WATER, MEGACITIES AND GLOBAL CHANGE

CHICAGO

Chicago, Illinois, United States: City by the Lake and Centerpiece of America's Third Largest Metropolitan Region

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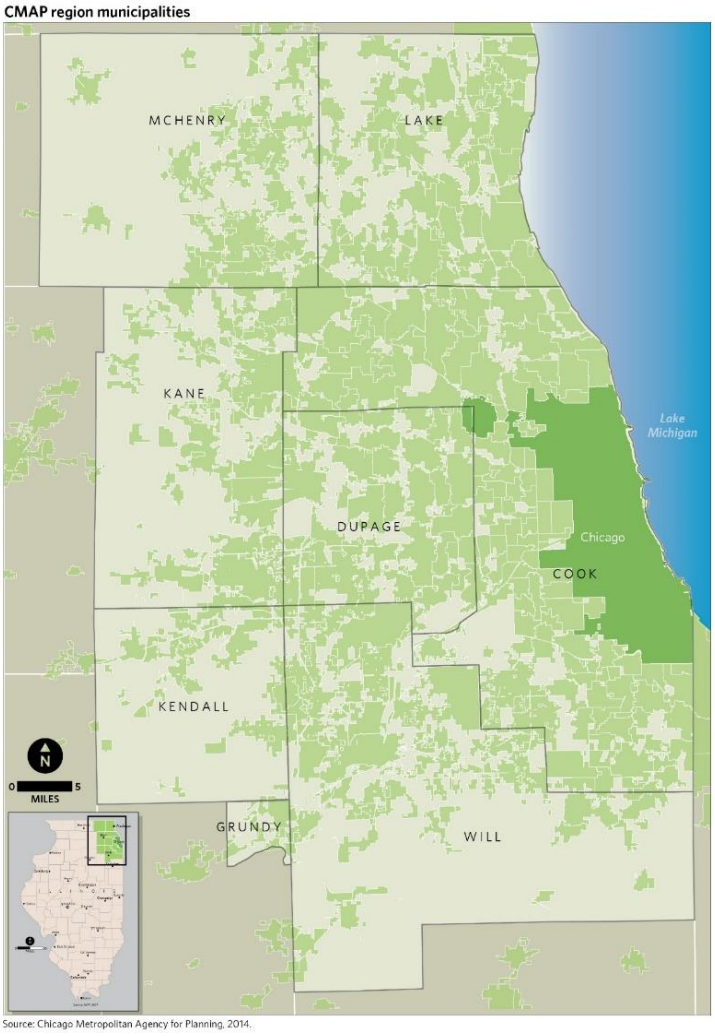
Part A

CHAPTER 1
Geography

The City of Chicago (41˚88′ N -87˚62′ W, 178.9 m height above mean sea level) is the third largest city in the United States and is situated in a seven-county metropolitan region that is home to 8.3 million people (Figure 1.) Chicago enjoys a continental climate that features warm summers (23.3 ˚C July mean) and cold winters (-4.6 ˚C January mean)[1]. Situated on the southwest shore of Lake Michigan, Chicago's climate is influenced considerably by the Great Lake with seasonally diverse water temperature being a primary factor in regional weather variability, particularly in the spring and fall.

Image 1 –Chicago



[1] US Dept. of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service. 2015. Summary of Monthly Normals: 1981-2010. Station: Chicago O'Hare International Airport, IL, US.

Average annual precipitation is 937.3 mm[2] with about ten percent of that falling as snow (922 mm median annual snowfall.[3]) There is, however, an upward trend in annual precipitation in Chicago during the period 1867-2013. For the period 1900-2010, there has been an increase in frequency of extreme precipitation events. These two trends[4] are remarkable for their impacts on the built environment including infrastructure and for what they portend should they continue.

Chicago and the majority of the metropolitan region are situated in the Central Corn Belt Plains Ecoregion. The primary distinguishing characteristics of this Level III Ecoregion include extensive prairie communities intermixed with oak-hickory forests that are native to the glaciated plains of this ecoregion.[5] Natural vegetation was gradually replaced by agriculture beginning in the nineteenth century and much of that has given way to urban land use throughout the twentieth century and into the present day. Today, an urbanized core is surrounded by suburban and agricultural land use with remnant natural communities interspersed throughout. Urban and Agricultural land uses have negatively impacted river and stream water chemistry, hydrology, and habitat. Finally, the 10,543.84 km^2 region is relatively flat, featuring 183.8 m in relief, about the length of a Chicago city block.

One of the most distinguishing geographic features of Chicago is its location on the shore of Lake Michigan. To view or enter Chicago from the lake is to do so through the City's "front door." While not a common experience for most, Lake Michigan defines the City in many ways nonetheless.

