Climate Adaptation Implications in *The Notre Dame Plan of Chicago 2109*

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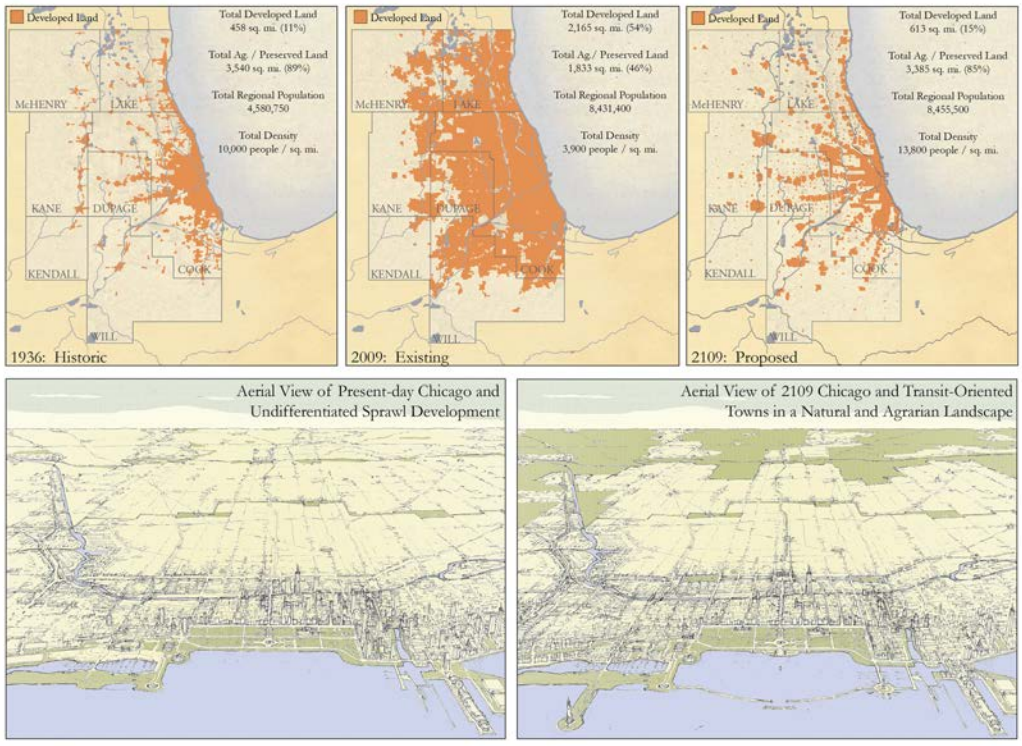

Historic, Existing, and Projected Metropolitan Chicago Land Use Patterns
From the City as problem and the Suburb as solution, to the Suburb as problem and the City as solution

ABSTRACT:
Chicago long has been synonymous with muscular modernism and industrial-scale manipulation of the natural order. But time, climate change, and invasive species now confront present-day Chicago with significant environmental challenges to the re-ordered nature for which Chicago is famous. Imagining metropolitan Chicago almost a century forward in light of certain near-term demographic and economic trends, *The Notre Dame Plan of Chicago 2109* addresses these environmental challenges and their relationship to other aspects of architecture, urban design, and their multidisciplinary implications. Focusing on transportation policy and compact regional settlement types ranging from rural hamlets to the city of Chicago itself, *Chicago 2109* proposes better land use, a combination of urban sewage treatment plants and rural constructed wetlands, and restoration of Chicago's original sub-continental divide as policies that also address Chicago's current (and long-standing) stormwater and wastewater management challenges, and in so doing demonstrate how this holistic approach to urban design and regional land use is also a *de facto* adaptation to climate change. *Chicago 2109* envisions Chicago as a new paradigm for modern metropolitan regions as urban-agrarian units characterized by human settlements designed in collaboration with the natural order, both as an immediate strategy of adaptation to climate change and as an ongoing demonstration of the human stewardship possibilities and obligations that follow from an understanding of cities as natural, and of human beings as both part of and unique within nature.

Keywords:
Chicago, river, wastewater, climate, land use, adaptation, Notre Dame

1. INTRODUCTION

Chicago at the end of the nineteenth century was the fascinating and terrifying poster-child of American industrial ingenuity, audacity, and wealth. The economic powerhouse of the Midwest, Chicago represented a new future for humanity, one in which age-old constraints of nature had been shed for an economy of abundance limited only by the reach of modernity's ongoing innovations.

Technological achievements of this era included the skyscraper, the elevator, and the construction of Lower Wacker Drive. But one of the most famous --and arguably the most iconic-- was the reversal of the Chicago River. Ancient cultures worshipped rivers, trappers and traders had built settlements on them, but Chicago industrialists bent the river back on itself, relegating it to servitude as part of the sanitary system for the city and its stockyards.

Chicago's Union Stockyards of the 1880s were a wonder of the world. Hundreds of acres in size, they gave Chicago the moniker "Hog butcher for the world (Sandburg 1914)." But stockyard offal was routinely dumped into the southern headwaters of the Chicago River, joining the sewage already present therein; and the foul water meandered its way to Lake Michigan (source of Chicago's drinking water), becoming a mortal threat to Chicagoans. In 1900, city leaders successfully reversed the flow of the Chicago River, sending contaminants from Chicago and the stockyards away from Lake Michigan, across the state of Illinois to the Mississippi River. A century has passed, the Union Stockyards have closed, Chicago's population quickly grew larger and then began steadily contracting as its suburbs expanded, yet the river continues its unnatural flow even as Chicago flood events become more common.

The Notre Dame Plan of Chicago 2109, a joint effort of students, faculty, and alumni of the Notre Dame School of Architecture Graduate Urban Design Studio, imagines the Chicago metropolitan region 100 years forward, and in doing so identifies a variety of reasons for rethinking this marvel of modernity, envisioning a new paradigm of human beings working both more in concert with the natural order and more adaptively to changes in the earth's climate. This paper focuses especially on Chicago's historic and present water issues. Our expertise however is not water, but rather architecture and urban design. And though *Chicago 2109* makes several water-related policy suggestions, we hasten to say we are not claiming the expertise needed to manage water details at the scale and complexity of metropolitan Chicago. Our primary purpose here is rather to show how *Chicago 2109*'s transportation and land use recommendations *and the water policy opportunities they create* would both improve the quality of metropolitan Chicago water and reduce the frequency and impact of metropolitan Chicago floods, thereby functioning as an important regional adaptive response to climate change.

A word about our methodological approach as architects and urbanists: Human flourishing depends –not entirely, but necessarily-- upon an enduring reciprocal relationship to specific climates and landscapes demonstrably affected for better or worse by the kinds of settlements human beings make and the ways we make them. The large question overarching and embracing the issues central to both *Chicago 2109* and this paper asks: *In what kinds of settlements-related-to-their-landscape do human beings best flourish?* -- an essentially anthropological-and-existential question concerning the relationship between good land use, good settlements, and human wellbeing. The perspectives from which *Chicago 2109* engages that primary question are those of classical humanist urbanism and a classical-biblical view of human nature. From these points of view, as well the perspectives of both modern science and historic natural philosophy, *homo sapiens* is a certain kind of animal occupying different kinds of landscapes in certain kinds of ways; and seems most often to flourish in a loose range of low-density-to-high-density place-based settlement types historically called *urban. Chicago 2109*'s approach to climate change adaptation is therefore less science-and-data driven than philosophical, visual, and (albeit empirically-based and grounded in history and precedent) essentially *artistic*, in the mainstream of a classical humanist urban tradition that routinely integrates ideals of beauty with ideals of usefulness, durability and environmental stewardship -- ideals that industrial civilization has separated from each other and in separating too often have corrupted. Ours therefore is less an exercise in quantifying adaptive measures now on the ground than an inter-related set of design and policy proposals *responding to adverse conditions now on the ground*. It is, if you will, an effort to identify and overcome *barriers* to climate change adaptation, the chief of which are modern construction and most especially our cultural habit of suburban sprawl.

