Project	**Albany Park Stormwater Diversion Tunnel**
Applicant	Chicago Department of Transportation
Authorized Agent	MWH Americas, Inc.
County	Cook
Project Location	North Branch of Chicago River at Eugene Field Park and North Shore Channel at River Park Chicago, Illinois USACE Application No. LRC-2014-409

INCIDENTAL TAKE AUTHORIZATION

CONSERVATION PLAN FOR BANDED KILLIFISH (*FUNDULUS DIAPHANUS*)

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Section 1 PROJECT DESCRIPTION

The Chicago Department of Transportation (CDOT; the Applicant) proposes to alleviate overbank flooding issues from the North Branch of the Chicago River (NBCR) that impact Chicago's Albany Park neighborhood by constructing a large-diameter stormwater tunnel to divert a portion of flows during flooding conditions from NBCR to the North Shore Channel (NSC; Figure 1).

The proposed Albany Park Stormwater Diversion Tunnel would consist of the following elements:

- A 5,800 foot long, 18-foot finished diameter rock tunnel located generally under Foster Avenue, approximately 125-150 feet below grade;
- An inlet shaft with flow diversion structures at NBCR in Eugene Field Park, north of Foster Avenue and near N. Springfield Avenue;
- An outlet shaft and flow discharge facilities at NSC in River Park, south of Foster Avenue;
- Channel side-slope scour protection near inlet and outlet facilities;
- Facilities at the outlet shaft to dewater the tunnel following operation; and
- Site restoration.

The purpose of this project is to alleviate overbank flooding along the NBCR in the Albany Park neighborhood. There is a clear need for the project, as this neighborhood has experienced overbank flooding three times since 2008, damaging hundreds of structures and costing millions of dollars in repairs and clean up. The City of Chicago seeks to reduce the potential for future NBCR overbank flooding and associated damages in the Albany Park neighborhood.

When the water level in the NBCR rises following a storm event and exceeds the fixed weir height at the inlet structure, excess NBCR flow would be diverted into the stormwater tunnel. By diverting a portion of the river flow to the tunnel when the river rises, the NBCR reach that runs through the Albany Park neighborhood would be at a much smaller risk of overtopping its banks.

The tunnel, inlet, and outlet were designed based on detailed hydrologic and hydraulic modeling results. The tunnel would have a slight pitch to allow gravity flow toward the Outlet shaft. The system was designed to accommodate flows for up to a 1% annual chance storm event (the "100-year storm"). When the tunnel and shafts have filled, the system would function like an inverted siphon, passing approximately 2,300 cubic feet per second (cfs) of water through the diversion tunnel during the design event (and less flow for smaller events). After the event, water remaining in the tunnel would be pumped out at the outlet structure to the NSC.

The inlet and outlet structures would be equipped with trashracks with 4-inch open spacing. These trashracks would prevent people and large debris from entering the tunnel system. The inlet structure would also include two sluice gates, which would be equipped with trashracks with 2-inch open spacing and periodically used for maintenance purposes, but not for passing flood flows.

The inlet weir would overtop when NBCR flows reach approximately 600 cfs, which corresponds to a storm event with a 2-3 month recurrence interval. Therefore, 4-6 diversions would be anticipated per year during a "typical" year. In addition, when the system operates, backflow from the NSC into the outlet structure may occur during the initial tunnel filling stage if the NSC water level rises more quickly than the NBCR water level.

The inlet structure will be located on the "upper" NBCR, located upstream of the North Branch Dam (Figure 1). The North Branch Dam was constructed in the early 1900s and provides grade control between the "upper" NBCR and the dredged "lower" NBCR channel below the dam. It also acts as a fish barrier between the "upper" NBCR and the "lower" NBCR. The North Branch Dam is scheduled for removal in the next few years as part of a project being planned by the United States Army Corps of Engineers and the Chicago Park District. Consequently, permitting agencies have requested that permit documents for the Albany Park Stormwater Diversion Tunnel project include analyses of both existing conditions and of future conditions with the dam removed. This conservation plan addresses both existing conditions and future conditions with the dam removed.

Potential fish impacts have been analyzed and conservatively estimated (Appendix A). There are two points of entry to the tunnel system that may result in fish impacts: (1) entrainment at the Inlet structure during system operation and (2) entrainment at the Outlet site during a backflow event. All entrainment is conservatively assumed to result in fish mortality due to (a) a steep drop during initial filling, (b) rapid changes of hydrostatic pressure during tunnel operation, (c) passage through pumps during dewatering, or (d) survival during tunnel passage but predation due to disorientation when discharged into the NSC.

Section 2 CONSERVATION PLAN

The following Conservation Plan for impacts to banded killifish follows the IDNR's suggested outline, with the associated Illinois Administrative Code sections (17 IAC Ch. I, Section 1080.10) shown in parentheses in the headings below.

- This Incidental Take Authorization (ITA) request and conservation plan only apply to tunnel operation. Impacts to banded killifish are limited to direct entrainment impacts during system operation following large storm events. Indirect impacts to banded killifish (e.g., impacts to banded killifish habitat) are not anticipated.
- Project construction does not pose a risk to banded killifish. Tunnel construction will be performed from upland areas and will not impact banded killifish. Construction of the inlet and outlet structures will include some in-stream work, but is not anticipated to impact banded killifish.
- The requested permit duration is 100-years, equal to the estimated lifespan of the tunnel structure.

2.1 Area to be Affected (1.A)

The project site is shown on Figure 1. Site photographs are included in Appendix B. The inlet structure is located on the "upper" NBCR (above the North Branch Dam) and the outlet structure is located on the NSC. The populations of fish subject to entrainment are those that are present in the immediate vicinity of the inlet and outlet structures (Appendix A).

2.1.1 Inlet Site

The inlet site is located on a lens-shaped piece of land owned by the Chicago Park District, north of Foster Avenue, near the intersection with Springfield Avenue. The address for Cook County property identification number (PIN) 13-11-102-007 is 5205 N. Pulaski Avenue (even though no portion of the parcel is connected to Pulaski Avenue). The site is bounded by Foster Avenue to the south and the NBCR in all other directions. The legal description of the site is as follows:

> A subdivision of north half of Section 11, Township 40 North, Range 13, East of the Third Principal Meridian in Cook County Illinois.

2.1.2 Outlet Site

The outlet site is located in River Park on land owned by (1) the Chicago Park District or (2) the Metropolitan Water Reclamation District. Portions of the land owned by the Metropolitan Water

Reclamation District have been leased to the Chicago Park District. The addresses for the three PINs associated with the outlet site are 2907 W. Foster Avenue, 2921 W. Foster Avenue, and 3035 W. Foster Avenue. The Site located within an area bounded by Foster Avenue to the north, NSC to the west, and River Park to the east and south.

> A subdivision of the southwest quadrant of Section 12, Township 40 North, Range 13, East of the Third Principal Meridian in Cook County Illinois.

2.2 Biological Data (1.B)

2.2.1 Systematics

The banded killifish, *Fundulus diaphanus,* is a member of the topminnow family, Fundulidae (Page et al. 2013). The species is listed as state-threatened in Illinois (IESPB 2015). Formerly, two subspecies were recognized: the eastern banded killifish, *Fundulus diaphanu diaphanus*, and the western banded killifish, *Fundulus diaphans menona* (Trautman 1957, Scott and Crossman 1973, Smith 1979). These subspecies have been found to be races that recolonized the present species distribution area from the Atlantic and Mississippian glacial refugia, respectively (April and Turgeon 2006). The banded killifish is known to exhibit genetic variation within and among populations. Such variation has been found in the St. Lawrence River in response to hydrographic conditions (Rey and Turgeon 2007).

2.2.2 Distribution and Abundance

The banded killifish is widely distributed in the northeastern part of the United States, and the Maritime Provinces and Newfoundland in Canada (Lee et al. 1980). The species ranges from the coastal region of South Carolina north to the Maritime Provinces and Newfoundland, west through the northern portion of the United States and southern portion of Canada to the Yellowstone River in Montana. The eastern form is found to the east of eastern drainages in Ohio; the western form to the west of those drainages. An area of integration lies in the drainages of western Lake Ontario and the St. Lawrence River. Thus, in Illinois, only the western form is present (Smith 1979).

In Illinois, the banded killifish has been found in Greys Lake, Cedar Lake, Turner Lake, Wolf Lake and Loon Lake in Cook and Lake Counties; and, formerly, in McHenry and McLean Counties (Smith 1979). Rivera et al. (2013) reported the species was also found in Mill Creek (Rock River drainage) in Rock Island County. Tiemann et al. (2015) reported further range extensions for the banded killifish in Illinois based on recent collections stored as museum specimens. Those collections show the species is also found in Coon Creek (Rock River drainage) in Whiteside County; Pools 19 and 20 of the Mississippi River, Hancock County; and Sandy Creek (Illinois River drainage), Putnam County. Tiemann (Illinois Natural History Museum, personal communication) also reported the species was collected in the Cal-Sag Canal (Cook County) in 2015.

Additionally, the species has been recently found in isolated habitats in the Illinois River and Chicago River system as a result of collections for the Asian Carp Monitoring and Response Plan (MRRWG 2013, MRWG 2014 and 2015). In 2014, 51 banded killifish were collected by electrofishing, and an additional 227 specimens collected by fixed minnow fyke netting, downstream of the Electric Dispersal Barrier in the Illinois Waterway (Table 1 and Table 2, respectively). Upstream of the Electric Dispersal Barrier, 171 specimens were collected in 2014 (Table 3). From 2010 – 2014, a total of 1,106 banded killifish were collected upstream of the Electric Dispersal Barrier in the MRWG program (Table 4). Of the numbers collected in the area upstream of the Electric Dispersal Barrier, only 16 were collected in the vicinity of the Albany Park Stormwater Diversion Tunnel Project from 2011 – 2014 (Table 5), of which 9 were captured in 2014. Although present in the NSC and NBCR below the North Branch Dam, no banded killifish have been found in the NBCR above that dam (Appendix A).

2.2.3 Habitat

The habitat of the western form of the banded killifish consists of lakes, and quiet backwaters and sluggish reaches of medium to large streams having low gradients; in clear, shallow water with dense rooted aquatic vegetation and substrates of clean sand, sand/gravel, sand/mud, mud or organic debris, all free of silt (Trautman 1957, Becker 1983, Smith 1979, Ohio DNR Division of Wildlife website: http://wildlife.ohiodnr.gov/species-and-habitats/species-guide-index/).

Spawning and rearing habitat: The spawning and rearing habitat of banded killifish differs from the general habitat only at the microhabitat level. Spawning takes place in late spring and early summer near aquatic vegetation, with the fertilized eggs adhering to the vegetation (Smith 1979). After hatching, the larval banded killifish move towards the shore into shallower water, being found singly or in small numbers (http://fishbabies.ca/freshwaterspecies/fundiap.html).

2.2.4 Dispersal and Migration

The banded killifish is non-migratory and dispersal appears to be "quite limited" (Rey and Turgeon 2007). The species is usually found in small schools of 3-6 adults, and 8-12 younger individuals (COSEWIC 2014). The schools tend to remain in the same place (Rey and Turgeon 2007, COSEWIC 2014). Banded killifish reportedly remains in shallow water near dense vegetation during daylight hours, but moves into deeper water during the night, and likely moves into locally deeper water to overwinter (COSEWIC 2014).

2.2.5 Age and Growth

Becker (1983) reported that banded killifish reached an age of 3 years in Wisconsin. Trautman (1957) reported that young of the year western banded killifish were 0.8 inches to 2.2 inches in length; around 1 year old, they were 1.3 inches to 2.5 inches long; and adults were usually 1.5 inches to 2.8 inches in total length, with the largest specimen being 3.2 inches long. In Illinois, adults reach a maximum size of about three inches in total length (Smith 1979).

2.2.6 Diet

Banded killifish feed at all levels of the water column on a wide variety of aquatic organisms (Smith 1979). Keast and Webb (1966) reported the diet of juveniles consists of chironomid larvae, ostracods, cladocerans, copepods and amphipods. Adults also consume those species, but additionally consume nymphs, molluscs, tubellarians and crustaceans.

2.2.7 Ecological Importance

The banded killifish serves as a forage fish for gamefish and fish eating birds (Becker 1983). Banded killifish is also known to be a host in the reproductive cycle of the Eastern Elliptio (*Elliptio complanata*), a freshwater mussel widely distributed along the Atlantic Coast (Lellis, et al. 2013). Although the Eastern Elliptio is found as far west as the Lake Superior drainage (NatureServe 2015), it is not found in Illinois (Jeremy Tiemann, Illinois Natural History Museum, personal communication, June 1, 2016). However, banded killifish may also be a host for other species mussels (including other species of Elliptio).

2.2.8 Commercial Importance

Scott and Crossman (1973) reported that the banded killifish is used as a bait in recreational fishing, and is quite hardy. However, Becker (1983) noted that there were conflicting reports regarding the sensitivity of the banded killifish to handling, and, thus, its suitability as a bait fish. Nonetheless, Becker (1983), citing Cooper (1936), also reported that the species had been successfully propagated for use as a bait fish in a small pond in Michigan; and Jenkins and Burkhead (1993) reported that the banded killifish (presumably only the eastern subspecies) is raised in some areas for that purpose. It is assumed that banded killifish are not sold for bait in Illinois.

2.3 Activities Resulting in Taking Species and Numbers Taken (1.C)

Potential impacts to banded killifish will only occur during project operation due to entrainment. Impacts to banded killifish during construction are not anticipated. Impacts to banded killifish habitat are not anticipated.

2.3.1 Activities Resulting in Taking Species

In order to analyze how the Albany Park Stormwater Diversion Tunnel Project could impact banded killifish, the project was divided into three phases: (1) construction, (2) tunnel completed but empty, and (3) tunnel completed and operating following a storm event.

Construction. Impacts to banded killifish during construction are not anticipated. Shaft and tunnel construction will be performed from upland areas and will not impact banded killifish. Construction of the inlet and outlet structures will include some in-stream work, but is not anticipated to directly or indirectly impact banded killifish.

Tunnel Completed but Empty. After the project is constructed, the tunnel will be empty the majority of the time. There will be no impacts to banded killifish when the tunnel is empty and not operating.

Tunnel Completed and Operating Following a Storm Event. During operation, the Albany Park Stormwater Diversion Tunnel Project could entrain banded killifish into the diversion tunnel where they would likely suffer mortality. There are two points of entry to the tunnel system that may result in fish impacts: (1) entrainment at the Inlet structure during normal system operation and (2) entrainment at the Outlet site during a backflow event (i.e., if the NSC rises above the outlet weir height before the tunnel fills from the inlet end). Banded killifish could be entrained into the tunnel via the outlet under existing conditions, and, potentially, at the inlet under future conditions when the North Branch Dam is removed.

2.3.2 Estimated Number Taken

The number of fish entrained into the system each year will depend on the number of times the project operates. Detailed hydrologic and hydraulic modeling studies indicate that the NBCR water level will rise above the inlet weir during a storm event with a recurrence interval of approximately 2-3 months. Therefore, the system is anticipated to operate 4-6 times per year in a “typical” year.

In order to estimate the annual impacts on the fisheries resource and the number of banded killifish taken, the system was conservatively estimated to operate six times per year, consisting of five 1-year flood events and one 10-year flood event, with backflow occurring from the NSC into the outlet at each event. Backflow occurs when the NSC rises more quickly than the upper NBCR. Presently, banded killifish in the project area is only found in the NSC and NBCR below the North Branch Dam (Table 5, and Appendix A). Thus, the species could only enter the diversion tunnel via backflow under existing conditions. However, banded killifish would have access to move into the upper NBCR when the North Branch Dam is removed in the future, and also be subject to entrainment at the project inlet.

An analysis of the impact on banded killifish under the conservative operating conditions described above concluded that the project could potentially entrain one banded killifish via backflow each time the system operates (Appendix A). Thus, a total of 4-6 banded killifish could be entrained per year at the project outlet under existing conditions. If banded killifish moves into the upper NBCR after the North Branch Dam is removed, the species could also enter the diversion tunnel at the project inlet. Under the future condition scenario with the North Branch Dam removed, it was estimated that one banded killifish could also be entrained at the inlet each time the system operates, resulting in an additional 4-6 fish entrained at the inlet. Thus, with the North Branch Dam removed, a maximum total of 8-12 banded killifish could be entrained by the project per year.

2.3.3 Location of Suitable Habitat Impacted by Project

Construction and operation of the Albany Park Stormwater Diversion Tunnel will not directly or indirectly impact banded killifish habitat. Impacts to banded killifish will solely be due to direct entrainment impacts to individual fish during tunnel operation.

Habitat suitable for banded killifish is based on the habitat description provided in Item 1.B. above. In the NSC and NBCR, it would consist of quiet backwaters and sluggish reaches having low gradients; in clear, shallow water with dense rooted aquatic vegetation and substrates of clean sand, sand/gravel, sand/mud, mud or organic debris, all free of silt. The locations of such suitable habitat in the project area were estimated for the NBCR and NSC based on recent habitat data collected by MWRD (2013) and LimnoTech (2010), from a review of aerial photographs (GoogleEarth 2007), and site visits during 2015. In addition, personal communication with IDNR fisheries staff during the project permitting process also confirmed that aquatic beds are present upstream of the project outlet.

Table 6 provides a summary of the aquatic habitat present at the MWRD annual water quality monitoring sites, and identifies which sites likely contain suitable habitat for banded killifish. The locations of the sites are shown in Figure 2. In the NBCR above the North Branch Dam, habitat suitable for the banded killifish is likely present at Sites 103, 31 and 32 (Figure 2 and Table 6). The closest of these sites to the project is Site 103, which is located about 18 river miles upstream of the project inlet site (Table 7). Additionally, based on the aerial photos, as well as sampling results from the Asian Carp Monitoring Program, the locations of those segments of the NSC and NBCR below the North Branch Dam that likely contain suitable habitat for banded killifish are shown in Figure 3**.**

As shown in Figure 3, most of the NSC is estimated to possess suitable habitat for the banded killifish. This is supported by the collection of the species at IDNR Fixed Site 4, Fixed Site 5 and Random Site 4 (Table 5). The aerial photographs (GoogleEarth 2007) and 2015 site visits revealed an intermittent weedbed along the banks of the NSC upstream of the outlet site. This weedbed, which is located on nearshore shallow shelves of slumped earth from eroded channel slopes (Figures 4 and 5), is likely occupied by banded killifish. MWRD Site 101 (Figure 2) is located about 200 feet upstream of the project outlet and has aquatic vegetation that is part of the linear NSC weedbed. Aquatic vegetation has been observed near the outlet construction site, but it has not been observed within the project construction boundary. In-stream construction requires erosion control measures that must be approved by North Cook County Soil and Water Conservation District, thereby protecting nearby aquatic beds and nearby banded killifish habitat. Therefore, direct impacts to the existing weedbeds are not anticipated due to construction of the outlet structure.

Based on observations made during 2015, there is no suitable habitat for the banded killifish present within the NBCR along the lens-shaped inlet site parcel. The section of NBCR adjacent to the inlet site is channelized and vertical retaining walls are present along portions of both streambanks. In areas where retaining walls are not present, riparian trees are present on steep streambank slopes down to the normal water level. Near the inlet site, the NBCR channel is 40-50 feet wide at the normal water level, typical mid-summer water depths are approximately 2-4 feet, the mean channel flow is approximately 45 cfs, and mean velocity is approximately 2.5 feet per second. At six channel cross sections taken near the inlet site, soft silts ranged from 0.1 to 1.2 feet deep (mean depth was 0.5 feet). During site visits in 2015, MWH did not observe any aquatic vegetation or in-stream habitat structure in this portion of the NBCR. As such, none of the known habitat in the NBCR that is potentially suitable for banded killifish will be impacted by the project.

There is some in-stream large woody debris present in the NBCR near Gomper's Park, approximately ¼ - ½ river mile upstream of the inlet site, and the USACE has installed a series of three stone riffle structures along Eugene Field Park, approximately 800 feet downstream of the inlet site. However, aside from the aforementioned structure, the NBCR channel between Gompers Park and the North Branch Dam is lacking physical habitat structure and aquatic vegetation (Frank Viraldi, USACE, personal communication).

2.3.4 Timeline of Activities

The potential project impacts to banded killifish would only occur when the tunnel is operational. Construction is scheduled to begin in the late-spring of 2016 and to conclude approximately 24 months later. Therefore, impacts to banded killifish due to entrainment during project operation could first occur in the spring of 2018 and may continue for the lifespan of this passively operated stormwater diversion project. The lifespan of the project structure is estimated to be 100 years.

2.4 Explanation of Anticipated Adverse Effects (1.D)

Project impacts to fish, including banded killifish, were estimated (Appendix A) and the results were reviewed by IDNR. During a "typical" year, 4-6 banded killifish would be entrained and suffer mortality. Under the future condition with the North Branch Dam removed, during a "typical" year 8-12 banded killifish would be entrained and suffer mortality. Essentially, the tunnel will act like a minor predator of banded killifish, figuratively swallowing a few fish each year. The project is not anticipated to directly or indirectly impact banded killifish habitat.

During operation, the Albany Park Stormwater Diversion Tunnel Project could entrain banded killifish residing in the NBCR in the vicinity of the project into the diversion tunnel via the inlet (after the removal of the North Branch Dam) where they would likely suffer mortality as a result of dropping over 100 feet in the tunnel and experiencing pressure changes in the diversion tunnel during transit from the NBCR to the NSC. Banded killifish residing in the NSC in the vicinity of the outlet structure could also be entrained into the outlet via backflow at the start of an operation when the NSC rises faster than the NBCR and experience mortality by the drop into the tunnel. Fish entrained via the outlet would not experience pressure changes in the tunnel because they would exit the tunnel before it became pressurized. However, banded killifish exiting the tunnel at the outlet would be disoriented and subject to predation. Additionally, any fish remaining in the tunnel after the project ceases operation would be killed as a result of passing through the pumps removing remaining water from the tunnel.

As previously described, the system is anticipated to operate 4-6 times per year in a "typical" year. Based on the analysis that the project could potentially entrain one banded killifish via backflow each time the system operates, a total of 4-6 banded killifish could be entrained per year at the project outlet under existing conditions. Presently, there are no banded killifish in the NBCR above the North Branch Dam, and thus none in the vicinity of the project inlet. The species is found only in the NSC and the NBCR below the North Branch Dam under existing conditions. If banded killifish moves into the upper NBCR after the North Branch Dam is removed, the species could also enter the diversion tunnel at the project inlet. Under the future condition scenario with the North Branch Dam removed, it was estimated one banded killifish could also be entrained at the inlet each time the system operates, resulting in an additional 4-6 fish entrained at the inlet, and a total of 8-12 banded killifish entrained by the project per year.