History

Chicago derives its name from the Miami and Illinois peoples and means "striped skunk," words that were also given to the aromatic wild leeks found in the area.[6] Over the years, Chicago has been called by many names: "Windy City" by a New York journalist who referred to the city's bragging politicians, "Second City" given its size relative to New York City (and before Los Angeles grew to be the second largest city in the United States,) "City that Works," "City of Big Shoulders," "The Jungle" after Upton Sinclair's novel, "City of Neighborhoods," and "City of Churches" to name a few.

Volumes have been written about Chicago. Most stories begin with reference to two Frenchman: a priest, Father Jacques Marquette and an explorer, Louis Joliet. Marquette

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[2] *Ibid.*
[3] Assumes an average of ten inches of snow per inch of water equivalent.
[4] Nancy Elizabeth Westcott, Ph.D., Midwestern Regional Climate Center, personal communication with T. Loftus, May 2015.
[5] The Encyclopedia of Earth. Ecoregions of the United States-Level III (EPA), accessed on 5/13/15, http://www.eoearth.org/view/article/152242/
[6] The Encyclopedia of Chicago, 2004. Edited by J.R.Grossman and others. The University of Chicago Press. 1,117 p.

and Joliet are said to be the first two white men to visit the boggy shore of Lake Michigan near the mouth of the Chicago River. Upon a trip in 1673 to return northeast from a point on the lower Mississippi River, they were given instructions from the local Indian nation to take a short cut up the Illinois River, Des Plaines River, over to the Chicago River via a short portage, and on to the shore of Lake Michigan. Upon their eventual arrival at the lakeshore, the potential of this site at the mouth of the Chicago River and its connectivity between the East and a still relatively unexplored West was not lost on these two men.

Chicago became a bustling port city, rich in natural resources and convenient for connecting markets. While the early days required reconciliation between the people that were native to the area and those that came from Europe, often involving bloodshed, Chicago's population was over four thousand when it became incorporated in 1837. The Great Chicago Fire of 1871 devastated much of the city, rendered thousands of Chicagoans homeless, and claimed the lives of about 300 people; a surprisingly low figure given the magnitude of the conflagration. Rebuilding the city laid the foundation for Chicago's famed architecture enjoyed today by residents and tourists alike.

Chicago grew and for the half million people that lived here in 1880, the Chicago River was not only a major highway, but the city's primary sewer. Population doubled in just ten years to surpass one million in 1890. Since the Chicago River flowed into Lake Michigan, the city's primary water supply, citizens in late nineteenth century suffered from a variety of waterborne diseases including typhoid, cholera, dysentery, and more.

In 1889, the Illinois state legislature passed the Sanitary District Enabling Act to provide for the construction of the Chicago Sanitary and Ship Canal that would breach the continental divide and reverse the flow of the sewage-laden Chicago River away from Lake Michigan and into the Des Plaines River and eventually down to the Gulf of Mexico. Construction of the canal, now part of the Chicago Area Waterway System would have a remarkable effect on the city and its future.

Resources

Chicago's greatest resource has always been its diverse population. Known also as a city of immigrants, Chicago attracted large numbers of the Irish especially after their Great Famine in the mid-1800's. This mass emigration from Ireland was followed largely by the Germans that by the end of the century had become Chicago's largest ethnic group. Others from Europe and elsewhere followed these trends. At different times, Chicago has been the largest Polish city outside of Warsaw, the largest Swedish and Czech cities outside of those countries, and so on.[7] Today, Chicago is also home to a significant number of African-Americans and people that identify as Hispanic or Latino.

[7] Dominic A. Pacyga, *Chicago: A Biography*. 2009. The University of Chicago Press: Chicago.

Chicago and the surrounding region have always been blessed with an abundance of natural resources. Primary among them is fresh water to sustain life, provide food, and serve as a means of conveyance. While serving different functions, both Lake Michigan and the Chicago River have played major roles in Chicago's growth and development.

Chicago is home to two of the world's largest water filtration plants.[8] Today, these two plants withdraw almost 3.8 billion liters from Lake Michigan per day and provide potable water to Chicago residents, business, and industry as well as 125 suburban communities that nearly encircle the city proper. Today, the population served by drinking water treated, pumped, and distributed by the City of Chicago exceeds five million people.

Infrastructure

The Chicago Region is home to notable infrastructure. For example, O'Hare International Airport is the world's busiest airport.[9] Chicago is also the hub of the nation's freight network thanks to a unique combination of freight transportation modes and infrastructure. It is estimated that between a quarter and a third of all freight tonnage in the United States originates, passes through, or terminates in the Chicago region.[10]

Drinking water also entails significant infrastructure. In addition to the two water treatment plants noted above, the City of Chicago's Department of Water Management is on course to rehabilitate 1,609.3 km of 100-year-old water mains. In a network of twelve pumping stations, the City is retrofitting four stations, converting them from steam power to electric to reduce carbon emissions and save more than US$7.5 million in energy and operating costs.