2. METROPOLITAN CHICAGO WATER OF THE PRE- AND POST-INDUSTRIAL ERAS

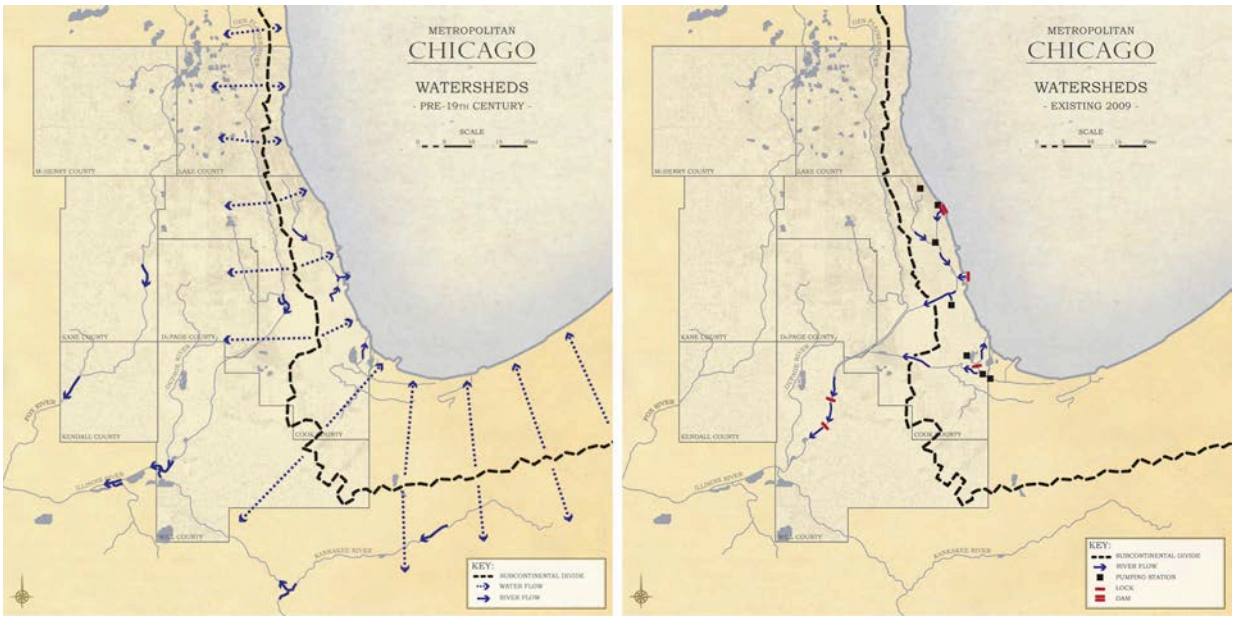

FIG. 1: Pre-19th Century Metropolitan Chicago Watersheds (left) / Existing Metropolitan Chicago Watersheds (right)

2.1. Chicago's First Water Crisis

Understanding water in metropolitan Chicago begins with understanding the city's location in its continental context. The historic center of Chicago sits at the mouth of the Chicago River on Lake Michigan, but a more obscure geographical fact is that a sub-continental divide runs along the city's western edge, separating the Great Lakes watershed from that of the Mississippi River **[Figure 1, left]**. But for subsequent events, water that falls on the eastern side of the divide would travel naturally through the Great Lakes to Canada's Gulf of St. Lawrence, while water that falls on the western side would be destined for the Gulf of Mexico by way of the Des Plaines, Illinois, and Mississippi Rivers.

Sited near this strategic lake-to-river portage the young city grew, eventually building a sewer system in the 1850s which included raising the existing streets and buildings (Einhorn 2005). But the sewers discharged into the Chicago River and eventually Lake Michigan, the city's drinking water source; and the level of pollution grew as Chicago quickly grew to become one of the largest cities in the world (Nugent 2005). With the growth of the Union Stockyards the problem reached a critical level. The stockyard's hog and cattle offal was dumped in the headwaters of the South Branch of the Chicago River, which came to be known locally as Bubbly Creek for the pollution that continues to plague it. Chicago's water pollution threatened the health of the city's population, and city leaders responded with an audacious plan regarded in its time as progressive.

Reversing the flow of the Chicago River seemed a magic answer. Rather than address or mitigate the pollution at its source, Chicago famously rerouted its primary river, sending the problem elsewhere and thereby saving the people of Chicago **[Figure 1, right]**. Pure water came into the city from the east and left, contaminated, to the west. To accomplish this, a lock was built at the Lake Michigan mouth of the Chicago River, and now the North Branch of the river essentially flows past the mouth, directly into the South Branch. Combined they flow to the 28-mile Chicago Sanitary & Ship Canal, then onward via a system of locks to the Illinois River. Another important piece of this puzzle was the reversal of the Calumet River, on the south side of the city, which now flows about six miles inland to Lake Calumet, the city's port. A lock allows vessels to transition across the sub-continental divide, into the Cal-Sag Channel, towards the Chicago River flow, and ultimately the Gulf of Mexico.

2.2. Chicago's Current Water Crises

Today's Chicago waterways are again mired in crises, not all of which can be attributed to climate change.

Like several hundred other cities with older infrastructure, Chicago's wastewater flows through sewers carrying both sewage and stormwater to treatment facilities (U.S. Environmental Protection Agency 2016). Such "combined sewer" systems are inherently subject to a phenomenon called Combined Sewer Overflow (CSO) in which the capacity of the system is exceeded due to precipitation; and in Chicago, such overflow wastewater is released into Lake Michigan untreated in order to avoid flooding the city, as occurred twice in the 1950s (Bukro 2017). In the 1970s Chicago began to address this problem with its Tunnel and Reservoir Plan (TARP), known widely as the "Deep Tunnel," a multi-billion dollar storage chamber for storm runoff buried beneath the city (Power 2013). The project is operational but still under construction, and slated for completion in 2029; though the Chicago Tribune reports that officials from the Metropolitan Water Reclamation District state that CSOs will still occur even after the project's completion (Hawthorne 2015).

The historical degradation of the Chicago River remains most acutely evident in Bubbly Creek. In the heyday of the Union Stockyards, pollutants in the water caused the river to burn on multiple occasions long before Cleveland's famed Cuyahoga fire (Krohe 2004). The stockyards closed in the 1970s, but continue their damage through the slow decay of submerged slaughterhouse waste (Hawthorne 2015). Additional contamination comes today from the Racine Avenue Pump Station, which regularly dumps overflow sewage into Bubbly Creek during significant storms (Schneider 2013).

The increased polarity of weather patterns accompanying climate change will exacerbate this problem, according to a report by Henry Henderson at the National Resources Defense Council (2013). He points out that "the waterway has actually re-reversed itself almost annually in response to violent rain storms over the last decade" (when the rains are heavy), and that a similar phenomenon occurs when the water level in Lake Michigan is critically low (when the rains are absent). Whichever way the pendulum swings, the unplanned flow of the river into the lake leads to health hazards and ecological concerns (Henderson 2013).

Even when operating more-or-less as designed, the Chicago wastewater system has prompted environmental concerns. In the first decades of the Twentieth Century, Chicago was sued by both the City of St. Louis for the pollution of their drinking water source (the Mississippi River), and fellow Great Lake states for the depletion of Lake Michigan (Adams 2009). The construction of a treatment facility in St. Louis and the world's largest Water Reclamation Plant (WRP) in the Chicago suburb of Stickney resolved these issues, but today's greater environmental awareness has lead to greater scrutiny and, with that, more litigation. Writing in 2013, Matthew Power (2013) noted that Chicago was alone among major American cites in not disinfecting wastewater, resulting in *treated* wastewater being discharged into the water system with *E. coli* bacteria levels "700 times above the legal limit for swimmable water," a circumstance recently resolved by infrastructure upgrades at Chicago's several treatment plants. The next frontier appears to be the phosphorus levels in Chicago's wastewater, now wreaking damage across thousands of square miles in the Gulf of Mexico (Cosier 2016), which the city has recently agreed to address (Alexander 2017).

