

REvision 2020:
Redefining Public Works in New York City's Sixth Borough

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis.
This is a true copy of the thesis, including any required final revisions, as
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I understand that my thesis may be made electronically available to the public.

Abstract

On March 14, 2011 the Bloomberg Administration unveiled New York City's 10-year comprehensive waterfront plan entitled, "Vision 2020." Though the document follows a long line of waterfront revitalization proposals, it offers an extraordinarily profound and historically unprecedented ambition to re-establish New York as one of the world's premiere waterfront cities by transforming its post-industrial harbour into a "Sixth Borough" capable of sustaining expanded urban development, recreation, local ecologies, and water-based economies. Underlying this extensive redevelopment scheme is a massive environmental remediation initiative that aims to improve water quality throughout the region by upgrading the city's

crumbling, century-old sewer system to prevent it from spilling millions of gallons of untreated effluent into the New York Harbor every week. With no federal funding available for these costly upgrades, the city will depend on its taxpayers to finance the new borough's extensive list of infrastructural needs. Convincing the public to support this initiative will however prove to be immensely difficult as most New Yorkers are unaware of the critical need for infrastructure at the waterfront and would rather see their taxes spent on parks, amenities, transportation, housing or the creation of jobs. Despite this, "Vision 2020" proposes the construction of standardized, single-service, shovel-ready, infrastructure that

will be buried underground where it will make no visible social, aesthetic, or economic contribution to the transformation of public waterfront. For these reasons, REvision 2020 is proposed.

Rather than subscribing to the 20th century understanding of infrastructure as a service-based utility, REvision 2020 examines the potential for the renovation New York City's sewer system to catalyze a much larger and more visible public benefit in the Sixth Borough. In doing so, the document investigates the complex social, political, economic, and environmental challenges underlying the revitalization of the post-industrial waterfront and presents strategies for addressing these matters through a renegotiation

of conventional infrastructural form. These strategies are then synthesized and applied to the design of a buoyant, high-performance sanitation system deployed in Brooklyn's notoriously toxic Gowanus Canal to transform the derelict shipping channel into a public Wastewater-To-Resource Park that converts the region's excess sewage into fresh water, nutrients, and energy which are reused to sustain recreational activities and new water-based economies. In addition to proposing a bottom-lined approach to the development of the Sixth Borough, REvision 2020 and the Gowanus W.T.R. Park champion the exploration of infrastructure not only as an engineering endeavor, but as a robust design opportunity.

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Dedication

For My Family

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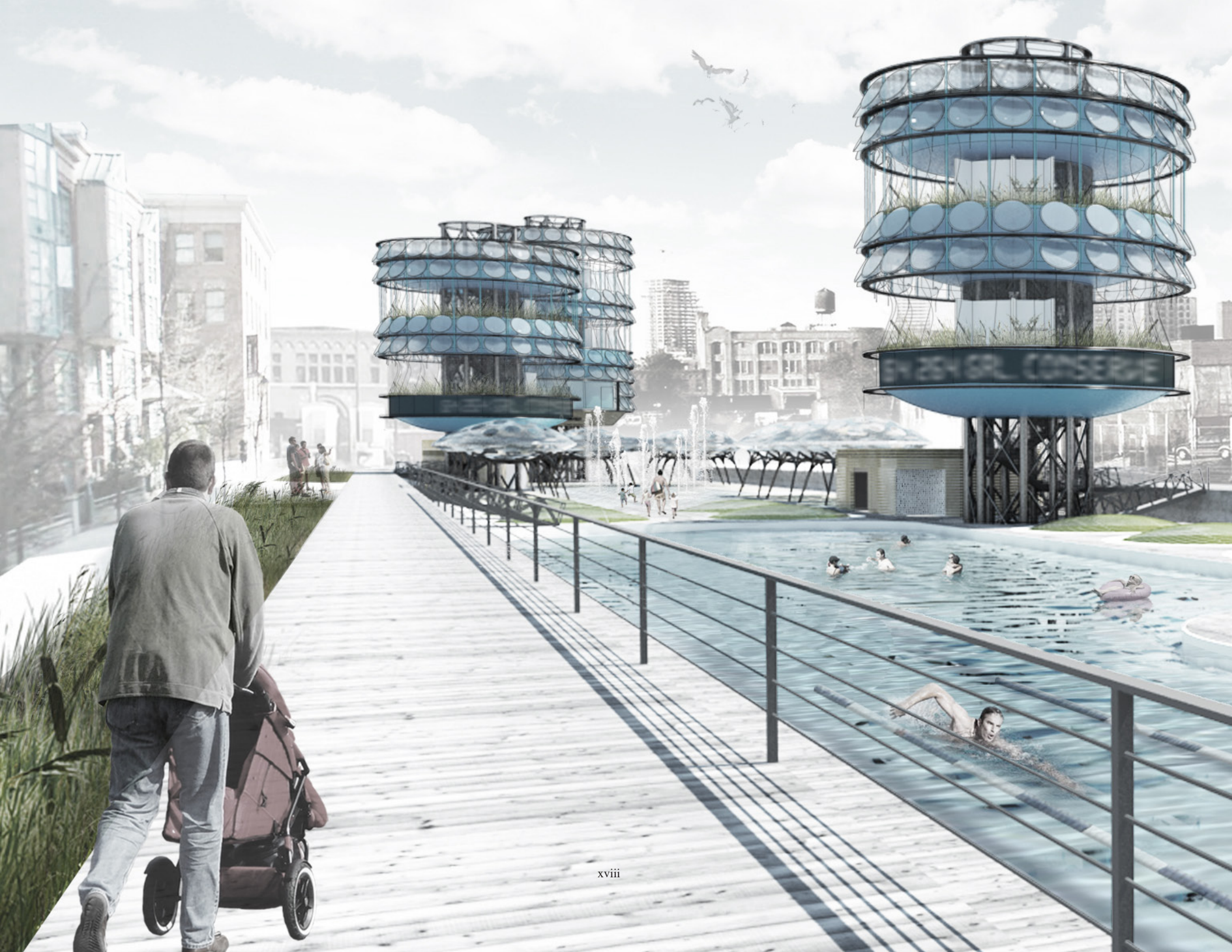
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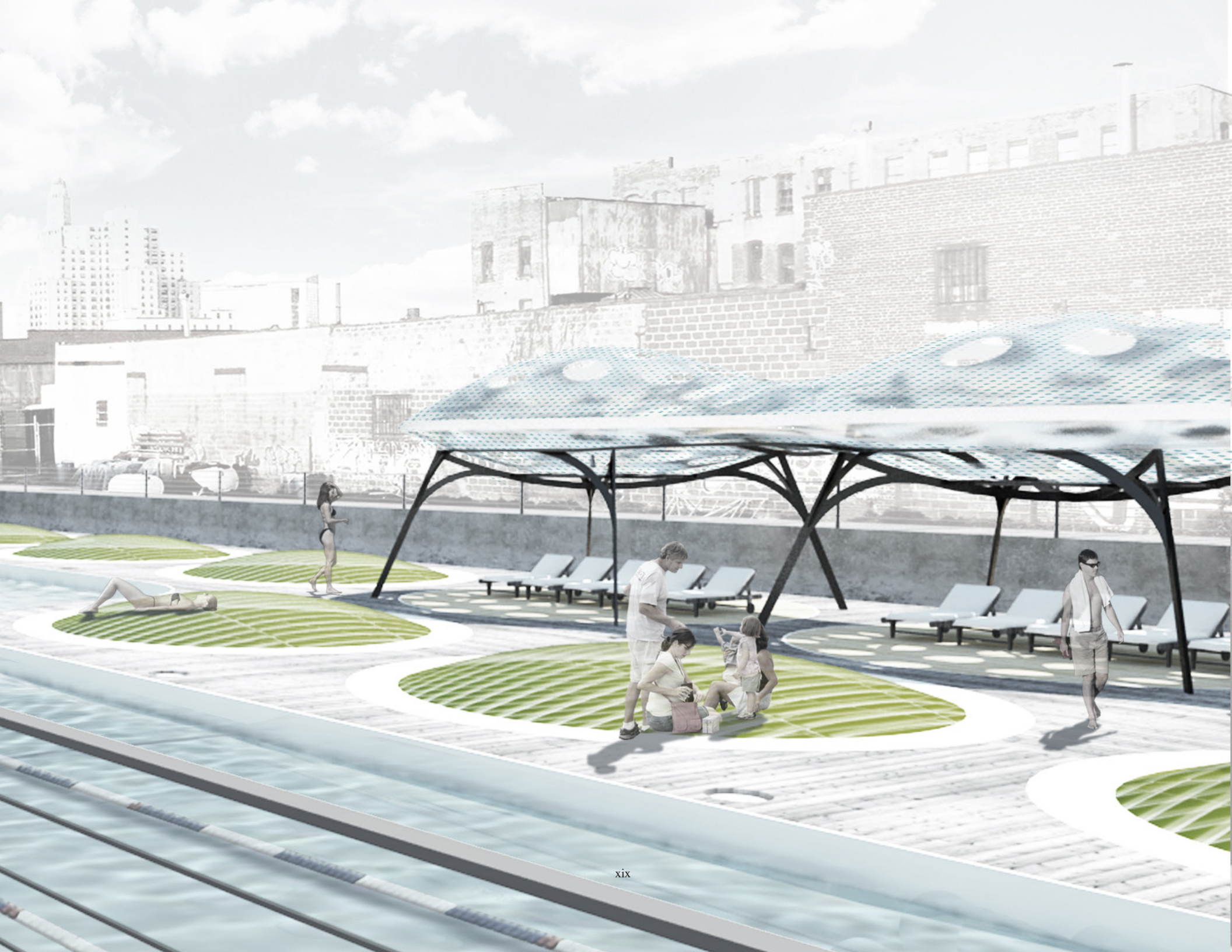
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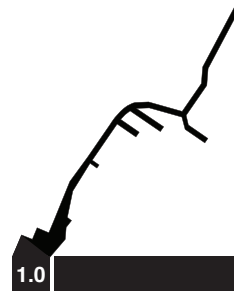
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1.0

REvision 2020



Fig. 1.0 A waterfront lot in Brooklyn soon to be developed into “Brooklyn Bridge Park” as outlined in “Vision 2020.”

1.0

REvision 2020

“Our water is the connective tissue between our boroughs and is, in effect, our Sixth Borough. We are now planning for our waterfront and waterways with the same intensity and passion that we have traditionally planned for our land.”¹

Amanda M. Burden, 2011

On March 14, 2011 the Bloomberg Administration unveiled New York City’s 10-year comprehensive waterfront plan entitled, “Vision 2020.” Though the document supports ongoing efforts to integrate housing, commercial enterprises, open space, greenways, and public amenities into more than 500 miles of urban

¹ Burden, Amanda M.. “Comprehensive Plan for New York City’s Waterfront and Waterways.” Vision 2020. New York City. 14 Mar. 2011. Speech.

waterfront it offers an extraordinarily profound and historically unprecedented ambition to extend this development into the water itself by expanding the use of the region’s waterways for transportation, recreation, education, and economic growth. Ultimately this plan seeks to reconnect the city with its most vital natural resource by transforming its post-industrial harbour and its contiguous shoreline into a “Sixth Borough” where New Yorkers can live, work, and play. Underlying this extensive redevelopment scheme is a massive environmental remediation initiative that aims to improve water quality throughout the region by upgrading the city’s crumbling, century-old sewage system to prevent

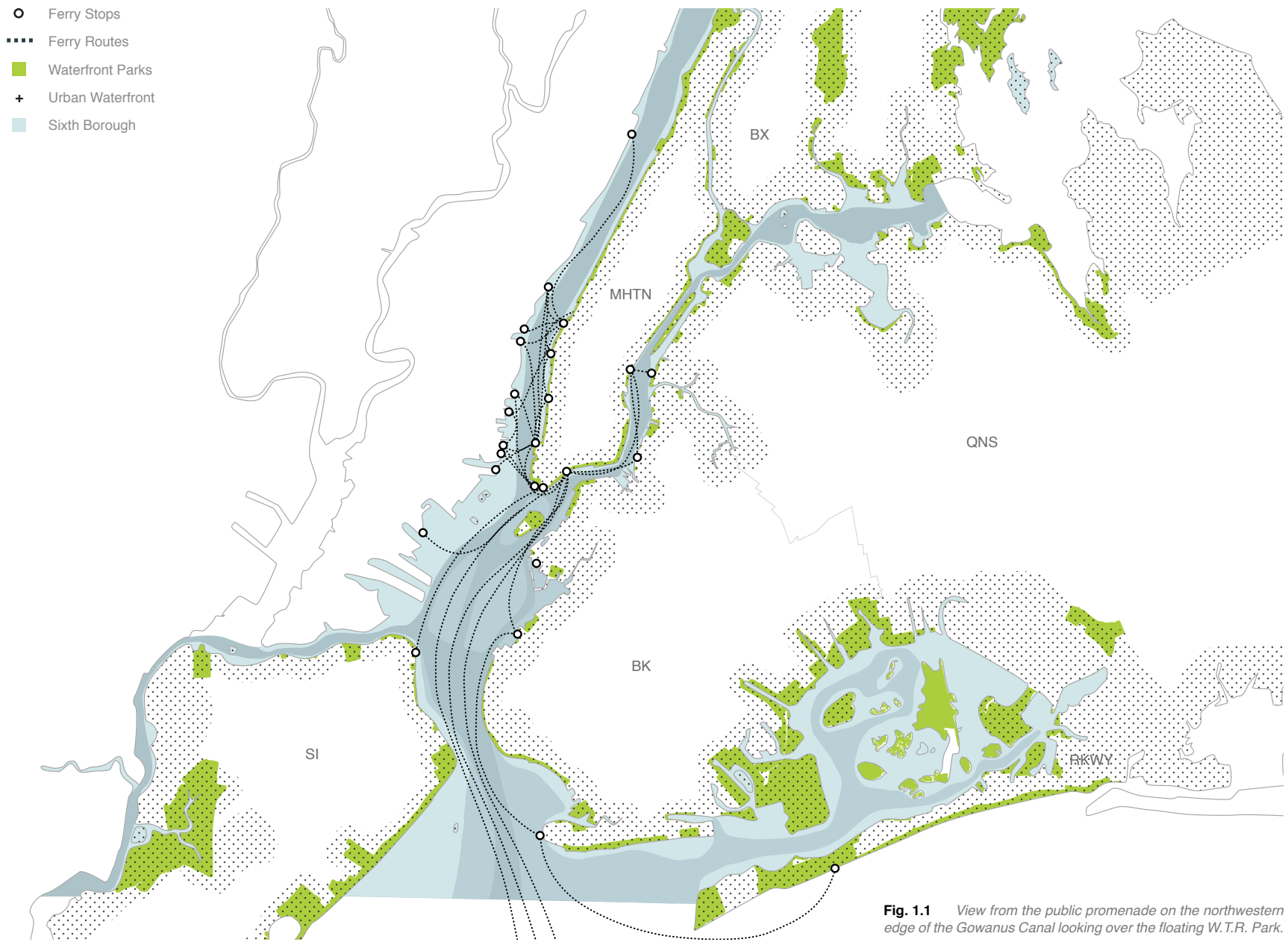


Fig. 1.1 View from the public promenade on the northwestern edge of the Gowanus Canal looking over the floating W.T.R. Park.



Fig. 1.2 A photograph taken on the East River shows New York City's sewer system spilling untreated effluent into the harbour.

it from spilling millions of gallons of untreated effluent into the New York Harbour every week. To execute this initiative, "Vision 2020" proposes the construction of reinforced concrete cisterns in a number of locations along the waterfront to intercept the excess sewage that currently overflows into the region's waterways. While these standardized mitigation strategies have proven effective in cities around the world, they are extremely costly and with no long-term source of federal funding available for their construction, the city's extensive list of infrastructural needs will have to be financed with municipal tax dollars. As a result, the successful development of the Sixth Borough will depend entirely upon the



Fig. 1.3 A photograph of a typical cistern designed to intercept and store excess sewage that overflows into urban waterways.

Bloomberg Administration's ability to secure the long-term political, and financial support of their taxpaying constituents. Garnering this support will however prove to be immensely difficult as alternative needs for waterfront parks, docks, piers, transportation, housing, and jobs make the renovation of the city's antiquated sewer system an extremely low priority in the eyes of the public whose interests in waterfront revitalization are primarily vested in social, aesthetic, and economic benefits. This problem is also perpetuated by the fact that sewer overflow is an invisible problem and therefore most New Yorkers are unaware of the critical role wastewater infrastructure will play in reconnecting the city with its waterways. With

all of these matters considered, evidence suggests that the conventional single-service, shovel-ready approach to infrastructural development proposed in "Vision 2020" will fall short on addressing the complex social, political, and economic challenges New York City faces in transforming its post-industrial harbour into the Sixth Borough. Not only will the proposed cisterns not be able to make any meaningful social, aesthetic, or economic contribution to the taxpayers who will be charged with meaningful contribution to the social, aesthetic or economic transformation of the public waterfront but their construction underground will only contribute to the public's lack awareness. For all of these reasons, REvision 2020 is proposed.



Fig. 1.4 *New York City's largest sewage treatment facility, the Newton Creek Water Pollution Control Plant.*

Rather than subscribing to the 20th century understanding of infrastructure as a service-based utility, REvision 2020 examines the potential for the renovation New York City's sewer system to catalyze a much larger and more visible public benefit in the Sixth Borough. In doing so, the document confronts the complex social, political, and economic challenges underlying the revitalization of the post-industrial waterfront and proposes strategies for addressing these matters through a renegotiation of conventional infrastructural form. These proposed strategies are generated from two primary bodies of research in which wastewater infrastructure is positioned as the primary subject of design investigation. The first

of these entitled, "Matters of Overflow" provides an indepth look at the performance of New York City's sewage network and reveals recent increases in sewer overflow to be a result of the city's own neglect to maintain its aging infrastructure. Through an analyses of trends in municipal spending, the chapter reveals that the city has not only been unable to adequately fund the renovation and repair its polluting sanitation system but, has been unable to garner public support to do so. The research links these larger social and economic issues to specific flaws inherent within the design of the city's sewage network and determines that mitigating sewer overflow throughout the harbour nessesitates an infrastructure that is not only

less capital-intensive, but capable of attracting longterm public investment.

With better understanding of the challenges at hand, the second chapter entitled, "Redefining Public Works," proposes five ways in which the form and performance of conventional infrastructure might be renegotiated to address challneges the city faces in keeping its harbour clean. Each strategy is outlined individually and accompanied by an analysis of exemplary waterworks that illustrate the particular theories discussed. These precedents not only demonstrate the potential for hydrologic infrastructure to be planned according to the proposed principles, but provide insight into specific stratetgies for

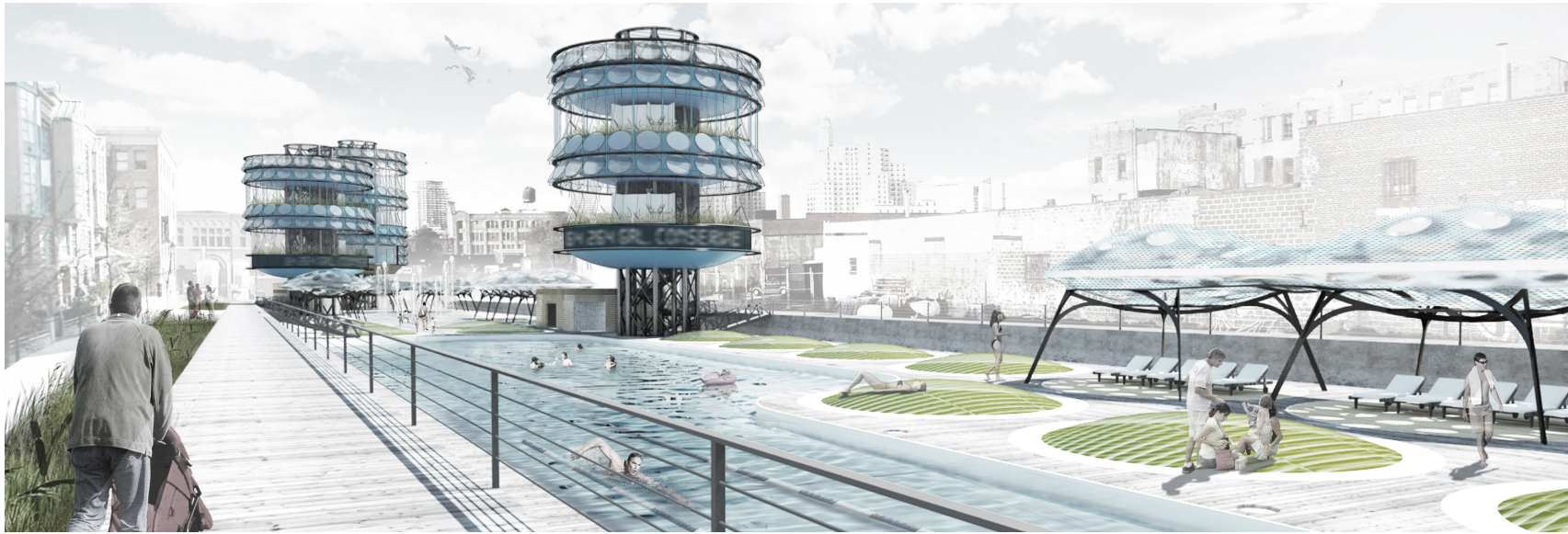


Fig. 1.5 View from the public promenade on the northwestern edge of the Gowanus Canal looking over the floating W.T.R. Park.

formatting the New York City's sewage network in similar ways. The five principles are defined as follows:

1. Decentralized

Centralizing the collection, storage, and treatment of urban wastewater is an extremely capital-intensive enterprise which is proving to be increasingly unsustainable in today's economic climate. Decentralizing these processes has a number of short- and long-term cost savings that would make maintaining and upgrading the urban sewage system far more affordable.

2. Integrated

Concealed underground and relegated to the periphery of the city, wastewater infrastructure

has been exempt from making any meaningful social or aesthetic contribution to the urban fabric rendering it undesirable and valueless in eye of public taxpayers. Infrastructure must instead be integrated into the formal inhabited city and designed to enhance the urban public landscape.

3. Productive

Though the construction, operation, maintenance, and renovation of New York City's sewage network consumes large quantities of public money, fresh water, and energy, the majority of its infrastructural components produce no capital to subsidize their cost or to replenish the valuable resources they deplete. Infrastructure in the Sixth Borough must be productive so it can give back to

the city and its public sphere.

4. Legible

Since the collection, distribution, and purification of effluent is concealed underground and locked behind closed gates at the periphery of the city, the majority of New Yorkers are unaware of the vital role wastewater infrastructure plays in protecting the condition of their harbour until it fails to do so. The next generation of wastewater infrastructure must be made legible so that New Yorkers are conscious of how and when these critical systems are operating to serve them.

5. Multifunctional

Segregating interdependent systems of infrastructure into separate and unrelated



Fig. 1.6 *View from the public promenade on the northwestern edge of the Gowanus Canal looking over the floating W.T.R. Park.*

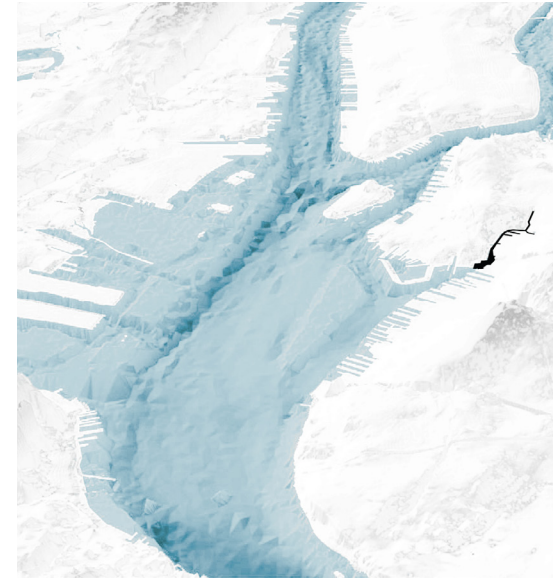


Fig. 1.7 *View from the public promenade on the northwestern edge of the Gowanus Canal looking over the floating W.T.R. Park.*

departments is an inefficient use of municipal funds which are too meagre to be adequately divided among different enterprises. Separate infrastructural networks should instead be combined into composite networks that serve multiple functions to maximize the value of a single municipal investment.

The proposed strategies are then synthesised into are then The potential for these principles to be applied to the design of infrastructure in the Sixth Borough is examined in a third and final chapter entitled “A New Infrastructure,” which presents a concept for a buoyant, high-performance sanitation system that plugs into New York City’s existing sewer grid to intercept

and treat the excess effluent that overflows into the region’s waterways. Brooklyn’s notoriously toxic Gowanus Canal acts as the primary testing ground for the new infrastructure which is deployed in various locations along the waterway. In addition to upgrading the capacity of the region’s sewage network, the new infrastructure transforms the derelict shipping canal into a public Waste-To-Resource Park that converts the region’s excess sewage into fresh water, nutrients and energy which are re-used to sustain recreational activities and new aquatic economies that subsidize long-term municipal costs and generate public interest in the enterprise of infrastructural development. In addition to proposing a bottom-lined approach to

the development of the Sixth Borough, REvision 2020 and the Gowanus W.T.R. Park champion the exploration of infrastructure not only as an engineering endeavour, but as a valuable design element that can revitalize cities and address the complex urban design challenges confronted by the contemporary city.



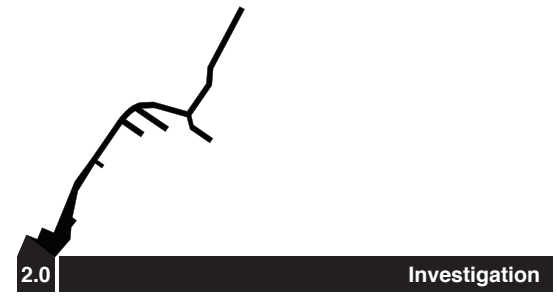




Fig. 2.0 *New York City's Newton Creek Wastewater Treatment Facility in Greenpoint, Brooklyn photographed during construction.*

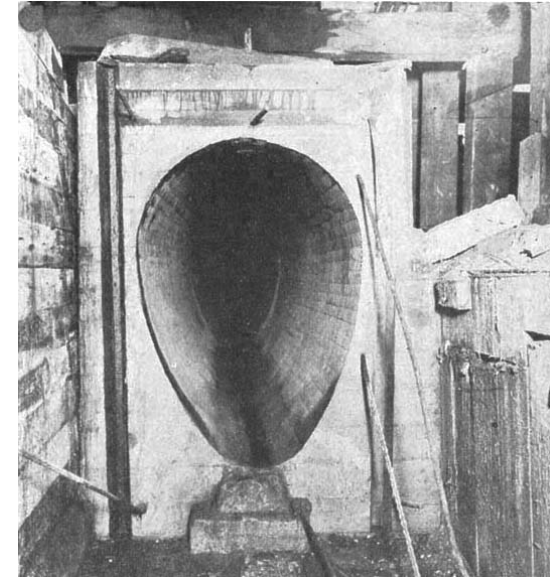


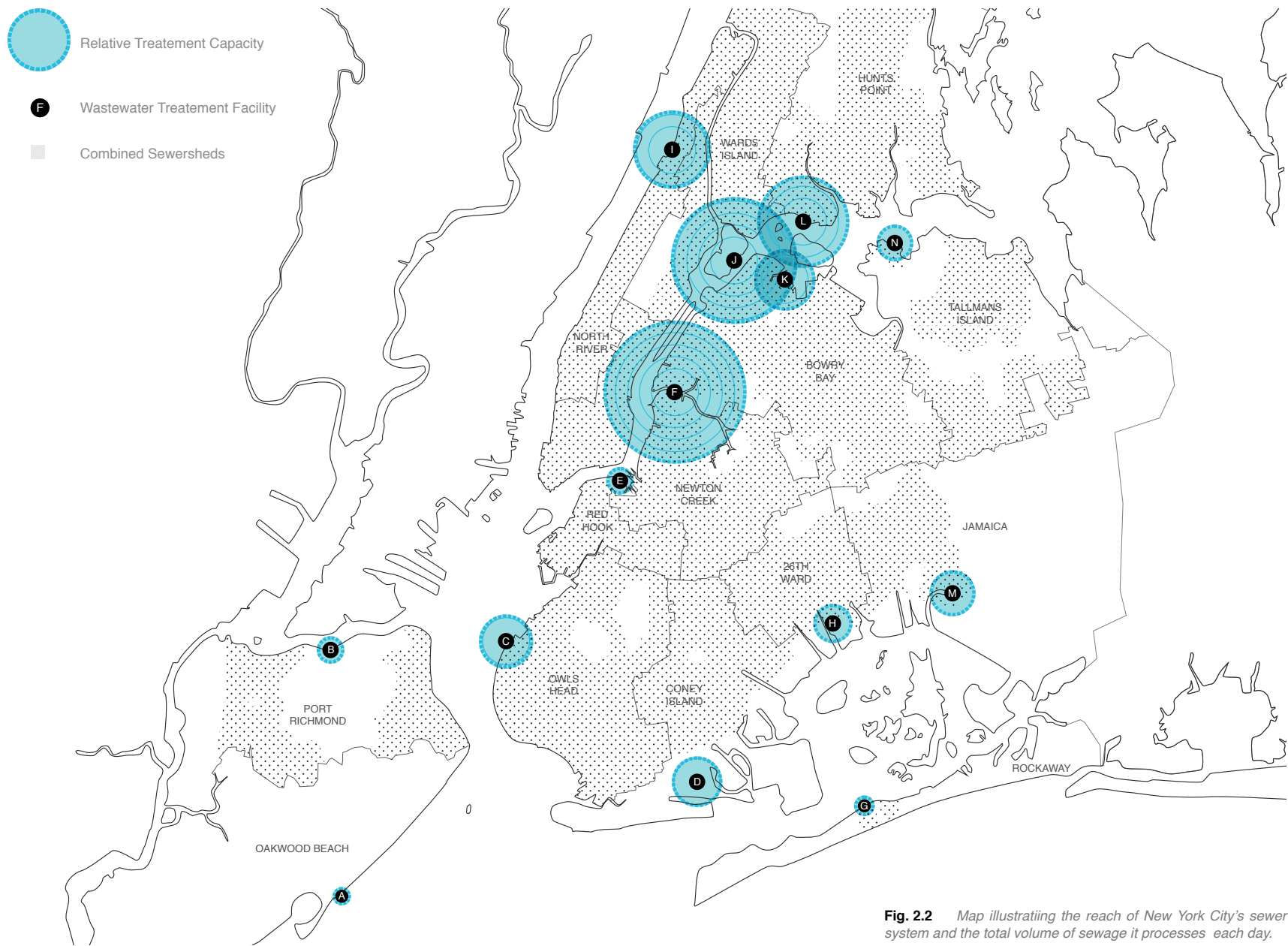
Fig. 2.1 *An egg-shaped sewer laid alongside the subway on 7th Avenue in Manhattan circa 1916.*

2.0 Matters of Overflow

Comprised of more than 7400 miles of conduit, 93 pumping stations, and 14 treatment facilities that collect and filter approximately 1.3 billion gallons of wastewater every day, New York City's sewage system is one of the great infrastructural marvels of the 20th century.¹ Primarily constructed between 1849 and 1978 this massive sanitation network was the first of its kind in North America and has been celebrated for drastically improving the quality of life for New Yorkers by preventing deadly outbreaks of waterborne disease from spreading throughout the densely populated city. Although this vital infrastructure continues to preserve the health of

¹ "New York City's Wastewater Treatment System." NYC DEP. <<http://www.nyc.gov/html/dep/pdf/wssystem.pdf>>.

New Yorkers, its ability to do so has diminished significantly in recent years largely because of its tendency to overflow into the New York Harbour. This pervasive problem is one that the city has attempted to thwart for decades and its inability to do so provides evidence of the limited capacity of conventional solutions to address the challenges at hand. As New York City embarks on a new era of infrastructural spending to catalyze the development of the Sixth Borough, it is absolutely critical that new mitigation strategies are explored. To begin this process, it is necessary to examine the key factors which contribute to sewage overflow in the city. As always, understanding the problem is the first step to finding an appropriate solution.



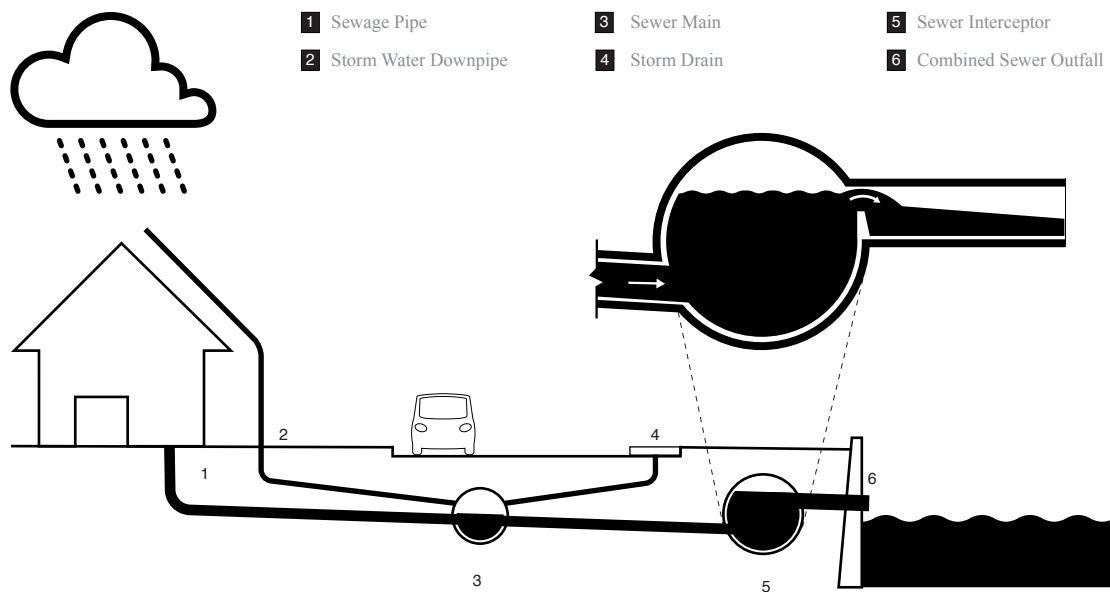


Fig. 2.3 Diagram illustrating the configuration of a typical combined sewer system, the various sources of wastewater that it collects, and how combined sewer overflows occur.

