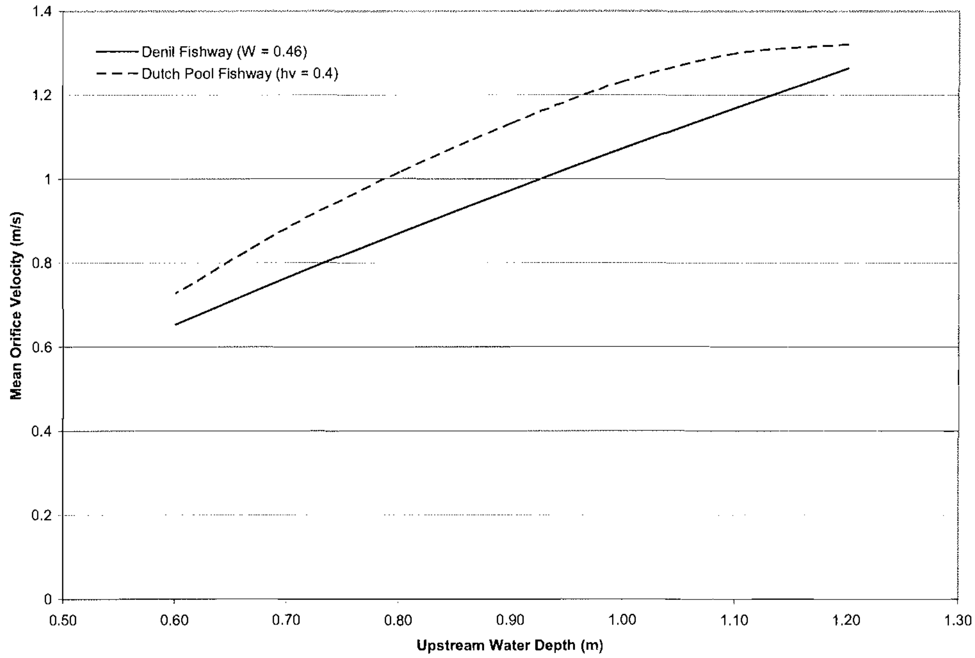


Figure 6.6 – Mean orifice velocity for the standard Denil and Dutch Pool and Orifice fishways.

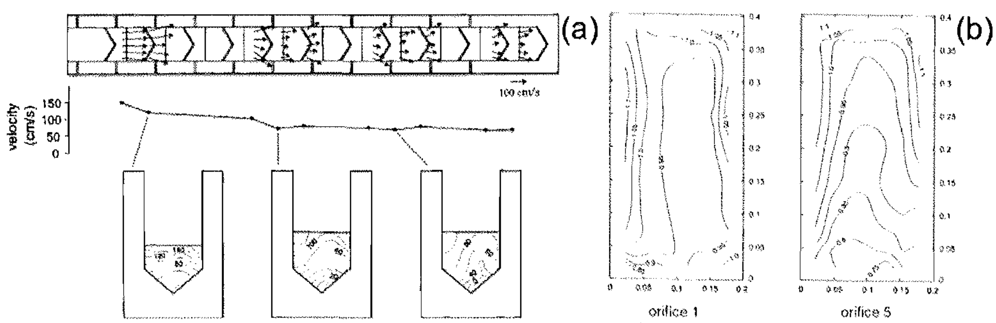


Figure 6.7 – Velocity contours at different longitudinal locations for (a) the standard Denil fishway and (b) the Dutch Pool and Orifice fishway.

Another important consideration is the level of turbulence that is found within the fishway. Rodriquez et al (2006) recommends an average turbulent dissipation rate of less than 150 W/m^3 (Rodriguez et al, 2006) be maintained throughout the fishway in order for smaller, non-anadromous fish species to remain orientated within the flow. The turbulent energy dissipation rate can be calculated as follows:

$$K = \rho g Q \frac{\Delta h}{V_p} \tag{9}$$

where K is the dissipation rate of turbulent kinetic energy in W/m^3, ρ is the density of the water, g is gravitational acceleration, Q it the discharge through the fishway, Δh is the change in water-surface elevation between the upstream and downstream ends of the fishway, and Vp is the volume of the water in the fishway – calculated as follows:

$$Vp = \left(\frac{H_{US} + H_{DS}}{2} \right) LW \tag{10}$$

where H_{US} and H_{DS} are the upstream and downstream depths, respectively, L is the total length of the fishway and W is the fishway width. It can be seen that the turbulent dissipation rate in the Dutch Pool fishway is significantly lower that for a comparable Denil fishway (figure 6.8).

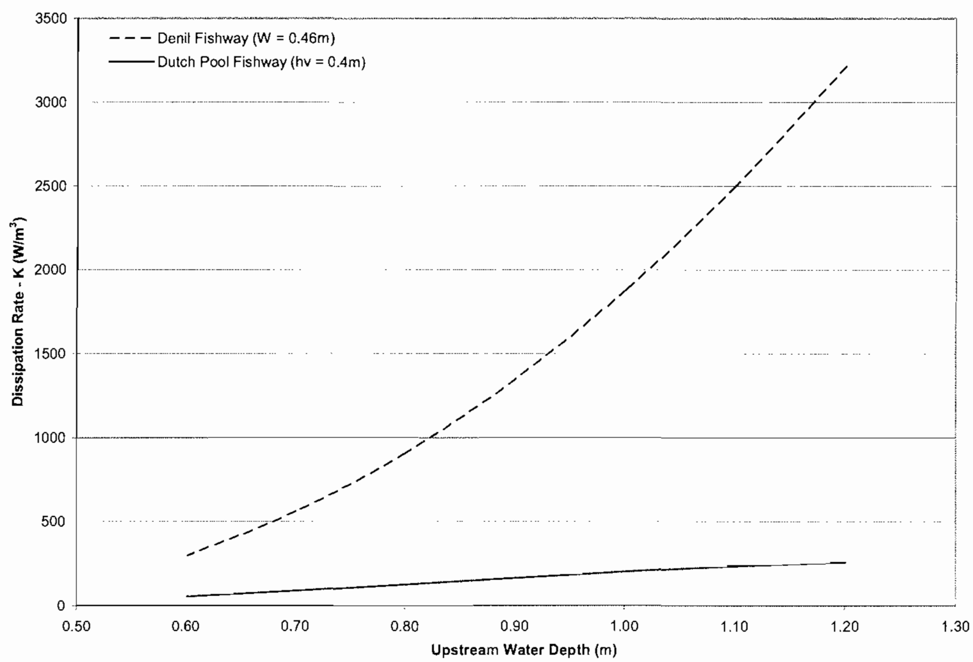


Figure 6.8 – Turbulent dissipation rate, K (W/m^3) for the standard Denil and Dutch Pool and Orifice fishways.

The relevant design characteristics of the Dutch Pool and Orifice Fishway recommended for the North Branch Dam are listed below (recommendation as per Boiten and Dammerholt, 2006).

- Each fishway run will consist of 7 baffles with orifice openings 0.98-ft (0.3 m) tall and 0.66 ft (0.2 m) wide.
- Baffles openings should be encased in 0.33-ft (0.09 m) diameter PVC pipe to prevent clogging with debris
- Center-to-center distance between baffles will 2.62 ft (0.8 m)
- Fishway run slope will be 0.0625 with an elevation change between pools of 1.67 ft (0.51 m) with a total horizontal fishway run length of 26.67 ft. This will result in a total of 4.46 ft (1.36 m) of the sloped fishway bottom lying upstream of the first baffle and 4.46 ft (1.36 m) of the bottom lying downstream of the last baffle for each run.

The final recommended design layout for the Dutch Pool and Orifice fishway is presented in figure 6.9

(a) (b)

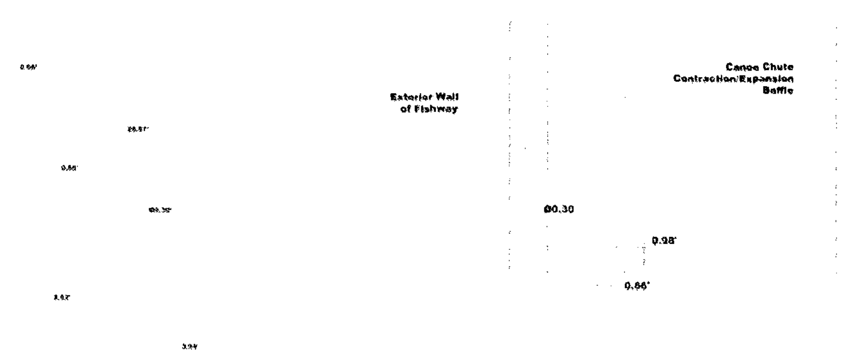


Figure 6.9 – Recommended configuration for the Dutch Pool and Orifice fishway for the North Branch Dam.

7 CANOE CHUTE/FISHWAY MODELING

7.1 Canoe Chute Modeling Results

The canoe chute was initially designed as described in §5.1. Preliminary testing ensued to determine the safety of the canoe chute with respect to the hydraulic jump type that was developed – the results of this testing is presented in table 7.1. "A" indicates a type-A jump in which the drop structure is submerged and a definitive surface reverse flow is apparent, "B" indicates a type-B curve in which a defined hydraulic jump is detected downstream of the structure, "W" indicates a wave jump where a standing wave pattern is detected with surface currents moving in a downstream direction, and "W/B" indicates a transitional jump between the type-B and wave jump (as described previously in §6.1 and figure 6.1). Discharges and elevations are as previously detailed in tables 3.1 and 3.2).

Figure 7.1 is the rating curve for the preliminary canoe chute/fishway design. For reference, the rating curve measured in the model for the existing dam and the published USGS rating curve are also included. It should be noted that this rating curve was developed for the canoe chute with the fishways inactive resulting in all of the discharge passing over the canoe chute drops, the "worst case" condition with respect to water-level increases.

The effect of the canoe chute is to increase water-surface elevations upstream of the dam by a maximum of 0.7 ft (0.21 m). It should be noted that there are four distinct regions for the rating curve. The first region occurs while the rating curve is still controlled by the concrete walkway (as previously discussed in §5.1.2). With the increase in stage caused by the presence of the canoe chute, the effect of this walkway is decreased and flow becomes controlled by the dam at a discharge of approximately 150 cfs as opposed to approximately 550 cfs for the existing dam. This second, dam controlled region, is from 150 to approximately 275 cfs, at which time flow begins to pass over the secondary spillway located on the right side of the dam resulting in a change in the slope of the rating curve. This third region lasts from 275 cfs to 600 cfs, at which time water begins to pass over the top of the canoe chute's contraction baffles, with complete overtopping of the dam occurring at 725 cfs. For discharges greater that

725 cfs, it is expected that the slope of the rating curve pre- and post-canoe chute should be the same, with a net increase in water-surface elevation of approximately 0.30 ft (0.09 m).

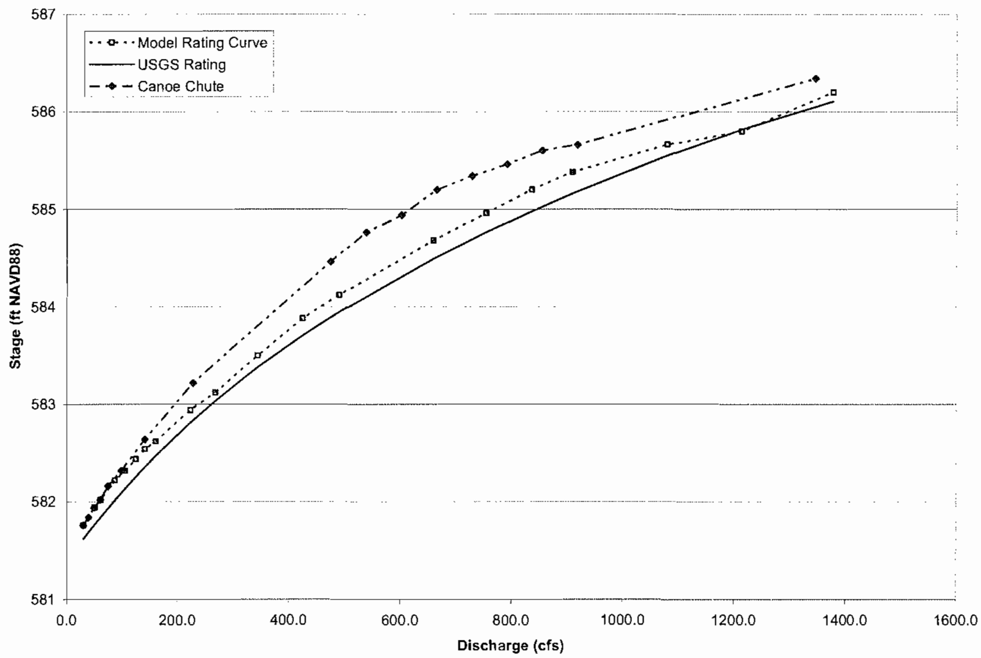


Figure 7.1 – Rating curve measured for the preliminary canoe chute design.

Table 7.1 – Hydraulic jump type developed with the preliminary canoe chute drop design.

Flow Exceedance	85	75	65	55	45	35	25	15	5
Pool 1	A	A	A	A	A	A	A	A	A
Pool 2	A	A	A	A	A	A	A	A	A
Pool 3	W	W	W	W	W	W	W	W	W/B
Pool 4	A	A	A	A	W	W	W	W	W/B

As a consequence of the results presented in table 7.1, it became necessary to modify the drop structures in order to ensure that the hydraulic jumps remained in the wave regime for as wide a flow range as possible. Since the type-A jump was observed most often it was determined that, in general, the backwater elevation in the downstream pools was too high with respect to the drop elevation. In order to compensate for this, the elevation of the horizontal portion of the drop structures was increased until a wave jump was observed for all drops for the stage-discharge combinations summarized in tables 3.1 and 3.2.

After some trial and error manipulation of the drop elevations, the final configuration was determined. In order to minimize any additional increase in upstream water-surface elevation above that already reported in Figure 7.1, it was decided that the maximum crest elevation of each drop would not be changed and neither would the total width of the canoe chute drops. This resulted in a drop configuration in which the length of the horizontal portion of the drop varies from one drop structure to the next. The final canoe-chute drop configuration is presented schematically in figure 7.2 with elevations relevant dimensions summarized in table 7.2.

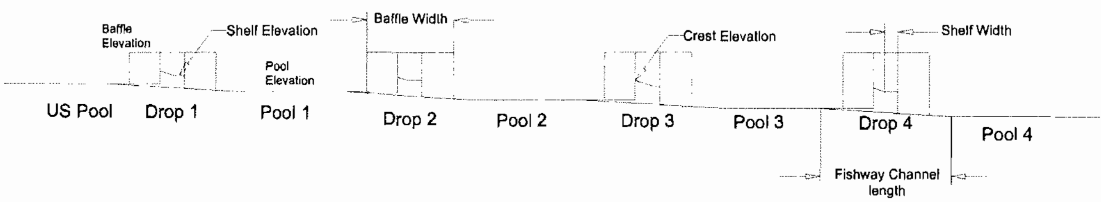


Figure 7.2 – Schematic of the final canoe chute design describing relevant dimensions.

Table 7.2 – Final canoe chute design dimensions.

Location	Baffle Elevation	Baffle Width	Pool Elevation	Fishway Channel Length	Crest Elevation	Shelf Elevation	Shelf Width
US Pool			578.47				
Drop 1	584.86	17.70		26.67	581.06	580.14	2.17
Pool 1			576.81				
Drop 2	584.86	17.70		26.67	579.91	579.26	3.00
Pool 2			575.15				
Drop 3	584.86	17.70		26.67	579.09	577.81	1.00
Pool 3			573.48				
Drop 4	584.86	17.70		26.67	577.68	576.93	2.69
Pool 4			571.82				

Figure 7.3 presents the results of a sensitivity analysis performed to determine the tailwater stage (stage in the North Shore Channel/Lower North Branch) at which the flow transitions between hydraulic jump regimes. This was necessary because the stage in the North Shore Channel/Lower North Branch can vary so much for a given Upper North Branch discharge. From this figure it can be determined that for the

modified canoe chute drop configuration, a wave-type jump was observed for all discharges for Upper North Branch flows ranging from 30-228 cfs (85%-15% exceedance) at the median downstream stage reported in table 3.2. (It should be noted that the change in tailwater stage only effected the hydraulic jump formed downstream of the last (downstream-most) drop with all others remaining in the wave regime at all times.

The results presented in this figure indicate that, for low discharges, the flow will transition into the A-jump regime for tailwater stages only slightly higher than the median.

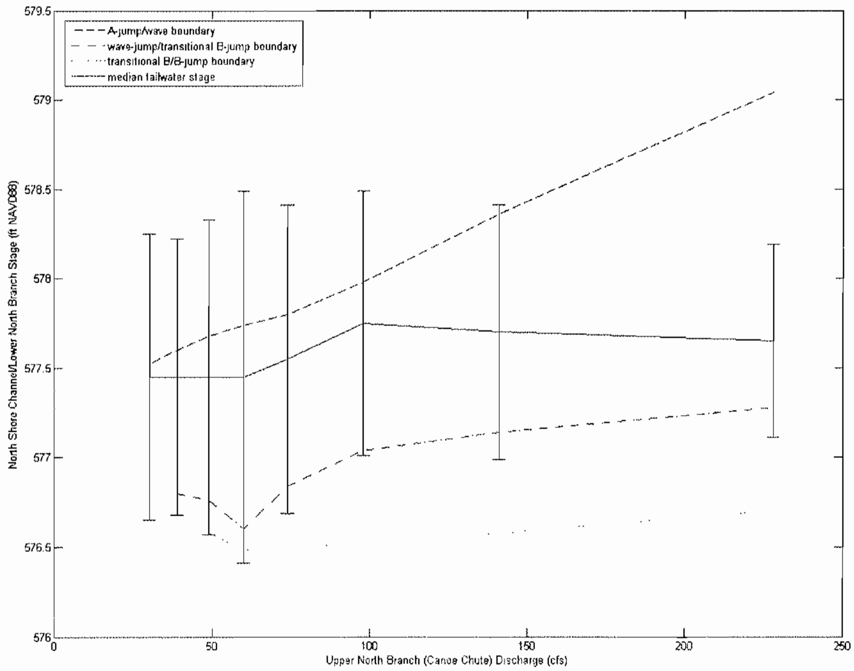


Figure 7.3 – Sensitivity analysis of hydraulic jump type to tailwater condition.
Error bars represent one standard deviation of stage at the given exceedance.

7.1.1 Flow velocity measurements

Depth averaged velocity vectors are presented in figures 7.4 and 7.5 for the 85% and 15% exceedance discharges, respectively. In the vicinity of the canoe chute, velocities were expected to be largely three-dimensional. Therefore, it was not considered useful to make velocity measurements using the UVP – only the Vectrino was used. Flow velocities upstream of the canoe chute in the North Shore Channel were not anticipated to change dramatically so velocity measurements were only collected at section E and G and inside the interior of the canoe chute (see figure 4.4 for section locations).

One concern expressed by District staff was that the canoe chute structure would pose an obstruction to the flow passing down the North Shore Channel and would act to deflect high velocity flow to the opposite (left-hand) bank, resulting in the potential for significant stream bank erosion. The results presented in figures 7.4 and 7.5 tend to indicate that this should not be a problem. Velocity vectors at section E (the section of maximum encroachment by the canoe chute) are relatively uniform in magnitude and distribution across the open width of the North Shore Channel for both exceedance discharges and do not exhibit a strong transverse (cross-channel) component.

This result is also supported by FLOW-3D modeling results that are included in figure 7.5 for the 15% exceedance discharge (the yellow vectors). For this model run, the Dutch Pool and Orifice fishway was included, but only on the left-hand side of the canoe chute. It should be noted that there was a problem with the FLOW-3D model for this discharge in the manner in which it resolved the fishway baffles. The method that FLOW-3D uses to determine the free water-surface (the Volume of Fluid Method, Hirt and Nichols, 1981) relies on a calculated fractional fluid volume (the percentage of a cell that contains fluid) to determine whether a cell contains water or some other phase (the solid surface in the case of the boundary or air in the case of the air-water interface). Due to the relatively small thickness of the fishway baffles with respect to the computational mesh, the baffles were not correctly interpreted by the software as a solid boundary and were instead generally considered to be open water – the program essentially did not "see" the baffles (figure 7.6). This resulted in a much greater flow through the fishway channel than would be expected. This is the reason area of high velocity flow present on the left-hand side of the canoe chute structure. Although this result does not accurately represent the velocities in this area, it can been seen that even the presence of a high velocity jet (2-3 times faster than flow passing from the North Shore Channel) with a strong transverse component does not result in higher flow velocities directed toward the bank downstream, as demonstrated by velocity vectors at the next downstream cross-section.

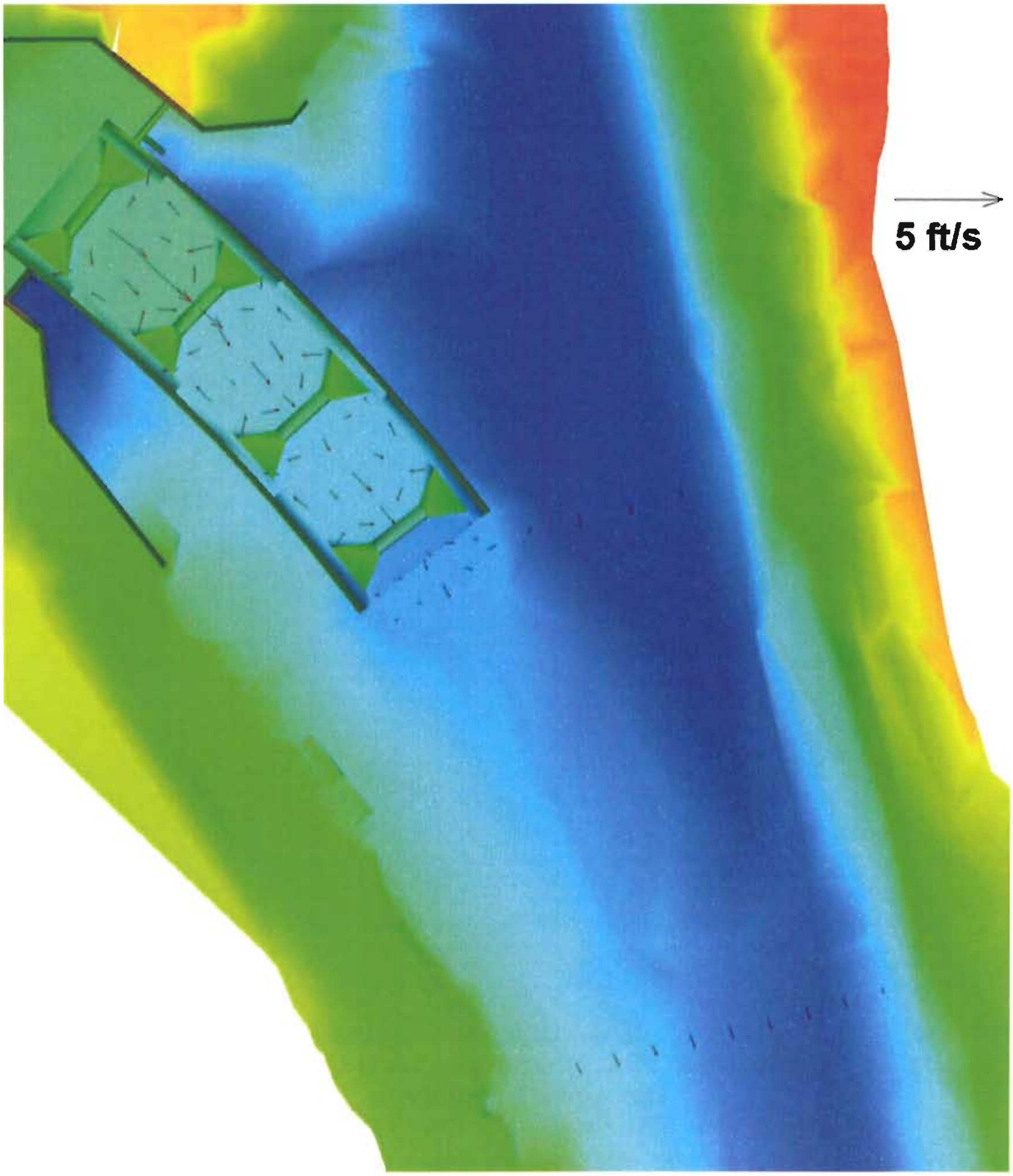


Figure 7.4 – Comparison of depth averaged velocity vectors for the 85% exceedance discharge.
(Q_{UNB} = 228 cfs, Q_{NSC} = 526 cfs, Q_{LNB} = 754 cfs). Red vectors are measurements made with the Nortek Vectino.

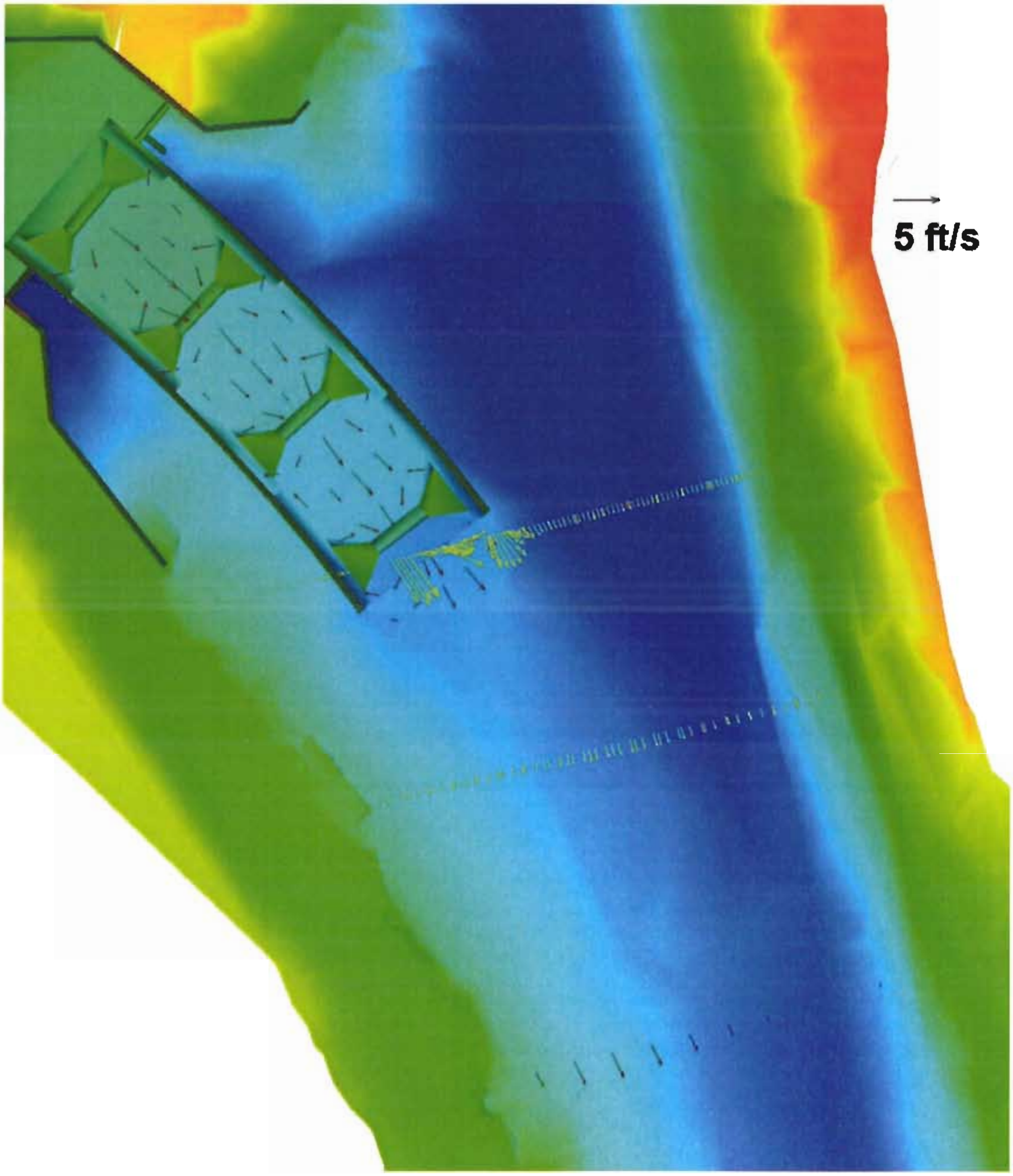


Figure 7.5 – Comparison of depth averaged velocity vectors for the 15% exceedance discharge.

(Q_{UNB} = 228 cfs, Q_{NSC} = 526 cfs, Q_{LNB} = 754 cfs). Yellow vectors represent FLOW-3D modeling results, red vectors are measurements made with the Nortek Vectrino.

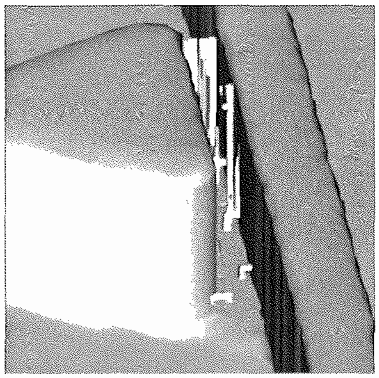


Figure 7.6 – Interpretation of the Dutch Pool and Orifice baffles by FLOW-3D for the 15% exceedance model run.

A comparison of the pre- and post-modification velocity magnitude plots of the FLOW-3D modeling results also supports the conclusion that the canoe chute does not present a substantial obstruction to the flow (figures 7.7 and 7.8). The overall magnitude and general distribution of velocities does not appreciably change for with or without the canoe chute for both the 85% and 15% exceedance discharges.

It can also be noted in figure 7.5 that the downstream-most cross section measured by the Vectrino has a larger velocity magnitude along the right-hand bank. This result seems to indicate that the flow issuing from the canoe chute travels primarily in a downstream direction and does not move across the channel, adding support to the conclusion that the presence of the canoe chute should not increase erosion along the left-hand bank.

Examining the depth-averaged velocity vectors inside the canoe chute for figures 7.4 and 7.5 and the three-dimensional vectors in figures 7.9 provides insight into the flow patterns established in the canoe chute. Flow in chute shows the same general pattern, a core of high velocity flow immediately downstream of each individual drop feeding a large scale recirculation pattern within the areas shielded by the expansion/contraction baffles. As intended through the use of the baffles, the flow shows evidence of expansion immediately following the drop, resulting in a decrease in flow velocity.