Yet another crisis is the steady encroachment of invasive species of Asian carp. These unwelcome guests in Illinois are estimated to constitute as much as 90% of the biomass in parts of the Illinois River (Renault 2016), and should they make it into Lake Michigan could inflict catastrophic damage both to the ecology of the Great Lakes and their commercial and recreational fishing industries (Smith 2010). Independent of the directional flow of Chicago's rivers, this problem stems from the desire to create a seamless transportation connection between the Great Lakes (and the Atlantic Ocean via the St. Lawrence Seaway) and the Mississippi River and Gulf of Mexico. According to Renault (2016), a variety of solutions are in various stages of implementation or testing – electric fences, carbon dioxide, noise fences, poisons, targeted fishing, and introducing natural predators – and there are still hopes that one

or all of these measures will be able to push back on the carp expansion and protect Lake Michigan's current ecosystem.

Another contributing factor to Chicago's CSOs is the quantity of impervious surface in the city and near suburbs. According to the Environmental Protection Agency (2003), highly impervious areas increase surface runoff from 10% to 55% of precipitation, while reducing infiltration. The City of Chicago (2014: 10) estimates that impervious surfaces account for about 60% of the city area today, which, by multiplying the volume of runoff in any storm event, increases the likelihood of CSOs. Furthermore, impervious surfaces can contribute to erosion of riparian edges, increased water temperatures, streamside habitat loss, and pollutant generation (Arnold and Gibbons 1996). The City of Chicago has recognized the importance that water plays in the quality of life of its residents and has become a leader in promoting green infrastructure to combat the negative impacts of impervious surface development.

Not as readily apparent but as worrisome as any of these crises is the diminishing aquifer below Metropolitan Chicago's surface. Northeastern Illinois sits atop the Cambrian-Ordovician aquifer system, which the Illinois State Water Survey (2017) reports has been stressed by development in the suburban counties of the Chicago region for much of the last 70 years. Although recent regulations and greater use of Lake Michigan water have reversed aquifer depletion into replenishment, the balance is delicate, and additional water need in the region could lead to desaturation and contamination of ground water (Illinois State Water Survey 2017). Aquifer depletion becomes a greater problem if the city's rainfall diminishes or becomes more irregular due to climate change. Greater dependence on groundwater as a resource reserve during periods of drought could be met with insufficient supply.

3. ADAPTING TO CLIMATE CHANGE IN *CHICAGO 2109*

The Notre Dame Plan of Chicago 2109 was prompted in part by the tepid response of the City of Chicago to the 2009 centennial observance of Daniel Burnham and Edward Bennett's *Plan of Chicago*, also known as The Burnham Plan. Arguably the most significant document in the history of American city planning, it is especially noteworthy for the classical humanist sensibility Burnham and Bennett brought to the challenges of modern city planning, and as much for the holistic and regional nature of their approach to Chicago. It is arguable as well that in the century after the *Plan of Chicago*, by forsaking its far-sighted urban vision in favor of modernist architecture, utilitarian planning, and suburban sprawl, Chicagoans themselves have created many of the problems they face today. The challenge for the makers of *Chicago 2109* therefore (in the spirit of Burnham and Bennett) was to re-imagine metropolitan Chicago at the bicentennial of the Burnham Plan as a great urban-agrarian entity, building upon and improving those physical elements of present-day Chicago we imagine will endure over the next century.

3.1. The Transportation and Land Use Nexus

Part of that challenge is to make the most of Chicago's existing transportation infrastructure, improving it in order to promote more beautiful and economically and environmentally sustainable human settlements as well as better land use, both of which themselves would constitute an adaptation to climate change. The premise of *Chicago 2109*'s transportation and land use proposals is the economic and environmental unsustainability of Chicago's suburban sprawl, and most immediately its economic unsustainability. Simply put, both fiscally and demographically, it is not going to be possible to maintain Chicago's existing automobile-suburb infrastructure into the next century; and in order for metropolitan Chicago to flourish again (and to make the most of its genuine assets) it will be necessary to consolidate its transportation infrastructure and re-organize its settlement patterns around it **[Figures 2-4 below]**. The story line of *Chicago 2109* therefore is one of near term decline followed by revival –including near term population decline followed by revival to metropolitan Chicago's current population numbers, redistributed-- with decline being the more certain short-term bet.[1]

[1] Away from its spectacular downtown lakefront early 21st century Chicago already exhibits multiple markers of decline, which it shares with both its collar counties and the State of Illinois: crushing debt from unfunded entitlements, repeated and predictable budget deficits, failing infrastructure and inadequate funding, declining city and state population, a disappearing middle class, the

FIG.2: Metropolitan Chicago: Existing Mass Transit (left) / Proposed Mass Transit (right)

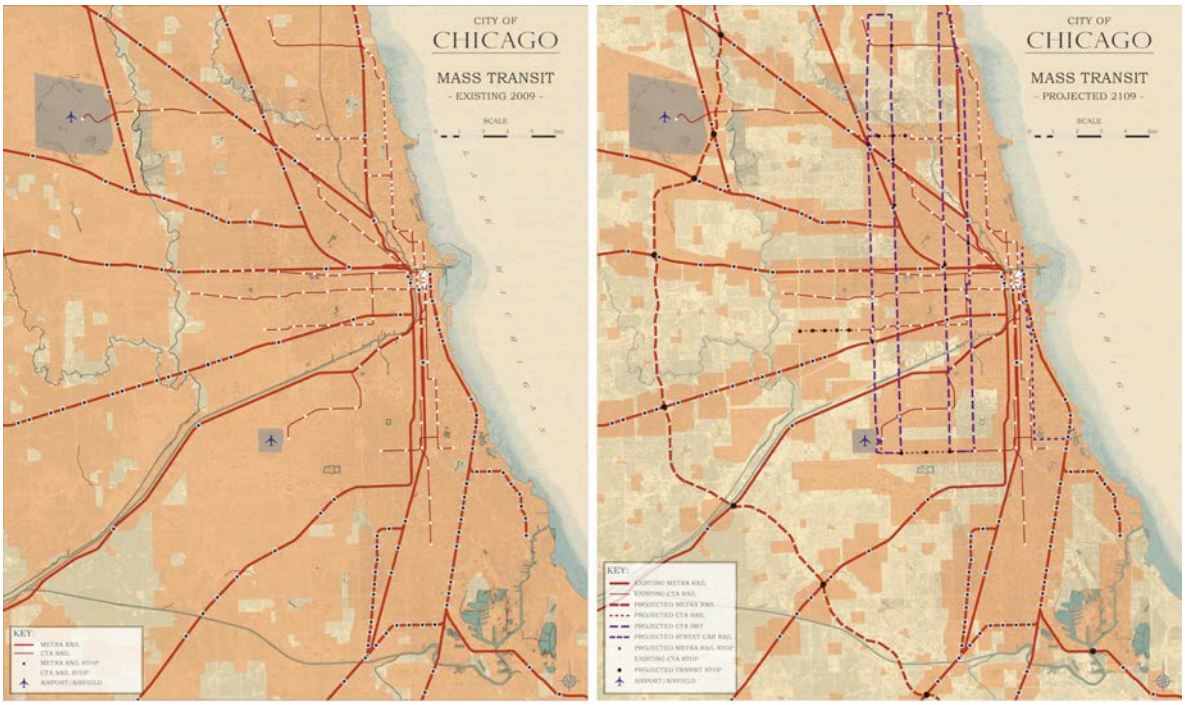

FIG. 3: City of Chicago: Existing Mass Transit (left) / Proposed Mass Transit (right)

immediate pension needs of the retiring baby boom generation, a culture of below-replacement fertility, the decline of marriage and the increase of out-of-wedlock births, racial tension and conflict, and a corrupt political class demonstrably unable to govern Chicago's way out of these problems (not all of which, admittedly, lend themselves to political solutions). We acknowledge that this list might grow or shrink depending on one's own perspective; but that Chicago and Illinois have serious systemic problems is evident to anybody paying attention. For the purposes of this article, three examples should suffice: Chicago and the State of Illinois have both made national press for the dismal outlook of their pension funds (Associated Press 2017); among other social woes, Chicago's murder rate has been widely discussed, as by Bosman and Smith (2016); and Chicago's startling demographic changes have been well documented by Daniel Kay Hertz (Hertz 2015).