It needs to be stressed that the estimated numbers of banded killifish potentially lost to entrainment is based on a "best guess" of the number of that species in the vicinity of the project; the assumed maximum swimming speed of adult banded killifish; and the proportion of flow diverted into the project during a flood event (Appendix A). Because there are no similar projects from which to base estimates of fish lost, obtaining those estimates required assumptions that may not be met, resulting in the estimated numbers being speculative. As described below, some assumptions likely resulted in an overestimate of the number of banded killifish in the vicinity of the project and the number entrained.

Based on sampling in the NSC during 2014, it was estimated that two banded killifish could be in the vicinity (within 30 meters) of the outlet during each flood event. Although the closest known potential banded killifish habitat in the NBCR above the North Branch Dam is approximately 18 miles upstream of the project inlet, it was assumed that the number of banded killifish near the inlet was the same as near the outlet (2) to account for fish that may be in the inlet reach of river.

The maximum swimming speed of adult banded killifish was assumed to be equivalent to the adult of another species of the same genus (*Fundulus heteroclitus*). The maximum swimming speed is, thus, only an estimate. However, because the estimated maximum swimming speed for adult banded killifish is considerably less than the velocity of water entering the outlet and inlet structures during each flood event, the species likely would be entrained via the velocities of the diverted flow.

Based on the available information, the location of banded killifish near the project during a flood event could not be known. To estimate the number of that species lost, it was assumed the proportion of the population near the outlet that would be entrained was equivalent to the proportion of the flow entering the project at that site. The process was the same for entrainment at the inlet. The diverted proportion of flow (always less than 1.0), applied to a banded killifish population of two at the outlet and the inlet, respectively, was rounded up to one at each site. However, it is very unlikely that the number of fish diverted into the project is proportional to the diverted flow because fish are not evenly distributed in the water column and, during flood events, remain on the bottom, or near cover, where they are not subject to strong currents. Consequently, the number of banded killifish entrained into the project each year (4-6 at each site) is likely an overestimate.

Finally, banded killifish may not readily move into the NBCR above the North Branch Dam after the dam is removed. As noted above, the species is non-migratory and dispersal appears to be “quite limited” (Rey and Turgeon 2007). Banded killifish have been found not to disperse to suitable upstream habitats in a watershed as a result of riverine conditions upstream of their existing location (Osborne and Brazil 2006, COSEWIC 2014). One such condition of relevance to the upper NBCR is a velocity barrier (such as a reach with strong currents or a rapids). As a consequence, banded killifish may not traverse the remains at the North Branch Dam removal site if conditions there are similar to those at the Hoffman Dam on the Des Plaines River (Photo 1), or the Blackberry Dam on Blackberry Creek in Yorkville (Photo 2). Thus, even with potential suitable habitat present upstream of the North Branch Dam, the species may not move into it when the dam is removed. If that occurs, there will be no entrainment at the project inlet.

Photo 1 – Hoffman Dam Removed
(Photo from: Forest Preserves of Cook County, New Life on the Des Plaines River: Hofmann Dam Removal Project, Oct 1, 2012; http://fpdcc.com/hofmann-dam-removal-project/)

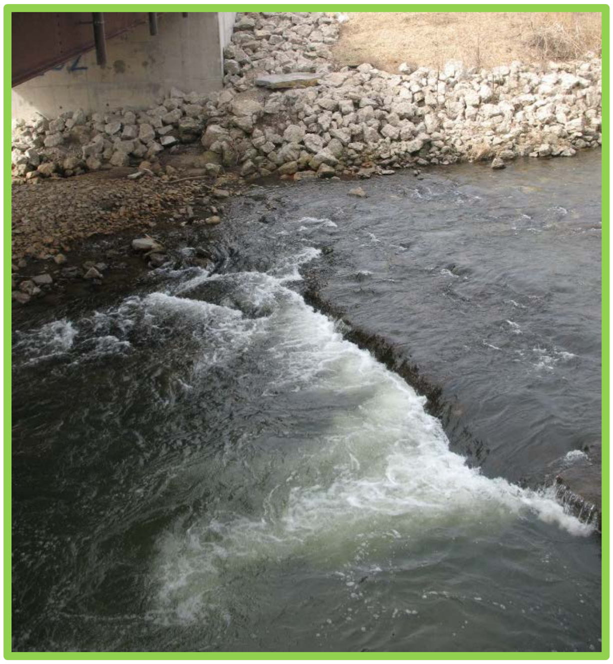

Photo 2 – Blackberry Dam Removed

Further, fish can be entrained only when the project operates. In years when flood flows do not overtop the inlet, or in years with little or no flooding (for example, in drought years), the project will not operate and no fish will be entrained. As a consequence, the total number entrained during such years will be fewer than the typical year estimate.

2.5 Minimize Impacts (2.A)

The proposed project may impact banded killifish during system operation by entrainment, but is not anticipated to impact banded killifish habitat. As described in Item 1.C, banded killifish habitat is not present in the vicinity of the inlet site and banded killifish habitat has not been observed within the immediate vicinity of the outlet site. However, there appears to be suitable habitat present throughout the NSC upstream of the outlet site (Figure 3). Since the potential impacts to banded killifish include direct impacts during project operation but do not include reduction of available habitat, efforts to reduce and minimize impacts to banded killifish focused on system operations.

The Illinois Administrative Code requires applicants to address three minimization goals:

Minimize Area Affected. This is not applicable. The inlet and outlet structures will not directly or indirectly impact banded killifish habitat, and the size of each structure does not affect the number of individuals that will be taken. The impacts to banded killifish are due solely to entrainment during project operation.

Minimize Amount of Habitat Affected. This is not applicable. Banded killifish habitat will not be impacted by the project.

Minimize Estimated Number of Individuals Taken. A number of ideas were analyzed for minimizing fish entrainment and these are discussed below in more detail.

The following items were analyzed by the design team as options for reducing or minimizing impacts to fish, and to the banded killifish in particular: (1) shallower tunnel, (2) frequency of operation, (3) reduce backflow at the outlet, (4) fish screen at the inlet, and (5) fish screen at the outlet.

2.5.1 Shallower Tunnel

With a tunnel at a shallower depth, the vertical drops and higher pressures that cause the majority of the estimated fish mortality would be decreased, potentially reducing fish kills. However, the tunnel depth was selected based on geology, avoiding conflicts with other underground utilities, hydraulics, constructability, and cost. A shallower tunnel is not a viable option.

2.5.2 Frequency of Operation

This project could be designed to keep a constant flow through the diversion tunnel, but the Applicant preferred to minimize the impacts to aquatic resources and only have the system operate intermittently. The design goal was to minimize the number of operations per year while still providing the hydraulic capacity required to alleviate overbank flooding during the 100-year storm event.

2.5.3 Reduce Backflow at Outlet

When hydrologic and hydraulic models revealed that the NSC can rise more quickly than the NBCR during some storm events, and starts filling the tunnel with backflow from the NSC, the design team limited the occurrence of NSC backflow events by raising the weir height at the outlet structure. The outlet weir height has been raised to its maximum height while still maintaining the required hydraulic capacity of the system, thereby minimizing impacts to fish in the NSC during backflow events.

2.5.4 Fish Screen at Inlet.

Incorporating a fish screen at the inlet was considered early in the project design phase. Screening options were compared and evaluated against project goals and limitations. The following key project goals and limitations are relevant the fish screening analysis:

a) **Passive Flow-Through System.** This flood protection system is intended to be passive. The Applicant does not want downstream flood protection to be contingent on human operators, valves, gates, mechanical systems, or extensive maintenance requirements. Since this is a passive flow-through system, the grate openings at the outlet structure should be equal to or larger than the openings at the inlet structure, so that any object entering the inlet can passively pass through the outlet.

b) **Range of Flows.** The inlet structure must function through a wide range of flows (approximately 100 - 2,300 cfs). A fish screen would also need to operate throughout that same range of flows.

c) **No New Dam.** Fish screening and associated fish bypass projects are often associated with dams. Long-term management goals for the upper NBCR include removal of existing dams. This project should not include construction of a new dam.

d) **Headloss.** Under the proposed project design, the hydraulic head during the design storm event (the difference in water levels at the inlet and outlet during a 100-year event) is approximately 8 feet, which is balanced by headloss at the inlet structure, tunnel, and outlet structure (i.e., there is no available hydraulic head). Any changes that increase headloss need to be balanced by increased hydraulic head.

Fish Screen Options. The design team considered the following common physical barrier fish screen options: (1) Vertical Flat Plate, (2) Inclined Flat Plate, (3) Travelling, (4) Drum, (5) Coanda, and (6) Eicher. Out of these screening options, the following options were removed from consideration:

- Screens with mechanical components (Drum and Travelling). These screens do not meet the criteria for a passive flood protection system.
- Screens not suited for high flows (Coanda and Travelling). These screens are typically used for flows an order of magnitude less than the 2,300 cfs design event flow. In addition, the

Coanda screen would require an off-stream fish bypass that, due to the flat topography of the surrounding area and low gradient of the NBCR, would be challenging to reconnect to the NBCR.

- Screens for closed conduits (Eicher). Eicher screens are used in closed conduits that are continuously full of water and are not applicable to this diversion tunnel project.

Flat Plate Screens. The remaining screen options, vertical or inclined flat plate screens, were evaluated in more detail. Fish survey data from the NBCR at Albany Avenue indicate that fish shorter than 3 inches in total length dominate the existing population. A screen with 2-inch open spaces, which is the size of fish screen typically suggested by IDNR, would not provide a physical barrier for the small fish that are most abundant in the upper NBCR. In order to exclude these small fish from the tunnel, the openings in vertical or inclined flat screens also need to be small, on the order of a few millimeters (i.e., a wedgewire screen).

To incorporate a screen with such narrow openings, the inlet design would need to be altered to maintain system hydraulics by either (1) lowering the inlet weir elevation or (2) increasing the length of the weir. Lowering the inlet weir height would increase the frequency of operation, and would conflict with the goal of minimizing the number of operations. Therefore, a longer weir would be required.

To maintain the hydraulic capacity of the system, an inlet structure equipped with a flat plate wedgewire screen would need to be approximately 3 times the length of the proposed inlet structure. There is not enough land available within the lens-shaped Chicago Park District parcel to include an intake weir of that length. The nearest parcel that could accommodate a weir of than length and protect the Albany Park neighborhood is upstream in Gompers Park, which would increase both the tunnel length and project expense by approximately 50%.

In addition, the small fish observed in the upper NBCR have maximum, critical, or burst speeds that, for the most part, are less than 2 feet per second (Appendix A). Maintaining velocities at the face of an approximately 600-foot-long curving wedgewire screen to be less than 2.0 feet per second would be difficult.

The designers were also concerned that a wedgewire screen would become clogged with debris and would require intensive maintenance. When a flat plate wedgewire screen is used for an intake, the design typically includes a mechanical cleaning system to maintain the hydraulic characteristics of the screen. Keeping the screen free of debris would be especially important during operation of the diversion tunnel system, when it would not be feasible to manually clean a screen or to repair a damaged cleaning system. A clogged screen would reduce the hydraulic capacity needed to provide the Albany Park neighborhood with the intended flood reduction and would increase velocities at the face of the screen, potentially increasing fish impingement.

Overall, to protect the small fish observed in the upper NBCR from entrainment, a vertical or inclined flat plate screen with very small openings (e.g., a few millimeters) would be the preferred screening option. To maintain system hydraulics, a much longer intake structure would be required and would not fit on the current intake site parcel of land. A wedgewire (or similar) screen would require routine cleaning, which is typically performed by a mechanical system. The combination of these factors led the designers to conclude that a physical barrier fish screen that protects the small fish that are most abundant in the upper NBCR would not be a viable alternative. As a result, the team designed the project screening system to maximize the size of the grate openings while still keeping people and large objects from entering the tunnel. The designers selected 4-inch open spacing for the inlet structure.

2.5.5 Fish Screen at Outlet

Fish screening at the outlet structure was also considered during the design phase. The very conservative June 2015 fish impact analysis (Appendix A) assumes that each time the system operates, the NSC will rise above the outlet weir height before the tunnel fills with water from the inlet. This NSC backflow is estimated to last 30 minutes for each event, regardless of rainfall intensity, with approach velocities at the outlet grate increasing over the course of the 30-minute backflow event and peaking at 4.3 feet per second.

The June 2015 fish impact analysis estimated that 1 banded killifish fish would be entrained per event. However, it should be noted that this is likely an overestimate based on the short 30-minute duration of a backflow event and that backflow events are unlikely to occur every time the project operates.

The banded killifish is a small fish with a low escape velocity. To protect it from entrainment, a screen with open spacing of a few millimeters and approach velocities less than 1.0 feet per second would be required. To accommodate these specifications, the outlet structure would need to be several times larger than the existing design. In addition, since the screen open spacing at the outlet structure needs to be equal to or greater than the open spacing at the inlet structure, as previously described, an inlet structure with similarly narrow screen spacing would need to be approximately three times longer to maintain system hydraulics.

Given the short duration of the backflow events and the expense of increasing the sizes of both the outlet and inlet structures, the design team concluded that a physical barrier fish screen that protects the banded killifish from entrainment would not be a viable alternative. Consequently, the design team selected 4-inch open spacing for the outlet structure to match the grate openings at the inlet structure.

2.6 Management Plan (2.B)

The project will not impact banded killifish habitat, and therefore, a habitat management plan has not been prepared.

The stormwater diversion tunnel project operates passively and is not anticipated to impact existing banded killifish habitat. There is no existing habitat near the inlet site and there is habitat available upstream of the outlet site in the NSC. Neither construction nor operation of the tunnel is anticipated to impact habitat availability in the NSC. Therefore, a habitat management plan for the NSC near the outlet structure and the NBCR near the inlet structure is not necessary.

2.7 Proposed Mitigation Measure (2.C)

The Applicant proposes to mitigate for the potential loss of entrained banded killifish by providing a one-time in-lieu compensatory mitigation payment of $26,000 to the Illinois Wildlife Preservation Fund, earmarked for the conservation benefit of the banded killifish.

IDNR utilized an aquatic mitigation scaling tool to assess a rough estimate of where “mitigation to the maximum extent practicable” (as prescribed by the Illinois Endangered Species Protection Act) fell for the proposed Albany Park Stormwater Diversion Tunnel project. In consideration of the potential project impacts with the awareness that this is an operational ITA, which may extend to 100 years; mitigation for the potential taking of the banded killifish was scaled to $26,000, or the equivalent of a one-year fish propagation project. The compensatory mitigation payment will be placed in the Illinois Wildlife Preservation Fund earmarked to support conservation benefit of the species potentially impacted.

Mitigation for other fish species. The Applicant has proposed measures to mitigate for the estimated loss of other fish species as part of an approved USACE permit. These measures include fish stocking and installation of in-stream habitat structures, including riffles and boulder clusters upstream of the inlet site. These stocking and instream habitat structures are not anticipated to impact banded killifish and will not create banded killifish habitat.

2.8 Monitoring (2.D)

The Applicant will use fish monitoring data collected by MWRD and/or IDNR to summarize the presence of banded killifish in the NBCR and NSC.

The NSC and NBCR in the vicinity of the project have been monitored for many years by IDNR and the MRWD (Appendix A). MWRD plans to continue their long-term fish monitoring efforts for the foreseeable future in the NSC and NBCR (personal communication, Jennifer Wasik), and presumably the IDNR will continue their aquatic resource monitoring program. The Applicant will request fish collection data from MWRD and IDNR every 5 years, and use data collected at monitoring sites nearest the inlet and outlet site for analysis. This reporting frequency is equal to the reporting frequency required in the USACE permit mitigation plan. The Applicant will submit a brief letter report to the IDNR every 5 years for the duration of the permit, summarizing the abundances of banded killifish collected by the two agencies.

2.9 Adaptive Management Measures (2.E)

The Applicant proposes the following adaptive management measures to deal with changed or unforeseen circumstances that affect the effectiveness of measures instituted to minimize or mitigate the effects of the proposed action on the banded killifish:

1. If the monitoring results indicate that banded killifish abundances are distinctly different from the estimates provided in this application, the Applicant will consult further with IDNR on adaptive mitigation measures. However, since this is a passively operating system, the opportunities for adaptive management of system operation are very limited.
2. If both IDNR and MWRD discontinue their fish monitoring programs, the Applicant will consult with IDNR regarding an acceptable replacement monitoring plan.
3. If the system operates at an average annual frequency over a period no shorter than 5 years that is distinctly different from the operational frequency included in this application, the Applicant will consult further with IDNR to determine if mitigation measures are still adequate.

2.10 Funding (2.F)

The implementing agreement (Item 5) includes a line verifying that the Applicant has funding available to support and implement the mitigation activities described in this conservation plan.

2.11 Alternative Actions (3)

Prior to selecting the diversion tunnel option, the Applicant considered alternatives for meeting the project purpose of alleviating overbank flooding from the NBCR in the Albany Park neighborhood.

2.11.1 Alternatives Considered, But Dismissed

Some alternatives considered were dismissed early in the process as being ineffective, too costly, and/or having unacceptable environmental and/or social impacts. These dismissed alternatives include:

- **Ridgeway Bridge Modification –** This alternative involves modifying a bridge that is a known hydraulic restriction on the NBCR channel in the Albany Park neighborhood. A review of hydraulic models revealed that the extent of benefit would be limited to a few blocks immediately upstream and to about a one-foot reduction in water surface level at the 100-year flood elevation.
- **Modifying the North Branch Dam –** Removal or modification of dam would not, by itself, adequately reduce flood elevations in the Albany Park neighborhood. The hydraulic capacity of the NBCR upstream of the dam would also need to be increased by lowering the channel invert by several feet (e.g., by dredging). Lowering the channel invert would likely destabilize the existing streambanks and a structural analysis of existing infrastructure near the stream (e.g., roads, bridges, and buildings) would need to be performed. Dam removal, dredging, and structural reinforcement to streambanks together were too disruptive to consider in more detail. In addition, the Applicant did not want to take on the risk of potential impacts and costs associated with structural improvements to existing infrastructure located adjacent to the channel.
- **Construction of Upstream Flood Storage Reservoir –** Upstream flood storage reservoirs with 25-year and 100-year flood capacities were considered. The 100-year flood capacity reservoir would likely reduce flood elevations in the Albany Park neighborhood significantly, but the costs for the reservoir and appurtenant structures (floodwalls, levees, modifications to roads and other infrastructure) were too high ($116 -260 million) and an adequate site for the large project footprint was never identified in the detailed watershed plan.
- **Green Infrastructure –** The design team considered the use of green infrastructure in the NBCR watershed upstream of the North Branch Dam, but dismissed the option based on high cost and the inability of green infrastructure to adequately reduce overbank flooding for the design event (1% annual chance storm event). While green infrastructure has numerous benefits, even a highly aggressive green infrastructure plan implemented throughout the 109.4 square miles of NBCR watershed above the North Branch Dam would not meet the project objective of alleviating overbank flooding problems in the Albany Park neighborhood. Using Milwaukee’s Green Infrastructure plan for a rough cost comparison, the implementation of watershed-wide green infrastructure plan with a goal of capturing the first 0.5 inch of stormwater falling on impervious surfaces throughout the upper NBCR watershed would cost between $0.65-1.1 billion. This level of stormwater runoff reduction would have very little impact on overbank flooding in the Albany Park neighborhood and would cost at least one order of magnitude more than the proposed stormwater diversion tunnel project.

2.11.2 Alternatives Considered

Four project alternatives, plus the no-action alternative, were analyzed in more detail. Alternatives (b), (c), (d), and (e) would not result in the taking of banded killifish.

a) Constructing a Stormwater Diversion Tunnel – Proposed Action

A stormwater diversion tunnel would be provide supplemental conveyance capacity and reduce flood levels within the Albany Park neighborhood. The project would include some impacts to waters of the U.S. Minor excavation and fill activities below the ordinary high water mark (OHWM) in the NBCR and NSC would be required. This alternative would be expensive (~$60 million). There would be little visual impact, since most of the infrastructure would be located underground.

b) Constructing Floodwalls along the NBCR

This alternative, which was considered in the NBCR Detailed Watershed Plan (DWP; HDR 2011), would construct floodwalls (up to the mapped FEMA 100-year floodplain elevation) along the south bank of the NBCR between the upstream Foster Avenue crossing (east of Pulaski Road) and Kimball Avenue, and along the north bank of the NBCR between Monticello Avenue and Kimball Avenue.

The NBCR Floodwalls Alternative would be effective in reducing flood damage within the Albany Park neighborhood, but would require significant land acquisition and would generate significant impacts during construction. The project would include some impacts to waters of the U.S. Excavation and fill activities would be required in the NBCR below the OHWM. This alternative would increase water surface elevations during flood events for a few hundred feet downstream of the walls, requiring flood-proofing of vulnerable properties in this area. Modification of existing storm sewer outfalls to the NBCR would also be required to eliminate pathways for floodwater to move beneath the floodwalls. The Applicant objected to the Floodwalls Alternative due to the extensive construction requirements on numerous individual properties, the long-term impacts (including visual impacts) it would have on properties within the Albany Park neighborhood, and the floodwall's isolating effects on the NBCR corridor.

c) Flood-proofing Vulnerable Structures

Approximately 336 structures in the Albany Park neighborhood have been identified as being vulnerable to overbank flooding during the 100-year event (HDR 2011). This alternative would provide provisions to individually flood-proof vulnerable structures on these properties. Flood-proofing efforts could include constructing a wall or berm surrounding the structure with sliding gates or stoplogs at access points, reinforcing basement windows, installing gates in exterior doorframes, installing pumps, and adding backflow protection. Individual flood-proofing measures would not likely impact waters of the U.S. and would not likely require excavation or fill activities in the NBCR below the OHWM. The reliability of many individual flood-proofing measures (e.g., installation of stoplogs in doorways) requires actions to be taken by property owners. These owners may be unwilling or unable to take these actions when necessary. Individual flood-proofing measures would not prevent the need for evacuations during extreme flood events, nor would they prevent surface flooding of streets or basement flooding caused by the entry of floodwaters into local sewer systems. Lastly, the use of public funds for individual flood-proofing measures would set a precedent that may not be acceptable to the City of Chicago. Therefore, this alternative is believed to provide an ineffective solution to flooding problems in the Albany Park neighborhood.

d) Buying-out Vulnerable Properties and Demolishing Vulnerable Structures

As described above, approximately 336 structures in the Albany Park neighborhood have been identified as being vulnerable to overbank flooding during the 100-year event (HDR 2011). Under this alternative, the City of Chicago would purchase these properties, demolish the structures located there, and create open space with naturalized floodplain conditions. Such measures would not likely impact waters of the U.S and would not likely require excavation or fill activities in the NBCR below the OHWM. Typically, buy-outs are used as a last resort where the costs of chronic flooding are shown to exceed the value of the vulnerable properties and/or the creation of open space within the floodplain has additional benefits. Implementation of the Buy-out Alternative would be effective in reducing flood damages, but would be very costly and would adversely affect the social fabric of the Albany Park neighborhood. The use of public funds for buy-outs would set a precedent that may not be acceptable to the City of Chicago. Therefore, this alternative is believed to an unacceptable solution to flooding problems in the Albany Park neighborhood.

e) No Action

The no action alternative would not address overbank flooding issues in the Albany Park neighborhood, and would not meet the project objective.