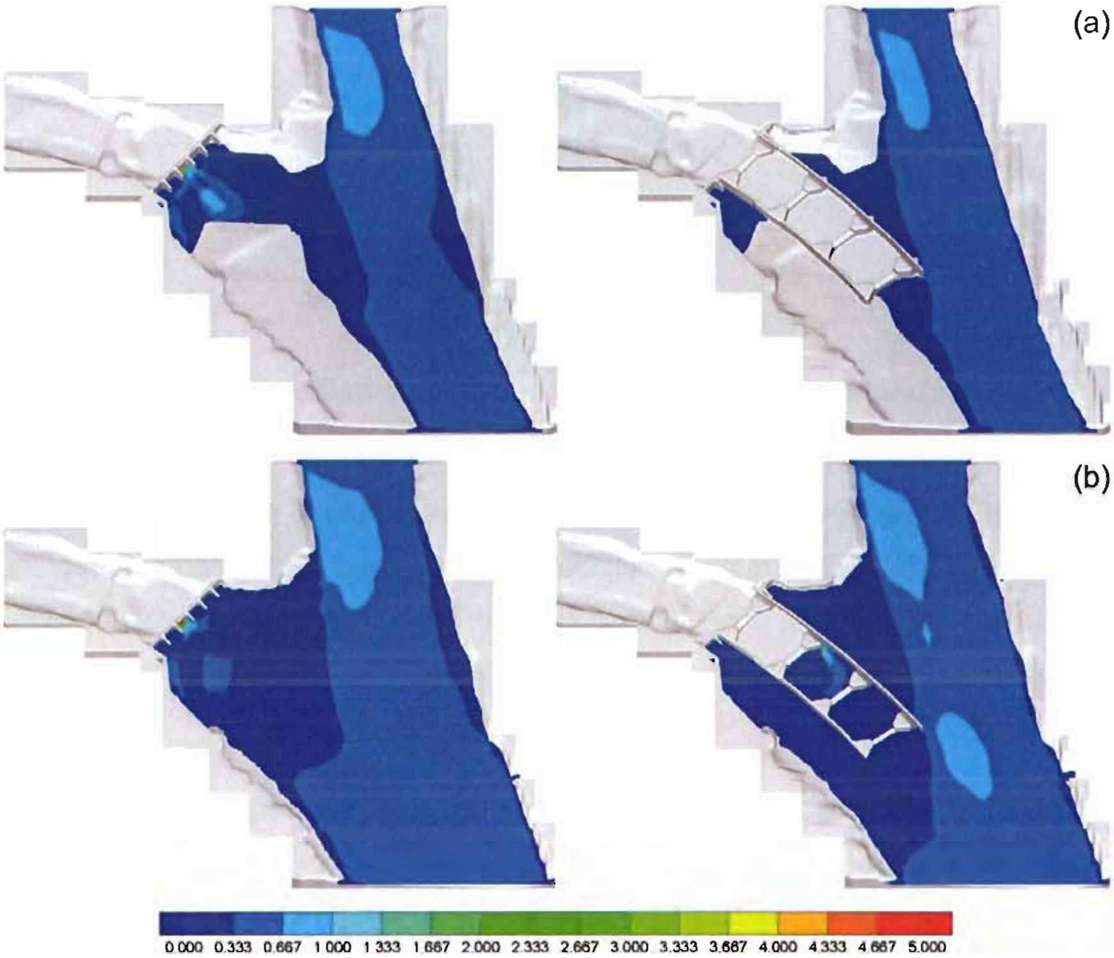


Figure 7.7 – Pre- and post-modification FLOW-3D velocity magnitudes for the 85% exceedance discharge.

Units are ft/s. Horizontal slices are located at elevation (a) 572.1 ft (b) 576.5 ft NAVD88.

The two-dimensional (longitudinal and vertical) velocity vectors recorded at the centerline of each canoe chute pool for the 85%, 55%, and 15% exceedance discharges (figure 7.10(a), (b), and (c), respectively). It should be noted that it was not possible to determine a vertical velocity component for the top-most measurement locations with the Vectrino. The two receiving arms used to resolve the vertical velocity component were above the water surface, allowing resolution of the longitudinal and transverse velocity components only (Lohrmann, 2007). The vertical component was assumed zero for these locations when generating figure 7.10. Average water-surface elevation measurements for each pool are recorded in table 7.3.

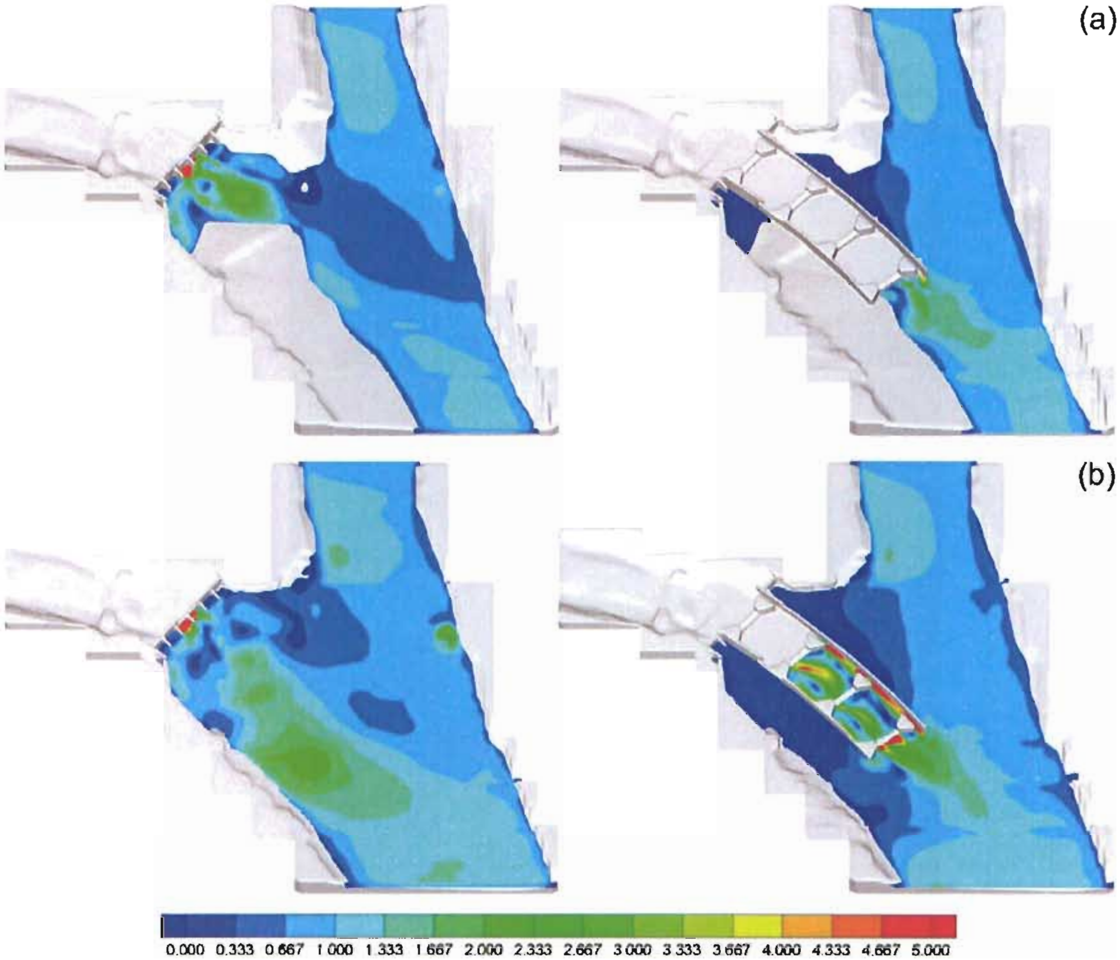


Figure 7.8 – Pre- and post-modification FLOW-3D velocity magnitudes for the 15% exceedance discharge.

Units are ft/s. Horizontal slices are located at elevation (a) 572.1 ft (b) 576.5 ft NAVD88.

From this figure, it can be seen that the highest velocities occur as a skimming flow near the surface, with a maximum longitudinal velocity of 5.25 ft/s for both the 85% and 55% exceedance discharges and 8.70 ft/s for the 15% exceedance discharge. The maximum cross-sectional averaged velocity for each flow condition is 0.57 ft/s, 0.90 ft/s, and 1.32 ft/s for the 85%, 55%, and 15% exceedance discharges, respectively. For the 85 and 55% exceedance discharges, there is evidence of a large scale persistent vortex in front of the upstream drop as indicated by the smaller, upward pointing velocity vectors. This vortex is a result of the high surface velocities and the shielding provided by the upstream drop structure. For the 15% exceedance discharge, the largest vertical velocities are found in the center of the chute pools, possibly indicating that the recirculation cell discussed previously has been pushed away from the drop structure by the strength of the surface flow.

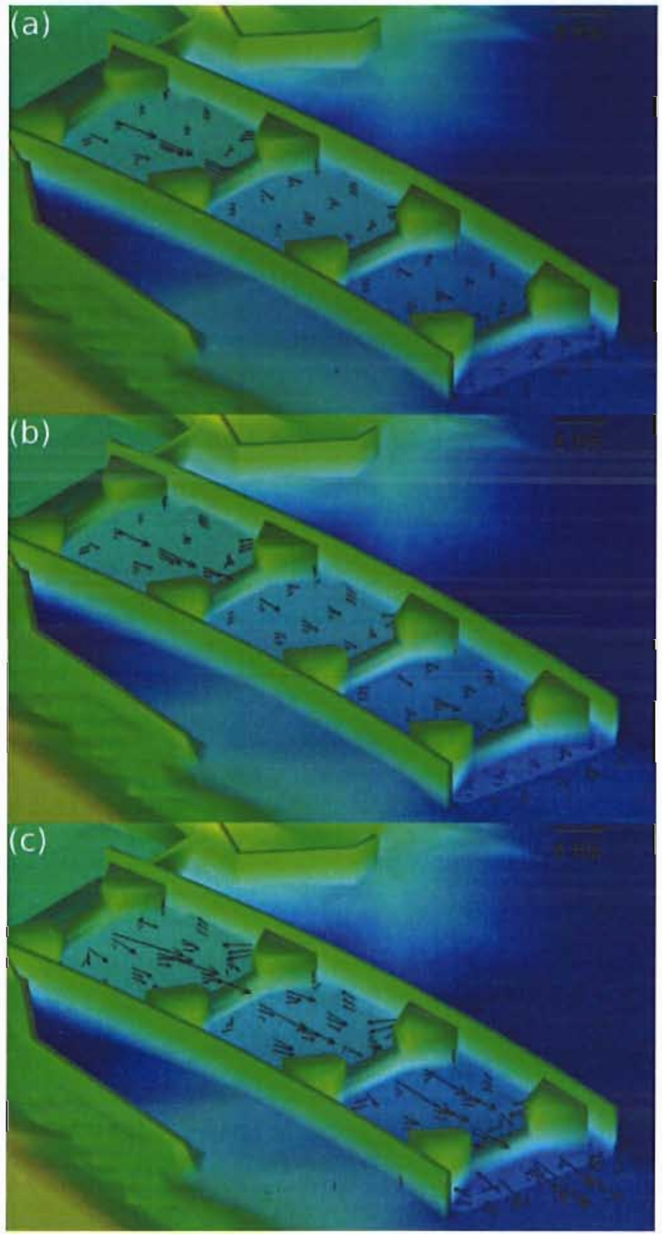


Figure 7.9 – Three dimensional velocity vectors measured in the canoe chute using the Vectrino.
Measurements for (a) 85%, (b) 55%, and (c) 15% exceedance discharges.

Velocities deeper below the surface are highest in the middle of the chute pools where flow expansion is the greatest. These velocities decrease and become more vertically orientated as the flow approaches the next downstream drop.

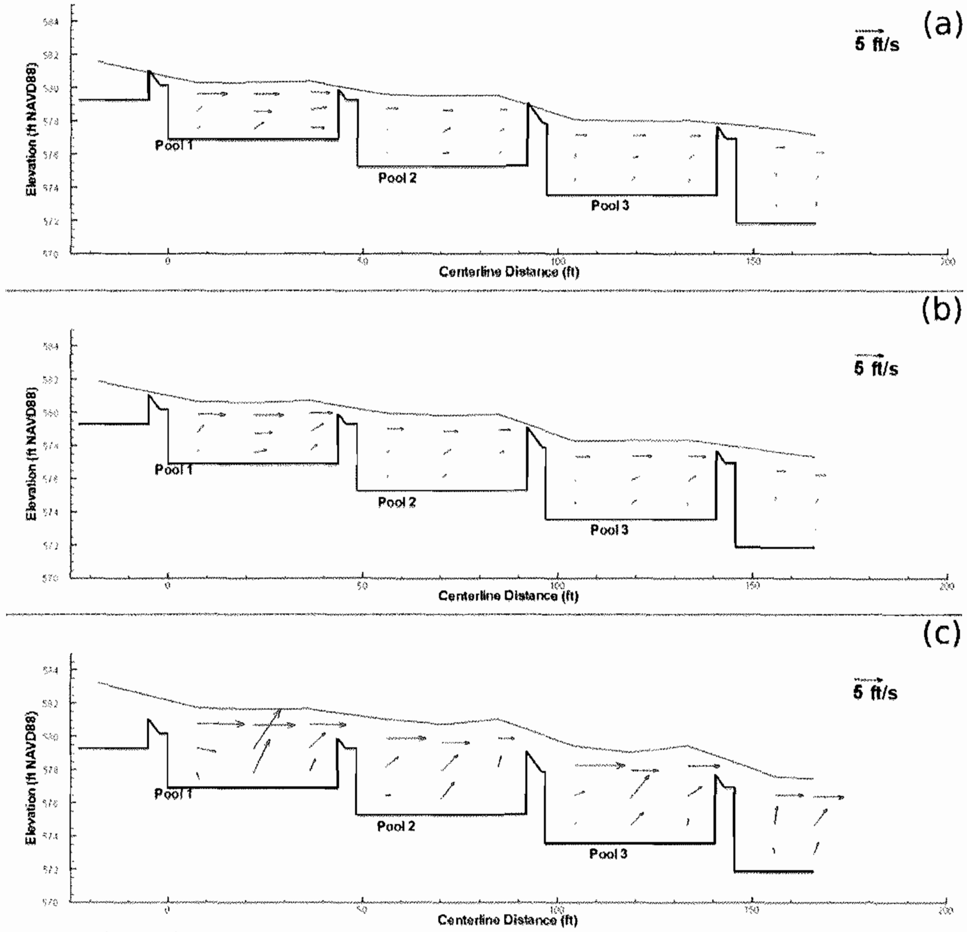


Figure 7.10 – Centerline velocity vectors measured in the canoe chute. *Measurements presented for (a) 85%, (b) 55%, and (c) 15% exceedance discharges. (Note: due to the proximity of the water-surface for the top-most measurements, the Vectrino is not completely covered, resulting in a 2-d configuration unable to measure z (upward) component – show as zero.)*

Table 7.3 – Average water-surface elevation measured for 15%, 55%, and 85% exceedance discharges.

	Exceed			
Pool	15	55	85	Bottom El
US of dam	583.26	581.9	581.6	579.26
1	581.71	580.67	580.37	576.89
2	580.95	579.88	579.57	575.25
3	579.32	578.32	578.07	573.56
Lower NB	577.56	577.49	577.40	571.87

7.1.2 Flow visualization

Flow visualization exercises were performed on the 15% exceedance discharge with the canoe chute in place. Figure 7.11 shows the evolution of dye injected upstream of the canoe chute in the North Shore Channel at section C. The relative velocities as indicated by the dye evolution indicate that slightly higher velocities are experienced along the left-hand side of the waterway in the deeper portion of the channel. This is similar to the observation made with the existing dam configuration in place (§5.3).

Figure 7.12 shows the evolution of dye injected immediately downstream of the canoe chute. As noted in the previous section of this report, the highest velocities are found immediately in front of the canoe chute where the flow is issuing from the downstream-most drop. Close examination of the dye evolution and other observations in the model indicate that the flows coming from the canoe chute may be strong enough to entrain some of the ambient flow entering the junction from the North Shore Channel. This is the source of the higher-velocity flow along the right-hand side of the channel that was noted in the Vectrino velocity measurements. This increase in velocity along the right side of the channel is persistent downstream (figure 7.13).

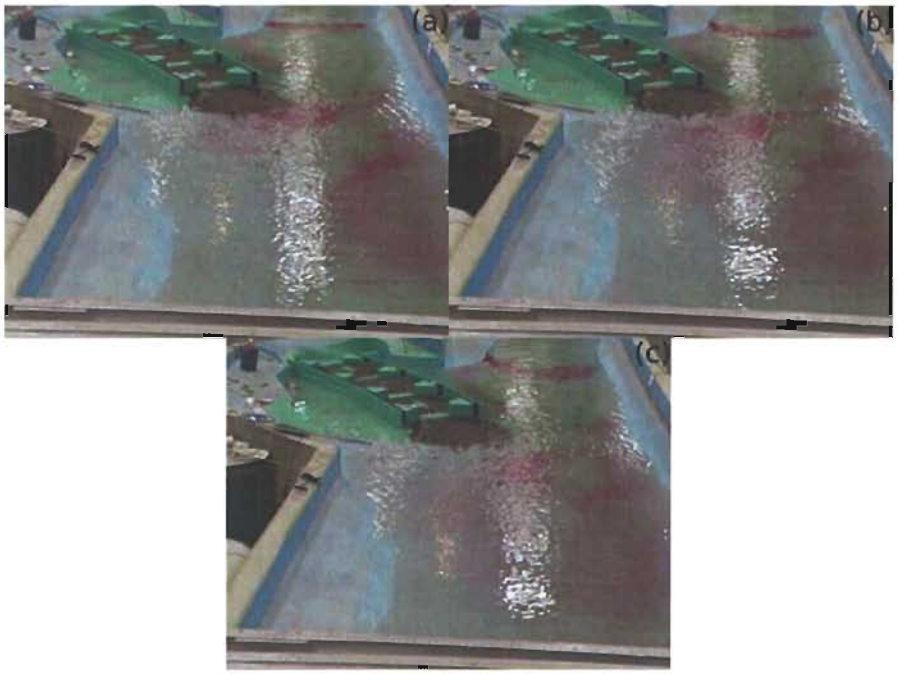


Figure 7.11 – Evolution of dye injected in the North Shore Channel upstream of the proposed canoe chute.
Time interval between pictures is approximately 5 seconds.

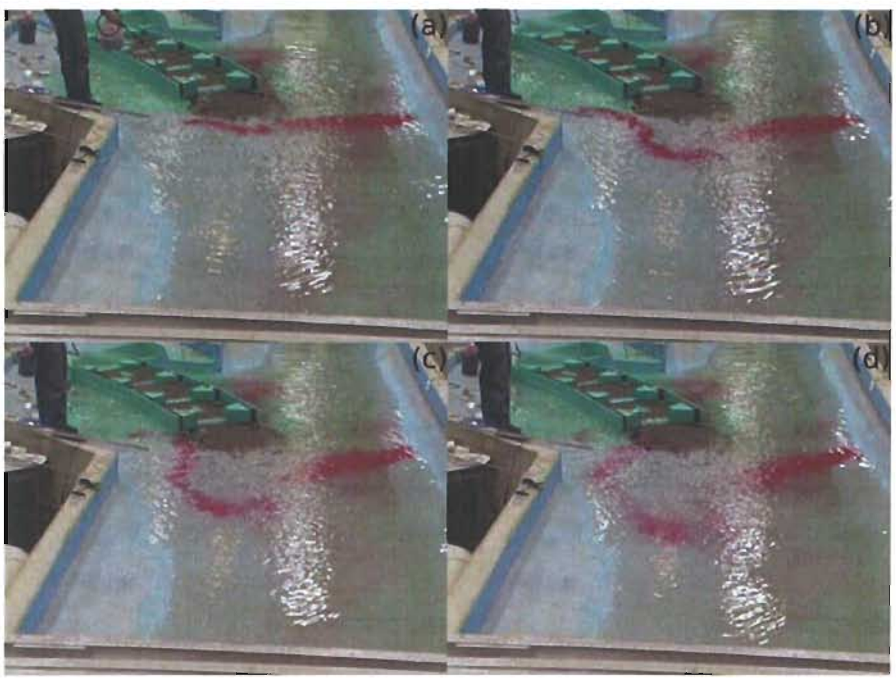


Figure 7.12 – Evolution of dye injected in front of the canoe chute at cross-section E.
Ttime interval between pictures is approximately 2.5 seconds.

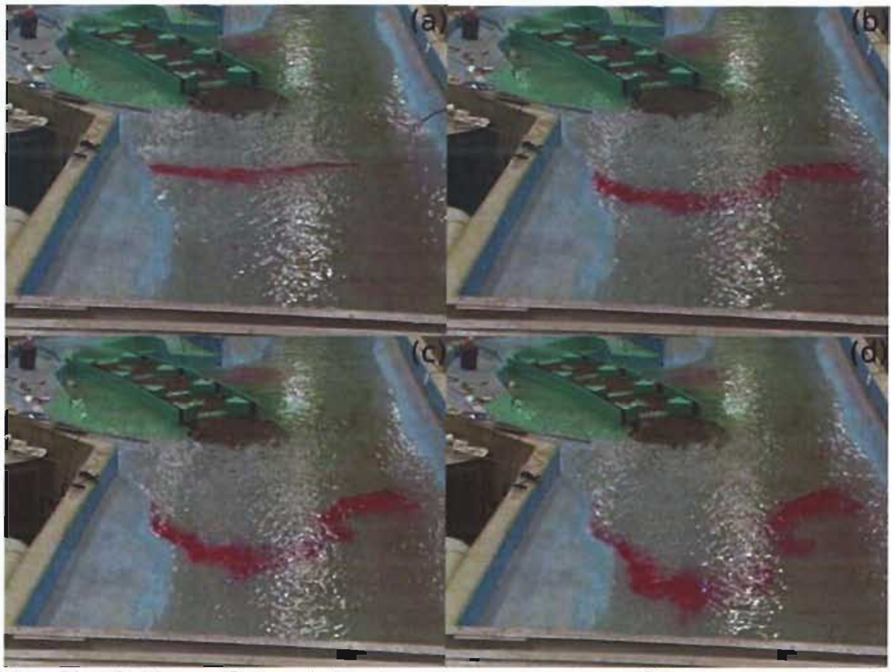


Figure 7.13 – Evolution of dye injected downstream of the canoe chute at cross-section G.

Time interval between images is approximately 2.5 seconds.

7.1.3 Critical depth considerations

The results of the physical model study indicated that the canoe chute/fishway design presented in figure 6.9 should be safe with respect to hydraulic jump regime for discharges ranging from approximately 30 to 228 cfs (85 – 15% exceedance) at the median North Shore Channel/Lower North Branch water depth. Safe hydraulic jumps were observed for the top three drops for flows <15 cfs (the lowest flow rate measurable with the flow meter used of the North Shore Channel water-supply line). For the last drop, a type-A jump was observed at 15 cfs for the downstream-most drop. However, the strength of the submerged jump was such that it should not pose a large risk of trapping a boater.

At low discharges, primary controlling factor for successful operation of the canoe chute is maintaining a minimum critical depth over the drop. As discussed in §6.1, the nominal draft for an open water canoe is approximately 4-inches and it is advisable to add a factor of safety to make sure that a boat does not become hung up on the crest of the drop. Goodman and Parr (1994) comment that a minimum depth of 150-mm (approximately 6-inches) is suitable for short distances but that depths on the order of 450-mm (18-inches) is necessary for successful use of the canoe paddle.

Performing a critical depth calculations for the canoe chute drop (assuming a rectangular channel with a bottom width of 20-ft – the width of the canoe chute drop), the minimum required depth over the drop of 4-inches is achieved when there is 22.5 cfs of flow passing over the drop structure and a depth of 6-inches is achieved for a flow of 40 cfs.

It is possible to break the flow-duration curve developed in §3.2.1 down by month to determine the amount of flow that will be available during the most likely months for recreational canoeing. This data (based upon 15-minute flow data) is presented in table 7.4. With the two fishways are in operation (withdrawing a total of 6 cfs), the minimum flow over the canoe chute to maintain a 6-inch minimum depth is 46 cfs. Assuming that the canoe chute is most likely to be used from May-October, there will be enough water passing over the canoe chute approximately 90% of the time in May, 75% of the time in June, 50% of the time in July, and 45% of the time during the months of August – October.

Table 7.4 – Flow-duration data by month.

	Flow exceedance probability									
	5%	15%	25%	35%	45%	55%	65%	75%	85%	95%
Jan	466	221	141	115	96	80	68	57	44	30
Feb	576	241	165	130	106	90	77	65	56	44
Mar	651	413	255	180	132	104	88	76	66	52
Apr	657	357	232	173	126	99	81	66	56	43
May	719	362	233	159	120	91	73	63	53	37
June	613	331	201	138	98	73	60	50	37	22
Jul	356	165	97	66	51	43	37	32	27	19
Aug	576	211	100	65	49	39	33	28	23	18
Sep	561	159	85	60	46	36	30	25	22	17
Oct	421	122	75	56	46	38	32	28	24	20
Nov	357	160	102	75	57	49	41	36	30	26
Dec	354	167	118	93	81	69	61	53	44	32

If it is desired to provide a higher possible utilization rate for the canoe chute, one option is to modify the shape of the canoe chute drop from a horizontal crest-cross section to a trapezoidal cross-section. Although the use of a trapezoidal cross-section will have effect of reducing the width of the drop at low discharges below the 20-ft recommended in Caisley, et al. (1999) to minimizing the potential for boats and/or debris to become trapped at the drop, it will have the effect of increasing the critical depth at low discharges, thereby allowing use of the canoe chute at lower discharges, while keeping the entire 20-ft width available for discharges larger than a certain threshold discharge determined by the side-slope of the trapezoidal section (see figure 7.14). The results of critical depth calculations on the proposed rectangular cross-section as well as the trapezoidal cross-section with different bottom widths (b) and side slopes (z) are presented in Table 7.5.

Transforming the canoe chute cross-section from a rectangular to a trapezoidal cross-section increases the critical depth, and by extension the resultant stages upstream of the canoe chute, for all discharges. This increase in stage gets larger as the discharge increase until the maximum top width of the canoe chute is reached, at which time the difference between the rectangular and trapezoidal cross-sections become constant independent of discharge.

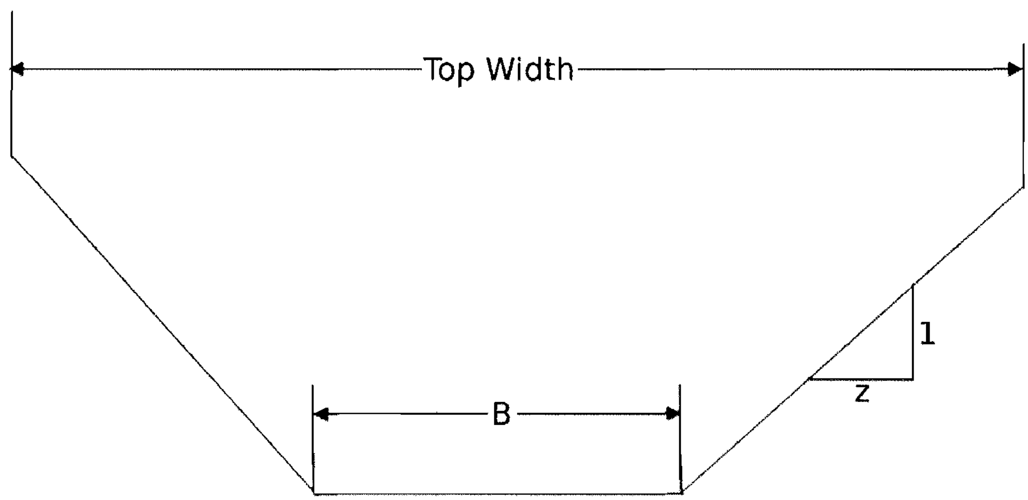


Figure 7.14 – Schematic of trapezoidal canoe chute drop.

Table 7.5 – Critical depth above canoe chute drop crest for different drop geometries.

(indicates the approximate discharge in which the full drop width of 20-ft is utilized, + indicates the approximate discharge in which a minimum critical depth of 6-inches is achieved)*

	Critical depth above drop crest (in)						
Discharge	b =20-ft	b = 10-ft			b = 5-ft		
(cfs)	z = 0	z = 20	z = 15	z = 10	z = 20	z = 15	z = 10
5	1.5	2.2	2.2	2.2	2.8	2.9	3.1
10	2.4	3.4*	3.3	3.4	4.0	4.2	4.6
15	3.1	4.4	4.1*	4.4	4.8*	5.2	5.7+
20	3.8	5.2	4.8	5.2	5.5	6*+	6.7
25	4.4	5.9+	5.4	5.9+	6.1+	6.6	7.5
30	4.9	6.4	5.9+	6.4*	6.6	7.2	8.2
35	5.5	7.0	6.5	7.0	7.2	7.7	8.8
40	6+	7.5	7.0	7.5	7.7	8.2	9.4*
45	6.5	8.0	7.5	8.0	8.2	8.7	9.9
50	6.9	8.4	7.9	8.4	8.6	9.2	10.3
60	7.8	9.3	8.8	9.3	9.5	10.1	11.2
70	8.7	10.2	9.7	10.2	10.4	10.9	12.1
80	9.5	11.0	10.5	11.0	11.2	11.8	12.9
90	10.3	11.8	11.3	11.8	12.0	12.5	13.7
100	11.0	12.5	12.0	12.5	12.7	13.3	14.4
125	12.8	14.3	13.8	14.3	14.5	15.0	16.2
150	14.5	16.0	15.5	16.0	16.1	16.7	17.8
175	16.0	17.5	17.0	17.5	17.7	18.3	19.4
200	17.5	19.0	18.5	19.0	19.2	19.8	20.9
300	22.9	24.4	23.9	24.4	24.6	25.2	26.3
400	27.8	29.3	28.8	29.3	29.5	30.0	31.2
500	32.2	33.7	33.2	33.7	33.9	34.5	35.6
600	36.4	37.9	37.4	37.9	38.1	38.7	39.8
700	40.4	41.9	41.4	41.9	42.0	42.6	43.7

7.1.4 Scour/Erosion Potential

During the construction of the canoe chute in the physical model, the bottom of the pools was left recessed approximately 0.5-inches below the desired grade. This was done in order to examine the potential for erosion and/or scour in the canoe chute pools during high discharges.

Erosion was first observed during the 15% exceedance discharge. Erosional depressions tended to form at the interface between the wave-type hydraulic jump and the large scale recirculation cells present to the outside of the canoe chute pools.

Erosion was first observed at the flow interface on the left-hand side of the pool, most likely due to the change in canoe chute orientation from drop to drop. At higher discharges, the erosional pools were observed on both sides of the canoe chute pool, although the size of the erosional depression on the left-hand side of the chute tended to be larger. Figure 7.15 is a picture of pool 3 (the upstream of the fourth drop) after the 5% exceedance discharge had been run for a period of several hours. It should be noted that for a given discharge, the aerial extents of the erosional depression eventually reached an equilibrium size and did not continue to grow until the discharge was increased.

Figure 7.15 – Photograph of erosional depressions observed in pool 3 after running the 5% exceedance discharge.

A second area where scour was noted was at the upstream face of the drop structures (figure 7.16). Scour in this case was caused by the abrupt change in flow direction caused by the physical obstructions to the flow and the resultant high velocities that were observed moving away from the contraction baffles (see figures 7.4 and 7.5).

Although it may not be possible to eliminate the potential for scour for all flow events, especially extreme flood events, it may be possible to limit their occurrence by adjusting the elevation of the secondary overflow weir and/or adding an additional overflow weir external to the canoe chute/fishway structure on the left-hand side of the dam.

Figure 7.16 – Erosion observed at the upstream face of drop 3 after running the 5% exceedance discharge.

Currently, the existing secondary spillway is at an elevation of 583.06 ft NAVD88. A critical depth calculation on the upstream-most canoe chute drop indicates that flow will not begin to pass over this spillway until a discharge of approximately 320 cfs, which has been approximately validated by the model. Although the exact discharge where this spillway becomes active was not determined, it was verified that overtopping occurred between the 15% and 5% exceedance discharges (228 and 476 cfs, respectively).

If the crest of the existing 12-ft wide overflow spillway on the right-hand side of the dam is lowered to an elevation of 582.25-ft from its current elevation of 583.06-ft, it would be possible to reduce the discharge passing through the canoe chute from 228 cfs to 214 cfs for the 15% exceedance discharge. If a second, 16-ft wide overflow spillway with the same crest elevation of 582 were added to the left-hand side of the dam, the flow through the canoe chute could be reduced further to 203 cfs. For reasons of safety, it is not recommended that the secondary spillway crest elevation be decreased lower that 582.25-ft. At this elevation, a discharge of 147 cfs is required before the secondary spillways become active. For discharges lower than this, it is more likely that a boater may be on the water and may accidentally pass over the secondary spillway rather than passing through the canoe chute. If some other form of deterrent is present to prevent boaters from accidentally passing over the overflow weirs, these crest elevations may be decreased even further. However, the minimum should be 581.75-ft in order to maintain the minimum depth of greater than 6-inches over the canoe chute drops prior to activation of the secondary spillways (see §7.1.3). For a secondary spillway elevation of 581.75-ft, the discharge over the canoe chute for the 15% exceedance discharge will be 189 cfs with only one overflow spillway and 161 cfs with two overflow spillways.