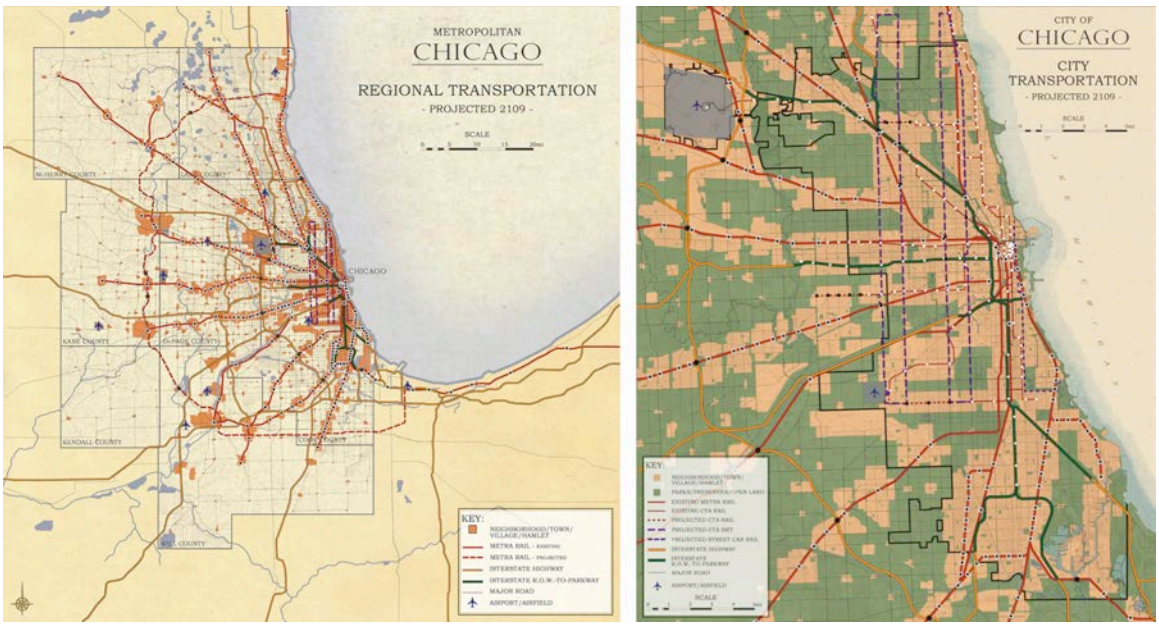

FIG. 4: Proposed 2109 Metropolitan (left) and City (right) Full Transportation (including Rail and Road)

Chicago 2109's strategy for the revival of metropolitan Chicago presupposes the equivalent of re-shuffling the political deck and the rise of new civic, political, and probably even religious leadership; and promotes long-term environmental, economic and cultural sustainability in metropolitan Chicago by imagining and depicting good land use, good transportation policy, good building practices, and good urban form. The marks of Chicago's revival will include things like a re-structured tax code, fiscal prudence both personal and communal, incremental development, and more place-based work (including, for northeast Illinois, local agriculture). To better understand the region the project engaged the geography, history, and transportation systems of metropolitan Chicago in the context of the American Continental Grid, and these informed our proposals for metropolitan infrastructure policies and land use, and the rationale for the settlement types depicted.

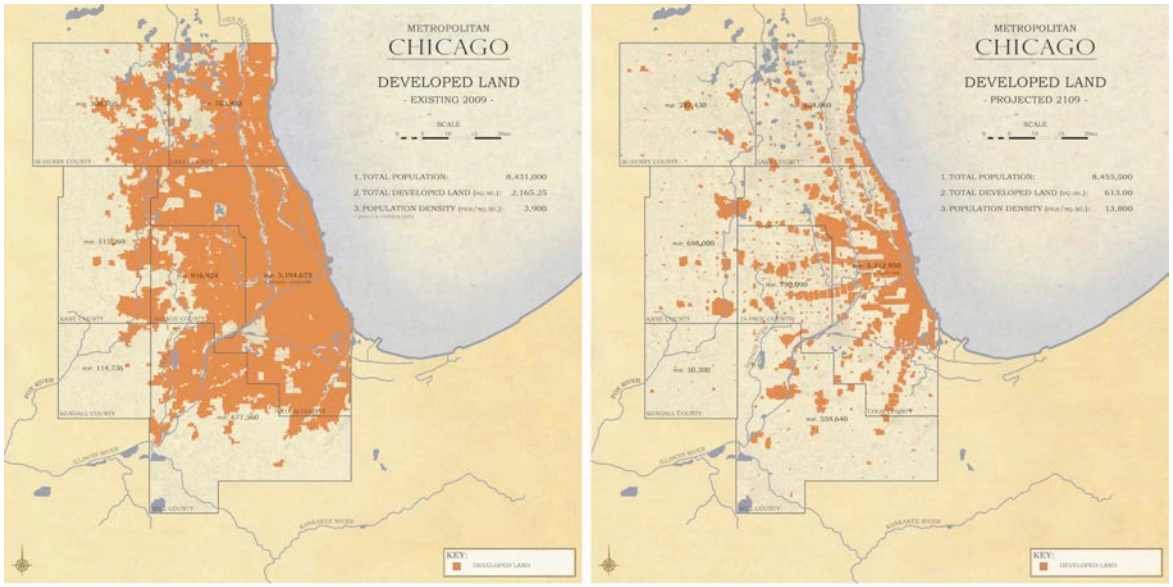

FIG. 5: Metropolitan Chicago: Existing Land Use (left) / Proposed 2109 Land Use (right)

Regarding land use: anticipating (again, primarily for economic and demographic reasons) the decay and abandonment of post-1945 sprawl suburbs, *Chicago 2109* depicts reclamation of nearly 70% of the land [sic] currently occupied by metropolitan Chicago –i.e. it envisions recovery of some 1500 square miles now currently occupied by post-1950 automobile suburbs-- as open land to be re-purposed for agriculture, commercial forestry, rural hamlets and villages, passive waste-water treatment, forest preserves, and prairie **[Figure 5]**.[2]

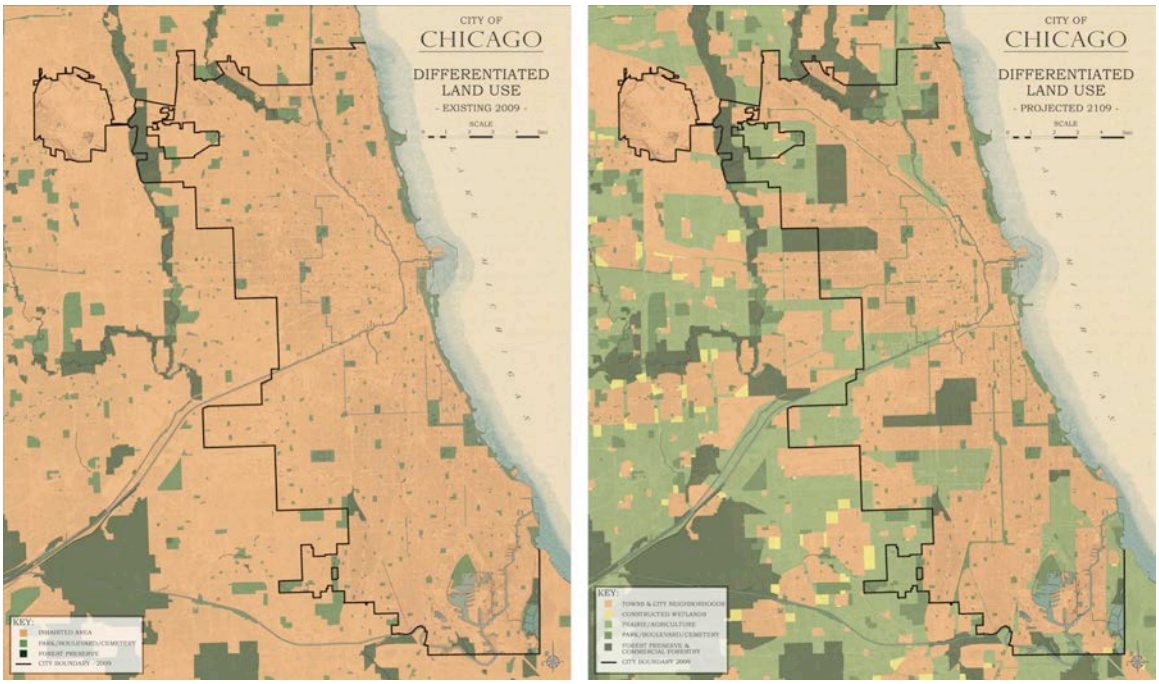

FIG. 6: City of Chicago: Existing Land Use (left) /
Proposed 2109 Land Use (right); note proposed constructed wetlands as yellow