2.12 Impact on Likelihood of Survival (4)

The proposed action will not reduce the likelihood of the survival of banded killifish in the wild in Illinois, the biotic community to which banded killifish belongs, nor the habitat essential for the species' existence in Illinois.

2.12.1 Distribution of Banded Killifish and the Biotic Community Affected by the Project

The distribution of the banded killifish in Illinois is described in Item 1.B above. The portion of the distribution considered to be the biotic community of which the species is a part consists of the population in the Illinois River system. With respect to the project, the portion of the population above the electric dispersal barrier near Lockport will be primarily affected. Although gene flow in this species throughout the Illinois River system is likely, it will be most frequent among those fish above the dispersal barrier.

2.12.2 Existing Conditions

Presently, the banded killifish is found in the NSC, and the NBCR downstream of the North Branch Dam in the vicinity of the project, as well as in Lake Calumet, the Calumet River, the Little Calumet River, the Cal-Sag Channel, and the South Branch of the Chicago River above the dispersal barrier in the Illinois River (MRWG 2015). The number of banded killifish collected in these reaches in 2014 is provided in Table 3. Downstream of the dispersal barrier, the banded killifish was collected in the Illinois River pools at Lockport, Brandon Road, Dresden Island and Marseilles (MRWG 2015), and the numbers collected at these sites during 2014 given in Tables 1 and 2.

As previously described, it was estimated that one banded killifish would be lost via entrainment at the tunnel outlet as a result of backflow from the NRC each time the project operated. Because there are no banded killifish in the NBCR above the North Branch Dam, none would be entrained at the project inlet. Assuming the project would operate 4 – 6 times during a typical year, a total of 4 – 6 banded killifish would be lost each year.

As shown in Table 4, 465 banded killifish were collected in the Illinois River system above the electric dispersal barrier in 2013, whereas 171 were collected in 2014. The reduction in the number collected during 2014 is the result of a reduction in sampling effort above the barrier to enable additional sampling effort below the barrier (MRWG 2015). The intensive sampling efforts used in 2010 – 2013, with monthly samples during March through December, was reduced in 2014 to two sampling events during June and another two in September. The reduction in sampling effort from 10 days in 2013 to 4 days in 2014 resulted in the reduced number collected in 2014. The number of banded killifish collected above the barrier increased each year from 2010 to 2013 (Table 4). Thus, had the intensive sampling program continued in 2014, the number of banded killifish collected above the electric dispersal barrier in that year likely would have been at least in the 400s, and quite possibly greater.

The loss of 4 – 6 fish in a population of over 400 will not likely reduce the survival of banded killifish in the Illinois River system above the electric dispersal barrier. Further, although the actual size of the population of banded killifish in the Illinois River system above the barrier cannot be determined from available data, it can be safely assumed that the total population exceeds the 465 fish collected in 2013. Thus, the impact on the banded killifish population above the barrier is even smaller.

During 2014, MRWG (2015) collected the following numbers of banded killifish in the Illinois River/Chicago River systems: 171 in the seasonal intensive sampling above the electric dispersal barrier (Table 3); 51 in the fixed and random electrofishing samples (Table 1), 227 in the fixed minnow fyke netting (Table 2), and 84 in the random sampling for small Asian carp below the barrier; and 1 as part of the maintenance of the barrier. Thus, a total of 534 banded killifish were collected in the

Illinois River/Chicago River community in 2014. The total population of banded killifish in the Illinois River/Chicago River system is undoubtedly much greater than the numbers in these sampling results. Consequently, it is reasonable to assume that the loss of 4 – 6 fish each year at the project outlet will not likely reduce the survival of the banded killifish in the State of Illinois, nor in the biotic community of which the species is a part.

2.12.3 Future Conditions

The North Branch Dam on the NBCR is to be removed in the future. Under those conditions, it will be possible for the banded killifish to disperse into the upper NBCR. This would expand the distribution of the species beyond present conditions, and result in an increase in the number of banded killifish in the Chicago River system above the electric dispersal barrier. The extent of the increase cannot be predicted because the number of fish entering the upper NBCR cannot be known, and the capacity of upstream habitats to support the increased population is unknown.

If the species moves into the upper NBCR and is in the vicinity of the project inlet, it may get entrained at that site during project operation. For the hypothetical analysis of the number of fish entrained at the inlet under such conditions, it was assumed that one banded killifish would be lost via entrainment at the inlet site each time the project operated. For a typical year, in which the project operates 4 – 6 times, a total of 4 – 6 banded killifish would be lost at the inlet each year. Including those lost at the project outlet, the cumulative total entrainment loss would be 8 – 12 fish per year. Assuming the size of the future population of banded killifish in the Illinois River system remains at the same level as in 2014 (well over the 465 fish collected above the electric dispersal barrier in 2013, and the 534 collected in the Illinois River/Chicago River systems in 2014), the loss of 8 – 12 fish is unlikely to reduce the survival of the banded killifish in the reach of river above the electric dispersal barrier, or in the State of Illinois, or in the biotic community of which the species is a part.

Additionally, there is even less likelihood that the survival of banded killifish would be reduced under the future conditions with the North Branch Dam removed with the estimated loss of 8 – 12 fish per year. It is quite likely the species will not be in the vicinity of the project inlet during any flood event. As such, it would not get entrained.

As previously noted, it is questionable whether banded killifish would traverse the remains of the North Branch Dam after its removal. Based on distribution patterns elsewhere, there is a reasonable possibility that the remains of the North Branch Dam will result in a velocity barrier that banded killifish will not cross. Further, the habitat near the inlet is not suitable for banded killifish. Because the closest known suitable habitat is 18 miles upstream of the inlet (Figure 2, Tables 6-7), the species would not likely be present in the reach of river at the project site should the species enter the portion of river above the dam.

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Section 4 IMPLEMENTING AGREEMENT (5)

The City of Chicago Department of Transportation shall be responsible for fulfilling the obligation of the approved conservation plan.

Proposed Data Analysis and Report Schedule

Task	**Schedule**
Year 1 – Project Operation Begins	2018
Year 5 – Request fish monitoring data from MWRD and IDNR; Prepare letter report[1], which will include a summary of banded killifish abundance and will address adaptive management measures	2023
Year 10 – Report[1] (see Year 5 description)	2028
Year 15 – Report[1] (see Year 5 description)	2023
Year 20 – Report[1] (see Year 5 description)	2028
Year 25 – Report[1] (see Year 5 description)	2033

[1] Reports shall be prepared and provided to IDNR by January 30th.

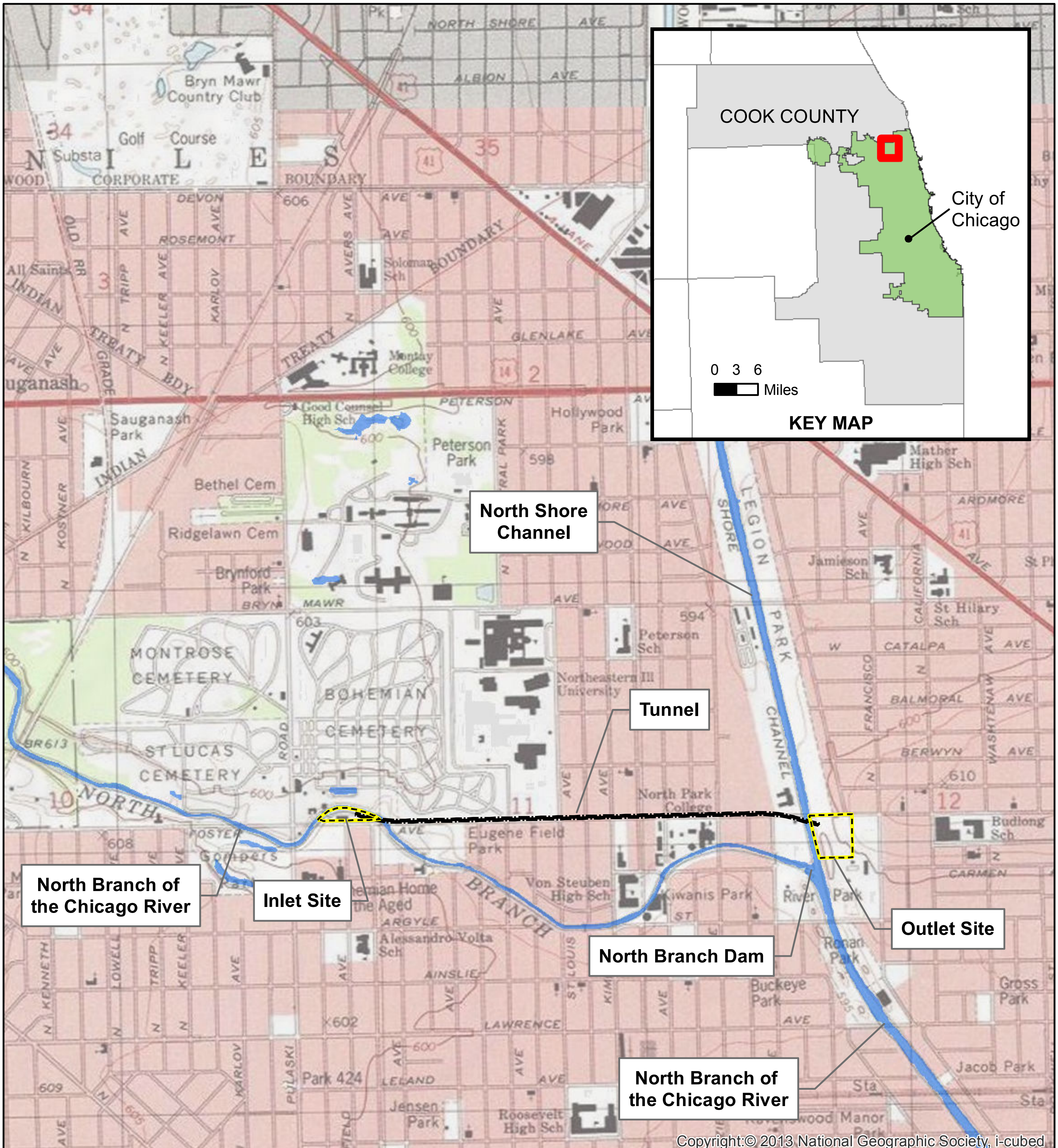
Application is hereby made for authorizations for the activities described herein. I certify that I am familiar with the information contained in the application and that I possess the authority to undertake the proposed activities. I further certify that to the best of my knowledge and belief, such information is true, complete and accurate and that the proposed actions, including those described in the conservation plan herein, will be executed in compliance with all other federal, State, and local regulations pertinent to the proposed action and to execution of the conservation plan. I also verify that adequate funding is available to support and implement the mitigation activities described in this conservation plan. No other federal authorizations for taking have been issued to the City of Chicago.

Daniel Burke ____________________ 9/23/16 ____________

(Signature of Applicant or Authorized Agent) *(Date)*

Dan Burke
Deputy Commissioner, Chicago Department of Transportation, Division of Engineering

Figures



Legend

Project Boundary

Tunnel and Shafts

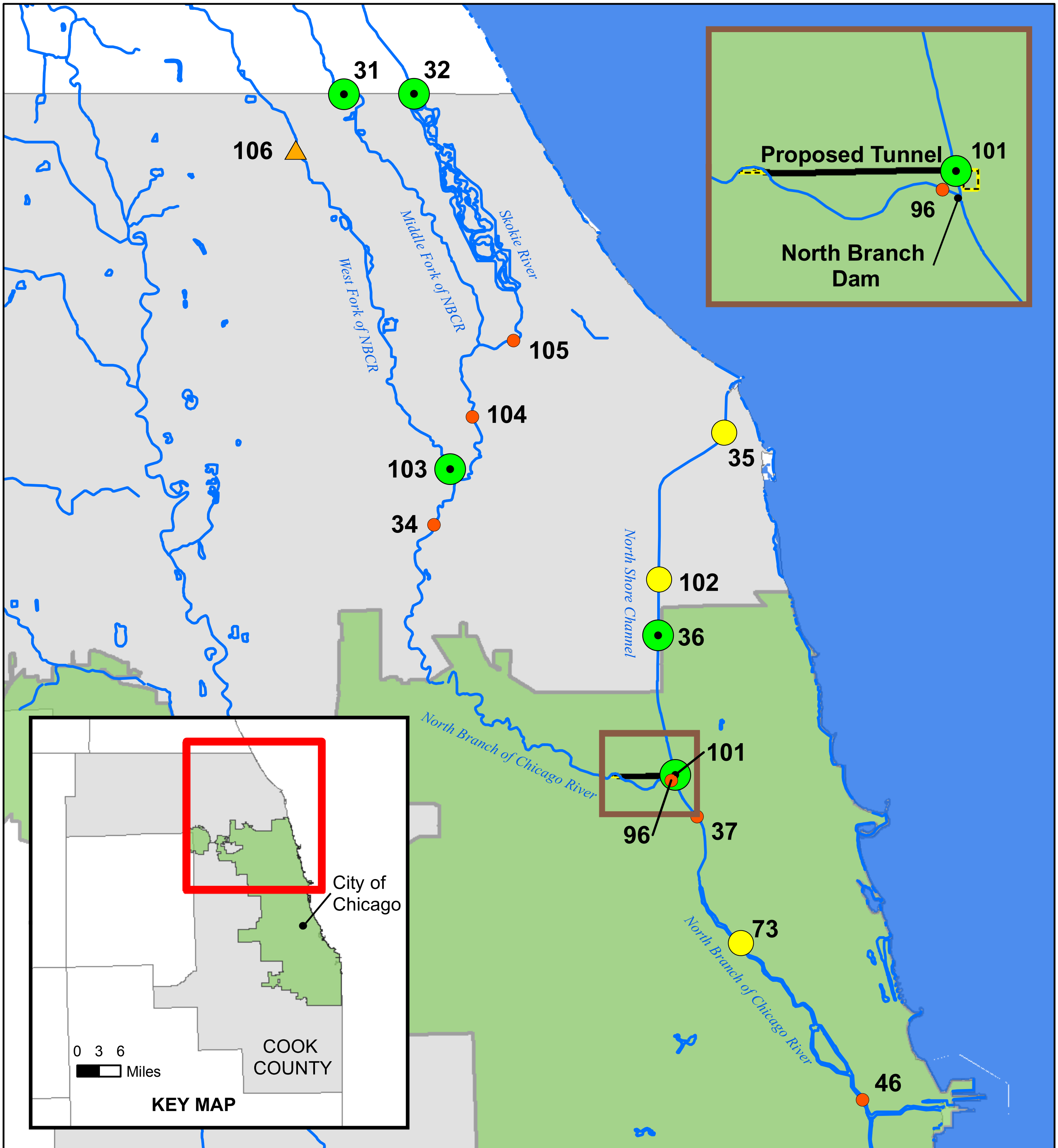
N

0 0.25 0.5 0.75 1 Miles

Figure 1
Location Map
Albany Park Stormwater
Diversion Tunnel
Cook County, Illinois

MWH

March 2016



Legend

Banded Killifish Habitat Presence at MWRD AWQM Site

- Yes
- Possible
- Questionable
- No

For additional details, see Table 6.

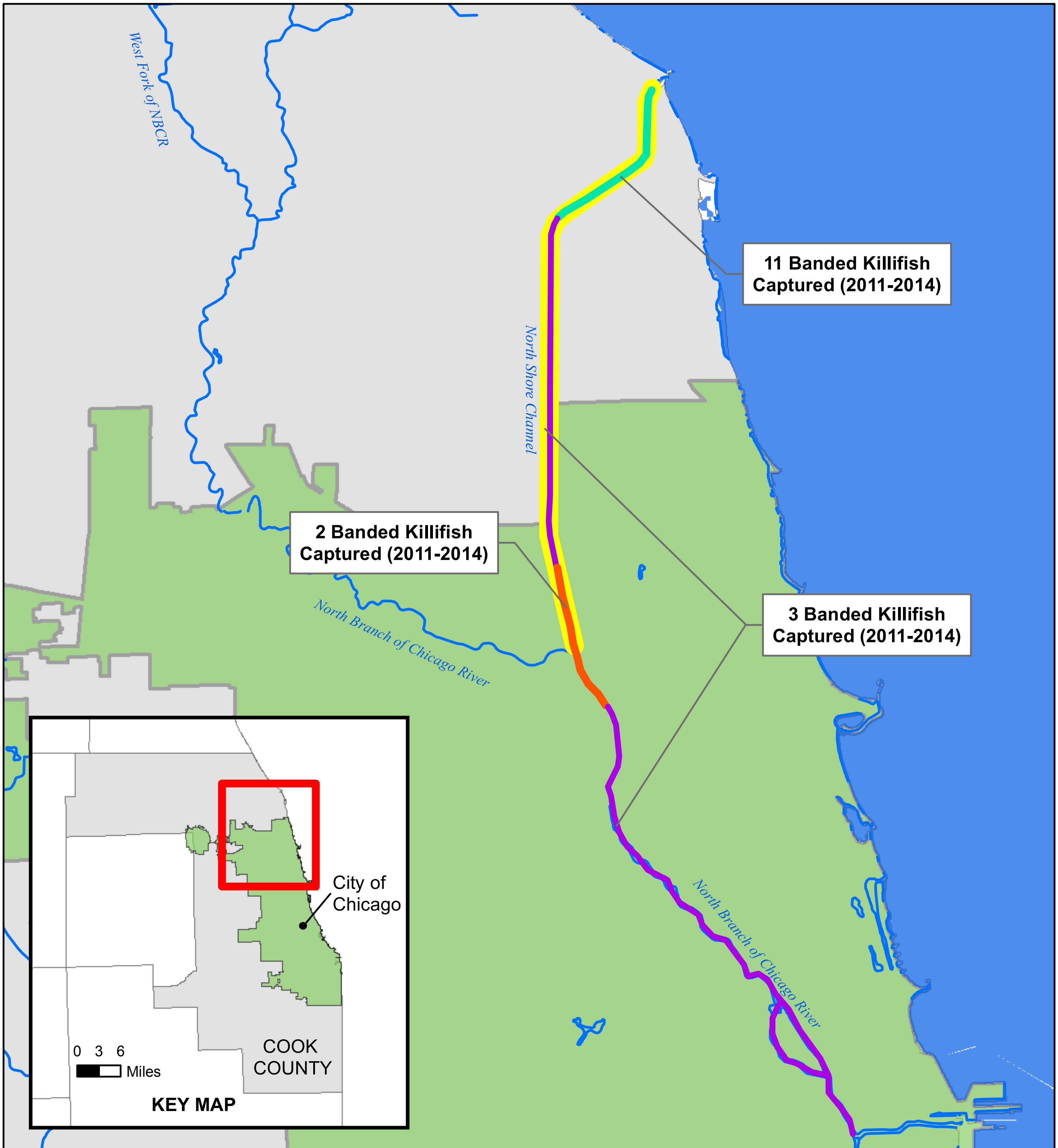
N

0 1 2 4

Miles

Figure 2
Existing Banded Killifish Habitat at MWRD AWQM Sites
Albany Park Stormwater Diversion Tunnel
Cook County, Illinois

MWH March 2016



Legend

Potential Banded Killifish Habitat (Aquatic Vegetation Beds Present)

ACMP Monitoring Site

Fixed Site 4

Fixed Site 5

Random Site 4

For additional details, see Table 5.