Chicago's voluntary MeterSave program is installing 15,000 water meters per year where historically, water meters were not included in homes built during the previous two centuries. Today, over eighty percent of the water sold is metered. These related efforts constitute the largest investment in water infrastructure in the City's history. Furthermore, they are part of a diverse menu of infrastructure improvements that launched in 2012 under a three-year US$7 billion program dubbed, Building a New Chicago.[11]

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[8] The Jardine Water Purification Plant and the South Water Purification Plant are both operated by the City of Chicago, Department of Water Management.

[9] Such a ranking varies from year-to-year and is measured two different ways: number of takeoffs and landings, and number of passengers passing through per year.

[10] CMAP, 2012. Analysis from a variety of sources presented in "Metropolitan Chicago's Freight Cluster: A Drill-Down Report on Infrastructure, Innovation, and Workforce," accessed on 5/18/15, http://www.cmap.illinois.gov/documents/10180/27214/CMAP-FreightReportFULL-07-11-12.pdf/622f29bf-572c-4b79-afff-110d880091a8

[11] City of Chicago Press Release, 2012, accessed on 5/19/15, http://www.cityofchicago.org/city/en/depts/mayor/press_room/press_releases/2012/march_2012/mayor_emanuel_announces7billionbuildinganewchicagoprogram.html

As referenced above, the Sanitary District Enabling Act (1889) led to the multi-year construction of a project to breach the continental divide between the Great Lakes Basin and Mississippi River Basin and reverse the flow of the Chicago River. Driven largely to protect a growing city's water supply – Lake Michigan – from raw sewage, this marvel of engineering prowess would also facilitate the transport of goods into and out of the region. The original project was modified and expanded over time and today, the Chicago Area Waterway System (CAWS) is a seventy-seven mile network of canals that are controlled and operated by the Metropolitan Water Reclamation District of Greater Chicago.[12] The CAWS involves other agencies, both federal and state, in its day-to-day operations and plays a key role in the functional nature of the region.

Economy[13]

The Chicago Region features a very diverse economy with no single industry as the dominant source of productivity and/or employment. In 2013, the region's real gross regional product (GRP) was measured to be about US$551 billion. Since 2001, real GRP has grown more slowly than peer regions such as Los Angeles, New York City, Boston, and Washington, DC. Median household income (2013) was estimated to be US$60,564 in the Chicago Metropolitan Statistical Area (MSA)[14]; higher than the estimated national median household income of US$52,250.

Median household income in the region has declined 7.1 percent since 1989 as it has for the nation, 7.5 percent, during the same time. Presently, job counts are growing and are estimated to stand at 4.7 million. This is less than the pre-recession jobs peak of 4.8 million, but preliminary data for 2014 indicate a fourth straight year of growth in the region's total job count. Lastly, the unemployment rate (2013) in the Chicago MSA was 9.1 percent; higher than both the national average of 7.4 percent and higher than the peer regions enumerated above.

Main trends and forthcoming issues

There are several water-related trends underway. Among them is a new interest in establishing the Chicago River and other reaches of the CAWS as another major waterfront beyond its industrial and sanitary uses in effect since its replumbing was completed in 1900. Now viewed as a recreational asset and for its potential to revitalize neighborhoods and spur economic development, the rivers/canals that slice through the

[12] Richard Lanyon, 2012. Building the Canal to Save Chicago. Xlibris Corp. 386 p.
[13] Information in this section comes from the Chicago Metropolitan Agency for Planning (CMAP) Regional Economic Indicators, Trends, accessed on 5/20/15, http://www.cmap.illinois.gov/economy/regional-economic-indicators/trends
[14] Metropolitan Statistical Areas, as defined by the US Census Bureau, have at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties. They are delineated by whole counties. The Chicago-Naperville-Elgin, IL-IN-WI MSA includes nine counties in Illinois, four in Indiana, and one in Wisconsin, accessed on 5/20/15, https://www.whitehouse.gov/sites/default/files/omb/bulletins/2013/b-13-01.pdf

city are enjoying new attention and signs of a renaissance. As an example, the City of Chicago has created four new boathouses on the Chicago River that cater to paddlers.[15]

Space to Grow: Greening Chicago Schoolyards is an award-winning, innovative, and multi-objective program made possible by a unique partnership involving Chicago Public Schools, City of Chicago Dept. of Water Management, Metropolitan Water Reclamation District, Openlands, and the Healthy Schools Campaign. *Space to Grow* transforms Chicago schoolyards to meet the outdoor recreation and physical fitness needs of students while creating inviting places where communities can reconnect with their schools. Implementing green infrastructure solutions throughout the schoolyard also allows for a significant reduction in stormwater runoff that will reduce neighborhood flooding and potential for combined sewer overflows. The first four *Space to Grow* schoolyards were completed in 2014 with another six scheduled for completion in 2015.[16]

Among other trends is an increase in craft-beer brewing. There are about sixty craft-beer brewers in and around Chicago compared to three just ten years ago. Part of a nationwide trend, the local craft-beer brewing industry is notable for both its innovation in beer making and variety of delicious beers; a combination and scale of activity that is not commonly found elsewhere in the country.[17] Given the demographics and population of Chicago, craft brewers from around the country view the Chicago market as a prime growth opportunity. Good beer requires good water!