7.2 Fishway Modeling

The approach to modeling of the Dutch Pool and Orifice fishway was by necessity different than the approach for the rest of the model study. Due to the small scale of the model and the resulting small dimensions of the fishway within the physical model, it was not possible to measure the relevant parameters for the fishway within the physical model. The scaled width of the fishway was on the order of 6 cm and the minimum width required to use the Vectrino is 8-cm (3-cm for the probe head width and 5-cm focal distance). Therefore, it became necessary use the FLOW-3D model exclusively to determine the flow characteristics in the proposed fish passage. The results of the FLOW-3D model and the results presented in Boiten and Dommerholt (2006) could then be coupled with water-surface data gathered in the physical model of the canoe chute to predict discharges for the fish passages.

In their paper, Boiten and Dommerholt (2006) have presented a methodology (tested against experimental measurements) for the design of the Dutch Pool and Orifice fishway structure. To validate the FLOW-3D results from the current modeling effort, several of the flow cases discussed in the paper has been modeled. Figure 7.17 shows the configuration of the Dutch Pool and Orifice fishway as used for the FLOW-3D model. In order to eliminate any potential effects from the boundary conditions applied to the model, channels were added for a length of approximately 10m upstream and downstream of the test section with a longitudinal slope of 0.00001. The fishway channel has a longitudinal slope of 0.0625. Uniform flow conditions have been assumed, therefore, the upstream and downstream water depths are the same.

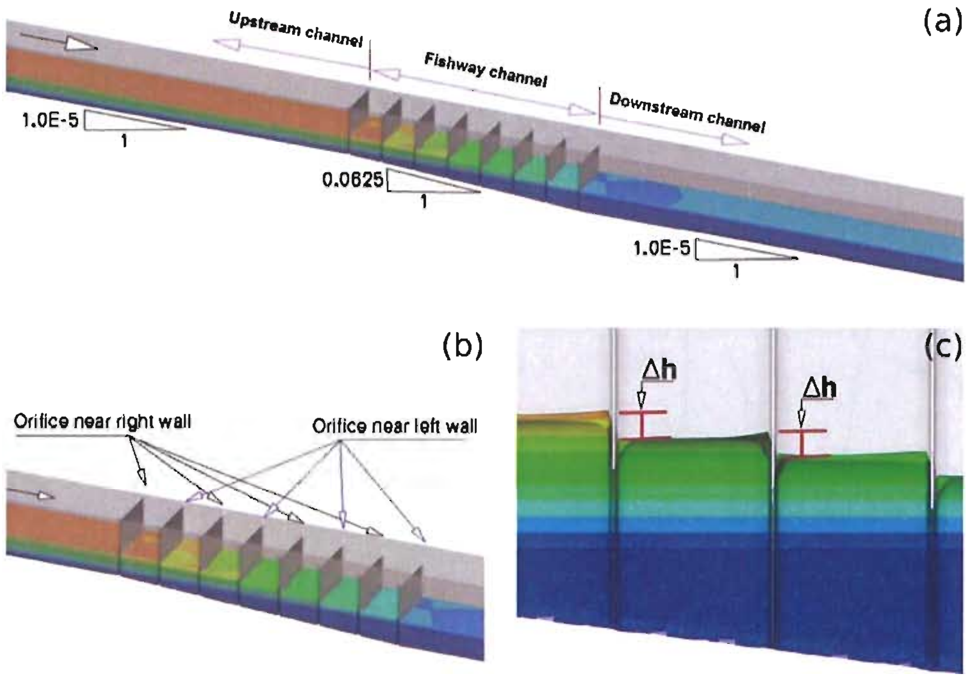


Figure 7.17 – Dutch Pool and Orifice fishway configuration.
The figure shows (a) a 3D view showing the upstream channel reach, fishway and downstream channel reach, (b) 3D view showing the alternating orifice fishway plates, and (c) a side view showing the difference in water surface elevation at two consecutive pools. The designed water drop elevation is set to 5cm.

Several discharges (from 2.01 cfs (0.057 m^3/s) to 5.97 cfs (0.141 m^3/s) for a range of depths, H=1.64 ft (0.5 m) to 3.28 ft (1.0 m) were studied. The length and width of each pool are 2.62 ft (0.80 m) and 3.94 ft (1.20 m) respectively. The height and width of each orifice are 1.31 ft (0.40 m) and 0.66 ft (0.20 m) respectively. A total of 8 orifice fishway structures were placed into the channel, with the first orifice opening located near the right side wall. The design water-surface drop (Δh) between consecutive pools is around 0.16 ft (5 cm).

Figure 7.18 shows the comparison of velocity magnitudes at orifice 5. While the agreement is not perfect, it reproduces the averaged velocity magnitude and its distribution. Higher velocities are found near the right lower corner as found in the experiments performed by Boiten and Dommerholt (2006).

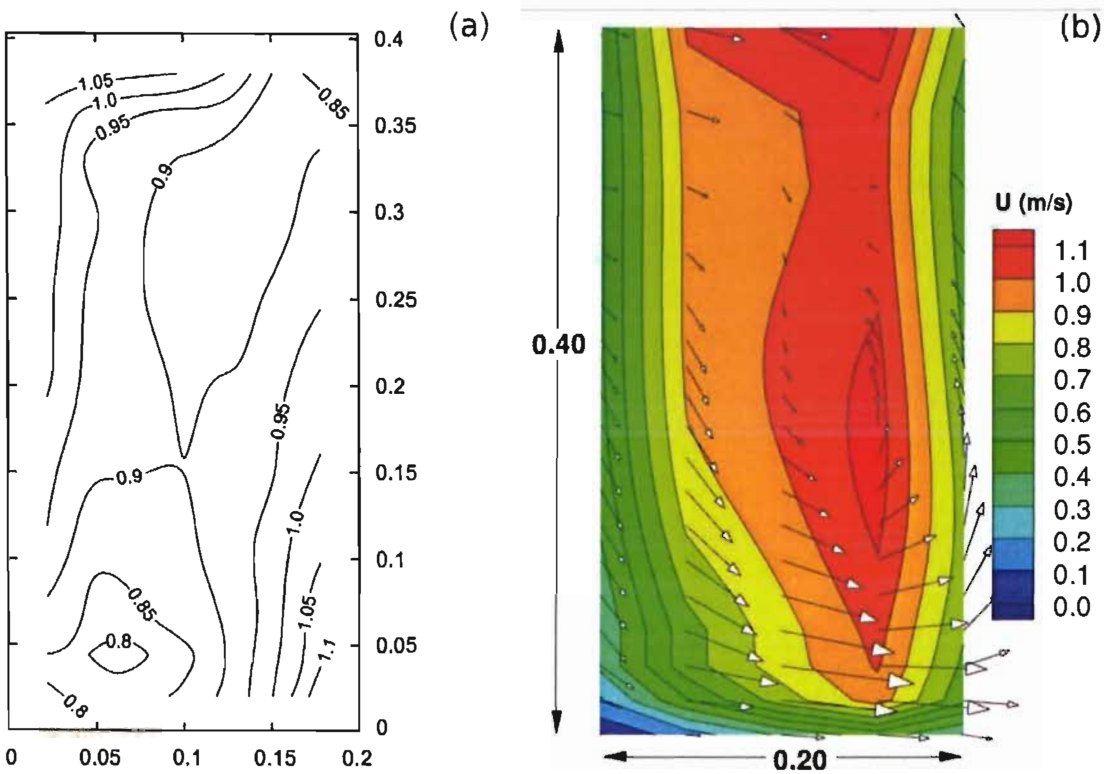


Figure 7.18 – Comparison of the Dutch Pool and Orifice fishway velocities.
(a) Measurements performed by Boiten and Dommerholt (2006) and FLOW-3D modeling results at orifice fishway 5. The water depth is H=1.0m.

Figures 7.19 and 7.20 show a plan view of velocity distribution at different elevations for water depths of H=1.64ft (0.5m) and 2.95ft (0.9m) respectively. As expected the velocity magnitudes are increased around the orifice fishway and recirculation cells are created along the pools. Since the orifices are on alternate sides from one baffle to the next, the core of higher velocity magnitude shifts from right to left and so on. The horizontal flow pattern observed for the two depth conditions is quite similar.

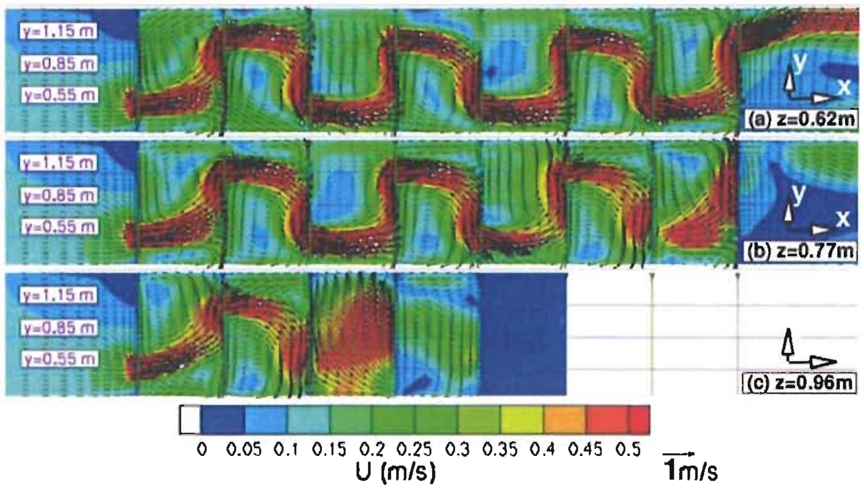


Figure 7.19 – FLOW-3D results for the Dutch Pool and Orifice Fishway for a water depth of *H* = 0.5 m.

Velocity magnitudes and vectors at (a) z=0.62m, (b) z=0.77m, and (c) z=0.96m.

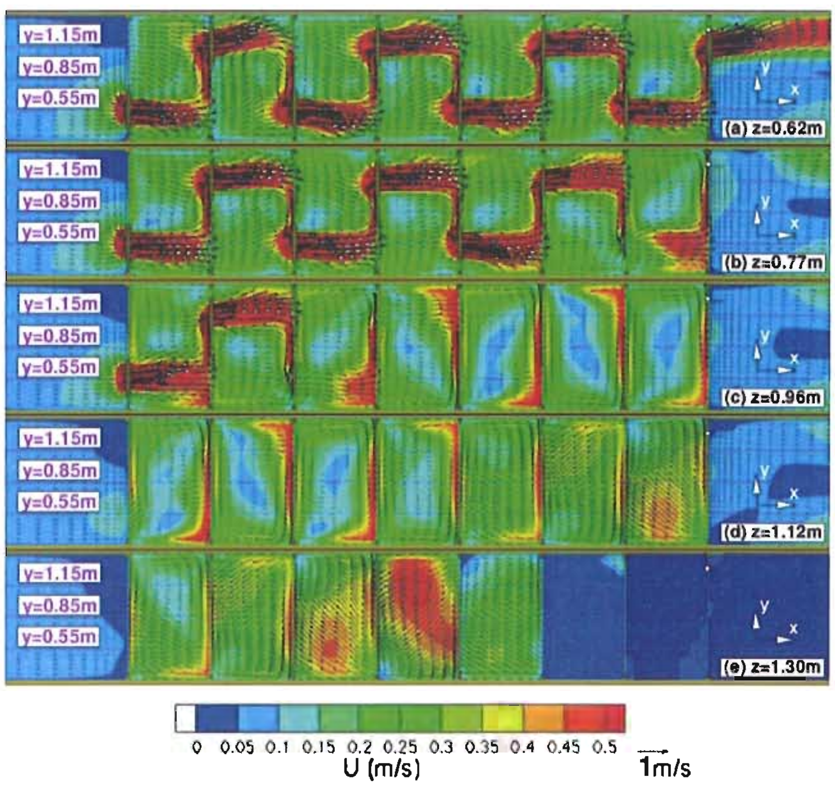


Figure 7.20 – FLOW-3D results for the Dutch Pool and Orifice Fishway for a water depth of *H* = 0.9 m.

Velocity magnitudes and vectors at (a) z=0.62m, (b) z=0.77m, (c) z=0.96m, (d) z=1.12m, and (e) z=1.30m.

Figures 7.21 and 7.22 show the side view of the velocity distribution at different longitudinal planes along the transverse coordinate (y=1.80ft (0.55m), 2.79ft (0.85m) and 3.77ft(1.15m)) for water depths *H*=1.64ft (0.5m) and 2.95ft (0.9m) respectively. The flow at y=2.79ft represents the cross section at the center of the channel, therefore the velocity distribution is quite similar for all of the pools, while the other longitudinal cross sections (y=0.55m and y=1.15m) represent the center location of the orifices, therefore, alternate pools present similar flow pattern. The higher the water depth, *H*, the higher the vertical velocities along the pools, since the disturbance flow coming out from the orifice is higher and it produces pronounced recirculation cells. As designed, the water drop in consecutive pools is around 5 cm (2 inches), therefore, the CFD model was able to capture this macroscopic feature.

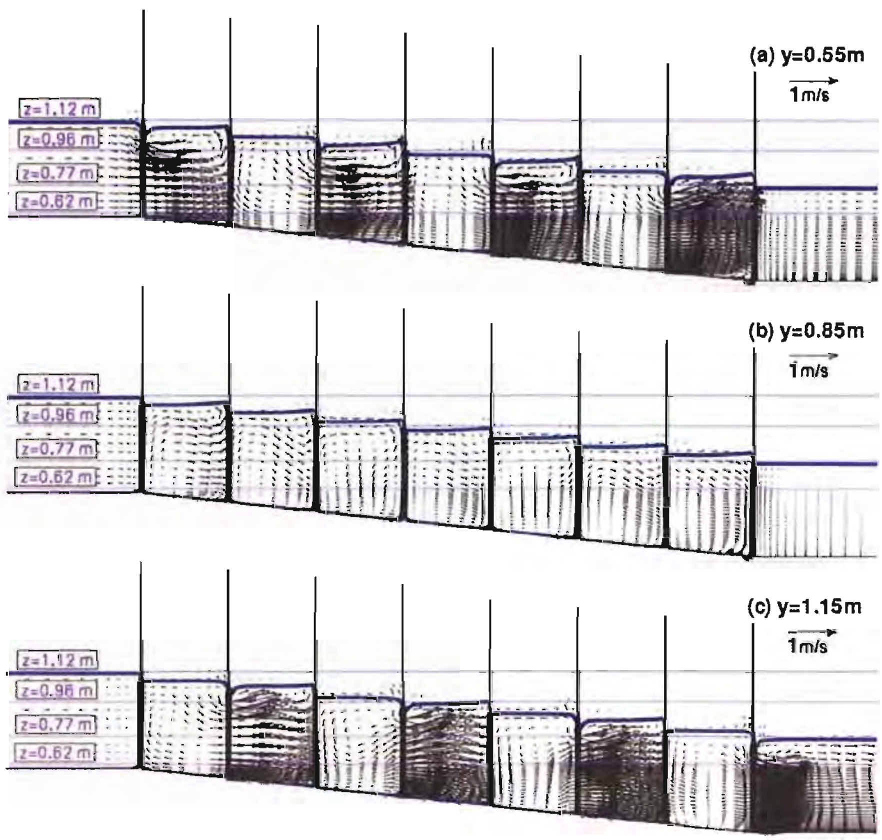


Figure 7.21 – FLOW-3D results showing the velocity distribution at different cross sections along the transversal direction for a water depth, *H* = 0.5 m.
Cross sections located at (a) y=0.55m (orifice location), (b) y=0.85m (channel centerline), and (c) y=1.15 (orifice location).

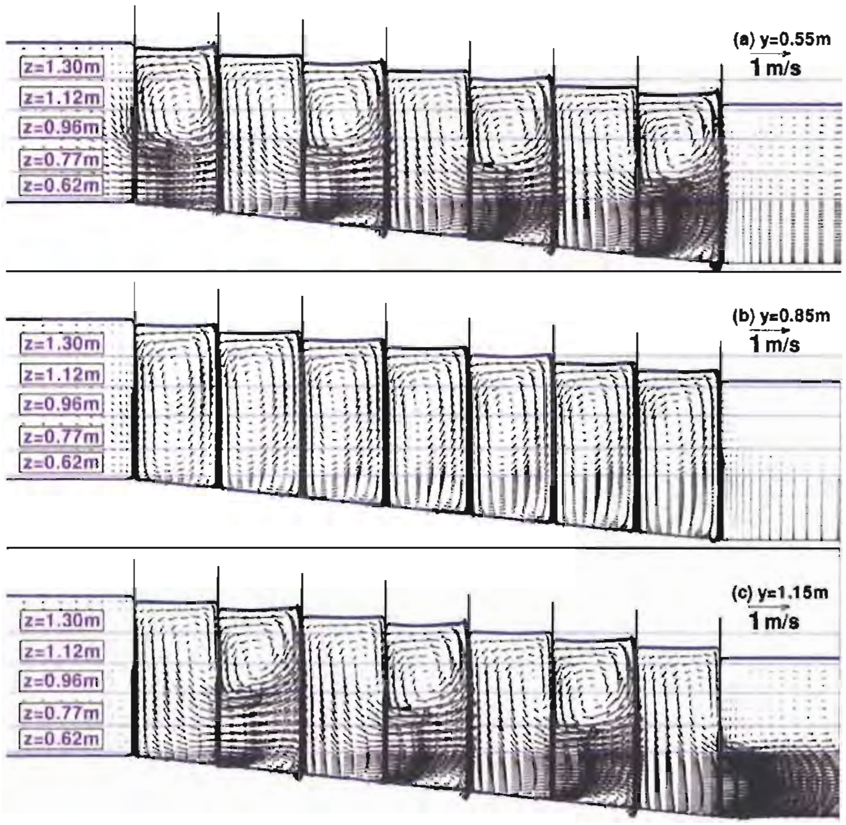


Figure 7.22 – FLOW-3D results showing the velocity distribution at different cross sections along the transversal direction for a water depth, *H* = 0.9 m.
Cross sections located at (a) y=0.55m (orifice location), (b) y=0.85m (channel centerline), and (c) y=1.15 (orifice location).

Figures 7.23 and 7.24 present turbulent kinetic energy dissipation contours for water depths of 1.64 ft (0.5m) and 2.95ft (0.9m), respectively. As discussed previously (§6.2), it is recommended that the rate of dissipation of turbulent kinetic energy remain below 150 W/m3 when calculated as a bulk parameter (Rodriguez et al, 2006). From these figures, it can be determined that the maximum dissipation rate is on the order of 190 W/m3 for *H* = 1.64 ft and 130 W/m3 for *H* = 2.95ft. These maximum values tend to only occur in small areas in front of the orifice openings and average (bulk) values for any individual pools are much smaller then this maximum value. Therefore, the FLOW-3D results support the conclusion that the Dutch Pool and Orifice fishway would be suitable for use at the North Branch dam with respect to turbulent dissipation intensities.

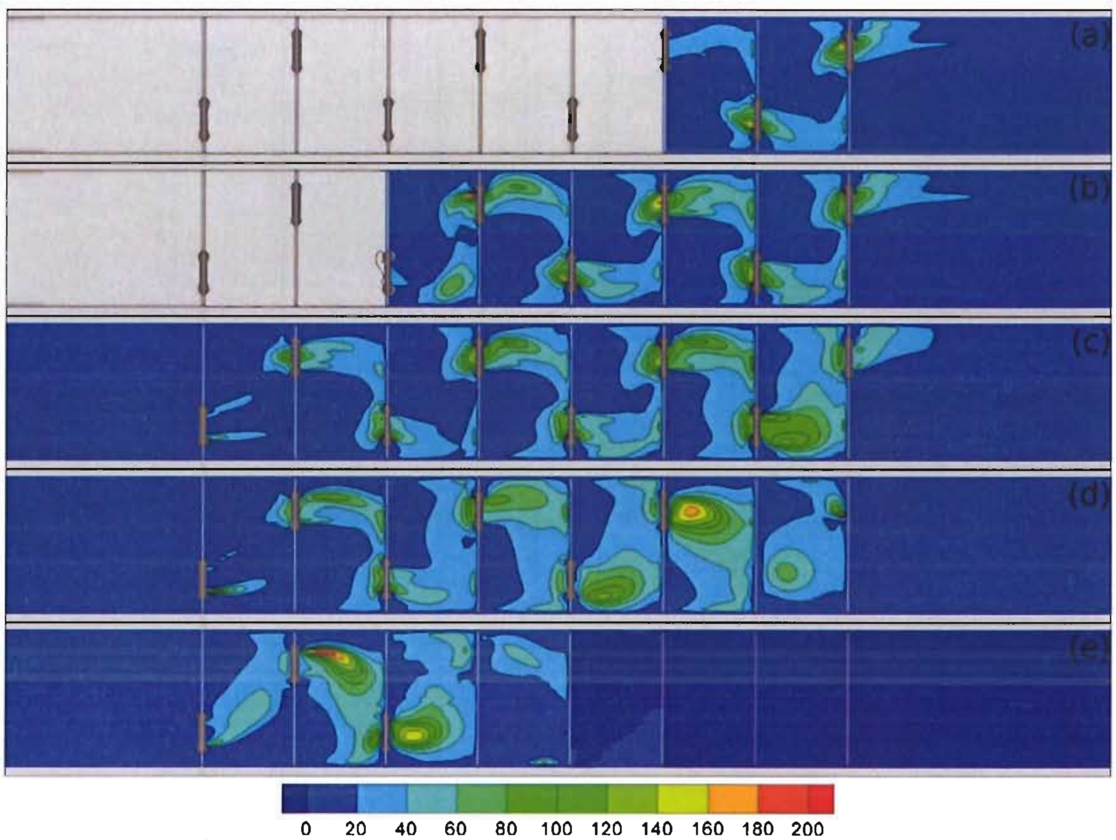


Figure 7.23 – FLOW-3D results showing turbulent Dissipation rate (ε) contours for a water depth of *H* = 0.5 m.

Dissipation is in W/m^3. Horizontal slices taken at (a) z=0.35m, (b) z=0.50m, (c) z=0.65m, (d) z=0.80m, and (e) z=0.95m

Based on the water-surface elevations measured in the physical model for the 85%, 55%, and 15% exceedance discharges (table 7.3) , it is possible to predict the discharge through each individual fishway when coupled with the canoe chute (assuming that discharges through the fishway are small enough to minimize changes to the observed water-surface elevations).

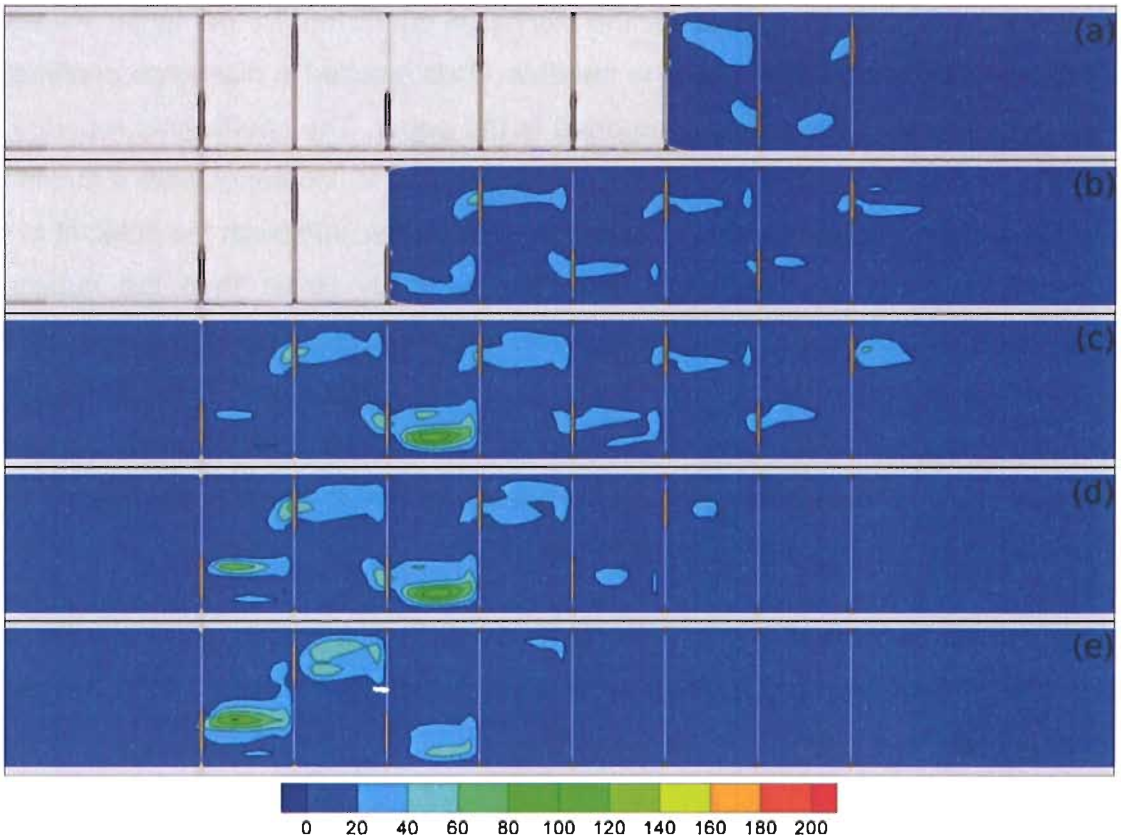


Figure 7.24 – FLOW-3D results showing turbulent Dissipation rate (ε) contours for a water depth of *H* = 0.9 m.

Dissipation is in W/m³. Horizontal slices taken at (a) z=0.35m, (b) z=0.50m, (c) z=0.65m, (d) z=0.80m, and (e) z=0.95m

Discharge through the Dutch Pool and Orifice fishway is calculated using the equation

$$Q = Cbh_v\sqrt{2g\overline{\Delta h}} \tag{11}$$

where C is a discharge coefficient that is dependant upon the orifice height (h_v) and the downstream water depth (Y_0), b is the orifice width, g is gravitational acceleration, and $\overline{\Delta h}$ is the average change in water-surface elevation per baffle:

$$\overline{\Delta h} = \Delta\text{htotal}/\#\text{ baffles} \tag{12}$$

The discharge coefficients developed in Boiten and Dommerholt for the fishway with 0.4m tall orifice openings range from 0.871–0.939, valid for Y_0 ranging from 0.6m–1.2m. Since downstream water depths measured in the physical model are larger than this value, it was necessary to extrapolate the discharge coefficient for the larger values of Y_0. To do so, a cubic equation was fit to the data. This resulted in discharge coefficients that are generally larger than those reported in the paper. The coefficients reported by Boiten and Dommerholt have a tendency to increase as Y_0 increases until a maximum is reached and then decrease as Y_0 increases even further. Although the cubic fit to the data results in discharge coefficients that are generally larger than the maximum reported value (and therefore does not follow the observed trend exactly), it was felt that the larger coefficients (which will result in larger discharges) will represent a conservative, maximum likely value for discharge and can therefore be used as a worst-case condition when determining the amount of water that is likely to be diverted from the canoe chute. This data is presented in table 7.6.

The maximum fishway discharge is 2.66 cfs for the 15% exceedance discharge for drop #3 (the downstream-most drop), resulting in a maximum total diversion from the canoe chute of 5.32 cfs.

Table 7.6 – Predicted discharge through an individual fishway as a function of flow exceedance and canoe chute pool.

Exceedance	15			
Drop	Yo (ft)	C	dh	Q (cfs)
1	4.00	0.93	0.22	2.28
2	5.70	1.21	0.11	1.75
3	5.76	1.24	0.23	2.59
4	5.69	1.21	0.25	2.66

Exceedance	55			
Drop	Yo (ft)	C	dh	Q (cfs)
1	2.64	0.94	0.18	2.03
2	4.64	0.96	0.11	1.62
3	4.76	0.97	0.22	2.29
4	5.62	1.18	0.12	1.80

Exceedance	85			
Drop	Yo (ft)	C	dh	Q (cfs)
1	2.34	0.92	0.18	2.03
2	4.32	0.94	0.11	1.64
3	4.51	0.95	0.21	2.24
4	5.53	1.15	0.10	1.60

8 CONCLUSIONS AND DESIGN RECOMMENDATIONS

The final canoe chute/fish passage design as specified in §7.1 maintains a wave-type hydraulic jump for flow rates ranging from <15 cfs to 228 cfs (>85%–15% exceedance) for the median tailwater stage in the North Shore Channel/Lower North Branch. The hydraulic jump for the first three drops remains in the wave regime for all cases – however, this regime changes for the downstream-most drop depending on the tail water elevation.

The recommended fish passage is the Dutch Pool and Orifice. This type of passage requires significantly less flow than the standard Denil fishway and is generally better suited in terms of velocity and turbulence intensities for weaker swimming, freshwater fish like those found in Chicago River System.

Below is a list of general design recommendations to ensure the best possible operation of the boat-chute/fish passage for the widest range of flow conditions.

- Scour of the pool bottom was noticed at high flow rates. It may be possible to limit the number of flow events that will cause damage to the pool bottoms by adjusting the height of the secondary overflow weir currently located on the dam and possibly adding a second weir to accommodate more flow. A crest elevation of 585.25 is recommended for the adjusted elevation of the overflow weir in order to minimize the likelihood that a boater will be able to pass over these weirs at low discharges – flow events for which boaters are most likely to be present. Should steps be taken to prevent access to the overflow weirs, the crest elevation can be lowered to 581.75 in order to maximize the flow diversion away from the canoe chute.
- Some care will need to be taken to ensure that canoe chute usage is limited to ranges stated. The canoe chute will be most sensitive to increases in stage in the North Shore Channel/Lower North Branch (smaller factor of safety for increases above the median stage until the start of A-jump formation). Due to the heavily controlled nature of Chicago River system, it is assumed that increases in stage occur after rainfall events where it is unlikely that boaters will be on the

waterway, but this may need to be verified by more rigorous analysis of backwater conditions.

- Critical depth criteria needs to be looked at more closely – critical depth @ the 85% exceedance discharge is on the order of 4" which is the approximate draft for a boat loaded to capacity. It is advisable to look at a trapezoidal cross-section shape for the drop crest in order to increase the depth at low discharges while maintaining the full width at higher flow rates. If it is determined by the District that a trapezoidal section is desired, it is recommended that additional modeling be performed to verify the hydraulic jump regime to ensure the safety of the canoe chute.
- Adjustment to the secondary spillway crest elevation is recommended to divert flow away from the canoe chute at lower discharges than it currently becomes active. This is recommended to prevent erosional damage in the canoe chute pools at relatively frequent (15% exceedance) flow events and allow the potential that the canoe chute can be used for a wider range of discharges.
- Fishway baffles should be extended to the top of the expansion/contraction baffles. This will prevent concentrated flow from passing over the top of the baffles during high flow events and will make it easier to prevent vandalism/injury if an open grating is installed over the fishway channel opening.
- As modeled, the expansion/contraction baffles have a uniform top elevation equal to the elevation of the existing dam crest. It is possible to lower this elevation for the drops progressing downstream in order to minimize construction costs. However, this may result in flow passing laterally over the walls of the canoe chute for high discharges.
- Care should be taken to ensure that boaters are unable to enter the fishway channels. This may be achieved by adding pylons or a coarse screen at the upstream entrance to the fishway channels. The design and/or placement recommendations for any deterrent apparatus are outside of the scope of this report.