N

0 0.5 1 2

Miles

Figure 3
Existing Banded Killifish Habitat at ACMP Sampling Sites
Albany Park Stormwater Diversion Tunnel
Cook County, Illinois

MWH March 2016

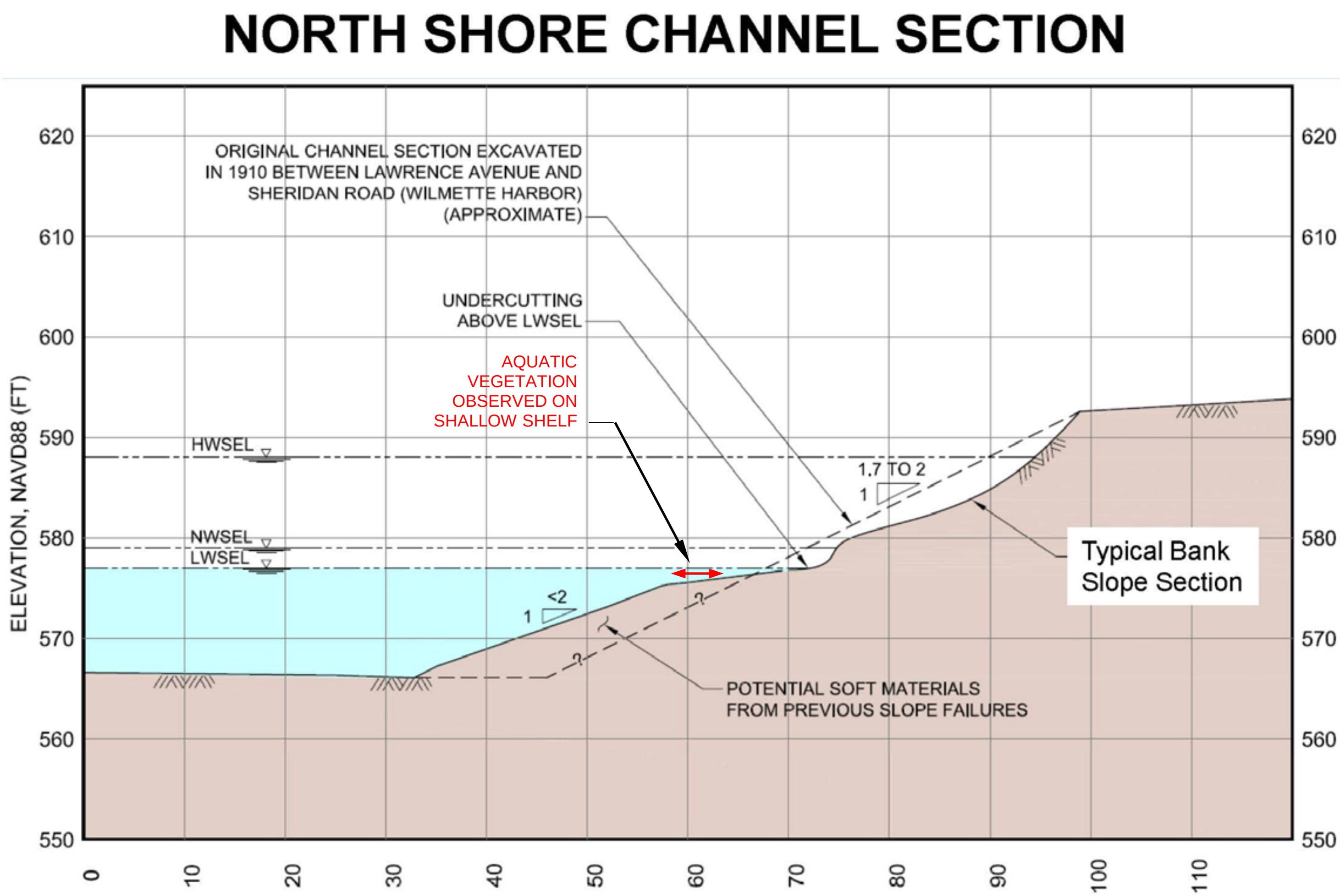
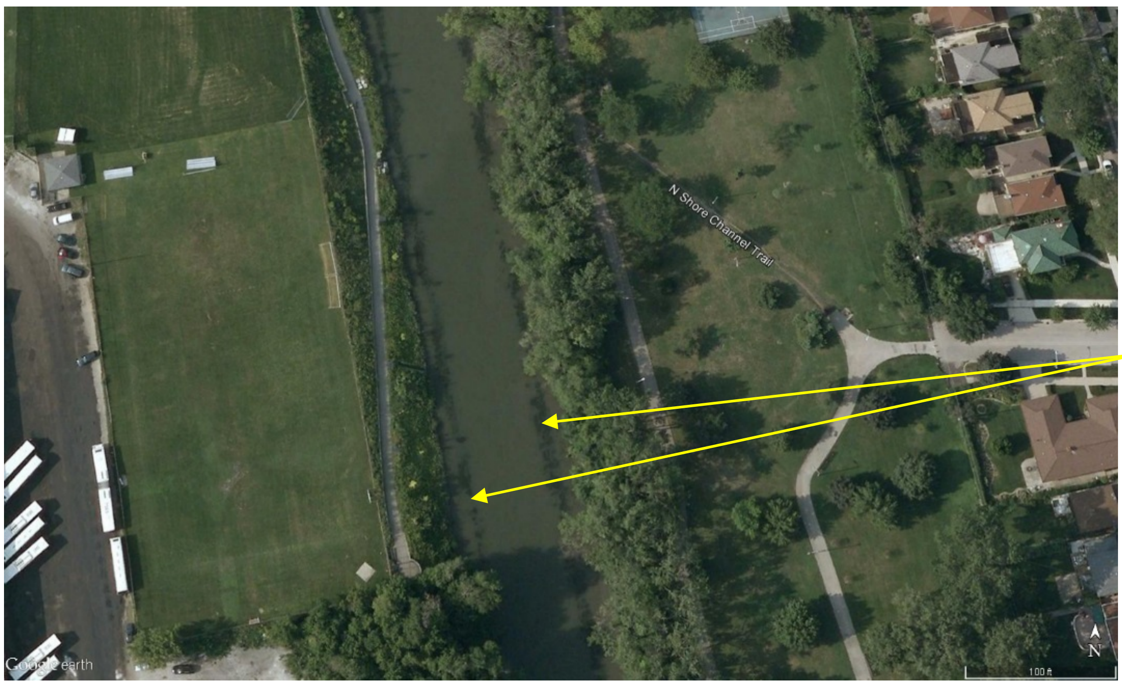


Figure 4

Typical North Shore Channel Cross Section

A linear bed of submergent and emergent aquatic vegetation is visible near the east bank of NSC just north of Foster Avenue (2015). The bed is 3-5 feet wide, and contains arrowhead (*Sagitarria sp.*) and pondweed (*Potamogeton sp.*).



Fairly continuous linear beds of aquatic vegetation are visible in this 2007 aerial photograph (GoogleEarth) of the NSC near Balmoral Avenue. The linear beds of aquatic vegetation are visible throughout much of the NSC.

Figure 5

Aquatic Vegetation Beds in NSC

Tables

Table 1. Total number of banded killifish captured by Electrofishing during the 2014 Asian Carp Monitoring Program below the Electric Dispersal Barrier and 2010-2014 totals.

	2014 Fixed Sites						**2014 Random Sites**						**2010-2014**	
Species	**Pool***				**Total Captured**	**Percent**	**Pool***				**Total Captured**	**Percent**	**Total Captured**	**Percent**
	(1)	**(2)**	**(3)**	**(4)**			**(1)**	**(2)**	**(3)**	**(4)**				
Banded Killifish	14	7	2	2	25	0.2%	11	10	3	2	26	0.2%	80	<0.1%
Total Caught	2,189	1,991	4,357	7,844	16,381	100%	1,893	2,985	3,959	4,651	13,488	100%	100,910	100%
Total Species	30	37	55	58	77	-	25	37	61	62	78		97	-
Total Hybrid Groups	2	2	2	1	3	-	1	3	3	1	4		7	-

Adapted from MRWG (2015).

* Pools: (1) Lockport

(2) Brandon

(3) Dresden

(4) Marseilles

Table 2. Total number of banded killifish captured by Mini-Fyke Netting during the 2014 Asian Carp Monitoring Program below the Electric Dispersal Barrier and 2012-2014 totals.

	2014 Fixed Sites						2012-2014	
Species	Pool*				Total Captured	Percent	Total Captured	Percent
	(1)	(2)	(3)	(4)				
Banded Killifish	207	10	5	5	227	2.3%	237	0.64%

Adapted from MRWG (2015).

* Pools: (1) Lockport
(2) Brandon
(3) Dresden
(4) Marseilles

Table 3. Numbers of banded killifish captured during the seasonal Asian Carp Monitoring Program upstream of the Dispersal Barrier by location, 2014.

Sampling Location	2014
Lake Calumet and Calumet River	138
Little Calumet River and Cal-Sag Channel	20
Chicago Sanitary and Ship Canal and South Branch of Chicago River	4
Chicago River	0
NBCR and NSC	9
Total	**171**

Adapted from MRWG (2015).

Table 4. Total number of fish captured with electrofishing, trammel/gill nets, hoop nets, trap nets and commercial seine upstream of the Electric Dispersal Barrier, 2010-2014.

Species	2010	2011	2012	2013	2014	Total
Banded Killifish*	3	58	409	465	171	1,106
Total (all species)	36,127	57,308	100,570	57,308	27,678	278,991

Adapted from MRWG (2015**).**

*Banded killifish were only captured using electroshocking methods. No banded killifish were caught in trammel/gill nets, commercial seines, hoop nets, or trap nets.

Table 5. Banded killifish and total fish numbers collected in Asian Carp Monitoring Program by electrofishing at Fixed Site 4, Fixed Site 5, and Random Site 4 (2011-2014).

Species	2011	2012	2013	2014	Total
Fixed Site 4	-	-	1	1	2
Fixed Site 5	-	-	5	6	11
Random Site 4	-	1	-	2	3
Banded Killifish*Subtotal	0	1	6	9	16
Total (all species)	12,550	40,047	12,378	7,719	72,694

Adapted from spreadsheet of ACMP data provided by IDNR in March 2015.

Sample Sites Included in Table

Fixed Site 4 - NBCR and NSC between Montrose Avenue and Peterson Avenue

Fixed Site 5 - NSC between Golf Road and Wilmette Pumping Station

Random Sites in Area 4 - Area 4 includes the NSC (between Fixed Sites 4 and 5), NBCR below the North Branch Dam, and the Chicago River

Table 6 – Summary of potential banded killifish habitat at MWRD Annual Water Quality Monitoring (AWQM) sites

MWRD AWQM Site	Aquatic Vegetation Present (% Cover)[1]	Top 3 Components of Sediment (Descending Percentage)	Depth of Fines in Sediment (ft)	Stream Depth (ft)	Data Source[2]	Potential Banded Killifish Habitat Present
32	Yes (NA)	Sand, Silt, Plant Debris	0.7 – 2.7	0.7 – 2.7	(A)	Yes
105	No	Silt, Sand, Gravel	0.2 – 0.7	0.8 – 2.6	(A)	--
31	Yes (NA)	Gravel, Silt, Sand	NA	1.3 – 2.1	(A)	Yes
106	Yes (NA)	Sand, Silt, Gravel	<0.1 – 1.5	0.4 – 0.6	(A)	Questionable (too shallow)
103	Yes (NA)	Boulder, Sand, Woody Debris	< 0.1 – 0.6	1.2 – 2.7	(A)	Yes
104	No	Silt, Sand, Asiatic Clams	0.4 – 1.0	0.6 – 1.4	(A)	--
34	No	Sand, Silt, Gravel	0.2 – 0.6	1.1 – 2.3	(A)	--
96	No	Concrete, Boulder, Cobble	< 0.1	0.5 – 2.2	(A)	--
37	No	Gravel, Sand, Cobble	< 0.1 – 1.3	1 – 9	(A)	--
73	Yes (NA)	Silt, Sand, Plant Debris	0.6 – 3.6	3 – 12	(A)(B)(C)	Possible[3,4]
46	No	Silt, Sludge, Gravel	0.3 - > 5	15 – 21	(A)(B)	--
35	Yes (9%)	Silt, Detritus, Clay	0.25 – 1.0	1 – 10	(A)(B)	Possible[5,6]
102	Yes (10%)	Silt, Detritus, Sand	0.1 – 3.2	2 – 7	(A)(B)	Possible[5,6]
36	Yes (13%)	Gravel, Sand, Detritus	0.2 – 1.9	3 – 11	(A)(B)	Yes[6]
101	Yes (9%)	Sand, Gravel, Silt	0.1 - 0.9	2 – 9	(A)(B)	Yes[6]

1 NA = Not Available
2 Data Sources: (A) MWRD 2013, (B) LimnoTech 2010, and (C) GoogleEarth 2007
3 A wetland pilot project intended to establish aquatic vegetation in a quiet backwater area south of Diversey Avenue has had limited success. Limited aquatic vegetation has established.
4 Banded killifish have been collected as part of the Asian Carp Monitoring Program near this site, making it likely that there is suitable habitat in the vicinity of the site.
5 There is potential banded killifish habitat at this site, but silt is the predominantly sediment component.
6 Based on aerial photos and vegetative cover data from sites 35, 36, 101, and 102, it appears that fairly continuous strips of submergent/emergent vegetation are present along both banks of the NSC. However, the predominance of silt in the upper half of the NSC makes for less desirable habitat.

Table 7. IDNR and MWRD Sampling Sites on the Chicago River System

Site ID	Street	Stream	Agency	Distance Upstream of North Branch Dam (River Distance in Miles)	Distance from Proposed Outlet (River Distance in Miles)
North Branch Dam	-	NBCR & NSC	-	0.0	0.095 (500 feet)
96	Albany Ave.	NBCR	MWRD	0.076 (400 feet)	-
Proposed Inlet	-	NBCR	-	1.2	-
34	Dempster Ave.	NBCR	MWRD	10.6	-
104	Glenview Rd.	NBCR	MWRD	13.4	-
HCCC-08	East Lake Ave.	Skokie River	IDNR	15.6	-
105	Frontage Rd.	Skokie River	MWRD	15.7	-
HCCD-09	Willow Rd.	Skokie River	IDNR	16.8	-
32	Lake Cook Rd.	Skokie River	MWRD	21.5	-
31	Lake Cook Rd.	Middle Fork NBCR	MWRD	21.2	-
HCCC-06	Deerfield High School	Middle Fork NBCR	IDNR	24.5	-
103	Golf Rd.	West Fork NBCR	MWRD	12.0	-
HCCB-13	Walters Ave.	West Fork NBCR	IDNR	18.2	-
106	Dundee Rd.	West Fork NBCR	MWRD	19.3	-
101	Foster Ave.	NSC	MWRD	-	0.038 (200 feet)
HCCA-04	Peterson Ave.	NSC	IDNR	-	1.1
36	Touhy	NSC	MWRD	-	2.5
HCCA-02	Oakton St.	NSC	IDNR	-	3.5
102	Oakton St.	NSC	MWRD	-	3.5
112	Dempster Ave.	NSC	MWRD	-	4.6
35	Central	NSC	MWRD	-	6.7
HCC-02	Wilson Ave.	NBCR	IDNR	-	0.8
37	Wilson Ave.	NBCR	MWRD	-	0.8
73	Diversey	NBCR	MWRD	-	3.5
HCC-04	North Ave.	NBCR	IDNR	-	5.7
46	Grand	NBCR	MWRD	-	7.3

Appendix A

Revised Impacts on Fishery Resources (June 2015)

Albany Park Stormwater Diversion Project
Revised Impacts on Fisheries Resources
by

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June 11, 2015

Background

The impacts of the Albany Park Stormwater Diversion Tunnel Project (Project) on the fisheries resources in the vicinity of the Project were initially addressed in an analysis dated September 2014 (Appendix E of the Project Joint Permit Application). In a letter dated January 28, 2015, the Illinois Department of Natural Resources (IDNR) requested that the original analysis be updated. This document provides the revised and updated fisheries impact analysis.

This revised and updated analysis incorporates more recent fisheries data provided by IDNR and the Metropolitan Water Reclamation District of Greater Chicago (MWRD). The initial analysis was qualitative and based on Dennison et al (2001) and MWRD (2005), which provided the most recent information that the authors identified on the internet at the time. It was acknowledged in the September 2014 analysis that these data were limited and dated. In their review of the Project, the IDNR considered these data "out-of-date and invalid," and requested that the analysis be quantitative using IDNR data collected during the IDNR Lake Michigan Basin Surveys and the Asian Carp Monitoring and Response Surveys. Specifically, IDNR requested that the number of fish expected to suffer mortality, including all species recorded in the vicinity and different size classes, be estimated using data they provided. Further, the IDNR requested that the potential removal of the North Branch Dam (also known as the West River Park Dam) on the North Branch of the Chicago River (NBCR) and associated changes in fish assemblages in the NBCR be considered in the impact analysis. Finally, the IDNR also requested that special attention be given to the state endangered Iowa darter (*Etheostoma exile*) and banded killifish (*Fundulus diaphanus*) in the analysis. These requests were discussed with IDNR subsequent to the January 28, 2015 letter in conference calls and emails.

In addition, MWH has revised portions of the Project design since the September 2014 fisheries impact analysis was submitted, significantly changing the intake structure and modifying the outlet structure. These revisions will result in some changes in the magnitude of the Project impacts. This revised report addresses these changes in Project design, the IDNR requests, and comments and suggestions in the subsequent discussions with IDNR.

Salient Project Features for Impact Analysis

Project Location and Features

Inlet. The inlet will be located on the NBCR just upstream of Foster Avenue and about 1.9 miles above the confluence of the NBCR and the North Shore Channel (NSC), as shown in Figure 1. During flood events, when NBCR river stage exceeds the elevation of the fixed weir, a portion of the NBCR flow will crest the weir, enter the inlet structure, and flow into the diversion tunnel. At the modeled design event (1% annual chance flood, also known as the 100-year event), with the NBCR flow at 4,095 cubic feet per second (cfs), approximately 55% of the flow will be diverted to the tunnel and 45% will remain in the channel. The inlet structure will have a horizontal trashrack with 4-inch clear spacing. Water diverted into the inlet will flow into the inlet structure, and drop 110 feet through a vertical shaft into the diversion tunnel. No water will return from the inlet to the NBCR.

The inlet structure will have two manually operated gates that will allow water to enter the inlet during periods of normal flow for purposes of maintaining the pumps at the outlet structure. The gates will be parallel to the flow of the NBCR and have a trashrack with 2-inch clear spacing.

The streambank along the length of the weir will be protected with a two-foot thick layer of riprap, keyed in with a sheetpile toe.

Diversion Tunnel. The diversion tunnel will be approximately 5,700 feet long, 18 feet in diameter and 110 feet below the surface. The tunnel system will function as an inverted siphon, diverting water through the tunnel (and past flood-prone areas) to the outlet on the NSC. During the design event, the tunnel will pass approximately 2,300 cfs. After the flood event, excess water in the tunnel will be pumped out at the outlet structure to the NSC. The pump-out will be accomplished using two redundant variable-frequency drive (VFD) trash pumps, each capable of pumping 5 cfs through a 10-inch outlet pipe. It will take approximately 3 days to pump out the tunnel. The pumps will have no screening and can pass up to a 3-inch solid.

Outlet. The outlet is located on the NSC, about 500 feet upstream of the confluence of the NSC and the NBCR (the North Branch Dam is located at this confluence), and slightly over 3 miles downstream of the MWRD Northside Wastewater Treatment Plant discharge. During flood events, diverted flows up to 2,300 cfs from the NBCR will pass through the diversion tunnel and be discharged over a concrete apron with energy-dissipating baffle blocks and into the NSC. A two-foot thick apron of riprap will protect the shoreline adjacent to the outlet structure. The outlet will also have a 4-inch clear spacing trashrack to prevent entrance into the facility.

Project Operation

The Project operation characteristics under various flow conditions are given in Table 1. In accordance with the results of the detailed hydraulic modelling efforts, the inlet structure weir will begin to overtop when flows in NBCR reach approximately 600 cfs, which corresponds to an event with a recurrence interval of 2-3 months. In other words, on average, the diversion tunnel system would be expected to operate 4-6 times per year.

As shown in Table 1, the velocities of water entering the inlet at the weir on the NBCR under flood conditions vary between 3.0 ft/sec to 5.0 ft/sec, and between 4.0 ft/sec and 8.0 ft/sec at the trashrack. Corresponding velocities at the outlet structure vary between 0.0 ft/sec to 5.1 ft/sec. Total transport time through the diversion tunnel (from the inlet structure through the outlet) is estimated as 10 minutes during a 100-year storm event.

Depending on how rain from a storm event is spread across the watershed, the NSC waters levels may rise near the outlet structure before the NBCR levels rise near the inlet structure. Under some scenarios, water may backflow from the NSC into the outlet shaft before the diversion tunnel takes on water at the inlet structure. The peak velocity of water backflowing from the NSC into the outlet structure is 4.3 ft/sec. The peak backflow is 700 cfs and is approximately the same for every event greater than the 1-year event (backflow characteristics are related to the rise of NSC water levels, which is about the same for the range of storm events modeled). The duration of the backflow event would not exceed 30 minutes, which is approximately the time it would take to fill the tunnel. While it is difficult to predict the number of times that the NSC water levels will rise before the NBCR overtops the inlet weir, for purposes of this analysis, it will be conservatively assumed that a backflow event occurs every time the system operates.

In addition, the gates at the inlet structure will be used up to four times per year to allow NBCR water into the tunnel to exercise the outlet sump pumps. The inlet gates will have a trashrack with 2-inch clear spacing. The gates will be opened to allow 5 cfs into the inlet shaft. Water velocity at the gate trashrack during such periods will be less than 1.5

ft/sec. Gate operators will be provided with an operation plan to coordinate how far the gate can be opened, while maintaining minimum flow conditions downstream of the inlet structure. Minimum flow conditions equal to 30% of the annual mean flow must be maintained downstream of the inlet structure (Tenant 1976) in order to operate the gate.

Challenges for the Impact Analysis

In conference calls with IDNR regarding their requests during early 2015, a number of difficulties were identified and discussed. Quantifying the impacts of the Project on the fisheries resource will be a challenge because:

- The Albany Park Stormwater Diversion Project has not been built, so no estimates can be made based on sampling data at the Project.
- The Project is unique in that it will operate only for short periods of time during intermittent flood events. Neither the duration of any future flood event nor its time of occurrence can be predicted, and the alternative scenarios for flood events are nearly endless. Flows into the project inlet will vary depending on flood stage, which changes during the course of each flood event.
- There are no known comparable projects with fish sampling data from which to base an estimate. Hydropower and steam electric station projects do not have comparable operating characteristics, as they operate continuously and their intake flows are higher than those predicted to occur during the more frequent lower stage flood events.

Given these challenges, and in the absence of transferable information from other similar projects, quantifying the number and size classes of species entrained by the Project will be "best guesses" relying on existing information on the affected fisheries resources in the vicinity of the Project.

Affected Fisheries Resources

Physical Environment

North Branch of the Chicago River. The confluence of the NBCR and the NSC is located about 500 feet east of Albany Avenue. Just upstream (about 100 feet) of the confluence is the North Branch Dam. The dam fragments the river, blocking upstream fish passage into the NBCR from below the dam and from the NSC. Upstream of the dam, the NBCR is a shallow stream, while downstream, it is part of a deep-draft navigational waterway (Dennison et al 2001). The flow conditions at the site of the Project inlet are given in Table 1. At that location, about 1.2 miles above the dam, the river channel has a maximum depth of about 4.5 feet and a width of about 40 feet under mean non-flood flow conditions (45 cfs). The channel velocity at this flow is 2.5 ft/sec.

MWRD collected habitat data at the Albany Avenue site in 2009 (Gallagher et al, 2013). Sediment composition at that site, in descending order of percent cover, was concrete, boulder, cobble, gravel, sand, and plant debris. The layer of soft silt was less than 0.1 feet thick. Instream cover consisted of boulders and brush-debris jams.

According to data collected by surveyors in 2014, the channel bottom at the inlet site is covered with 0.1-1.2 feet of soft silt. No aquatic vegetation was visible from the shoreline during July 2014 site visits. Additional information on the aquatic habitat in the immediate vicinity of the inlet was not identified.

North Shore Channel. The flow conditions at the site of the Project outlet are given in Table 1. At that location, the channel has a maximum depth of about 8.5 feet and a width of about 80 feet under mean non-flood flow conditions (250 cfs). The mean channel velocity at this flow is 0.5 ft/sec.

MWRD collected habitat data at the Foster Avenue site in 2009 (Gallagher et al, 2013). Sediment composition at that site, in descending order of percent cover, was sand, gravel, silt, plant debris, clay, and cobble. The layer of soft silt was 0.1-0.9 feet thick. Instream cover consisted of aquatic vegetation and boulders.