Like many of North America's oldest cities, New York is served by a combined sewer system. This means that its sanitary waste- and storm water are collected and treated simultaneously by a single infrastructural network. As a result, the city's sewers and treatment facilities are susceptible to flooding during periods of heavy rainfall or snow melt, when the volume of wastewater entering the system exceeds its maximum capacity. To prevent sewage from backing up into buildings and streets when flooding occurs, the combined sewer system is designed to discharge excess effluent into the city's rivers and harbour through outfalls distributed along the shore. This discharge of excess sewage is known as a combined sewer

overflow (C.S.O.) event. Every year New York City's overtaxed sewer system discharges more than 27 billion gallons of untreated effluent -- a mixture of sewage, oils, garbage, and industrial waste -- into the New York Harbour during C.S.O. events.² For this reason, combined sewer overflow is considered to be a significant environmental threat and public health risk throughout the greater New York Metropolitan area. This was never meant to be the case. In fact when New York City's sewer system was designed, each of its 14 wastewater treatment facilities were equipped with enough capacity to manage twice their average expected dry-weather intake which would allow them to

manage runoff from 50-year storms. Despite this, the majority of C.S.O. events that occur today are induced by as little as 2.5mm of rain.³

The unusually high frequency at which C.S.O. events have begun to occur in New York City is the direct result of three primary factors. The first of these is climate change. Since the completion of the city's sewer network in the late 1970s, the frequency and intensity of precipitation events have increased considerably throughout the region resulting in larger volumes of storm water entering the city's sewers on a more regular basis.⁴

² Riverkeeper. *Combined Sewage Overflows (CSOs)*. <<http://www.riverkeeper.org/campaigns/stop-polluters/sewage-contamination/cso/>>.

³ Riverkeeper. *Combined Sewage Overflows (CSOs)*. <<http://www.riverkeeper.org/campaigns/stop-polluters/sewage-contamination/cso/>>.

⁴ New York City Department of City Planning. *Climate Risk Information: New York City Panel on Climate Change*. <http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf>.

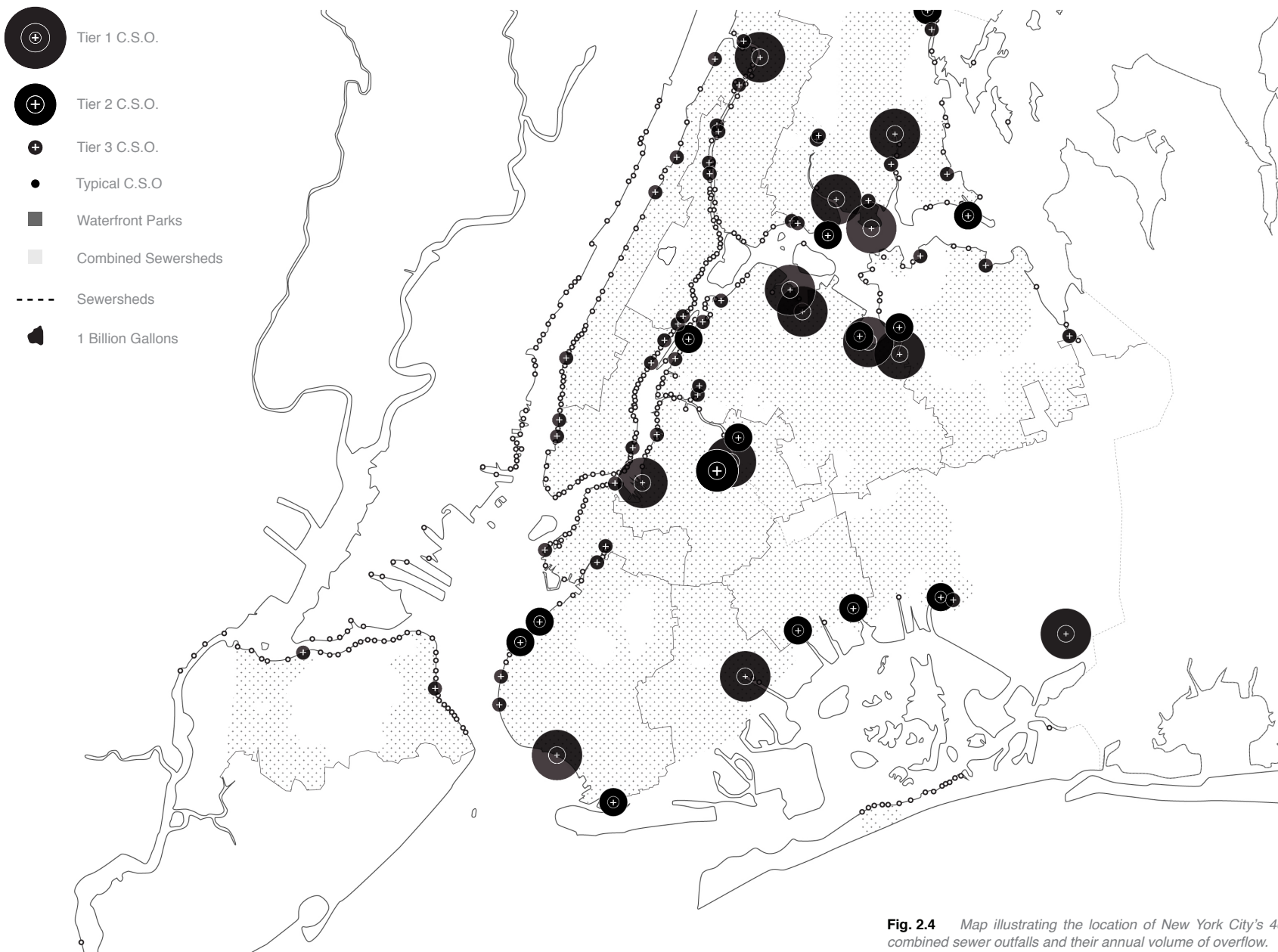


Fig. 2.4 Map illustrating the location of New York City's 460 combined sewer outfalls and their annual volume of overflow.

- F Wastewater Treatment Facility
- Highest Polluting
- Urban Development 1612-1813
- Urban Development 1813-1898
- Urban Development 1898-1945

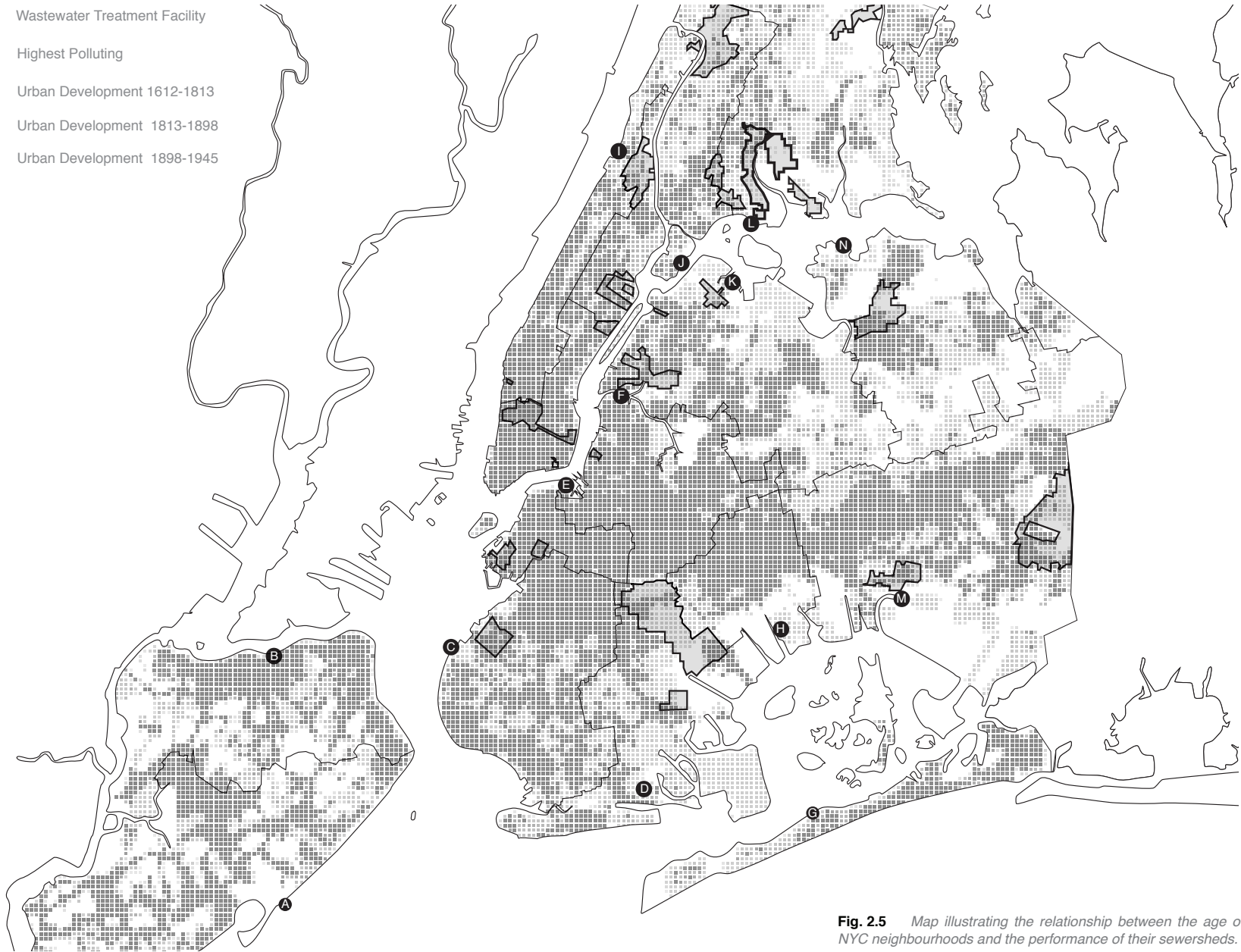


Fig. 2.5 Map illustrating the relationship between the age of NYC neighbourhoods and the performance of their sewersheds.

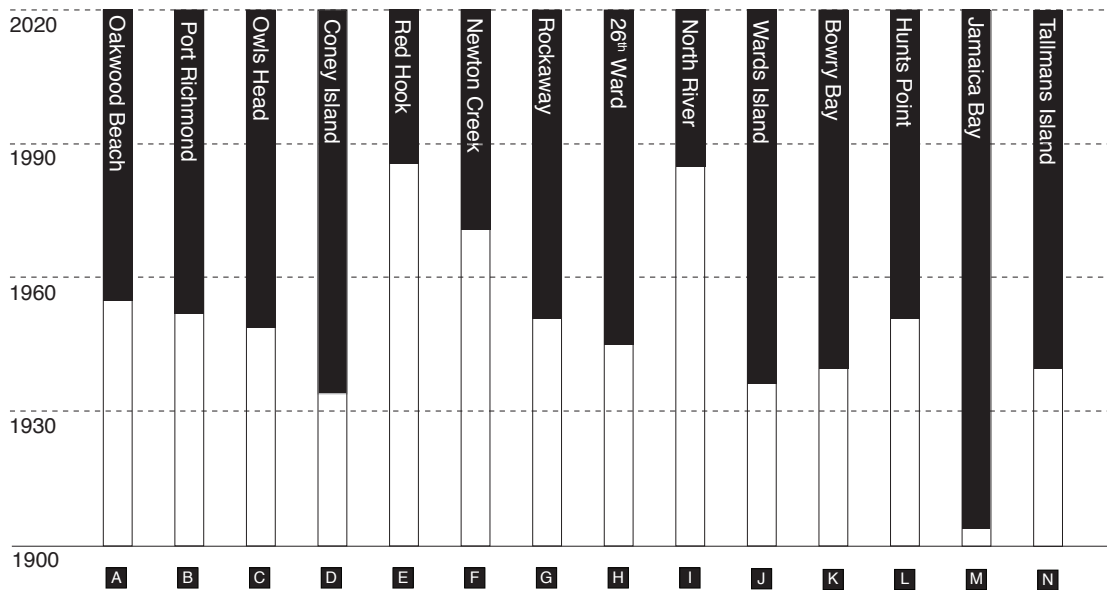


Fig. 2.6 Graph illustrating the age of New York City's wastewater treatment facilities. This graph indicates that 11 of the city's 14 facilities are operating beyond their useful service life of 60 years.

The affects of increased precipitation have also been amplified by the increased development of paved areas throughout the city. From 1984 to 2002 alone, 9000 acres of trees, bushes, and vegetative cover were replaced with buildings and water-impermeable landscapes leaving approximately 243 million gallons of storm water -- which would have otherwise been absorbed -- to enter the city's sewers.⁵ Finally, to make both of these matters worse, a large percentage of the city's wastewater infrastructure -- most of which was constructed more than a century ago -- has begun to exceed its useful service life and is simply incapable of mananging larger volumes of effluent. Evidence of

⁵ DePalma, Anthony. The New York Times. *When It Rains*. <http://www.nytimes.com/2007/08/11/nyregion/11drain.html?_r=1&>.

this is provided by Figure 2.5 which identifies the city's lowest performing sewersheds to be those comprised of its oldest sewers and wastewater treatment facilities.

While increased precipitation, a loss of urban vegetation, and aging infrastructure have all increased the frequency C.S.O. events throughout the last two decades, the city's reluctance to address these matters by upgrading its sewer system suggests that the larger underlying cause of sewer overflow is in fact neglect. Like much of North America's infrastructure, New York City's sewer system has been deferred regular maintenance and upgrades for decades which has had a profound effect on its operational performance and even

propelled it into a state of decay. This decay has not only resulted in an overwhelming number of overflows, backups, and leaks throughout the five boroughs but has also triggered a number of severe infrastructural failures in recent years. One of these occurred in June of 2011 when the city's North River wastewater treatment facility caught fire and discharged millions of gallons of untreated sewage into the Hudson River for two days while repair crews struggled to get the plant back online. The fire was caused by a loose nut which would have been repaired if the regular maintenance inspections were being conducted.⁶

A second major incident occurred exactly one
⁶ New York Times. *Fire at N.Y. Sewage Plant Linked to a Single Nut*. <<http://cityroom.blogs.nytimes.com/2011/11/01/fire-at-sewage-plant-may-be-linked-to-a-single-nut/>>.

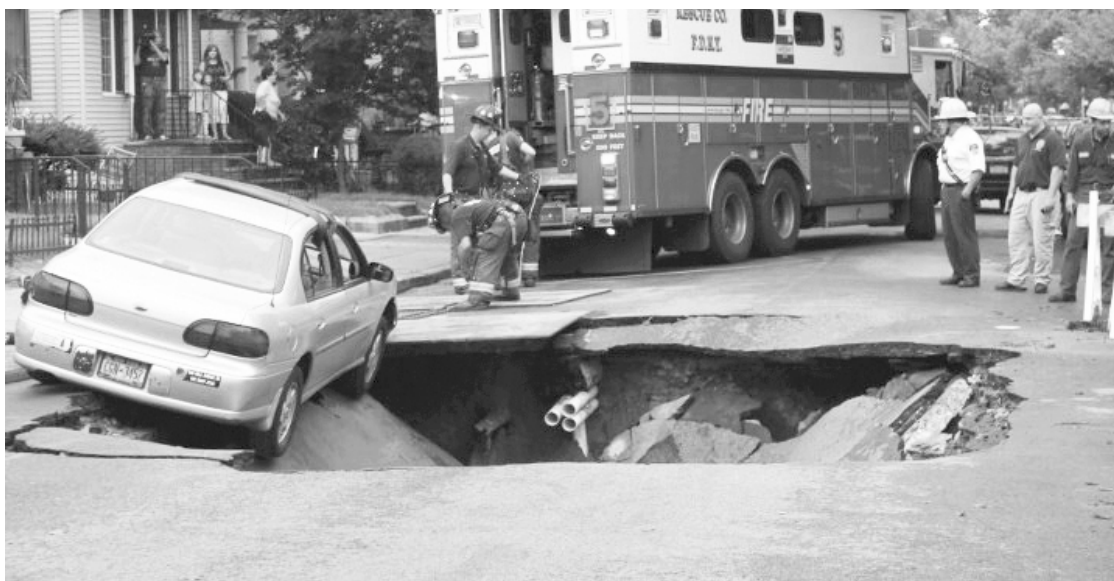


Fig. 2.7 A sinkhole on 79th Street in Bay Ridge, Brooklyn caused by a broken sewer main floating W.T.R. Park. This image depicts the consequences of the city's failure to manage the condition of its sewer system proactively.

year later in suburban Brooklyn when a residential street collapsed to reveal a 70-foot deep sinkhole created by a broken sewer main below. The main was more than a century old and had not been inspected in years.⁷ While events such as these are isolated, they provide evidence of the decay that has precipitated throughout the city as a result of neglect. So how is it that one of the great marvels of modern engineering has been left to crumble before the very people it has been constructed to serve?

The ubiquitous decay of New York City's sewage network is the consequence of a massive de-investment in sanitary infrastructure which has

⁷ CBS New York. *70-Foot Deep Sinkhole Unleashes Brutal Smell On Bay Ridge*. <<http://newyork.cbslocal.com/2012/09/14/70-foot-deep-sinkhole-unleashes-brutal-smell-on-bay-ridge/>>.

occurred over the course the last two decades. When the majority of the city's sewers and wastewater treatment facilities were constructed in the first half of the 20th century, federal grants covered 55 or 75 percent of the total cost of replacing, repairing, and upgrading sanitary infrastructure. These funds were also matched by an additional 12.5 or 30 percent by the New York State government, leaving the city responsible for financing as little as 12.5 or 15 percent of its infrastructural needs. In 1990 federal grant programs for the construction of wastewater infrastructure were cancelled and since then, the amount of annual government funding provided for sewers and treatment facilities

has been decreased by as much as 70 percent.⁸

With little federal and state assistance, the financial burden of maintaining and upgrading wastewater infrastructure has been placed upon local municipalities leaving New York City with the responsibility of funding its own infrastructural needs. While this change in financial structure was intended to decentralize the management of America's infrastructure, it came at a time when much of the city's century-old wastewater infrastructure was nearing the end of its useful service life. In addition, growing populations coupled with an increasing annual precipitation rate dramatically increased the demand for upgrades

⁸ New York State Department of Environmental Conservation. *Wastewater Infrastructure Needs of New York State*. <http://www.dec.ny.gov/docs/water_pdf/infrastructure rpt.pdf>.

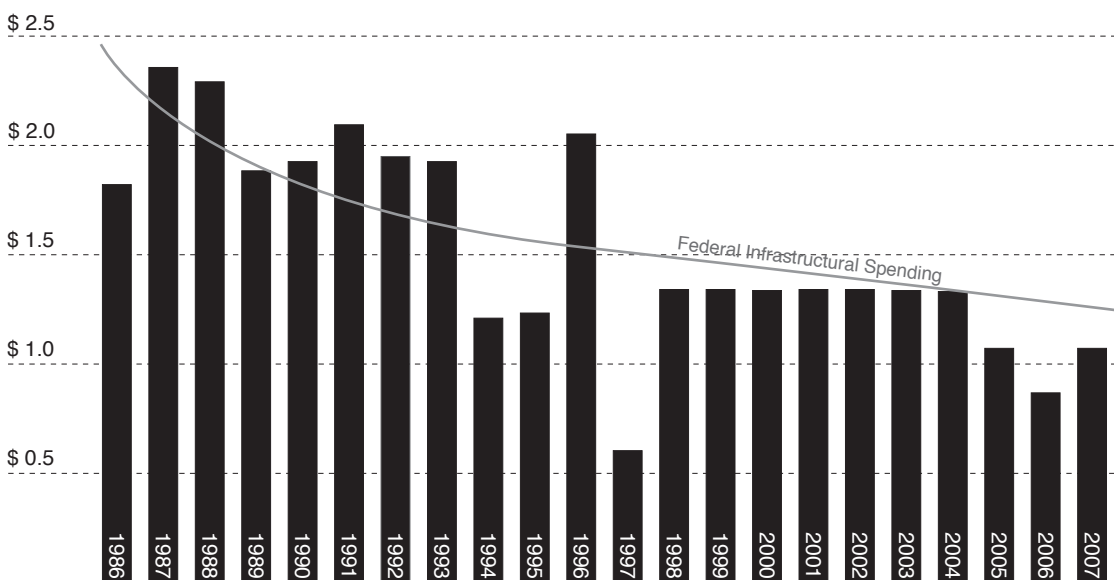


Fig. 2.8 Bar graph completed by the New York State Department of Environmental Conservation indicating the decrease in federal and state grant funding for wastewater infrastructure over the past 20 years.

and repairs. With an extensive list of needs, the city’s expansive sewage network -- comprised of industrial machinery, complex electronic systems, and immense subterranean structures -- became far too capital intensive for New York’s limited municipal budgets to afford. Though sewer rates were raised during this time to finance regular renovations and repairs, much of that money has been committed to operating costs which have been steadily increasing throughout the last two decades due to a growing reliance on energy-intensive wastewater management systems. With no way of generating enough revenue to finance the renovation and repair of the city’s antiquated sewage system, politicians have turned

to increasing municipal taxes and spending public money that would ordinarily fund alternative public works projects on wastewater infrastructure.⁹ Garnering taxpayer support to do so, however, has proven immensely challenging. As former New York City Mayor Ed Koch once said, “It’s hard to have a ribbon-cutting ceremony for a new sewer... People would rather you opened schools, libraries, and parks.”¹⁰ Columbia University’s Professor of Urban Development Kate Ascher makes a similar observation writing,

“[Infrastructure] is simply not something

9 New York State Department of Environmental Conservation. *Wastewater Infrastructure Needs of New York State*. <http://www.dec.ny.gov/docs/water_pdf/infrastructure.rpt.pdf>.

10 Pileggi, Nicholas. *Wounded City*. New York Magazine 2 Nov. 1981: 27-31. Print.

that voters want badly. When given a choice between investing in schools, health and housing or investing in sewers, tunnels or roads, the latter will always lose out.”¹¹

The widespread public reluctance to pay for infrastructure stems from a number of social, economic, cultural, and political factors which are all directly related to the form and performance of the conventional urban sewage network. Unlike other publicly funded services of the city, the collection and treatment of sewage is carried out underground and at the periphery of the city behind locked gates where the condition of the city’s sewer system is invisible to the public

11 Ascher, Kate. CNN.com. *New York’s Neglected Infrastructure Fails*. <<http://www.cnn.com/2012/11/02/opinion/ascher-new-york-infrastructure/index.html>>.



Fig. 2.9 Aerial photograph of New York City's Newton Creek Water Pollution Control Plant illustrating the unpleasant and uninhabitable urban spaces that have been created by the need to facilitate heavily industrialized wastewater treatment processes.

eye. This results in New York residents being unaware of the critical role regular maintenance and upgrades play in protecting the environment and their health. As New York state official Peter Baynes has said, “There’s no appetite for residents to pay for it because they really don’t understand what it entails.”¹²

The lack of public interest in maintaining their sewer system is, of course, perpetuated by the fact that the benefits of long-term infrastructural renovations and repairs are neither direct, immediate, observable or tangible and as a result, the public often questions the value of this investment, and where their money is being spent.

¹² Campbell, John. *Watchdog Report: New York's water, sewer systems need \$75 billion for repairs 'invisible' to taxpayers.* <<http://rocdocs.democratandchronicle.com/delegates/article/76621>>.

While the city’s wastewater treatment facilities are a visible manifestation of the public’s tax dollars at work, they contribute very little to the public sphere and in most cases they are perceived to be a detriment to the city because of their appearance and the foul odours they emit. For all of these reasons, taxpayers have been more inclined to vote in favour of political platforms that endorse the development of alternative public works projects that catalyze a larger and more visible public benefit.

For all of the reasons, politicians have been unable to persuade the public to manage the city’s sewage network pro-actively and consequently, its long-term care has been deferred for long

periods of time until the need for renovations and repairs has become visibly evident and the city has saved enough money to finance them. As city officials have come to understand, “These issues are difficult because there isn’t interest in them unless there’s a sewage spill in the Hudson or dead fish floating in the Sound.”¹³ These retroactive development strategies have proven increasingly ineffective at addressing the city’s growing needs for wastewater infrastructure during the last two decades. As a result, combined sewer overflow events have become more frequent. Fast-forward to 2012 and these trends have continued and years of infrastructural spending deficits have

¹³ Campbell, John. *Watchdog Report: New York's water, sewer systems need \$75 billion for repairs 'invisible' to taxpayers.* <<http://rocdocs.democratandchronicle.com/delegates/article/76621>>.



Fig. 2.10 *Overtaxed sewers spilling untreated effluent into New York City's East River through combined sewer outfalls.*



Fig. 2.11 *Overtaxed sewers in midtown Manhattan backup through a manhole spilling untreated sewage into the streets.*

culminated in an extreme financial crises. As Peter Baynes says, “Just to perform the day-to-day municipal tasks is a huge fiscal challenge, but then when you add capital infrastructure costs for water and sewer -- which are very big-ticket projects -- it’s hard to imagine where the money is going to come from.”¹⁴

While recent efforts to address these particular matters have been predominantly focused on finding alternative sources of funding for the city’s sewage system, there has been very little consideration given to the prospect of re-evaluating the century-old conventions of infrastructural development which are inherently

¹⁴ Campbell, John. *Watchdog Report: New York's water, sewer systems need \$75 billion for repairs 'invisible' to taxpayers.* <<http://rocdocs.democratandchronicle.com/delegates/article/76621>>.

problematic. As the presented evidence shows, the shift in funding for wastewater infrastructure from federal grants to public taxes has rendered conventional wastewater management practices financially unsustainable. Not only are New York City’s annual municipal budgets too meagre to adequately finance the renovation and repair of its capital-intensive sewage network, but New Yorkers are unwilling to pay for costly long-term infrastructural projects which have no visible or immediate benefits. With an estimated \$16 billion of infrastructural needs to be financed throughout the next two decades, and no reliable source of federal funding for wastewater infrastructure, politicians will continue to rely upon public

taxes as a primary source of capital to finance the maintenance of the city’s expansive sewage network. Consequently, improving and preserving water quality within the New York Harbor will depend entirely on the city’s capacity to address the larger social and economic issues related to the long-term neglect of the city’s sewage system. To do so, efforts must be made to re-evaluate the form and performance of standardized, single-service, shovel-ready infrastructure in favour of constructing a new generation of public works that can be sustained by smaller municipal budgets and attract long-term investment by catalyzing a much greater and more visible public benefit. How then might this be accomplished?





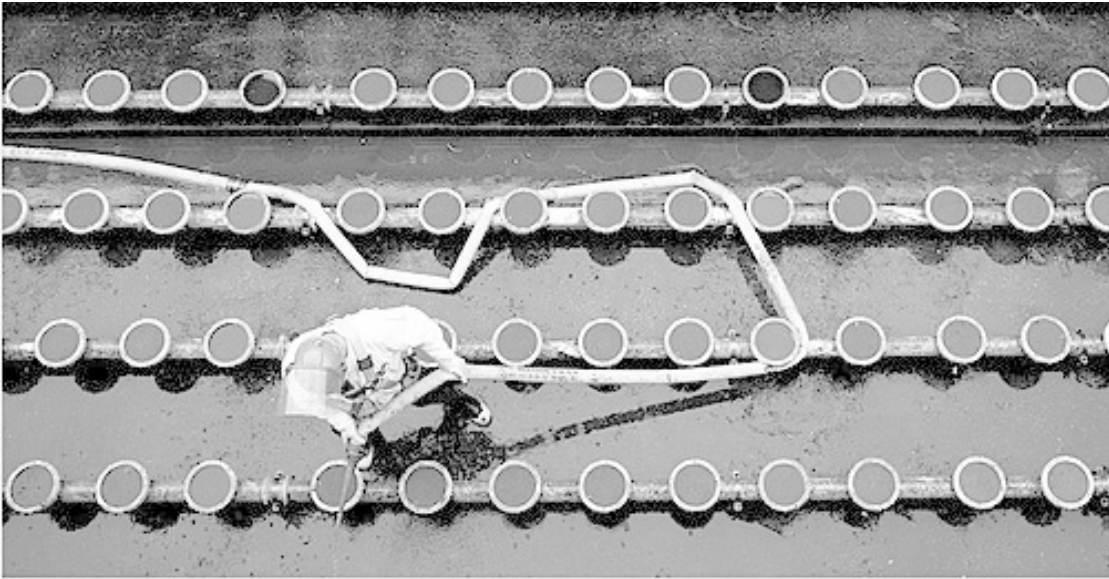


Fig. 3.0 *View from the public promenade on the northwestern edge of the Gowanus Canal looking over the floating W.T.R. Park.*

3.0 Redefining Public Works

“Incidents such as bridge collapses, dyke failures, levee breaks, coastal flooding, power outages, water shortages, road cave-ins, decaying sewers, and deferred maintenance, when considered together, provide evidence of the limited capacity of conventional infrastructure to deal with the complex challenges of mass urbanization.”¹

Pierre Belanger, 2009

As Pierre Belanger’s statement suggests, the long-term decay of New York City’s sewage network is not an isolated event but rather part of a widespread problem which cities throughout

North America are beginning to confront. When the majority of North America’s infrastructure was built more than a century ago, it was designed to sustain urbanization in dense centres of mass production where populations were concentrated, resources were abundant and technical efficiency was favoured overall. In a post-industrial era characterized by sprawling land development, mounting environmental concerns, and the rapid depletion of natural resources, conventional infrastructural models have become too complex to manage, too large to renovate, too energy-intensive to operate, and too costly to build or repair. As the resultant failure of infrastructure suggests, the change in the way we inhabit our contemporary

¹ Belanger, Pierre. *Landscape as Infrastructure*. *Landscape Journal* 28 (2009): 79-95. Print.



Fig. 3.1 *Workers replacing damaged pumps at the Bay Park wastewater treatment facility in East Rockaway, New York.*

cities now requires a change in the way we develop the infrastructure that services them. Our urban environments are shaped by complex, social, political, economic, and environmental conditions, and therefore it is no longer possible to rely on the conventional techno-centric model of infrastructural design.

In the wake of this realization, a new generation of architects, engineers, urban planners, ecologists, scientists, and inventors have emerged, and begun to challenge the 20th century conventions of infrastructural development by inventing new, more resilient systems that confront issues of financial sustainability, public interest, and neglect to underpin the next era of urban revitalization.

Inspired by this movement the following chapter draws from the ideas of these contemporaries, to generate a series of strategies for addressing social, economical, political, and environmental concerns through the design of infrastructure. These strategies are then assembled under the banners of five principles -- decentralization, integration, productivity, legibility, and multifunctionality -- which challenge the next generation of wastewater infrastructure to perform socially, ecologically, and economically to address the complex challenges New York City faces in developing its Sixth Borough. The investigation of each principle is accompanied by analyses of past, present and future precedents which best exemplify the outlined

theories and have the most potential to affect change. The intention is to not only illustrate the potential for wastewater infrastructure to operate in excess of its prescribed function, but to provide insight into ways the city's seemingly pragmatic network of conduit, pumping stations, reservoirs, and treatment facilities can be formatted to do so. While the embodied research is primarily focused on sanitary infrastructure, it should be noted that the principles themselves are intended to apply to all types of infrastructure. Ultimately, the intention of the principles is to provide grounds for an expanded understanding of infrastructure as a vital instrument of contemporary urban design.

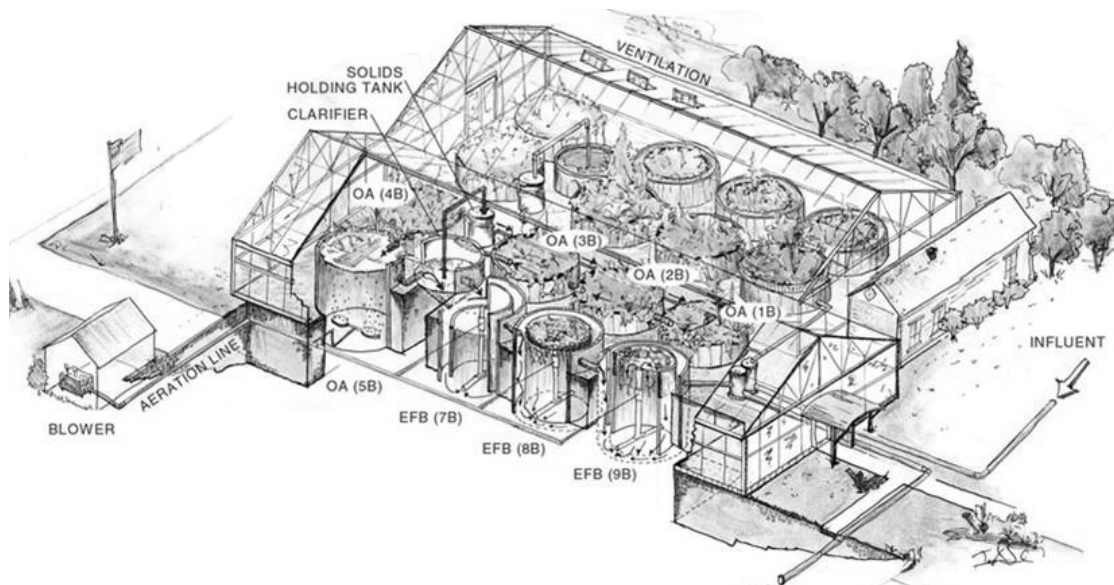


Fig. 3.2 One of John Todd's "Living Machines" constructed in Burlington, Vermont. This modest 720 square meter facility processes 80 000 gallons of effluent per day using a series of constructed ecosystems that mimic the cleaning functions of natural wetlands.

"This moment in history demands a reconsideration of the conventional, centralized... practice of infrastructure... that has overshadowed the landscape of bio-physical systems as a decentralized infrastructure..."²

Pierre Belanger, 2009

[Decentralized] While centralizing the basic provisions of food, water, waste, energy, and transportation was an efficient way to sustain urbanization in dense cities of the 19th century, this model of infrastructural development has proven to be slow, inflexible, costly, and ineffective in contemporary urban environments defined by

rapid land development and urban sprawl. As the implications of this unsustainable paradigm of infrastructural development have become increasingly evident throughout the last decade, alternatives have emerged and now there is a growing awareness that the most effective way to respond to the spatial decentralization of the North American city, is to decentralize infrastructure itself.

In the context of the Sixth Borough, this would have a number of economic benefits which would allow the city to address the fiscal challenges it faces in rebuilding its antiquated sewage network. As a system of smaller, less costly, and quick-to-build components, a decentralized network of

infrastructure can be upgraded on an as-needed basis, which avoids the large upfront capital costs of renovating a conventional municipal sewage network.³ This eliminates the need to finance upgrades with loans which not only frees the city of long-term debt but allows municipal funds to be spent on more infrastructure instead of accumulated interest. This also decreases the long-term planning associated with upgrades which would allow the city to expand its sewage network more rapidly in response to unpredictable changes in population and ensures that the city's needs for added capacity are more closely matched to its growth.