- Measures should be taken to ensure that the canoe chute is only available for use within the proscribed discharge range (~30 to 228 cfs). Use of the chute by boaters outside of this range may be hazardous.

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APPENDIX A – CANOE CHUTE DESIGN CALCULATIONS

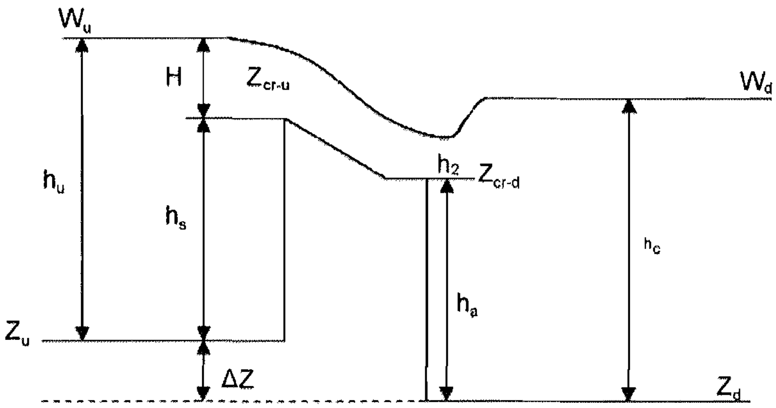


Figure A.1 – Relevant dimensions used for the canoe chute design calculations per Caisley, et al (1999).

<u>Flow limits</u>

Q_{hi} = 223 cfs

Q_{low} = 26 cfs

Low Discharge (Q = 26 cfs)

Downstream Pool (Pool 4)

Downstream water surface elevation:	W_d= 577.32
Downstream pool elevation:	Z_d= 571.81
Upstream pool elevation:	Z_u= 573.48
Drop upstream crest elevation:	Z_{cr-u}= 577.65
Drop downstream crest elevation:	Z_{cr-d} = 576.35
Dowstream Depth: $h_d = W_d - Z_d$= 577.32-571.81	h_d = 5.51
Upstream Step height: $h_s = Z_{cr-u} - Z_u$ =577.6-573.56	h_s = 4.17
Downstream Step height: $h_a = Z_{cr-d} - Z_d$ = 576.3 – 571.81	h_a = 4.54
Submergence depth: $h_{sub} = h_s + \Delta Z = h_s + (Z_u - Z_d)$ = 4.04+(573.56-571.81)	h_{sub} = 5.84

$$Q_{\dim} = \frac{Q}{\sqrt{gh_s^5}} = \frac{26}{\sqrt{32.2(4.17)^5}}$$ Q_{dim} = 0.114

In order to have an acceptable wave-type jump, the downstream depth should be between the upper and lower limits of the B-type jump and A-type jump, respectively.

The boundary between the wave and B-jump is defined by the equation

$$\frac{h_d - h_a}{h_s} = 0.2136 Q_{\dim} - 0.0109$$

The boundary between the wave and A-jump is defined by the equation

$$\frac{h_d - h_a}{h_s} = 0.2559 Q_{\dim} - 0.2269$$

In order for the jump to fall within the acceptable range, the above equations should be solved for h_d, and the design value of h_d for the drop should lie within the range defined by these two equations.

b-wave boundary < h_d < a-wave boundary: 4.60 < h_d < 5.61 OK

Submergence ratio = h_d/h_{sub} = 5.51/5.84 = 0.94 < 1.2 Jump is not submerged

For an unsubmerged structure, the upstream water depth above the upstream crest is

$$H = \left[\frac{Q_{\dim}}{b/h_s}\left(\frac{1}{0.55}\right)h_s^{1.15}\right]^{1/1.15} = \left[\frac{0.114}{20/4.17}\left(\frac{1}{0.55}\right)4.17^{1.15}\right]^{1/1.15}$$ H = 0.27

For a submerged structure or the upstream-most drop structure, the water depth above the crest is

$$H = \left[\frac{Q_{\dim}}{b/h_s}\left(\frac{1}{0.59}\right)h_s^{1.5}\right]^{1/1.5}$$

Therefore, the upstream water-surface elevation for the first drop is

$W_u = Z_{cr\text{-}u} + H = 577.65 + 0.27$ W_u = 577.92

The same steps are followed for each subsequent pool, progressing from the downstream to upstream end.

Pool	4	3	2	1
W_d	577.32	579.61	580.92	582.12
Z_d	571.81	573.48	575.14	576.81
Z_u	573.48	575.14	576.81	578.48
Z_{cr-u}	577.65	578.90	579.9	580.90
Z_{cr-d}	576.35	577.6	578.6	579.60
h_d	5.51	6.13	5.78	5.31
h_s	4.17	3.76	3.09	2.42
h_a	4.54	4.12	3.46	2.79
h_{sub}	5.84	5.42	4.76	4.09
Q_{dim}	1.105	1.437	2.341	4.299
B-wave boundary	5.48	5.24	4.97	4.99
A-wave boundary	6.67	6.36	6.01	6.01
h_d/h_{sub}	0.94	1.13	1.21	1.30
H	1.96	2.02	2.22	2.31
W_u	579.61	580.92	582.12	583.21

The same steps are followed for the high discharge with the following results

Pool	1	2	3	4
W_d	577.32	579.61	580.92	582.12
Z_d	571.81	573.48	575.14	576.81
Z_u	573.48	575.14	576.81	578.48
Z_{cr-u}	577.65	578.90	579.9	580.90
Z_{cr-d}	576.35	577.6	578.6	579.60
h_d	5.51	6.13	5.78	5.31
h_s	4.17	3.76	3.09	2.42
h_a	4.54	4.12	3.46	2.79
h_{sub}	5.84	5.42	4.76	4.09
Q_{dim}	1.105	1.437	2.341	4.299
B-wave boundary	5.48	5.24	4.97	4.99
A-wave boundary	6.67	6.36	6.01	6.01
h_d/h_{sub}	0.94	1.13	1.21	1.30
H	1.96	2.02	2.22	2.31
W_u	579.61	580.92	582.12	583.21

APPENDIX B - FISHWAY DISCHARGE COMPARISON

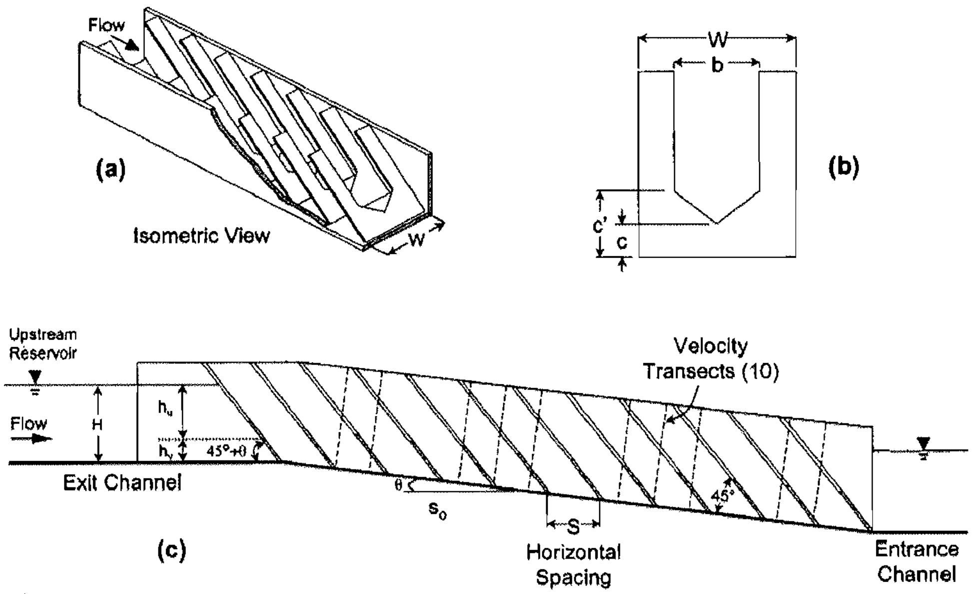


Figure B.1 – Denil fishway definition sketch and general dimensions. *(a) isometric view of section of fishway, (b) baffle cross section, and (c) longintudinal cross section showing fishway components and locations of velocity transects*

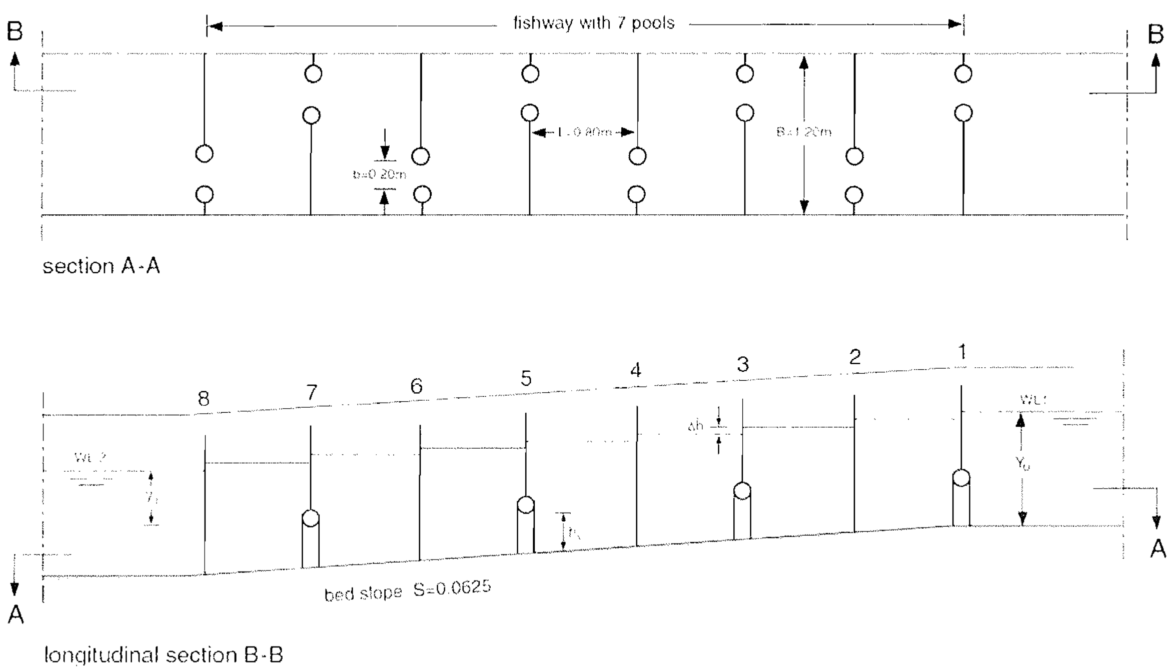


Figure B.2 – Standard design of the Dutch Pool and Orifice fishway.

The discharge equation for the Denil fishway (Odeh, 2006) is

$$Q = C_d h_u^{1.75} b^{0.75} \sqrt{g s_o} \tag{B.1}$$

where C_d is a coefficient of discharge (C_d = 1.34-1.85s_o), h_u is the water depth above the bottom of the baffle notch in the upstream-most pool (distance above dimension "*c*" in figure 1), *b* is the fishway width, *g* is the gravitational accelaration constant, and s_0 is the bottom slope. The discharge equation for the Dutch Pool and Orifice fishway (Boiten and Dommerholt, 2006) is

$$Q = C_d b h_v \sqrt{2g\overline{\Delta h}} \tag{B.2}$$

where C_d is a coefficient of discharge (which is a function of the upstream water depth, Y_0), *b* is the orifice width, h_v is the orifice height, and $\overline{\Delta h}$ is the average head-loss across the fishway (total expected head-loss/number baffles).

Using a hypothetical arrangement, it is possible to show that the discharge through the Denil fishway is significantly higher than that through the Dutch Pool fishway.

Downstream bed elevation (z_0) = 572 ft

Upstream bed elevation (z_1) = 573.75 ft

Length ($_L$) = 28 ft

Bottom slope ($s_0 = (z_1 - z_0)/L$) = 0.0625

Downstream water surface elevation = 575 ft

Upstream water surface elevation = 577.69 ft

Denil Fishway:

C_d = 1.34 – 1.85*0.0625 = 1.22

H = (577.69 – 573.75) = 3.94 ft = 1.2m

h_v = *c* sin(45+arctan s0) = 0.3*sin(45+arctan(0.0625)) = 0.22 m

$h_u = H - h_v$ = 1.2m – 0.22m = 0.98m

b = 0.35 m

$$Q = 1.22 \times 0.98^{1.75} 0.35^{0.75} \sqrt{9.81 \times 0.0625} = 0.420 \frac{\mathrm{m}^3}{\mathrm{s}}$$

Dutch Pool and Orifice Fishway:

$Y_0 = H$ = 1.2 m

C_d = 0.927

b = 0.2 m

h_v = 0.4 m

n = 7

Δh = (Y0 – Yd)/n = (1.2 – (577-573.75))/7 = 0.2094/7 = 0.030 m

$$Q = 0.927 \times 0.2 \times 0.4\sqrt{2 \times 9.81 \times 0.03} = 0.0569 \frac{\mathrm{m}^3}{\mathrm{s}}$$

Attachment B

Chicago River Corridor Design Guidelines and Standards

City of Chicago

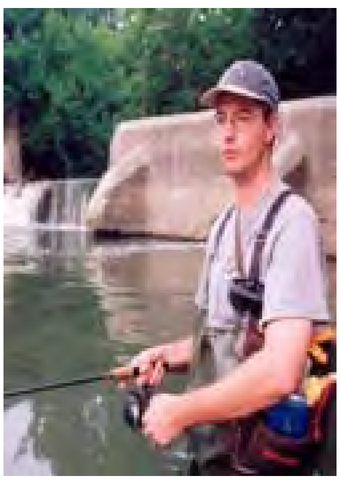
Richard M. Daley, Mayor

Department of Planning and Development

Denise M. Casalino, Commissioner

April 2005 Revised Edition

Contents



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Chapter One: Introduction

The Chicago River is one of Chicago's most precious and recognized natural resource. Winding its way through the length of the city, it offers a peaceful, natural contrast to the urban environment. For most of Chicago's history, the river has been an important working asset, serving as the city's harbor, supplying water for industry, and carrying away waste water. In the process, the river has been neglected and abused. Renewed development and changes in technology have made it possible to reclaim the river as an aesthetic and recreational resource to improve the quality of life for all Chicagoans.

The framework for the revitalization of the Chicago River is provided by the **Chicago River Corridor Development Plan**. The five goals of this plan are to:

- Create a connected greenway along the river, with continuous multi-use paths along at least one side of the river.
- Increase public access to the river through the creation of overlooks and public parks.
- Restore and protect landscaping and natural habitats along the river, particularly fish habitat.
- Develop the river as a recreational amenity, attracting tourists and enhancing Chicago's image as a desirable place to live, work, and visit.
- Encourage economic development compatible with the river as an environmental and recreational amenity.

Since the implementation of the **River Plan**, there has been a significant amount of public and private investment that have transformed abandoned, underused waterfront areas into new parks and trails, mixed-use and residential projects, and industry. New riverfront communities have emerged, land values have increased, water quality has improved, and the river has become a prime destination as the City's greatest natural amenity after the lake.

1.1 Role of Design Guidelines and Standards

The **Chicago River Corridor Design Guidelines and Standards** outline the requirements for development in and adjacent to the setback area along the Chicago River and its branches within the city limits. Setbacks are a very important planning and zoning tool. They provide space for the development of important greenway corridors, multi-use trails, and riverwalk amenities.

The role of the Design Guidelines and Standards is to outline the City's goals, expectations and requirements for development along the Chicago River.

Appropriately developed, the river corridor will provide additional open space and recreational opportunities, increase property values, economic vitality, increase environmental awareness, and enhance Chicago's attractiveness as a tourist destination. The **Design Guidelines and Standards** address development options along the river, including but not restricted to architectural treatments, building construction, parking, fencing, lighting, landscaping, and riverbank treatments. Specific information relating to appropriate riverbank treatments, permit requirements, site furnishings, elements, construction materials and specifications may be found in the Appendices.

1.2 Applicability of Design Guidelines and Standards

Design Guidelines and Standards apply to all new development within 100 feet of the Chicago

The Chicago Zoning Ordinance (Municipal Code of Chicago, Title 17 Section 8-0912) requires that all new development within one hundred (100) feet of Chicago waterways, with the exception of single family homes, two flats and three flats, be processed as planned developments, subject to review and approval by the City of Chicago Department of Planning and Development, the Chicago Plan Commission, and the Chicago City Council. The ordinance further requires new developments to provide a thirty (30) foot setback from the river and comply with with general goals of the waterway design guidelines established by the Chicago Plan Commission. Those development projects not subject to the Chicago Plan Commission approval are urged to voluntarily comply with these guidelines.

The **Design Guidelines and Standards** provide the basis for review for riverside planned developments by the Department of Planning and Development. Upon completion of review, a description of the applicant's proposal and obligations will be incorporated into the planned development ordinance, subject to approval by the Chicago Plan Commission and the Chicago City Council, and enforceable through the Zoning Administrator.

1.3 Precedence of Design Guidelines

This document replaces the 1999 edition of the **Chicago River Corridor Design Guidelines and Standards** and the 1990 **Chicago River Urban Design Guidelines for the Downtown Corridor.**

1.4 Review by Other Public Agencies

In addition to the City of Chicago planned development approval process, riverside projects that include modification of the riverbank may require permits from the following state and federal authorities:

> **U.S. Army Corps of Engineers** - has jurisdiction under Section 10 and 404 of the Rivers and Harbors Act to issue regional permits, individual permits, and letters of permission for construction on waterways.

Illinois Department Natural Resources / Office of Water Resources - requires permits for construction activity in waterways of the State of Illinois.

Illinois Environmental Protection Agency - issues permits under Section 404 of the Clean Water Act for projects that may have chemical, physical or biological impacts on the waterway.

City of Chicago Department of Transportation Division of Engineering- issues harbor permits for construction within 40 ft of a waterway.

Metropolitan Water Reclamation District of Greater Chicago - may require approval for construction projects on the Chicago River that may impede its hydraulic flow. The MWRD owns portions of the Chicago River and leases them to private parties; these leases may impose additional requirements.

U.S. Coast Guard - approval is required for activity that may impinge on the navigation interests and safety of the Chicago River.

Illinois Environmental Protection Agency - issues National Pollutant Discharge Elimination System (NPDES) permits for industrial discharges, stormwater sewer point discharges, and earth moving construction projects, disturbing at least one acre of land, that may discharge pollutants into water bodies.

1.5 Areas Affected by the Design Guidelines and Standards

These guidelines apply to all branches of the Chicago River and connected waterways within the boundaries of the City of Chicago. (see Figure 1.1)

The Design Guidelines are intended for use by property owners, developers, designers, individuals, and civic groups interested in development along the Chicago River.

- Main Branch of the Chicago River
- North Branch of the Chicago River
- North Branch Canal (on the east side of Goose Island)
- North Shore Channel
- South Branch of the Chicago River
- Sanitary and Ship Canal
- South Fork of the South Branch of the Chicago River (‘Bubbly Creek’)
- Associated slips and inlets along the South Branch and Sanitary and Ship Canal

1.6 Outline of Design Guidelines and Standards

The **Design Guidelines and Standards** are organized into six chapters:

- Setbacks
- Riverbank Zone
- Urban Greenway Zone
- Development Zone
- Bubbly Creek Development Guidelines
- Appendices (Design Specifications)

Figure 1.1 Map of Chicago River

1.7 Setbacks

A setback defines the requirements for the minimum distance between new development and the river. Setbacks are required for all new development, but do not apply to existing buildings or development. Persons responsible for projects along the Chicago River should consult the "Setbacks" section of this document before preparing development or architectural plans for a river edge site.

1.8 Riverfront Development Zones

Land adjacent to the Chicago River can be categorized into three zones: (see Fig. 1.2)

- Riverbank Zone, between the water's edge and the top of bank
- Urban Greenway Zone, between the top of bank and the river setback
- Development Zone, on the land side of the river setback

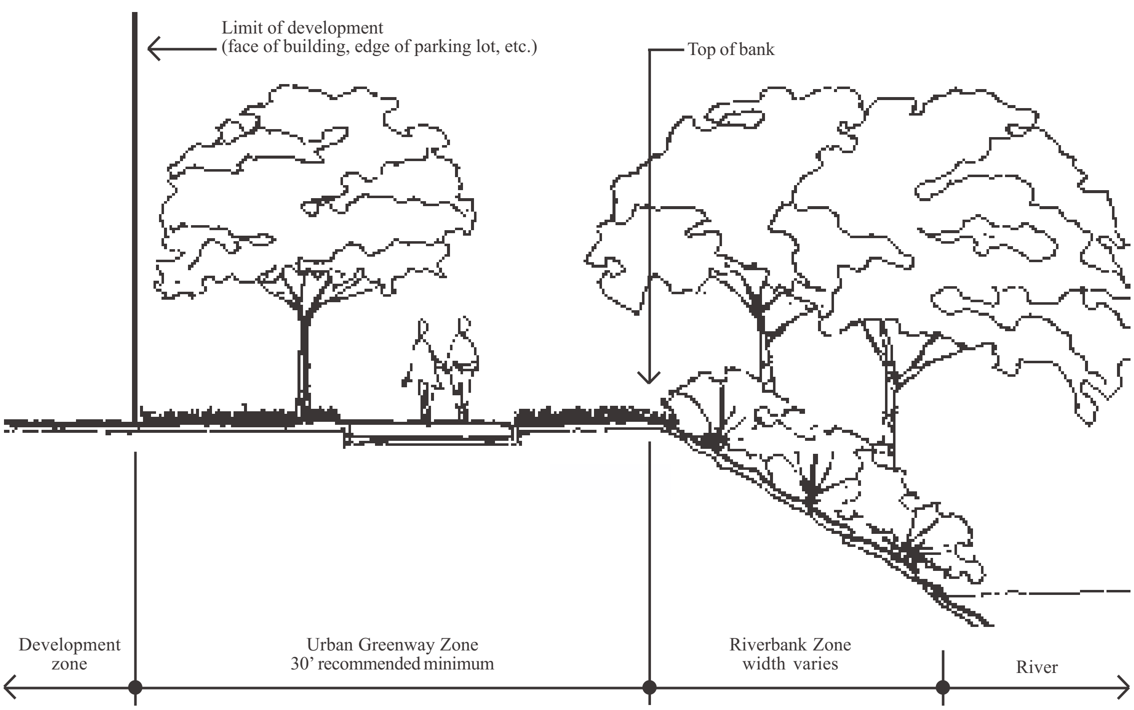


Figure 1.2 Typical riverbank section

1.9 Riverbank Zone

The riverbank zone is the area adjacent to the river between the water's edge and the top of bank. Where there is no bank, but rather a vertical bulkhead or other engineered vertical structure, there is no riverbank zone.

The riverbank zone should not be developed or disturbed except for environmental restoration, landscaping, and nature trails, so that it can act as a buffer between the river and adjacent uses and enhance the natural aspects of the continuous greenway corridor. Exceptions to this principle include development or construction required by river dependent uses and existing buildings or structures.

1.10 Urban Greenway Zone

The urban greenway zone is the area between the top of bank and the development zone, and should be developed with landscaping and a recreational multi - use trail. Exceptions to this principle include development or construction required by river dependent uses, incompatible industrial use, and existing buildings or structures.

1.11 Development Zone

The development zone is the area adjacent to, and on the land side of, the urban greenway zone. The development zone is the area where renovation, redevelopment, or new development will occur. Such development may be commercial, residential, institutional, or any other use permitted by the zoning for the site.

1.12 Bubbly Creek Development Guidelines

In the Bubbly Creek river corridor, the river setback is expanded from thirty (30) feet to sixty (60) feet for the purpose of stormwater management and environmental protection. This chapter addresses the specific requirements for new development within the 60 foot setback area.

1.13 Appendices

Detailed specifications for site furnishings, elements, construction materials, and requirements are presented to facilitate continuity of appearance and functionality of river development sites.

Chapter Two: Setbacks

2.1 Applicability

A setback is a important zoning tool used to regulate and direct development on individual parcels of land to preserve or achieve a public good or benefit. The most common example of zoning setbacks are front yard, rear yard, and side yard setbacks, which bring order to the street facades of buildings and preserve open space around and between buildings.

A setback is a zoning tool used to regulate development to preserve or achieve a public good.

It is important that new development be set back from the Chicago River to protect the natural, scenic, recreational, historical, and economic resources of the river; and to preserve the potential for future development of greenway corridor improvements; and for the development of public access or multi - use trails.

New development must be set back a minimum of thirty (30) feet from the top of the bank of the Chicago River, except for the South Fork of the South Branch (Bubbly Creek), where sixty (60) feet is required (see Chapter 6 for Bubbly Creek guidelines).

Minimum set back requirements:
30 feet setback required along the Chicago River.

60 feet setback required on Bubbly Creek.

The setback should be measured horizontally from the top of the bank, rather than from the water's edge, because the riverbank itself can be very steep and may not be suitable or wide enough for landscaping or a multi - use trail.

2.2 Exceptions

A Setback is not required for:

- Existing structures or buildings that are within the setback zone
- New single - family homes and two flats and three flats
- River dependent uses

River dependent uses are those uses or activities that can be carried out only on, in, or adjacent to a waterway because the use requires access to the waterway and cannot be located inland (see Appendix 1 for a listing of river dependent uses).

2.3 Improvements or Structures Permitted in Setback Area

- Paved or unpaved walkways
- Projections from buildings in the private development zone, including but not limited to awnings and canopies, bay windows and balconies, overhanging eaves and gutters, provided the projection does not extend three (3) feet or more into the setback area, and has a minimum clearance of ten (10) vertical feet from setback grade.
- Arbors and trellises
- Fences and walls not exceeding 6 feet in height
- Light standards, benches, drinking fountains, and other riverwalk amenities
- Wheelchair lifts and ramps that meet federal, state, and local accessibility standards for persons with disabilities

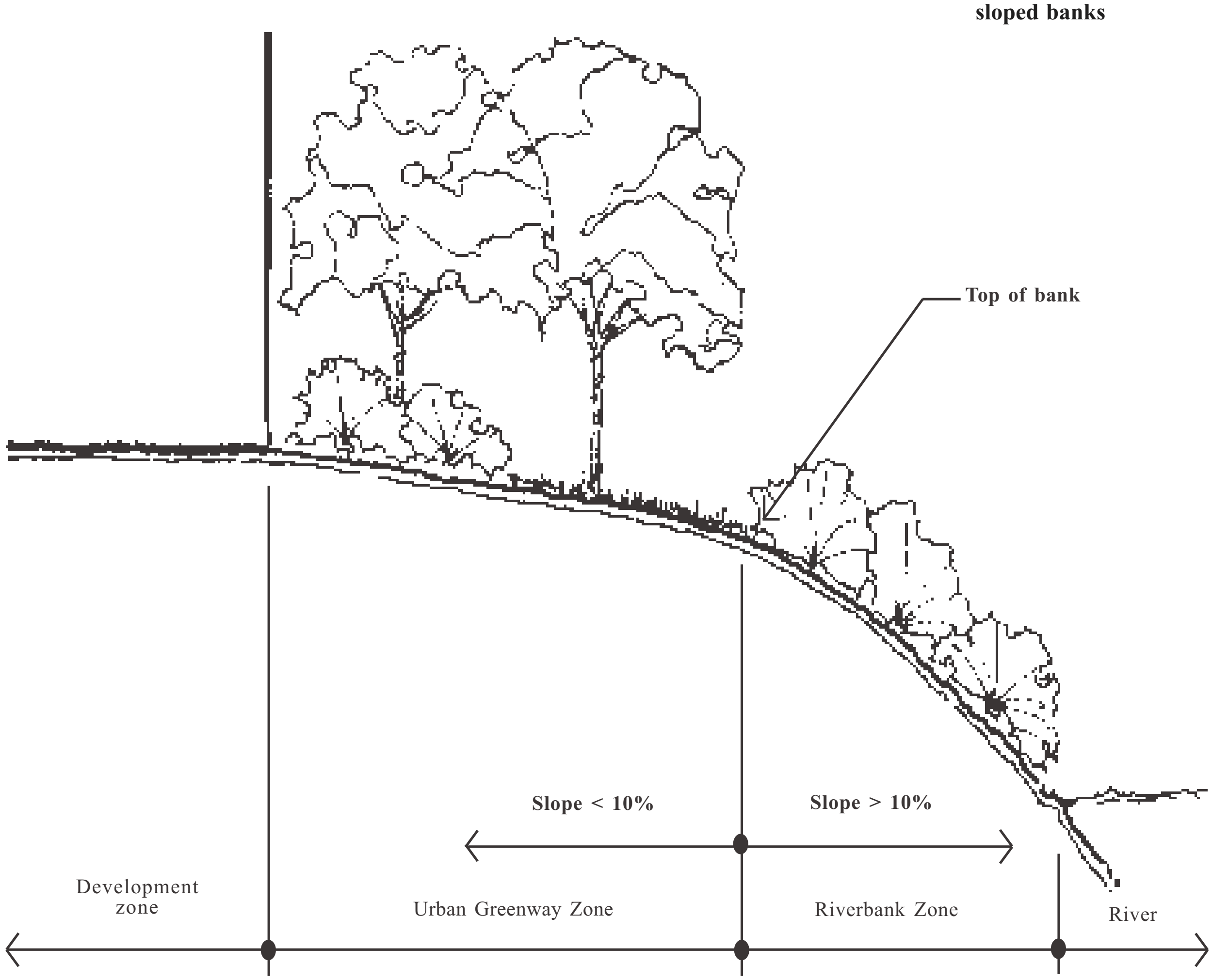
2.4 Improvements or Structures Not Permitted in Setback Area

- Buildings or structures of any kind (except as noted below)
- Vehicular use areas (parking lots, driveways, service drives, loading docks, vehicular staging or storage areas, etc.)
- Overhead utilities
- Private yards, patios, terraces or decks

2.5 Definition, Top of Bank (sloped bank)

Where the bank is sloped, the "top of bank" is defined as the point at the top of the slope where the slope becomes less than 10 percent (see Fig. 2.1). Where there is a terrace or "bench" in the slope, the top of bank is the point furthest from the water's edge where the slope becomes less than 10 percent.