According to data collected by surveyors in 2014, the channel bottom is covered with 0.2-1.6 feet of soft silt. No aquatic vegetation was visible from the shoreline during July 2014. However, IDNR indicated during a conference call that they have observed aquatic vegetation beds in the vicinity of the outlet site, near Foster Avenue on the NSC. Additional information on the aquatic habitat in the immediate vicinity of the outlet was not identified.

Fish Communities

Available Recent Data: The IDNR provided reports of their fish surveys in the Lake Michigan Basin during 1996 - 2006 (Pescitelli and Rung 2009) and during 2001 - 2011 (Pescitelli and Rung undated). These reports provided the results of fish sampling using backpack electrofishing and an electric seine at sites on the NBRC above the North Branch Dam, and using boat electrofishing at sites below the dam and on the North Shore Channel. Total length data for the species collected in the Lake Michigan Basin surveys were also provided in electronic format (Nathan Grider, IDNR, personal communication, March 16, 2015). The locations of the IDNR sites are described in Table 2 and shown on the map in Figure 1.

IDNR also provided the reports of the 2012 and 2013 Asian Carp Monitoring and Response Surveys (MRRWG 2013 and 2014, respectively), and unpublished data (in electronic format) for the fish sampling results of those surveys from 2011 to 2014 (Nathan Grider, IDNR, personal communication, March 16, 2015). The results of these surveys provided boat electrofishing data for the NBCR below the North Branch Dam and for the North Shore Channel. The locations of the sites and area in the vicinity of the Project sampled in the Asian carp surveys are shown in Figure 1.

IDNR also provided fish count data for the Hofmann Dam removal project. Hoffman Dam, which was located on the Des Plaines River near Lyons, Illinois, was removed in 2012. Fish counts collected before and after the dam removal indicate how the community above the dam changed after the dam was removed.

Recent data were also obtained from MWRD. MWRD provided reports of their biological, habitat and sediment quality sampling during 2009 and 2010 (Gallagher et al 2013 and 2014, respectively), as well as fish sampling results at several stations from 2006-2013. The reports provided additional results of sampling using backpack electrofishing at sites on the NBRC above the North Branch Dam, and at sites below the dam and the North Shore Channel using boat electrofishing. The locations of the MWRD sites are described in Table 2 and shown on the map in Figure 1.

Data Gaps and Limitations for Analysis. To estimate the numbers and sizes of fish species that could be entrained into the Project and suffer mortality, the total numbers (population or abundance) of those species and their size classes at the inlet weir and outlet must be known[1]. No population (total abundance) estimates are available for any of the locations sampled by IDNR (Nathan Grider, IDNR, personal communication, March 16, 2015) or MWRD (Dustin Gallagher, MWRD, personal communication, March 16, 2015). Consequently, the total population (abundance) of each species at a site must be estimated.

There are two methods commonly employed to obtain population (total abundance) estimates at a site (hereafter referred to as "population estimates" in this report): mark and recapture; and depletion sampling (using electrofishing gear, with at least two passes of the electrofisher). Unfortunately, the data available for such estimates are either

[1] This is the number and size range of fish subject to entrainment during any flood event. It is assumed that only the fish in the immediate vicinity of the intake or outlet can be entrained.

lacking or the sampling was not designed to estimate population size. These deficiencies include:

- No mark-recapture data exist for the fish populations in the vicinity of the Project. Although IDNR did mark-recapture sampling, it was not conducted in the vicinity of the Project (Nathan Grider, IDNR, personal communication, March 16, 2015). MWRD did not conduct any mark-recapture sampling (Gallagher et al 2013, 2014).
- Although IDNR and MWRD conducted electrofishing sampling in the vicinity of the Project, the sampling results or procedures were not designed to obtain depletion numbers. The IDNR sampling results (Pescitelli and Rung 2009, undated) were not separated by sampling pass. MWRD separated their data by sampling pass (two passes per sample, where multiple passes were made), but the passes were in adjacent areas or only included one pass on opposite sides of the stream, and hence, were not depletion samples (Dustin Gallagher, MWRD, personal communication, March 16, 2015).

Further, there are additional deficiencies and limitations to the available data for the analysis:

- As shown in Table 2 and Figure 1, no fish sampling has been conducted at the site of the project intake.
- The Asian carp survey data (MRRWG 2013, 2014 and electronic data for 2014) provide only distribution and relative abundance information on species. Fish were not measured during those surveys (Nathan Grider, IDNR, personal communication, February 24, 2015).
- Although the Asian carp surveys were conducted annually from March-December during 2010-2014, the IDNR Lake Michigan Basin Surveys and MWRD samples were only collected during the summer (when species diversity and abundance in the samples are anticipated to be at their highest). The Lake Michigan Basin Surveys are conducted on a five-year basis (the most recent of which was in 2011). The MWRD surveys are annual (the most recent data available were for 2013). The composition of the fish community at a site will change seasonally and vary from year to year. Although the MWRD sampling results for sites above the North Branch Dam will reflect the annual changes in the fish community, none of the samples will reflect the seasonal changes.

Consequently, obtaining the quantitative estimates requested by IDNR requires an approach relying on a number of assumptions. In any event, the estimates will be speculative.

Project Impacts

Approach to Obtaining Entrainment and Mortality Estimates

Population Estimates. For the purposes of this exercise, the electrofishing data provided by MWRD were utilized to obtain population estimates of the fish communities at their sampling sites. MWRD usually conducted two passes of the electrofisher at their wadeable and deep water sites (Gallagher et al 2014). Based on the numbers of fish collected during these two passes, the sizes of their populations were determined using the depletion method following the procedure described by Lockwood and Schneider (2000). In this method, the number of fish obtained during each pass is used to calculate the population estimate utilizing the equation:

$N = N_1^2 / (N_1 – N_2)$, where:

N = total population estimate;
N_1 = number of fish in first sample pass; and
N_2 = number in second sample pass

Population estimates at sites sampled by IDNR could not be calculated using the depletion method because IDNR electrofishing sampling results were not separated by pass. Therefore, population estimates at IDNR sites at the same location as MWRD sites were based on the calculations from the MWRD population estimates. Using the two-pass MWRD data, depletion method calculations yielded a proportion, which was used to estimate the fish population at the MWRD sampling site. This same proportion was then used with IDNR fish count data to estimate populations at IDNR sampling sites. Obtaining population estimates in this manner required a number of assumptions, including:

For sites on the NBCR upstream of the North Branch Dam:

- Because no fish sampling has been conducted at the site of the project intake, data obtained at a nearby site can be transposed to the site of the inlet.
- Using the electrofishing data at any site where two passes of the electrofisher were made can be used for depletion population estimates at that site.
- Because sampling gears are selective for species and no mark-recapture data exist, population estimates determined by the electrofishing depletion method can be transferred to other gear types (seine).

For sites in the NBCR and North Shore Channel:

- Data obtained by boat electrofishing can be used for depletion population estimates.
- Using the electrofishing data at any site where two passes of the electrofisher were made can be used for depletion population estimates at that site.
- Calculations used to estimate fish populations obtained by the depletion method at one site can be utilized to estimate the populations at a nearby site where the data cannot be used for depletion estimates.
- Data for sites in the vicinity of the Project downstream of the North Branch Dam under existing conditions can be used to estimate the fish population at the site of the project inlet when the dam is removed.

Because the sampling procedures were not designed for depletion analysis, the resulting population estimates will likely be unrealistically high. The second pass of the electrofisher does not sample a depleted area. Consequently, N_2 can be expected to be higher than when sampling a depleted area, with the result that the difference between N_1 and N_2 is small. The population estimate (N) will thus be higher than when N_2 is small (as in a depleted area) and that difference is larger.

For expediency, the total number of a given species in the population at a site was determined based on the proportion of the total number of fish in the sample in relation to the population estimate (N). It was assumed that the number of a given species in the population estimate was in the same proportion as in the sample. Thus, to estimate the total number of a given species in the population, the number of that species in the sample was multiplied by the proportion of the total sample size in N.

<u>Entrainment Estimates</u>. Not all the fish at the site of the project inlet will be entrained because they will seek out the lowest velocity areas in a stream during flood events. This usually is near the edges of the stream or at the bottom in the absence of any cover. Thus, the proportion of the total population that will be entrained needs to be estimated. This proportion will change with flood stage and corresponding intake velocities.

For the purposes of this exercise (and ease of calculation), the proportion of the estimated population that would be entrained was assumed to be equivalent to the proportion of flow diverted into the project inlet at various flood stages. This procedure assumes that fish are evenly distributed in the water column. As a consequence, the number entrained will be overestimated because, during a flood, fish will be at the bottom and sides of the channel, not evenly distributed throughout the water column. Further, it was assumed that all the fish entrained during a flood event will be estimated using the instantaneous proportion of diverted flow. However, fish will be entrained over the period of the flood, not all at one time. Thus, the number of entrained fish will change in relation to the duration of the flood and the rate of entrainment, neither of which can be predicted for any flood event (although numerous alternative scenarios exist). Consequently, for the purpose of this exercise, the number of entrained fish was based on the instantaneous proportion of diverted flow.

For expediency, the number of a given species that could be entrained was estimated by multiplying the number of that species in the population by the proportion of flow diverted into the project inlet. As with the total population entrainment, this number will likely be an overestimate. Additionally, fish entrainment at the project inlet depends on the velocity of the flow into the inlet and the swimming speed of the fish in relation to that velocity. Thus, the number of a given species that would be entrained can be less than the number based only on the proportion of diverted flow.

The swimming speed of fish depends on length, body shape and water temperature. Swimming speeds are greater for larger and more fusiform fish. Swimming speeds are also highest at water temperatures near the species' final temperature preferendum. To avoid entrainment, fish will utilize their "burst speed" (the maximum speed available for a short period of time) when sensing the increase in velocity that will occur at the project inlet. Burst speed information for some species and sizes in the vicinity of the Project is available in the literature. To the extent possible, these data were used to estimate the species and sizes of fish that would be entrained. In the absence of such data for a species or specimen size, the critical swimming speed (Brett 1964) or maximum swimming speeds in the literature were used. For species having no information in the literature, swimming speeds were based on species of similar shape and size as surrogates. Swimming speeds determined at water temperatures that would occur under summer conditions were used as the maximum speeds.

To estimate the number of a given species entrained by size class, the number derived from the proportion of flow diverted into the intake was further divided (on the basis of total length) into the percentages of the flow-diverted number having swimming speeds less than, and greater than, the velocity of the flow into the inlet. The percentage (number) having swimming speeds less than the velocity of the flow into the project inlet was assumed to be entrained.

<u>Mortality Estimates</u>. Based on studies of the effect of pressure changes on fish in simulated fish passage through hydropower turbines, in which pressure changes similar to those in the diversion tunnel system occur (although over shorter periods of transport time), a relatively high rate of mortality of entrained fish can be expected (Becker, et al 2003, Foye and Scott 1965, Tevetkov, et al 1972). For the purposes of this exercise, it was assumed that all fish entrained into the project intake will be killed. This will likely

overestimate (to an unknown extent) the mortality of phystomous species (shad, minnows, suckers and catfish) passing through the system because they can survive substantial pressure changes (Becker, et al 2003), and do so to a greater extent than physoclistous species (killifish, sunfish and bass). In addition, during tunnel dewatering after a large rain event, all fish that are entrained into the project pumps will likely be killed. Because neither the number of fish passing through the system that survive, nor the proportion of entrained fish that pass through the system versus those that are further entrained into the pumps can be estimated, the mortality estimate for entrained fish is conservatively assumed to be 100%.

Fish entering the system via the outlet during backflow from the NSC will not pass through the pressurized tunnel to the NBCR at the project inlet because the system does not operate in that manner. However, entering the outlet during a backflow event, the fish will experience a drop up to 110 feet and likely be damaged or killed. Larinier (2001) cited studies by Bell & Delacy (1972) demonstrating that fish falling over spillways had significant damage (with injuries to gills, eyes and internal organs) when the impact velocity of the fish on the water surface in the downstream pool exceeded 16 m/s, regardless of fish size. A column of water reaches the critical velocity for fish after a drop of about 43 feet. Beyond this distance injuries become significant and mortality increased rapidly in proportion to the drop. Mortality reached 100% for drops of 164 - 197 feet. Drops of shorter distances (110 feet or less) can be expected to result in some mortality, significant damage, or loss of equilibrium, depending on the length of the drop and the species. Because such fish re-entering the North Shore Channel in the discharge will be disoriented (at best), they will be ready prey to predators and may not survive. Consequently, for the purposes of this exercise, all fish entering the outfall during a backflow are assumed to be killed.

Species, Numbers and Size Classes Entrained Under Existing Conditions

Population at Project Inlet. The population of the fish community subject to entrainment at the Project inlet was based on the sampling results by MWRD at Albany Avenue. The Albany Avenue site is located in the NBCR above the North Branch Dam and about one mile downstream of the project inlet (Table 2). As such, it is the closest sampling site to the inlet. However, it is likely that there are differences in microhabitat between the Albany Avenue site and the site of the inlet. Consequently, the species composition and numbers of fish at the two sites are also going to be somewhat different. Nonetheless, for the purpose of this estimate, it is assumed that the fish populations at the MWRD Albany Avenue site are representative of those at the site of the inlet.

MWRD conducted backpack electrofishing and seine sampling at the Albany Avenue site from 2006 to 2013 (Table 3). Electrofishing consisted of two 40-meter long passes, one along each bank of the river. A single 40-meter long seine haul parallel to the bank was also conducted at this site. The results of the sampling over the 2006 - 2013 period show that the fish community at the site is neither highly diverse nor abundant, and is comprised of small specimens. It is also seen that the community population fluctuates from year to year, with the highest number of species (6) collected in 2009, 2011, and 2013, and the highest number of specimens (101) collected in 2013.

For the purpose of this exercise, the populations of fish species at Albany Avenue (and, by transposition, at the project inlet) subject to entrainment under existing conditions are based on the sampling effort on August 27, 2013. The results of that sampling and the population estimates based on that sampling effort are provided in Table 4. The list of species in this table (and subsequent tables, except Table 8) follows the latest phylogenetic order given in Page et al (2013). The number of fish species collected in each pass of the electrofisher and total collected are provided in Table 4A. The calculations used to estimate the total population of the fish community at the site, based on two-pass electrofishing results, are provided in Table 4B.

To determine the total population and numbers of each species at the site, the seine sample results were included in the estimate (Table 4C). The estimates were obtained by first determining the proportion of the total population represented by the electrofishing sample. That proportion was then applied to the total number of a species collected by electrofishing and seine (Table 4C).

The burst speed, critical swimming speed or maximum speed for each of the species collected in the electrofishing and seine samples at Albany Avenue was determined from the literature based on their total lengths in the samples. In some cases, no literature values could be found for a species or size class, and a surrogate species was used to estimate the swimming speed. The estimated total number, maximum and minimum total lengths, and burst, critical or maximum swimming speeds for each species (with literature references) are provided in Table 4D. Surrogate species used to provide swimming speeds for species having no literature values are listed in the notes of Table 4D.

Numbers and Total Lengths of Species Entrained at Inlet. The proportion of the fish population at the project inlet that could be entrained was determined for various flood stages (Table 5). The proportion of the flow diverted into the inlet and the velocity (ft/sec) of that flow at the inlet weir during a flood event for each flood event are provided in Table 5A.

The number of each species entrained into the project intake at various flood events was then determined based on the proportion of diverted flow and swimming speeds of each species and size class. The results of this analysis are provided in Table 5B by flood event (1-, 2-, 10-, 50-, and 100-year events). Because the maximum swimming speeds of all the species and size classes at the inlet were less than the velocity of the flow diverted into the inlet, all the fish in the proportion of flow diverted into the inlet were considered to be entrained. The species and size classes entrained thus correspond to those in the sample, with blackstripe topminnow having the highest number of entrained specimens. The increase in the number of entrained fish during increasingly higher flood events also corresponded to the increase in the proportion of diverted flow.

Population at Project Outlet. The population of the fish community subject to entrainment at the project outlet was based on the sampling results by MWRD at Foster Avenue. The Foster Avenue site is located in the North Shore Channel about 200 feet upstream of the project outlet. As such, it is the closest sampling site to the outlet. MWRD conducted boat electrofishing sampling at the Foster Avenue site most recently in 2009 (Table 6). Electrofishing sampling consisted of two 400-meter long passes, one along each bank of the river. The population estimate for the fish community at Foster Avenue is based on the 2009 sampling (Table 6A) and was calculated in the same manner as the population estimate at Albany Avenue. The results of that analysis are shown in Table 6B.

Numbers and Total Lengths of Species Entrained at Outlet. The proportion of the fish population at the project outlet that could be entrained was determined for various flood stages (Table 7). However, the technique used to estimate entrainment at the inlet (using the proportion of flow into structure versus flow in the channel) yields unlikely results at the outlet. For example, during the 1-year event when a peak of 700 cfs of backflow from the NSC would enter the outlet structure and the flow in the NSC is 350 cfs (Table 1), the calculated proportion is "2.0". This would indicate that two times the population at the project outlet would be entrained during a 30-minute backflow event, which is an unlikely conclusion. Therefore, an alternative entrainment estimation technique is required for backflow events.

The characteristics of the backflow event are very similar for each of the five storm events. A backflow event occurs early in the flood event and lasts approximately 30 minutes. Flows and velocities of water cresting the outlet weir increase as the water level rises in the NSC, peaking at approximately 700 cfs and 4.3 ft/s. Nearby flows in the channel, approximately 5 meters from the outlet structure, are less than 2.0 ft/s during the backflow event. Therefore, approximately the same portion of the fish population at the project outlet would be entrained during a backflow event, regardless of the size of the event. Taking the width of the outlet structure and adding 5 meters to both sides yields a total of approximately 30 meters. To be conservative, the zone of influence around the outlet structure will be rounded up to 50 meters. The outlet population was based on sampling of 400 meters of stream. Therefore, in order to calculate the proportion of the outlet site population subject to entrainment during backflow, a distance ratio (50:400) is used. This calculation is shown in Table 7B.

The number of each species entrained during a backflow event is shown in Table 7C, and was determined based on the proportion of the outlet population subject to backflow entrainment and swimming speeds of each species and size class. The results of this analysis are provided in Table 7C (each of the 5 flood events yields similar results). Because the maximum swimming speeds of most of the species and size classes at the outlet were less than the peak velocity of the flow backflowing into the outlet, most of the fish were considered to be entrained. Three species with burst speeds that exceeded the backflow velocities (common carp, gizzard shad, and spotted sucker) would not be entrained. Two species had some size classes with burst speeds that equaled or exceeded the backflow velocities (white sucker and largemouth bass). The species and size classes entrained thus correspond to those in the sample, with bluegill, bluntnose minnow, spotfin shiner, golden shiner, and pumpkinseed having the highest number of entrained specimens.

<u>Species, Numbers and Size Classes Entrained Under Future Conditions</u>

The IDNR requested that the number of fish expected to be entrained and suffer mortality at the Project, including all species and different size classes recorded in its vicinity, be estimated when the North Branch Dam has been removed. Removing the dam will reconnect the NBCR and provide access to the reach of river above the dam site for species below that site, including those in the North Shore Channel. Thus, species moving into the reach upstream of the dam site could come from almost anywhere in the vicinity of the Project below the dam.

To assist in the evaluation of which species would likely move upstream, the IDNR provided tabulated results of their sampling above and below the Hoffman Dam on the Des Plaines River prior to (2010) and after (2013) its removal in June 2012 (Nathan Grider, IDNR, personal communication, March 16, 2015). The results (Table 8) indicate that the species most likely to move upstream were cyprinids (minnows), catostomids (suckers), ictalurids (catfish), fundulids (killifishes) and centrarchids (sunfish). Reportedly, a total of 10 species not previously found upstream of the dam were collected in the pool area, including channel catfish, northern pike, rockbass, and blackside darter (Forest Preserves of Cook County 2012). The results also show that, while the number of gizzard shad downstream of the dam decreased dramatically after the dam was removed, none were collected upstream of the dam. Because the upstream sampling results are only for the pool area of the dam, it is assumed that gizzard shad moved upstream farther than the pool area, rather than left the area by moving downstream. The results further show there was a dramatic increase in the number of species and specimens in both sampling areas following the removal of the dam.

The results of the Hoffman Dam removal demonstrate that species found downstream of the dam will move upstream beyond the dam, resulting in an increase in size of the fish population and a change in the fish community in the reach above and below the dam. When the North Branch Dam is removed, the fish community in the vicinity of the project inlet can be expected to increase in size and diversity. For the purposes of this exercise, it was assumed that the new fish community at the inlet under such conditions will be similar to those found in the immediate vicinity downstream of the dam. Accordingly, four sites were selected to represent the possible new inlet fish community: MWRD Site 37 (Wilson Avenue); IDNR Site HCC-02 (also at Wilson Avenue); MWRD Site 101 (Foster Avenue); and IDNR Site HCCA-04 (Peterson Avenue).

The fish communities at these representative sites were evaluated in the same manner as the evaluation at Albany Avenue (Tables 4 and 5). Population estimates of the species found at the MWRD Wilson Avenue site, along with the respective swimming speeds of the species for the size classes collected at the site are provided in Table 9. Similar data for the species collected at IDNR Site HCC-02 are given in Table 10, for IDNR Site HCCA-04 in Table 11, and for MWRD Site 101 in Table 6. The numbers and size classes of species that would be entrained - when using the MWRD Wilson Avenue community to simulate the inlet community - are provided in Table 12. Similar simulations for IDNR Site HCC-02, the MWRD Foster Avenue site (based on the data in Table 6), and IDNR Site HCCA-04 are provided in Tables 13, 14 and 15, respectively. Because of their total length, the swimming speeds of some species would allow them to escape entrainment when the velocity of flow into the project inlet was less than the swimming speed. For expediency (because the number of such species in the population could not be easily quantified), an assumed number was used for the purpose of this exercise. The assumed percentages of the population of such species having swimming speeds greater than the inlet flow velocity for each flood event are given in the tables. Based on all the sites used for these simulations, most of the species that would be entrained would be small cyprinids (spotfin shiner, golden shiner, bluntnose minnow), catostomids (white sucker) and centrarchids (pumpkinseed, bluegill and largemouth bass). Larger fish (gizzard shad and carp) could escape entrainment during the warmer months of the year. However, as water temperatures declined, it is possible that these large fish would also be entrained (especially gizzard shad, which experiences a natural die-off when water temperatures approach winter conditions).

The species, numbers and size classes entrained at the project outlet during backflow when the West Park River Dam is removed is assumed not to change from those estimated under existing conditions. The species composition and population size of the fish community in the vicinity of the outlet will change in the future, with or without the dam in place. Estimating the changes in the downstream fish community in the vicinity of the outlet that result from the dam removal (which will result in an unknown recruitment to the reach from the North Shore Channel and NBCR) is beyond the scope of this exercise.