Chapter 2

Institutional framework and governance model

The planning and management of drinking water is highly decentralized in the region and throughout Illinois not unlike other places in the country. This is largely due to the fact that about eighty-five percent of community water supplies are run by local municipal governments. The balance is operated by investor-owned utilities. The 168 communities that rely on Lake Michigan for their water supply[18] do so under a use-permit system,

[15] Boathouses are part of a $7 billion, three-year infrastructure program, Building a New Chicago, underway since 2012.
[16] Openlands, accessed on 5/26/15, http://www.openlands.org/space-to-grow
[17] Chicago Tribune, May 13, 2015, "The state of Chicago craft beer," accessed on 5/28/15, http://www.chicagotribune.com/entertainment/dining/ct-craft-beer-week-roundtable-goose-island-5-rabbit-half-acre-20150513-story.html#page=1
[18] 6.39 million people as of the 2010 US Census.

unique in the state, that is regulated by the Illinois Department of Natural Resources (IDNR).[19]

Water that is withdrawn from Lake Michigan is not returned to the lake. Rather, after its indoor use and treatment it is discharged to the CAWS and thus, ultimately diverted to the Gulf of Mexico. Precipitation that falls within the historic Lake Michigan watershed is diverted too insofar as most it winds up as stormwater runoff that enters the combined sewer system, receives treatment, and is discharged to the CAWS. The Illinois diversion of Lake Michigan is limited to 90.6 cubic meters per second or about 8 billion liters per day. Stormwater runoff accounts for about twenty-five percent of Illinois' use of the Lake Michigan diversion; second only to domestic pumpage that accounts for the majority of the diversion.

As a result of adjudication, the Illinois diversion is governed by a US Supreme Court Consent Decree. This makes Illinois unique among Great Lakes Basin states that otherwise take their guidance from the Great Lakes Compact.[20] The Compact, ratified in 2008, seeks primarily to limit, if not prevent, out-of-basin diversions. Illinois is obligated to comply with the conservation program provisions of the Compact.

One hundred eleven communities in the region are groundwater dependent.[21] Groundwater withdrawals in Illinois are governed under the rule of reasonable use and defined in the Water Use Act of 1983 as "the use of water to meet natural wants and a fair share for artificial wants. It does not include water used wastefully or maliciously."[22] There are no statutory remedies for disputes that might arise over groundwater withdrawals. Thus, such disputes will have to see remedy via litigation. While this legal arrangement seems to work fine during times of relative abundance, there is reason to suspect its adequacy should scarcity and conflicts become more commonplace.

Presently, just five communities use a combination of groundwater and inland river water or river water alone.[23] The Rivers, Lakes, and Streams Act enables IDNR to manage and safeguard the rivers and lakes of Illinois. The Illinois Environmental Protection Agency (IEPA) and the Illinois Pollution Control Board provide oversight for Lake Michigan and inland water bodies. Matters that pertain to water supply, however, are not given explicit expression in this Act and other relevant state legislation will benefit from new amendments to clarify IDNR's role in water supply management, particularly during drought.

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[19] Specifically the IDNR Office of Water Resources, Lake Michigan Water Allocation Program, accessed on 5/28/15, http://www.dnr.illinois.gov/WaterResources/Pages/LakeMichiganWaterAllocation.aspx

[20] Great Lakes-St. Lawrence River Basin Water Resources Council, accessed 6/29/15, http://www.glslcompactcouncil.org/

[21] 1.17 million people as of the 2010 US Census.

[22] 525 ILCS (Illinois Compiled Statutes) 45/

[23] 0.35 million people as of the 2010 US Census.

Local water legislation

As noted, the majority of community water systems are municipal-run and thus, subject to local control. City councils and village boards determine water rates and other matters that impact ratepayers including investment in infrastructure. Investor-owned water utilities are subject to regulation by the Illinois Commerce Commission. The Commerce Commission provides oversight on matters of management and business operations of public utilities. One can argue, therefore, that investor-owned water utilities are held to a higher standard than those that are municipal-run and subject only to the wishes of locally elected officials. All community water suppliers regardless of ownership must comply with the federal Safe Drinking Water Act that is enforced by IEPA.

Weight and place of the public and private sectors

In the United States, the weight and place of both the public and private sectors is considerable on most matters, water resources planning and management included. Since the institutional structure for water supply planning and management is limited at the state level in Illinois, efforts by IDNR to pursue state and regional water supply planning are heavily dependent on voluntary participation by these two sectors as organized by nine regions.