For the physical form of metropolitan Chicago we imagine better land use to follow from: a) focusing Chicago's limited resources upon maintaining and upgrading its regional rail transportation network; and b) promoting a range of well-defined settlement types located along rail-transportation lines and at the intersection of major state and county roads **[Figure 7]**. *Chicago 2109* depicts metropolitan Chicago as a regional agrarian-urban economic culture that includes new rural *Hamlets* and *Villages* located at the crossing of existing state and county roads; *Towns* as more compact versions of existing historic railroad suburbs; and the western perimeter *Cities* Joliet, Aurora, and Elgin. This pattern of settlements of such size and density allows the significant increase in undeveloped land noted above, while simultaneously accommodating a regional population equal to today's *in mostly low-rise buildings* (including detached single-family houses). In this vision rural environments are re-populated with compact low-density Hamlets and Villages, and the traditional Towns and Neighborhoods that characterized metropolitan Chicago prior to 1945 are re-established. *Chicago 2109* also presumes that a variety of light industrial and manufacturing jobs can be accommodated within the borders of these proposed settlement types; and working industrial districts, though not shown here, are also located throughout metropolitan Chicago along selected existing freight lines, interstates and waterways.

[2] In the city of Chicago itself, an area just under 231 square miles, *Chicago 2109* envisions undeveloped city land increasing from 8.65 square miles to 64.86 square miles, a recovery of almost 55 square miles within the city limits themselves (all based on a policy of concentrating developed land around existing CTA and Metra rail stops) **[Figure 6]**. Note that these figures do not include Chicago's existing parks and planted medians, which we've counted as developed city land.

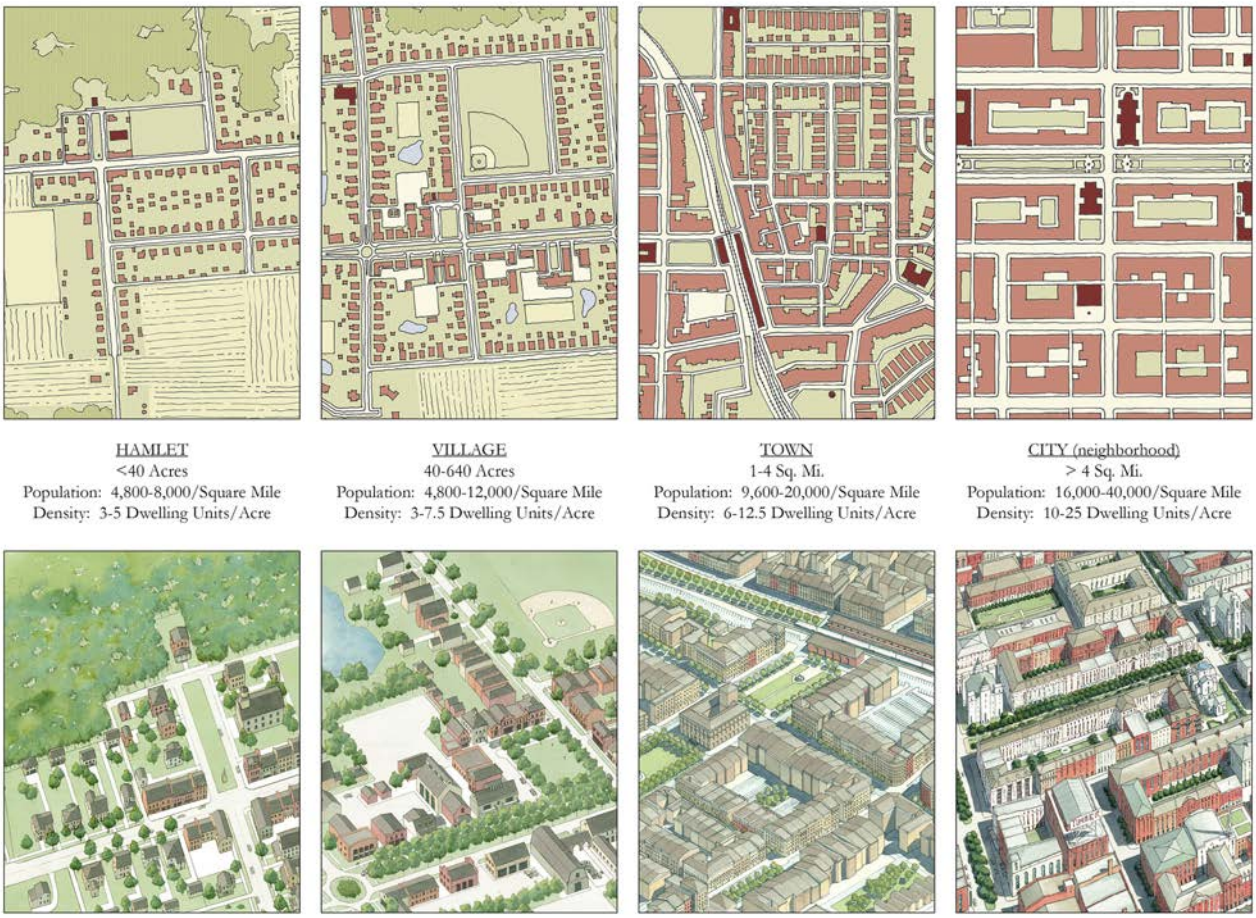

FIG. 7: Metropolitan Chicago Settlement Types by Area and Density:
Hamlets and Villages organized around rural roads, Towns and City Neighborhoods organized around public rail transit

Chicago 2109 presumes driving and commercial aviation in 22nd century Chicago, but that because of the price of fuel these will be more costly and less common. In particular, as noted above, we presume that the built environment will be organized primarily not around the automobile but around various existing forms of rail. In the city of Chicago our primary proposed transportation network includes improved and extended CTA rail lines, light rail, trolleys, and new Bus Rapid Transit (BRT) service to supplement existing city and suburban bus routes. Regionally, towns are located on and around improved and extended metropolitan passenger rail; and although our most basic conjectures don't require it, we also depict a possible public-private venture inter-urban High Speed Rail which we hypothesize might be located in existing interstate ROWs. Finally, though *Chicago 2109* retains regional interstate highways, it imagines in-city interstate rights-of-way recreated as urban thoroughfares.

3.2. Dealing with Water, at Three Scales [Figure 8]

For adapting to storm-and-waste-water events *Chicago 2109* proposes three scales of intervention: 1) at the scale of metropolitan Chicago, including regional land use policy, major waterway interventions, and active wastewater treatment in the cities of metropolitan Chicago; 2) at the intermediate scale of smaller communities in or adjacent to a rural landscape, in particular the adoption of local, passive, "natural" wastewater treatment by means of constructed wetlands in metro Chicago's towns, villages, and hamlets, with virtually all local wastewater returned to the ground as pure water *on site*; and 3) at the smallest scale, as local practices occurring in all the blocks and buildings located throughout metropolitan Chicago.