² Belanger, Pierre. *Landscape as Infrastructure*. *Landscape Journal* 28 (2009): 79-95.

³ Geoflow. *Decentralized Wastewater Treatment Can Be Cost Effective and Economical*. <<http://www.geoflow.com/EPA%20Decentralized%20MOU/EPA%20Decentralized%20MOU%202012.pdf>>.



Fig. 3.3 A site plan of Jonah Humphrey's *Landscape* illustrates the deployment of buoyant, decentralized living machines in Hamilton Ontario's harbour. These clusters intercept sewer overflow by plugging into the city's existing sewer grid.

By dividing the total volume of effluent that the region produces among a number of smaller treatment facilities, the city would no longer need to rely on expensive, industrialized machinery to process effluent. Instead, alternative wastewater management technologies could be used which are less complex, more affordable, and ultimately more sustainable. New York City's massive centralized facilities could be supplemented by smaller, less complex systems like in South Burlington Vermont where a portion of municipal effluent is treated in two small green-houses by a series of constructed wetlands.⁴ Similarly, costly underground reservoirs could be replaced with

⁴ Todd, John. University of Vermont. *Ecological Design Applied*. <http://fenraft.uvm.edu/gjee/pubpdfs/Todd_2003_Ecological_Engineering.pdf>.

gardens or bioswales distributed along city streets to absorb and store stormwater.

Decentralizing wastewater infrastructure would also have a number of social benefits that would allow the city to generate greater public interest in renovating and repairing its sewage network. With the collection and treatment of wastewater executed in a smaller more localised radius, taxpayers would have a greater connection with the infrastructure that serves them. Living in close proximity to these systems New Yorkers would be able to see exactly where their money is being spent and how it benefits them directly. Neighbourhoods could be charged with maintaining their own networks and local

residents would be imparted with a proprietary obligation to maintain them.

While decentralization is a radically different approach to urban wastewater management, it is important to keep in mind that this is not an alternative to existing centralized sanitation but rather a complementary system which can increase the capacity, resiliency and overall economic performance of the city's existing sewage system. With this understanding of Consequently, designers will need to find ways of incorporating these networks into the existing grid. With hundreds of combined sewer outfalls distributed along the waterfront there is great potential for this integration to be seamless.

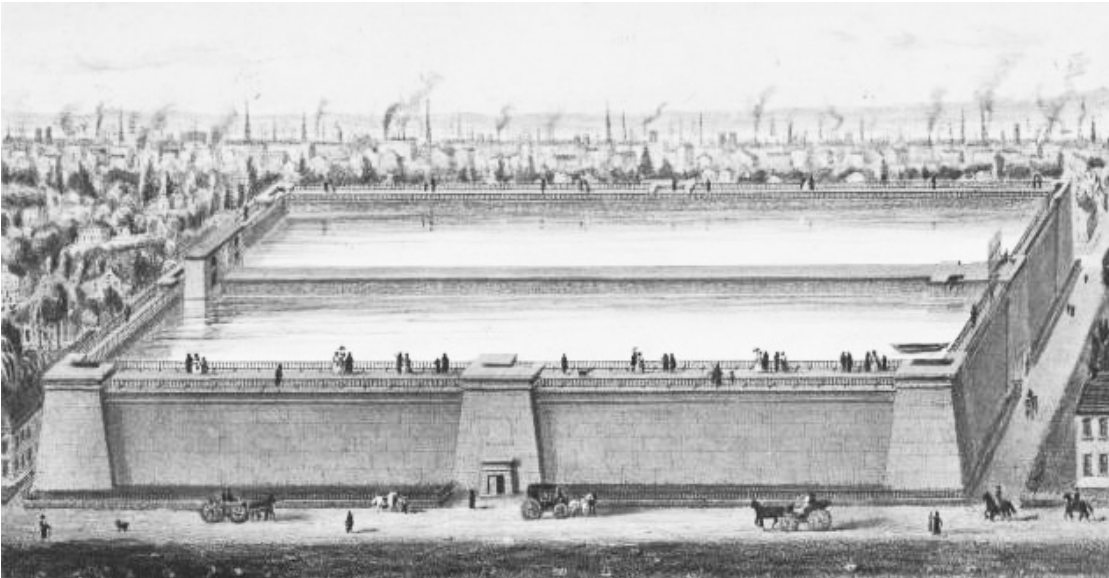


Fig. 3.4 A print of the Murray Hill Reservoir completed in mid 19th century demonstrates how the infrastructure was integrated into the city through its architectural design and its ability to function as an inhabitable public space.

“In the course of the 20th century we have seen the increasing standardization of infrastructural systems as they meet higher standards of technical efficiency. These ubiquitous urban environments have been considered and evaluated solely on technical criteria and somehow exempted from having to function socially, aesthetically, or ecologically.”⁵

Elizabeth Mossop, 2006

[Integrated] Though the construction, maintenance, and operation of infrastructure is primarily funded with public tax dollars, very little of it has been formatted to make any kind of

⁵ Mossop, Elizabeth . *Landscapes of Infrastructure*. The Landscape Urbanism Reader . New York: Princeton Architectural Press, 2006. 163-176. Print.

meaningful contribution to the social or aesthetic character of the urban public realm. Instead, the last era of infrastructural development has littered the urban landscape with countless standardized, single-service utilities that are neither inhabitable, beautiful, or ecologically sensitive. This unfortunate legacy has rendered most infrastructure an unaccepted element of the city and decreased its significance and value in the eyes of taxpayers who are responsible for its long-term care. If the next generation of infrastructure is to attract public investment, then it must be designed as an integrate element of the city. This re-examination of infrastructural space not only requires that it be designed to enhance the aesthetic character

of the city but also formatted to be inhabited in a meaningful way. As Elizabeth Mossop suggest, this involves a “recognition that all types of space are valuable, not just the privileged spaces of more traditional parks and squares...”⁶ With this in mind, infrastructural space in the Sixth Borough must be designed and conceived of as public space.

The potential for New York City’s hydrologic infrastructure to be formatted in this manner is exhibited in the “Murray Hill Reservoir” constructed 1842 to store the city’s drinking water. Integrated as part of the dense urban fabric of 19th century Manhattan, the four acre, 20 000 000 gallon above-ground storage tank was designed as a

⁶ Mossop, Elizabeth . *Landscapes of Infrastructure*. The Landscape Urbanism Reader . New York: Princeton Architectural Press, 2006. 163-176. Print.



Fig. 3.5 An aerial photograph of New York City's North River Wastewater Treatment Facility illustrates how the infrastructure was made an accessible and integrated element of Manhattan's public waterfront by its ability to function as a public park.

public park and celebrated as one of the city's most valued urban spaces.⁷ The structure's 15-metre-tall perimeter walls were made of polished granite and acted as an edifice for architectural expression giving the reservoir a facade with depth, scale, and architectonic elements which allowed it to relate to its urban context while providing a favourable surface for ivy to grow. The thick walls were also hollow, and enclosed an interior circulation space where a number of public stairs provided access to a promenade located on top of the structure. The elevated walkway became a fashionable destination for strolling on Sunday afternoons where New Yorkers flocked to escape the dark and crowded

⁷ Daytonian in Manhattan. *The Lost Egyptian Revival Croton Reservoir*. <<http://daytoninmanhattan.blogspot.ca/2011/11/lost-egyptian-revival-croton-reservoir.html>>

streets, and take in unobstructed panoramic views of the surrounding rooftops and harbour.

A more contemporary example of an integrated wastewater infrastructure is the city's North River Water Pollution Control Facility. Constructed on the banks of the Hudson River in the upper west side of Manhattan, the roof of the 28-acre wastewater treatment facility boasts New York City's Riverbank State Park, a popular recreational facility with three swimming pools, an amphitheatre, an athletic centre, a skating rink, a restaurant and sports fields.⁸ As an integrated element of the public waterfront the facility not only serves the adjacent residential communities

⁸ New York City Department of Environmental Protection. *North River Wastewater Treatment Plant*. <<http://www.nyc.gov/html/dep/html/wastewater/northri.shtml>>

as an amenity but also contributes aesthetically by containing its industrial components and the noxious odours of untreated sewage within a concrete envelope of arches making a conventional water treatment facility into a more valued element of the urban landscape.

Should the next generation of wastewater infrastructure be designed with the principle of integration in mind, urban designers will be able to explore the need to repair New York City's antiquated sewage network as an opportunity to enrich the Sixth Borough socially and architecturally and large infrastructural budgets could be used to transform the waterfront on a scale never imagined.

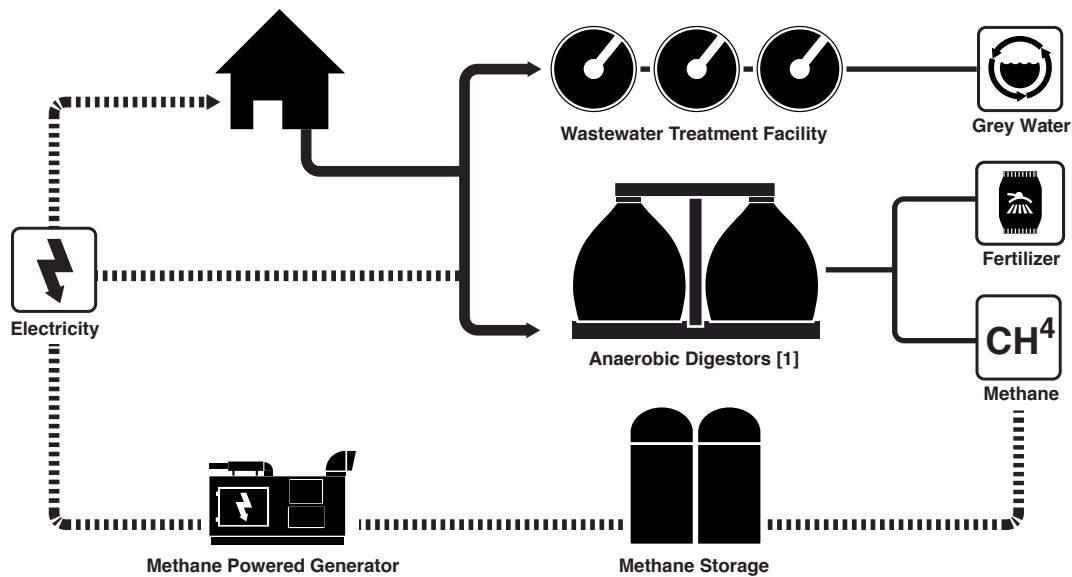


Fig. 3.6 A process diagram for New York City's Newton Creek Wastewater Treatment Facility demonstrates how anaerobic digestion can convert sewage into valuable resources that can be sold or reused to offset maintenance and operation costs.

“Infrastructure is an untapped resource that could be productive as well as service-oriented.”⁹

Dana Cuff, 2010

[Productive] Though the construction, operation, maintenance, and renovation of public works consumes municipal tax dollars and valuable resources, conventional infrastructural networks generate very little capital to subsidize their long-term costs or to replenish the valuable resources they deplete. For these reasons, financing infrastructure has become an enormous burden that tax payers have been reluctant to bear

and cities can no longer afford. As the collective systems which are responsible for distributing and managing the resources that make urban culture possible, infrastructure has enormous potential to give back to the city and the public sphere by generating new resources that could be sold or reused to offset operation and maintenance expenses or supplement the use of energy altogether. In order to tap into this potential the next generation of infrastructure must be formatted to be productive.

When considering the application of the principle in the design of a sewage system, the emergence of alternative wastewater treatment technologies provides opportunities to re-position urban sewage as one of the largest untapped

sources of fresh water, nutrients, and energy, in the contemporary city. This new understanding of sewage provides a number of opportunities for New York City to address the fiscal challenges it faces in financing its sewage system to sustain its Sixth Borough. Evidence of this potential is provided by New York City's own Newton Creek Water Pollution Control Plant which achieves lower operational costs and generates a long-term income by producing electricity and fertilizer.¹⁰ The facility does this by using large egg-shaped vessels known as anaerobic digestors to catalyze the natural decomposition of sewage into water, organic matter, and biogas. While the organic matter that settles

⁹ Cuff, Dana. *Architecture as Public Work. Infrastructure As Architecture*. Berlin: Jovis, 2010. 18-26. Print.

¹⁰ Water-technology.net. *Newton Creek Water Pollution Control Plant*. <<http://www.water-technology.net/projects/newtown/>>.

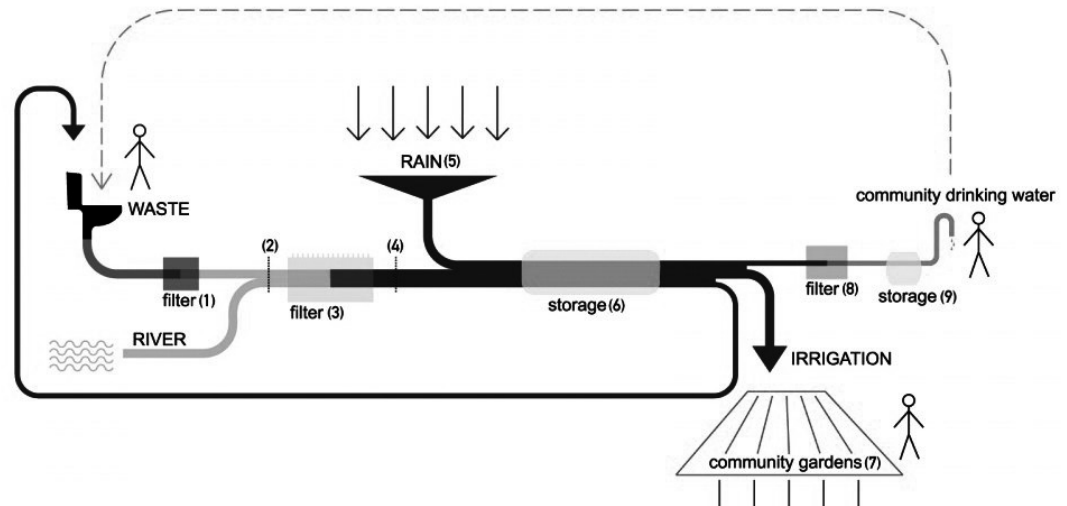


Fig. 3.7 A process diagram for the Emscher River Community Garden in Sturmshfo, Germany demonstrates how black water from a local canal and public washrooms is converted into clean water for irrigation, recreation, and drinkinking.

at the bottom of the digester is extracted, dried, baked into nutrient rich pellets, and sold for food production, the biogas collected at the top of the vessel is re-used as fuel for generators that power the facility. This not only allows for a closed-loop model of wastewater management, but makes for self-sustaining infrastructure that pays for itself.

In addition to subsidizing public expenditure, a productive sewage network also has a greater capacity to attract long-term public investment in the city's sewage system by catalyzing a more tangible and visible public benefit. This might be accomplished by configuring infrastructure so that the resources it generates can be used directly by the public or to

transform the urban landscape in a positive way. Infrastructure's capacity to be formatted in this manner is demonstrated by the Emscher River Community Garden in Germany which facilitates the re-use of the black water it treats to benefit the local community and generate public interest in wastewater management. To do so, infrastructural components for purifying effluent are integrated with public amenities such as gardens, washrooms, splash pads, and a drinking fountain which provide a means of displaying sewage and the infrastructure that manages it as an asset. By formatting the next generation of wastewater infrastructure in this way, the next era of infrastructural spending could be leveraged through a larger contribution to

the city and public sphere. Wastewater treatment facilities could be the city's future water parks.

While a productive infrastructure could address the financial challenges New York City faces in sustaining water quality, its ultimate potential would be its capacity to catalyze the emergence of new water-based economies needed to transform the post-industrial waterfront into a new borough where New Yorkers can work. In fact the Sixth Borough could be conceived of as a new self-sustaining region that is underpinned by industries that thrive from the purification of sewage. With a renewable resource as abundant as sewage the possibilities are endless.

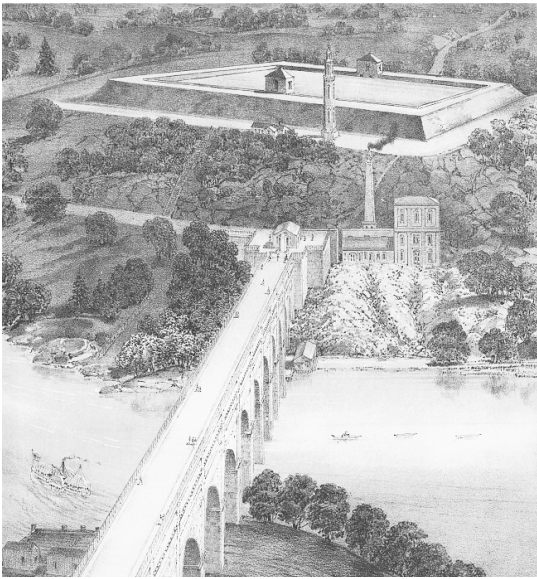


Fig. 3.8 *New York City's legible Croton Waterworks comprised of aqueducts, open reservoirs, and water towers.*



Fig. 3.9 *The iconic anaerobic digestors of the New York City's Newton Creek Wastewater Treatment Facility.*

“Designers have most often been charged with hiding, screening and cosmetically mitigating infrastructure.... They are rarely asked to consider infrastructure as an opportunity, as a fundamental component of urban and regional form.”¹¹

Gary L. Strang, 1996

[Legible] Though infrastructure is arguably the most fundamental element of the contemporary city, the majority of it is buried underground, hidden behind screens or constructed at the periphery of the inhabited urban realm where its function and condition are invisible. This has not only multiplied the cost of its renovation and

repair, but has rendered it largely insignificant in the eyes of taxpayers who are neither aware of how or when it is operating to serve them. Considering that public awareness will be fundamental to the future stewardship of these systems, the next generation of infrastructure must be made legible so that the public is conscious of how and when these critical systems are operating to serve them. Such a re-examination of wastewater infrastructure necessitates a consideration for how the city's sewage network and its function might be expressed as a primary element of urban form.

The potential for hydrologic infrastructure to be formatted in this way is best exhibited by some of New York City's own pre-industrial

waterworks which traced the conveyance of water across the urban landscape by way of a monumental aqueduct and a series of water towers, open reservoirs, pump houses, and fountains. These iconic structures not only marked significant sources, paths, and points of transition in the city's water supply, but their distinct architectural form indicated the vital service they provided. While sewers may remain buried, their invisible courses and hidden outfalls should be indexed above ground to show the public where their waste is being conveyed. Similarly, wastewater treatment facilities should be given a unique appearance which denotes their function and location. Facilities may be formatted like Brooklyn's

¹¹ Strang, Gary L. *Infrastructure as Landscape*. Places 10.3 (1996): 10-15. Print.



Fig. 3.10 A photograph of the public viewing platform integrated into New York City's High Bridge Water Tower.

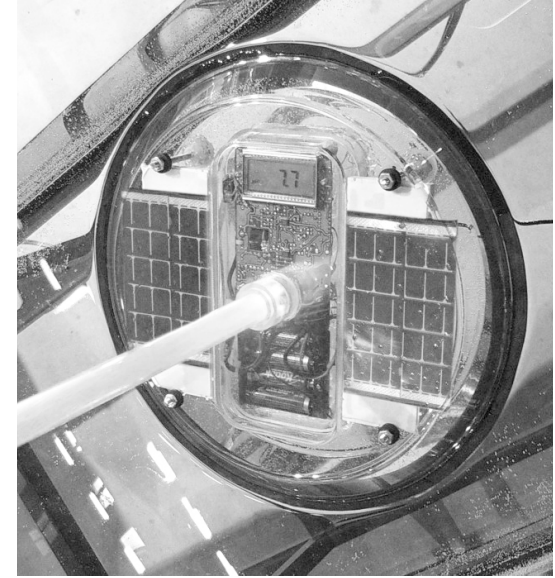


Fig. 3.11 A photograph of the PH sensor and LED light system developed by New York City Architecture firm "The Living."

Newton Creek Water Pollution Control Plant which proudly displays its eight sculptural sludge digestors as an iconic part of the urban skyline.

The storage and the treatment of wastewater should also be carried out in an open accessible landscape so that critical processes can be exhibited in a way that facilitates a greater public understanding of the systems at work. With the emergence of new landscape-based wastewater management systems this can easily be achieved. Other elements of the city's sewage network should be publicly accessible, as well. Future treatment facilities may be formatted like the city's High Bridge Water Tower which boasted a large public stair that provided access to a platform

where New Yorkers were permitted a closer look at the tower's exposed water tank as well as a bird's-eye view of an adjacent aqueduct and reservoir.¹² The tower not only generated long-term investment interest by engaging the public in a meaningful way, but it revealed the assembly of systems at various scales providing visitors with a greater understanding of its role.

Finally, New Yorkers should be made aware of when their sewer system is operating to serve them and when it is not so that the need for upgrades and repairs is easily identified by taxpayers. Since environmental conditions are the best indication of infrastructural performance, water

quality should be monitored regularly and relayed to the public. The city's sewage network may be outfitted with devices similar to those recently installed in the Hudson River by architects Soo-in Yang and David Benjamin which were equipped with sensors and LED lights to warn New Yorkers of changing pollution levels in local waters.¹³

With all of these strategies considered New York City's future sewage network could operate as a didactic public landscape which would inform New Yorkers of the role they play in sustaining the condition of their harbour and protecting their ability to enjoy local waterways as a recreational amenity.

¹² The Croton Waterworks. *High Bridge Tower*. <<https://crotonaqueduct.wordpress.com/field-notes/individual-structures/high-bridge-tower/>>.

¹³ Foreman, Eric J. *The Living – River Glow*. <<http://www.ericforeman.com/projects/river-glow/>>.



Fig. 3.12 A rendering of Raalf Steeg's *Spree 2011* project demonstrates how the buoyant C.S.O. reservoirs double as a floating public dock that facilitates a variety of public activities at the water's edge.

"Limited public budgets have often necessitated the standardization of infrastructure. "Multi-performative infrastructure -- where architects organize multiple functions in composite networks -- can produce long-term savings that avoid redundancy."¹⁴

Katrina Stoll & Scott Lloyd, 2010

[Multi-functional] Though the myriad of public works needed to sustain contemporary urbanization are interdependent, infrastructural design standards have dictated that they be separated into unrelated departments and formatted to provide only a single instrumental service.

This mono-functional approach to infrastructural design is proving to be unsustainable simply because municipal budgets are far too meagre to be adequately divided among distinct enterprises leaving vital public works underfunded. If separate infrastructural systems were instead combined into composite networks that provide many services, limited municipal funds could be pooled together to maximize the value of a single infrastructural investment and eliminate competition among different departments making it less likely for any one civic need to be neglected. In order to facilitate this hybridization of systems and capitalize on these potential benefits, the next generation of infrastructure must be multi-functional.

In the context of the Sixth Borough, formatting wastewater infrastructure in this way would not only be a more effective use of limited funds, but could also renew the public's interest in the city's sewage network as wastewater infrastructure would be integrated with other public works that catalyze a greater and more visible public benefit. Like New York City's five terrestrial boroughs, the Sixth Borough will require an extensive system of public works for the provision of food, water, energy, waste, transportation, and recreation. There are a number of synergies shared among all of these systems which makes their combination natural. For instance, wastewater treatment facilities are capable of

¹⁴ Stoll, Katrina, and Scott Lloyd. *Performance As Form. Infrastructure As Architecture*. Berlin: Jovis, 2010. 4-8. Print.



Fig. 3.13 Stormwater retention lagoons at Brooklyn Bridge Park double as public gardens and support local aquatic ecologies.

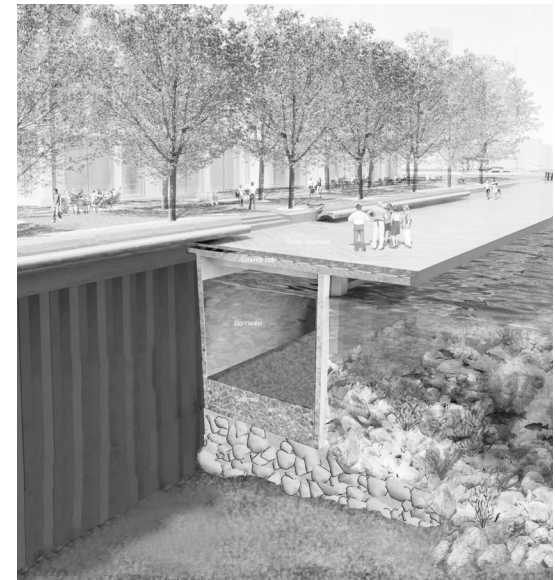


Fig. 3.14 A rendering of Toronto's new waterfront promenade coupled with a stormwater water conveyance system.

recycling domestic sewage into water, nutrients, organic matter, and bio-gas which would permit them to additionally function as fresh-water supply depots, urban farms, energy production plants, or urban water parks. The potential for this to be realized is illustrated by the Emscher River water treatment facility which reuses treated effluent to irrigate an integrated public garden and to recharge washrooms, a drinking fountain, and a splash pad.¹⁵

Similarly the Sixth Borough's waterfront parks may also be conceived as wastewater infrastructure and the city's effluent could be collected, stored, distributed, and treated in a landscape that also fulfills the city's need for

recreational space and ecological habitat. This has proven extremely successful in Brooklyn Bridge Park (Fig. 3.13) where combined sewer overflow is collected and distributed through a number of lagoons that sustain local species, clean effluent, and reuse it as irrigant for the park's public lawn.¹⁶

In addition, Public docks and piers could have integrated storage cisterns that collect and store combined sewer overflow like the project proposed for the Spree River in Berlin. In addition, Esplanades and paths might double as wastewater collection or distribution systems like the new promenade proposed for Toronto's waterfront

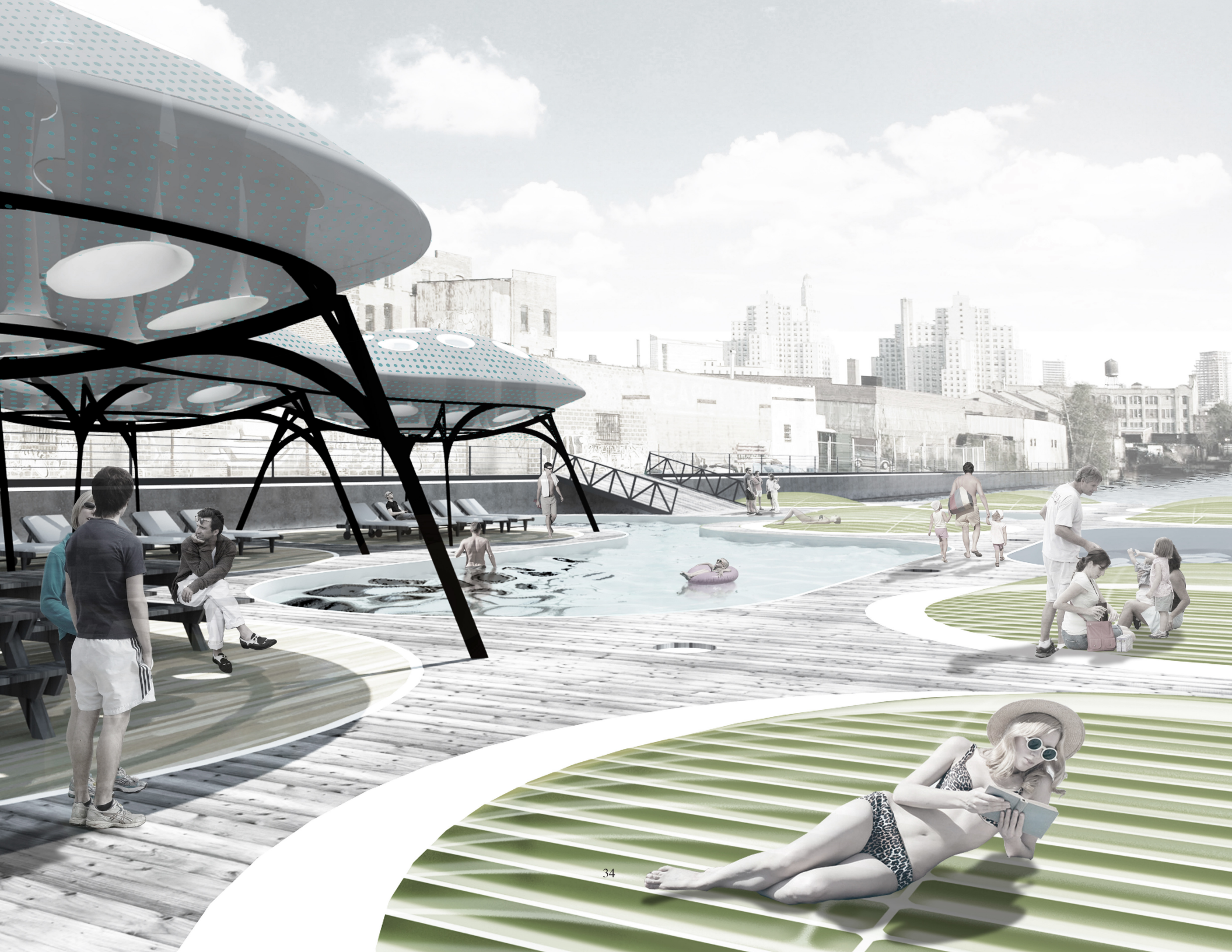
(Fig. 3.14) which doubles as an interceptor sewer for combined sewer overflow. These ideas can also be employed in open landscapes as planted bike lanes; or running paths could double as storm-water distribution networks.

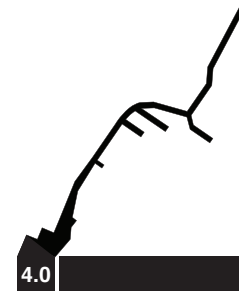
Ultimately, the combinations of possibility are endless and it is up to the next generation of designers to seek out opportunities for hybridization. As Jesse LeCavalier suggests, "With the expanded notion of infrastructure beyond the large technical systems of the past, there is even more potential to creatively combine, collide, repurpose, invent, or suggest new ways to inhabit, experience, or participate."¹⁷

¹⁵ Architecture View. *The Emscher Community Garden*. <<http://www.architecture-view.com/the-emscher-community-garden/>>.

¹⁶ Stormwater Management :: Brooklyn Bridge Park. *Brooklyn Bridge Park*. <<http://www.brooklynbridgeparknyc.org/sustainability/stormwater-management>>.

¹⁷ LeCavalier, Jesse. *Let's Infra-ecture*. Infrastructure As Architecture Berlin: Jovis, 2010. 4-8. Print.





Synthesis

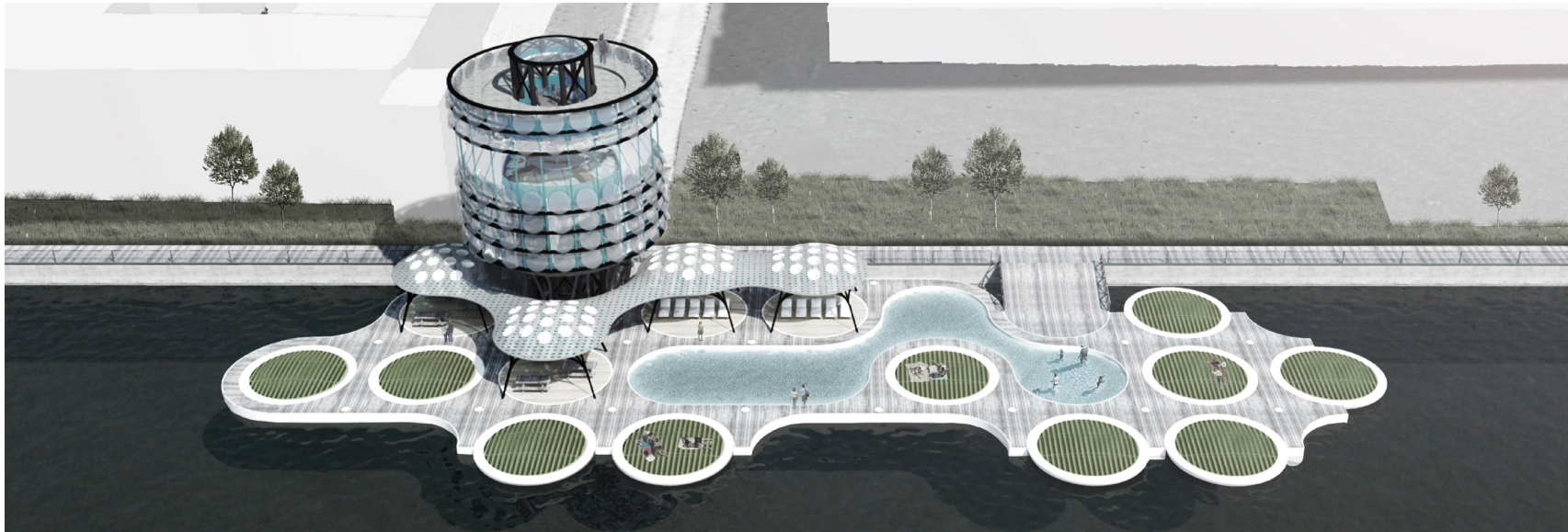


Fig. 4.0 A Bird's-eye view of a typical Wastewater-To-Resource park illustrates its integration into a typical waterfront site.

4.0

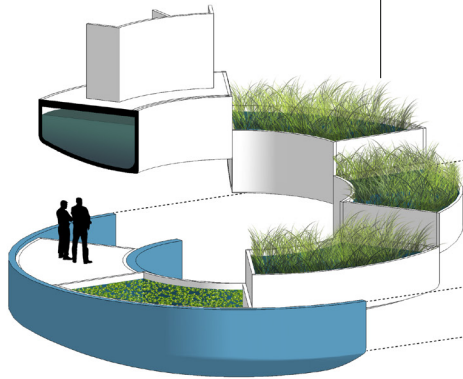
The W.T.R. Park

As the Bloomberg Administration looks to upgrade New York City's century-old sewer system to prevent billions of gallons of untreated effluent from spilling into the New York Harbor, it is critical that it invests in infrastructural alternatives that are not only more affordable, but capable of attracting long-term public investment. In recognition of the need for such an infrastructural system, the Wastewater-To-Resource (W.T.R.) Park is proposed. Part decentralized wastewater treatment facility and part high-performance public landscape, the W.T.R. Park is designed to intercept combined sewer overflow and convert it into fresh water, nutrients, and energy which it reuses to sustain recreational activities and new

water-based economies. In doing so the park not only operates to offset long-term maintenance and renovation costs, but aims to engage New Yorkers in the enterprise of urban wastewater management.