In northeastern Illinois, for example, the regional planning agency, CMAP, has been the state-sanctioned lead for regional water supply planning since the agency's inception in 2006. CMAP is advisory only. Implementation of *Water 2050: Northeastern Illinois Regional Water Supply/Demand Plan*[24], therefore, relies entirely on voluntary actions that are motivated largely by individual (e.g. community) needs. The private sector plays a key consulting and engineering role in supporting municipal-run systems.

Participation of the civil society

Regional water supply planning efforts that got underway in 2006 as a result of a Gubernatorial Executive Order,[25] serve as an example of how civil society has participated in a key water resource planning initiative. CMAP led one of the two regional pilot-planning processes and developed a new deliberative body composed of thirty-five delegates representing nine interest groups including two levels of elected officials. The Regional Water Supply Planning Group (RWSPG) was thusly designed to involve a broad swath of civil society and over a three-year period that featured monthly meetings, the RWSPG provided key input and guidance on the development of *Water 2050* mentioned

[24] CMAP, 2010, accessed on 5/29/15, http://www.cmap.illinois.gov/livability/water/supply-planning/water-2050

[25] State of Illinois, Executive Department, 2006-1: Executive Order for the Development of State and Regional Water-Supply Plans, accessed on 5/29/15, http://www.illinois.gov/Government/ExecOrders/Documents/2006/execorder2006-1.pdf

above. Other regional planning processes have also involved similar deliberative bodies for purposes of plan development.

At more local scales, however, public participation is not an automatic response to day-to-day management and the decision making of city and village water departments. For example, in a study of communities that use Lake Michigan water, community water suppliers were asked if they communicate system water-loss information to their rate-paying citizen customers.[26] Nearly three-quarters of respondents (65/89) indicated "no." Thus, more of a mechanism might be put in place to ensure that relevant information is shared with an appropriate audience in order to involve the public in understanding and buying into water management solutions.

[26] CMAP and CNT (Center for Neighborhood Technology,) 2014. "An Assessment of Water Loss Among Lake Michigan Permittees in Illinois," accessed on 5/29/15, http://www.cmap.illinois.gov/programs-and-resources/lta/idnr

Part B

Chapter 3

Striking and priority issues of the moment connected to climate change and its impact on the water in the city.

Flooding and flood control efforts

By virtue of its relatively flat topography,[27] flooding is a common problem with attendant economic costs and potential threats to water quality and public health. The degree of urbanization and associated impervious surface,[28] of course, has amplified the problem and a historical overreliance on engineered gray infrastructure is now seen to need complementary approaches to reduce the burden of flooding.

Record-setting floods in 1986 and 1987 led to legislation that enabled creation of county stormwater management ordinances. Since then, there has been ongoing coordination between state, county, and federal agencies with flood control management responsibilities. Annual flood damage has been estimated to exceed $41 million in the Chicago region, affecting approximately 20,000 homes and businesses.[29] More recent insurance claims data for Cook County alone suggest annual flood-damage costs exceeding US$150 million.[30] With the trends of both increasing annual precipitation and frequency of extreme events as noted above, new types of solutions are being explored to better address the issue.

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[27] The Chicago region lies primarily within the Great Lake Section of the Central Lowlands physiographic province. The Great Lake Section is subdivided into the Chicago Lake Plain (relief is generally less than 50 feet, but varies from 580 to 699 feet above sea level) that captures most of the City of Chicago, and the Wheaton Morainal Plain (relief is generally less than 100 feet) where most of the rest of the seven-county region lies. Geology of the Upper Illinois River Basin, U.S. Geological Survey, accessed on 8/10/15, http://il.water.usgs.gov/nawqa/uirb/description/geology.html

[28] The City of Chicago, for example, is almost 60 percent covered with roads, sidewalks, rooftops, parking lots and other forms of impervious surface. City of Chicago Green Stormwater Infrastructure Strategy, accessed on 8/11/15, http://www.cityofchicago.org/content/dam/city/progs/env/ChicagoGreenStormwaterInfrastructureStrategy.pdf

[29] From a 1998 estimate cited by the Illinois Department of Natural Resources, Office of Water Resources, accessed on 8/10/15, https://www.dnr.illinois.gov/WaterResources/Pages/HistoryofFloodControlDrainageinNortheasternIllinois.aspx

[30] Center for Neighborhood Technology, 2014. The Prevalence and Cost of Urban Flooding: A Case Study of Cook County, IL, accessed 8/12/15, http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrbanFlooding20141.pdf

Chicago infrastructure basics: A prelude to a green infrastructure strategy

The City of Chicago's water management challenge is as significant as water is in defining this Midwestern city. The City's current infrastructure features a network of approximately 8047 km of sewers of which over 7081 km are maintained by the Department of Water Management and over 804 km maintained by the Metropolitan Water Reclamation District of Greater Chicago (MWRD). In addition to replacing water mains as mentioned above, the City will line 160,000 stormwater catch basins and replace or reline 1223 km of sewer pipes.[31] Chicago's drinking water leak detection program aims to monitor 3218 km of pipes per year. Together with the MeterSave program, Chicago's water conservation and efficiency strategy is focused more broadly on infrastructure.