Impacts on Species of Special Concern

Iowa Darter. The Iowa darter was collected only in the upper reaches of the NBCR, well upstream of the project inlet. MWRD collected the species (one specimen) in 2009 only at their Site 106 (Dundee Road) on the West Fork of the NBCR (Table 16). That site is located 19.3 miles upstream of the North Branch Dam (Table 2), and over 18 miles upstream of the project inlet. IDNR also collected only one specimen of the Iowa darter, and only at Site HCCC-06 on the Middle Fork of the NBCR in 2011 (Table 17). Site HCCC-06 is located 24.5 miles upstream of the North Branch Dam (Table 2), and over 23 miles upstream of the project inlet.

The preferred habitat of the Iowa darter is reported to be at depths of less than 1.5 meters in slow moving streams having clear to slightly turbid water, with substrates primarily of sand, gravel, mud or silt and masses submerged vegetation (Becker 1983, Page 1983). In northern Illinois, the species is on the southern edge of its native distribution (Fuller and Neilson 2015a). Consequently, its populations in the NBCR will likely be small and its occurrence localized in isolated habitats.

The Iowa darter is not likely to come into contact with the Project under existing or future conditions. The species was not collected in the North Shore Channel or in the NBCR downstream of the North Branch Dam. It was only found in the upper reaches of the NBCR in very small numbers, at distances 18 to 23 miles upstream of the project inlet. Further, both sites at which the Iowa darter was found had aquatic vegetation.

Gallagher et al (2013) reported that MWRD Site 106 (Dundee Road) had aquatic vegetation as instream cover. Although there is no direct description of the habitat at IDNR Site HCCC-06, aquatic vegetation was almost certainly present. The QHEI value for the site was 43 out of 100, with a score of 9 for the instream cover metric (Nathan

Grider, IDNR, personal communication, March 16, 2015). The details for the instream cover metric (which includes aquatic vegetation) were not provided. However, 110 specimens of the central mudminnow were collected in the same samples as the Iowa darter. Mudminnows strongly prefer (and are thus usually found with) aquatic vegetation as cover (Meldrim 1968). As such, it is very likely that aquatic vegetation was present at the site.

The habitat preferences of the Iowa darter are not met at the location of the project inlet, as no aquatic vegetation was observed at that site. Given this condition and the distance the species was found upstream of the project inlet, the Iowa darter will not likely be impacted by the Project.

Banded killifish. The banded killifish was collected only in the Asian carp surveys. Results of those surveys show no specimens were collected in the vicinity of the Project (at Fixed site 4, Fixed Site 5 and Random Area 4) prior to 2012 (Table 18). The largest number of specimens (9) was collected in 2014. Of that 9, only one was found at Fixed Site 4, the closest site to the Project outlet. Based on the 2014 sample, the estimated population of the species at Fixed Site 4 was determined in the same manners as that for Foster Avenue, using the ratios of the sample numbers as at Foster Avenue (Table 6). This resulted in a population estimate for banded killifish of two (Table 19).

Based on the sampling results, the number of banded killifish at Fixed Site 4 estimated by this process is very small. However, it is likely that the population at that site is somewhat larger because killifish are small and boat electrofishing is not a highly efficient method in sampling them. Nonetheless, in northern Illinois, the banded killifish is on the western edge of its native distribution (Fuller and Neilson 2015b). Consequently, its populations in the Chicago River system will likely be small and its occurrence localized in isolated habitats.

Even though its population numbers may be low, the project could potentially entrain the banded killifish during backflow into the outlet under existing conditions, and at the inlet after the North Branch Dam is removed. No size information is available for the banded killifish collected in the Asian carp surveys, and no swimming speed data are available for the species in the literature. However, Becker (1983) reported an average total length of 51 mm for banded killifish in Wisconsin. Assuming the mummichog (*Fundulus heteroclitus*) of a similar size to be a suitable surrogate to represent the swimming capabilities of the banded killifish, its maximum swimming speed would likely be less than 1.0 ft/sec, based on the studies by Fangue et al (2008). As such, the species would be entrained at the project inlet during all the flood events described in Table 1. Based on the population estimate provided in Table 19, and using the backflow entrainment methodology used in Table 7, approximately one specimen of banded killifish would be entrained each time the system operates, for a total of approximately 4-6 banded killifish entrained per year. Under a future condition scenario with the North Branch Dam removed, the banded killifish population may expand to the NBCR. Transposing the estimated population from the outlet site to the inlet site would yield a population of 2 at the inlet site. Consequently, with the dam removed, an additional one specimen of banded killifish would be entrained each time the system operates.

Summary and Conclusions

At the request of IDNR, this revised and updated fish impact analysis was prepared for the Albany Park Stormwater Diversion Tunnel Project. This analysis is based on more current fish data provided by IDNR and MWRD. Estimates of fish populations and number of fish entrained per tunnel operation are necessarily based on a number of assumptions and are "best guesses", relying on existing information on the affected fisheries resources in the vicinity of the Project.

This impact analysis is based on several conservative assumptions and likely overestimates the number of fish that would be impacted by the Project. With that in mind, the analysis shows that during a 1-year storm event, approximately 16 fish would be entrained at the inlet and 42 fish entrained at the outlet during backflow. With the North Branch Dam removed, the number of fish entrained at the inlet may increase up to 36 per event. The system is anticipated to operate 4-6 times per year, which, on average, would include one 1-year event and several smaller events.

Two state-listed fish species have been collected in the NBCR and NSC: Iowa darter and banded killifish. Both species are at the edges of their respective distributions, and therefore, the populations in the Chicago River system will likely be small and occurrences localized in isolated habitats. The Iowa darter was only found in small numbers at locations 18-23 miles upstream of the project inlet, and its preferred habitat conditions, which include aquatic vegetation, were not observed at the inlet site. Given this condition and the distance the species was found upstream of the project inlet, the Iowa darter will not likely be impacted by the Project. The banded killifish has been observed in increasing numbers in the NSC. Using a surrogate maximum swim speed, the banded killifish would not be able to avoid entrainment during backflow events at the outlet structure. Based on the population estimate and using the described backflow entrainment methodology, approximately one specimen of banded killifish would be entrained each time the system operates, for a total of approximately 4-6 banded killifish entrained per year. With the dam removed, one additional specimen of banded killifish would be impacted per event.

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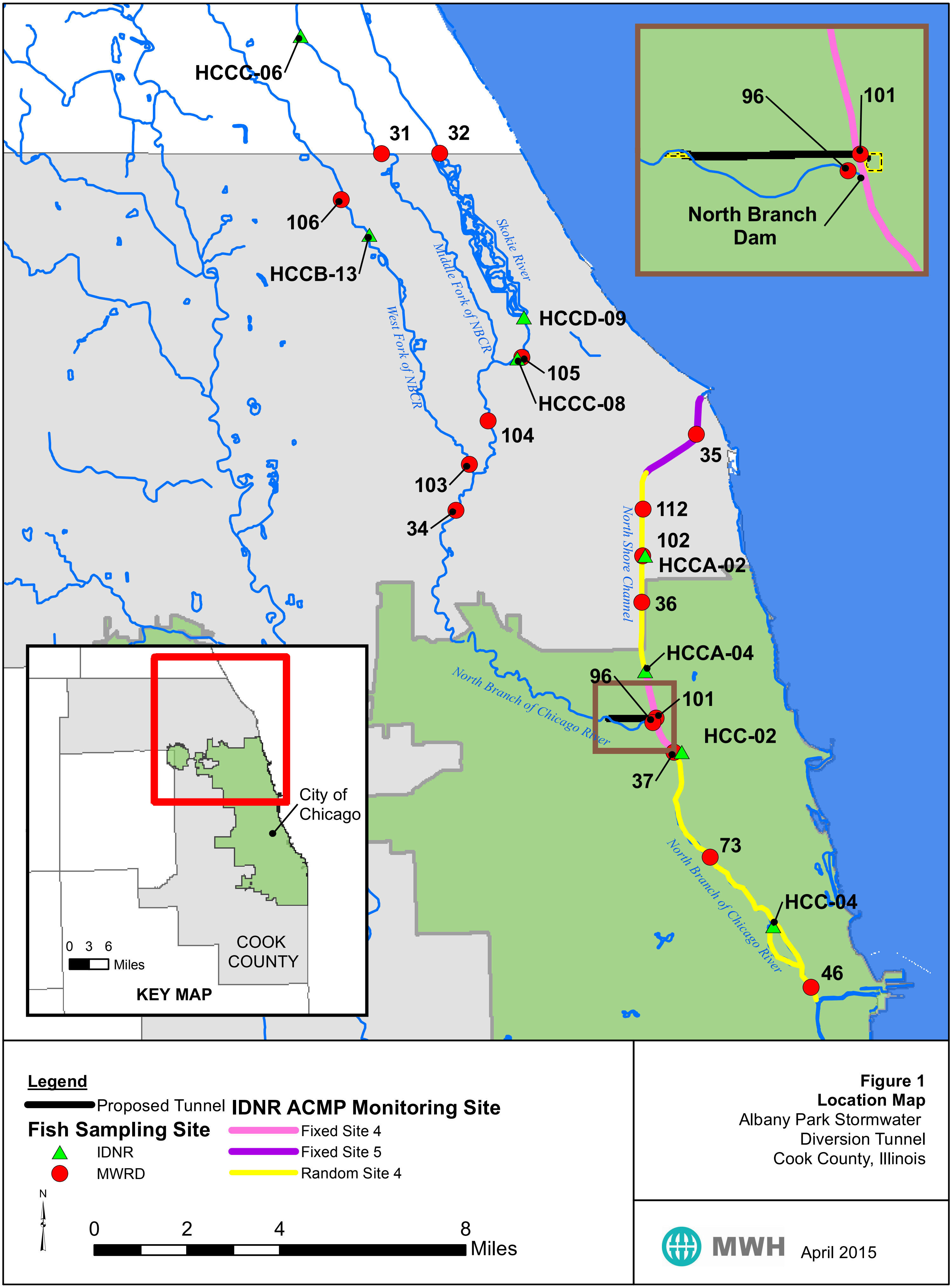

Figure 1
Location Map
Albany Park Stormwater Diversion Tunnel
Cook County, Illinois

Table 1. Project Operation Characteristics Under Various Flow Conditions.

North Branch Chicago River Inlet	Non-Operation	Operation				
	Non-Flood	Flood Event				
	(Mean Range of Values)	1-year	2-Year	10-Year	50-Year	100-Year
Stage (CCD)	6.5	13.2	13.6	14.3	15.7	16.3
Invert of Channel Centerline (CCD)	2.1	2.1	2.1	2.1	2.1	2.1
Water Depth at Centerline (ft)	4.4	11.1	11.5	12.2	13.6	14.2
Channel Flow (cfs) upstream	45	1050	1342	2232	3550	4095
Channel Flow (cfs) downstream	45	950	1092	1332	1650	1795
Channel Velocity (ft/s)	2.5	2.5	3.0	4.4	5.1	5.0
River Width	40	40	40	40	40	40
Inlet Flow (cfs)	-	100	250	900	1900	2300
Inlet Velocity (ft/s) at Weir	-	3.0	3.5	4.0	4.5	5.0
Inlet Velocity (ft/s) at Trash Rack	-	4.0	5.0	6.0	7.0	8.0
% Flows Diverted	-	10%	19%	40%	54%	56%

North Shore Channel Outlet	Non-Operation	Operation				
	Non-Flood	Flood Event				
	(Mean Range of Values)	1-year	2-Year	10-Year	50-Year	100-Year
Stage (CCD)	-3.5	1.0	1.5	3.0	4.5	5.5
Invert of Channel Centerline (CCD)	-12.0	-12.0	-12.0	-12.0	-12.0	-12.0
Water Depth at Centerline (ft)	8.5	13.0	13.5	15.0	16.5	17.5
Channel Flow near Outlet (cfs)	250	350	500	1150	2150	2550
Channel Velocity (ft/s)	0.5	0.5	0.7	1.7	3.4	5.4
River Width	60	60	60	60	60	60
Outlet Flow (cfs)	-	100	250	900	1900	2300
Outlet Velocity (ft/s)	-	0.0	1.3	3.1	4.9	5.1

North Shore Channel Outlet during Backflow Event	Operation				
	Flood Event				
	1-year	2-Year	10-Year	50-Year	100-Year
Peak Backflow into Outlet Structure (cfs)*	700	700	700	700	700
Peak Outlet Backflow Velocity at Weir (ft/s)**	4.3	4.3	4.3	4.3	4.3
Duration of Backflow Event (min)	30	30	30	30	30

* As the NSC level rises (and notably, the NSC water levels rise at a similar pace for each of these 5 flood events), the backflow into the Outlet structure increases as the water level rises in the channel. The peak flow (700 cfs) occurs just before the tunnel and outlet shaft fill. During backflow events, backflow may exceed typical channel flow, and water will be drawn into the Outlet structure from both directions (from downstream and upstream).

** As the NSC level rises, the backflow velocity increases at the weir. The peak backflow velocity (4.3 ft/s) occurs just before the tunnel and outlet shaft fill.

Table 2. IDNR and MWRD Sampling Sites on the Chicago River System

Site ID	Street	Stream	Agency	Distance Upstream of North Branch Dam (River Distance in Miles)	Distance from Proposed Outlet (River Distance in Miles)
North Branch Dam	-	NBCR & NSC	-	0.0	0.095 (500 feet)
96	Albany Ave.	NBCR	MWRD	0.076 (400 feet)	-
Proposed Inlet	-	NBCR	-	1.2	-
34	Dempster Ave.	NBCR	MWRD	10.6	-
104	Glenview Rd.	NBCR	MWRD	13.4	-
HCCC-08	East Lake Ave.	Skokie River	IDNR	15.6	-
105	Frontage Rd.	Skokie River	MWRD	15.7	-
HCCD-09	Willow Rd.	Skokie River	IDNR	16.8	-
32	Lake Cook Rd.	Skokie River	MWRD	21.5	-
31	Lake Cook Rd.	Middle Fork NBCR	MWRD	21.2	-
HCCC-06	Deerfield High School	Middle Fork NBCR	IDNR	24.5	-
103	Golf Rd.	West Fork NBCR	MWRD	12.0	-
HCCB-13	Walters Ave.	West Fork NBCR	IDNR	18.2	-
106	Dundee Rd.	West Fork NBCR	MWRD	19.3	-
101	Foster Ave.	NSC	MWRD	-	0.038 (200 feet)
HCCA-04	Peterson Ave.	NSC	IDNR	-	1.1
36	Touhy	NSC	MWRD	-	2.5
HCCA-02	Oakton St.	NSC	IDNR	-	3.5
102	Oakton St.	NSC	MWRD	-	3.5
112	Dempster Ave.	NSC	MWRD	-	4.6
35	Central	NSC	MWRD	-	6.7
HCC-02	Wilson Ave.	NBCR	IDNR	-	0.8
37	Wilson Ave.	NBCR	MWRD	-	0.8
73	Diversey	NBCR	MWRD	-	3.5
HCC-04	North Ave.	NBCR	IDNR	-	5.7
46	Grand	NBCR	MWRD	-	7.3

NBCR = North Branch of the Chicago River
NSC = North Shore Channel

Table 3. Fish Species, Numbers, and Lengths at MWRD Albany Avenue Monitoring Site on the North Branch of the Chicago River (2006-2013)

	Number								Total Length (mm)		
Common Name	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Min**	**Mean**	**Max**
Goldfish				14	1				60	78.7	88
Common carp	2	1	1			1			44	59.4	73
Fathead minnow			28	11	4				26	43.0	67
white sucker	15	7	5	8			1	6	29	45.4	100
Yellow bullhead					6		1	11	32	78.1	155
Channel catfish						2			42	44.5	47
Central mudminnow				2	13	3		3	46	59.0	76
Blackstripe topminnow	6	1	3			20	23	67	26	55.7	71
Green sunfish	1	5	15	2	49	38	12	12	23	54.1	117
Bluegill						4		2	24	31.8	36
Largemouth bass				1					76	76.0	76
Grand Total	**24**	**14**	**52**	**38**	**73**	**68**	**37**	**101**			

Table 4. Estimated Fish Populations at Albany Avenue Based on Sampling by MWRD on August 27, 2013.

A. Fish Species and Numbers Collected by Backpack Elecrofisher. Each Pass Was 40 meters in Length.

Species	Pass 1	Pass 2	Total
White sucker	0	3	3
Yellow bullhead	8	3	11
Central mudminnow	2	1	3
Green sunfish	9	2	11
Bluegill	0	1	1
Total:	**19**	**10**	**29**

B. Calculations to Estimate Fish Population Using Depletion Method (Lockwood and Schneider 2000).

Total Population Size = $(N_1)^2/(N_1-N_2)$ — N_1 = Number collected in Pass 1

$(19)^2/(19-10) = 40$ — N_2 = Number collected in Pass 2

Total Fish Population in 80 meters (262.5 ft) of shoreline 40

Proportion of Total Population Represented in Sample = 29/40 0.73

C. Fish Species and Numbers Collected by Backpack Electrofisher and Seine. Population Estimates Based on Proportion of Fish Collected in Electrofishing Samples.

Species	Electrofisher Total	Seine Total	Total	Population Estimates*
White sucker	3	3	6	8
Yellow bullhead	11		11	15
Central mudminnow	3		3	4
Blackstripe topminnow		67	67	92
Green sunfish	11	1	12	17
Bluegill	1	1	2	3
Total:	**29**	**72**	**101**	**139**

Notes:

* Population Estimates = Sample number/ 0.73

D. Total Numbers, Lenghts and Swimming Speeds of Fish Species Collected at Albany Avenue.

Species	Total Number	Total Length (mm)		Maximum, Critical or Burst Swimming Speed (ft/sec)	References
		Min	Max		
White sucker	6	49	72	Critical Speed (TL = 170-370) = 1.56 - 5.76	Jones et al 1974
Yellow bullhead**	11	32	144	Maximum Speed (TL = 30-39) = 1.0; (TL= 140-154) = 2.01	King 1969; Hocutt 1973
Central mudminnow*	3	60	67	Burst Speed (adults) = 1.2	Meldrim 1968
Blackstripe topminnow***	67	33	71	Critical Speed (TL = 33-71) = 0.11 - 1.33	Fangue et al 2008
Green sunfish****	12	40	65	Maximum Speed (TL = 39-54 mm) = 0.48 - 0.92	Normandeau 2009
Bluegill	2	35	36	Maximum Speed (TL = 25-40 mm) = 0.3 - 0.75	Normandeau 2009
Total:	**101**				

Notes:

*=Olympic mudmiinow (adults) used as surrogate

**= Channel catfish used as surrogate

***= Mummichog (TL= 75-90 mm) used as surrogate

****= Bluegill used as surrogate

Table 5. Species, Numbers and Lengths of Fish Entrained During Various Flood Events Into Albany Park Stormwater Tunnel Intake Under Existing Conditions.

Simulated Scenario: Albany Avenue Populations Transposed to Intake Area.

A. Project Operation Characteristics Under Various Flow Conditions.

	Flood Event				
	1-Year	2-Year	10-Year	50-Year	100-Year
North Branch Channel Flow Upstream of Intake (cfs)	1050	1342	2232	3550	4095
Intake Flow (cfs)	100	250	900	1900	2300
Intake Velocity at Weir (ft/secs)	3	3.5	4	4.5	5
Proportion of Flow Entering Intake	0.095	0.186	0.403	0.535	0.562

B. Numbers and Lengths of Fish Species Entrained Into Intake at Various Flood Events Based on Swimming Speeds and Flows Entering Intake.

				Flood Event					
				1-Year			2-Year		
Species	Population Number	Length TL (mm)	Maximum Swimming Speed (ft/sec)	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
White sucker	8	49-72	1.56	100	0.095	1	100	0.186	2
Yellow bullhead	15	32-144	1.0 - 2.01	100	0.095	2	100	0.186	3
Central mudminnow	4	60-67	1.2	100	0.095	1	100	0.186	1
Blackstripe topminnow	92	33-71	0.11 - 1.33	100	0.095	9	100	0.186	18
Green sunfish	17	40-65	0.48 - 0.92	100	0.095	2	100	0.186	4
Bluegill	3	35-36	0.3 - 0.75	100	0.095	1	100	0.186	1
Total	139				Total	16		Total	29

	Flood Event								
	10-Year			50-Year			100-Year		
Species	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
White sucker	100	0.403	4	100	0.535	5	100	0.562	5
Yellow bullhead	100	0.403	7	100	0.535	9	100	0.562	9
Central mudminnow	100	0.403	2	100	0.535	3	100	0.562	3
Blackstripe topminnow	100	0.403	38	100	0.535	50	100	0.562	52
Green sunfish	100	0.403	7	100	0.535	10	100	0.562	10
Bluegill	100	0.403	2	100	0.535	2	100	0.562	2
Total		Total	60		Total	79		Total	81

Notes:

*= Fractions of fish entrained rounded up to next whole number

Table 6. Fish Species, Numbers and Estimated Populations at Foster Avenue Based on Sampling by MWRD on August 18, 2009.