The W.T.R. Park system is comprised of various containers which function to facilitate the collection, storage, treatment, and re-use of combined sewer overflow. These containers come in various shapes and sizes, and are assembled within two structures, one being a tower and the other a floating grid of pontoons. These two structures provide a system of organization for the containers and allow them to be deployed within the harbour's waters where they operate as a legible extension of the city's combined sewer

Living Machine
Six different tanks retain effluent and filter it into nutrient-rich irrigant and potable water ideal for recreational and commercial reuse within the park.



Public Stair
An open stair provides public access to the Eco-machine and permits views of its inner workings and the floating landscape beyond.

Vertical Eco-machine
Part wastewater treatment facility and part water tower, the iconic Eco-machine cleans and re-distributes effluent within the W.T.R. Park.

Solar Facade
A productive facade comprised of pivoting solar dishes that track the sun's movement collect energy to power the W.T.R. Park.

Biogas Bladder
A latex bladder that doubles as a shade structure stores biogas yielded during the wastewater treatment process for reuse.

Overflow Storage
A buoyant receptacle that stores sewage below the surface of the water and provides a floating platform where public activities occur.

Anaerobic Digester
A tank at the bottom of the tower converts solid organic waste into water, carbon dioxide, and methane transforming waste into a resource.

Clean Water Reuse
Floating pods that plugged into the distribution grid facilitate the recreational and commercial reuse of filtered sewage within the harbour.

Distribution Pontoons
Buoyant pontoons distribute water, energy, and biogas throughout the W.T.R. Park and facilitate public activities within the harbour.

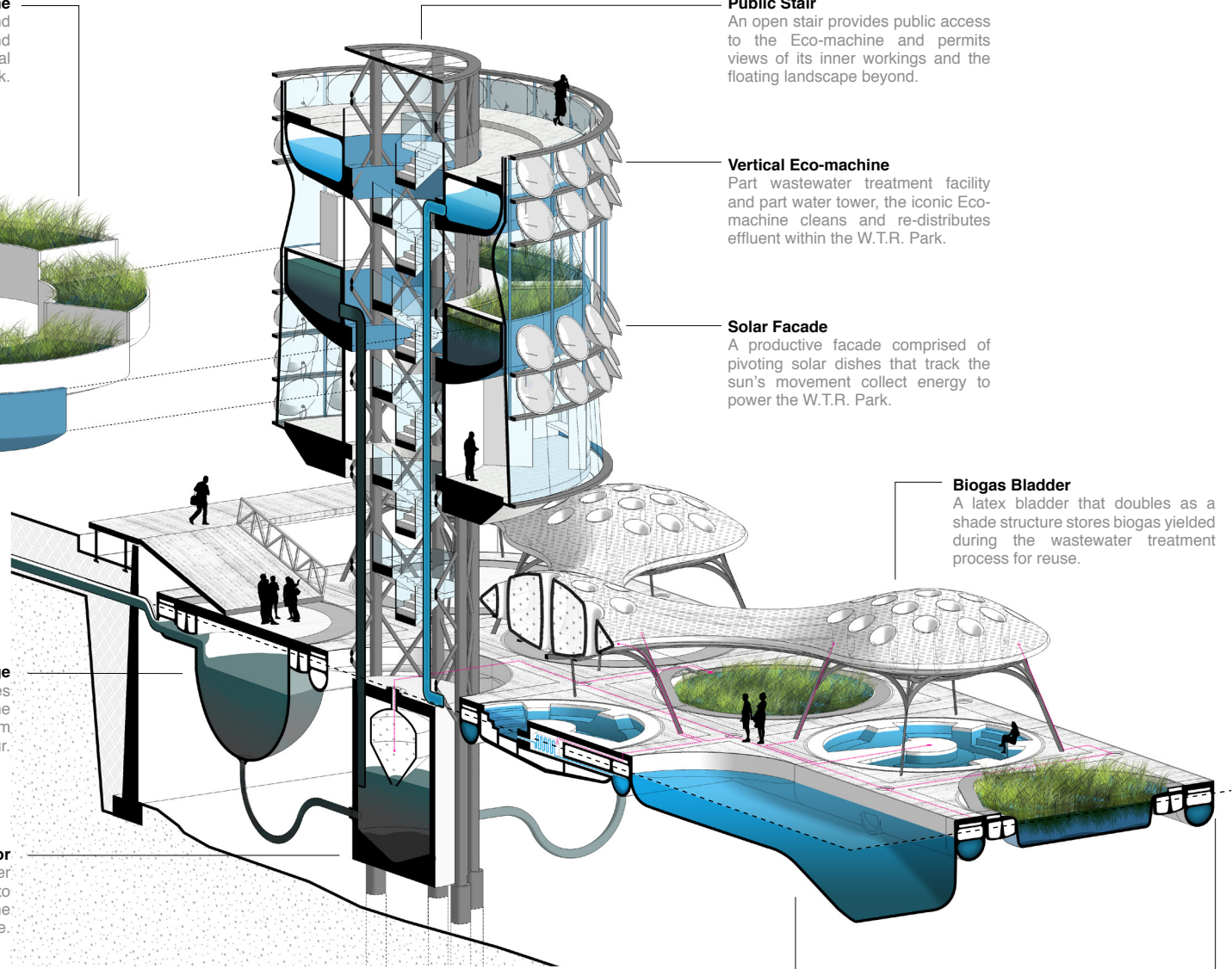


Fig. 4.1 A diagram illustrating the typical assembly of infrastructural systems integrated into a W.T.R. Park.

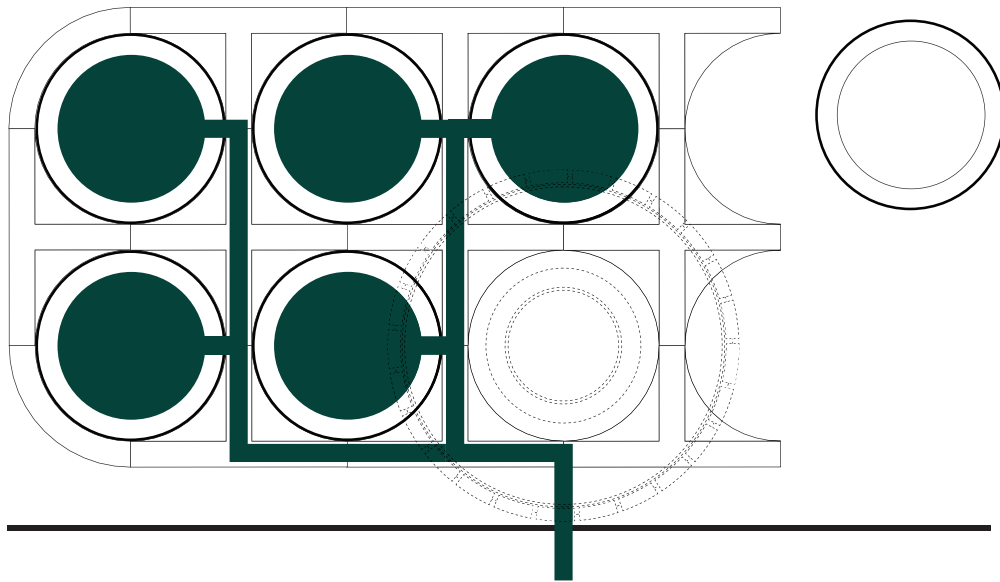


Fig. 4.2 A diagrammatic plan of the W.T.R. Park system illustrating the typical arrangement of overflow receptacles and how effluent is distributed among them during a combined sewer overflow event.

network. In addition to facilitating the aggregation of infrastructural components, the tower and the pontoon grid function respectively as a vertical stair and a network of floating pathways which permit circulation and provide access to the city's waterways. Together these structures allow the water-borne infrastructure to be occupied by the public.

Positioned along the shoreline the W.T.R. Park's primary function is to intercept combined sewer overflow. A flexible extension facilitates a seamless connection between the buoyant infrastructure and the city's combined sewer outfalls, preventing untreated sewage from entering the harbour by directing it into a hollow

channel integrated into the bottom of the pontoons. From there, the sewage is distributed to a number of storage receptacles that fit within the circular voids of the pontoon matrix. Upon being discharged into the receptacle, the sewage passes through a metal screen which sifts out non-biodegradable solids such as trash and debris that cannot be processed by the W.T.R. Park. The remaining effluent and waste is then permitted to settle within a flexible membrane suspended below the surface of the water where it is stored for treatment. To obscure the sight and smell of the stored sewage, the receptacles are capped with a sealed wood deck. Each receptacle is designed to store 40 000 gallons of sewage, however, their flexible membranes are

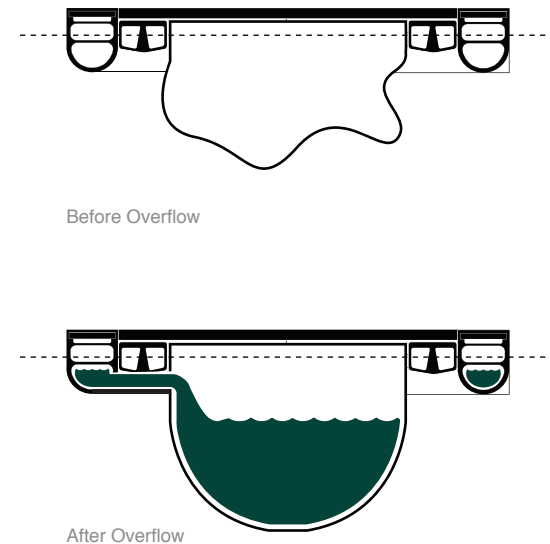
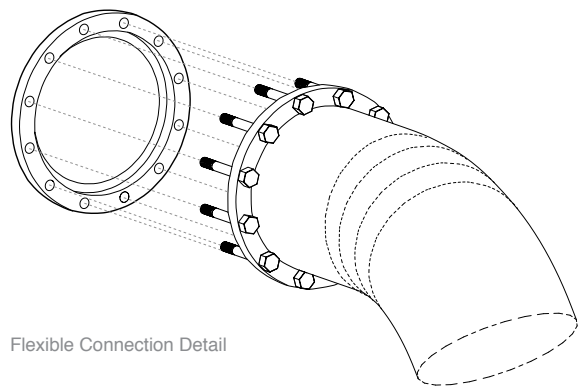


Fig. 4.3 A diagrammatic section through a typical storage receptacle illustrates its ability to expand during a C.S.O. event.

capable of expanding to accommodate as much as 60 000 gallons to provide extra storage capacity for heavy or extended periods of precipitation. Since the storage capacity of a single receptacle is limited, W.T.R. Parks may be comprised of a number of modules to contain all of the sewage discharged from a single outfall. In order to ensure that the sewage is evenly distributed among all of the modules, they are connected by flexible tubes that distribute the sewage equally among all of the receptacles. These tubes also allow the stored sewage to be distributed to a centralized location for processing.

Once the sewage is ready to be treated, it is drawn from the storage receptacles into an



Flexible Connection Detail

Multifunctional Deck

Waterfront Promenade

Combined Sewer

Combined Sewer Outfall

Flexible Extension

Flexible Module Connection

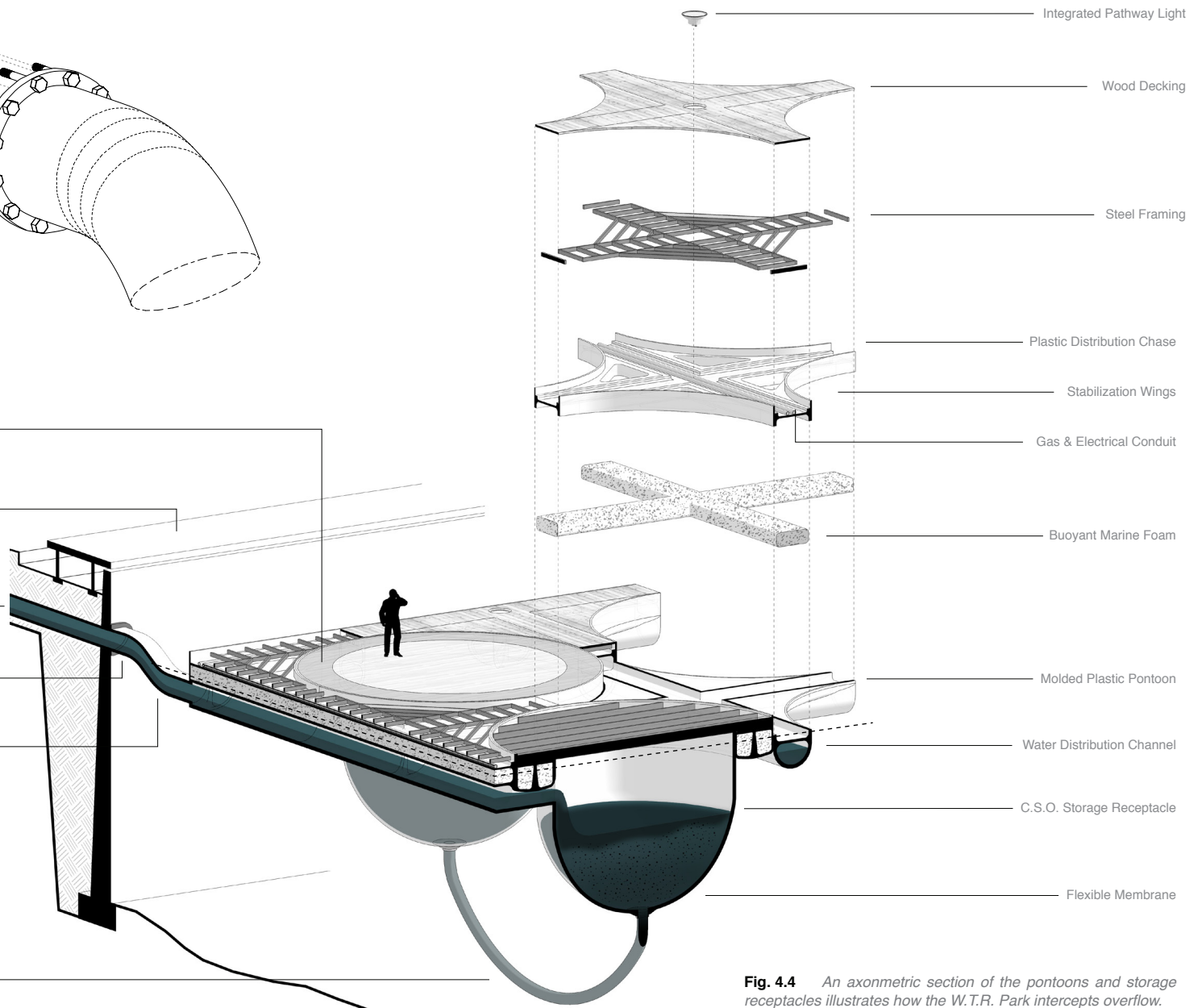


Fig. 4.4 An axonometric section of the pontoons and storage receptacles illustrates how the W.T.R. Park intercepts overflow.

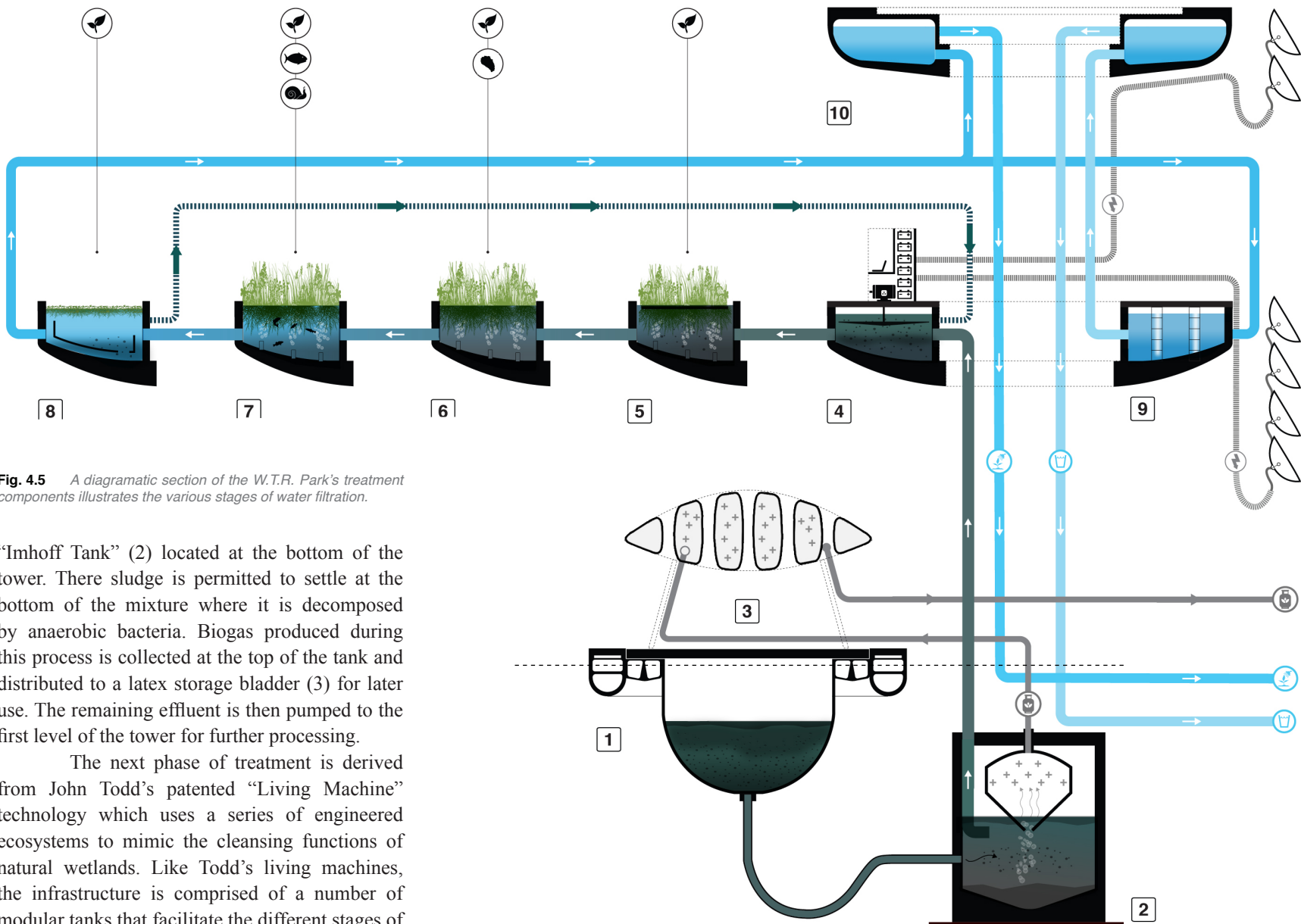


Fig. 4.5 A diagrammatic section of the W.T.R. Park's treatment components illustrates the various stages of water filtration.

“Imhoff Tank” (2) located at the bottom of the tower. There sludge is permitted to settle at the bottom of the mixture where it is decomposed by anaerobic bacteria. Biogas produced during this process is collected at the top of the tank and distributed to a latex storage bladder (3) for later use. The remaining effluent is then pumped to the first level of the tower for further processing.

The next phase of treatment is derived from John Todd's patented “Living Machine” technology which uses a series of engineered ecosystems to mimic the cleansing functions of natural wetlands. Like Todd's living machines, the infrastructure is comprised of a number of modular tanks that facilitate the different stages of

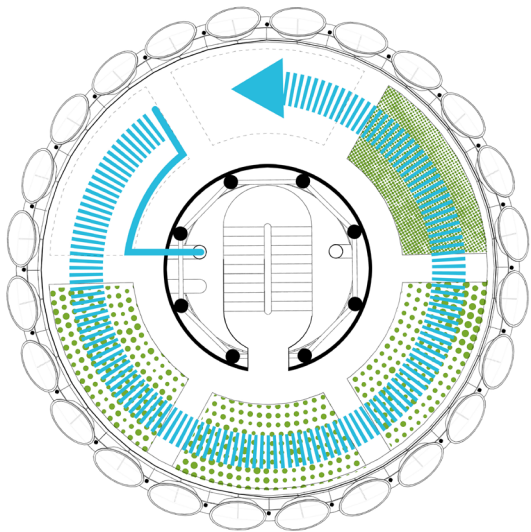


Fig. 4.6 A floorplan of a typical “Living Machine” greenhouse shows the movement of effluent through its modular tanks.

filtration. The tanks are connected to one another and assembled into a circular treatment loop that is capable of processing 40 000 gallons of sewage per day. Since the treatment capacity of a single loop is limited, towers can be designed to accommodate multiple loops. This vertical assembly of living machines allows the treatment capacity of the W.T.R. Park to be upgraded without redefining the configuration of the overall system. Each tower assembly is enveloped in glass facade to protect the living machines from the New York City’s harsh winters. The facade system is also comprised of solar dishes which generate energy to power the water pumps and air compressors that circulate effluent within the tower.

The first tank in the treatment loop is the anoxic reactor (4) where effluent is stirred in a oxygenless environment to promote the growth of beneficial micro-organisms that accelerate the removal of dissolved waste. Next the effluent is pumped into a closed aerobic reactor (5) where bubble diffusers aerate the effluent from below and a planted biofilter mounted on the top of the tank reduces odourous gasses and dissolved waste. Following this stage, the effluent is conveyed into an open aerobic reactor (6) where plants mounted on the top of the tank process waste for nutrients and restore oxygen back into the water with their roots. Effluent is then conveyed to a second aerobic reactor (7) which operates the same way as

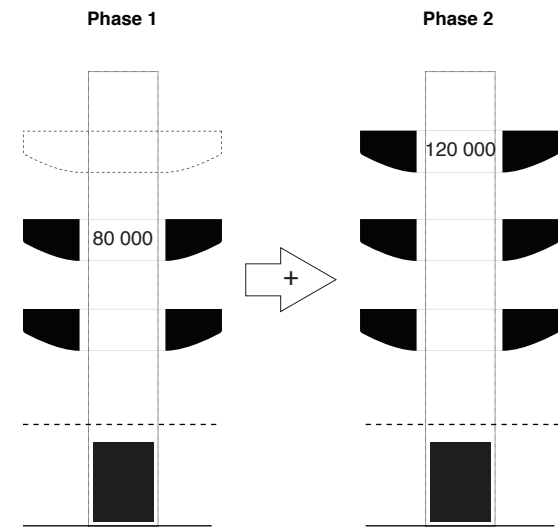


Fig. 4.7 A diagrammatic section of a typical treatment tower demonstrates how its capacity can be expanded vertically.

the first only this tank contains different species of plants and other beneficial organisms such as fish and insects that restore water quality. Finally, the effluent is pumped into a clarifier (8) where it is allowed to settle in an open tank while remaining solids are collected at the bottom where they can be pumped back through the treatment loop for further processing. Once the water has reached this stage it still contains many nutrients and for this reason it is considered to be as reusable grey water. Some of this grey water will be pumped to a tank at the top of the tower where it will be stored for reuse while the rest will be pumped into a sixth tank on the first level of the tower where it undergoes ultraviolet treatment to make it potable.




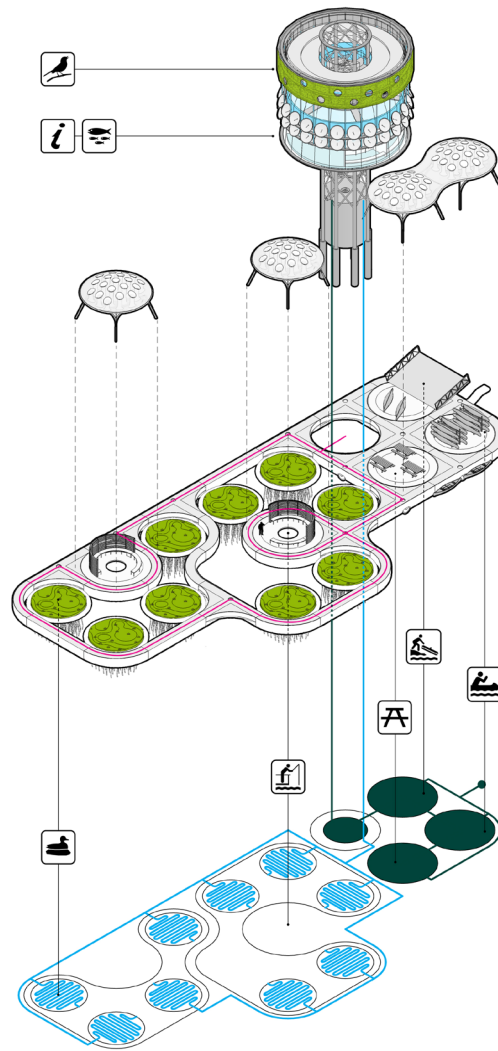
-  Public Program & Amenities
-  Sewage Storage & Distribution
-  Filtered Water Distribution
-  Biogas Distribution

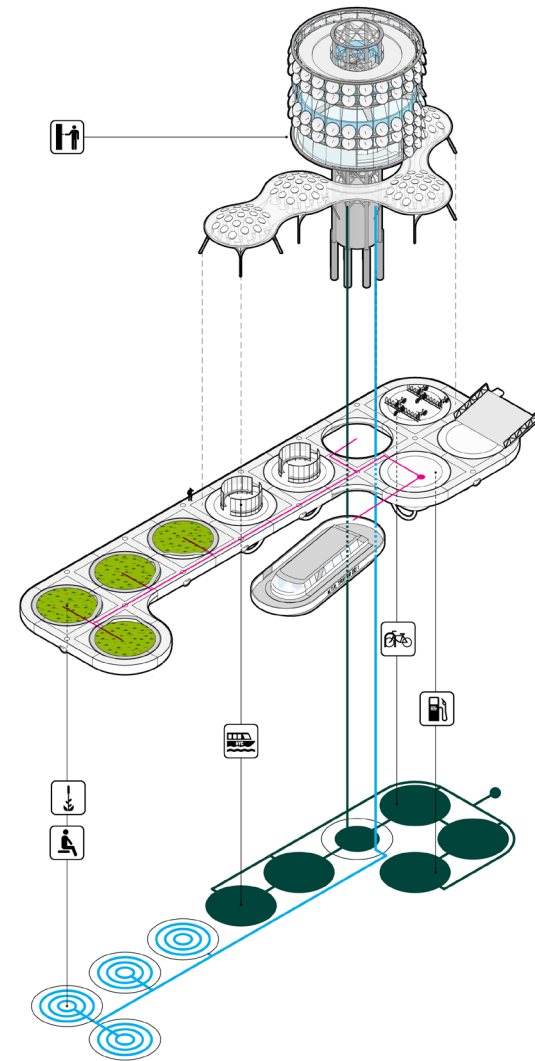
Fig. 4.8 A series of axonometric diagrams identify the five typologies of W.T.R. Parks and illustrate how *each one operates*.

Once the treatment process is complete there are a number of ways in that the filtered water and biogas can be reused to sustain public activities, commercial enterprises, and aquatic ecologies. To facilitate these reuse opportunities, the W.T.R. Park system includes a series of modular pods which plug into the floating pontoon grid to receive a constant supply of water from the tower and biogas from the storage bladder. These reuse pods give agency to the infrastructural system and define its character as a public space allowing it to make a larger contribution to the public. The combination of reuse strategies, pods, and amenities allows for five different types of W.T.R. parks. These types are described in Fig. xx .



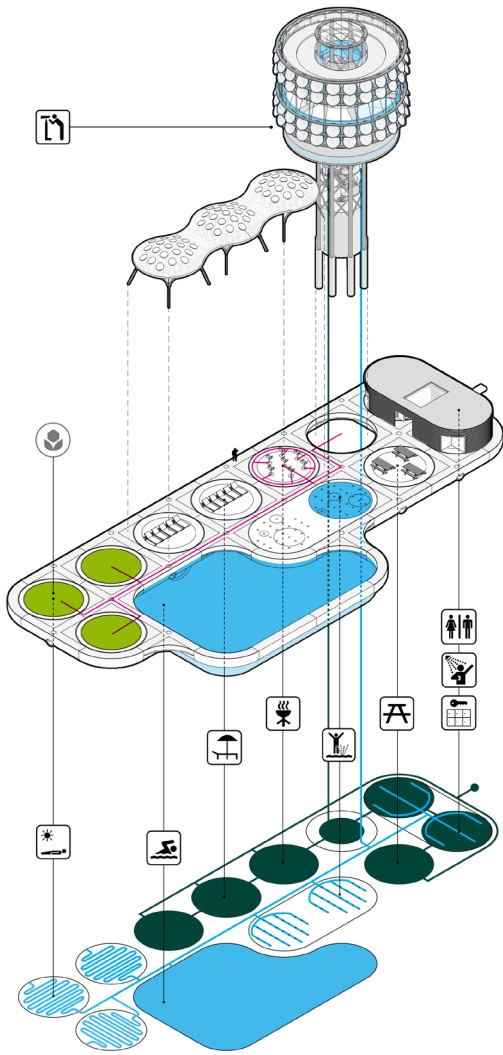
W.T.R. Park Type 1: Habitat Park

The Habitat Park reuses effluent and biogas to produce warm water which it discharges into the harbour through floating pods to create microclimates where fish can gather and birds can nest. pontoons are arranged to provide a floating network of public paths where visitors can observe local wildlife and fish.



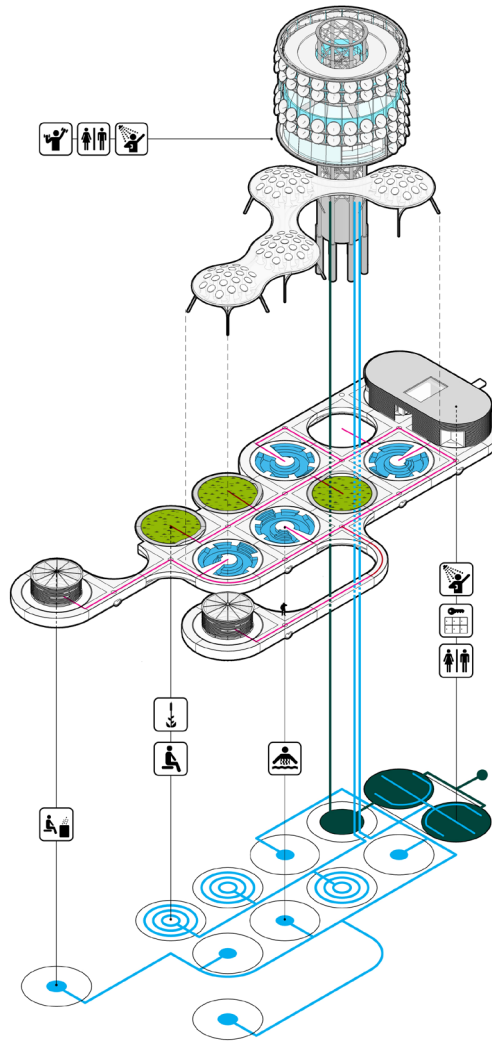
W.T.R. Park Type 2: Commuter Park

The Commuter Park reuses biogas as a fuel source to power a modular ferry. Here biogas storage vessels double as shelters for visitors awaiting the arrival of a ferry. Filtered effluent is reused in floating gardens where commuters can also await their ferry. Transit tickets can be purchased in the towers.



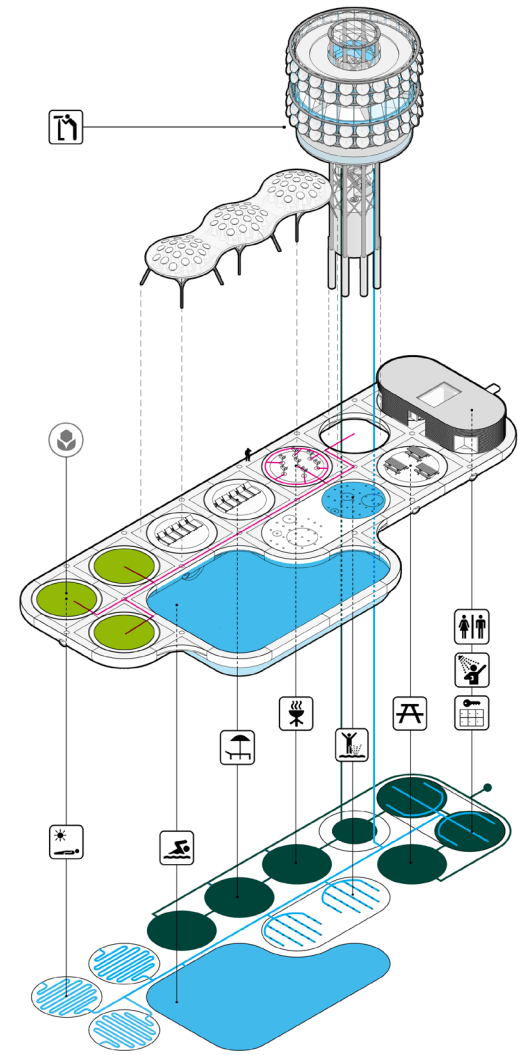
W.T.R. Park Type 3: Recreation Park

The Recreation Park distributes filtered effluent to a series of public pools, and foundations. Biogas is reused as a fuel source to power public barbecues, and feed a series of floating algae bioreactors that double as inflatable surfaces for visitors to tan. Here storage receptacles provide space for public change rooms.



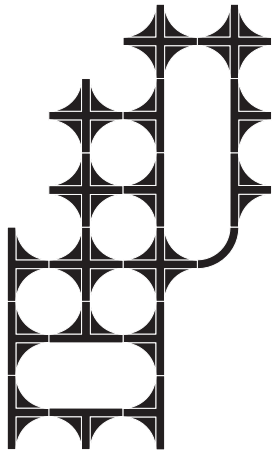
W.T.R. Park Type 4: Liesure Park

The Liesure Park reuses biogas to heat filtered effluent and distributes it to thermal pools, gardens, and saunas which visitors can use. A public gym is located in the bottom of the tower and changing facilities are located on top of the park's overflow storage receptacles.

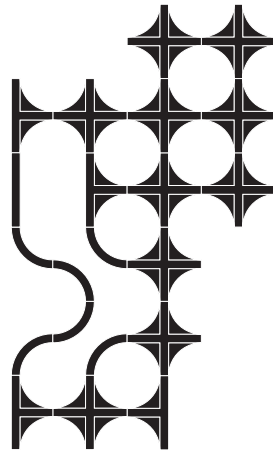


W.T.R. Park Type 5: Production Park

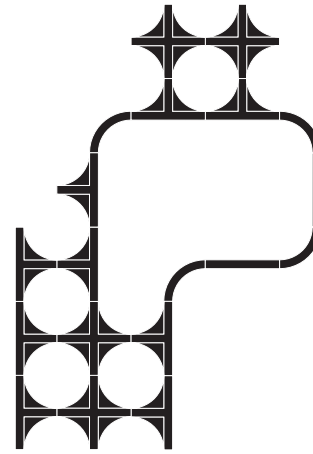
The Production Park reuses filtered effluent that is rich in nutrients to irrigate floating hydroponic gardens and fish farms. These products are cultivated and sold at a floating marketplace that is sheltered by the biogas storage vessels. Biogas is reused as a food source for the plants grown here.