Nearly 100 percent of the City's sewered area is made up of dual-purpose sewers that collect both stormwater and raw sewage (i.e., combined sewers.) The sewer network directs the combined flow to one of MWRD's water reclamation plants for treatment before discharge to local water ways. When combined flow exceeds treatment capacity, MWRD's Tunnel and Reservoir Plan (TARP), under construction since 1972, captures and stores the water until it can be pumped to treatment plants when capacity becomes available.[32] Phase I of TARP was completed by 2006 and includes over 175 km of tunnels and 7.6 million m^3 of temporary storage capacity. Phase II includes three reservoirs, all former hard-rock quarries, which will increase storage volume to about 66.2 million m^3 The last reservoir will come online by 2029.[33] Costs incurred to construct TARP and the integrated (in Phase II) U.S. Army Corps of Engineers Chicagoland Underflow Plan stand at over US$3.8 billion.

One inch of rainwater falling on the City proper generates approximately 15.1 million m^3 of stormwater. If conveyed to the combined sewer system, it is lost as a resource and uses considerable energy and chemicals when treated with mixed sewage. When TARP is overwhelmed, there is home basement flooding along with combined sewer overflows into the Chicago and Calumet Rivers (i.e., Chicago Area Waterway System or CAWS.) If the storm is severe enough, then there can be backflow of stormwater and untreated sewage

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[31] *Ibid* 2.

[32] TARP or "Deep Tunnel" is a response to federal and state water quality standards for the 375 square mile combined sewer system area that includes Chicago and 51 suburbs. TARP's main goals are to protect Lake Michigan, improve the water quality of area rivers and streams, and provide an outlet for floodwaters to reduce street and basement sewage backup flooding. MWRD, TARP Status Report as of June 30, 2015, accessed on 8/11/15, https://www.mwrd.org/pv_obj_cache/pv_obj_id_4109CACC2D66C46541CCD61FE3A97FA6D5195500/filename/TARP_Status_Report_complete.pdf

[33] Metropolitan Water Reclamation District of Greater Chicago, Tunnel and Reservoir Plan, accessed on 8/11/15, https://www.mwrd.org/irj/portal/anonymous/tarp

from the CAWS into Lake Michigan; an event that occurs on average about once per year since 1985.

Chicago's Green Infrastructure Strategy

Chicago's Green Stormwater Infrastructure Strategy offers a framework and first plan for improving stormwater management, protecting water quality, and supporting a robust economy on 21st century infrastructure.[34] The basic premise of green infrastructure is to manage rainwater and snowmelt where it falls and prior to entering a sewer system. Green infrastructure (GI) is meant to complement traditional gray infrastructure or serve as an alternative. In either case, GI mimics nature and more natural processes that occurred prior to urban development. Examples include green roofs, bioswales and rain gardens that incorporate native vegetation, cisterns and rain barrels that capture and store rainwater for reuse, and permeable pavement that enables infiltration rather than runoff. GI treats precipitation as a resource rather than a nuisance and generates co-benefits beyond reduction in threats or damage from flooding.

The City's GI strategy builds on several existing policies and programs. For example, Chicago's Stormwater Ordinance (2008) requires that any building with a footprint of 1393.5 m^2 or any parking lot over 696.8 m^2 detain at least the first 1.3 centimeters on-site. To be flexible a 15 percent reduction in prior impervious surface can be pursued during redevelopment as an alternative. Another example concerns the required incorporation of green stormwater strategies on new developments that receive special approvals or public financing.

Other examples of complementary policies include a plan that informs the City Council in regulating new development projects and urban design more generally.[35] The same plan aims to achieve greater coordination among the City's various agencies and incorporation of GI in public projects. The Chicago Department of Transportation (CDOT) has formalized policies and standards for including innovative techniques into various types of projects as well.[36] Thus, transportation infrastructure design is held to environmental performance goals including green stormwater infrastructure.

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[34] *Ibid* 2.

[35] Chicago Plan Commission, 2008. Adding Green to Urban Design: A City for Us and Future Generations, accessed 8/12/15, http://www.cityofchicago.org/dam/city/depts/zlup/Sustainable_Development/Publications/Green_Urban_Design/GUD_booklet.pdf

[36] City of Chicago, Department of Transportation, 2013. Sustainable Urban Infrastructure: Polices and Guidelines, Volume 1, accessed 8/12/15, http://www.cityofchicago.org/content/dam/city/depts/cdot/Sustainable%20Transportation/SUIGv1.pdf