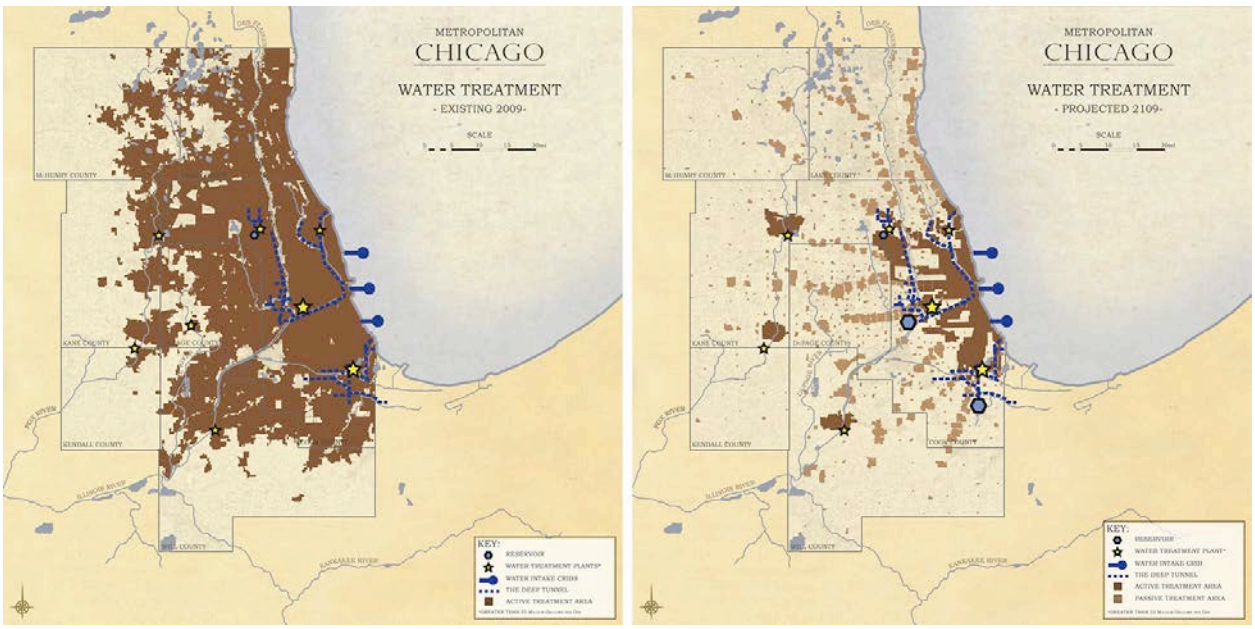

FIG. 8: Metropolitan Chicago Existing and Proposed Waste Water Treatment:
Proposed Passive "Natural" Constructed Wetlands in the rural landscape / Active Water Reclamation Plants in the cities

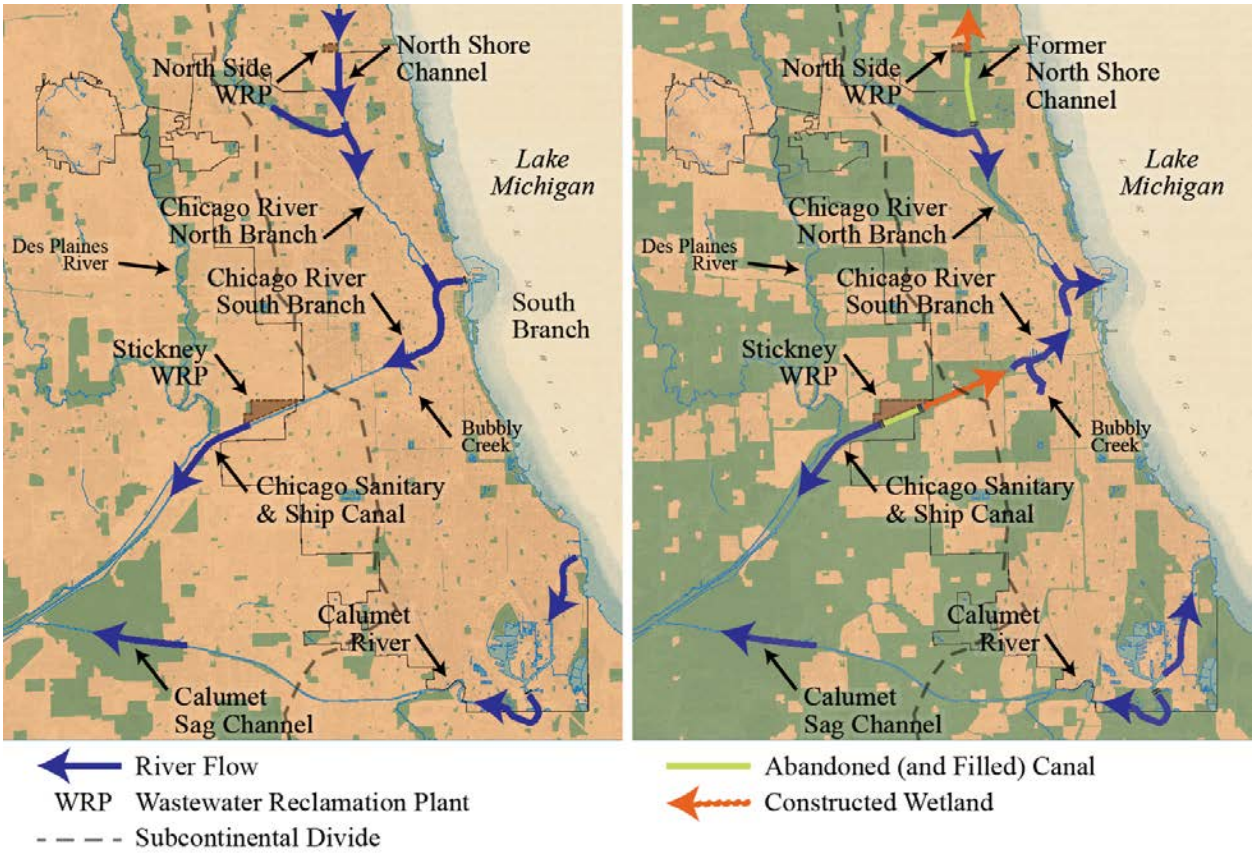

FIG. 9: City of Chicago Existing Water Path (left) / Proposed (Re-reversed) Water Path (right)

FIG. 10: New Proposed South Damen Avenue "headwaters" of the Chicago River South Branch

3.2.1. The Metropolitan Region: As described above, the primary hydrological adaptation proposed in *Chicago 2109* is actually a land use intervention: a decades-long transformation of Chicago's sprawl suburbs to a range of compact settlement types, and the subsequent restoration of vacated land to natural or cultivated conditions. Generally, we anticipate this change as an organic (if painful) response to changing economic and demographic conditions –on some occasions boosted by extreme weather events-- by hundreds of thousands of individuals and individual families seeking greater economic stability, social cohesion, and ecological resilience: in short, an adaptive response *en masse*. In this respect, *Chicago 2109* does not prescribe its envisioned settlement pattern as an urgent political mandate, but rather as a proactive vision to guide regional planning and prepare local political leaders to respond calmly and vigorously to the coming wave of predictably stressful conditions even now visible on the horizon.

A more direct intervention proposed at the regional scale is the restoration of Chicago's original sub-continental divide via the re-reversal of the Chicago River. *Chicago 2109* proposes a modified version of a plan to separate the Great Lakes and Mississippi River watersheds known as the "Mid-System Alternative" in a 2012 report prepared by the Great Lakes Commission (GLC) and Great Lakes and St. Lawrence Cities Initiative. That plan includes a physical barrier at Bubbly Creek separating the Chicago River to the east from the Sanitary and Ship Canal to the west. Additional barriers would also be constructed at the Calumet, Grand Calumet and Little Calumet Rivers (Great Lakes Commission 2012).

Unlike the GLC report, *Chicago 2109* proposes that the Chicago River separation occur at the Stickney Water Reclamation Plant **[Figure 9]**, filling and abandoning a mile-long stretch of the canal, with the Stickney WRP pumping treated wastewater east and west into each of the now separated channels. The fledgling South Branch headwaters (located within the existing canal walls) could be engineered as a meandering series of constructed wetlands that provide tertiary wastewater treatment, introducing a new riparian habitat and recreation area to

Chicago's Southwest Side **[Figure 10]**. A similar proposal at the North Side WRP would fill and abandon the North Shore Channel (currently connecting North Side WRP with the Chicago River). The North Branch of the Chicago River would then flow from its origins back to Lake Michigan completely free of any treated water, while the treated discharge from the North Side WRP would flow north through its own constructed wetland stream and into Lake Michigan at Wilmette (at what is today the pumping station that pushes water from the lake towards the North Side WRP and the North Branch, and eventually down the Mississippi).