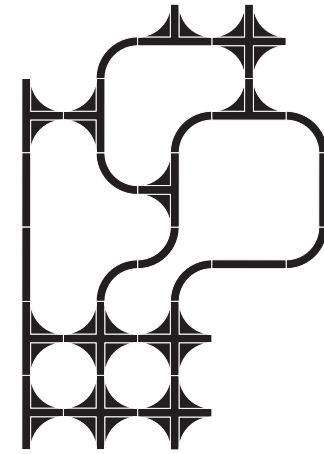
Configuration 1.
The use of 'Type A' and 'Type D' pontoons allows for lozenge-shaped voids and a regular linear grid for distribution of water and people.



Configuration 2.
The combination of 'Type B' and 'Type A' pontoons allows for diagonal voids and more organic geometry.



Configuration 3.
The use of 'Type B' and of 'Type C' pontoons allows for large rectangular voids for integrating larger program.



Configuration 4.
The combination of 'Type B', 'Type C', and 'Type D' pontoons allows for meandering circulation.

While the five different types of parks allow for the infrastructural system to respond to various programmatic needs, its four different types of pontoons allow the parks to be shaped and configured in a number of ways to respond to varying site conditions or performance requirements. Simple manipulations of the grid matrix provides void spaces of various shapes and sizes which accommodate reuse pods of equal variety. With nearly an infinite number of possibilities for combination and configuration, the W.T.R. Park system would perform effectively in an infinite number of locations making it ideal for replication and, ultimately, construction at a large regional scale. Its implementation at this scale would also

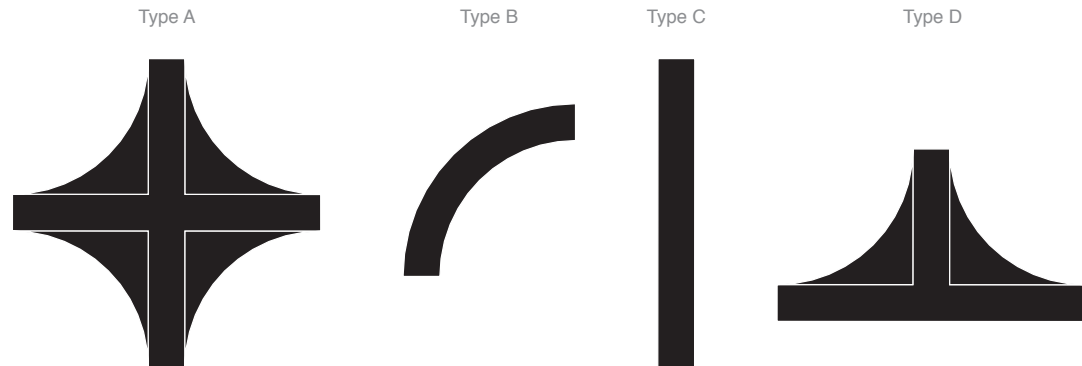
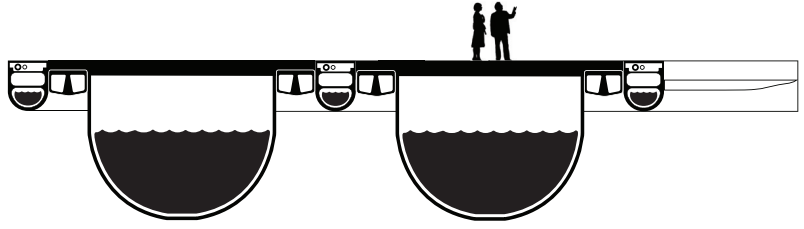
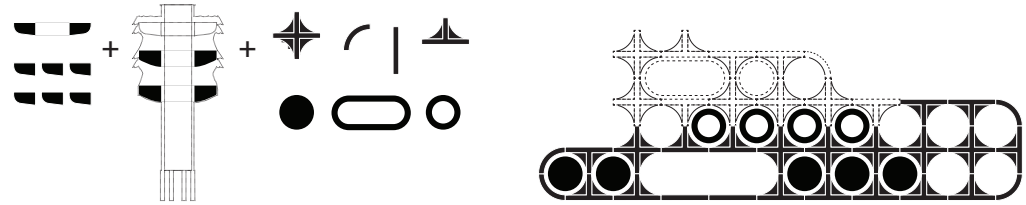


Fig. 4.9 Diagrammatic plans of various pontoon configurations demonstrate the grid's ability to accommodate different program.

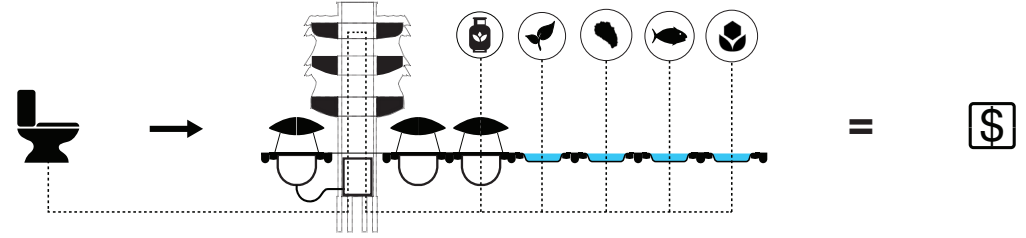
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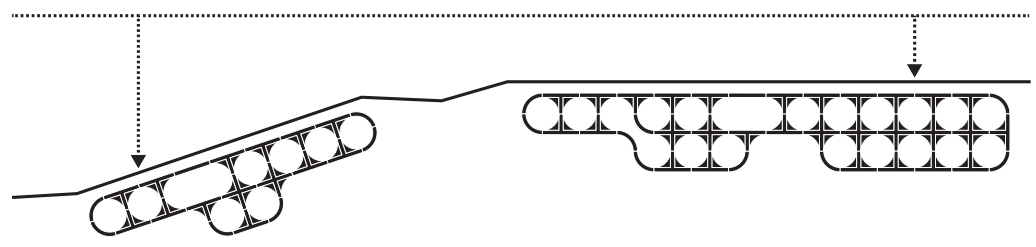
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3



4



1

Basic Storage & Distribution

2

W.T.R. Parl Expansion

3

Resource Generation & Revenue

4

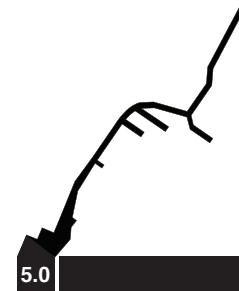
Decentralized Expansion

Fig. 4.10 Diagrammatic plans of various pontoon configurations demonstrate the grid's ability to accommodate different program.

be extremely cost effective as the system's modular design would allow it to be purchased in smaller pieces and assembled over time. In this way the system can be thought of much like a computer where the city can purchase a base model that meets its most immediate needs and then purchase additional components to improve its performance. Figure 4.10 illustrates the three primary stages in which this process would be likely to occur.

With all of the benefits of the W.T.R. Park system considered, it is likely that the new infrastructure would serve as a robust foundation for the development of the Sixth Borough. However, in order to be certain, it is critical that the system be further tested through a site-specific design exercise.





5.0

Examination



Fig. 5.0 An aerial photograph of South Brooklyn highlights the Gowanus' location relative to Manhattan and the New York Harbor.

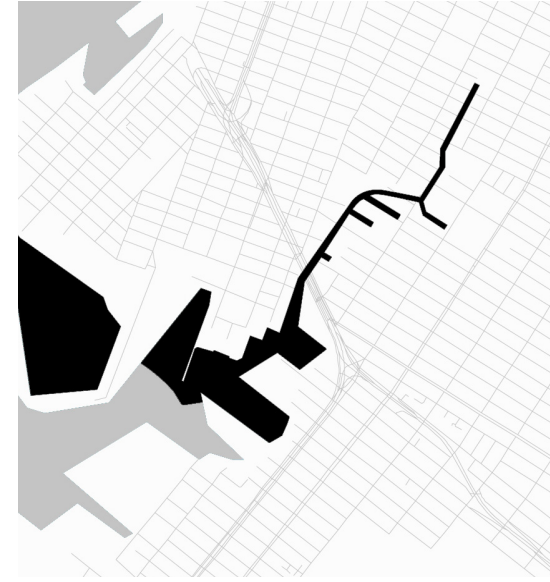


Fig. 5.1 A close-up of the New York Harbor map shows the Gowanus Canal's position amid the city's street grid.

5.0

A Testing Ground

In order to thoroughly investigate the capacity for the W.T.R. Parks to be deployed throughout the Sixth Borough, it is necessary for the city to establish a site where the system can be deployed and piloted. Considering that the new infrastructure should be tested for its capacity to be integrated into challenging sites and to treat particularly large volumes of sewage, an ideal testing site would be one that has limited space and receives large volumes of combined sewer overflow on a regular basis. As Figure 5.2 illustrates, the sites that meet these specific criteria are small, narrow tributaries where space for building infrastructure is limited and combined sewer overflow has rendered their waters hazardous

to public and ecological health. Out of all of the water bodies highlighted on the map, the one which is considered to be New York City's most toxic is the Gowanus Canal.¹ Throughout the last 50 years, politicians have invested millions of dollars in infrastructural improvements to remediate the canal and prevent sewage from spilling into its waters, however these efforts have proven futile. Given the challenges the city has faced, this site will serve as an ideal testing ground for New York City's next generation of wastewater infrastructure.

The Gowanus Canal is a 2.4-kilometre-long tributary connected to the Upper New York Harbor and situated in the borough of Brooklyn.

¹ New York City Department of Environmental Protection. *New York Harbor Water Quality Report*. <<http://www.nyc.gov/html/dep/pdf/hwqs2008.pdf>>.

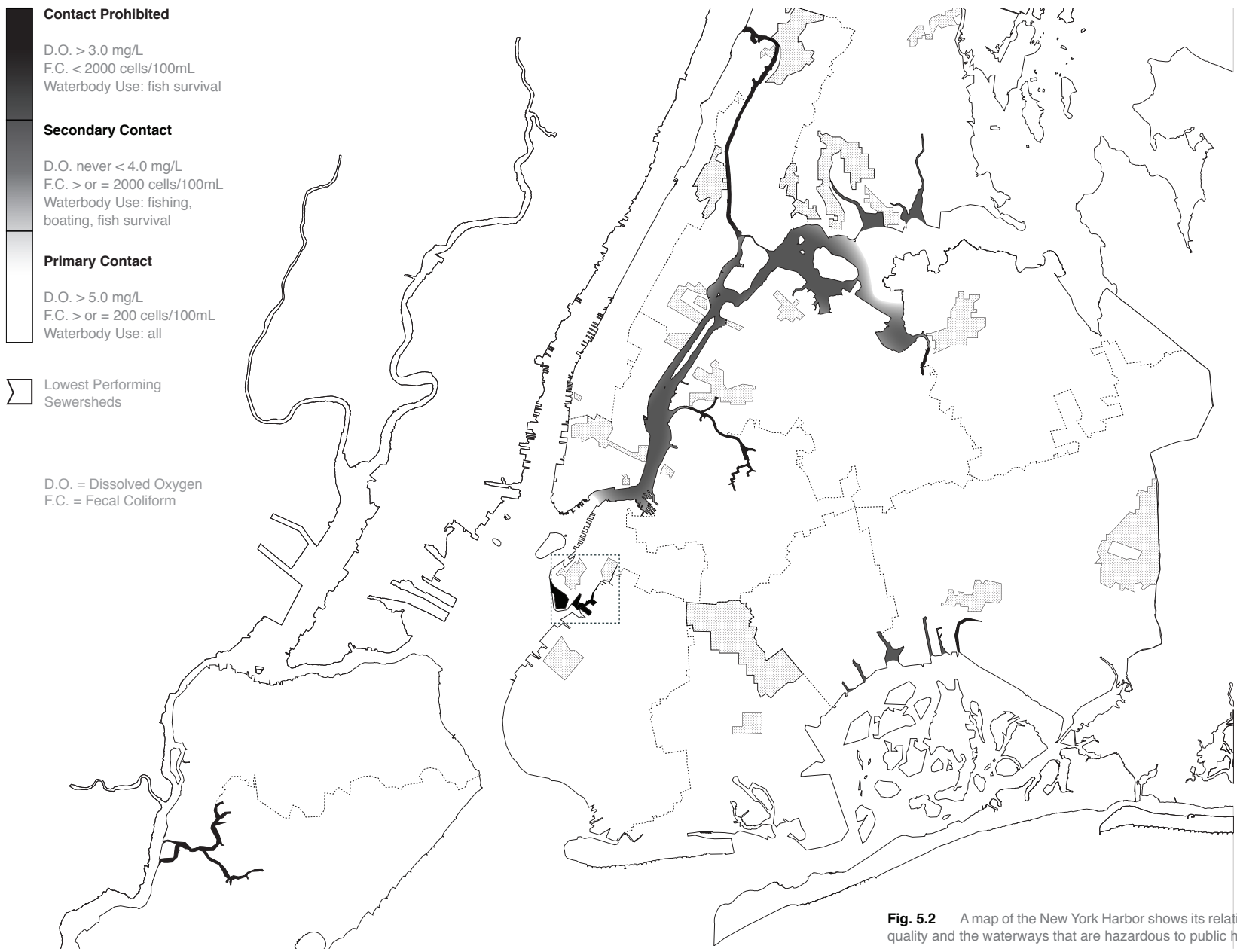


Fig. 5.2 A map of the New York Harbor shows its relative water quality and the waterways that are hazardous to public health.



NYC Highline

Gowanus Canal

Carroll Street

3rd Street

50

Fig. 5.3 An aerial photograph of the Gowanus Canal illustrates its position within a dense residential fabric of South Brooklyn.



Fig. 5.4 A photograph of the Gowanus Canal taken from the Carroll Street bridge shows the character of the waterway.

Winding inland, the waterway is bordered by some of New York City's oldest residential neighbourhoods where it has played a critical role in catalyzing the rapid development of the region.² As a small navigable creek, the Gowanus was used as a public landing site in the 17th century and along its shores the city's first mills were constructed. As local populations grew in the 19th century and New York City's burgeoning shipping industry expanded into Brooklyn, the need for larger, more navigable docking facilities grew and the creek was dredged transforming it into a commercial waterway. During this time the canal served as a vital infrastructure which

² Neidl, Phoebe. Brooklyn Daily Eagle. *History of The Gowanus Canal*. <<http://www.brooklyneagle.com/articles/brief-history-gowanus-canal>>.



Fig. 5.5 A photograph of the Gowanus Canal taken from the 3rd Street bridge illustrates the urban fabric around the waterway.

permitted the distribution of building materials inland to sustain Brooklyn's booming construction industry. Despite this, the waterway's historical legacy is its status as the city's largest open sewer.

Situated in the middle of the dense, heavily industrialized fabric of 19th-century Brooklyn, the waterway functioned as a sump for collecting local industrial waste rendering its waters extremely toxic and earning the canal the nickname "Lavender Lake" for its unnatural purple hue. Following the construction of Brooklyn's first sewers in the early 20th century, the environmental condition of the canal became even worse as domestic sewage from the region's dense residential neighbourhoods was collected

and discharged untreated into the waterway.³ As Brooklyn's population grew, waste rapidly accumulated within the canal posing a significant threat to public health. In an attempt to ameliorate these conditions, the city constructed a flushing tunnel to pump fresh water from the New York Harbor into the northern end of the canal. Though the daily supply of fresh water was enough to rid the Gowanus of its noxious odours, it failed to prevent waste from accumulating as a toxic sediment below the surface of its waters. Despite this the discharge of untreated sewage continued for another 50 years while the city invested in various dredging programs to keep the waterway

³ Neidl, Phoebe. Brooklyn Daily Eagle. *History of The Gowanus Canal*. <<http://www.brooklyneagle.com/articles/brief-history-gowanus-canal>>.

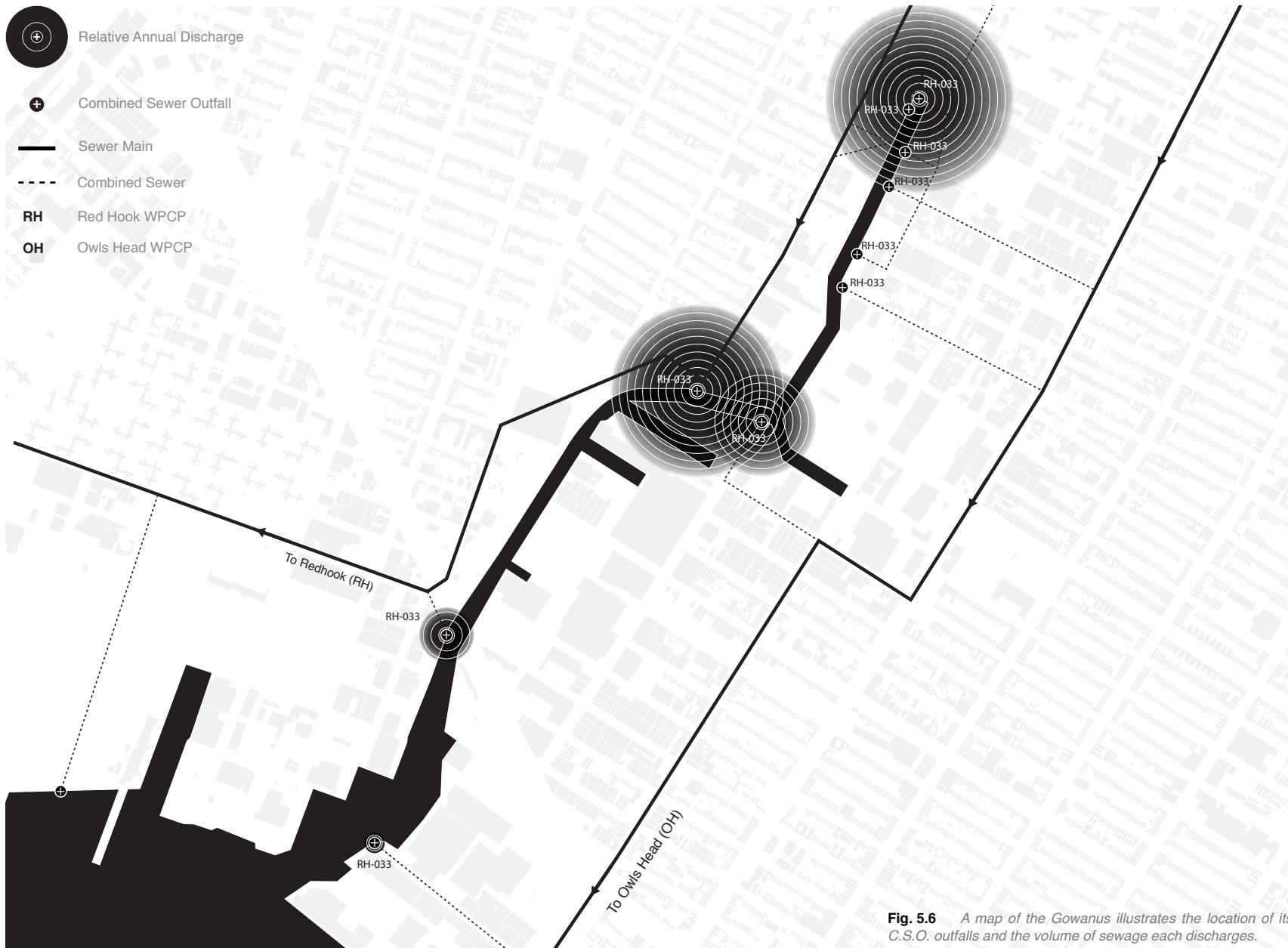


Fig. 5.6 A map of the Gowanus illustrates the location of its C.S.O. outfalls and the volume of sewage each discharges.

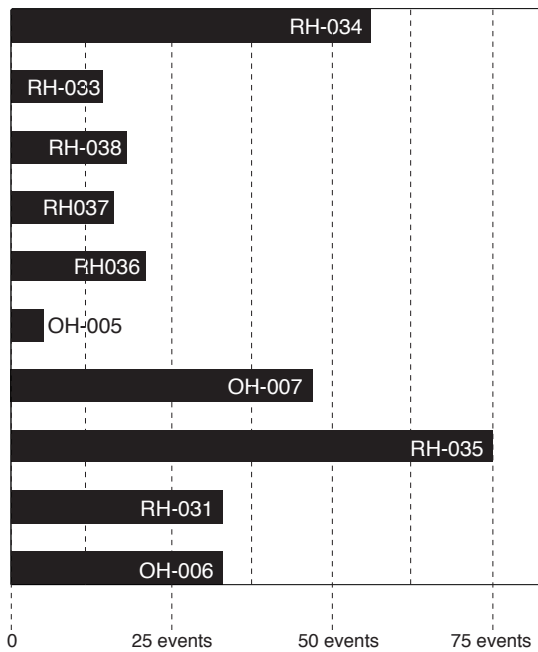


Fig. 5.7 A bar graph illustrates the annual number of discharges that occur at each C.S.O. location along the Gowanus.

Fig. 5.8 A photograph taken after a storm shows canoers floating in untreated sewage at the northern end of the Gowanus.

open for use. As industry began to withdraw from the region in the 1950s, the city ceased to dredging the canal and an era of post-industrial decay beset the region. Though the construction of the Owls head and Red Hook wastewater treatment facilities in the second half of the 20th century would end the dry weather discharge of effluent into the Gowanus Canal, it remains New York City's most toxic waterway and the region's deficient sewage network remains its largest source of pollution.

Every year, 377 million gallons of untreated sewage spills into the Gowanus Canal from nine combined sewer outfalls located along its shores.⁴ This immense volume of sewage is

⁴ New York City Department of City Planning. *Environmental Review*. <http://www.nyc.gov/html/dcp/pdf/env_review/363_365_bond_street/13_feis.pdf>.

enough to fill the canal three times over. As Figure 3.6 indicates, the frequency and intensity of these C.S.O. events varies among different outfalls and those which are responsible for polluting the most are located at the northern end of the waterway. In fact, the sewage discharged from these three outfalls alone comprises 80 percent of the annual overflow that spills into the canal. The long, narrow and winding course of the Gowanus makes the discharge of large volumes of waste at these locations particularly problematic as tides and currents are unable to disperse and contaminants into the larger, deeper water. With overflow events occurring weekly, discharged waste accumulates as a thick noxious sediment below the surface of

the canal's shallow and stagnant waters where it decomposes and bubbles to the surface as a noxious gas.⁵ This thick sludge is a breeding ground for bacteria and pathogens which emit foul odours and render its waters hazardous to public and ecological health. The canal's position amid a number of highly populated residential neighbourhoods has made its hazardous condition the subject of much political debate throughout the last decade. As one of the America's "most extensively contaminated water bodies" the Gowanus was added to the Environmental Protection Agency's (EPA's) list of national priorities for remediation in March 2010. Since this time, EPA officials

⁵ Riverkeeper. *Gowanus Canal*. <<http://www.riverkeeper.org/campaigns/stop-polluters/gowanus-canal/>>.

- 1** **Location:** Bond & Union Street
Size: 11 buildings, 360 units
Type: Mixed-use Residential
- 2** **Location:** 340 Bond Street
Size: 34 existing units
Type: Residential
- 3** **Location:** Carroll & Bond Street
Size: 450 units
Type: Mixed-use Residential
- 4** **Location:** 3rd Ave & 3rd Street
Size: 60 000 sq. feet
Type: Commercial Market
- 5** **Location:** 5th & Smith Street
Size: 774 units
Type: Mixed-use Residential
- 6** Gowanus Canal Sponge Park Promenade & Gardens



Fig. 5.9 A map of the Gowanus illustrates the location of waterfront lots that are slated for residential development.



Fig. 5.10 A series of renderings present a new vision for the Gowanus as a recreational corridor for the local community.

and the American Army Corps of Engineers have been developing strategies for dredging the canal to rid the waterway of its toxic sediments.⁶

Discussions surrounding the canal's remediation during the last decade have also sparked interest in the revitalization of the surrounding region. With South Brooklyn's residential fabric expanding closer to the waterway and the withdrawal of heavy industry along its shores, the Gowanus Canal and its adjacent waterfront is emerging as a new frontier for urban growth. Since the northern half of the canal was re-zoned for residential and commercial use in 2008, a number of urban renewal schemes

⁶ US Environmental Protection Agency. *Gowanus Canal Superfund Site | Region 2 | US EPA*. <<http://www.epa.gov/region02/superfund/npl/gowanus/>>

have surfaced which propose the redevelopment of its vacant waterfront lots into high-density residential housing blocks.⁷ A shared vision among these proposals re-appropriates the canal as a new public landscape defined by a network of paths, promenades, floating docks, and parks that facilitate a water-based transportation network, recreational activities, and a local need for open space.

With an ambitious plan for remediation and renewal in place, New York City is set to transform its most toxic waterway into a new recreational corridor that will provide the growing region of South Brooklyn with some much needed public space. However, in order

⁷ New York City Department of City Planning. *Gowanus Canal Corridor Framework*. <<http://www.nyc.gov/html/dcp/html/gowanus/index.shtml>>

to ensure that the canal is capable of sustaining future development and increased public activity, it is critical that the city stops its sewers from spilling untreated effluent into its waters. With no federal funding available for wastewater infrastructure and little public interest in financing sewer upgrades, the W.T.R. Park emerges as the ideal system for addressing the challenges at hand.

Considering that the majority of lots that could be developed are located at the northern end of the waterway, it is reasonable to assume that the first W.T.R. Parks would be deployed there. As a neighbourhood primarily comprised of single-family housing is only blocks away from a number of subway stops, the northern end of the Gowanus



Fig. 5.11 A series of photographs illustrate the primary recreational activities that give agency to the Gowanus.

is home to a large number of commuters. Here the streets are busiest in the morning and evening. Despite being a large residential neighbourhood, it has only one public park which is a small run-down pool complex. Given these conditions, the local community would benefit most from of an infrastructure that can facilitate the local need for recreational space and amenities to support the local working class. The proposal is therefore an assembly of three different types of W.T.R. parks. The first is a recreation park, positioned in front of two open lots awaiting the development of multi-use housing blocks. The second is a leisure park, located next to two major cross-streets that carry heavy bicycle traffic. And the

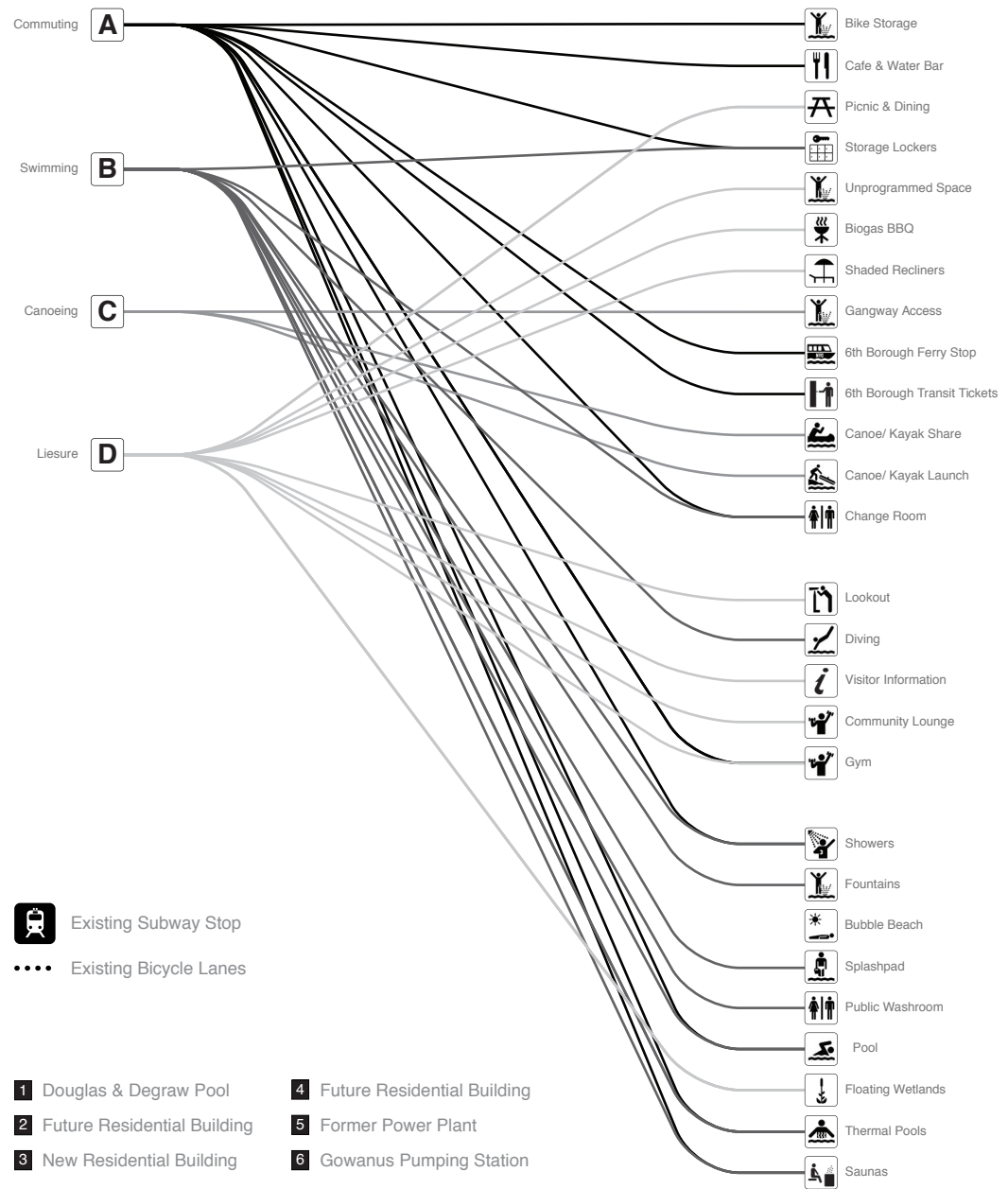


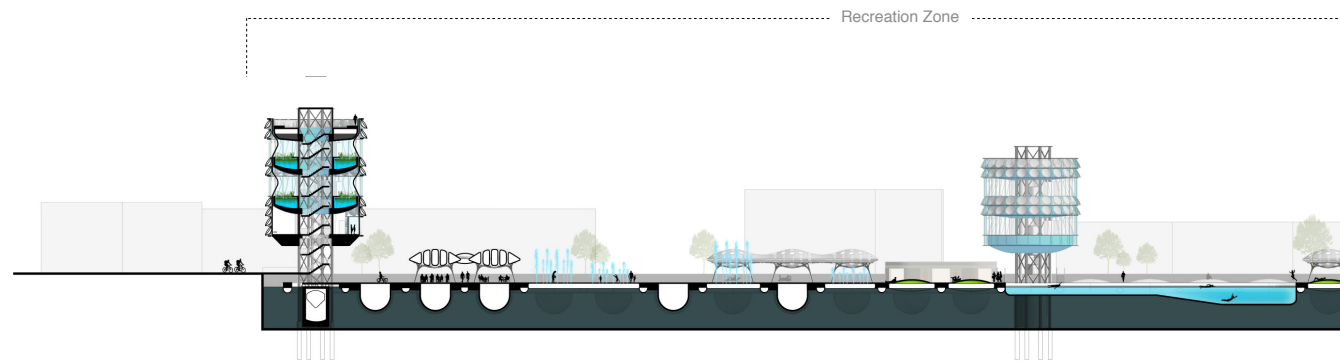
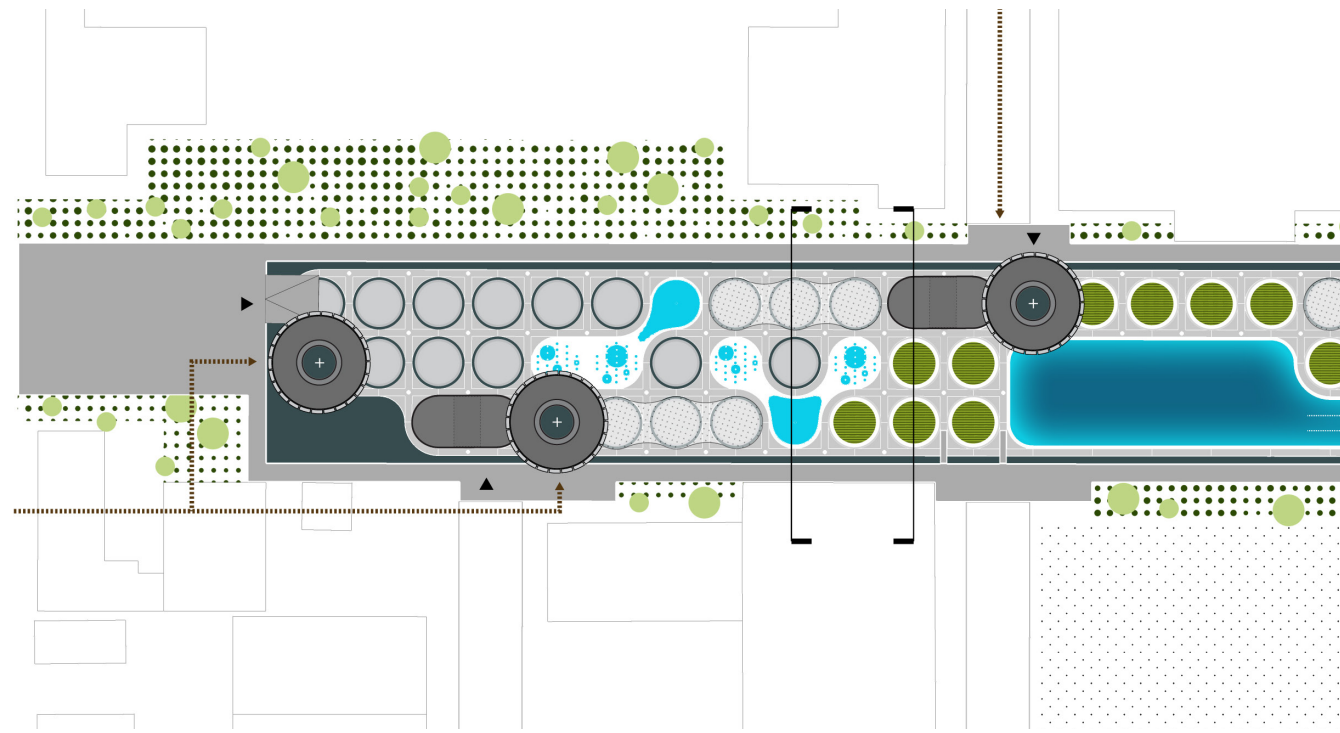


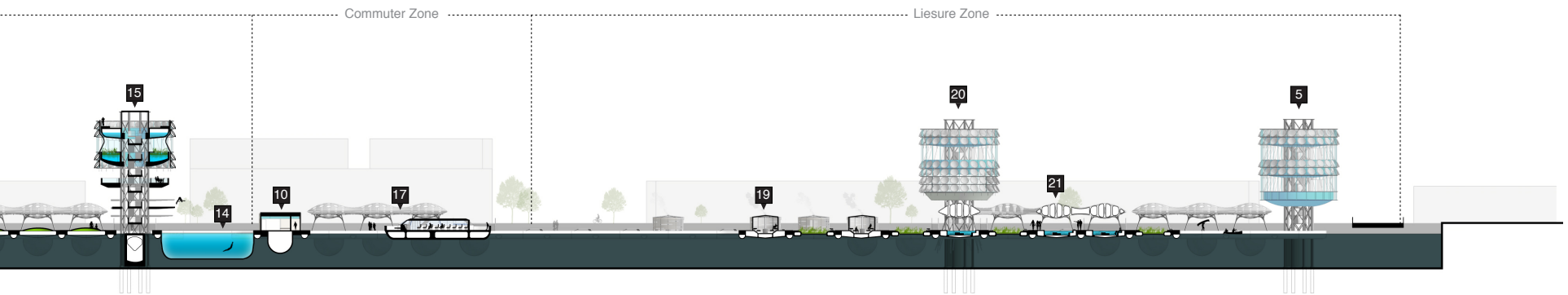
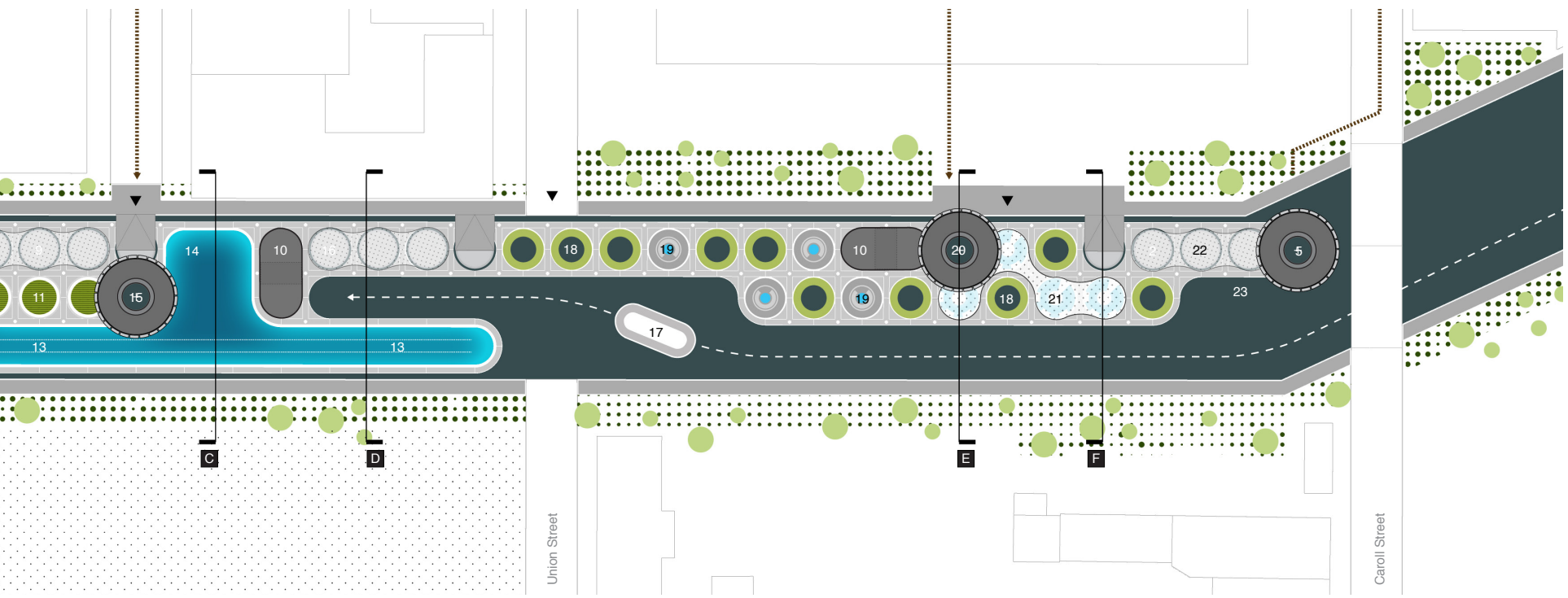
Fig. 5.12 A rendering of the Gowanus' northern end shows the new W.T.R. Park and its connection to the existing urban fabric.