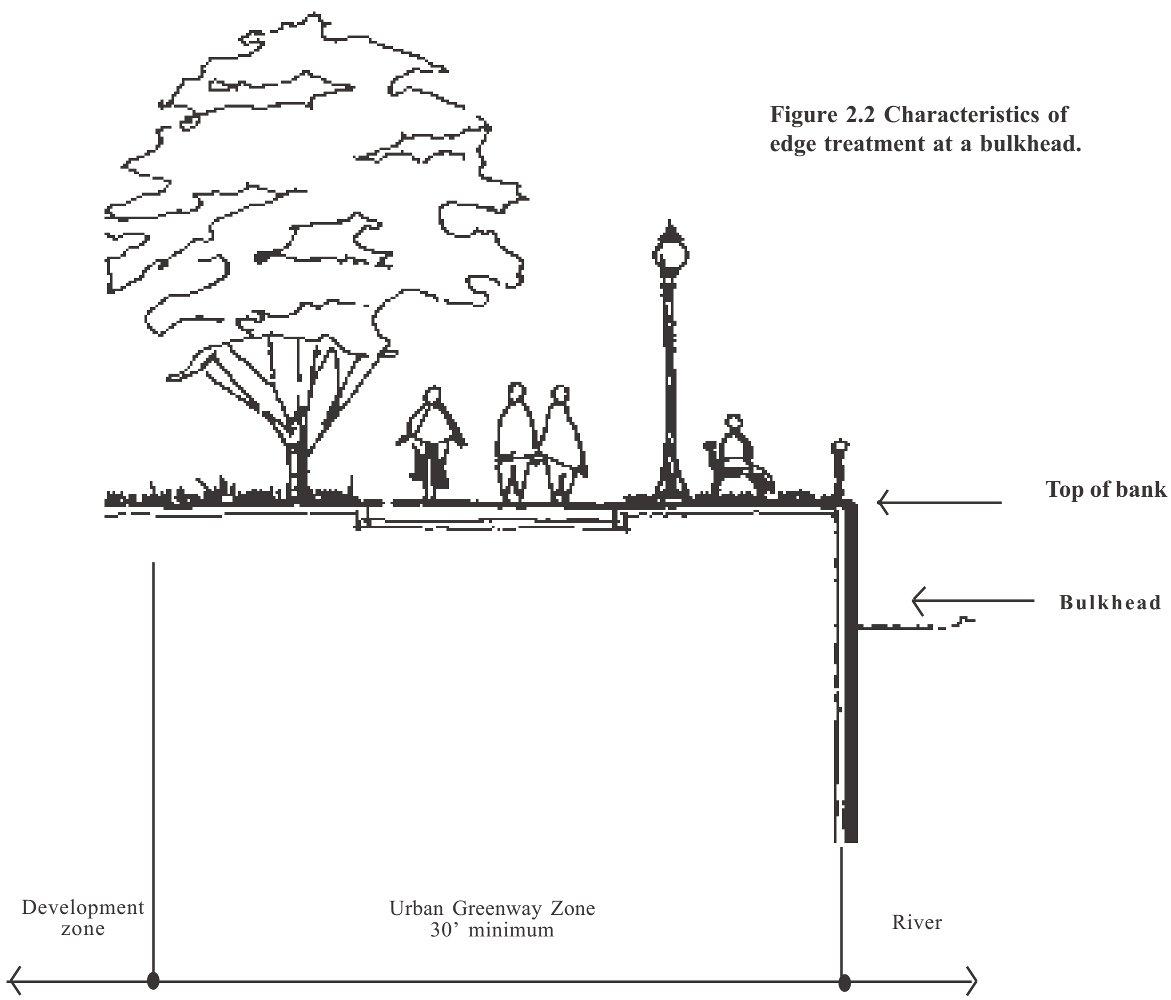
Figure 2.1 Characteristics of sloped banks



2.6 DEFINITION, TOP OF BANK (VERTICAL BULKHEAD OR SEAWALL)

Where there is a vertical bulkhead or seawall or other engineered structure, the "top of bank" is defined as the point at the top of the bulkhead on the river side (see Fig. 2.2). Where the bulkhead is not in a straight line, the top of bank is defined as the line between points on top of the bulkhead located continuously over land, and does not cross over the water. Where there is a terrace or "bench" between two bulkhead walls, the top of bank is the line furthest from the water's edge.

Figure 2.2 Characteristics of edge treatment at a bulkhead.



2.7 Zoning Bonuses for Setbacks

The Chicago Zoning Code (Chapter 17-4-1006) provides floor area bonuses for riverside projects in downtown zoning districts that provide a river setback space exceeding the required minimum 30 feet.

Chapter 17-4-1012 provides floor area bonuses for water features built within the public riverwalk setback area.

Consult the Chicago Zoning Ordinance for details regarding bonuses for river amenities.

2.8 Variances

In certain cases a setback less than the recommended 30 feet may be permitted in order to address constrained sites; small, irregularly shaped sites; and to allow flexibility for optimal site plans.

In certain cases, variances are permitted in the setback zone to accomodate irregular and constrained sites.

Maximum variance (depth): Structures and private yards may encroach into the 30-foot river setback a maximum of ten (10) feet, so that the minimum setback is never less than twenty (20) feet from the top of bank.

Maximum variance (length): Structures and private yards may encroach into the required river setback, provided that the encroachment, or the area with a reduced setback, occurs along a maximum of one - third (1/3) of the site's river frontage, measured in linear feet (LF), so that the required setback never occurs along less than two – thirds (2/3) of the site's river frontage.

2.9 Mitigation for Variances

To mitigate for the loss of riveredge open space in the setback zone due to the encroachment of structures or private yards where a setback less than the recommended has been permitted, additional open space must be provided elsewhere on site according to the following guidelines:

Requirement for additional open space for mitigation of variances: Where structures and/or private yards encroach into the river setback and urban greenway zone, and the setback is therefore less than thirty (30) feet from the top of bank, additional land free of structures, which is not defined or developed as a private yard, should be provided adjacent to the river setback and urban greenway zone to compensate for the loss of open space.

Amount of additional open space for mitigation of variances: Additional land should be provided adjacent to, and contiguous with, the setback zone at a rate of 2.5 times the land or open space lost to the encroachment.

Proportion of additional open space for mitigation of variances: Additional open space must have proportions of no more than two (2) feet of depth (perpendicular to the setback line) per one (1) foot of frontage along the river setback line, in order to avoid excessively long or deep and narrow parcels of land that could be relatively or completely unusable and have little or no public benefit.

Additional land should be provided at the rate of 2.5 times the area lost to development.

2.10 Example of Amount of Additional Open Space Required in Mitigation of a Setback Variance

A parcel with 300 feet of river frontage may have a reduced setback of no less than 18 feet for up to no more than 100 feet, or one - third of the river frontage. The remaining 200 feet, or two – thirds of the river frontage, should have the standard 30 foot setback. The total amount of land free of structures should be as follows:

100 Lineal Feet x 12 feet (reduction from 30 foot to 18 foot setback) = 1200 Square Feet (total land lost in the setback zone)

1200 Square Feet x 2.5 (replacement ratio) = 3000 Square Feet (total amount of additional open space required)

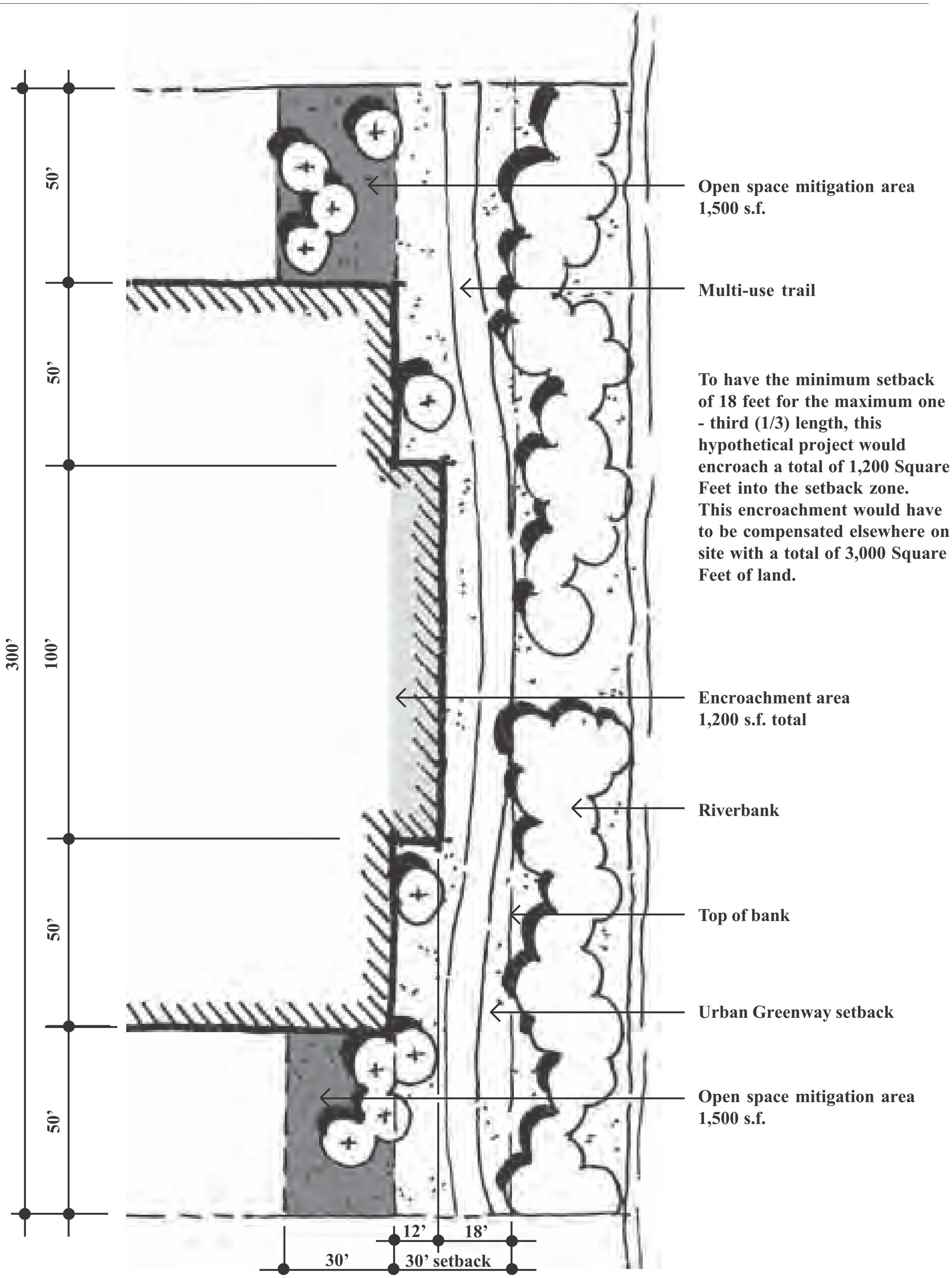


Figure 2.3 Example setback variance

Chapter Three: Riverbank Zone

3.1 Definition of Riverbank Zone

The riverbank zone is the area adjacent to the river between the water's edge and the top of bank. Where there is a vertical bulkhead or other engineered vertical structure there is no riverbank zone. See the "Setbacks" section for a definition of the water's edge and the "top of bank."

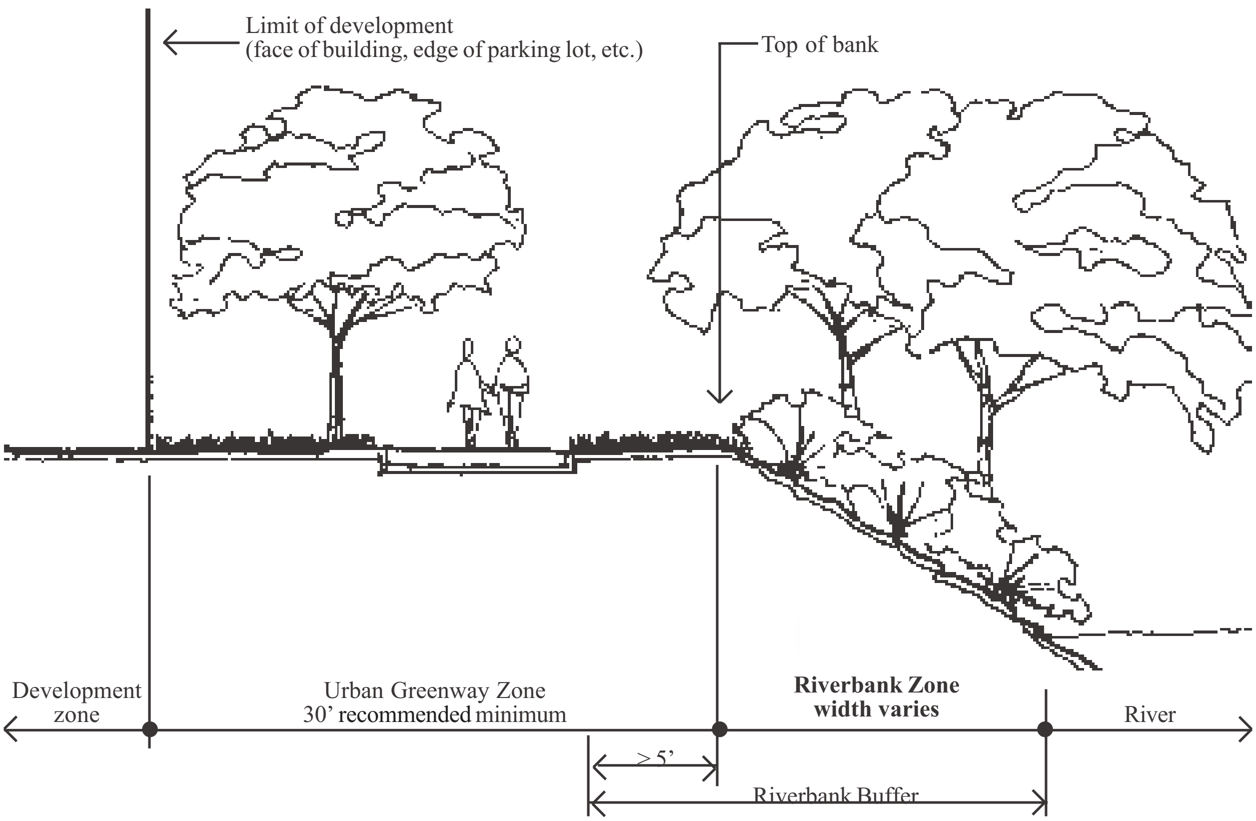


Figure 3.1 Typical riverbank section

3.2 Responsibility for the riverbank

The Chicago Municipal Code requires riverfront property owners to maintain riverbanks, seawalls, and other attached structures on their property from deterioration that may endanger the health or safety of individuals or impair river navigation (see Appendix J).

Land owners are responsible for the condition of their riverbank or seawall.

3.3 Riverbank Buffer

Objectives within the riverbank buffer include (see Fig. 3.1):

The Riverbank Buffer should be managed as a natural area.

- New developments should create, restore, and protect riverbank buffers along the river in order to stabilize riverbanks, provide wildlife habitat, protect water quality, and provide an appealing natural environment.
- The riverbank buffer should be managed as a natural sloped bank, utilizing native riparian vegetation and avoiding incompatible structures.
- Where natural riverbanks exist, care should be taken to preserve the natural slope to the extent possible by selective thinning and pruning of weedy and dead vegetation. However, if the steepness of the bank poses a stability and environmental hazard, the bank will have to be recontoured and replanted with native riparian vegetation.
- The riverbank buffer should extend from the water's edge to the edge of the riverwalk path or a minimum of the first twenty (20) feet of the urban greenway zone adjacent to the top of bank, whichever is less. The multi-use trail or its shoulder shall not be located less than five (5) feet from the top of bank.

3.4 Bank Treatment

The riverbank buffer zone should be managed as a natural area, utilizing native riparian and prairie vegetation and avoiding incompatible structures. Degraded riverbanks will lead to higher erosion rates and habitat destruction, water quality impairment, and other threats to infrastructure. In contrast, a natural riverbank will become stronger over time as the native vegetation roots and anchors itself to the riverbank soils.

3.5 Appropriate Bank Treatments

The goal of riverbank treatment, where there is a sloped or "natural" bank, is to create an environmental buffer and to preserve, restore, or create a naturalistic appearance. Recommended bank treatments may be found in Appendix K.

New riverbanks need to be regraded to a minimum 3H:1V slope.

Bank steepness. Excessively steep slopes, especially those with soil erosion and / or are steeper than the "angle of repose" of the soil, should be regraded to a minimum 3:1 (horizontal to vertical) slope that can be planted and maintained with naturalistic plantings. This treatment will minimize or eliminate soil erosion.

Bank profile. The grading and profile of the regraded bank should vary to be steeper in some places, gradual in others, and not be a single, consistent profile for the entire length.

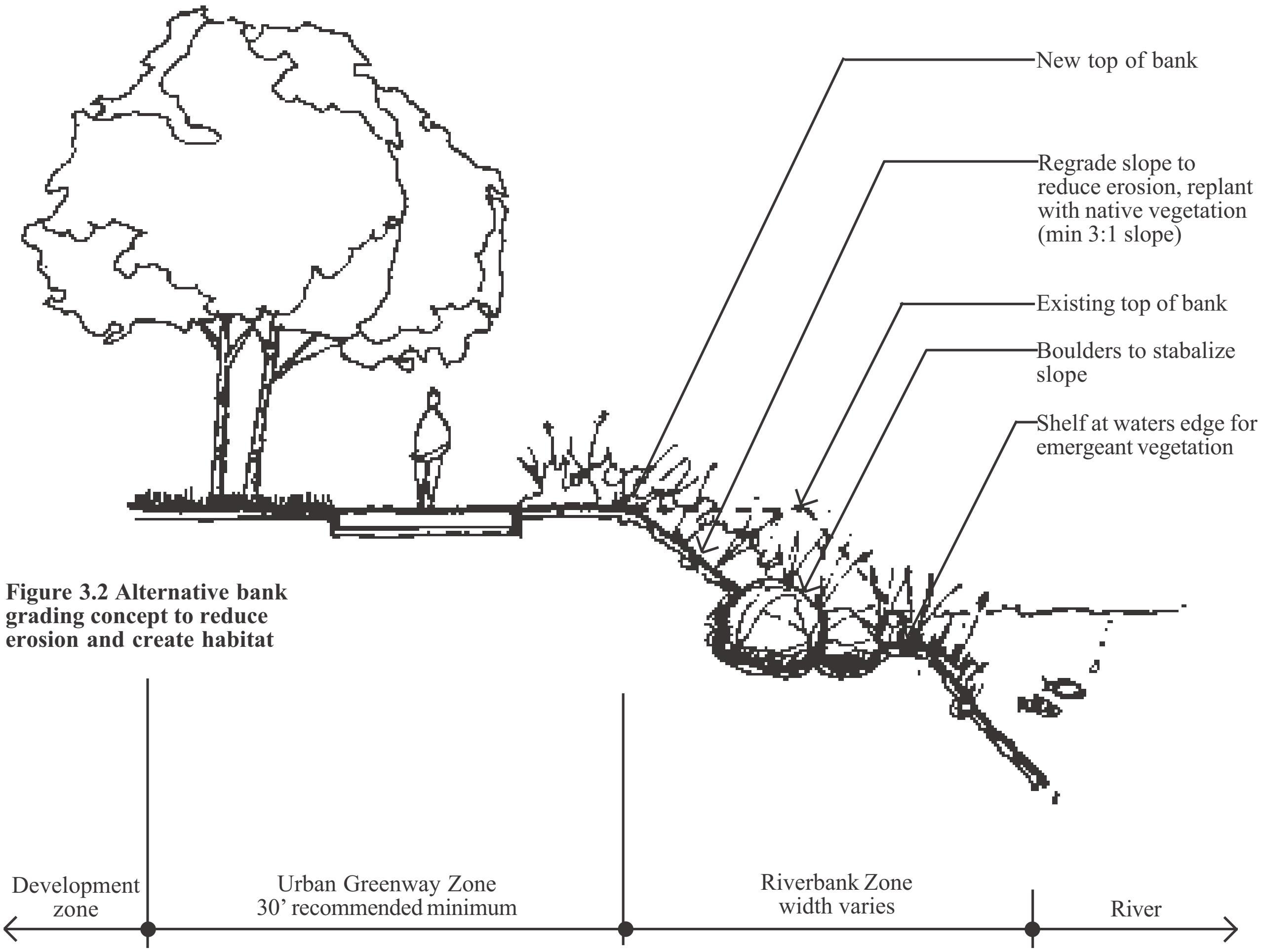


Figure 3.2 Alternative bank grading concept to reduce erosion and create habitat

Bank stabilization. The riverbank should be stabilized to meet the environmental and aesthetic objectives of the riverbank buffer, and may require the use of an erosion control blanket, geotextile reinforcement, or armoring of the toe of the bank.

Native vegetation. Native vegetation adapted to the riparian zone should be used. The recommended reference for native plants is the "Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois," which has been incorporated into the Recommended Plant Palette in Appendix E.

Structures and fixtures within the riverbank buffer. Structures should not be located within the riverbank buffer, with the exception of those required by river dependent uses. Fixtures associated with the multi - use trail, that include ramps, steps, and fishing platforms are permitted within the buffer, but should be consolidated in a single area, rather than distributed throughout the buffer.

Figure 3.3 Example of natural riverbank with native plants

Clean - up. Garbage, litter, rubble, paving materials, construction materials, and any other unnatural, unattractive, or inappropriate materials shall be removed from the riverbank.

Surface treatment. Paving or other hardening of the bank with engineered treatments is undesirable and should be avoided for non-access related purposes. Such treatments include, but are not limited to, concrete and timber crib walls, retaining walls, “reinforced earth” retaining walls, concrete and asphalt paving, gabions (rock - filled wire baskets), gabion mats (rock - filled wire blankets), concrete - filled fabric blankets, cells, or bags, rip rap (broken stone installed on the surface of the bank), and other engineered or paving solutions.

Figure 3.4 Example of riverbank with inappropriate surface treatment

Figure 3.5 Example of effective and appropriate stabilization of riverbank

Soil erosion. To minimize or eliminate soil erosion on the banks and sedimentation in the water, sloped banks should be planted such that there are no bare areas. On steeper slopes, soil erosion control blankets or geotextile reinforcement will be necessary.

Toe of bank stabilization. Waterline erosion the result of fluctuating water levels and wakes will contribute to the continued erosion and scour of the bank. In these conditions, armoring of the toe of the bank with rip rap or other material is required.

Figure 3.6 Beaver Protection

Beaver protection. Beavers are becoming more prevalent on the Chicago River and pose a threat to trees. Preventive measures, such as galvanized wire fence of at least 3 feet tall warapped around the base of trees, are recommended to discourage beavers from gnawing on trees.

Stormwater discharge. Chicago's **Water Agenda** promotes efforts to protect, conserve, and manage the City's water wisely to improve the quality of life for residents and future Chicagoans. New developments along the Chicago River are required to direct stormwater discharge into the river and attain 80% of total suspended solids removal, preferably through above ground stormwater best management practices that include rain gardens, bioswales, infiltration areas, green roofs, and permeable pavements.

Figure 3.7 Example of Construction Site with Tree Protection Fence

Figure 3.8 Example of Bioswale and Permeable Pavements

3.6 Preservation, Restoration, and Implementation of Planting and Habitat

A landscape plan should be prepared to identify vegetation to be removed or preserved. Soil Erosion and Sediment Control Plans are required for any construction activity along the waterway, and should be consistent with the National Resource Conservation Service **Illinois Urban Manual.** Existing native riparian and aquatic planting contributes to the natural and scenic qualities of the greenway corridor, providing habitat for birds, fish, and other wildlife. These native plantings should be preserved.

Grading. Existing planting and habitat, both aquatic (in - water) and riparian (adjacent to the water), should be preserved to the extent possible to establish an environmentally stable natural riverbank.

Protection. Existing planting and habitat should be protected during construction by installing a tree protection fence at the top of the bank (maintained throughout the construction period). Where grading or other construction or development activities must occur on the riverbank, such areas should be no larger than required, and should be protected by a tree preservation fence around the area in question (see Fig. 3.7).

New planting. Advice from an expert in plant selection should be sought before installing new plantings. Existing vegetation should be supplemented with new native plant species to provide habitat for birds, fish, and other animals. Understory shrub and tree planting provide shade cover for fish and serve as a food source (fruits, seeds, etc.) for birds and small mammals.

Existing native plantings contribute to the natural and scenic values of the greenway corridor providing habitat for birds, fish, and other animals.

Ideally, live planting should be done in the spring (April-June) or fall (September-November) when the temperature is cooler to ensure the plant a greater chance of survival. Some plantings are only suited to spring installation. In areas where seeding is appropriate, a cover crop such as seed oats with a biodegradable soil stabilization mat should be used to establish a stable vegetative cover.

Formal vs. informal landscape treatment. Naturalistic plantings is preferred except in densely built up areas such as downtown that are characterized by high seawalls, hardscaped plazas, and high pedestrian traffic. In these areas more formalized landscape treatment is appropriate.

3.7 Appropriate and Inappropriate Plants

Appropriate plants. Plants on the portion of the riverbank subject to inundation and fluctuating water levels should be riparian or floodplain species. See “Recommended Riverbank Plant Palette” in the Appendix E for a detailed list of recommended plant species.

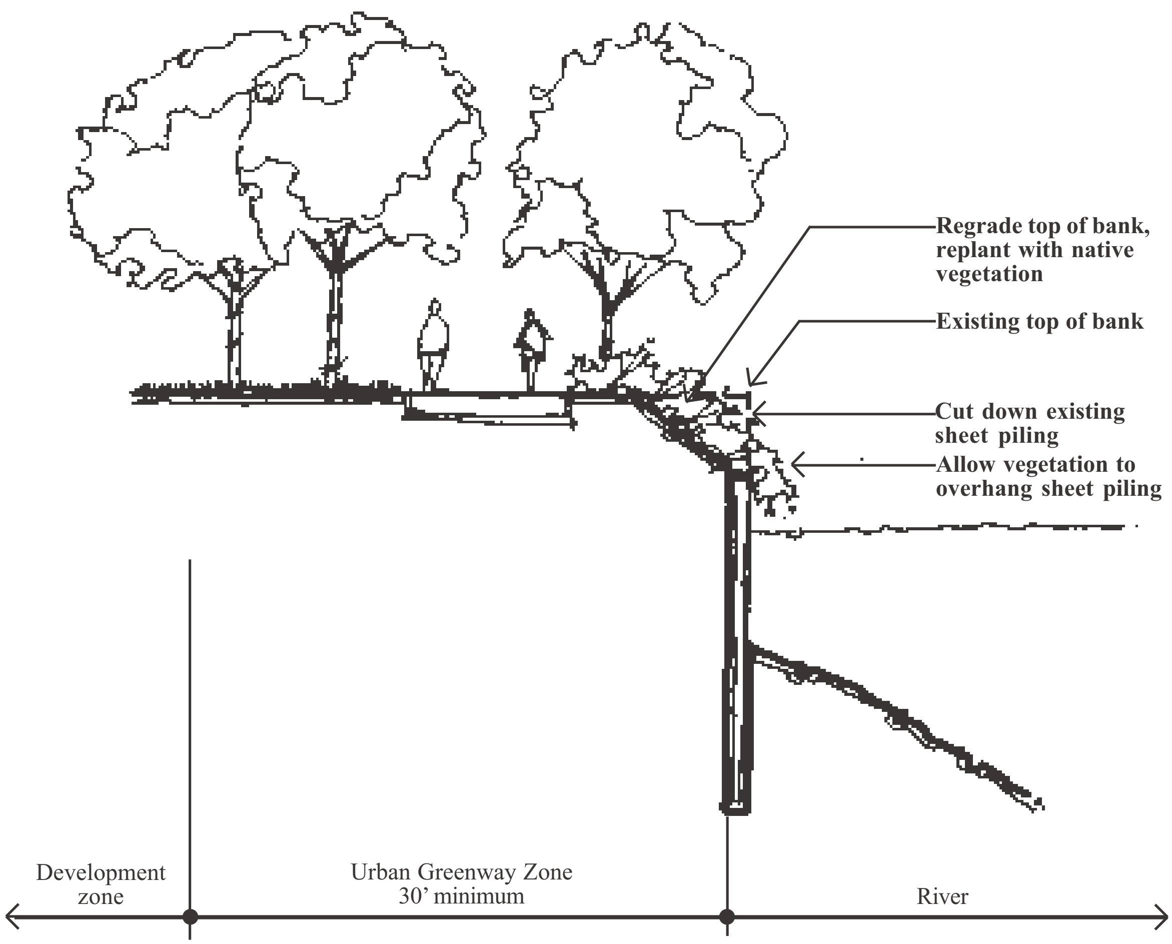
Inappropriate plants. Do not use plants that are "invasive" species which will dominate riverbank planting, "alien" species that are not consistent with native plants, high maintenance plants, or plants with little seasonal interest.

3.8 Bank Treatment (Bulkhead or Seawall)

Where the bank is a vertical structure such as bulkhead or seawall there is no riverbank zone per se. Planting at the top of the bulkhead or seawall may soften the appearance of these structures.

Railing. Provide a continuous safety railing for the length of the vertical bulkhead or seawall more than 30 inches above the mean water level. The railing should comply with all applicable building codes and other regulatory requirements.

Figure 3.9 Alternative edge treatment at a bulkhead.



Ladder. Provide ladders attached to the face of the bulkhead to enable access for persons who may fall into the river to reach safety.

Life rings. Provide life rings in cabinets attached to poles or the railing near the bulkhead to provide emergency assistance for persons who may fall into the water.

Planting. Vines and shrubs that spill over the top of the bulkhead should be planted at the top of the bulkhead, where space and function permit, to soften the hard appearance of the bulkhead.

Seawall height. The finished height of new seawalls or bulkheads should be the mininum necessary above the high water mark, and must not exceed the height of seawalls or bulkheads located on adjacent properties.

3.9 River Dependent Uses

River dependent uses are those uses or activities that can be carried out only on, in, or adjacent to a waterway (see Appendix A for definition of river-dependent uses). Although the river dependent use may be located in the adjacent greenway zone and / or development zone, such uses will necessarily impact the riverbank zone.

Existing river dependent uses. Existing river dependent uses are appropriate uses that should remain.

New river dependent uses. New river dependent uses are appropriate uses that should be accommodated. Such new uses should, to the degree

Figure 3.10 Examples of river dependent use on the Chicago River.

possible, impact hte riverbank and urban greenway as little as possible and should accommodate an alignment for a potential multi-use trail.

Multi-use trail alignment. The alignment for a proposed or potential multi-use trail should be located on the land side of river dependent uses, rather than adjacent to the river, to avoid circulation, saftey, and security conflicts or other unacceptable conditions.

Landscaping and screening. Though there is no setback requirement for river dependent uses, landscaping and screening is required for portions of the river frontage not in active use for loading of off-loading materials.

Chapter Four: Urban Greenway Zone

4.1 Definition of Urban Greenway Zone

The urban greenway zone is the area between the top of bank or face of vertical bulkhead and the stback line or development zone.

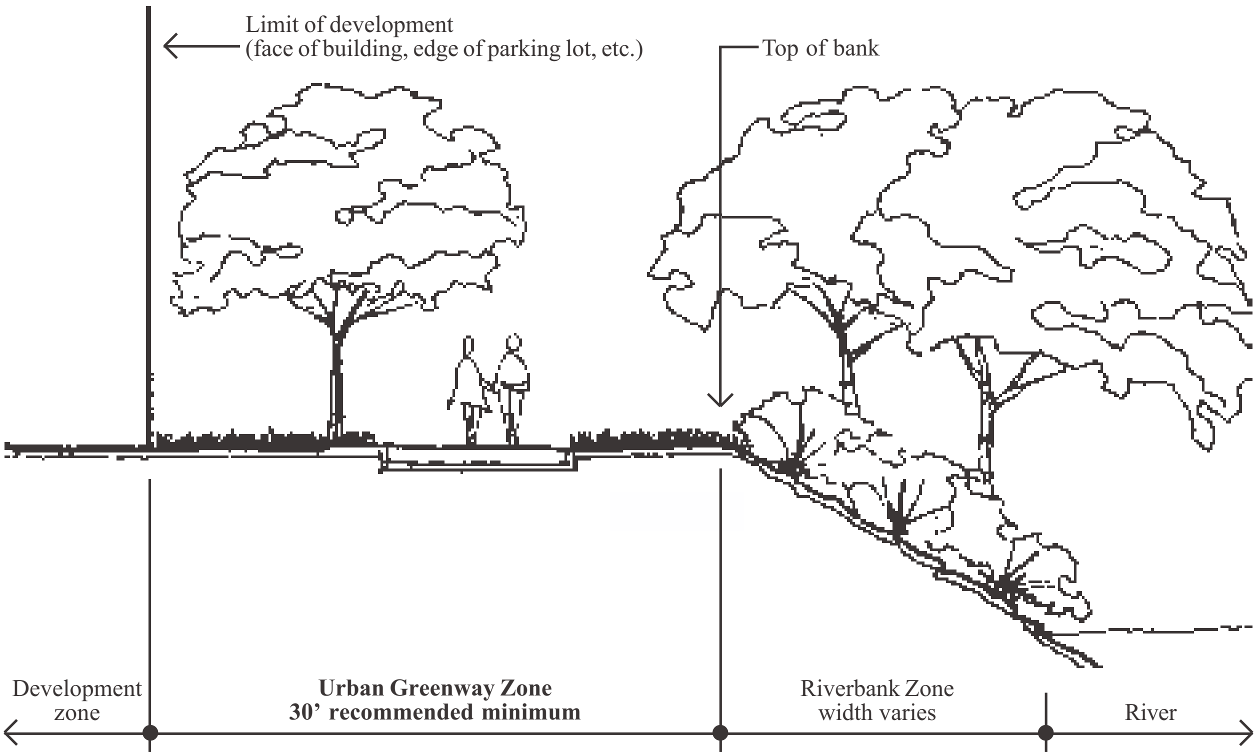


Figure 4.1 Typical riverbank section

4.2 Land - Based Recreational Uses

The urban greenway zone should be developed as a passive recreation linear park with a multi – use trail. In general, the urban greenway zone is too small to accommodate active, land - based recreational uses.