Chicago programs that are befitting of 21st century infrastructure include:

a. Green Roofs – there are over 350 installations totaling over 510,000 m2 that annually capture about 264.98 million m3 of stormwater.
b. Green Alleys – Over 200 permeable surface alleys have been retrofitted from about 2,000 public alleys that collectively feature the equivalent of 14.2 km2 of impervious surface. CDOT has installed about 30,658 m2 of permeable pavement to detain about 64,400 m3 of runoff each year.
c. Green Streets – Now over 20 years in progress, this initiative has planted 70,000 trees along major streets and other areas with "urban heat island" effects. Increasing urban tree canopy provides several social benefits besides aiding stormwater management.
d. Downspout Disconnections – Chicago roofs have historically drained directly to combined sewer systems via downspouts. Through a combination of outreach and education, the City is supporting homeowners to disconnect their downspouts and make beneficial use of rainwater. This program lowers the burden on the combined sewer system and helps to reserve capacity for other storm runoff.
e. Sustainable Backyard Program – Residents of the City benefit from rebates and educational initiatives for installation of rain barrels, native plants and trees, and compost bins. This program serves to involve everyone in the solution such that the cumulative effect of widespread adoption of green stormwater strategies is expected to reduce basement flooding and other onerous impacts stemming from extreme storm events.

Chicago's green stormwater management strategy has four long-term goals:

a. Minimize basement flooding in those Chicago neighborhoods most vulnerable,
b. Reduce pollution to the CAWS and Lake Michigan from combine sewer overflows,
c. Enhance environmental quality through water infrastructure investments, and
d. Increase the City's resilience to extreme rain events and climate change.

To achieve these goals, the City will implement a number of initiatives, half of which are directly related to construction and the other half to planning. A US$50 million commitment has been made to support these initiatives with an estimated reduction in runoff of 0.946 million m^3 each year.

Capital projects in priority stormwater management areas will be reviewed via a new interagency process to examine the potential for incorporating GI into design plans rather than as a separate or after-the-fact project. This will achieve economic efficiencies as compared to building green and gray projects separately. When sewer or water main repair/replacement projects necessitate street excavation, permeable pavement will be

used in the replacement where soil type and conditions allow. Parking and bike lanes are especially good candidates for stormwater-friendly permeable asphalt or concrete.

Bioswales will increasingly be used in streetscape projects to capture runoff from streets and sidewalks. These projects will lend natural support for the related objective of planting more trees and increasing urban tree canopy. Multiple city departments involved in such infrastructure-related work will collaborate to develop standard specifications and guidelines for implementing these types of projects and ensuring long-term success.

Chicago aims to develop a long-term stormwater management strategy by engaging in a series of planning studies. For example, the City needs to develop a keener understanding of the costs and benefits of using green infrastructure to manage stormwater at a large scale (i.e., citywide.) Learning about the long-term costs and benefits of GI, the effects on sewer system performance, and reductions in basement flooding are key points of knowledge to be gained.

To support capital project planning and design tasks, Chicago will collaborate with the Illinois State Climatologist and Illinois State Water Survey to update historic rainfall data to better reflect climate change both underway and predicted. This is an especially important task given the long service life of major infrastructure projects. Last, but not least, the Department of Water Management will collaborate more closely with MWRD given the direct connections of their combined sewer networks and common missions. Collectively, these initiatives will position Chicago to be among the leaders in the US in using 21st century green infrastructure to improve neighborhoods, adapt to climate change, and meet other sustainable development objectives.

Chapter 4
Innovations in technology, management, or governance that have been imagined as solutions even partial to these problems

The RainReady Initiative

The Chicago-based nonprofit Center for Neighborhood Technology has initiated a new program that is emblematic of a new approach taken to address an age-old problem. The RainReady program provides outreach, guidance with financing, and training course and workshops to enable homeowners and communities alike to reduce impacts from local flooding.[37] These impacts include basement flooding and/or sewer backups.

[37] Center for Neighborhood Technology, RainReady initiative, available at http://rainready.org/ accessed on 9/3/15.

Working with homeowners, CNT's RainReady program provides property assessment, construction oversight, and guidance with financing. Services include an examination of living space such as foundations and basements for damage. Sewers are inspected for breaks or blockages that contribute to basement flooding. Yards, gutters, and downspouts are studied to determine if regrading or downspout disconnection or relocation might alleviate a local problem. Opportunities are explored for implementing site-specific green infrastructure such as rain gardens and rain barrels. In sum, a customized solution is developed by both the homeowner and the RainReady experts.

As more homes participate in the program, neighborhoods eventually become more resistant to flooding. But the RainReady program can begin an assessment at the community scale too. The potential for implementing green infrastructure is evaluated and opportunities sought for enhancing streets and parkways for additional stormwater storage. This might include development of small parks, wetlands and bioswales, as well as restoration of the tree canopy.

While capable of bringing more immediate relief to individual homeowners, it is expected that the cumulative impact of site-, neighborhood-, and community-scale solutions will make a significant contribution to flood relief that is costly to homeowners in terms of both damage repair and diminished property value. RainReady offers a complementary benefit too: it serves to attract funding from local, state, and federal sources that aims to address flooding or water quality problems associated with stormwater.