There are three noteworthy benefits of this plan. First, the separation of the Great Lakes and Mississippi River watersheds would help deter Asian carp (and other invasive species) from migrating from one to the other. Second, the additional level of artificial wetlands treatment for all treated wastewater headed back to Lake Michigan would improve the water quality of Chicago's rivers (and perhaps the general health of Chicagoans), with benefits to the lake and river ecosystems, the municipal drinking water supply, and water recreation activities. And third, the return to a gravity-powered river network (with back-up pumps) and the removal of the lock at the mouth of the Chicago River would increase Chicago's resilience, passively addressing concerns about scenarios when the river level is above lake level (whether from storm or drought, as noted above).

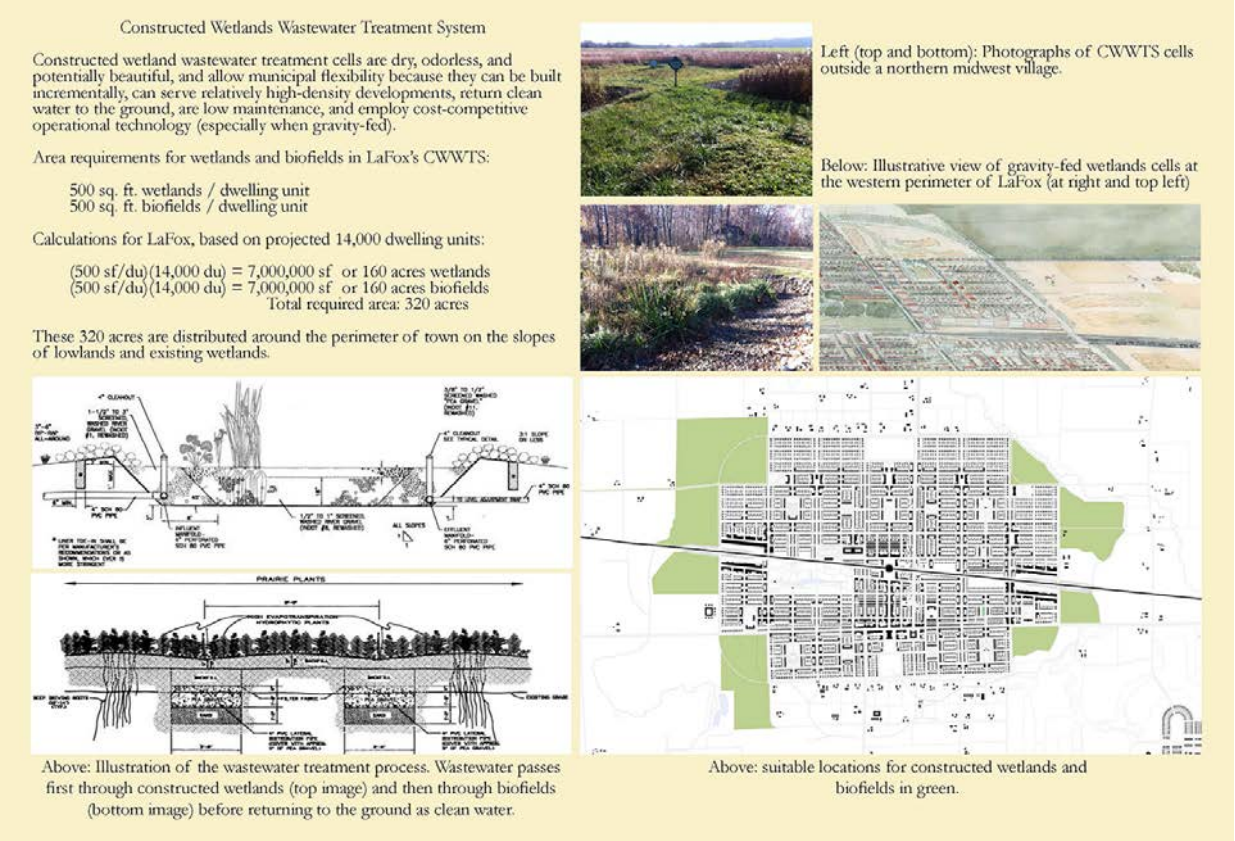

FIG. 11: Natural Waster Treatment for the proposed Kane County Town of LaFox, Illinois, population 35,000 (Constructed Wetlands technical diagrams courtesy of J.F. New and Associates, Walkerton, IN)

3.2.2. Purified Wastewater in the Rural Landscape: Unlike metropolitan Chicago's major cities, the towns, villages and hamlets envisioned in 2109 metro Chicago's rural landscape have appropriately smaller-scale wastewater treatment opportunities. While their individual impact may be small, there are some significant advantages in alternatives to city-scale active wastewater treatment. For these smaller communities, *Chicago 2109* proposes that wastewater be treated by constructed artificial wetlands that passively and naturally purify wastewater

and return it directly to the ground **[Figure 11]**. Wastewater enters the constructed wetland cell at one end and comes out the other end as almost pure water, save for its high ammonia content. From the wetland cell the water goes to a field planted with certain kinds of ammonia-dissipating rushes, after which it enters the ground as pure water. The wetland cells and bio-fields modestly disguise themselves as edge-condition landscape and wildlife refuge. These two systems would be distributed across the metropolitan region adjacent to their respective towns, villages, and hamlets, providing valuable ecological networks and "greenbelts" while serving an eminently practical environmental purpose.

This strategy localizes a portion of a regional concern, and decreases the extent of more complex wastewater infrastructure that depends for its maintenance on potentially limited resources. Similarly, as a more decentralized network, this approach to rural wastewater treatment brings with it greater resiliency in the face of significant storm events: inevitable failures will be at a smaller scale and geographically distributed. Finally, retaining and treating wastewater within the immediate surroundings of each settlement ensures that as much water as possible is returned to the aquifer, and perhaps in some cases available to serve community needs in times of drought.

3.2.3. The Block and Building: Solutions at the scale of the block and building lack the grand impressiveness of the other strategies, but play an important role nonetheless. The City of Chicago (2014) has already recognized the necessity of green infrastructure, and published the *Green Stormwater Infrastructure Strategy*. In line with that agenda, *Chicago 2109* calls for three techniques to address the various surface conditions: the increased use of rain barrels to capture roof runoff; pervious paving to capture run-off otherwise lost to impervious streets, sidewalks, and parking lots; and infiltration gardens to improve the filtration rate of planted areas. In addition to these three, improving the urban forest through a focus on street trees and private trees will decrease runoff, reduce urban heat island effect, and mitigate air pollution (Burden 2006). These techniques are all the more important in *Chicago 2109* because of the plan's emphasis on compact development within the City of Chicago and all of the region's other settlements, which will necessarily have a high percentage of municipal land allocated to buildings and streets. A vast, distributed network of stormwater absorption can assist the TARP / Deep Tunnel in managing the sudden barrage of a storm event, minimizing or eliminating CSOs in Chicago's future.

4. SUMMARY AND CONCLUSION

To summarize the first order policy arguments of *Chicago 2109*:

In the anticipated slow-growth economy of Illinois and metropolitan Chicago, under conditions of fiscal stress and comparative resource scarcity, we recommend generally the following principles and courses of action:

- Refurbish and re-use the most compact infrastructure you can afford to maintain (especially rail if you already have it)
- Organize compact mixed-use human settlements around retained and refurbished compact infrastructure

What these policies, implemented, might look like in metropolitan Chicago have been suggested by the illustrations included in this paper. The following items are also *Chicago 2109* general recommendations, but have not been discussed at any length here:

- Make buildings with durable, low-embodied-energy, locally-sourced materials
- Implement a regional Land Value Tax and promote a new culture of philanthropy to fund urban and suburban land reclamation for restoration as agricultural land, nature preserves, and compact rural settlements
- Promote and incentivize local agriculture (also one of the objectives of a Land Value Tax)

And to summarize the adaptive implications of our water arguments: Implementation of *Chicago 2109*'s multiple policy proposals in conjunction with TARP measures may not eliminate flooding in metropolitan Chicago, but it

would almost certainly reduce its impact by: 1) returning more stormwater and locally purified wastewater in rural areas directly to the ground; and 2) returning more thoroughly treated wastewater in metropolitan Chicago cities back to their original destinations in either the Great Lakes watershed or the Mississippi River watershed.