4.3 Water - Oriented Recreational Uses

Water - oriented recreational uses within the river corridor will often depend on access to facilities located within the urban greenway zone. Such uses include launching areas for human - powered craft (canoes, kayaks, rowboats, rowing shells, etc.), fishing docks or piers. Launch areas typically require gangways or ramps from the top of the bank down to river level floating docks or similar structures in the water, vehicular access to the launching area, and parking. Ancillary elements in the launching area may include lighting, signage, graphics, railings, fencing, seating, bicycle racks, trash receptacles, and landscaping. In addition to the launching facility and ancillary elements, these uses should offer convenient access to toilets and public telephones.

Location of water – oriented recreational uses. Water – oriented recreational uses may be located in both the urban greenway zone and the riverbank zone.

Location of ancillary elements of water – oriented recreational uses. Ancillary elements should be located conveniently close to the launching area or other water access point, but preferably not located or placed in the riverbank that compromises the natural character of the river corridor.

Location of parking serving water – oriented recreational uses. Parking should never be located in the riverbank or urban greenway zones, but should be located at a convenient distance from the river.

4.4 Multi - Use Trail

The City proposes to establish a continuous multi - use trail throughout the river corridor to accommodate uses that include walking, jogging, running, bicycling, roller-skating, in-line skating, and skateboarding. The multi - use path should be signed and striped as required to minimize use conflicts (see Appendix G for trail design).

A key goal of the Chicago River Development Plan is to construct a continuous multi-use trail along the extent of the Chicago River.

Location: A multi - use trail along at least one side of the river is a key goal of the **Chicago River Corridor Development Plan**, and should be constructed in the urban greenway zone as recommended in the development plan. The alignment and design of the multi-use trail should minimize impacts to sensitive areas and habitats, such as wetlands and floodplain areas.

Design criteria: The multi – use trail, including underbridge connections, cantilevered walkways, floating boardwalks, etc., should be designed to meet all relevant and current codes, standards, and regulations. These should include, but not limited to, the Americans with Disabilities Act (ADA), American Association of State Highway and Transportation Officials (AASHTO) standards for multi - use trails, the Chicago Zoning Code, the Chicago Building Code, the **Guide to the Landscape Ordinance**, and any other relevant codes, standards, and ordinances.

4.5 Paving

Safe, affordable, and maintainable paving is an important and integral part of the multi - use trail, in order to minimize hazards, injuries, and liability, reduce capital expenditures, and keep maintenance costs under control.

Width: Recommended multi - use trail width is 10 feet. Minimum width is 8 feet. In areas with heavy use or multiple modes (e.g., walkers, bicyclists, and rollerbladers, etc.), a wider trail of either 12 or 14 feet is recommended.

Striping: Pavement should be striped in accordance with AASHTO and other relevant standards.

The recommended path width of the riverwalk trail is 10 feet.

Pavement design and materials: See Appendix C for more information on appropriate paving materials and pavement design.

4.6 Lighting

Attractive pedestrian - scale lighting is recommended to make the urban greenway safe and secure, and is an important and integral part of the multi - use trail. Lights should be spaced closely enough together that pools of light from adjacent light sources are easily seen by trail users (see Fig. 4.2).

Lighting levels: Adequate lighting for safety and security should be provided. The actual lighting level will vary according to the individual site and the existing ambient light levels from other sources.

Spacing: Regardless of the spacing dictated by lighting levels, lights should be spaced no further than 100 feet apart.

Luminaires and poles: See Appendix C for specific lighting information.

Figure 4.2 River edge lighting

4.7 Furnishings

Appropriate furnishings and fixtures should be provided throughout the length of the multi - use trail to make it attractive and functional for users (where furnishings are to be provided on a linear foot basis, fractions should be rounded off to the nearest whole number). Specific information regarding the following site furnishings is included in Appendix C.

Benches. Benches are to be placed along the multi - use trail to encourage public access and at points of scenic interest. Benches should be securely fastened to a concrete slab or footing. One bench should be provided for every 250 linear feet of river frontage.

Trash receptacles. In addition to trash receptacles at seating areas, one trash receptacle should be provided for every 250 linear feet of river frontage.

Bicycle racks. Bicycle racks should be provided at seating areas and at points where the multi - use trail intersects points of access to the street grid.

Drinking fountains. Drinking fountains should be universally accessible, of robust construction, designed for outdoor use, mounted securely to a concrete slab, and equipped with a drain inlet or catch basin within five feet of the drinking fountain. Drinking fountains should be provided at seating areas as noted below.

Figure 4.3 Bike rack

Figure 4.4 Seating area at Fullerton Plaza

4.8 Seating Areas

Where appropriate, seating areas are encouraged along the multi - use trail, in addition to the individual benches and other site furnishings (see Fig. 4.4).

Location. One seating area should be provided for every 500 linear feet of river frontage.

Seating area. Each seating area should provide a minumum of two benches, one trash receptacle, and one bicycle rack (see "Furnishings" above). Drinking fountains are required in seating areas where the overall river frontage of the parcel is greater than 1,000 feet.

4.9 Signage

Directional, informational, identity, and regulatory signage and graphics are useful and necessary components of the multi - use trail. The City of Chicago has developed a riverwalk identity program that includes signage and graphic standards. For more specific signage information, see Appendix D.

The City of Chicago has developed signage standards to be used throughout the river corridor.

Directional and regulatory signage. Provide directional and regulatory signage where the multi - use trail intersects with streets or other trails and where there are regulatory requirements (e.g., "stop," "yield," etc., or as dictated by AASHTO standards).

Interpretive signage: Provide informational signage at points of historic or other interest.

Identity signage. Identity signage should be provided where the multi-use trail intersects with streets or other public access points. The signage should state the riverwalk is open to the public during defined hours (typically normal Park District hours).

4.10 Underbridge Connections

Bridges and their abutments are often barriers to continuous riverside access along the Chicago River. Underbridge connections should be built where space beneath the bridge deck permits, so that the multi - use trail can run continuously adjacent to the riverbank.

Underbridge connections provide safe continuous well-lit passage through bridges and heavy street arterials.

Responsibility. Responsibility for construction of the multi - use trail underbridge connection may be the City of Chicago, the adjacent property owner / developer, or shared between them. Cost sharing will be determined during the planned development review process.

Alignment. Properties adjacent to potential underbridge connections should be designed not to compromise or eliminate access to develop the multi-use trail connection. The alignment of the multi - use trail to and through the underbridge connection should avoid blind corners, tight radii, and steep slopes that present safety and security problems.

Width. Width should be per AASHTO standards and as indicated above under "Multi – use Trail."

Paving. Paving of the underbridge connection in the public right - of - way should be poured - in - place concrete with a light or medium broom finish, per "Multi - Use Trail Paving" above. Asphalt is not an acceptable material, due to the dark color and consequent poor visibility under the bridge.

Lighting. Underbridge connections should be illuminated with fixtures mounted to bridge abutments or piers. Illumination levels should be designed and maintained at 3.0 footcandles.

Railing. Provide a continuous safety railing, including a minimum of 20 feet on the approaches to the underbridge connection from the multi - use trail. Such a railing should comply with all applicable building code and other regulatory requirements. In the absence of more restrictive requirements, see Appendix 3 for specific information on railing articulation.

4.11 Cantilevered Walkways

Buildings that have been built to the water's edge, as well as bridges and their abutments are often barriers to continuous riverside access along the Chicago River. Where the multi - use trail cannot be built on land within the greenway zone, and where a detour around such an obstruction on the land side would be so long or indirect as to discourage use of the multi - use trail or effectively interrupt it, construction of a cantilevered walkway around the building or bridge should be considered to maintain a continuous multi - use trail adjacent to the riverbank.

> **Design guidelines.** Design specifications for cantilevered walkways should be consistent with the requirements for "Underbridge Connections." The deck material consist of poured-in-place concrete or treated heavy duty timber decking, with joints aligned perpendicular to the direction of travel on the trail.

4.12 Floating Walkways or Walkways Built over Water

Buildings, that have been built to the water's edge, as well as bridges and their abutments, are often barriers to continuous riverside access along the Chicago River. Where the multi - use trail cannot be built on land within the greenway zone or on a cantilevered walkway over water, and where a detour around such an obstruction on the land side would be so long or indirect as to discourage use of the multi - use trail, construction of a floating walkway around the building or bridge should be considered.

Floating boardwalks present opportunities to bring the public closer to the water's edge and extend the continuity of the riverwalk around difficult development conditions.

> **Design expertice:** Floating walkways should be designed by an experienced marina designer working with a landscape architect and / or civil engineer or other experienced trail designer.to ensure that the design is safe, and secure.

> **Design guidelines.** Design specifications for cantilevered walkways should be consistent with the requirements for "Underbridge Connections." The deck material consist of poured-in-place concrete or treated heavy duty timber decking, with joints aligned perpendicular to the direction of travel on the trail.

4.13 Water Features

Water features, including but not limited to fountains or cascading waterfalls, are encouraged architectural design elements which reflect the natural elements of the Chicago River.

Water features and nature trails present excellent opportunities to reflect the natural elements of the Chicago River.

4.14 Nature Trails

Nature trails are appropriate in the greenway zone where there are natural areas that merit access and / or interpretation. Bird houses/feeders and bat boxes are encouraged near these trails to attract wildlife.

Figure 4.5 Nature Trail

Nature trail location. Nature trails should not be the main trail, but secondary trails separated from the principal multi - use trail.

Nature trail surface. Nature trails should have a "soft" surface (e.g., wood chips or gravel), little or no lighting, and interpretive or informational signage.

4.15 Other Improvements

Other public are appropriate within and adjacent to the greenway zone provided they do not preclude the future development of a multi - use trail along the river.

4.16 Access Points, Street Ends, and Overlooks

Access to the river and the water's edge can be as important as development of continuous access along the river. Particularly where land ownership and development conditions do not easily permit public access along the river, it is important that access be provided to the river. Access points may developed where streets stop at the river.

Access points may be developed with a number of features, including but not limited to cul - de - sacs or turnarounds to remove vehicles from close proximity to the river; vehicular barriers which could be planters or highway type barriers to prevent vehicles from driving into the river; seating areas with benches, trash receptacles, bicycle racks, and other site furnishings; lighting, for ambiance, safety, and security; landscaping; and access by steps and / or ramps to the water's edge.

Access points: Develop access points to the river wherever possible, but especially where there is no public access along, or adjacent to, the river and where street rights - of - way stop at the river.

Overlook development: Develop overlooks at access points and street ends. Overlooks may include cul - de - sacs or turnarounds, vehicular barriers, seating areas with benches, trash receptacles, bicycle racks, and other site furnishings such as lighting, landscaping, and steps and / or ramps to the water's edge.

4.17 Riverside Cafes and Restaurants

Seating for riverside cafes and restaurants are encouraged within the development zone provided that it does not block public access to the multi-use trail or privatize or restrict use on the river greenway zone.

River Cafes provide new dining opportunities for residents and visitors as well as promote public appreciation for the Chicago River.

4.18 Landscaping

The greenway zone should be heavily and attractively landscaped with particular attention to screening through industrial, commercial, and residential areas. Plantings should respond to these conditions by aligning in more formal rows, grids, or bosques in or near the downtown area where space is limited and architectural influences suggest a more formal arrangement. Where the greenway zone passes through informal areas, trees and other plantings should be arranged informally with and whenever possible native plants should be selected.

Tree locations: Locate trees in informal groupings where the greenway zone and the river corridor have a more naturalistic, informal character. Align trees in more formal rows, grids, or bosques in or near the downtown where space is more limited and the architectural influences suggest a more formal arrangement.

Vine locations: Plant vines at the base of all blank buildings walls, retaining walls, bridge abutments, or other structures that have little inherent architectural interest.

The use of low mow wildflower and prairie mix is recommended on the riverbank and urban greenway zone.

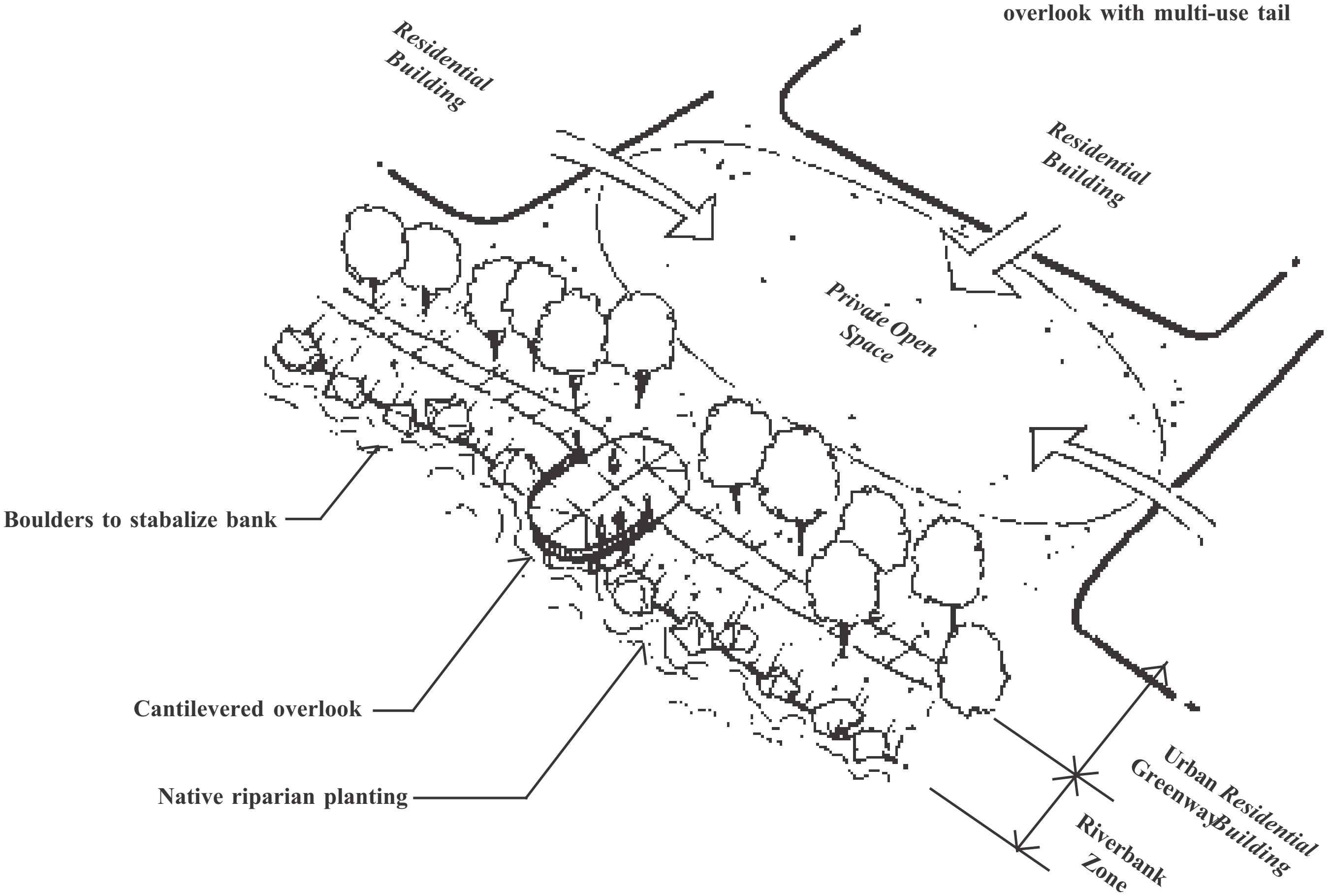
Shrub, groundcover, and perennial bed locations: Plant shrub, groundcover, and perennial beds throughout the greenway zone, to provide landscape interest near the ground and alongside the multi - use trail. To the extent possible, native wildflower and low mow grasses are encouraged for wildlife habitat enhancement and reduced maintenance responsibilities.

Plant species: See Appendix 8 for a detailed list of recommended plant species.

4.19 Public Art

Public art: Public art, including, but not limited to sculpture, mosaic and tile panels, water features and environmental artwork are encouraged within, or adjacent to, the greenway zone.

Figure 4.6 Cantilevered overlook with multi-use tail



Chapter Five: Development Zone

5.1 Definition of Development Zone

The development zone is the area adjacent to the Chicago River corridor that does not fall within the urban greenway / setback zone or the riverbank zone, and that may be developed or redeveloped with new or existing structures for private use as permitted by zoning.

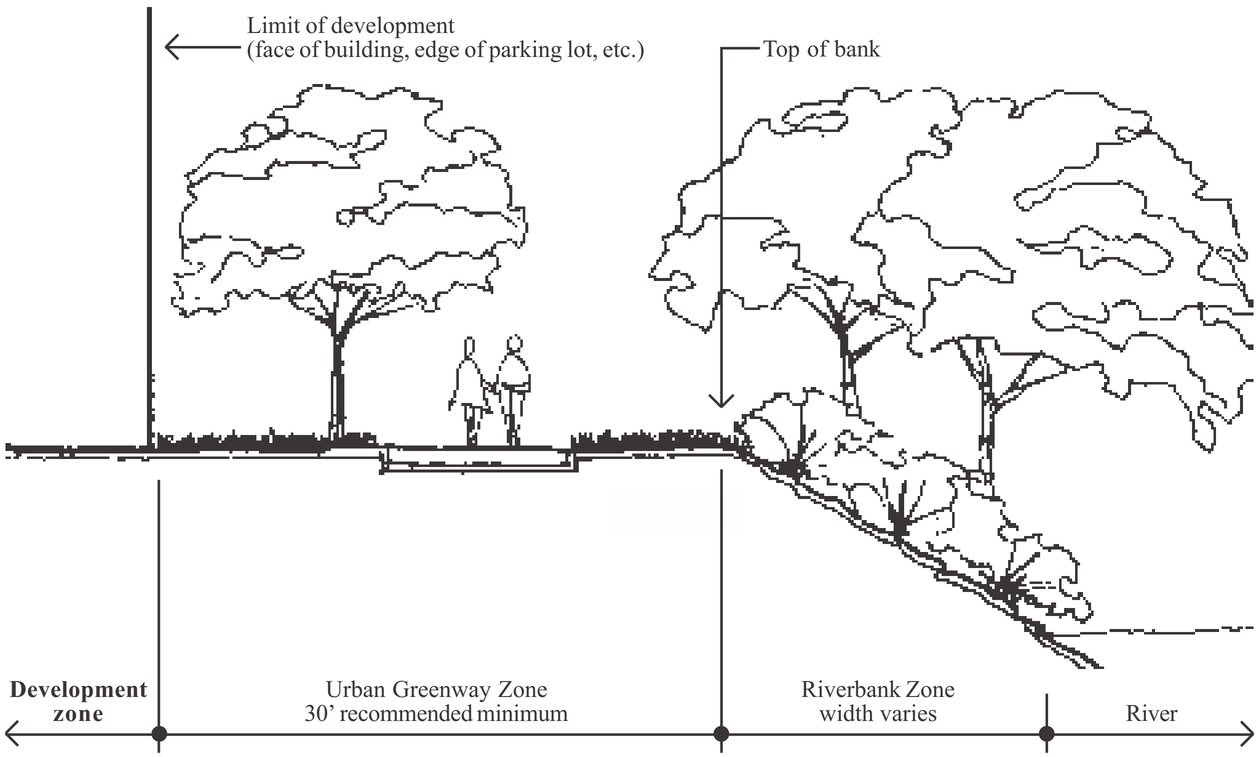


Figure 5.1 Typical riverbank section

5.2 Design, Orientation and Massing of New Structures and Buildings

The river elevation of any riverside building should be treated architecturally as one of its principal facades.

Building design: The river facade of buildings should be designed as a principal or major facade, and should have at least the same design elements, articulation, relief, and other architectural considerations as the other facades.

Building materials: The materials on the river facade of buildings should be of at least the same quality as the materials on the other facades.

Orientation. New structures and buildings should be oriented to the river, and not turn their back on the river, so that the greenway zone and

Figure 5.2 New buildings should be orientated to the river to create a safe and lively riverfront.

riverbank zone are not perceived only as the area behind the structure or building. Entrances and windows on the river side will generate pedestrian circulation and activity in the greenway zone, which will make it more active, safe, and secure.

Massing. It is equally important that the massing of new structures and buildings be sensitive to the river and the greenway zone, so that the river and greenway zone are not overwhelmed by tall and dense structures and buildings built to the setback line.

5.3 Renovation of Existing Buildings

It is equally important the adaptive re-use of existing buildings and structures on the river oriented to the river so that the greenway zone and riverbank zone are not perceived only as the area behind the structure or building. The design principles in the previous section for the "Design, Orientation and Massing of New Structures" apply.

5.4 Screening of Parking Lots and Vehicular Use Areas

Parking lots and vehicular use areas should be attractively landscaped such that the view from the river and greenway zone is a green, attractive one. These areas should meet the landscape requirements of the City of Chicago Zoning Ordinance Chapter 17-11 Landscape and Screening Requirements and the City of Chicago's **Guide to the Chicago Landscape Ordinance.**

Landscape Screen Requirements for:	Vehicular Use Areas	Non-Vehicular Use Areas
Fence	4ft ornamental metal fence, but not placed within river setback area. >6ft ornamental metal security fence requires approval of Zoning Administrator.	4ft ornamental metal fence is permitted, but not placed within river setback area.
Tree	2 per 25 linear feet of river frontage. Placement of trees is riverside of fence, and may be placed in natural layout.	1 per 25 linear feet of river frontage. Placement of trees is river side of fence, and may be placed in natural layout
Hedge	Continuous hedge 3ft on center spacing. Placement of hedge is river side of fence.	Not required.
Foundation Plantings	Not applicable.	Foundation plantings are required in front of building.

Figure 5.3 Riverfront screening requirements

Screening: In addition to the standard requirement of one (1) tree per 25 linear feet of river frontage within the river setback area, parking lots and vehicular use areas, per the Landscape Ordinance, require its own separate perimeter screening requirement of one (1) shade tree per 25 linear feet and a continuous hedge which must be maintained between thirty (30) inches and forty - eight (48) inches in height (see Fig. 5.3).

5.5 Screening of Storage Areas

Outdoor storage areas, should be screened from view from the river and greenway zone.

Outdoor storage area screening. Screen walls or fences of high quality durable materials are required for outdoor storage areas. Acceptable materials include poured-in-place concrete, split face or ground face concrete masonry units, and heavy wood. The height of the screen shall not exceed eight (8) feet.

Appropriate screening is required to maintain an aesthetically pleasing river front.

Unacceptable materials. Unacceptable materials for screening include chain - link fencing, plastic slat inserts, and lightweight lattice wood panels.

Landscaping of screening walls and fences. Screening walls and fences should be planted with vines at the base, and the vines should be trained up and over the walls and fences to soften their appearance and increase the amount of landscaping visible from the river and greenway zone.

5.6 Lighting

Lighting in the development zone should be adequate and appropriate for safety and security, and well as an attractive feature of the project site.

Appropriate lighting is required to provide for a safety and security, as well as attractive landscape elements to the development zone.

Lighting levels. Provide lighting with an adequate light level for project safety (visibility, adequate and safe illumination of vehicular use areas, etc.) and security (visibility, continuous illumination of vehicular use and other areas, avoidance of dark or unilluminated areas, etc.).

Light fixture and luminaire style. Light fixtures and luminaires should be attractive, pedestrian scale fixtures with articulated bases, poles, pole tops, and luminaires.

Light fixture height. Recommended light fixture height is less than twenty (20) foot; maximum light fixture height is thirty (30) feet.

Light pattern. Luminaires should be equipped with shields so that light does not shine into adjacent residential or institutional areas.

Chapter Six: Bubbly Creek Development Guidelines

The development of the South Fork of the South Branch of the Chicago River traces back to the 1860s and the origins of the Chicago Union Stock Yards, which occupied the area bounded by Pershing Road, Halsted Street, 47th Street and Ashland Avenue.

Five hundred thousand gallons of fresh water were pumped daily from the Chicago River into the yards, and vast quantities of untreated waste was dumped into the waterway. Bubbly Creek became a notorious open sewer, its name derived from the bubbles caused by decaying matter which filled the river bottom..

Upton Sinclair wrote about the deplorable conditions of the Chicago Union Stock Yards in his novel, *"The Jungle"* (1906). He described Bubbly Creek as if ..."grease and chemicals that are poured into it undergo all sorts of strange transformations, which are the cause of its name; it is constantly in motion, as if huge fish were feeding in it, or great leviathans disporting themselves in its depths. Bubbles of carbonic acid gas will rise

Figure 6.1 Historic Chicago Union Stockyards

Figure 6.2 Bubbly Creek today with the Racine Avenue Pump Station in background

to the surface and burst, and make rings two or three feet wide. Here and there the grease and filth have caked solid, and the creek looks like a bed of lava; chickens walk about on it, feeding, and many times an unwary stranger has started to stroll across, and vanished temporarily."

Bubbly Creek still effervesces today. At its southern terminus lies the Metropolitan Water Reclamation District's Racine Avenue Pump Station, the largest facility of its kind in the United States. Fourteen pumps drain a 30 square miles area discharging stormwater into the river during heavy storm events. The remainder of the time Bubbly Creek is stagnant.

Over time, stormwater management practices (BMPs) can significantly improve the water quality of Bubbly Creek. These BMPs include new parks, open spaces, greenways, green roofs, cisterns, swales, wetlands,

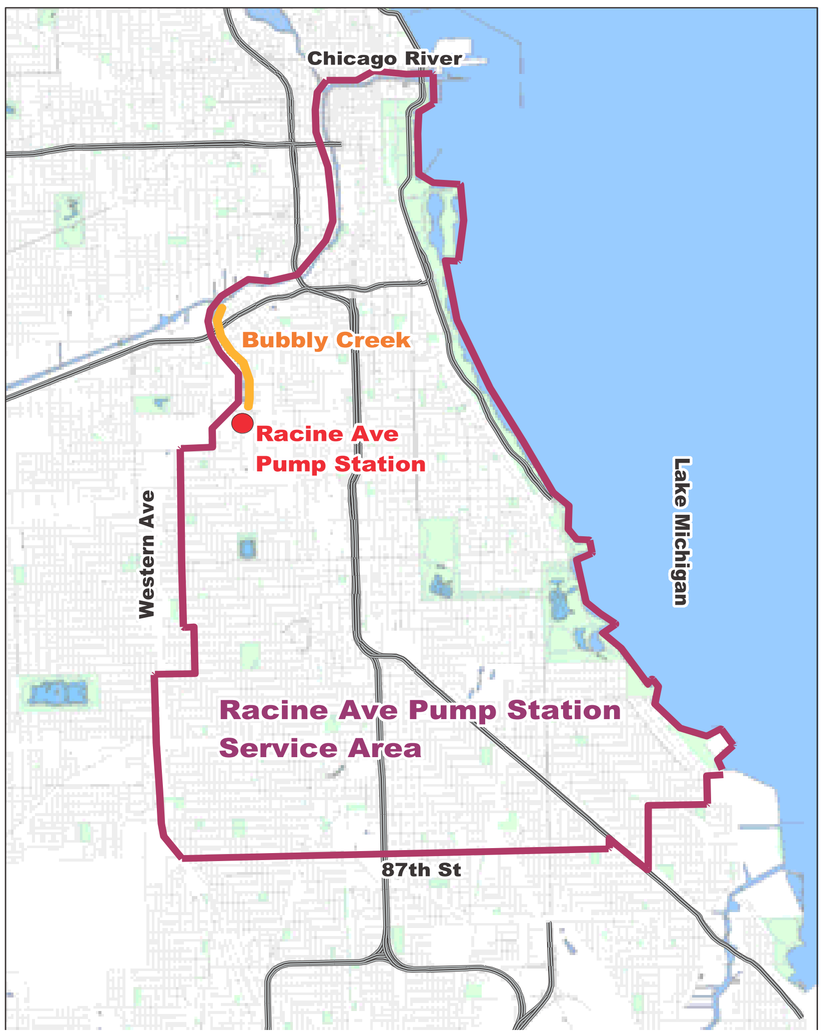


Figure 6.3 Racine Avenue Pump Station Sewershed 30 sq mile Service Area

and other improvements in public and private developments. Within this sewershed, all new developments are responsible for reducing their stormwater contribution.

6.1 Purpose of Setback for Bubbly Creek

Special measures are necessary at Bubbly Creek to mitigate the degraded conditions of the waterway and its banks. A wider setback is needed.to rebuild the riverbank in a manner that provides protection from sedimentation, erosion, and runoff.

Existing riverbanks along Bubbly Creeek are fairly steep (steeper than 3H:1V), high (greater than 10ft), eroded, and unstable. In many cases the original timber retaining wall has failed. These banks are susceptible to waterline erosion, sloughing and gullying, particularly if there are heavy weight loads located near the top of the bank.

The expanded setback provides the physical space to rebuild dilapidated banks in a sustainable manner for the purpose of stormwater management, stabilizing riverbanks, water quality improvements, and providing appropriate naturalistic landscaping and public access. Other benefits include improved wildlife and fish habitat, pollutant removal, runoff attenuation, and streamside aesthetics.

6.2 Bubbly Creek Boundary

Bubbly Creek extends south from the South Turning Basin of the South Branch of the Chicago River to its terminus at the MWRD Racine Avenue Pump Station. The boundaries approximate 27th Street on the north to 39th Street on the south (see Fig. 6.4).

Bubbly Creek extends from 27th Street to 39th Street.

6.3 Setback Requirements

All new developments on Bubbly Creek are required to setback sixty (60) feet from the existing top of bank as established by survey at the time of planned development application.

> **Exceptions to the Setback Requirement.** Exceptions to the setback requirement include existing structures or buildings that are located within the setback zone and river dependent industrial uses that require barge access

Figure 6.4 Map of   Bubbly Creek and area affected by 60ft river setback

Setbacks on Bubbly Creek shall accommodate (1) riverbank improvements, (2) stormwater best management practices, (3) public riverwalk trail, and (4) landscape buffer/screening.

6.4 Guidelines for the Repair of Slopes.

Excessively steep slopes are required to be repaired and re-contoured to a minimum 3H:1V slope (see Fig. 6.5). The slope shall be planted with native vegetation, and stabilized with an erosion control fabric or geotextile reinforcement system. Terracing, soil wraps, and other bioengineered solutions are other options that can be used to treat steeper slopes.

Toe of Bank Stabilization. The toe of the bank is the point where the riverbank meets the water, and may need to be reinforced with rip rap, coir biologs, and live staking to control water line erosion and scour from fluctuating water levels.

Tree Survey. A tree inventory of all trees larger than 8 inches in diameter at breast height will be required.

Removal of Trees. Recontouring of the bank may entail the removal of significant number of trees. Care should be taken to preserve the healthiest and largest trees, particularly trees located at the toe of the bank.