A. Numbers of Fish Species Collected by Boat Elecrofisher. Each Pass Was 400 meters in Length.

Species	Pass 1	Pass 2	Total	Population Estimate*
Gizzard shad	6	31	**37**	**62**
Goldfish	3	2	**5**	**8**
Common carp	2	3	**5**	**8**
Spotfin shiner	23	7	**30**	**51**
Golden shiner	19	4	**23**	**39**
Bluntnose minnow	33		**33**	**56**
White sucker	4	6	**10**	**17**
Spotted sucker	1		**1**	**2**
Yellow bullhead	1	1	**2**	**3**
Channel catfish		1	**1**	**2**
Pumpkinseed	12	11	**23**	**39**
Bluegill	27	16	**43**	**73**
Largemouth bass	7	6	**13**	**22**
Total:	**138**	**88**	**226**	**382**

* Population Estimate = Sample number/ 0.593

B. Calculations to Estimate Fish Population Using Depletion Method (Lockwood and Schneider 2000).

Total Population Size = $(N_1)^2/(N_1-N_2)$

$(138)^2/(138-88) = 381$

N_1 = Number collected in Pass 1

N_2 = Number collected in Pass 2

Total Fish Population in 800 meters (2,625 ft) of shoreline = 381*

*= Difference between calculated total population (381) and total in Table A (382) due to rounding

Proportion of Total Population Represented in Sample = 226/381 = 0.593

C. Total Number, Lenghts (mm) and Swimming Speeds of Fish Species at Foster Avenue.

Species	Total Number	Total Length (mm) Min	Total Length (mm) Max	Maximum or Burst Swimming Speed (ft/sec)	References
Gizzard shad	37	136	237	Burst Speed (25-75 mm) = 2.5^; (TL= 250-350 mm) = 8	USDA Forest Service FishXing 2006^; Normandeau 2009
Goldfish	5	157	298	Burst Speed (TL= 100-200 mm) = 2	USDA Forest Service FishXing. 2006
Common carp	5	486	736	Burst Speed (TL= 153 - adults) = 4.49 - 14	USDA Forest Service FishXing. 2006
Spotfin shiner*	30	62	117	Critical Speed (TL= 62-117 mm) = 1.53 - 2.27	Layher and Ralston (unpublished)
Golden shiner	23	84	146	Critical Speed (TL = 82-173 mm) = 1.8 - 3.02	Layher and Ralston (unpublished)
Bluntnose minnow*	33	63	98	Critical Speed (TL= 63-98 mm) = 1.54 - 2.01	Layher and Ralston (unpublished)
White sucker	10	99	404	Critical Speed (TL = 170-370 mm) = 1.56 - 5.76	Jones et al 1974
Spotted sucker**	1	405	405	Critical Speed (TL = 170-370 mm) = 1.56 - 5.76	Jones et al 1974
Yellow bullhead***	2	145	217	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154 mm) = 2.01	King 1969; Hocutt 1973
Channel catfish	1	457	457	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154) = 2.01; (juveniles) =3.93^	King 1969; Hocutt 1973; Venn Beecham et al 2009^
Pumpkinseed****	23	119	162	Burst Speed (TL= 100-150 mm) = 2.4	Normandeau 2009
Bluegill	43	71	175	Burst Speed (TL= 100-150 mm) = 2.4	Normandeau 2009
Largemouth bass	13	66	344	Burst Speed (TL=50-100 mm) = 3.2; (TL=148-265 mm) = 4.3	Normandeau 2009
Total	**226**				

Notes:

* Golden shiner equation used as surrogate

**White sucker used as surrogate

***= Channel catfish used as surrogate

****= Bluegill used as surrogate

^= American shad as surrogate

Table 7. Number and Species of Fish Entrained at Albany Park Stormwater Diversion Project Outlet During Backflow.

Simulated Scenario: Foster Avenue Populations Transposed to Outlet Area.

A. Project Operation Characteristics Under Various Flow Conditions.

	Flood Event				
	1-Year	**2-Year**	**10-Year**	**50-Year**	**100-Year**
North Shore Channel Flow at near Outlet (cfs)	350	500	1150	2150	2550
Peak Outlet Backflow (cfs)	700	700	700	700	700
Peak Outlet Backflow Velocity at Weir (ft/s)**	4.3	4.3	4.3	4.3	4.3
Duration of Backflow Event (min)	30	30	30	30	30

B. Calculate Portion of Outlet Population Subject to Backflow Entrainment

The zone where NSC channel velocities are greater than 2.0 ft/s during a backflow event are limited to the width of the outlet plus approximately 5 meters in each direction (approximately 30 meters total). Rounding this distance up yields a conservative value of 50 meters. To calculate the portion of the outlet population that would be subject to entrainment, a distance proportion was used.

50 meters	Channel distance where fish population is subject to backflow entrainment
400 meters	Outlet population based on electofishing sampling of 400 meters (both banks) of NSC near Foster Avenue.
0.125	Proportion of outlet population subject to entrainment. This is the same for each flood event, since the characteristics of the backflow event are similar during each of the 5 flood events.

C. Numbers and Lengths of Fish Species Entrained Into Intake at Various Flood Events Based on Swimming Speeds and Flows Entering Intake.

				Flood Event		
				1-, 2-, 10-, 50-, or 100-Year		
Species	**Population Number**	**Length TL (mm)**	**Maximum Swimming Speed (ft/sec)**	**Percent of Population With Swimming Speed < Intake Velocity**	**Proportion of Population Entrained**	**Number Entrained***
Gizzard shad	62	136-237	8.0	0	0.000	0
Goldfish	8	157-298	2	100	0.125	1
Common carp	8	486-736	14	0	0.000	0
Spotfin shiner	51	62-117	2.27	100	0.125	7
Golden shiner	39	84-146	3.02	100	0.125	5
Bluntnose minnow	56	63-98	2.1	100	0.125	7
White sucker	17	99-404	1.56-5.76	90**	0.113	2
Spotted sucker	2	405-405	5.76	0	0.000	0
Yellow bullhead	3	145-217	2.01	100	0.125	1
Channel catfish	2	457-457	2.01	100	0.125	1
Pumpkinseed	39	119-162	2.4	100	0.125	5
Bluegill	73	71-175	2.4	100	0.125	10
Largemouth bass	22	66-344	3.2-4.3	95**	0.119	3
Total:	**382**				**Total**	**42**

Notes:

*= Fractions of fish entrained rounded up to next whole number

**= Assumed for purpose of this exercise

Table 8. Fish species found upstream and downstream of the Hofmann Dam before and after removal. Upstream data are for the dam pool area. (Table provided by IDNR)

		Before Dam Removal (2010)		After Dam Removal (2013)	
Common name	**Scientific name**	**Downstream**	**Upstream**	**Downstream**	**Upstream**
Gizzard shad	*Dorosoma cepedianum*	70		3	
Northern pike	*Esox lucius*			2	
Muskellunge	*Esox masquinongy*				1
Goldfish	*Carassius auratus*	2			
Carp	*Cyprinus carpio*	8	4		9
Carp x Goldfish hybrid	*Cyprinus carpio x Carassius auratus*				3
Creek chub	*Semotilus atromaculatus*			1	
Hornyhead chub	*Nocomis biguttatus*	2		14	33
Suckermouth minnow	*Phenacobius mirabilis*			1	
Spotfin shiner	*Cyprinella spiloptera*	10	2	309	24
Fathead minnow	*Pimephales promelas*			4	
Bluntnose minnow	*Pimephales notatus*	4	2	27	68
Rosyface shiner	*Notropis rubellus*			16	18
Bigmouth shiner	*Notropis dorsalis*			8	
Sand shiner	*Notropis ludibundus*	4		141	53
Spottail shiner	*Notropis hudsonius*				1
Quillback	*Carpiodes cyprinus*			1	
River carpsucker	*Carpiodes carpio*			1	
White sucker	*Catostomus commersoni*	28		55	12
Spotted sucker	*Minytrema melanops*	2			
Channel catfish	*Ictalurus punctatus*	12		11	2
Yellow bullhead	*Ameiurus natalis*	2			
Blackstripe topminnow	*Fundulus notatus*		2	14	42
Mosquitofish	*Gambusia affinis*			2	
Yellow bass	*Morone mississippiensis*				2
Black crappie	*Pomoxis nigromaculatus*	12		2	2
Rock bass	*Ambloplites rupestris*	4		1	4
Largemouth bass	*Micropterus salmoides*	12	2	2	2
Smallmouth bass	*Micropterus dolomieu*			2	
Warmouth	*Lepomis gulosus*				1
Green sunfish	*Lepomis cyanellus*	4	2	3	20
Bluegill x Green sunfish hybrid	*Lepomis macrochirus x L. cyanellus*	2		2	3
Bluegill	*Lepomis macrochirus*	48	4	23	9
Redear sunfish	*Lepomis microlophus*				1
Pumpkinseed	*Lepomis gibbosus*				1
Orangespotted sunfish	*Lepomis humilis*	4		8	3
Walleye	*Stizostedion vitreum*	4			
Sauger	*Stizostedion canadense*	2			
Blackside darter	*Percina maculata*				2
Logperch	*Percina caprodes*			5	2
Johnny darter	*Etheostoma nigrum*			1	1
Round goby	*Neogobius melanostomus*	4		18	
Total fish		**240**	**18**	**677**	**319**
Total species		**20**	**7**	**27**	**24**

Table 9. Fish Species, Numbers and Estimated Populations at Wilson Avenue Based on Sampling by MWRD on September 3, 2009.

A. Fish Species and Numbers Collected by Boat Elecrofisher. Each Pass Was 400 Meters in Length.

Species	Pass 1	Pass 2	Total	Population Estimates*
Gizzard shad	2	2	**4**	**5**
Common carp	5	8	**13**	**17**
Common carp x goldfish	1		**1**	**1**
Spotfin shiner	53	12	**65**	**85**
Golden shiner	50	15	**65**	**85**
Emerald shiner	4		**4**	**5**
Bluntnose minnow	10	6	**16**	**21**
Fathead minnow	1	1	**2**	**3**
White sucker	16	6	**22**	**29**
Yellow bullhead		4	**4**	**5**
Channel catfish		1	**1**	**1**
Round goby		1	**1**	**1**
Green sunfish	1		**1**	**1**
Pumpkinseed	10	9	**19**	**25**
Bluegill	13	15	**28**	**37**
Largemouth bass	11	5	**16**	**21**
Black crappie	1		**1**	**1**
Yellow perch		1	**1**	**1**
Total:	**178**	**86**	**264**	**344**

* Population Estimate = Sample number/ 0.767

B. Calculations to Estimate Fish Population Using Depletion Method (Lockwood and Schneider 2000).

Total Population Size = $(N_1)^2/(N_1-N_2)$ — N_1 = Number collected in Pass 1

$(178)^2/(178-86) = 344$ — N_2 = Number collected in Pass 2

Total Fish Population in 800 meters (2,625 ft) of shoreline= 344

Proportion of Total Population Represented in Sample = 264/344 = 0.767

C. Total Number, Lenghts and Swimming Speeds of Fish Species at Wilson Avenue.

	Total	Total Length (mm)			
Species	**Number**	**Min**	**Max**	**Maximum, Critical or Burst Swimming Speed (ft/sec)**	**References**
Gizzard shad	4	213	253	Burst Speed (25-75 mm) = 2.5*; (TL= 250-350 mm) = 8	USDA Forest Service FishXing 2006*; Normandeau 2009
Common carp	13	442	636	Burst Speed (TL= 153 - adults) = 4.49 - 14	USDA Forest Service FishXing. 2006
Common carp x goldfish**	1	420	420	Burst Speed (TL= 153 - adults) = 4.49 - 14	USDA Forest Service FishXing. 2006
Spotfin shiner***	65	60	112	Critical Speed (TL= 60-172 mm) = 1.5 - 2.2	Layher and Ralston (unpublished)
Golden shiner	65	82	173	Critical Speed (TL = 82-173 mm) = 1.8 - 3.02	Layher and Ralston (unpublished)
Emerald shiner***	4	105	133	Critical Speed (TL = 105-133 mm) = 2.1 - 2.5	Layher and Ralston (unpublished)
Bluntnose minnow***	16	65	99	Critical Speed (TL= 65-99 mm) = 1.57 - 2.02	Layher and Ralston (unpublished)
Fathead minnow***	2	70	86	Critical Speed (TL= 70-86 mm) = 1.6 - 1,85	Layher and Ralston (unpublished)
White sucker	22	87	382	Critical Speed (TL = 170-370 mm) = 1.56 - 5.76	Jones et al 1974
Yellow bullhead****	4	194	256	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154) = 2.01	King 1969; Hocutt 1973
Channel catfish	1	424	424	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154) = 2.01; (juveniles) =3.93^	King 1969; Hocutt 1973; Venn Beecham et al 2009^
Round goby	1	135	135	Burst Speed (TL= 91-154 mm) = 1.8 - 2.46	Hoover, et al 2003
Green sunfish*****	1	99	99	Burst Speed (50 mm) = 1.8; (100-150 mm) = 2.4; (150 mm) = 4.3	Normandeau 2009
Pumpkinseed*****	19	71	190	Burst Speed (50 mm) = 1.8; (100-150 mm) = 2.4; (150 mm) = 4.3	Normandeau 2009
Bluegill	28	41	182	Burst Speed (50 mm) = 1.8; (100-150 mm) = 2.4; (150 mm) = 4.3	Normandeau 2009
Largemouth bass	16	56	312	Burst Speed (TL=50-100 mm) = 3.2; (TL=148-265 mm) = 4.3	Normandeau 2009
Black crappie******	1	71	71	Burst Speed (TL=75mm) = 1.0-2.0	Normandeau 2009
Yellow perch	1	74	74	Critical Speed (jTL= 90-100 mm) = 1.08	Otto and Rice 1974
Total	**264**				

Notes:

*=American shad as surrogate

**= Carp used as surrogate

***= Golden shiner equation used as surrogate

****= Channel catfish used as surrogate

*****= Bluegill used as surrogate

******= White crappie used as surrogate

^= Blue catfish as surrogate

Table 10. Fish Species, Numbers and Estimated Populations at Site HCC-02 Based on August 9, 2011 IDNR Lake Michigan Basin Surveys.

A. Species, Numbers and Population Estimates of Fishes Collected by Boat Elecrofisher. Sample Duration Was 30 Minutes and 3600 Feet in Length.

Species	Number	Population Estimates*
Gizzard shad	22	29
Carp	19	25
Spotfin shiner	40	52
Golden shiner	4	5
Emerald shiner	5	7
Bluntnose minnow	13	17
Fathead minnow	3	4
Black bullhead	1	1
Channel catfish	7	9
Blackstripe topminnow	1	1
Green sunfish	4	5
Pumpkinseed	6	8
Bluegill	45	59
Bluegill x Green sunfish hybrid	3	4
Largemouth bass	13	17
Grand Total	**186**	**243**

* Population Estimate = Sample number/ 0.767; based on population estimate factor for Wilson Avenue (Table 9).

B. Total Number, Lengths and Swimming Speeds of Fish Species at HCC-02.

Species	Total Number	Total Length (mm) Min	Total Length (mm) Max	Maximum, Critical or Burst Swimming Speed (ft/sec)	References
Gizzard shad	22	152	305	Burst Speed (TL= 250-350 mm) = 8	Normandeau 2009
Carp	19	61	698	Burst Speed (TL= 153 - adults) = 4.49 - 14	USDA Forest Service FishXing. 2006
Spotfin shiner*	40	47	90	Critical Speed (TL= 47-90 mm) = 1.33 - 1.9	Layher and Ralston (unpublished)
Golden shiner	4	59	114	Critical Speed (TL= 59-114 mm) = 1.49 - 2.23	Layher and Ralston (unpublished)
Emerald shiner*	5	90	110	Critical Speed (TL= 90 -110 mm) = 1.9 - 2.17	Layher and Ralston (unpublished)
Bluntnose minnow*	13	53	70	Critical Speed (TL= 53-70 mm) = 1.41 - 1.63	Layher and Ralston (unpublished)
Fathead minnow*	3	40	40	Critical Speed (TL= 40 mm) = 1.23	Layher and Ralston (unpublished)
Black bullhead**	1	130	130	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154 mm) = 2.01	King 1969; Hocutt 1973
Channel catfish	7	405	625	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154) = 2.01; (juveniles) =3.93^	King 1969; Hocutt 1973; Venn Beecham et al 2009^
Blackstripe topminnow***	1	63	63	Critical Speed (TL = 33-71) = 0.11 - 1.33	Fangue et al 2008
Green sunfish****	4	83	96	Burst Speed (TL= 50 mm) = 1.8; (TL= 100-150 mm) = 2.4	Normandeau 2009
Pumpkinseed****	6	80	111	Burst Speed (TL= 50 mm) = 1.8; (TL= 100-150 mm) = 2.4	Normandeau 2009
Bluegill	45	20	176	Burst Speed (TL= 50 mm) = 1.8; (TL= 100-150 mm) = 2.4	Normandeau 2009
Bluegill x Green sunfish hybrid****	3	97	110	Burst Speed (TL= 50 mm) = 1.8; (TL= 100-150 mm) = 2.4	Normandeau 2009
Largemouth bass	13	60	320	Burst Speed (TL=50-100 mm) = 3.2; (TL=148-265 mm) = 4.3	Normandeau 2009
Grand Total	**243**				

Notes:

*= Golden shiner equation used as surrogate

**= Channel catfish used as surrogate

***= Mummichog (TL= 75-90 mm) used as surrogate

****= Bluegill used as surrogate

Table 11. Fish Species, Numbers and Estimated Populations at Site HCCA-04 Based on August 9, 2011 IDNR Lake Michigan Basin Surveys.

A. Species, Numbers and Population Estimates of Fishes Collected by Boat Elecrofisher. Sample Duration Was 30 Minutes and 1500 Feet in Length.

Species	Number	Population Estimates*
Gizzard shad	25	42
Carp	14	24
Spotfin shiner	6	10
Golden shiner	22	37
White sucker	6	10
Channel catfish	1	2
Blackstripe topminnow	1	2
Rock bass	1	2
Pumpkinseed	1	2
Bluegill	10	17
Bluegill x Green sunfish hybrid	1	2
Grand Total	**88**	**148**

* Population Estimate = Sample number/ 0.593; based on population estimate factor for Foster Avenue (Table 6).

B. Total Number, Lengths and Swimming Speeds of Fish Species at HCCA-04.

Species	Number	Total Length (mm)		Maximum, Critical or Burst Swimming Speed (ft/sec)	References
		Min	Max		
Gizzard shad	42	173	324	Burst Speed (TL= 250-350 mm) = 8	Normandeau 2009
Carp	24	503	683	Burst Speed (TL= 153 - adults) = 4.49 - 14	USDA Forest Service FishXing. 2006
Spotfin shiner*	10	63	72	Critical Speed (TL= 63-72 mm) = 1.54 - 1.66	Layher and Ralston (unpublished)
Golden shiner	37	37	165	Critical Speed (TL = 37-165 mm) = 1.19 - 2.91	Layher and Ralston (unpublished)
White sucker	10	166	429	Critical Speed (TL = 170-370 mm) = 1.56 - 5.76	Jones et al 1974
Channel catfish	2	464	464	Maximum Speed (TL = 30-39 mm) = 1.0; (TL= 140-154) = 2.01; (juveniles) =3.93^	King 1969; Hocutt 1973; Venn Beecham et al 2009^
Blackstripe topminnow**	2	59	59	Critical Speed (TL = 33-71 mm) = 0.11 - 1.33	Fangue et al 2008
Rock bass***	2	142	142	Burst Speed (TL= 100-150 mm) = 2.4	Normandeau 2009
Pumpkinseed***	2	142	142	Burst Speed (TL= 100-150 mm) = 2.4	Normandeau 2009
Bluegill	17	112	136	Burst Speed (TL= 100-150 mm) = 2.4	Normandeau 2009
Bluegill x Green sunfish hybrid***	2	94	94	Burst Speed (TL= 100-150 mm) = 2.4	Normandeau 2009
Grand Total	**148**				

Notes:
*= Golden shiner equation used as surrogate
**= Mummichog (TL= 75-90 mm) used as surrogate
***= Bluegill used as surrogate

Table 12. Species, Numbers and Lengths of Fish Entrained During Various Flood Events Into Albany Park Stormwater Tunnel Intake With North Branch Dam Removed.

Simulated Scenario: Wilson Avenue Populations Transposed to Intake Area.

A. Project Operation Characteristics Under Various Flow Conditions.

	Flood Event				
	1-Year	2-Year	10-Year	50-Year	100-Year
North Branch Channel Flow Upstream of Intake (cfs)	1050	1342	2232	3550	4095
Intake Flow (cfs)	100	250	900	1900	2300
Intake Velocity at Weir (cfs)	3	3.5	4	4.5	5
Proportion of Flow Entering Intake	0.095	0.186	0.403	0.535	0.562

B. Numbers and Lengths of Fish Species Entrained Into Intake at Various Flood Events Based on Swimming Speeds and Flows Entering Intake.

				Flood Event					
				1-Year			2-Year		
Species	Population Number	Length TL (mm)	Maximum Swimming Speed (ft/sec)	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
Gizzard shad	5	213-253	8	0	0	0	0	0	0
Common carp	17	442-636	14	0	0	0	0	0	0
Common carp x goldfish	1	420	14	0	0	0	0	0	0
Spotfin shiner	85	60-112	2.2	100	0.095	9	100	0.186	16
Golden shiner	85	82-173	3.02	100	0.095	9	100	0.186	16
Emerald shiner	5	105-133	2.5	100	0.095	1	100	0.186	1
Bluntnose minnow	21	65-99	2.02	100	0.095	2	100	0.186	4
Fathead minnow	3	70-86	1.83	100	0.095	1	100	0.186	1
White sucker	29	87-382	1.56-5.76	50***	0.048	2	65***	0.121	4
Yellow bullhead	5	194-256	2.01	100	0.095	1	100	0.186	1
Channel catfish**	1	424	3.93	0	0	0	0	0	0
Green sunfish	1	99	2.4	100	0.095	1	100	0.186	1
Pumpkinseed	25	71-190	2.4	100	0.095	3	100	0.186	5
Bluegill	37	41-182	2.4	100	0.095	4	100	0.186	7
Largemouth bass	21	56-312	3.2 - 4.3	0	0	0	50***	0.093	2
Black crappie	1	71	2	100	0.095	1	100	0.186	1
Yellow perch	1	74	1.08	100	0.095	1	100	0.186	1
Round goby	1	135	2.46	100	0.095	1	100	0.186	1
Total:	**344**				**Total:**	**36**		**Total:**	**60**

	Flood Event								
	10-Year			50-Year			100-Year		
Species	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
Gizzard shad	0	0	0	0	0	0	0	0	0
Common carp	0	0	0	0	0	0	0	0	0
Common carp x goldfish	0	0	0	0	0	0	0	0	0
Spotfin shiner	100	0.403	35	100	0.535	46	100	0.562	48
Golden shiner	100	0.403	35	100	0.535	46	100	0.562	48
Emerald shiner	100	0.403	2	100	0.535	3	100	0.562	3
Bluntnose minnow	100	0.403	9	100	0.535	12	100	0.562	12
Fathead minnow	100	0.403	2	100	0.535	2	100	0.562	2
White sucker	75***	0.302	9	85***	0.455	14	90***	0.506	15
Yellow bullhead	100	0.403	2	100	0.535	3	100	0.562	3
Channel catfish**	100	0.403	1	100	0.535	1	100	0.562	1
Green sunfish	100	0.403	1	100	0.535	1	100	0.562	1
Pumpkinseed	100	0.403	11	100	0.535	14	100	0.562	15
Bluegill	100	0.403	15	100	0.535	20	100	0.562	21
Largemouth bass	90***	0.363	8	100	0.535	12	100	0.562	12
Black crappie	100	0.403	1	100	0.535	1	100	0.562	1
Yellow perch	100	0.403	1	100	0.535	1	100	0.562	1
Round goby	100	0.403	1	100	0.535	1	100	0.562	1
Total:		**Total:**	**132**		**Total:**	**177**		**Total:**	**184**

Notes:

*= Fractions of fish entrained rounded up to next whole number

**= Blue catfish (juveniles) used as surrogate

***= Assumed for purpose of this exercise

Table 13. Species, Numbers and Lengths of Fish Entrained During Various Flood Events Into Albany Park Stormwater Tunnel Intake With North Branch Dam Removed.