Amended Rules Governing Lake Michigan Permittees

The majority of people in the Chicago region, over 6.4 million, use Lake Michigan as their source of drinking water. Illinois Dept. of Natural Resources (IDNR) is the regulatory agency that manages an allocation system for lake water that includes over 200 permittees.[38] One of the management challenges that IDNR seeks to address is water loss from a vast network of underground pipes that are owned and managed by a decentralized collective of suppliers (i.e., permittees). For example, research has revealed that for the period 2007-2012, over 20 percent of community water supply permittees exceed the standard set for water loss. In 2012 permittees reported loss of over 83.3 million m^3 with a value estimated to range from US$64 million to US$147 million.[39]

[38] IDNR's management of Lake Michigan is consistent with both a US Supreme Court Consent Decree that governs Illinois' diversion of Lake Michigan and the Level of Lake Michigan Act (615 ILCS 50/) that enables Illinois compliance with the federal Decree. For more information, see Illinois DNR, Water Resources, Lake Michigan Water Allocation, at https://www.dnr.illinois.gov/WaterResources/Pages/LakeMichiganWaterAllocation.aspx

[39] Chicago Metropolitan Agency for Planning (CMAP) and Center of Neighborhood Technology (CNT), 2014. An Assessment of Water Loss Among Lake Michigan Permittees in Illinois. Available at, http://www.cmap.illinois.gov/programs-and-resources/lta/idnr accessed on 9/23/15.

For the first time since 1980, IDNR amended rules that govern permittee use of Lake Michigan water in at least three important ways. First, an outdated "unaccounted-for-flow" water-loss standard was replaced with a nonrevenue-water standard that is more current with the thinking behind water-loss audit and control best management practices.[40] Second, IDNR eliminated an accounting tactic called Maximum Unavoidable Loss that allowed systems to lose water because of old-age pipes and not have this amount count towards the loss standard that is a condition of permit. Third, IDNR will require suppliers that exceed the new nonrevenue water standard to submit a water system improvement plan.

Finally, IDNR is also coordinating with other agencies and organizations to bring new tools to communities to better understand and manage their water use / loss with the expectation that in time, suppliers of Lake Michigan water will not only reduce the loss of relatively high-value lake water, but reduce the associated loss of ratepayer dollars due to insufficient infrastructure management.

Hydrologic separation within the Chicago Area Waterway System

One of the more controversial discussions underway concerns the creation of a barrier within the Chicago Area Waterway System (CAWS) to minimize, if not eliminate, the potential for aquatic invasive species movement between the Great Lakes Basin and the Mississippi River Basin. While both ecosystems are already home to numerous invasive species, the more recent movement of two species of Asian carp up the Mississippi and Illinois Rivers has caused great concern among those individuals and organizations that advocate on behalf of conservation and stewardship of the Great Lakes.

In 2010, two organizations, the Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative initiated two committees to investigate the matter.[41] Participation is diverse, inclusive, and international. But the task under consideration is highly complex for a number of reasons. For one, the CAWS allows for a relatively small amount of waterborne freight transport.[42] Additionally, the CAWS is a pivotal link in regional flood control and as already noted, serves to convey a massive volume of treated wastewater away from Lake Michigan. Furthermore, the CAWS serve a thriving recreational and commercial boating industry that depends on access to/from Lake

[40] The long-standing 8 percent standard is replaced with an interim nonrevenue water standard of 12 percent for four years beginning with water year 2015, after which the standard will adjust to 10 percent.
[41] An initial report, Restoring the Natural Divide, was the outcome of the first two years of discussion and study. Available at, http://projects.glc.org/caws/ accessed 9/24/15
[42] For an assessment this aspect, please see CMAP Policy Updates, Waterborne Freight in the Chicago Metropolitan Region, available at http://www.cmap.illinois.gov/about/updates/policy/-/asset_publisher/U9jFxa68cnNA/content/waterborne-freight-in-the-chicago-metropolitan-region accessed 9/24/15.

Michigan. Any hydrologic separation at one or more points in the system, a long-term aim of some groups, will impact these industries and services that the CAWS presently provides.

The eight alternatives considered thus far range in cost from near nothing (no action) to US$18 billion over a 25-year project completion period.[43] Thus, no other water-related discussion underway in the region involves a similar mix of stakeholders, controversy, complexity, and potential cost to effect a remedy. The US Congress is involved and there has been adjudication over a swift closure of all lock systems that connect these two waterbodies. However, the matter is resolved, the issue spurs new thinking about a variety of interconnected systems and services and how any or all might be reimagined in the 21st century to create a more sustainable and prosperous region.

[43] A key report, Great Lakes and Mississippi River Interbasin Study (GLMRIS), was issued in 2014 by the Army Corps of Engineers and is available at, http://glmris.anl.gov/glmris-report/ accessed 9/24/15.