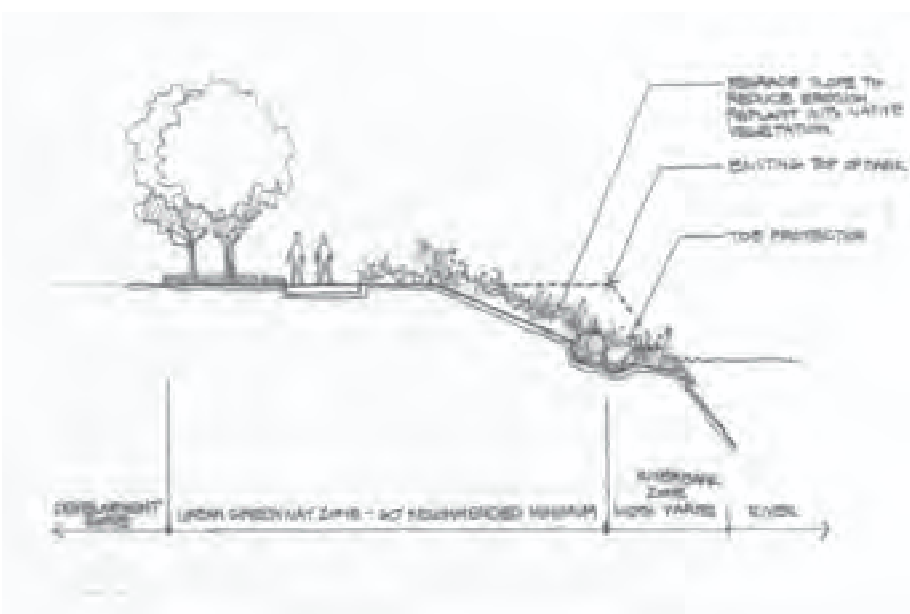


Figure 6.5 Recommended treatment of 60' river setback for an existing slope condition.

6.5 Guidelines for Repair or Modification of Seawalls

The construction of new seawalls or bulkheads is discouraged on Bubbly Creek. If a new seawall or bulkhead is necessary, the height of the new seawall shall be low as possible, but above the high water mark, and limited to the height of the seawall on adjacent properties.

Seawalls shall be lowered to the extent possible, but not below the existing tie back anchorage system, to accommodate a sloped natural vegetated embankment between the development site grade and the top of the modified seawall. The slope of this embankment shall not exceed 3H:1V (see Fig. 6.6)

Additionally, the top of the seawall shall be covered with overhanging native vines or vegetation.

6.6 Stormwater Management Requirements

Central to improving the environmental quality of Bubbly Creek is the integration of above ground stormwater BMPs. To the extent possible the river setback should manage as much of the stormwater from the development site before diverting stormwater into the sewer system or waterway.

> **Pupose.** Stormwater best management practices, such as vegetated bioswales, infiltration strips and level spreaders, will attenuate water flow and improve water quality.

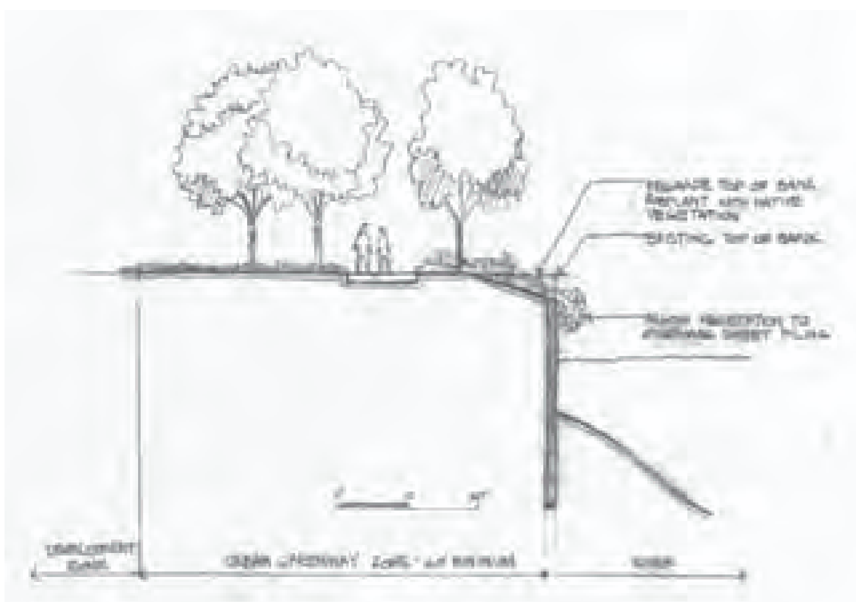


Figure 6.6 Recommended treatment of 60' river setback for an existing bulkhead condition.

Swales with native grass vegetation are nearly twice as effective as pavement in reducing velocity and flow. The slower the flow, the more effective the swale will be to assimilate nutrients before they reach the water body.

Design. The stormwater management plan extends beyond the river setback and should be integrated into the entire development site to include design elements such as parkway swales, grading, pumps, rain gardens, green roofs, permeable pavements, and ponding on roadways. Conveyance to the river setback is accomplished through a sewer pipe connection or swale. Underdrains are recommended as base for permeable pavements if underlying soil is not sand.

Avoid designing linear swale systems characteristic along highways. The design should be more fluid, sinuous, and naturalistic, and does not necessarily have to be designed as one continuous swale, but a network of swales connected by culverts. The design should also provide opportunity for public education and interpretation.

Design guidelines for stormwater BMPs are located Appendix L.

Figure 6.7 Example of riverfront industrial site utilizing riverbank recontouring, infiltration area, and porous pavers for stormwater management.

Size and Release Rate Requirements. Below are BMP sizing specifications that meet the target 80% total suspended solids reduction. Alternative sizing methodologies, in leiu of, or in addition to the ones below, may be specified by the Department of Water Management or Department of Environment.

For volume based BMPs (infiltration basins, rain gardens, permeable pavers) - BMPs should be sized to capture and retain the first flush volume, defined as the first one inch of precipitation.

BMPs should be designed and sized to meet the target 80% total suspended solids reduction.

For flow based BMPs (swales, filter strips) - BMPs should be sized to treat the first flush storm, defined as the two year, one hour storm based on the City's standardprecipitation data used in stormwater calculations (TP-40). First flush flow velocity should be kept to less than one feet per second with a minimum BMP residence time of nine minutes to allow for adequate settling of particulates. The 100 year flow velocity should also be evaluated to ensure it does not cause scour to the riverbank.

For ponds and stormwater wetlands - Release rates should be no greater than 0.04 cfs/acre for the two year, 24 hour storm event based on the City's TP-40 rain data.

Construction of a single BMP large enough to meet the water quality requirement may not always be possible. Therefore, a combination of BMPs in series ("treatment train") may be used. Landscaping. Stormwater bioswales shall be planted with native

Figure 6.8 Example of stormwater infiltration area along the river

wet prairie mix, predominated by native grasses at least 8 inches in height. Taller prairie grasses are more effective attenuating flow and capturing pollutants than turf grass.

Maintenance. Once the vegetation is established, stormwater BMPs require very little maintenance. Mowing or prescribed burning may be done once every two to three years to remove the dead organic accummulated material (see Appendix 10). Stormwater BMPs need to be kept free of obstructions and debris which may impede flow.

6.7 Landscape Buffer and Riverwalk Multi-Use Trail

Private uses outside the 60ft river setback need to be appropriately screened by landscaping. Apart from the specifications outlined in Chapter 5, the following apply:

Riverwalk trail. The placement of the riverwalk trail shall not be located on the riverbank nor on top of stormwater swales or infiltration areas as to impede the flow of water. Boardwalks are a solution to locate a path on top of a stormwater bmp without interfering with the function of the bmp.

Landscape design. The intent is that the entire 60 foot setback be planted with native vegetation. Trees and shrubs should be located in naturalistic layered groupings.

The placement of landscape screening should be sensitive to the placement of stormwater BMPs so as to not impede its capacity to convey or infiltrate stormwater.

Fencing. To create a naturalistic aesthetic, fencing is discouraged on the riverwalk trail, with the exception for saftey purposes where the trail approaches the riverbank.

6.8 Development Zone Requirements

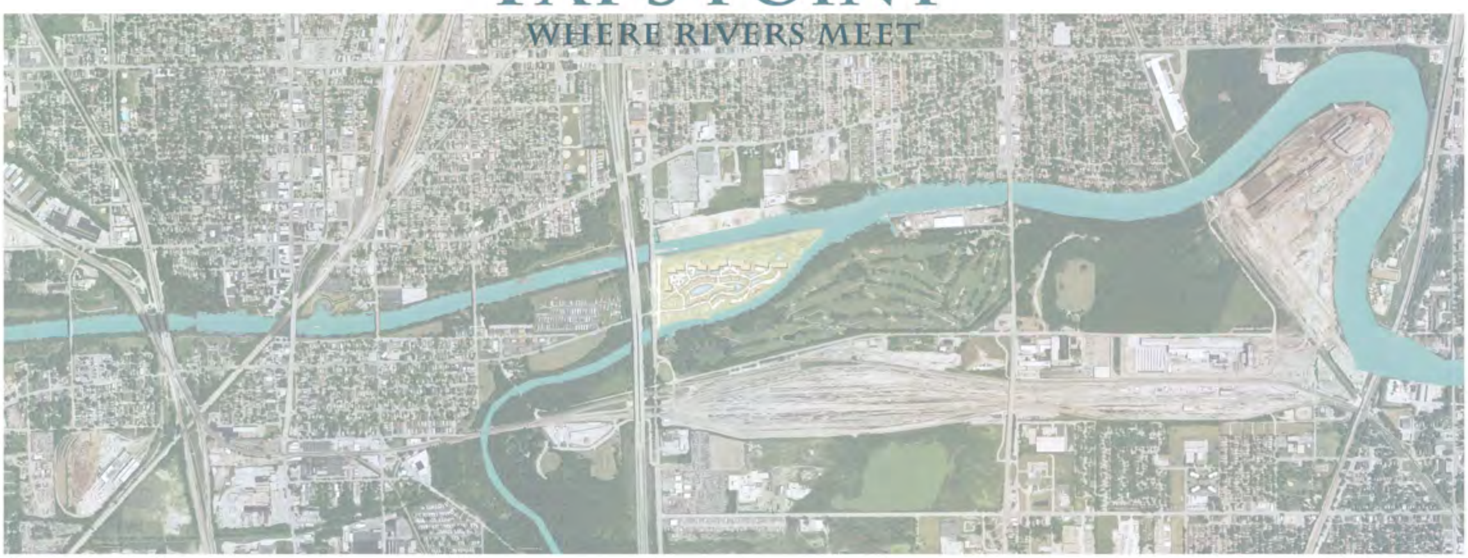
The development zone for Bubbly Creek is the area outside the 60 foot set-back zone, that may be developed or redeveloped with new or existing structures for residential, commercial, and manufacturing uses as allowed by zoning. Chapter Five Development Zone specifications apply.

Figure 6. 9 Example of landscaped buffer adjacent to riverwalk trail

Attachment C

Friends of the Chicago River :: Blue Ribbon Awards
Fay's Point . Blue Island, Illinois

FAY'S POINT
WHERE RIVERS MEET



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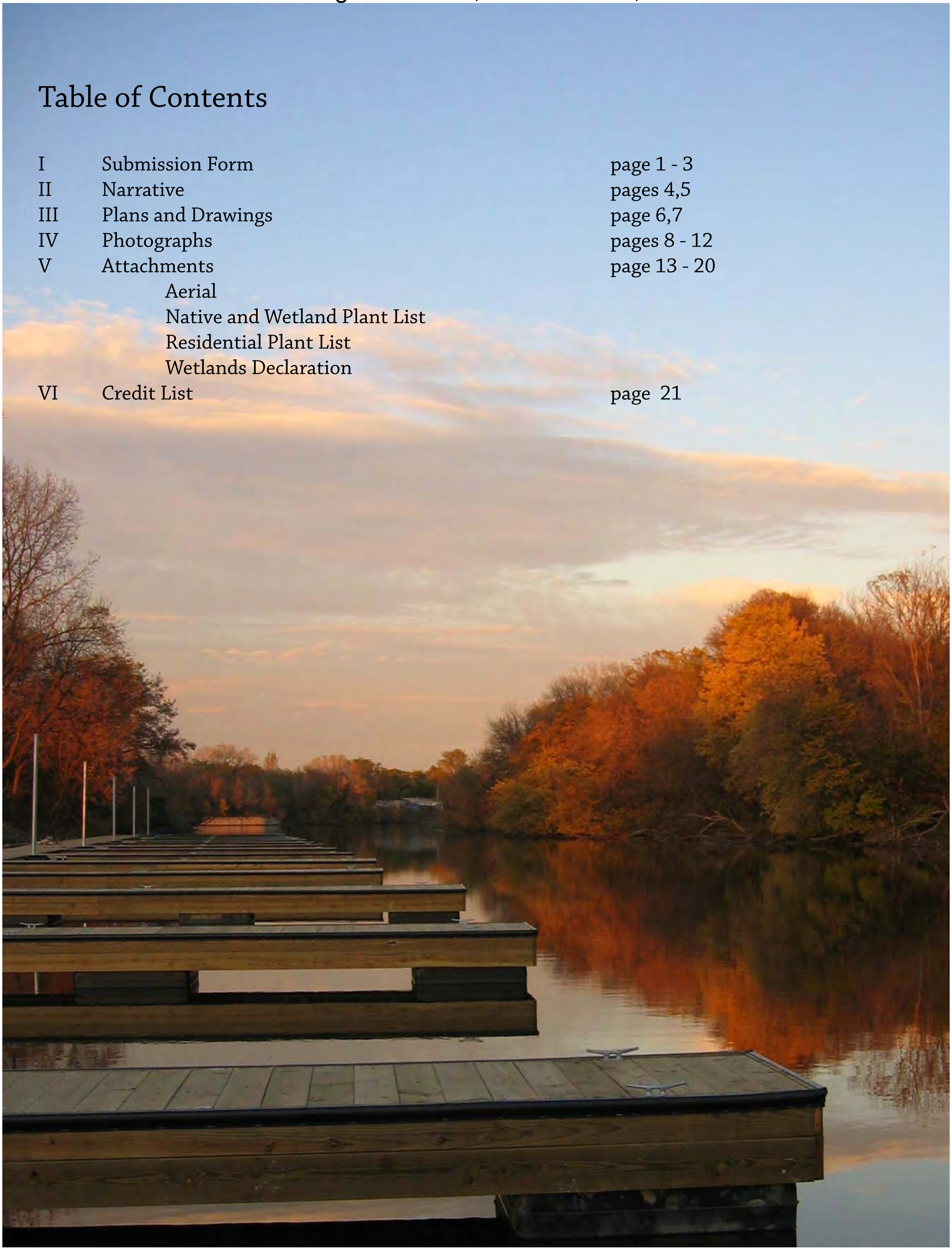


Friends of the Chicago River

Blue Ribbon Awards
2010 Submission and Narrative Questions Form
Forms shall be type-written using this form or retyped completely as long as the information is complete.

1) Entrant's Contact Information

Primary Contact Person Arvydas Laucius

Organization or Company Name Fay's Point, LLC

Address (Street, City, State, ZIP) 1518 Broadway Street, Blue Island, IL 60406

Phone: (708) 371-7200 Fax:

E-Mail arv@fayspoint.com

Friends of the Chicago River Business Member ☐ Yes ☐ No (Applying Now)

2) Payment Method and Information

☐ Contact is the same as above.
☒ Secondary Contact Person Michael Breclaw, LEED A.P., AIA

Organization or Company Name OKW Architects, Inc.

Address (Street, City, State, ZIP) 600 W. Jackson, Suite 250, Chicago, IL 60661

Phone: 312.798.7744 Fax: 312.798.7777

E-Mail mbreclaw@okwarchitects.com

Amount

☒ $100 *Blue Ribbon Awards* Registration Fee $100.00
☒ Friend's Business Membership $ 100.00
Please choose a membership level: $100 $250 $500 $1,000 $2,500 $5,000

Total $ 200.00

☒ My check made payable to Friends of the Chicago River is enclosed.
☐ Please charge my credit card. (Select one):
☐ American Express ☐ Discover ☐ MasterCard ☐ VISA

Card number ____

Expiration date ____ 3-4 digit security code ____

Name on card and/or billing address if different than above ____

We will send a check separately. Expect it in approximately ____ weeks.

3) Project Information

Blue Ribbon Awards Submission Project Name (As it should appear on the award) Fay's Point

Project Address (Street, City, State, ZIP) 1518 Broadway Street, Blue Island, IL 60406

Award Category
☐ Open Space ☐ Commercial ☐ Industrial ☐ Institutional: Public
☐ Single-Family Residential ☒ Multi-Family Residential

River Benefit Category (mark all that apply) ☒ People ☒ Water ☒ Wildlife

Year Completed/To be Completed

Project Team (As applicable - Company or Organization, Primary Contact and Phone Number)

Owner/s Arvydas Laucius, Fay's Point, LLC, (708) 371-7200

Developer Arvydas Laucius, Fay's Point, LLC, (708) 371-7200

Architect OKW Architects, Inc. Michael Breclaw, (312)798.7700

Landscape Architect George Kinsella, Kinsella Landscape,(708) 371-0830

Engineer(s) Paul Ulatowksi of Henderson Bodwell,(630)834-9406, Jan Blok of The Structural Group, (847) 562-1977 and Bob Johnson of R.I. Johnson,(630) 653-9060

Ecologist Wetlands and Permitting: Brad G. Schumacher, Marlin Environmental,(630) 4

Other Consultants Stream Consultant: Kestrel Design,(952) 928-9600

Contractor(s) Daniel Krause, Krause Construction, (708)371-9507

4) Narrative Questions

The goal of the *Blue Ribbon Awards* is to provide a forum through which a project team can share their specific river sensitive designs and recognize them for their good work. The most important part of the award submission is the narrative which should describe the project team's approach to the design in relation to the river. There are three main categories of river protection that are described in *People, Water and Wildlife: Blue Principles for River Design*, the narrative should address the questions as described in the three sections below:

Section 1 People

In narrative form, please describe how you feel your site has improved the quality of human life of the Chicago River by answering the following questions:

1. Does your site provide public access to the water? Does the project provide access across the entire length of the river frontage?
2. Do any publicly accessible portions of this site dead end?
3. Does this site provide boat access? If so, for what type of boats?
4. Was any environmental or historical interpretive information included on this site?

5. Does this site hold any known historical importance? If so, were they preserved? How so?
6. Was the orientation of the development and their facades oriented to the river?

Section 2 Water

In narrative form, please describe how you feel your site has improved the hydrologic roles of the Chicago River by answering the following questions:

1. Does your site provide on-site rainwater detention?
2. Did your project team include a civil engineer and landscape architect? If so, please describe their roles in the design process.
3. Does your site use entirely native plants or a mix of both? If a mix what percentage is native? Please provide a plant list.
4. Describe how stormwater management techniques from People, Water and Wildlife: Blue Principles for River Design were selected for this site.
6. Was a long term management plan written for this project and are any professional contract agreements in place for maintenance of all installed stormwater management techniques?

Section 3 Wildlife

In narrative form, please describe how you feel your site has improved the habitat roles of the Chicago River by answering the following questions:

1. Did you project conduct a preliminary survey of existing species and habitat health for your project site? If so, please submit the survey.
2. What was the calculated change in total land available for habitat at the development site?
3. Did you project install in-stream habitat provisions? If so, please illustrate.
4. Did your development team include a pre-qualified streambank contractor?
5. Describe how habitat techniques from People, Water and Wildlife: Blue Principles for River Design were selected for this site.
6. Was a long term management plan written for this project and are any professional contract agreements in place for maintenance of all installed habitat techniques?

Section 4 Other

In addition to the documents, management plans and list specifically requested in Sections 1-3, entrants may include up to five (5) additional attachments with this narrative.

5) Terms of Agreement

I have read the complete *Blue Ribbon Awards* submission information and form and certify that this entry is in full compliance with the criteria set forth. I understand that all submissions become the property of Friends of the Chicago River and will not be returned. Entries will be used for marketing purposes by Friends of the Chicago River to celebrate the *Blue Ribbon Awards* program and to promote river sensitive design along the Chicago River.

In submitting this project, I certify that I am a member of the project team, I am the sole copyright owner of the information, drawings or photographs submitted or that I have obtained written permission from all interested parties, including the property Owner, to submit this project for an award. I take full responsibility for proper release of any photographs from their respective photographers so that they may be used for publication and for the accuracy of the enclosed project information, holding harmless Friends of the Chicago River.

I understand that Friends of the Chicago River maintains the right to disqualify entrants or rescind awards at the discretion of the jury and/or Friends staff.

Signature of Entrant Contact ____________________ Date 4/22/2010

Project Description

Fays Point is a new residential community developed on a 43 acre peninsula of fallow land between the Cal- Sag channel and the Little Calumet River in Blue Island, Illinois. The full build out of the 30 acre development site will consist of 84 townhomes, 304 condominiums, an 90 unit senior housing building, a community building and restaurant, as well as an 80 slip marina define the program are sited to take maximum advantage of the site's natural characteristics.

Construction for the site began in 2006. Site work, including utilities, roadways, as well as the landscape and wetland and river bank restoration, and marina construction has been completed. Thirty of the proposed townhomes have been constructed and occupied, providing a substantial example of the character of the fully built community. The 90 Unit Senior Housing Building has likewise been completed and occupied. The economic and housing market contraction has slowed the velocity of the completion of the project. A full build out of the 120 million dollar project is anticipated in five to seven years.

The design solution was driven by the goal of creating a walkable, water focused community, imbedded in a restored natural landscape. With 11 acres of Metropolitan Water Reclamation District land dedicated as open natural space along the bank of the Cal-Sag Channel, over 1000 feet of the Little Calumet River bank restored to the highest environmental standards, expanded and enhanced wetlands, and mature stands of trees, the site provides a nature preserve-like setting for residents and visitors.

Branching off an existing neighborhood of 11 homes, a winding road loops through the peninsula, defining an inner ring of townhomes that surround naturally landscaped storm-water management ponds. Five-story condominium buildings at the higher elevation of the site are served by the northern part of the loop. The marina and the community building reside on the restored bank of the Little Calumet.

The townhomes are designed in groups of four to six units, in a style reminiscent of simple, arts and crafts homes common to the Blue Island area. Condominium buildings use the same palette of materials as the townhomes, but in a more streamlined style, creating multiple corner units, generous windows and large balconies to take advantage of the views along the canal, towards the city, or south to the marina and forest preserve beyond.

The community building, the "Marina Club," will be a very special structure on the site inspired by numerous sustainable design features. The structure will be constructed of salvaged old growth Alaskan Spruce. A monumental fireplace will be constructed with limestone salvaged from the foundation of the farmhouse of the original settler on the land. Its large expanses of south facing glass, shaded by a generous roof overhang, provide passive solar heating, while enabling a stunning view over the restored riverbank and marina.

Combined, the site plan, the buildings, and the landscape make Fay's Point a remarkable community development. Front porches, sidewalks, walking trails, canoe launches, river front terraces, as well as bird watching platforms, form a web of spaces and amenities that create an eco-friendly and neighborhood oriented river environment.

History and Process

Historically Fay's Point has been a very special place, starting with it's formation as the glacial sluiceway that formed the low area that is now the Cal- Sag channel. Glacial erratic boulders are common at Fay's Point and used in the landscaping. Prior to the creation of the Cal-Sag, Fay's Point was still a peninsula, with the junction of Stony Creek meeting the Little Calumet. As part of the river dredging we recovered boulders that most likely were from the Calumet Feeder Dam which was one of the water sources for the I & M canal in this location. The original settler, Jerome Fay, for whom the peninsula was named, had a home here and the foundation stones were still found and salvaged for use in the Marina Club fireplace. The Cal- Sag channel dug in 1920 straitened the peninsula and also utilized the Blue Island Locks, of which the north wall is still in existence. In 1950, with the advent of thSt. Lawrence Seaway, the Cal-Sag was widened to it's present 225' and the final form of the point was made.

Fay's Point LLC identified the potential of the Fay's Point peninsula near the intersection of Ashland and Broadway in the fall of 2003. The early due diligence process consisted of collecting information regarding the existing parcel with topographic surveys, a wetland delineation, geotechnical and environmental investigations meetings with the City of Blue Island and Mayor Peloquin. We then selected our Architect and Land Planner, OKW Architects. The process was aided by input from the City of Blue Island, the Center for Neighborhood Technologies, environmental groups like Openlands, Friends of the Chicago River, and CEPA, and eventually the US Army Core and IEPA. . The Land Plan was completed in spring of 2005. The City of Blue Island unanimously approved the zoning for the Land Plan on June 28th, 2005.

The existing shore of the Little Calumet River was characterized by approximately 1300' of solid concrete wall and concrete debris riprap, abandoned and sunken boats and was unusable for access to the river. Working through the complex process of wetland mitigation, work in floodways and the river itself, we obtained permits from the Army Core, IEPA, DNR and MWRD for restoring the river bank and overall site construction. Site work commenced with removal of the concrete wall, riprap and consolidate other concrete from the site and crush it and recycle it onsite for future use in roadbeds and parking lots. This saved the need to import over 20,000 tons of material. The river was dredged, with suspect dredged material placed under the new marina parking lots, and the slope restored to an upland prairie supporting the mitigated wetland at the base of the river. This restoration also provided the opportunity to relocate poor, atypical wetlands found in other areas of the site and create a larger, much higher quality wetland along the river. Floating docks were installed 8 to 15' away from the shore to help buffer the wetland and create a built in observation platform for the shoreline.

People and Access

There are approximately 1-3/4 miles of trails in the areas around the housing that circle and interconnect with all parts of the site. Adjacent to the marina parking lots a permeable Boardwalk which connects the residential zones with the docks and to the Birdwatching platform and the mulch trails in other areas of the site. The publicly developed Cal-Sag Multi UseTrail is being planned and engineered to run through the MWRD portion of the site and connect with points west such as the Metra Station, and downtown Blue Island, as well as a pedestrian bridge crossing east to Riverdale and the Joe Louis Golf Course. The present trails are used by walkers, joggers, cross country skiers, and other people who want to be close to the river. Public access includes the 35 and 40" slips available for rent, a Canoe launch that is part of the Calumet-Sag Waterway Trail, and the Boardwalk and mulch trails which loop around and are adjacent to the prairie and wetlands along all shores. Additionally, Fay's Point has made possible Rowing events such as the Southland Regatta at Fay's Point, Big Ten Men's rowing hosted by the University of Wisconsin, and scrimmages with high school teams. The straight section of the Cal-Sag channel north of the Fay's Point Peninsula is an ideal rowing venue with a 2000 meter course starting at the MWRD SEPA station and finishing at the remnant of the Blue Island Locks at the tip of Fay's Point. The City of Blue Island, Calumet Park and the Southland Visitors Bureau were instrumental in the partnership to bring rowing to the Cal-Sag.

Water

Water management on the site was also enhanced by it's location on the rivers. Although separation of storm and sanitary discharges is not required in this location, by separating the systems we accomplished several goals. First, the separation allowed us to utilize a much smaller sanitary sewer, and tie into existing sanitary infrastructure, rather than rebuild an extensive section of downstream combined sewers. And although we could have just channeled storm discharge directly to the rivers, we utilized Best Management Practices to both enhance water quality and aesthetics. Rainwater from roofs is generally discharged to naturally landscaped areas or to rain barrels. Driveways and pavement either uses sheet flow or is piped to a series of detention ponds with native and wetland plants that allow sediment to settle and the plants to cleanse the water. The ponds slowly absorb the water into the ground or with larger discharges lead to a 600' by 3' diameter storage pipe under the Marina parking lots which slowly release the water through a combined 600' of level spreader at the mitigated wetlands along the river shore. All the work was carefully planned with our team of OKW Architects as the land planner, Henderson and Bodwell our Civil Engineer, and Marlin Environmental and Kestrel Design as the plant and environmental consultants, and Kinsella Landscaping as the contractor and residential landscape designer.

Landscape

We have used an extensive palette of native plants on the restored river bank, wetlands and new stormwater retention ponds and paths. Near the residences a cleaner pallet of plants was used, with native grasses, hardy perennials, trees and shrubs with much of the same qualities as true natives.

Plant lists from both sets of areas are in an attachment. Landscaping is professionally maintained by Kinsella and in house staff for invasive species control, burning and supplementing in the native areas.

The existing woodlands on the site were cleared of invasive species and damaged trees. The mulch created by that effort was used on the extensive walking paths around the peninsula.

The 90 unit Senior Building, that has just been completed as part of our Planned Development utilizes much of the same principles of native landscaping, rain gardens, pervious pavement, geothermal heating, night sky compliant lighting and shading to reduce heat island effects. The green features of the Fay's Point Land Plan were instrumental in that project getting funded and it is a great compliment to our community.

Wildlife

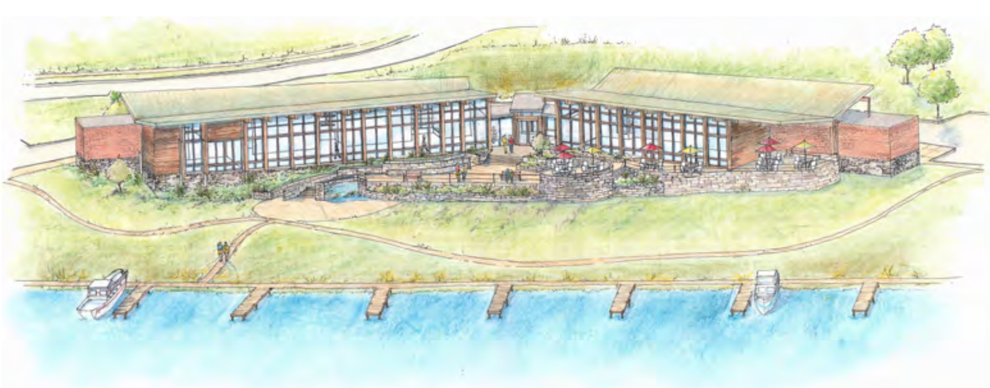
Wildlife at Fay's Point has always found a home, and the design with the perimeter natural areas has further enhanced the return of birds, animals, amphibians, and other wildlife. Wildlife such as beaver, muskrat, turtles, coyotes, deer, opossums, herons, egrets, cormorants, red tail hawks and even occasionally Bald eagles are regular and daily occurrences. The return of the natural shoreline has enhanced the ability of fish to find shelter and forage, with the underside of the floating docks offering food and cover, and the "bridge" ponds connecting the docks to shore act as shallow wetland nurseries for baby fish and amphibians. June brings a rash of nesting snapping turtles and when found the nests are protected by staff. Most importantly, the river edge being maintained in a natural state helps complete the natural corridor as it connects to adjacent forest preserves. The ready and direct access to seeing wetlands and it's supportive environment creates an everyday educational opportunity for residents, visitors and students from local schools on "Nature Day" field trips.