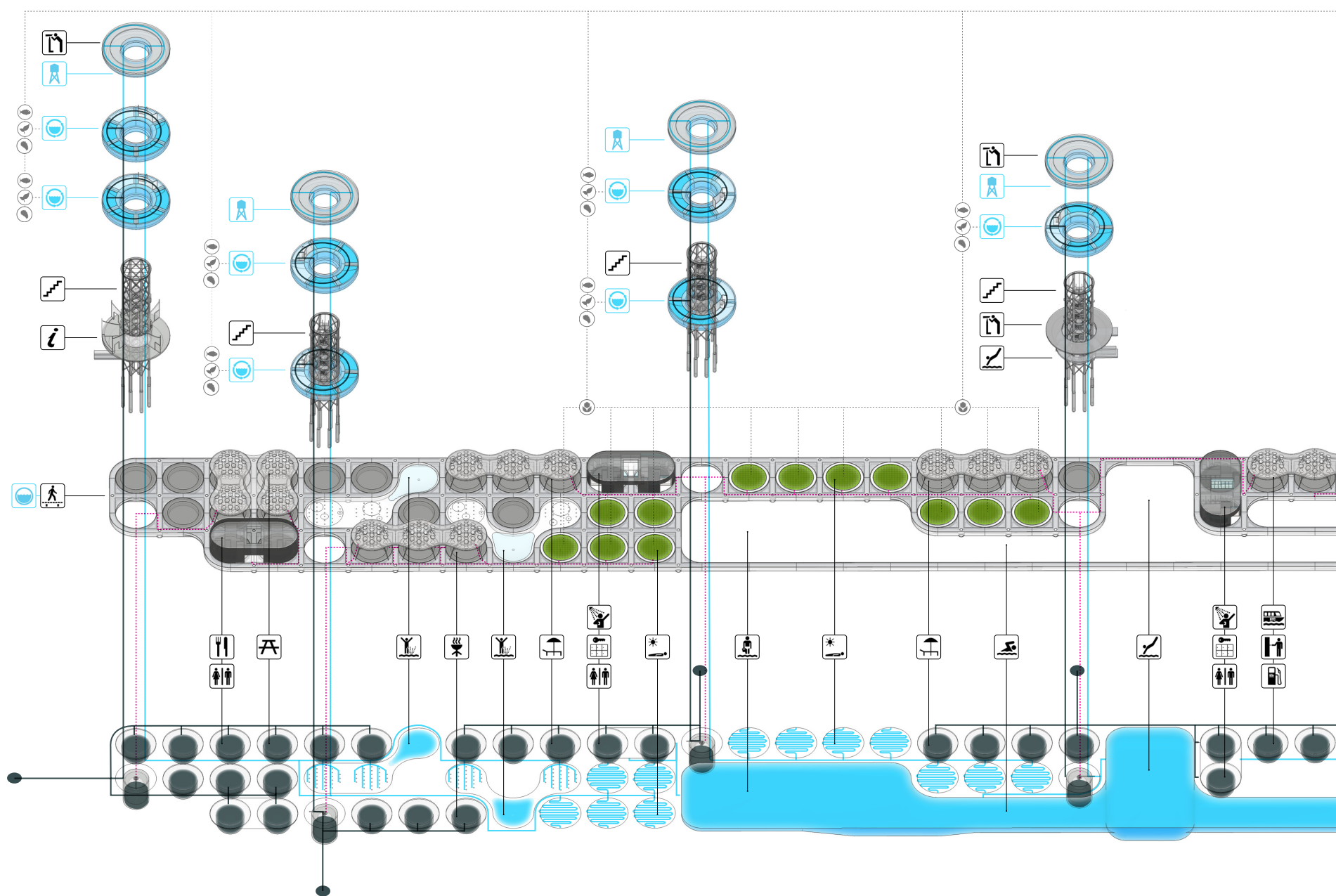
- | | |
|---------------------|------------------------|
| ▼ Access Points | ■ Canal Water |
| ■ Stormwater Garden | ■ Waterfront Promenade |
| ● Trees | ⋯ Combined Sewers |
-
- | | |
|-------------------------|---------------------------|
| 1 Information & Lookout | 13 Lap Pool |
| 2 Bicycle Storage | 14 5m Diving Pool |
| 3 Cafe & Water Bar | 15 Diving Tower & Lookout |
| 4 Sheltered Seating | 16 Ferry Stop & Refueling |
| 5 Display Tower | 17 Sixth Borough Transit |
| 6 Unprogrammed Space | 18 Wetland Pods |
| 7 Biogas Barbecues | 19 Floating Saunas |
| 8 Splashpad & Fountains | 20 Fitness Tower |
| 9 Shaded Recliners | 21 Thermal Pools |
| 10 Washrooms & Lockers | 22 Canoe Share |
| 11 Bubble Beach | 23 Canoe/Kayak Launch |
| 12 Shallow Pool | |

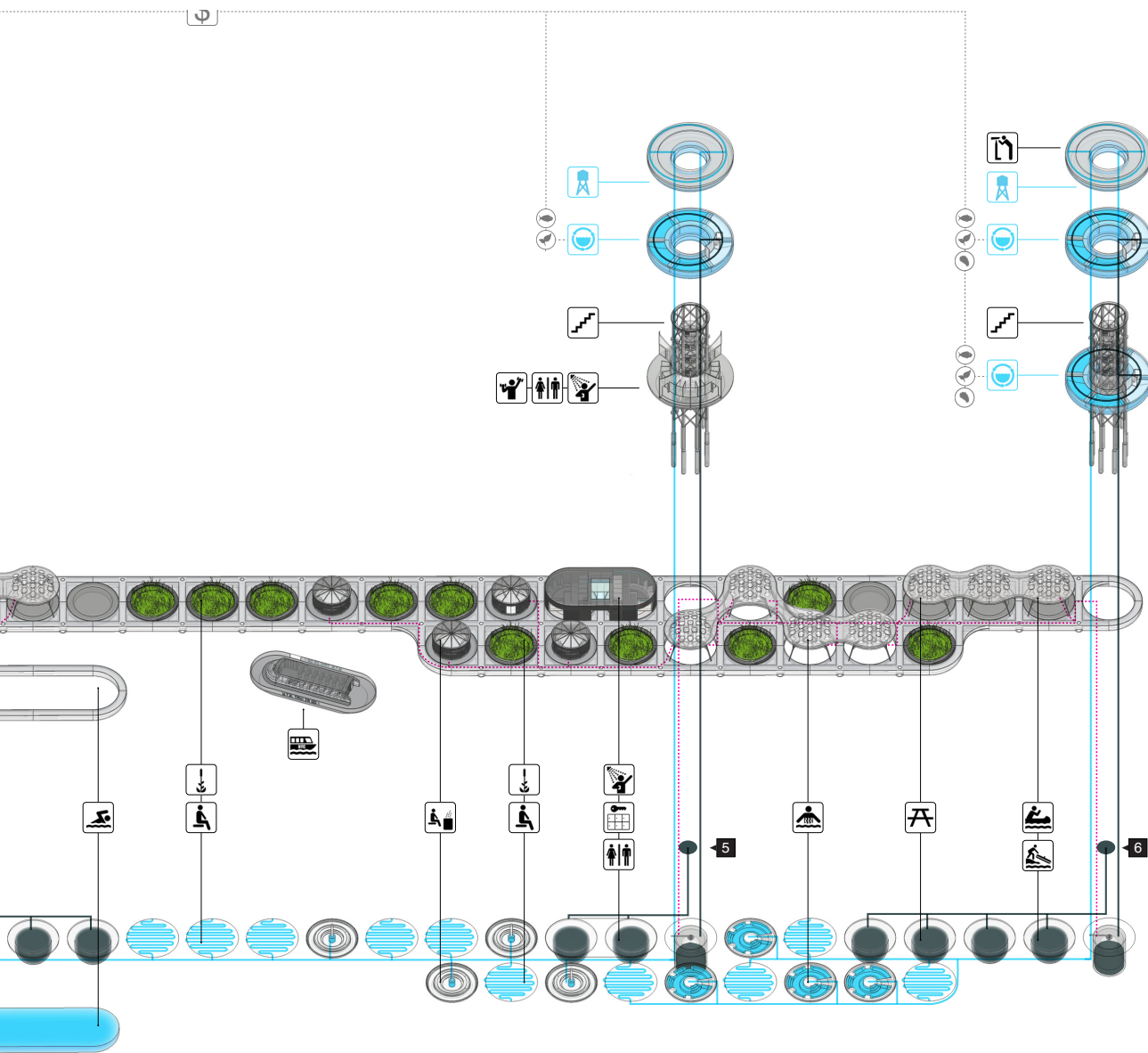
Fig. 5.13 A plan and longitudinal section identify the various amenities and program integrated into the new W.T.R. Park.

third type is a commuter park, connecting the first two and placed at the end of Union Street. It aligns with the nearest subway stop and provides a simple connection between local transit and the new waterborne transportation network. The entire assembly is comprised of six towers each of which is placed at a street end marking the locations of combined sewer outfalls. Each tower varies in size and contains a different number of living machines as well as different kinds of public amenities. The character of each tower is not only derived from its relative position within the park, but it is also determined by the distribution of combined sewer overflow along the canal. Towers located nearest the highest









Clean Water Storage	Clean Water Storage
Living Machine	Living Machine
Water Distribution	Water Distribution
Public Program [see p.74]	Public Program
C.S.O. Outfall	Biogas Distribution
Black Water Distribution	Clean Water Distribution

C.S.O gal/y	
1 RH-034: 121 100 000	4 RH-037: 500 000
2 RH-033: 200 000	5 RH-036: 1 600 000
3 RH-038: 900 000	6 OH-005: 700 000

Fig. 5.14 An exploded isometric diagram illustrates the layering of public program and infrastructural systems in the W.T.R. Park.

polluting outfalls are given a larger capacity making the volume of overflow that is discharged from each outfall more legible to the public. Since each of the system's living machines must be processing sewage at all times, and C.S.O. events occur on an average of once per week, the park is equipped with enough storage receptacles to hold the overflow for seven days while the towers process it. These receptacles are placed within the pontoon grid and also support such amenities as public change rooms and open space on top. These relationships are illustrated in Figure 5.14 which shows all of the systems and public program integrated into the park and how water is distributed, cleaned, and reused by each of them.

- 1 Stormwater Garden
- 2 Public Promenade
- 3 Access Bridge
- 4 Access Stair & Gangway
- 5 Greenhouse
- 6 Viewing Windows
- 7 Public Lookout
- 8 Floating Landscape
- 9 Living Machine Greenhouse
- 10 Public Information Display
- 11 Combined Sewer Overflow
- 12 80 000 Gal. Eco-Machine

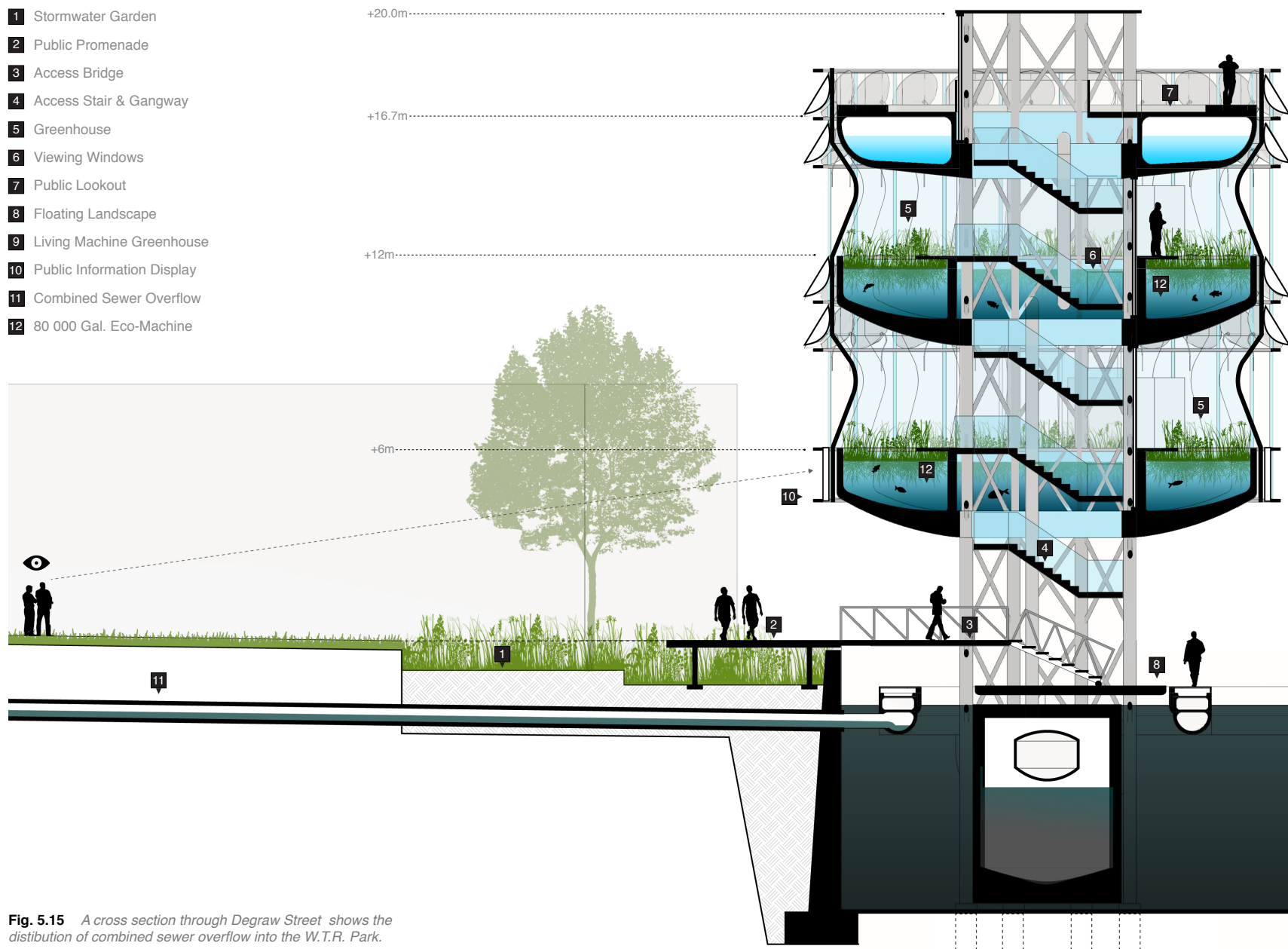


Fig. 5.15 A cross section through Degraw Street shows the distribution of combined sewer overflow into the W.T.R. Park.



Fig. 5.17 A down Degraw Street shows an iconic “Living Machine” tower positioned at its terminus.

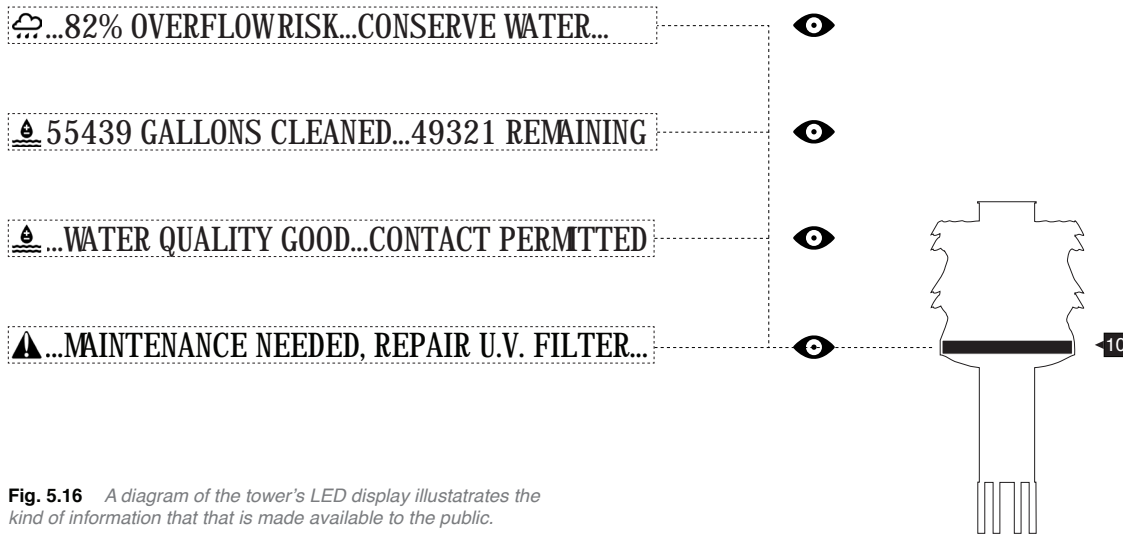


Fig. 5.16 A diagram of the tower's LED display illustrates the kind of information that is made available to the public.

The park's presence within the neighbourhood is marked by an un-obstructed view of the towers which can be obtained from any number of cross-streets within the neighbourhood. Each tower is equipped with an LED display (10) which relays information about the operation of the W.T.R. Park to the public. The towers are supported by a structural core which sits upon piles driven deep into the canal-bed. These cores contain stairs that provide public access to the greenhouses above. As visitors ascend the stair they are permitted a closer look at the inner workings of the eco-machine through viewing windows (6) placed in the side of the water tanks. During specific times of the day, visitors are

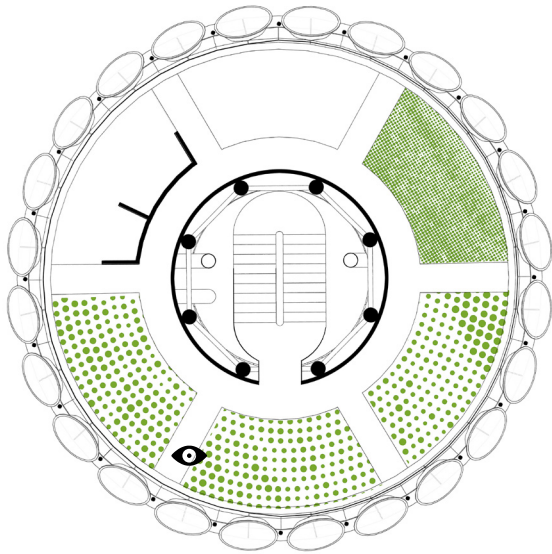
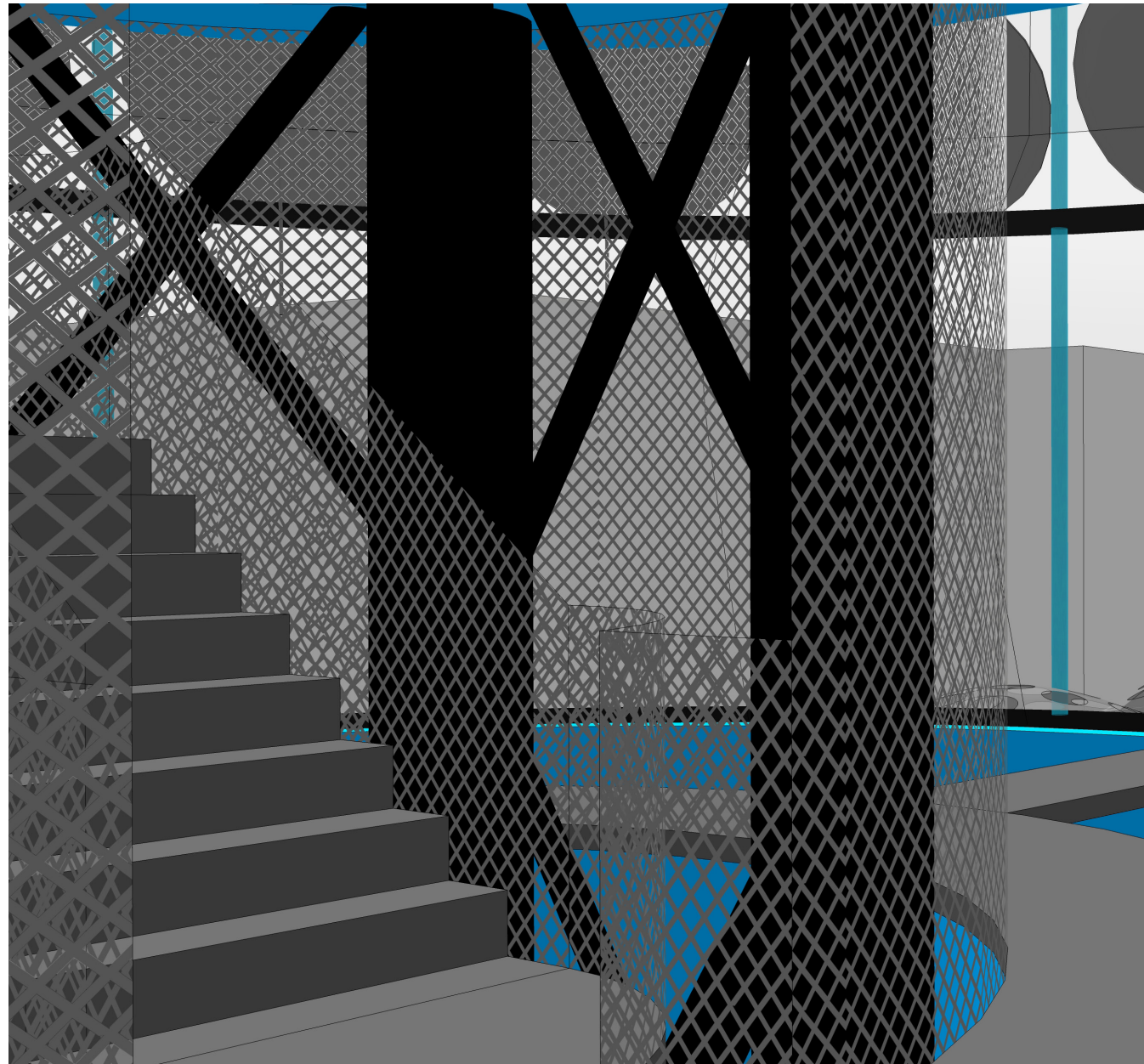


Fig. 5.18 A typical floor plan of the “Living Machine” greenhouse shows the access platforms that permit public circulation.

also permitted access to the greenhouses where city employees provide tours and information about how the eco-machine and the W.T.R. parks work. Platforms and catwalks elevated above the tanks (shown in Figure 5.18) allow visitors to walk around the greenhouse and to look at the plants and organisms responsible for treating the sewage while they take in a 360-degree panoramic view of the surrounding landscape. If visitors continue to ascend the stair they may also obtain similar vistas from an integrated viewing platform on the top of the tower. This provides the public with a better idea of how the clean water stored in the tower is being distributed.

Four of the towers also provide visitors



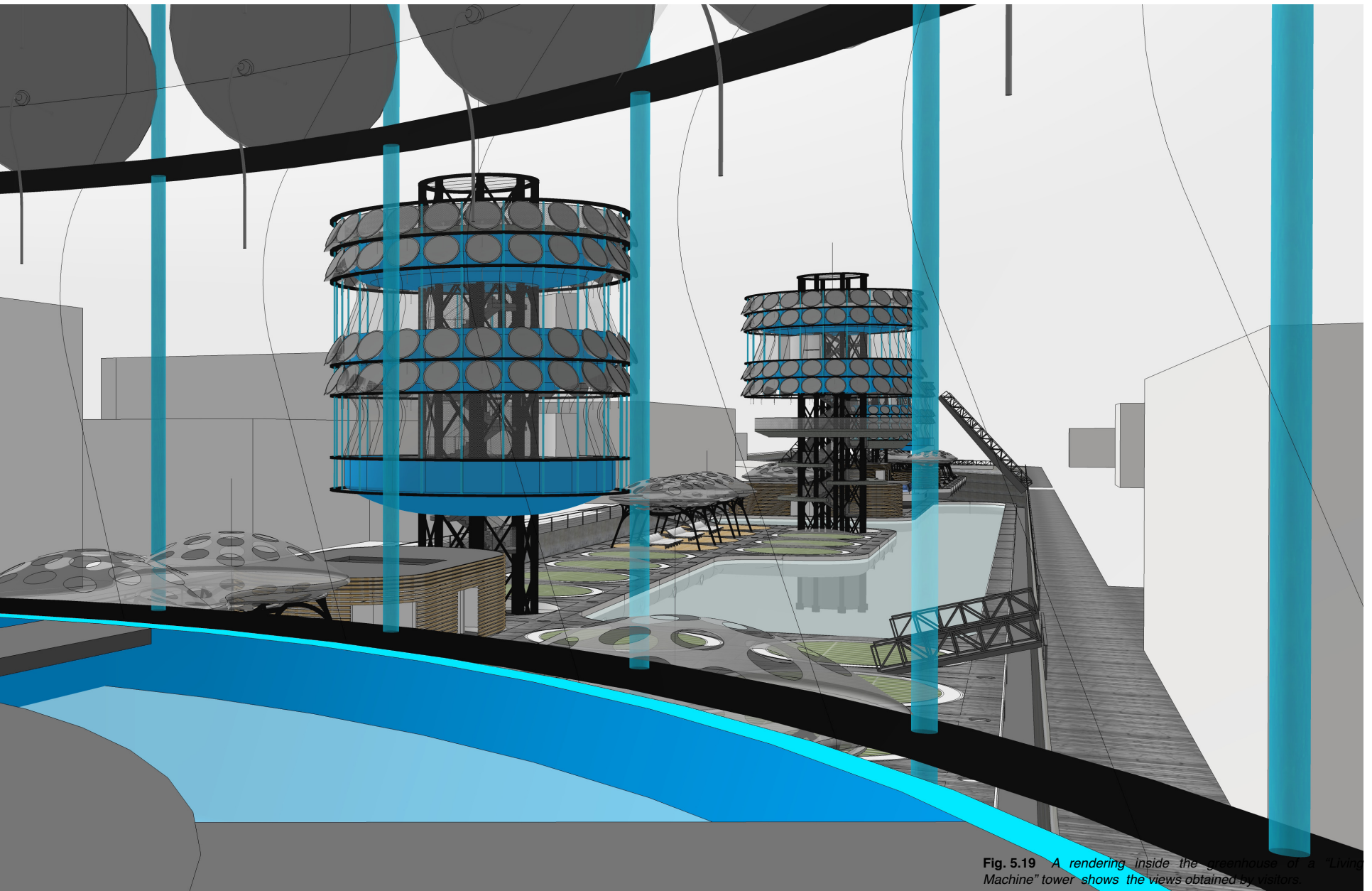


Fig. 5.19 A rendering inside the greenhouse of a "Living Machine" tower shows the views obtained by visitors.

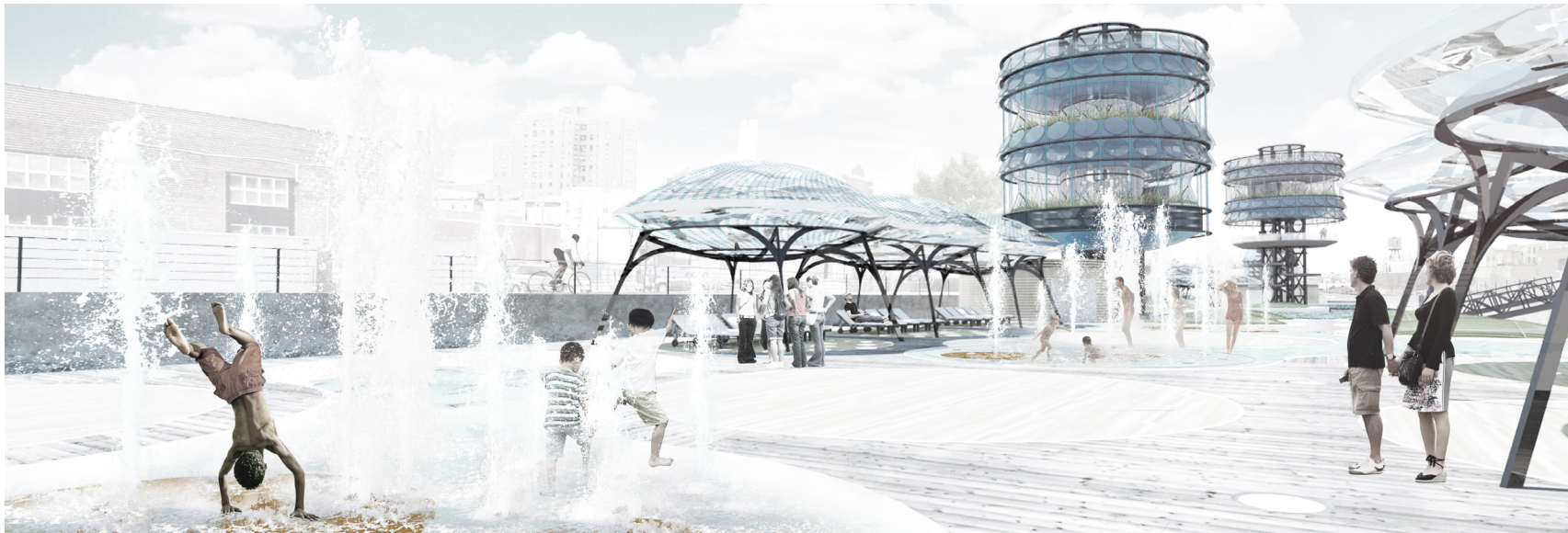
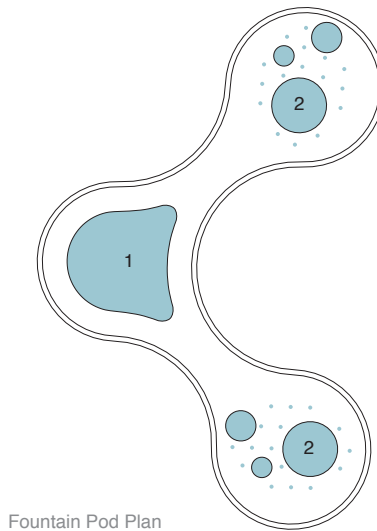


Fig. 5.20 (Above) A rendering of the W.T.R. Park's splash pads demonstrate the system's capacity to engage public interest.