Simulated Scenario: Site HCC-02 Populations Transposed to Intake Area.

A. Project Operation Characteristics Under Various Flow Conditions.

	Flood Event				
	1-Year	2-Year	10-Year	50-Year	100-Year
North Branch Channel Flow Upstream of Intake (cfs)	1050	1342	2232	3550	4095
Intake Flow (cfs)	100	250	900	1900	2300
Intake Velocity at Weir (cfs)	3	3.5	4	4.5	5
Proportion of Flow Entering Intake	0.095	0.186	0.403	0.535	0.562

B. Numbers and Lengths of Fish Species Entrained Into Intake at Various Flood Events Based on Swimming Speeds and Flows Entering Intake.

				Flood Event					
				1-Year			2-Year		
Species	**Population Number**	**Length TL (mm)**	**Maximum Swimming Speed (ft/sec)**	**Percent of Population With Swimming Speed < Intake Velocity**	**Proportion of Population Entrained**	**Number Entrained***	**Percent of Population With Swimming Speed < Intake Velocity**	**Proportion of Population Entrained**	**Number Entrained***
Gizzard shad	29	152-305	8	0	0	0	0	0	0
Carp	25	61-698	4.49 - 14	0	0	0	0	0	0
Spotfin shiner	52	47-90	1.66	100	0.095	5	100	0.186	19
Golden shiner	5	59-114	1.9	100	0.095	1	100	0.186	1
Emerald shiner	7	90-110	2.23	100	0.095	1	100	0.186	2
Bluntnose minnow	17	53-70	1.63	100	0.095	2	100	0.186	4
Fathead minnow	4	40-40	1.23	100	0.095	1	100	0.186	1
Black bullhead	1	130	2.01	100	0.095	1	100	0.186	1
Channel catfish**	9	405-625	3.93	0	0	0	0	0	0
Blackstripe topminnow	1	63	1.33	100	0.095	1	100	0.186	1
Green sunfish	5	83-96	2.4	100	0.095	1	100	0.186	1
Pumpkinseed	8	80-111	2.4	100	0.095	1	100	0.186	2
Bluegill	59	20-176	2.4	100	0.095	6	100	0.186	11
Bluegill x Green sunfish hybrid	4	97-110	2.4	100	0.095	1	100	0.186	1
Largemouth bass	17	60-320	3.2 - 4.3	0	0	0	50***	0.093	2
Total:	**243**				**Total:**	**21**		**Total:**	**46**

	Flood Event								
	10-Year			50-Year			100-Year		
Species	**Percent of Population With Swimming Speed < Intake Velocity**	**Proportion of Population Entrained**	**Number Entrained***	**Percent of Population With Swimming Speed < Intake Velocity**	**Proportion of Population Entrained**	**Number Entrained***	**Percent of Population With Swimming Speed < Intake Velocity**	**Proportion of Population Entrained**	**Number Entrained***
Gizzard shad	0	0	0	0	0	0	0	0	0
Carp	0	0	0	0	0	0	0	0	0
Spotfin shiner	100	0.403	22	100	0.535	28	100	0.562	30
Golden shiner	100	0.403	3	100	0.535	3	100	0.562	3
Emerald shiner	100	0.403	3	100	0.535	4	100	0.562	4
Bluntnose minnow	100	0.403	7	100	0.535	10	100	0.562	10
Fathead minnow	100	0.403	2	100	0.535	2	100	0.562	3
Black bullhead	100	0.403	1	100	0.535	1	100	0.562	1
Channel catfish**	50***	0.202	2	75***	0.401	4	80***	0.450	5
Blackstripe topminnow	100	0.403	1	100	0.535	1	100	0.562	1
Green sunfish	100	0.403	3	100	0.535	3	100	0.562	3
Pumpkinseed	100	0.403	4	100	0.535	4	100	0.562	5
Bluegill	100	0.403	24	100	0.535	32	100	0.562	33
Bluegill x Green sunfish hybrid	100	0.403	2	100	0.535	3	100	0.562	3
Largemouth bass	100	0.403	7	100	0.535	10	100	0.562	10
Total:		**Total:**	**81**		**Total:**	**105**		**Total:**	**111**

Notes:
*= Fractions of fish entrained rounded up to next whole number
**= Blue catfish (juveniles) used as surrogate
***= Assumed for purpose of this exercise

Table 14. Species, Numbers and Lengths of Fish Entrained During Various Flood Events Into Albany Park Stormwater Tunnel Intake With North Branch Dam Removed.

Simulated Scenario: Foster Avenue Populations Transposed to Intake Area.

A. Project Operation Characteristics Under Various Flow Conditions.

	Flood Event				
	1-Year	2-Year	10-Year	50-Year	100-Year
North Branch Channel Flow Upstream of Intake (cfs)	1050	1342	2232	3550	4095
Intake Flow (cfs)	100	250	900	1900	2300
Intake Velocity at Weir (cfs)	3	3.5	4	4.5	5
Proportion of Flow Entering Intake	0.095	0.186	0.403	0.535	0.562

B. Numbers and Lengths of Fish Species Entrained Into Intake at Various Flood Events Based on Swimming Speeds and Flows Entering Intake.

				Flood Event					
				1-Year			2-Year		
Species	Population Number	Length TL (mm)	Maximum Swimming Speed (ft/sec)	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
Gizzard shad	62	136-237	8.0	0	0	0	0	0	0
Goldfish	8	157-298	2	100	0.095	1	100	0.186	2
Common carp	8	486-736	14	0	0	0	0	0	0
Spotfin shiner	51	62-117	2.27	100	0.095	5	100	0.186	10
Golden shiner	39	84-146	3.02	100	0.095	4	100	0.186	8
Bluntnose minnow	56	63-98	2.1	100	0.095	6	100	0.186	11
White sucker	17	99-404	1.56-5.76	50**	0.048	1	50**	0.093	2
Spotted sucker	2	405-405	5.76	0	0	0	0	0	0
Yellow bullhead	3	145-217	2.01	100	0.095	1	100	0.186	6
Channel catfish	2	457-457	2.01	100	0.095	1	100	0.186	4
Pumpkinseed	39	119-162	2.4	100	0.095	4	100	0.186	8
Bluegill	73	71-175	2.4	100	0.095	7	100	0.186	14
Largemouth bass	22	66-344	3.2-4.3	0	0	0	50**	0.093	3
Total:	**382**				**Total**	**30**		**Total**	**68**

	Flood Event								
	10-Year			50-Year			100-Year		
Species	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
Gizzard shad	0	0	0	0	0	0	0	0	0
Goldfish	100	0.403	4	100	0.535	5	100	0.562	5
Common carp	0	0	0	0	0	0	0	0	0
Spotfin shiner	100	0.403	21	100	0.535	28	100	0.562	29
Golden shiner	100	0.403	16	100	0.535	21	100	0.562	22
Bluntnose minnow	100	0.403	23	100	0.535	30	100	0.562	32
White sucker	75**	0.000	6	90**	0.086	9	95**	0.534	10
Spotted sucker	0	0	0	0	0	0	0	0	0
Yellow bullhead	100	0.403	2	100	0.535	2	100	0.562	2
Channel catfish	100	0.403	1	100	0.535	2	100	0.562	2
Pumpkinseed	100	0.403	16	100	0.535	21	100	0.562	21
Bluegill	100	0.403	30	100	0.535	40	100	0.562	41
Largemouth bass	95**			100	0.535	12	100	0.562	13
Total:		**Total**	**119**		**Total**	**170**		**Total**	**177**

Notes:

*= Fractions of fish entrained rounded up to next whole number

**= Assumed for purpose of this exercise

Table 15. Species, Numbers and Lengths of Fish Entrained During Various Flood Events Into Albany Park Stormwater Tunnel Intake With North Branch Dam Removed.

Simulated Scenario: Site HCCA-04 Populations Transposed to Intake Area.

A. Project Operation Characteristics Under Various Flow Conditions.

	Flood Event				
	1-Year	2-Year	10-Year	50-Year	100-Year
North Branch Channel Flow Upstream Of Intake (cfs)	1050	1342	2232	3550	4095
Intake Flow (cfs)	100	250	900	1900	2300
Intake Velocity at Weir (cfs)	3	3.5	4	4.5	5
Proportion of Flow Entering Intake	0.095	0.186	0.403	0.535	0.562

B. Numbers and Lengths of Fish Species Entrained Into Intake at Various Flood Events Based on Swimming Speeds and Flows Entering Intake.

				Flood Event					
				1-Year			2-Year		
Species	Population Number	Length TL (mm)	Maximum Swimming Speed (ft/sec)	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
Gizzard shad	42	173-324	8	0	0	0	0	0	0
Carp	24	503-683	14	0	0	0	0	0	0
Spotfin shiner	10	63-72	1.66	100	0.095	1	100	0.186	2
Golden shiner	37	37-165	2.91	100	0.095	4	100	0.186	7
White sucker	10	166-429	1.56 - 5.76	50***	0.048	0	65***	0.121	1
Channel catfish**	2	464-464	3.93	0	0	0	0	0	0
Blackstripe topminnow	2	59-59	1.33	100	0.095	0	100	0.186	0
Rock bass	2	142-142	2.4	100	0.095	0	100	0.186	0
Pumpkinseed	2	142-142	2.4	100	0.095	0	100	0.186	0
Bluegill	17	112-136	2.4	100	0.095	2	100	0.186	3
Bluegill x Green sunfish hybrid	2	94-94	2.4	100	0.095	0	100	0.186	0
Total:	**148**				**Total:**	**7**		**Total:**	**14**

	Flood Event								
	10-Year			50-Year			100-Year		
Species	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*	Percent of Population With Swimming Speed < Intake Velocity	Proportion of Population Entrained	Number Entrained*
Gizzard shad	0	0	0	0	0	0	0	0	0
Carp	0	0	0	0	0	0	0	0	0
Spotfin shiner	100	0.403	4	100	0.535	5	100	0.562	6
Golden shiner	100	0.403	15	100	0.535	20	100	0.562	21
White sucker	75***	0.302	3	85***	0.455	5	90***	0.506	5
Channel catfish**	100	0.403	1	100	0.535	1	100	0.562	1
Blackstripe topminnow	100	0.403	1	100	0.535	1	100	0.562	1
Rock bass	100	0.403	1	100	0.535	1	100	0.562	1
Pumpkinseed	100	0.403	1	100	0.535	1	100	0.562	1
Bluegill	100	0.403	7	100	0.535	9	100	0.562	9
Bluegill x Green sunfish hybrid	100	0.403	1	100	0.535	1	100	0.562	1
Total:		**Total:**	**32**		**Total:**	**43**		**Total:**	**46**

Notes:

*= Fractions of fish entrained rounded up to next whole number

**= Blue catfish (juveniles) used as surrogate

***= Assumed for purpose of this exercise

Table 16. Fish Species and Numbers Collected by Backpack Electrofishing at MWRD Wadeable Sites Upstream of the North Branch Dam (2009)

Stream Crossroad Species	West Fork NBCR Golf WW103	NBCR Glenview WW104	Skokie River Frontage WW105	West Fork NBCR Dundee WW106	Middle Fork NBCR Lake Cook WW31	Skokie River Lake Cook WW32	NBCR Dempster WW34	NBCR Albany WW96	Total
Goldfish	1					1			2
Common carp	1			3					4
Golden shiner	1								1
Bluntnose minnow	1								1
Fathead minnow			1	4		2			7
White sucker				36	1	6	2	6	51
Yellow bullhead	2						1	11	14
Black bullhead							1		1
Central mudminnow		3	5		4		3	3	18
Blackstripe topminnow	2		4			1		67	74
Brook stickleback						18			18
Green sunfish	5		14	1	4	4	22	12	62
Pumpkinseed						1			1
Orangespotted sunfish						6			6
Bluegill			3					2	5
Largemouth bass	4		15	1	1	37	2		60
Iowa darter				1					1
Total	**17**	**3**	**42**	**46**	**10**	**76**	**31**	**101**	

Table 17. Fish Species and Numbers Collected by Boat Electrofishing or Electric Seine at IDNR Lake Michigan Basin Study Wadeable Sites Upstream of the North Branch Dam (2011)

Stream	West Fork NBCR	Middle Fork NBCR	Middle Fork NBCR	Skokie River	
Crossroad	Walters Ave.	Deerfield High School	East Lake Ave.	Willow Rd.	
Sampling Gear	Electric Seine	Electric Seine	Boat Electrofishing	Boat Electrofishing	
Station Length (ft)	350	524	2500	2500	
Sampling Period (min)	30	44	30	30	
Species	**HCCB-13**	**HCCC-06**	**HCCC-08**	**HCCD-09**	**TOTAL**
Gizzard shad	0	0	1	34	**35**
Goldfish	2	0	2	1	**5**
Common carp	56	1	7	12	**76**
Golden shiner	9	15	7	0	**31**
Fathead minnow	2	1	0	0	**3**
White sucker	108	11	88	51	**258**
Yellow bullhead	0	1	0	0	**1**
Black bullhead	0	2	1	0	**3**
Northern pike	0	0	0	3	**3**
Central mudminnow	0	110	0	0	**110**
Blackstripe topminnow	0	39	9	3	**51**
Mosquitofish	0	1	0	0	**1**
Yellow bass	0	0	0	9	**9**
Green sunfish	27	30	12	17	**86**
Bluegill	26	27	38	65	**156**
Bluegill x Green sunfish hybrid	2	0	0	0	**2**
Largemouth bass	6	5	7	35	**53**
Black crappie	0	0	4	9	**13**
Iowa Darter	0	1	0	0	**1**
Total Fish	**238**	**244**	**176**	**239**	
Total Species	**8**	**13**	**11**	**11**	

Table 18. Fish Species and Numbers Collected in IDNR Asian Carp Monitoring Program by Electrofishing at Fixed Site 4, Fixed Site 5, and Random Site 4 (2011-2014).

Species	2011	2012	2013	2014	Grand Total
Spotted gar				1	1
Bowfin	1	1	1	4	7
Silver Arowana			1		1
Alewife	453	166	168	48	835
Skipjack herring		1			1
Gizzard shad	2728	14434	4564	754	22480
Gizzard Shad < 6 in	1124	7468	1238	2108	11938
Threadfin shad		57		15	72
Goldfish	51	37	25	32	145
Common carp	820	1381	750	1116	4067
Carp x goldfish hybrid	5	7	3	1	16
Spotfin shiner	514	839	825	45	2223
Silver carp				1	1
Silver chub	6	1			7
Golden shiner	756	1699	390	236	3081
Emerald shiner	30	187	99	47	363
River shiner	1				1
Blackchin shiner				4	4
Spottail shiner	62	62	28	41	193
Sand shiner	1	3		7	11
Weed shiner				1	1
Bluntnose minnow	611	2541	601	383	4136
Fathead minnow	32	14	9	2	57
Bullhead minnow	4	47		2	53
Creek chub	14	6	1		21
Unidentified Cyprinidae (minnows)	2				2
River carpsucker			5		5
Quillback			1		1
White sucker	703	641	342	648	2334
Smallmouth buffalo		2		3	5
Bigmouth buffalo		1			1
Golden redhorse				1	1
Shorthead redhorse		1			1
Oriental Weatherfish	31	27	4	8	70
Black bullhead	26	26	23	15	90
Yellow bullhead	43	88	33	10	174
Brown bullhead	8	7	1	9	25
Channel catfish	26	45	25	49	145
Rainbow smelt	1				1
Coho salmon	1	4	1		6
Rainbow trout	8	4		1	13
Chinook Salmon	7	9	5		21
Brown trout	4				4
Unidentified Salmonid	4				4
Grass pickerel		2			2

Table 18. Fish Species and Numbers Collected in IDNR Asian Carp Monitoring Program by Electrofishing at Fixed Site 4, Fixed Site 5, and Random Site 4 (2011-2014).

Species	2011	2012	2013	2014	Grand Total
Northern pike	4		5		9
Central mudminnow	2				2
Freshwater drum			2	1	3
Brook silverside	1	38	1	3	43
Banded killifish		1	6	9	16
Blackstripe topminnow	141	297	43	9	490
Western mosquitofish		35	1		36
White perch	8	30	8	9	55
White bass	1			14	15
Yellow bass	3	15	1	1	20
Rock bass	58	29	1	2	90
Green sunfish	257	321	88	99	765
Pumpkinseed	890	869	300	224	2283
Warmouth		5	3		8
Orangespotted sunfish		28		3	31
Bluegill	2137	7116	2236	229	11718
Longear sunfish				1	1
Redear sunfish		2			2
Green sunfish x pumpkinseed hybrid	1				1
Green sunfish x bluegill hybrid		10			10
Hybrid Sunfish	24	25	8	4	61
Smallmouth bass	1	15	3	3	22
Spotted bass				6	6
Largemouth bass	729	1256	451	1461	3897
White crappie	3	6	26	2	37
Black crappie	44	75	48	29	196
Yellow perch	143	59			202
Logperch				1	1
Walleye	6	1	1		8
Round Goby	20	6	2	17	45
Grand Total	**12,550**	**40,047**	**12,378**	**7,719**	**72,694**

Data source: spreadsheet of ACMP data for 3 stations provided by IDNR in March 2015

Sample Sites Included in Table

Fixed Site 4 - NBCR and NSC between Montrose Avenue and Peterson Avenue

Fixed Site 5 - NSC between Golf Road and Wilmette Pumping Station

Random Sites in Area 4 - Area 4 includes the NSC (between Fixed Sites 4 and 5), NBCR below the North Branch Dam, and the Chicago River

Table 19. Fish Species, Numbers and Estimated Populations at Fixed Site 4 Based on IDNR Asian Carp Monitoring Program in 2014.

A. Numbers of Fish Species Collected by Boat Elecrofisher.

Species	Number	Population Estimates*
Gizzard shad	213	359
Gizzard Shad < 6 in	479	808
Goldfish	5	8
Common carp	212	358
Spotfin shiner	5	8
Golden shiner	5	8
Emerald shiner	7	12
Bluntnose minnow	25	42
White sucker	101	170
Smallmouth buffalo	1	2
Yellow bullhead	4	7
Black bullhead	1	2
Channel catfish	7	12
Freshwater drum	1	2
Banded killifish	1	2
Blackstripe topminnow	1	2
White perch	3	5
White bass	2	3
Green sunfish	24	40
Pumpkinseed	11	19
Bluegill	34	57
Hybrid Sunfish	1	2
Largemouth bass	175	295
White crappie	1	2
Black crappie	2	3
Round Goby	9	15
Grand Total	**1,330**	**2,243**

* Population Estimate = Sample number/ 0.593; based on population estimate factor for Foster Avenue (Table 6).

Appendix B

Site Photographs

Client:	**Chicago Dept. of Transportation**	**Project:**	**Albany Park Stormwater Diversion Tunnel**
Site Name:	**Albany Park Neighborhood**	**Site Location:**	**Chicago, IL**

Photograph ID: 1

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
South

Survey Date:
7/24/2014

Comments:
Access off of Foster Avenue

Photograph ID: 2

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
North

Survey Date:
7/24/2014

Comments:
Gravel access road to Site

Client:	Chicago Dept. of Transportation	Project:	Albany Park Stormwater Diversion Tunnel
Site Name:	Albany Park Neighborhood	Site Location:	Chicago, IL

Photograph ID: 3

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
East

Survey Date:
7/24/2014

Comments:
General surroundings as viewed from gravel access road

Photograph ID: 4

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
East

Survey Date:
4/23/2014

Comments:
Open turfgrass field on eastern half of Inlet site

Client:	Chicago Dept. of Transportation	Project:	Albany Park Stormwater Diversion Tunnel
Site Name:	**Albany Park Neighborhood**	**Site Location:**	**Chicago, IL**

Photograph ID: 5

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
West

Survey Date:
7/24/2014

Comments:
Retaining wall along North Branch of Chicago River at the west end of the Inlet site

Photograph ID: 6

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
West

Survey Date:
7/24/2014

Comments:
North Branch of Chicago River, facing upstream

Client:	**Chicago Dept. of Transportation**	**Project:**	**Albany Park Stormwater Diversion Tunnel**
Site Name:	**Albany Park Neighborhood**	**Site Location:**	**Chicago, IL**

Photograph ID: 7

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
East

Survey Date:
7/24/2014

Comments:
North Branch of Chicago River, facing downstream

Photograph ID: 8

Photo Location:
Albany Park Tunnel - Inlet Site

Direction:
Northwest

Survey Date:
4/23/2014

Comments:
North Branch of Chicago River, facing upstream from Foster Avenue bridge.

Client:	Chicago Dept. of Transportation	Project:	Albany Park Stormwater Diversion Tunnel
Site Name:	Albany Park Neighborhood	Site Location:	Chicago, IL

Photograph ID: 9

Photo Location:
Albany Park Tunnel - Outlet Site

Direction:
North

Survey Date:
7/24/2014

Comments:
Access of Foster Avenue

Photograph ID: 10

Photo Location:
Albany Park Tunnel - Outlet Site

Direction:
South

Survey Date:
4/23/2014

Comments:
Outlet shaft location

Client:	Chicago Dept. of Transportation	Project:	Albany Park Stormwater Diversion Tunnel
Site Name:	Albany Park Neighborhood	Site Location:	Chicago, IL

Photograph ID: 11

Photo Location: Albany Park Tunnel - Outlet Site

Direction: North

Survey Date: 7/24/2014

Comments: Paved pathway under Foster Avenue

Photograph ID: 12

Photo Location: Albany Park Tunnel - Outlet Site

Direction: West

Survey Date: 7/24/2014

Comments: Opposite bank of North Shore Channel

Client:	**Chicago Dept. of Transportation**	**Project:**	**Albany Park Stormwater Diversion Tunnel**
Site Name:	**Albany Park Neighborhood**	**Site Location:**	**Chicago, IL**

Photograph ID: 13

Photo Location: Albany Park Tunnel - Outlet Site

Direction: South

Survey Date: 4/23/2014

Comments: North Shore Channel and Outlet site from Foster Avenue bridge

Photograph ID: 14

Photo Location: Albany Park Tunnel - North Branch Dam

Direction: North

Survey Date: 4/23/2014

Comments: North Branch Dam at the confluence of North Branch of Chicago River and North Shore Channel