Master Plan

Pathways and Hydrology

Entry of Community Center

Interior View of Community Center

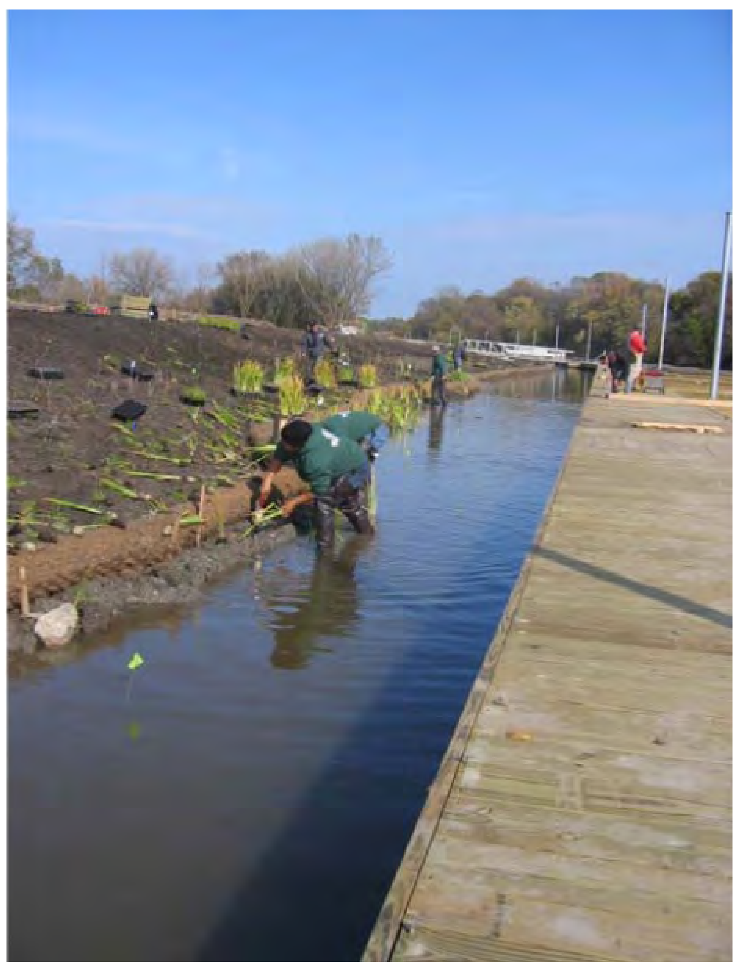


Aerial View from River

PROPOSED MARINA/COMMUNITY CENTER BUILDING

Shoreline in 2004 before work was started. Remnants of the old Marina and 800' concrete wall, and broken riprap comprises most of the river's edge

Dredging operations to remove concrete wall and widen and deepen the river in preparation of reshaping shoreline and installation of docks.

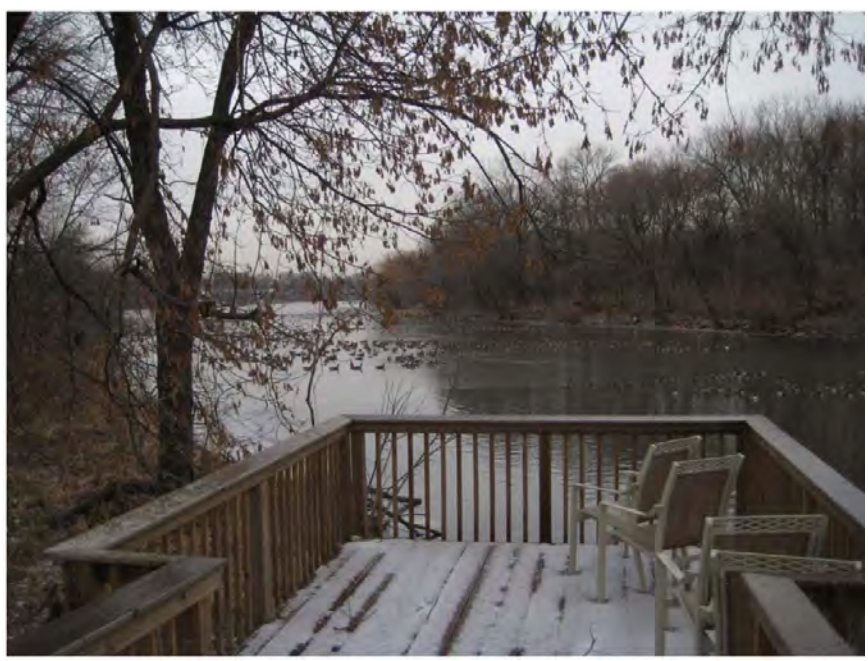


Coconut roll in place ready for Plantings, and wetland and emergent plugs being installed.

Second Year Supplemental Planting

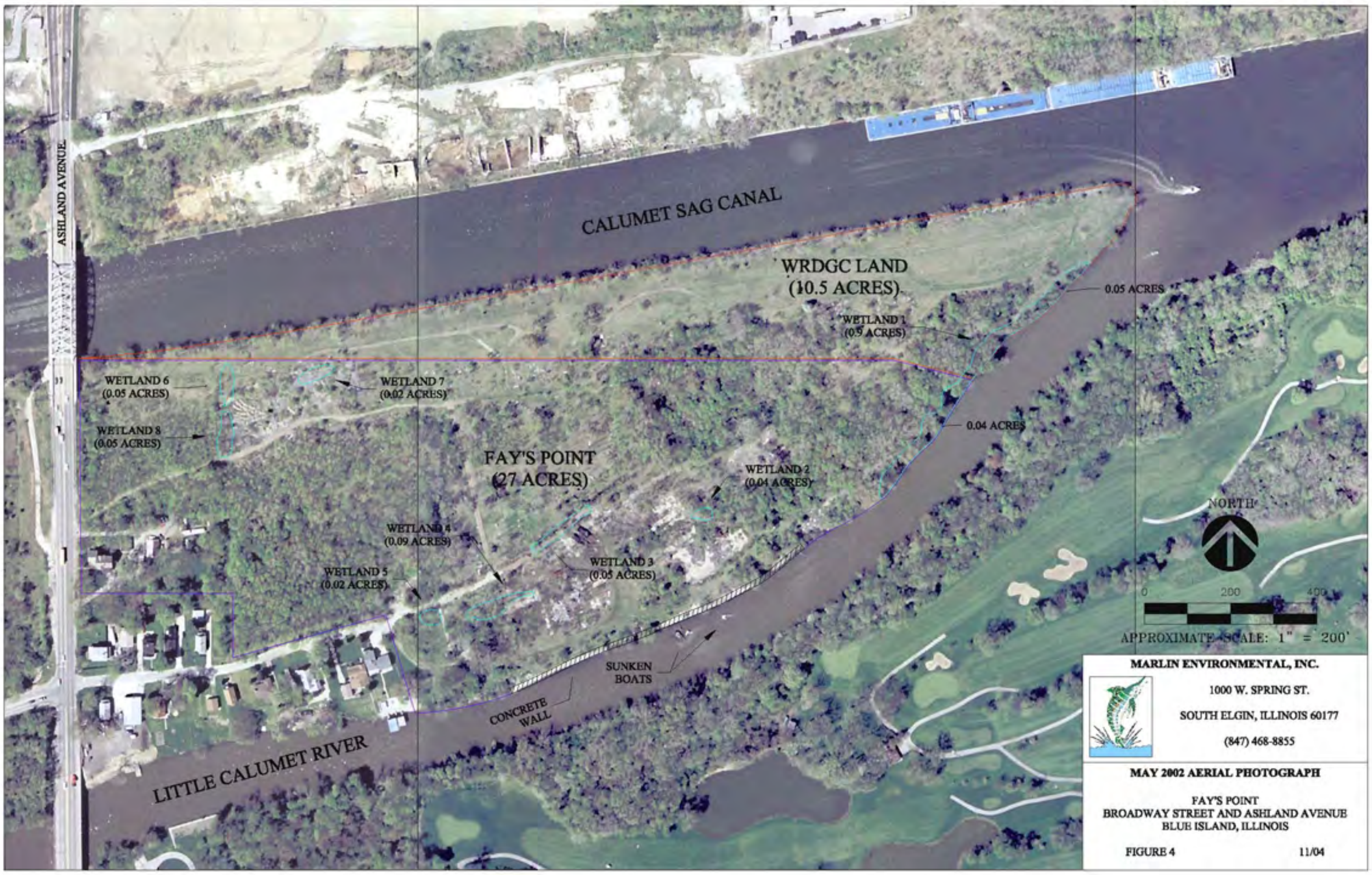
Prescribed Burn Spring 2010

Restored River and Wetlands



Birdwatch

RESTORED RIVER



ASHLAND AVENUE
CALUMET SAG CANAL
WRDGC LAND
(10.5 ACRES)
0.05 ACRES
WETLAND 1
(0.9 ACRES)
WETLAND 6
(0.05 ACRES)
WETLAND 7
(0.02 ACRES)
WETLAND 8
(0.05 ACRES)
0.04 ACRES
FAY'S POINT
(27 ACRES)
WETLAND 2
(0.04 ACRES)
WETLAND 4
(0.09 ACRES)
WETLAND 3
(0.05 ACRES)
WETLAND 5
(0.02 ACRES)
NORTH
0 200 400
APPROXIMATE SCALE: 1" = 200'
SUNKEN BOATS
CONCRETE WALL
LITTLE CALUMET RIVER
MARLIN ENVIRONMENTAL, INC.
1000 W. SPRING ST.
SOUTH ELGIN, ILLINOIS 60177
(847) 468-8855
MAY 2002 AERIAL PHOTOGRAPH
FAY'S POINT
BROADWAY STREET AND ASHLAND AVENUE
BLUE ISLAND, ILLINOIS
FIGURE 4
11/04

Fay's Point Native and Wetland Area Plant List

1. Alisma subcordatum	Common Water Plaintain
2. Apocynum sibiricum	Prairie Dogbane
3. Asclepias incarnate	Swamp Milkweed
4. Asclepias tuberose	Butterfly Milkweed
5. Aster novae-angliae	New England Aster
6. Aster puniceus	Bristly Aster
7. Aster ericoides	Heath Aster
8. Aster oolentangiensis	Sky Blue Aster
9. Aster simplex	Panicled Aster
10. Allium cernuum	Nodding Wild Onion
11. Acorus calamus	Sweet Flag
12. Andropogon gerardii	Big Bluestem
13. Anemone Canadensis	Meadow Anemone
14. Anemone cylindrical	Thimbleweed
15. Boltonia asteroides	False Aster
16. Bouteloua curtipendula	Side Oats Gramma
17. Calamagrostis Canadensis	Bluejoint Grass
18. Caltha palustris	Marsh Marigold
19. Carex comosa	Bristly Sedge
20. Carex bebbii	Bebb's Oval Sedge
21. Chelone glabra	Turtlehead
22. Coreopsis lanceloata	Sand Coreopsis
23. Coreopsis palmate	Prairie Coreopsis
24. Coreopsis tinctoria	Plains Coreopsis
25. Coreopsis tripteris	Tall Coreopsis
26. Dodecatheon meadia	Shooting Star
27. Echinacea purpurea	Broad-leaved Purple Coneflower
28. Erigeron philadelphicus	Common Fleabane
29. Eryngium yuccifolium	Rattlesnake Master
30. Eupatorium maculatum	Spotted Joe-Pye Weed
31. Eupatorium perfoliatum	Common Boneset
32. Eupatorium rugosum	White Snakeroot
33. Eupatorium serotinum	Late Boneset
34. Euthamia graminfolia	Common Grass-Leaved Goldenrod
35. Helenium autumnale	Sneezeweed
36. Helianthus pauciflorus	Prairie Sunflower

37. Helianthus mollis	Downy Sunflower
38. Heliopsis helianthoides	False Sunflower
39. Hibiscus moscheutos	Swamp Rose Mallow
40. Hypericum punctatum	Spotted St. John's Wort
41. Iris virginica	Blue Flag Iris
42. Juncus effusus	Common Rush
43. Juncus dudleyi	Dudley's Rush
44. Kuhnia eupatorioides	False Boneset
45. Liatris spicata	Marsh Blazing Star
46. Lobelia cardinalis	Cardinal Flower
47. Lobelia siphlitica	Great Blue Lobelia
48. Monarda fistulosa	Wild Bergamot
49. Nuphar advena	Yellow Pond Lily
50. Oenothera biennis	Common Evening Primrose
51. Panicum virgatum	Switch Grass
52. Peltandra virginica	Arrow Arum
53. Phlox divaricata	Woodland Phlox
54. Physostegia virginiana	Obedient Plant
55. Polygonatum biflorum	Smooth Solomon's Seal
56. Pontederia cordata	Pickerel Weed
57. Potentilla arguta	Prairie Cinquefoil
58. Ratibida columnifera	Mexican Hat Coneflower
59. Ratibida pinnata	Yellow coneflower
60. Rudbeckia hirta	Black-Eyed Susan
61. Sagittaria latifolia	Common Arrowhead
62. Scirpus atrovirens	Dark Green Rush
63. Scirpus fluviatillis	River Bulrush
64. Scirpus cyperinus	Wool Grass
65. Scirpus pungens	Chairmaker's Rush
66. Scirpus validus creber	Great Bulrush
67. Silene stellata	Starry Campion
68. Silphium laciniatum	Compass Plant
69. Silphium perfoliatum	Cup Plant
70. Silphium terebinthinaceum	Prairie Dock
71. Solidago canadensis v. scabra	Tall Goldenrod
72. Solidago canadensis	Canadian Goldenrod
73. Solidago juncea	Early Goldenrod
74. Solidago rigida	Stiff Goldenrod
75. Solidago rugosa	Rough Goldenrod
76. Solidago speciosa	Showy Goldenrod
77. Sorghastrum nutans	Indian Grass
78. Sparganium eurycarpum	Common Bur Reed
79. Tradescantia ohiensis	Common Spiderwort
80. Verbena hastata	Blue Vervain
81. Vernonia fasciculate	Common Ironweed
82. Veronicastrum virginicum	Culver's Root
83. Yarrow	White Yarrow
84. Zizia aurea	Golden Alexanders

***Plant Materials Used At Fay's Point adjacent to Homes**

Trees:
European Beech
Pear 'Chanticleer'
Crabapple 'Prairifire'
Fringe Tree
River Birch
Red Bud
Honey Locust
Magnolia 'Betty'
Gingko Princeton Sentry
Linden Littleleaf
Washington Hawthorn
Dogwood 'Kousa'
Serviceberry
Japanese Lilac 'Ivory Silk'

Shrubs:
Witchhazel 'Vernal'
St. Johnswort 'Hidcote'
Hydrangea 'Tardiva'
Hydrangea 'Annabelle', 'Endless Summer'
Spirea Birchleaf 'Tor'
Burning Bush
Dwarf Korean Lilac
Sweetspire 'Henry's Garnet'
Vibrunum 'Mohican'
Yew 'Densi'
Holly 'Shamrock Inkberry'
Russian Cypress

Grasses:
Feather Reed Grass
Purple Love Grass
Dwarf Fountain Grass
Various Maiden Grasses
Prairie Dropseed Grass

Perennials:
Catmint 'Walker's Low'
Dwarf Shasta Daisy 'Snowcap'
Daylily 'Chicago Apache', 'Stella De Oro'
Russian Sage
Coneflower

Groundcovers:
Sedum Stonecrop
English Ivy

DECLARATION OF DEED RESTRICTIONS AND COVENANTS
AFFECTING JURISDICTIONAL WETLANDS

WHEREAS, Fay's Point, LLC., an Illinois limited liability company located at 13031 S. Western Avenue, Blue Island, Illinois 60406, hereinafter called the Grantor, is the owner in fee simple of certain parcels of real estate located east of Ashland Avenue between the Cal-Sag Channel and the Little Calumet River in Blue Island, Illinois, which parcels in the aggregate are legally described on Exhibit A attached hereto and made part hereof (the "Development Parcel");

WHEREAS, the Development Parcel has been zoned as a Planned Unit Development pursuant to City of Blue Island Ordinance No. 05-552, enacted on June 28, 2005 (said ordinance, as the same may be amended from time to time, being herein called the "PD Ordinance");

WHEREAS, the Grantor has, or intends to, subdivide the Development Parcel into eleven (11) Parcels, as generally shown on the "Condo Parcel Exhibit of Fay's Point Subdivision", a copy of which is attached hereto as Exhibit "B". A copy of the subdivision Site Plan is attached hereto as Exhibit "C";

WHEREAS, the Grantor intends to develop and construct, or to cause to be developed or constructed, improvements on the Parcels in accordance with the PD Ordinance, a copy of which is attached as Exhibit "D"; and

WHEREAS, one of the eleven Parcels upon which the Grantor intends to construct improvements, hereinafter called the "Restricted Parcel", contains "Wetlands" under the regulatory jurisdiction of the Chicago District of the U.S. Army Corps of Engineers pursuant to Section 404 of the Clean Water Act (33 USC 1344);

WHEREAS, the Restricted Parcel is legally described as follows:

SEE LEGAL DESCRIPTION

ATTACHED HERETO AS EXHIBIT "E"

WHEREAS, the Grantor is the applicant for a Corps of Engineers permit, permit number 200500535, to place fill in the Wetlands on the Restricted Parcel, in accordance with plans which form a part of the U.S. Army Corps of Engineers permit number 200500535 and; the U.S. Army Corps of Engineers has regulatory jurisdiction of said wetland pursuant to Section 404 of the Clean Water Act (33 USC 1344);

WHEREAS, the Grantor and the U.S. Army Corps of Engineers have reached an agreement whereby the Grantor will be permitted to place fill in the Wetlands in accordance with the terms and conditions of Corps of Engineers permit number 200500535, and to construct the improvements on the Restricted Parcel generally shown on Exhibit "F" hereto; and that in consideration for the Grantor being permitted to place fill in the Wetlands and construct the improvements shown on Exhibit "F", the Grantor will mitigate the adverse environmental effects resulting therefrom by enhancing, enlarging, and/or creating wetlands per the approved wetland mitigation plan and establishing a buffer around said wetlands (if required by the Corps of Engineers), which when completed will be what is described as the Restricted Parcel, and which Restricted Parcel will be dedicated for the uses set forth herein, including the perpetual use of the Wetlands as a conservancy area in accordance with the terms and conditions of this document and the above mentioned permit.

WHEREAS, a permit to place fill in the Wetlands would not have been granted but for the dedication of the Restricted Parcel for the use and purposes set forth herein, and; which in 30 days of the receipt of this document from the U.S. Army Corps of Engineers, the Grantor shall submit to the U.S. Army Corps of Engineers a certified copy of this document, as recorded in the office of the County Recorder for Cook County, Illinois; and the Grantor specifically acknowledges as fact that said permit is issued in consideration for the execution and recording of this document and compliance with the covenants and deed restrictions herein.

NOW THEREFORE, the Grantor, for and in consideration of the facts recited above enters into the following covenants and deed restrictions on behalf of itself, its successors and assigns:

1. The U. S. Army Corps of Engineers will have the right to enforce by proceedings in law or equity the covenants and deed restrictions set out herein and this right shall not be waived by one or more incidents of failure to enforce said right;

2. Employees of the U. S. Army Corps of Engineers will have the right to view the Restricted Parcel in its natural, scenic, and open condition, and shall have the right to enter the Restricted Property at all reasonable times for the purpose of inspecting the Wetlands to determine if the Grantor, or his heirs or assigns, is complying with the covenants and deed restrictions herein;

3. Without prior express written consent from the U. S. Army Corps of Engineers there shall be no dredged or fill material placed on the Wetlands except as necessary for completion of mitigation as provided pursuant to the U.S. Army Corps of Engineers permit number 200500535.

4. With the exception of the improvements to be constructed on the Restricted Parcel as shown on Exhibits "C" and "F" and authorized by the PD Ordinance, the Grantor shall not, without the prior express written consent from the U. S. Army Corps of Engineers, construct additional commercial, industrial, agricultural, or residential developments, buildings, or structures, including but not limited to signs, billboards, other advertising material, or other structures, on the Restricted Parcel.

5. Without prior express written consent from the U. S. Army Corps of Engineers, there shall be no removal or destruction of trees or plants, mowing, draining, plowing, mining, removal of topsoil, sand, rock, gravel, minerals or other material, except as shall be necessary for (a) construction of the improvements on the Restricted Parcel as shown on Exhibits "C" and "F" and authorized by the PD Ordinance, and (b) completion of mitigation as provided pursuant to

the U.S. Army Corps of Engineers permit number 200500535 and the associated special conditions.

6. Without prior express written consent from the U. S. Army Corps of Engineers, there shall be no operation of snowmobiles, dunebuggies, motorcycles, all-terrain vehicles or any other types of motorized vehicles, except as shall be necessary for (a) construction of the improvements on the Restricted Parcel as shown on Exhibits "C" and "F" and authorized by the PD Ordinance, (b) completion of mitigation as provided pursuant to the U.S. Army Corps of Engineers permit number 200500535 and the associated special conditions, and (c) ingress and egress to and from the improvements located on the Restricted Parcel.

7. Without prior express written consent from the U. S. Army Corps of Engineers, there shall be no application of insecticides or herbicides except as specified by U. S. Army Corps of Engineers permit number 200500535.

8. Without prior express written consent from the U. S. Army Corps of Engineers there shall be no grazing or keeping of cattle, sheep, horses or other livestock.

9. Without prior express written consent from the U. S. Army Corps of Engineers there shall be no hunting or trapping on the Restricted Property.

10. With the exception of the improvements to be constructed on the Restricted Parcel as shown on Exhibits "C" and "F" and authorized by the PD Ordinance and the utility lines that will serve said improvements, without prior express written consent from the U. S. Army Corps of Engineers there shall be no utility lines placed overhead or within the Wetlands, including but not limited to: telephone or other communication lines, electrical, gas, water or sewer. Existing lines may remain, but any maintenance work requiring intrusion into the Wetlands shall require prior authorization by the U.S. Army Corps of Engineers.

11. Except as may be necessary to construct the improvements on the Restricted Parcel as shown on Exhibits "C" and "F" and authorized by the PD Ordinance, without prior express written consent from the U. S. Army Corps of Engineers there shall be no modifications to the hydrology of the Restricted Parcel, either directly or indirectly, that would allow more water onto, or that would drain water away from, the Restricted Parcel. Such prohibited modifications include, but are not limited to: ditching, changes to any water control structures, repairing of drainage tiles, or alterations to any naturally occurring structures.

These land use restrictions and other terms of these deed restrictions and covenants may be changed, modified or revoked only upon written approval of the U.S. Army Corps of Engineers. To be effective such approval must be witnessed, authenticated, and recorded pursuant to the law of the State of Illinois.

Except as expressly limited herein, the Grantor reserves for itself, its successors and assigns, all rights as owner of the Restricted Parcel, including the right to use the property for all purposes not inconsistent with this grant.

The terms and conditions of these deed restrictions and covenants shall, as of the date of execution of this document, bind the Grantor to the extent of its legal and/or equitable interest in Restricted Parcel, and; these deed restrictions and covenants shall run with the land and be binding on the Grantor, its successors and assigns, and all future owners of the Restricted Parcel, forever.

The terms and conditions of these deed restrictions and covenants shall be both explicitly included in any transfer, conveyance, or encumbrance of Restricted Parcel or any part thereof, and; any instrument of transfer, conveyance, or encumbrance affecting all or any part of Restricted Parcel shall set forth the terms and conditions of this document.

IN WITNESS WHEREOF, said Grantor has caused its name to be signed to these presents by its Manager this day of ________, 2006.

FAY'S POINT, LLC.

By: ____________________

Its: Manager

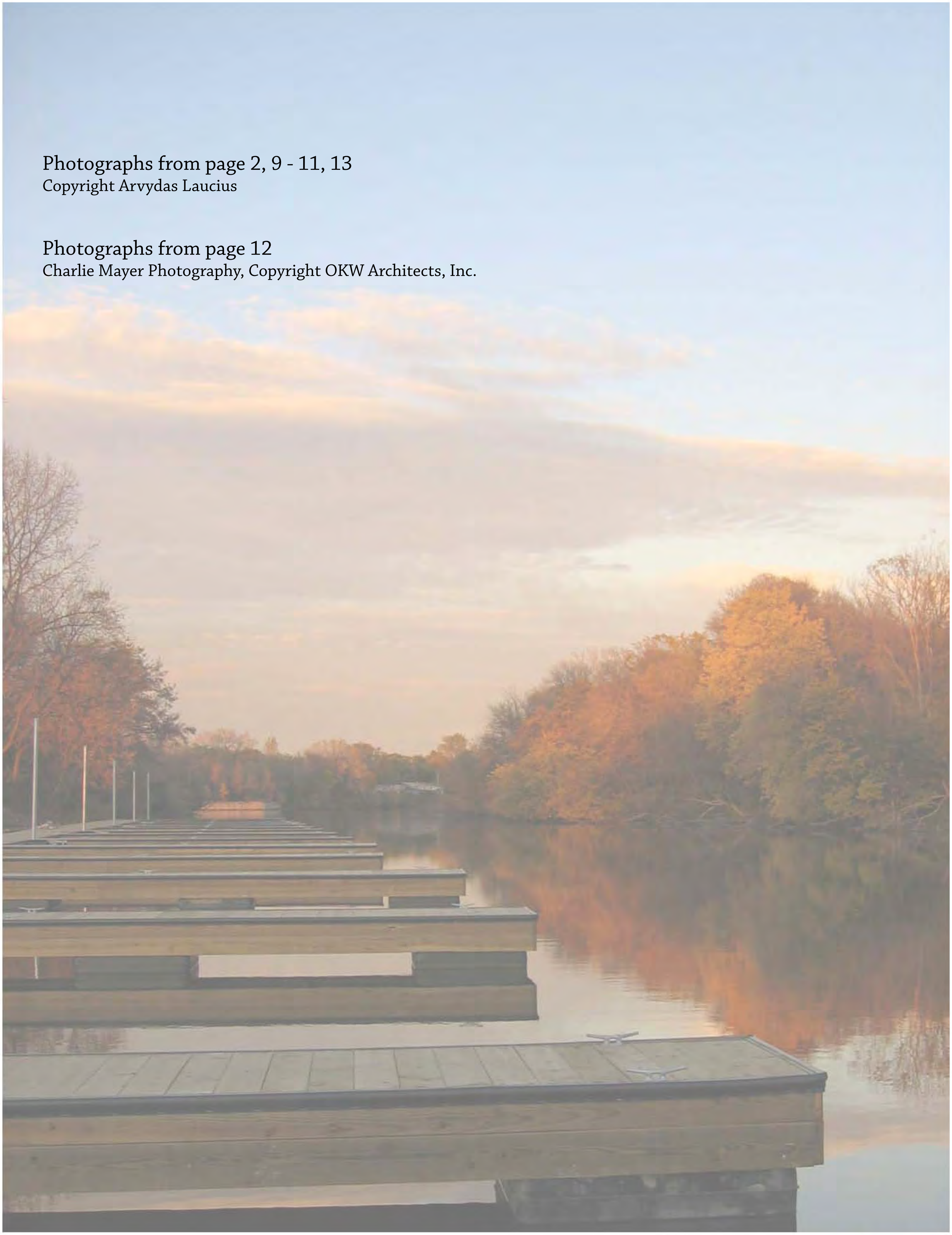
State of Illinois)
)
County of Cook)

I, the undersigned, a Notary Public in and for said County, in the State aforesaid, DO HEREBY CERTIFY, that personally known to me as Arvydas Laucius, Manager of Fay's Point, LLC., and personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person and severally acknowledged that as such Manager, he signed and delivered said instrument pursuant to authority given him by the Members of Fay's Point, LLC., as his free and voluntary act, for the uses and purposes therein set forth.

Given under my hand and official seal, this __ day of __________, 2006.

NOTARY PUBLIC

My Commission expires on _________, 200_



Photographs from page 2, 9 - 11, 13
Copyright Arvydas Laucius

Photographs from page 12
Charlie Mayer Photography, Copyright OKW Architects, Inc.

Attachment D

Images of Habitat Projects

Friends of the Chicago River

Electronic Filing - Received, Clerk's Office, 06/30/2011

Chicago River Fish Hotel—Downtown Chicago

Courtesy of WRD Environmental

Riverbank Neighbors —North Branch Restoration and fish lunker project

Courtesy of Riverbank Neighbors

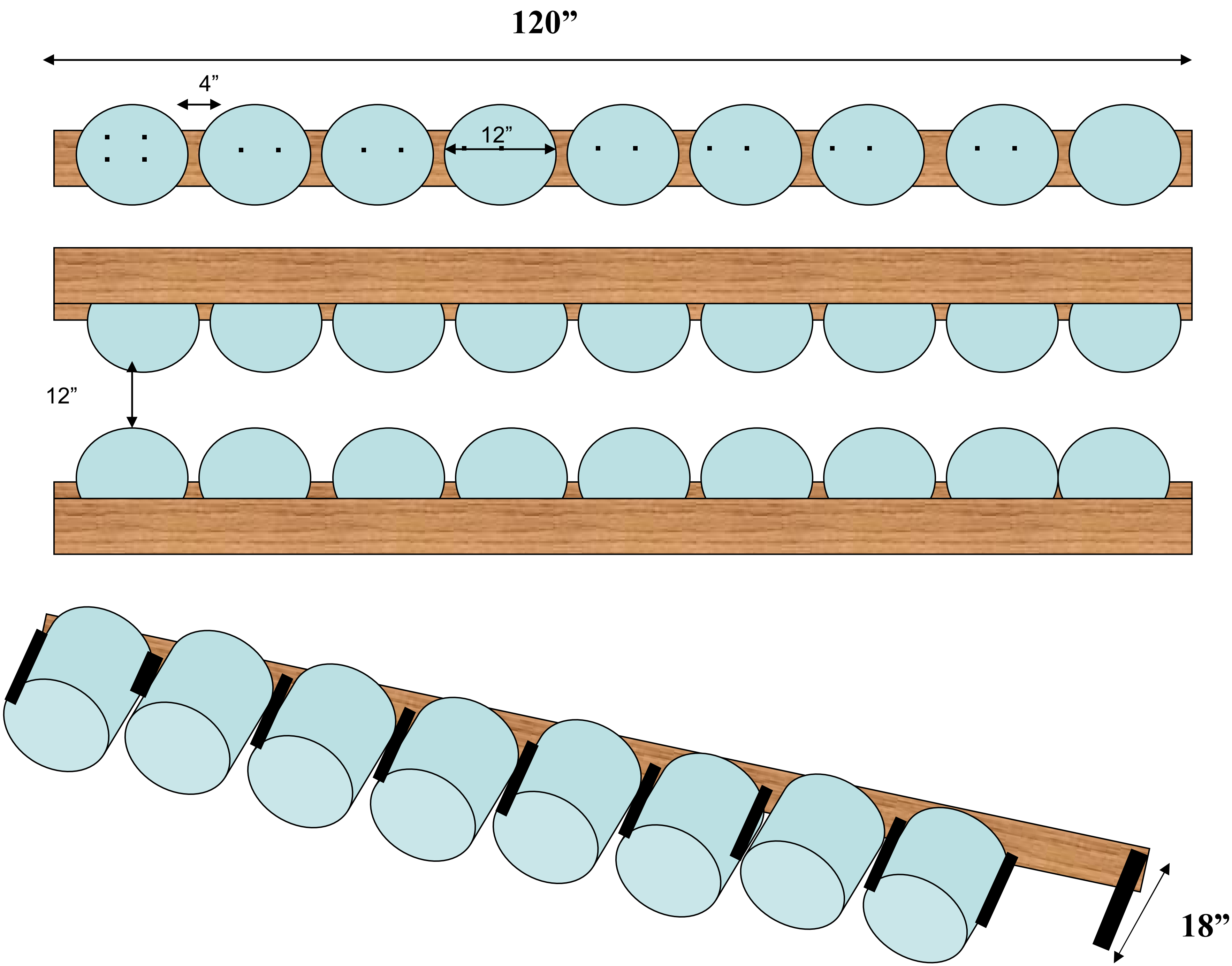
Floating Islands at Diversey Turning Basin

In partnership with the City of Chicago

Electronic Filing - Received, Clerk's Office, 06/30/2011

Plan for Downtown Habitat Project with IDNR

Plan for Downtown Habitat Project with IDNR



CERTIFICATE OF SERVICE

I, Albert Ettinger, hereby certify that I have served the attached **Testimony of Kimberly Rice** upon:

Mr. John T. Therriault
Assistant Clerk of the Board
Illinois Pollution Control Board
100 West Randolph Street, Suite 11-500
Chicago, Illinois 60601

via electronic filing on June 30, 2011; and upon the attached service list by depositing said document in the United States Mail, postage prepaid, in Chicago, Illinois on June 30, 2011.

Respectfully Submitted,

____
Jessica Dexter
Environmental Law and Policy Center
35 E. Wacker, Suite 1600
Chicago, IL 60601

DATED: June 30, 2011

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