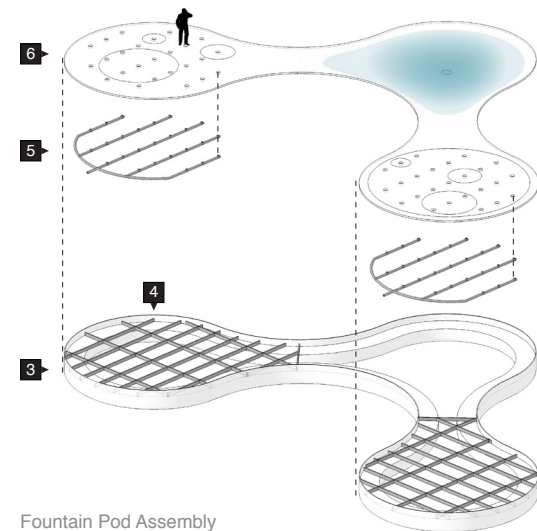
Fig. 5.21 (Below) A diagram of the W.T.R. Park's fountain pods shows how filtered water is distributed through pressurized jets.

Fig. 5.22 (Right) A cross section through the W.T.R. Park's splash pads illustrates the character of the floating public space.

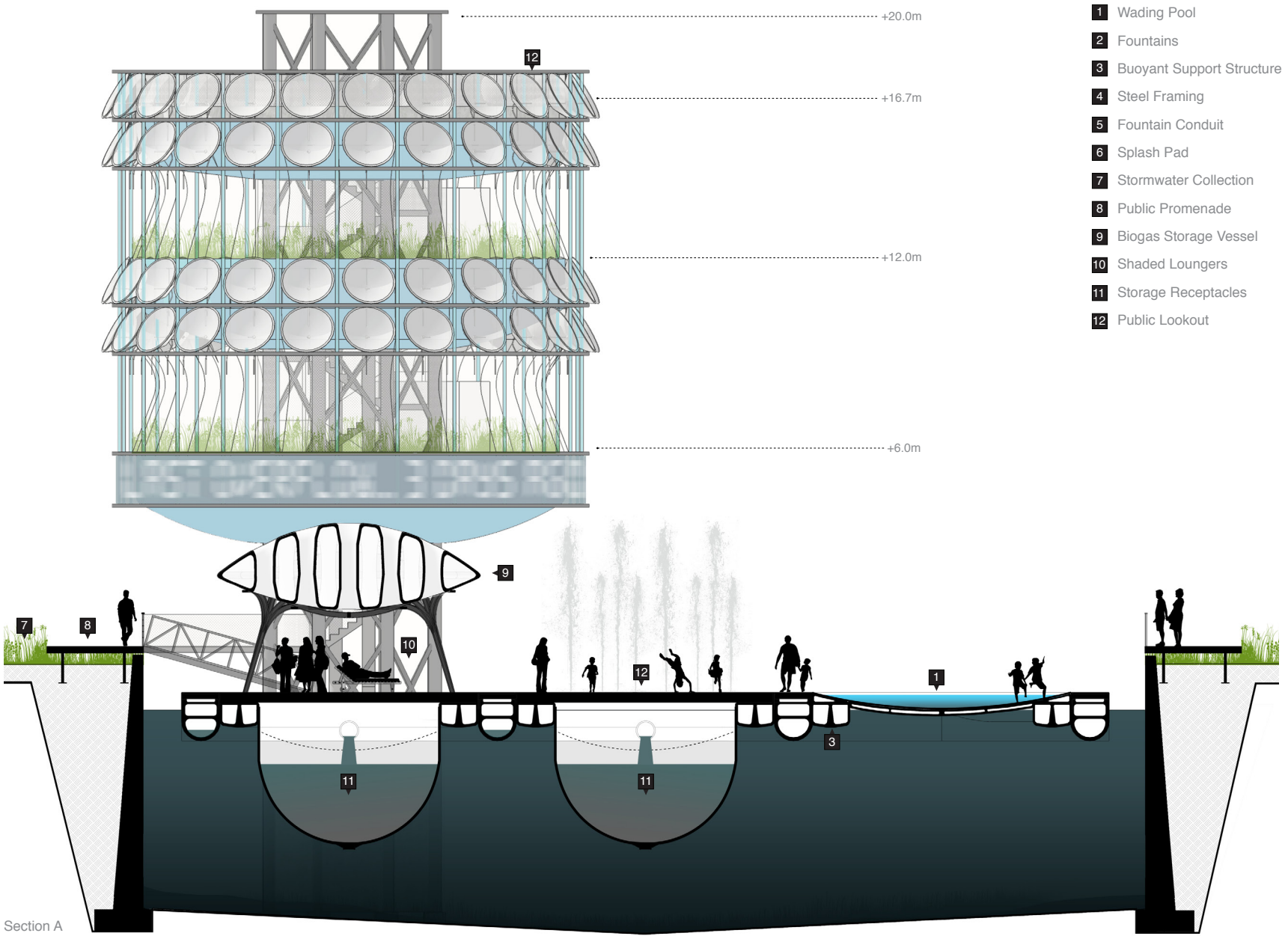
access to the recreational amenities integrated into the floating park. Public fountains and splash pads allow visitors to frolic and play in vertical jets of filtered water (2) which are powered by the potential energy gained from storing the clean water at the top of the towers. After the water is discharged from the fountains, it is collected by a sloped surface and conveyed to shallow wading pools (11) where it slowly drains into the canal below. Since the fountains' water supply is limited they operate for only a few short periods throughout the day. These periods of operation coincide with the completion of a single treatment cycle making the treatment process more visible to the public.



Fountain Pod Plan



Fountain Pod Assembly



- 1 Wading Pool
- 2 Fountains
- 3 Buoyant Support Structure
- 4 Steel Framing
- 5 Fountain Conduit
- 6 Splash Pad
- 7 Stormwater Collection
- 8 Public Promenade
- 9 Biogas Storage Vessel
- 10 Shaded Loungers
- 11 Storage Receptacles
- 12 Public Lookout

Section A

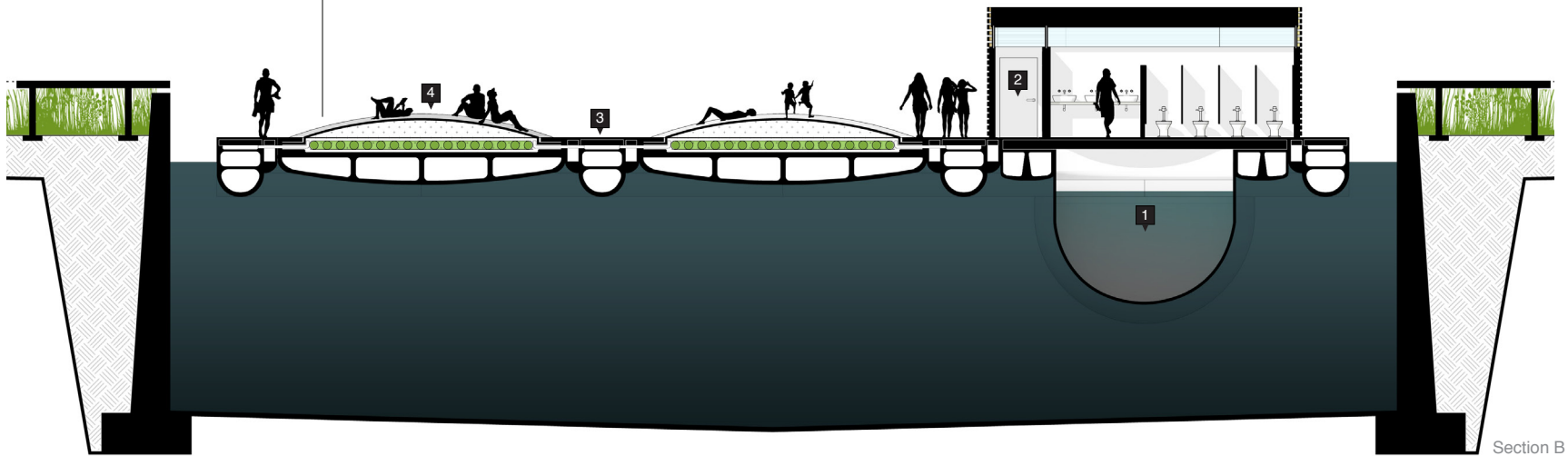
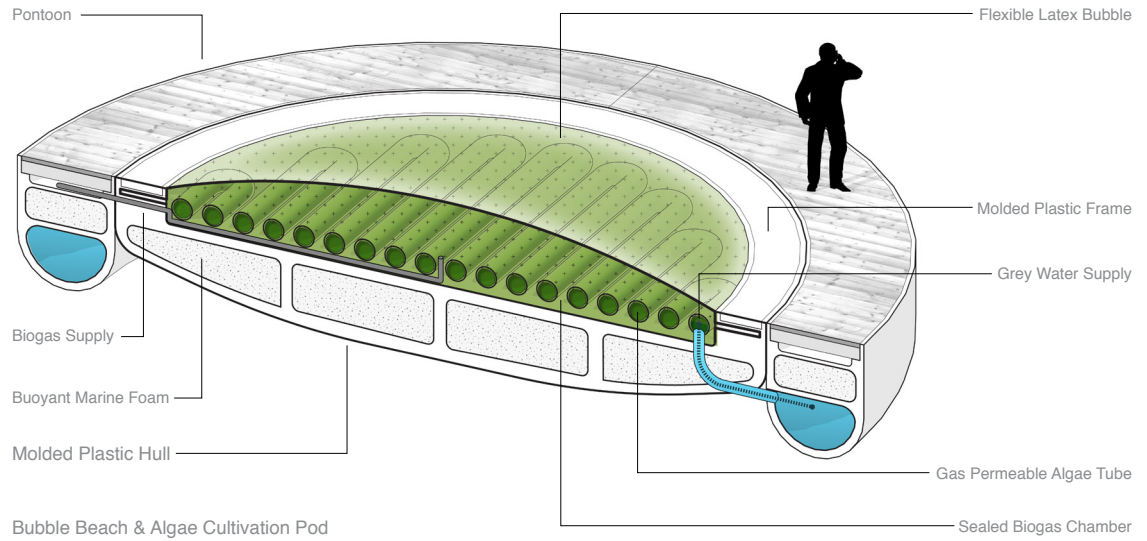
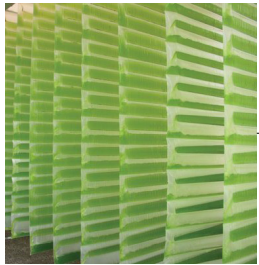
1 Storage Receptacle

3 Pontoon Path

2 Public Washrooms

4 Algae Bubble Pod

Typical Bioreactor



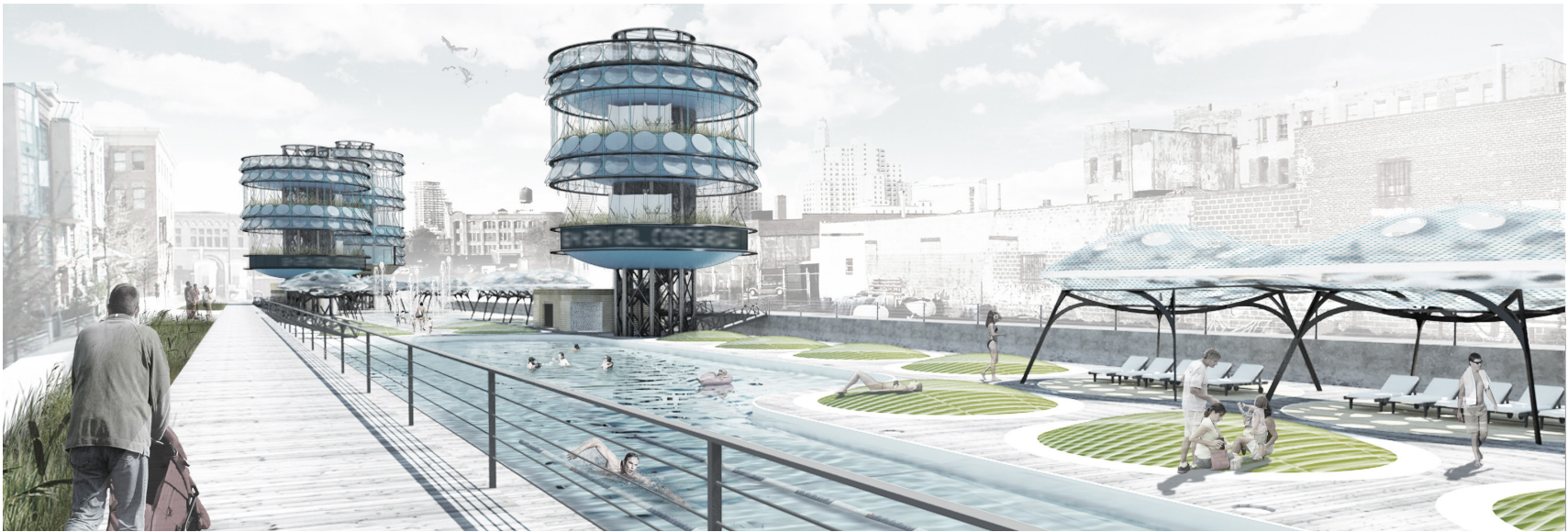
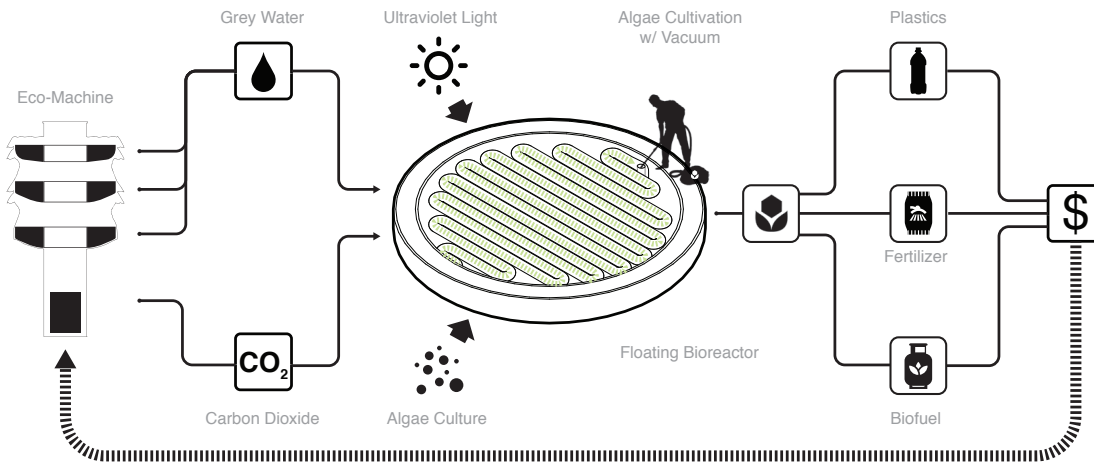


Fig. 5.23 (Left) A cross section taken through the Bubble Beach zone reveals the inner workings of the algae cultivation pods.

Fig. 5.24 (Below) A diagram of algae cultivation process demonstrates how algae is grown, harvested, and sold for income.

Fig. 5.25 (Above) A rendering of the lap pool and bubble beach shows how the W.T.R. Park might be occupied during the summer.



Another recreational amenity is the Bubble Beach. Here circular pods made of flexible latex membranes are filled with warm carbon dioxide gas produced during anaerobic digestion which allow them to function as comfortable spaces for sunning or relaxing. These pods also double as photobioreactors which facilitate the growth of algae. Algal cultures are placed in a long plastic tube at the bottom of the pod where they are provided with nutrient-rich grey water, carbon dioxide, and sunlight. Once the algae has matured it is harvested from the reactors with vacuum cleaners and sold to generate income for funding the ongoing maintenance and repair of both the park itself and the city's sewer system.

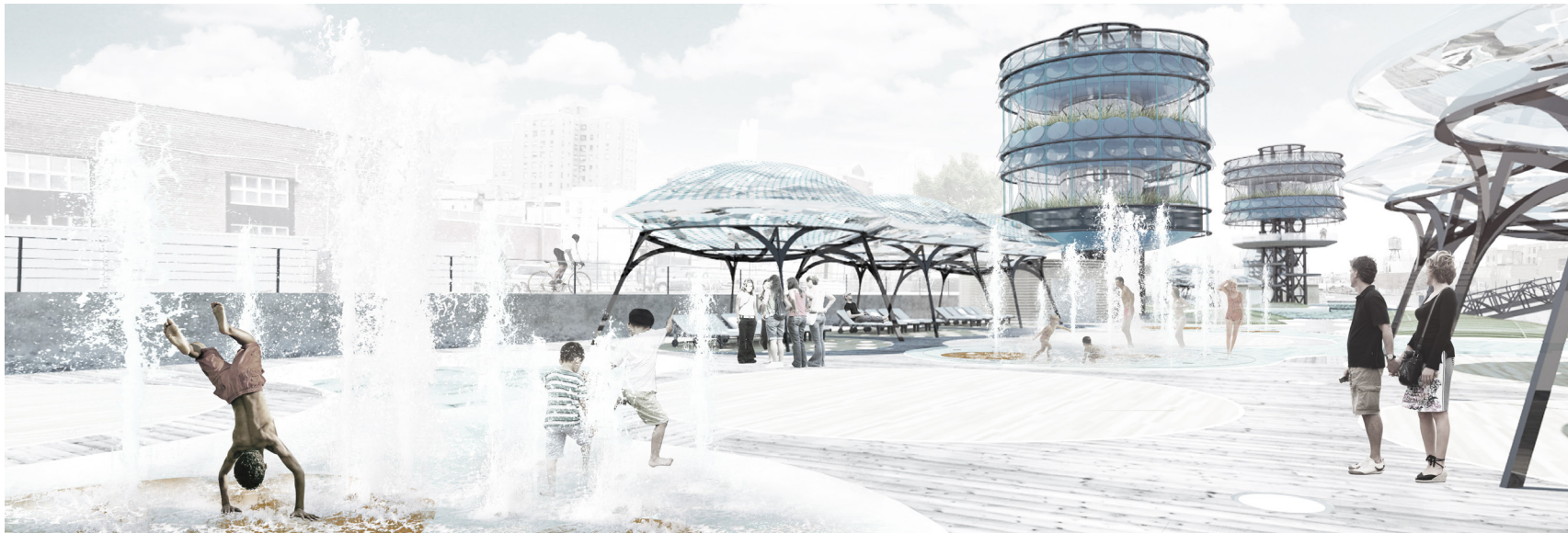
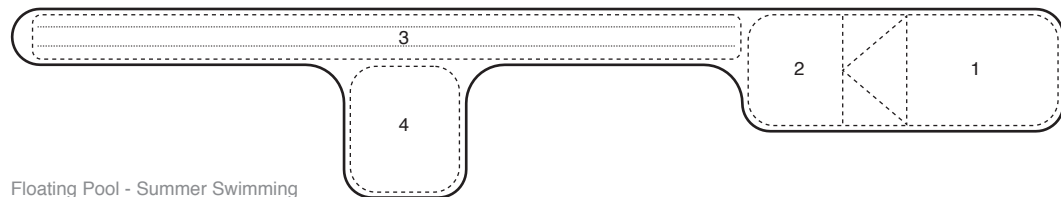


Fig. 5.26 (Above) A rendering of the floating pool illustrates its seasonal use as a floating skating rink during the winter months.

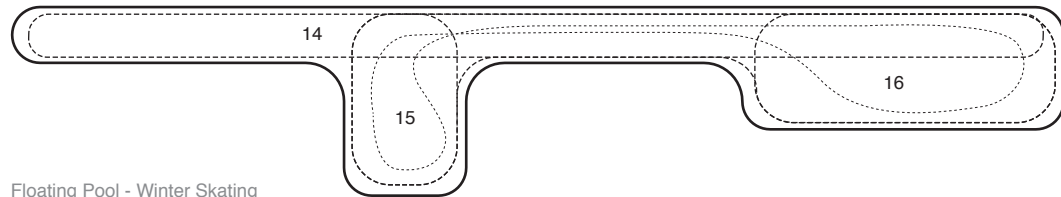
Adjacent to the Bubble Beach is a large swimming pool. The pool is supported by floating pontoons and is equipped with a membrane that hangs below the surface of the water to separate clean swimming water from the water in the canal. The pool itself is comprised of a 100m lap pool, a shallow wading pool, and a 5m diving pool. In the winter a membrane can be pulled over the top of the pool which allows its surface water to freeze so that it can be used as a public skating rink (Figure 5.26). Along the pool biogas storage vessels double as shade structures providing sheltered poolside spaces where visitors can lounge. Here towers are integrated with diving and viewing platforms for public use.

Fig. 5.27 (Below) Two diagrams show the various elements of the floating pool and their respective seasonal uses.

Fig. 5.28 (Right) A cross section through the diving pool demonstrates how the adjacent tower facilitates diving spectating.



Floating Pool - Summer Swimming



Floating Pool - Winter Skating

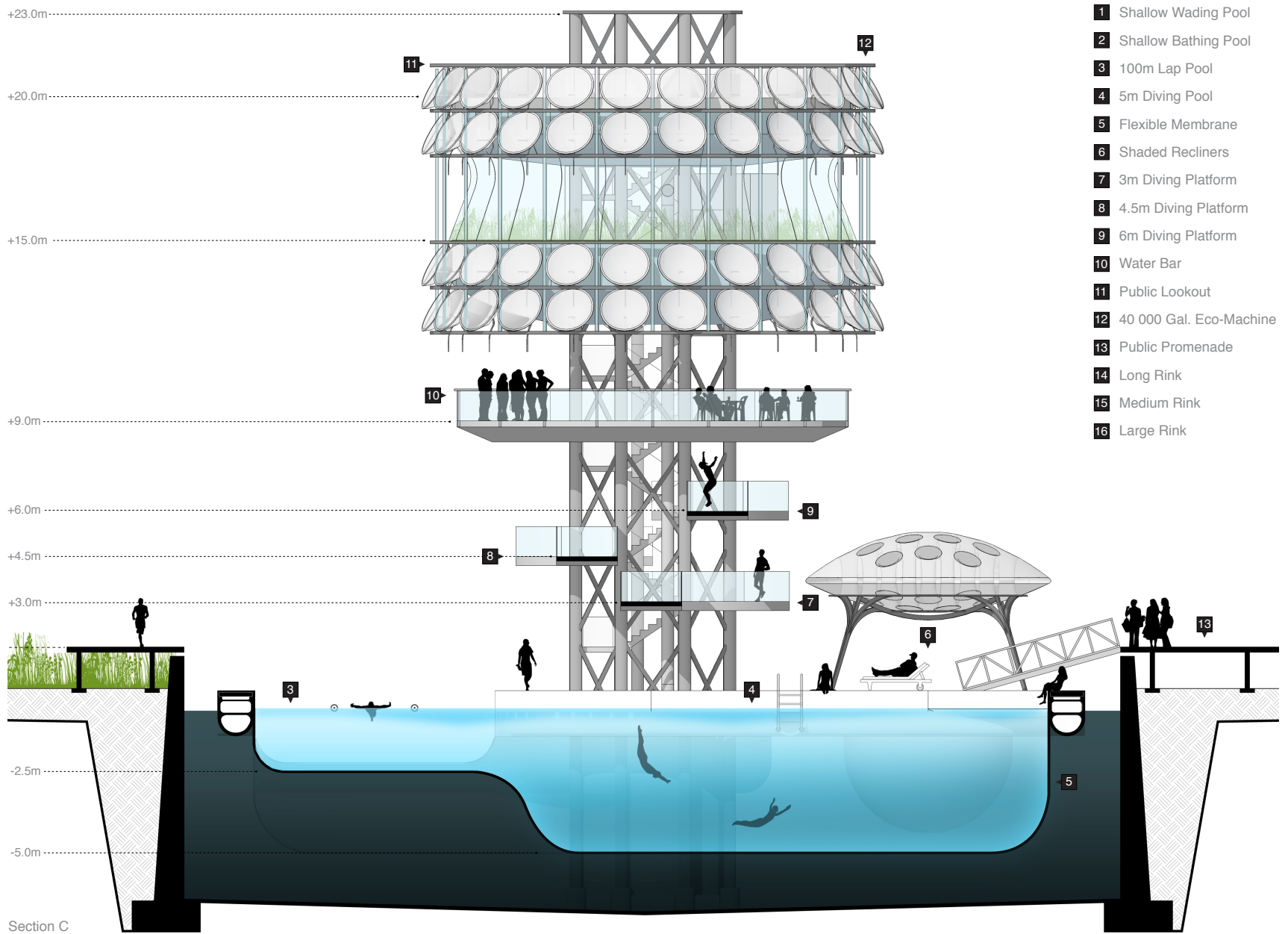




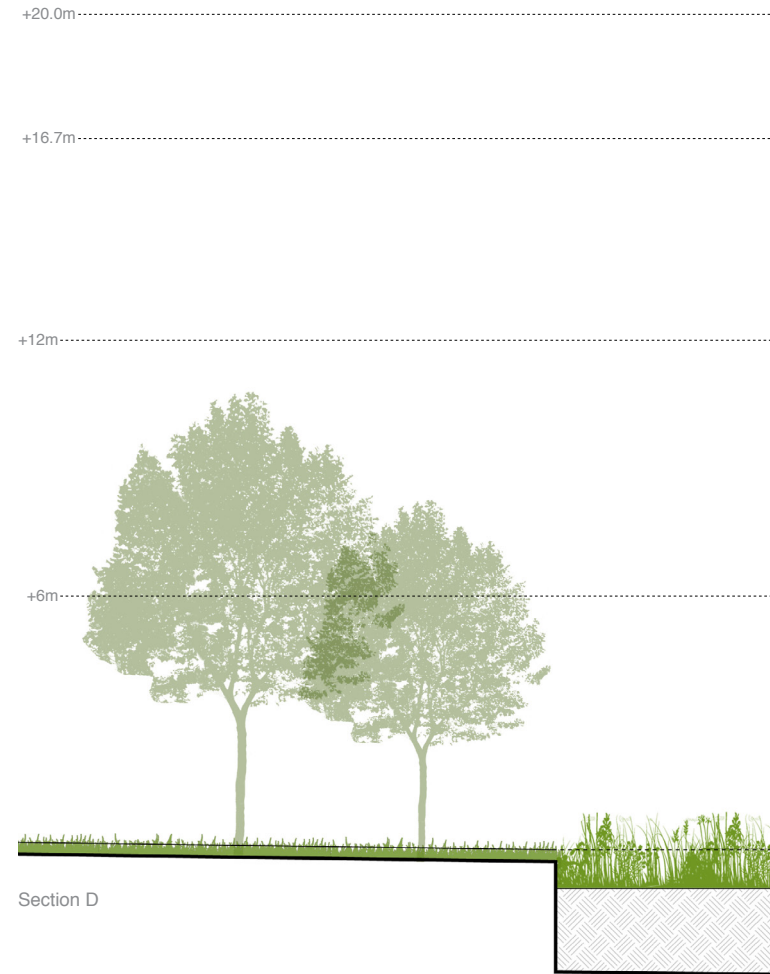


Fig. 5.29 A view south from the Gowanus' Union Street Bridge shows the W.T.R. Park's relationship with the surrounding fabric.



Fig. 5.30 (Above) A rendering of the public gym illustrates the panoramic view the Gowanus that can be obtained from inside.

Past the lap pool is the leisure park where the local program and amenities are oriented toward those who are looking for an experience similar to a day at the spa. This part of the park is accessed by a central tower that contains a public gym at its first level. Here visitors can enjoy panoramic views of the surrounding landscape and the rest of the park while engaging in a number of different exercise activities. This gym is also equipped with showers and washrooms which receive a constant supply of water from the living machines above. The gym can be accessed throughout most of the day and night with the use of a key card that can be purchased by the user thus generating income for the park.



Section D

Fig. 5.31 (Right) A cross section through the Liesure Zone reveals a public gym integrated into the first level of the tower.

- | | |
|--------------------------|--------------------------|
| 1 Public Access Bridge | 6 Washrooms |
| 2 Public Access Stair | 7 Public Lockers |
| 3 Public Gym | 8 Eco-Machine Greenhouse |
| 4 Change & Shower (Wmns) | 9 Elevated Yoga Platform |
| 5 Change & Shower (Mns) | 10 Floating Thermal Pool |

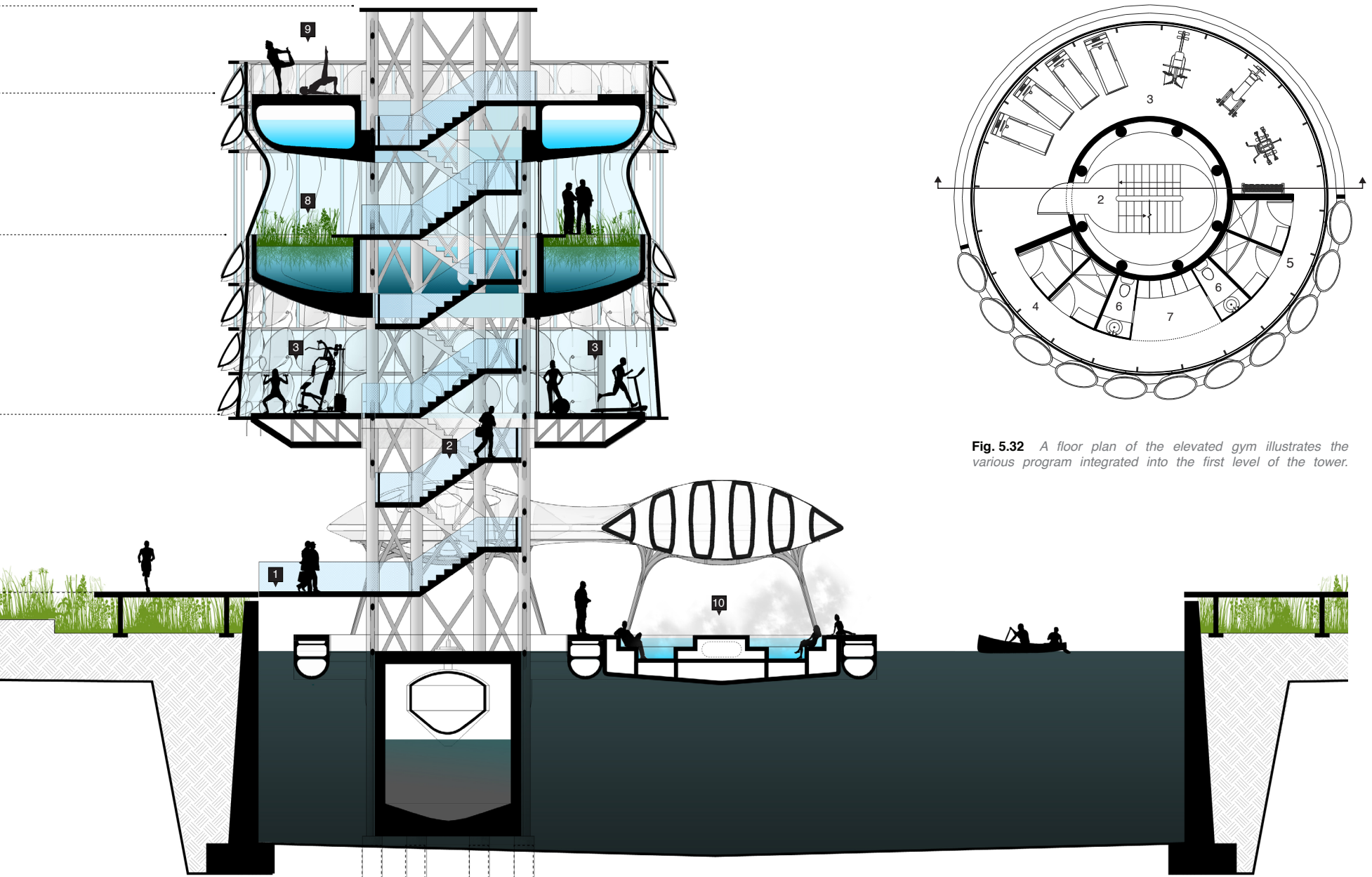


Fig. 5.32 A floor plan of the elevated gym illustrates the various program integrated into the first level of the tower.

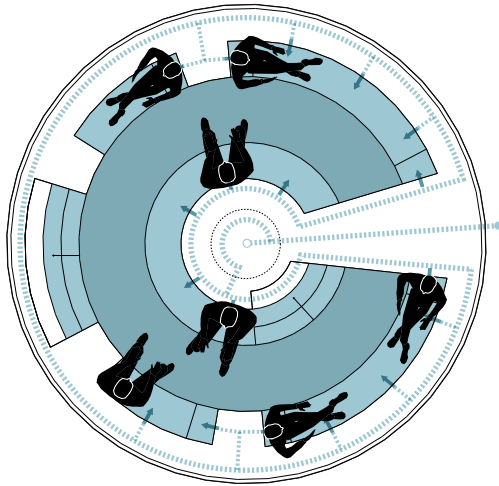


Fig. 5.33 (Above) Diagrams of the thermal pool illustrate how it functions and how it can be occupied in a number of different ways.

In addition to the gym, the public can choose from three other amenities. First, there are the floating thermal pools. Here visitors can submerge themselves in hot water that ranges from 40 to 50°C while they seek shelter from the elements under the warm biogas storage vessel that floats above. This vessel also serves as the main source of fuel for the water heaters integrated into the centre of the pool which heat filtered water from the adjacent towers and distribute it into the pools via pressurized jets integrated into the seating. Each pool offers a number of different seating positions and is designed to accommodate up to 20 adults. The configuration of the seats allows for a variety of social interactions among the users.