A core principle of *The Notre Dame Plan of Chicago 2109* is an understanding of humanity's status in nature as an intermediate being (Bess 2015). That is to say: a true comprehension of human nature grasps that we flourish neither by imagining ourselves standing apart from, dominating, and bending nature to our will; nor by imagining we are simply immersed in nature and lack both the power and the duty to superintend nature and help perfect it. We rarely articulate the implications of this view of human nature, and many today actively deny it. Nevertheless, we think a failure to recognize our intermediate status vis-à-vis nature and the cosmos –*if only by correct inference from our collective powers* (which powers seem implied in such concepts as The Anthropocene)-- is to lose any intellectually coherent notion of environmental stewardship, as well as any coherent moral critique of what human beings actually do both within and to the natural order. Our own wellbeing requires us to know and respect both the reality of nature within ourselves and the nature of reality beyond ourselves.

If ours is an accurate account of the place of human beings in nature, it imposes a general obligation upon every generation. Yet all general obligations occur in specific times and specific places, some of great urgency and practical necessity; and an age of changing climate and increased unpredictability raises the stakes on our collective decisions. The adaptive responses now required of us –including "first, do no harm"-- leave little room for errors, which can be consequential for both environmental stewardship and human lives. Finding our optimal balance point in and with nature, developing a felicitous and mutually beneficial working relationship, require an understanding of nature and human nature both honest and true. Whether in regional hydrology, as discussed here at length, or in other topic areas such as construction materials and craft or regional transportation systems, *Chicago 2109* seeks solutions that can make metropolitan Chicago a beautiful, durable, and resilient exemplar of successful climate adaption, once again a city and region at the forefront of a new era.

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FIG. 12: Aerial Perspective view of Chicago in 2109, looking east.

FIG. 13: Aerial Perspective view of Chicago in 2109, looking west.

References

Adams C (2009) Today's Question. Straight Dope Chicago. http://chicago.straightdope.com/sdc20090122.php. Accessed 29 March 2017

Alexander A (2017) MWRD and Environmental Groups Bury the Litigation Hatchet. National Resources Defense Council. https://www.nrdc.org/experts/ann-alexander/mwrd-and-environmental-groups-bury-litigation-hatchet. Accessed 29 March 2017

Arnold Jr. C and Gibbons C (1996) Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. American Planning Association APA Journal. APA, http://www.esf.edu/cue/documents/Arnold-Gibbons_ImperviousSurfaceCoverage_1996.pdf. Accessed 29 March 2017

Associated Press (2017) Chicago gets worst pension rating among 15 largest cities. Associated Press. http://bigstory.ap.org/article/a27d710fd4284d82a1e3a78a1b1e01fd/chicago-gets-worst-pension-rating-among-15-largest-cities. Accessed 29 March 2017

Bess, P (2015) "Even Mother Nature Has An Agent." First Things. https://www.firstthings.com/web-exclusives/2015/07/even-mother-nature-has-an-agent. Accessed 29 March 2017

Bosman J and Smith M (2016) As Chicago Murder Rate Spikes, Many Fear Violence Has Become Normalized. New York Times. https://www.nytimes.com/2016/12/28/us/chicago-murder-rate-gun-deaths.html?_r=0. Accessed 29 March 2017

Bukro C (2017) Deep Tunnel opens. Chicago Tribune. http://www.chicagotribune.com/news/nationworld/politics/chi-chicagodays-deeptunnel-story-story.html. Accessed 29 March 2017

Burden D (2006) Urban Street Trees. Walkable Communities, Inc. http://www.walkable.org/download/22_benefits.pdf. Accessed 29 March 2017

City of Chicago (2014) Green Stormwater Infrastructure Strategy. City of Chicago Department of Water Management.https://www.cityofchicago.org/content/dam/city/progs/env/ChicagoGreenStormwaterInfrastructureStrategy.pdf. Accessed 29 March 2017

Cosier S (2016) Let's Go Swimming in the Chicago River! Save the Date: 2030. National Resources Defense Council. https://www.nrdc.org/stories/lets-go-swimming-chicago-river-save-date-2030. Accessed 29 March 2017

Einhorn R (2005) Street Grades, Raising. Chicago Historical Society. http://www.encyclopedia.chicagohistory.org/pages/1202.html. Accessed 29 March 2017

Great Lakes Commission (2012) Restoring the Natural Divide Summary Report. Great Lakes Commission. https://restoring-the-natural-divide-glc.cemah.net/wp-content/uploads/sites/34/2016/11/CAWS-PublicSummary-mediumres.pdf. Accessed 29 March 2017

Hawthorne M (2015) Chicago River still teems with fecal bacteria, tests show. Chicago Tribune. http://www.chicagotribune.com/news/ct-chicago-river-bacteria-20150827-story.html. Accessed 29 March 2017

Henderson H (2013) Chicago River Re-reversal Debate: Getting Infrastructure Ready for the Rigors of Climate Change. National Resources Defense Council. https://www.nrdc.org/experts/henry-henderson/chicago-river-re-reversal-debate-getting-infrastructure-ready-rigors-climate. Accessed 29 March 2017

Hertz D (2015) Unnecessary population loss on the North Side is a problem for the whole city. City Notes. https://danielkayhertz.com/2015/03/16/unnecessary-population-loss-on-the-north-side-is-a-problem-for-the-whole-city/. Accessed 29 March 2017

Illinois State Water Survey. (2017) Groundwater Science: Northeastern Illinois. University of Illinois at Urbana-Champaign Prairie Research Institute. http://www.isws.illinois.edu/gws/neillinois.asp. Accessed 29 March 2017

Krohe Jr. J (2004) The Chicago River/Lake Shore: An Inventory of the Region's Resources. Illinois Department of Natural Resources Office of Realty and Environmental Planning. https://www.dnr.illinois.gov/publications/Documents/00000190.pdf. Accessed 29 March 2017

Nugent W (2005) Demography: Chicago as a Modern World City. Chicago Historical Society Electronic Encyclopedia of Chicago. http://www.encyclopedia.chicagohistory.org/pages/962.html. Accessed 30 March 2017

Power M (2013) Cry Us a River. National Resources Defense Council One Earth. http://archive.onearth.org/article/chicago-river. Accessed 29 March 2017

Renault M (2016) Poison pills, noise cannons: Researchers use arsenal of weapons to fight Asian carp. Chicago Tribune. http://www.chicagotribune.com/news/local/breaking/ct-lake-michigan-asian-carp-met-20160822-story.html. Accessed 29 March 2017

Sandburg C (1914) Chicago. Poetry. http://www.jstor.org/stable/20569994. Accessed 29 March 2017

Schneider E (2013) Chicago River cleanup will leave Bubbly Creek still bubbling with waste for now. Northwestern University Medill Reports Chicago. http://newsarchive.medill.northwestern.edu/chicago/news-224333.html. Accessed 29 March 2017

Smith M (2010) What Scientists Are Really Saying About Asian Carp Surviving in the Great Lakes. National Wildlife Foundation. https://www.nwf.org/News-and-Magazines/Media-Center/Reports/Archive/2010/What-Scientists-Are-Really-Saying-About-Asian-Carp.aspx. Accessed 31 March 2017

U.S. Environmental Protection Agency (2003) Protecting Water Quality from Urban Runoff. U.S. Environmental Protection Agency Nonpoint Source Control Branch. https://www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf. Accessed 29 March 2017

U.S. Environmental Protection Agency (2016) CSOs. Causal Analysis/Diagnosis Decision Information System. https://www3.epa.gov/caddis/ssr_urb_ww2.html. Accessed 29 March 2017