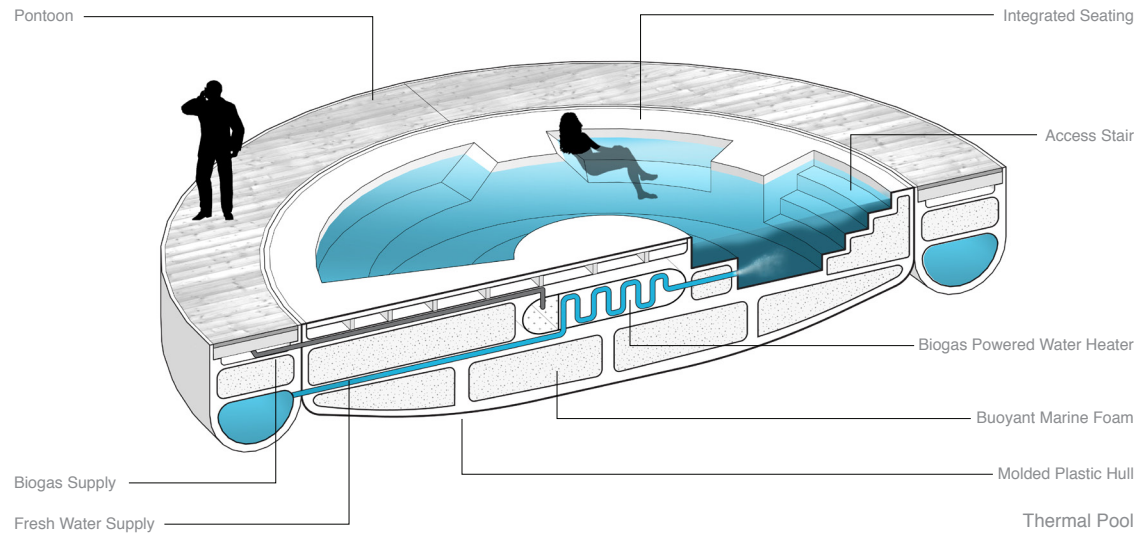
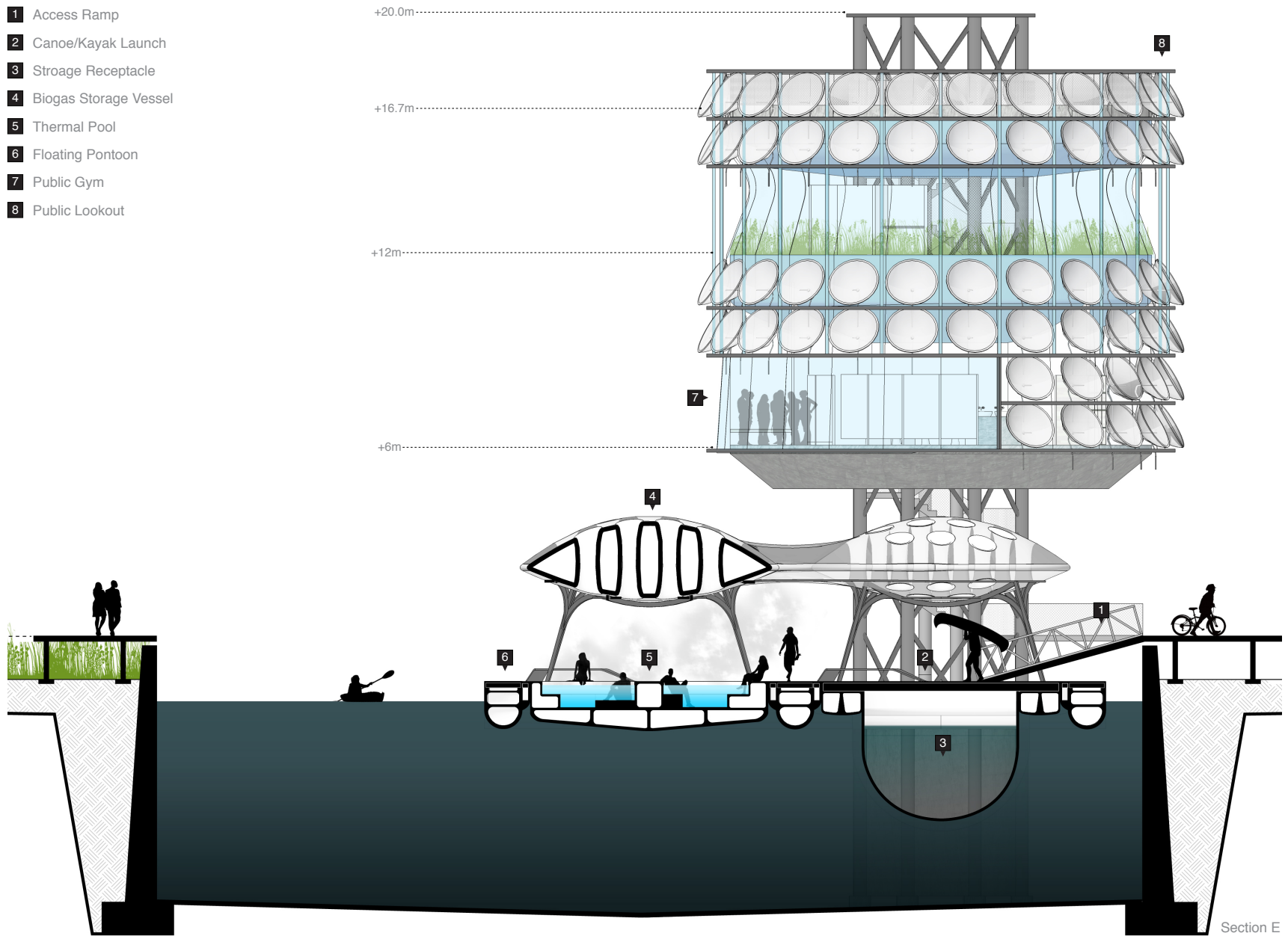


Fig. 5.34 (Below) A rendering of the thermal pools shows the multifunctionality of the W.T.R. Parks infrastructural elements.

Fig. 5.35 (Right) A cross section through the thermal pools illustrates how this region of the W.T.R. Park might be occupied.



- 1 Access Ramp
- 2 Canoe/Kayak Launch
- 3 Storage Receptacle
- 4 Biogas Storage Vessel
- 5 Thermal Pool
- 6 Floating Pontoon
- 7 Public Gym
- 8 Public Lookout



Section E

- 1 Distribution Pontoon
- 2 Floating Thermal Wetland
- 3 Integrated Public Bench
- 4 Sauna Water Supply
- 5 Buoyant Hull
- 6 Sauna Entrance
- 7 Hot Water Storage
- 8 Hearth
- 9 Biogas Supply
- 10 Glass Roof
- 11 Wood Privacy Screen
- 12 Sauna Exhaust



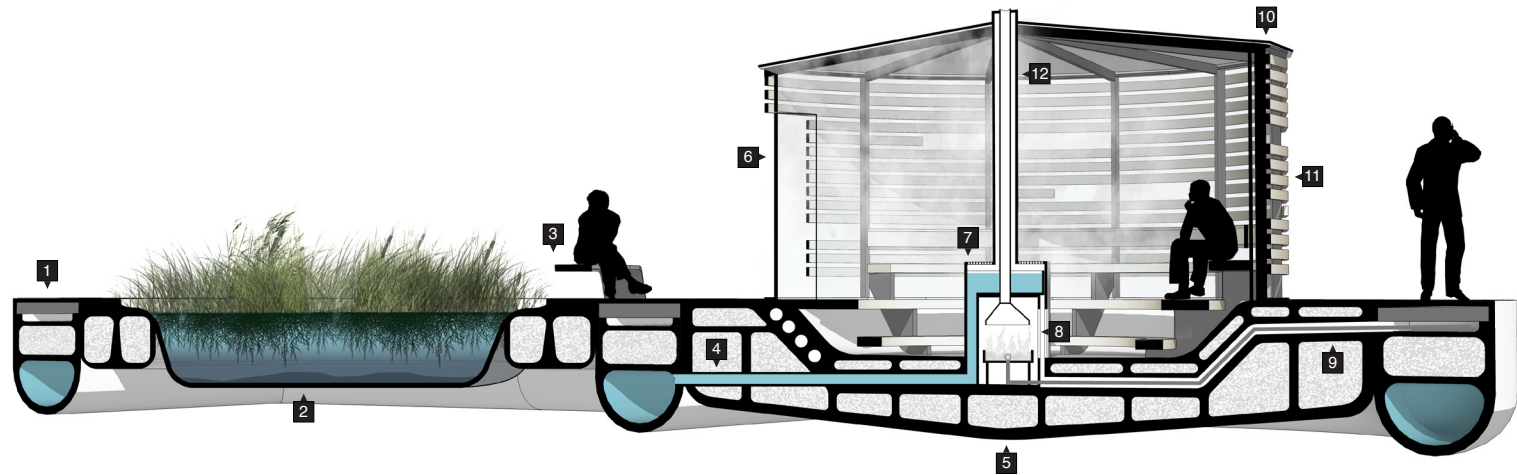


Fig. 5.36 Plan and longitudinal section of the Waste to Resource Park highlighting public program.

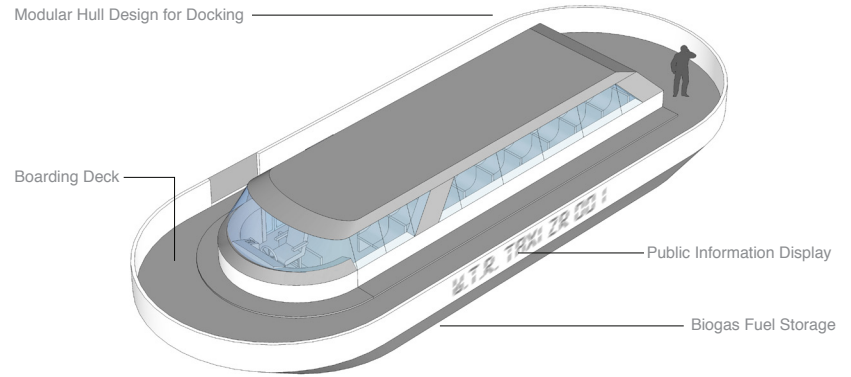
Fig. 5.37 Plan and longitudinal section of the Waste to Resource Park highlighting public program.



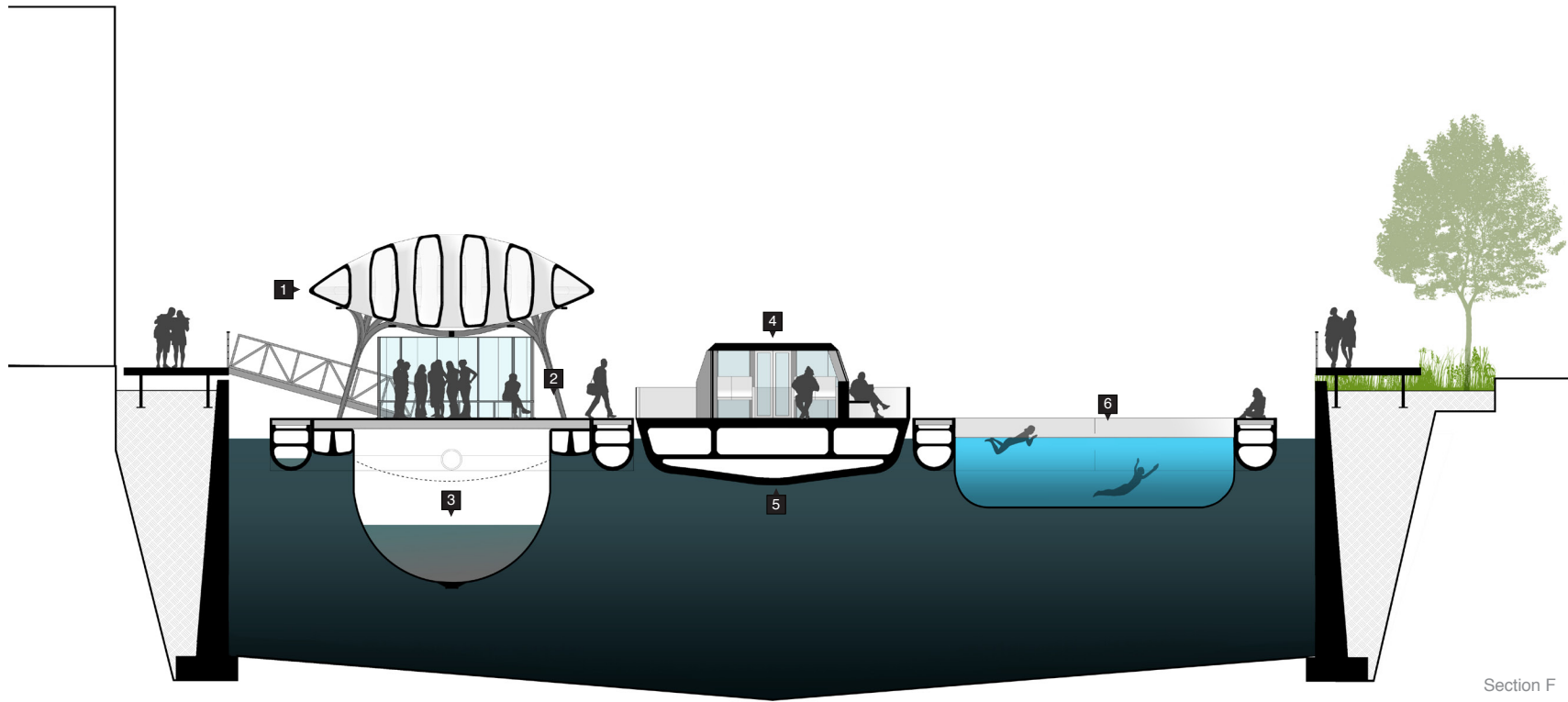
In addition to the thermal pools, this region of the W.T.R. Park contains floating saunas where visitors can seek refuge from the elements and immerse themselves in a cloud of hot steam created when fresh water from the living machines is heated by a biogas stove in the middle of the pavilion. The pavilions themselves are comprised primarily of glass and clad with a timber screen which provides a small level of privacy while still leaving much of the interior visible from the outside. The sauna pods are open and available for use only during certain times of the day for safety reasons. They can be accessed by a swipe card and the income generated from membership sales creates a source of funding to maintain the park.

Dispersed among the thermal pools and saunas are the thermal aquatic gardens. The flexible membrane that makes up the pods contains both the warm, nutrient-rich grey water produced by the park's living machines and shallow water aquatic plants. The combined elements make for living pods which have their own microclimate. The warmth of the pods not only provides a unique ecosystem for local aquatic species such as frogs, insects, and birds, but also serve as spaces around which visitors can gather for warmth. Benches are also integrated into the perimeter of each garden pod which allows visitors to sit next to the warm tranquil gardens and observe the public and ecological activity around them.

- 1 Biogas Storage Vessel
- 2 Ferry Stop/Shelter
- 3 Storage Receptacle
- 4 Gowanus Water Taxi
- 5 Fuel Storage/Hull
- 6 100m Lap Pool



Commuter Ferry



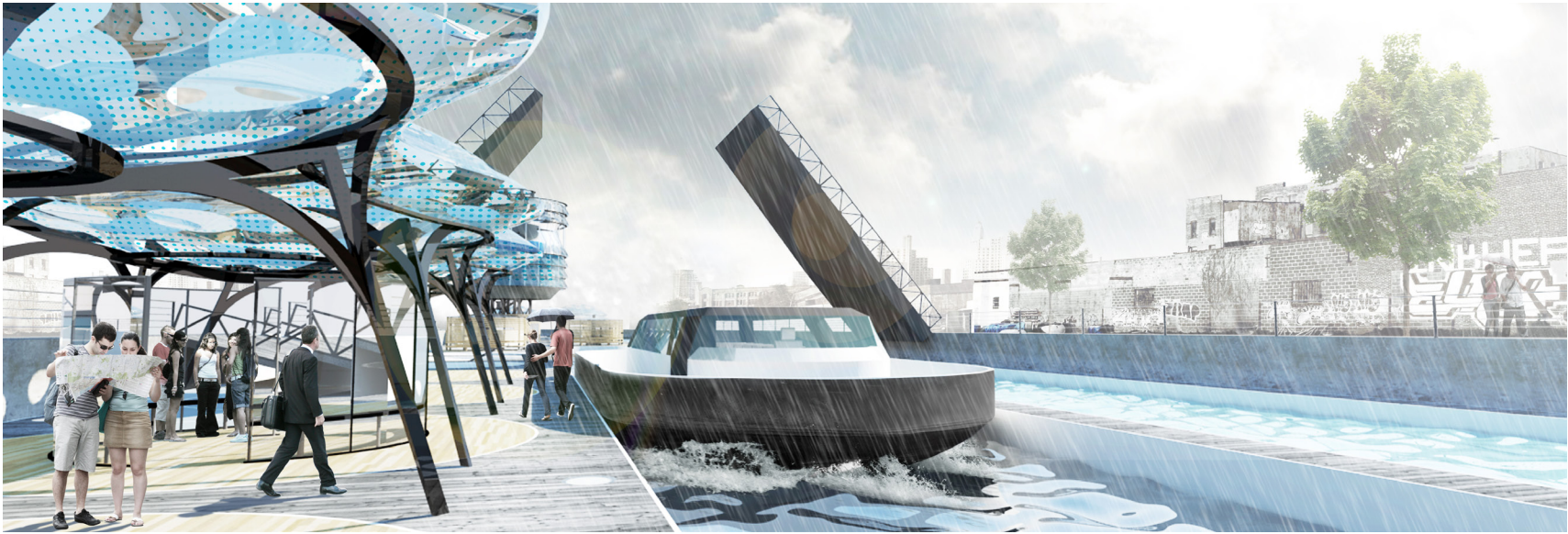
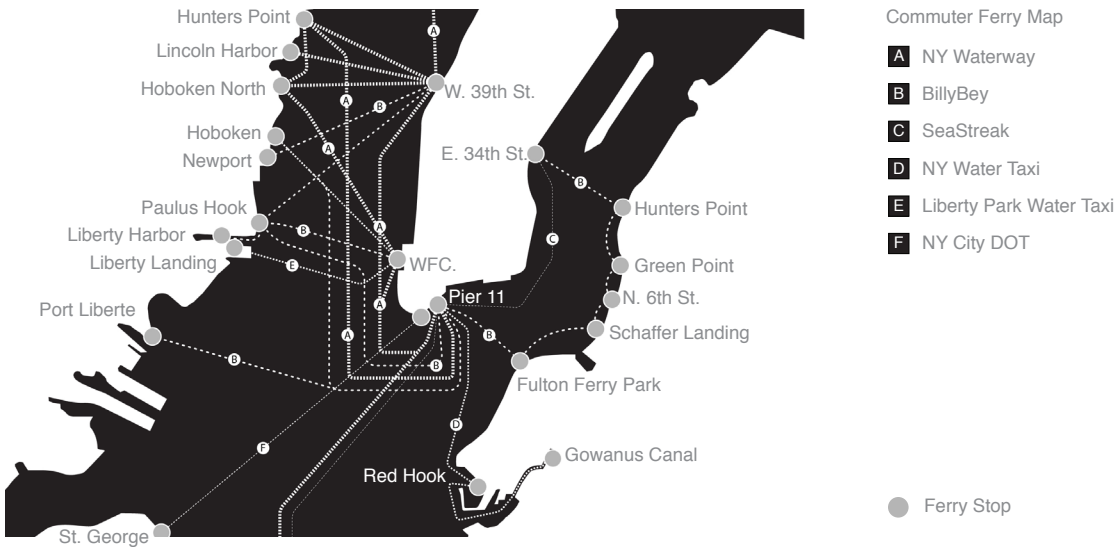


Fig. 5.38 (Left) A cross section through the Commuter Zone illustrates how the ferry docks within the W.T.R. Park.

Fig. 5.39 (Below) A map of New York City's ferry system shows how the Gowanus' new ferry is connected to a larger network.

Fig. 5.40 (Above) A rendering of the W.T.R. Park's integrate ferry stop illustrates how the biogas storage vessel doubles as a shelter.



Finally, joining the recreation and leisure zones is the the commuter hub where the W.T.R. Park's floating pontoons serve as a docking structure for a modular watercraft which is part of a newly proposed aquatic transportation network for the Sixth Borough. The watercraft itself is fuelled by the biogas generated from the treatment of ewage. A biogas storage vessel located adjacent to the docking area serves as a fueling station where gas can be transferred from the floating park into the boat's fuel tanks. This storage vessel also creates a sheltered area where commuters can store their bicycles or seek refuge from the elements while they await the arrival of their ferry.

When the W.T.R. Park at the northern end



When the W.T.R. Park at the northern end of the canal proves successful and the city gains public interest in the continued development of infrastructure along the waterway, additional parks could be added to the Gowanus' remaining outfalls. Since these parks can be purchased as smaller kits, this expansion could occur gradually, making renovations more cost effective over time. Towers might be purchased at first, or maybe just storage receptacles. Then, as the need for public programs becomes apparent, reuse pods can be added. Figure xx illustrates what the final outcome of this expansion process might be proposing the Gowanus as a testing ground where all the different typologies of W.T.R. Parks can be piloted

and then evaluated on their success or capacity to generate public interest and revenue. As a result, the proposal calls for the development of both Production and Habitat Parks. The Production Park is positioned in the middle of the canal where it would serve the residential neighbourhoods to its north and south as a floating hydroponic market garden which facilitates the growth of vegetables and fish with the nutrient-rich grey water it produces while processing sewage. The Habitat Parks would be deployed at the southern end of the Gowanus where the fabric is primarily comprised of industry and the waterway is used by residents for fishing and canoeing. Each of the said parks would also function as ferry stops that provide more

local access to the new waterborne transportation network and facilitates a link between the different parks dispersed along the canal. These separate parks would also support a canoe-share program that would allow the public to rent and canoe from one park and paddle it to another. In addition to all of this, the plan also proposes that a vacant industrial building located in the middle of the canal be redeveloped into a factory where W.T.R. Park components are manufactured and assembled. In this way the redevelopment of the Gowanus canal would also serve as a catalyst for the development of the Sixth Borough as the W.T.R. Park system is put into full production and constructed in other regions throughout the harbour.

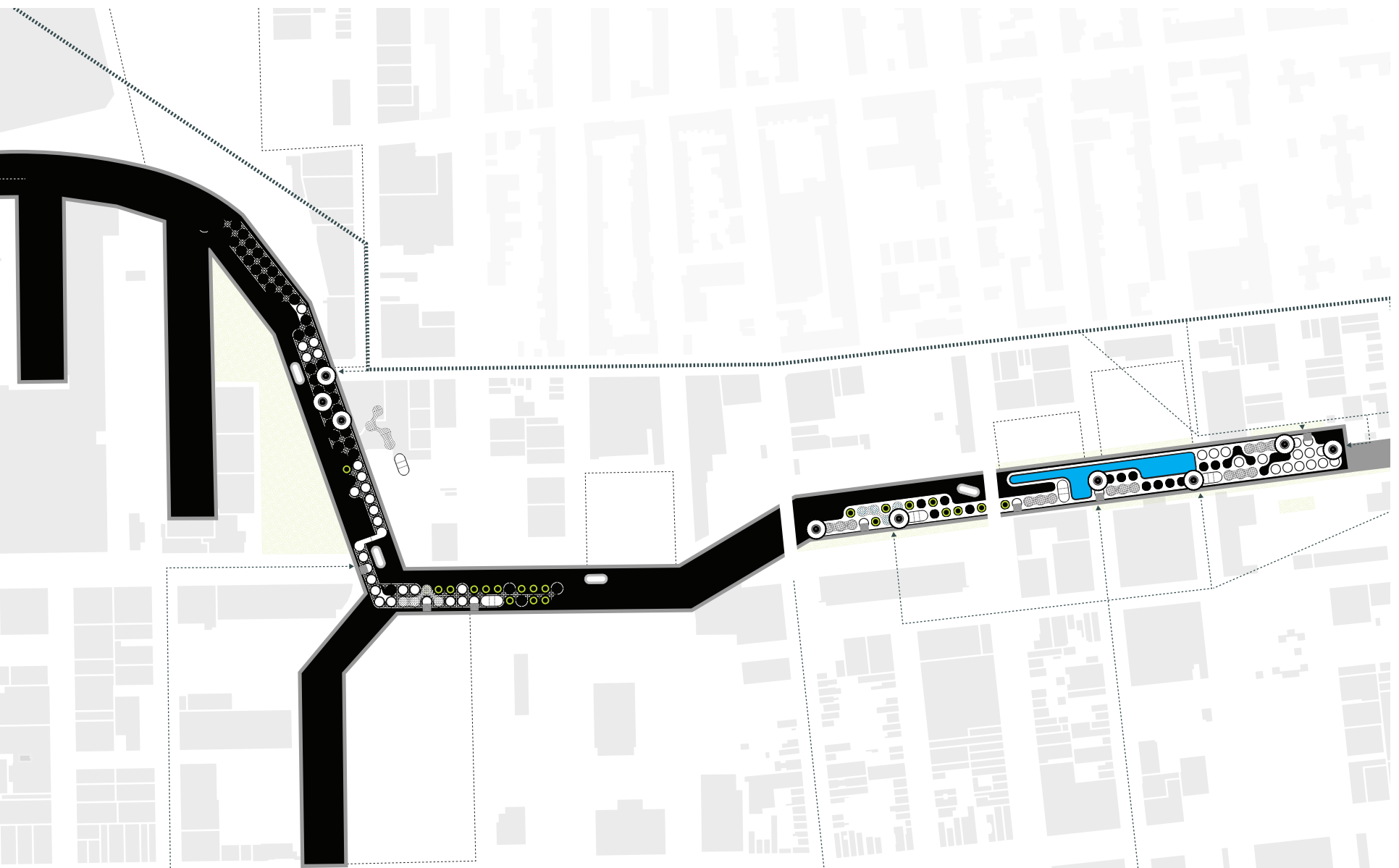


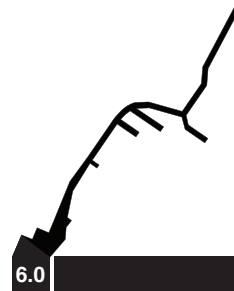
Fig. 5.41 A masterplan of the Gowanus Canal illustrates the potential for the W.T.R. Park system to be deployed along the canal.





Fig. 5.42 A rendering of the Gowanus W.T.R. Park at night.





6.0

Conclusion



Fig. 6.0 *A rendering of the W.T.R. Park's integrate ferry stop illustrates how the biogas storage vessel doubles as a shelter.*

6.0 Building the Borough

“Although the interdependence between infrastructure and urban development has been a central topic in urban planning, infrastructure plays a comparatively subordinate role as a design element.”¹

Volker Kleinekort, *Infrastructural Urbanism*

With 27 billion gallons of sewage spilling into the New York Harbor every year, the success of waterfront revitalization in New York City is completely dependent upon improving the performance of the region's overtaxed sewage network. In recognition of the role wastewater infrastructure will play in reconnecting New

¹ Hauck, Thomas, Regine Keller, and Volker Kleinekort. *Infrastructural Urbanism: A New Approach to Urban Design*. Berlin: DOM Publishers, 2011. Print.

Yorkers with their fouled waterways, REvision 2020 has positioned New York City's polluting sewer system at the the centre of design investigation with the intention of generating a more robust paradigm of infrastructural development to catalyze and sustain urbanization in the Sixth Borough. In doing so the document has challenged conventional approaches to urban planning that have limited the design of infrastructure to solving utilitarian problems and explores the need to replace crumbling and ineffective systems as an opportunity to confront larger social, economic, and environmental matters underlying the post-industrial renewal of the North American city. With the information gathered from this investigation,



Fig. 6.1 A photograph taken on the banks of the Gowanus Canal shows the present hazards of combined sewer overflow.

REvision 2020 has provided greater insight into the fiscal and political challenges New York City faces in keeping its harbour clean and determined that the key to addressing these challenges is securing long-term public interest in maintaining the city's sewer system. With this insight, the research has presented the principle strategies of decentralization, integration, productivity, legibility, and multi-functionality as a means of renegotiating the form and performance of the city's wastewater infrastructure to catalyze a much larger and more visible public benefit in pursuit of generating interest. These five strategies were subsequently synthesized into the design of the W.T.R. Park and tested on their capacity

to address two primary challenges confronted in the development of the Sixth Borough.

Increasing public awareness about combined sewer overflow and the need to upgrade New York City's sewer system will also play a fundamental role in convincing the New Yorkers to invest in wastewater infrastructure. As a legible and inhabitable infrastructure that displays the collection and treatment of combined sewer overflow at the source of its discharge, the W.T.R. Park system acts to inform the public of the role it plays in keeping their waterways clean and educates taxpayers about the importance of urban wastewater management. In addition, the system's iconic form marks the location of outfalls along

the shore indicating the harbour's connection to the city's sewers reminding the public of the need to mitigate overflow. In this way the system serves as joins the city's ubiquitous water towers in providing a physical trace of the city's hidden waterworks. Finally, as a decentralized infrastructure, the W.T.R. Park collects and treats sewage locally which not only allows the public to see how the system benefits them personally but makes the benefits of investing in wastewater infrastructure more visible to taxpayers.

Finding ways to catalyze a larger more immediate public benefit through infrastructural spending is also a major concern when it comes to convincing the public to support municipal spending



Fig. 6.2 (Above) A rendering of the W.T.R. Park's integrate ferry stop Illustrates how the biogas storage vessel doubles as a shelter.

on infrastructure in the Sixth Borough. As an integrated and multifunctional, infrastructure that is inhabitable, aesthetically pleasing, that fulfills the need for amenities, open space, transportation, and new jobs along the waterfront, the W.T.R. Park is capable of addressing this concern by making a more meaningful social contribution to the city and the public sphere which makes it a more valuable municipal investment. The system's legible components also allow it catalyze a larger visible benefit by serving as a physical manifestation of tax dollars at work and by making a formal and aesthetic contribution to the urban waterfront. In addition, the system's capacity to be productive also allows it to make a larger contribution to

the city by allowing it to contribute valuable resources to the public sphere that can be directly used by taxpayers or sold to generate municipal income. In this way the W.T.R. Park is capable of giving back to the city and its public sphere. Finally, as a decentralized system comprised of small modular components, that can be easily assembled and plugged into the existing sewer grid, the W.T.R. Park expedites the the process of infrastructural renovation making the benefits of such an enterprise much more immediate.

With all of the benefits and opportunities that have emerged from the design of the W.T.R. Park system, the author would like to acknowledge that there are a number of challenges that the

conceptual proposal must address before it can be realized. Though a great deal of consideration was made for how the system would operate, there is still a great deal of number crunching that needs to be done to determine if the parks are capable of generating enough water and biogas to facilitate the proposed uses. In addition to this, further investigation would need to be put into the proposed systems and technologies to ensure that they are capable of performing their prescribed task. A technology of particular concern would be the algae bioreactors, as these are derived from a technology is stil being tested in NASA laboratories. Given the limitations of the author's own field of study, the design of the W.T.R. Park

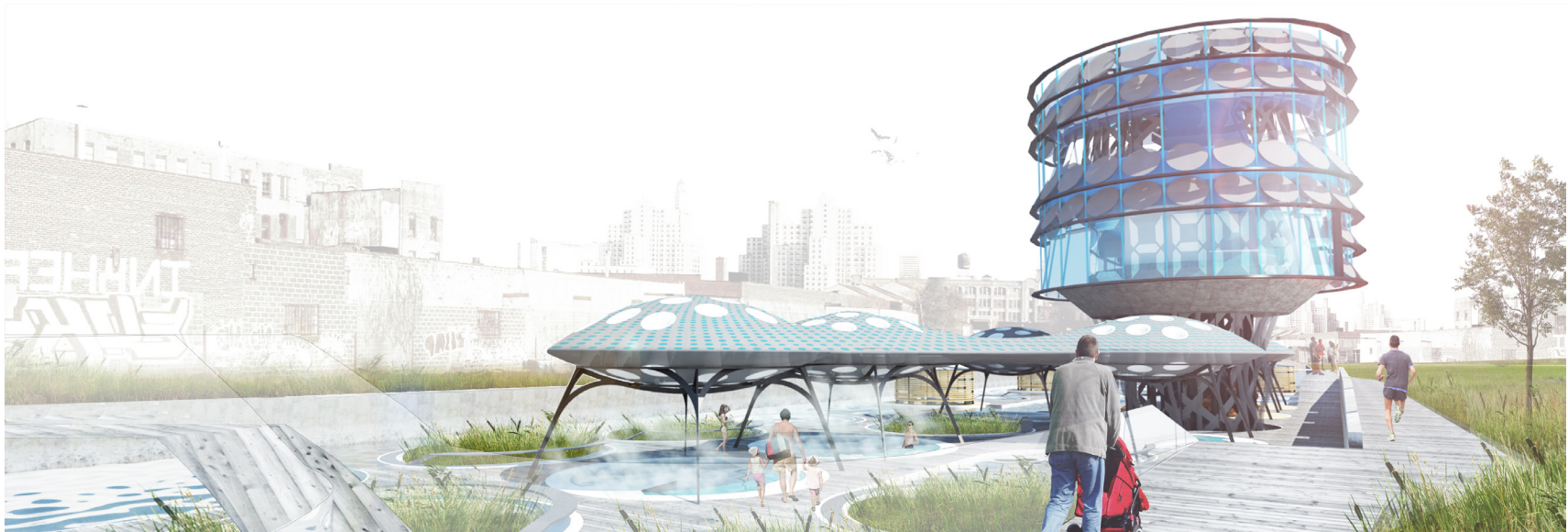


Fig. 6.3 A rendering of the Gowanus W.T.R. Park demonstrates how the new infrastructural system operates as an iconic

system could benefit greatly from the contributions of other fields of science and engineering. With this in mind, an interdisciplinary approach to further design phases would be necessary.

The idea of implementation also raises questions about the seasonality of the W.T.R. Park. Though the scheme did offer some insight into how the infrastructure would be occupied at all times of the year, these propositions were largely based on the idea that the effluent discharged from the living machine would be warm enough to avoid freezing. Certain uses would also be limited in the winter months however the ease with which the system can be disassembled and reconfigured provides opportunities for the program of the

parks to be changed during different periods of the year. This approach would require further investigation to determine its plausibility.

Since the W.T.R. Park's ability to catalyze a larger public benefit is linked to recycling wastewater as a public resource, the success of the system would be challenged by contemporary policies and stigmas related to the reuse of sewage. While the idea of swimming in a floating swimming pool of recycled sewage may be unappealing to many people and be scorned by the city's public health and safety board, projects such as the Emscher River Community garden in Germany that recycles sewage into drinking water provides evidence of how a project like the W.T.R

Park could work. While this notion will not be enough to change the opinion of policy makers, the W.T.R. Park could be implemented on a small scale much like the community garden which would allow it to be validated through demonstration.

While all of these challenges present hurdles in the process of implementing the proposal, they can all be addressed through additional design and development phases where systems, technologies, and performance are tested through the construction of a pilot project in the harbour. With this in mind, the next step in pursuing the paradigm of infrastructural development proposed in REvision 2020 is to expand the the construction of W.T.R. beyond the limits of the Gowanus Canal

- ⊕ Tier 3 C.S.O.
- Typical C.S.O.
- Waterfront Parks
- = 1 Billion Gallons
- - - Sewersheds

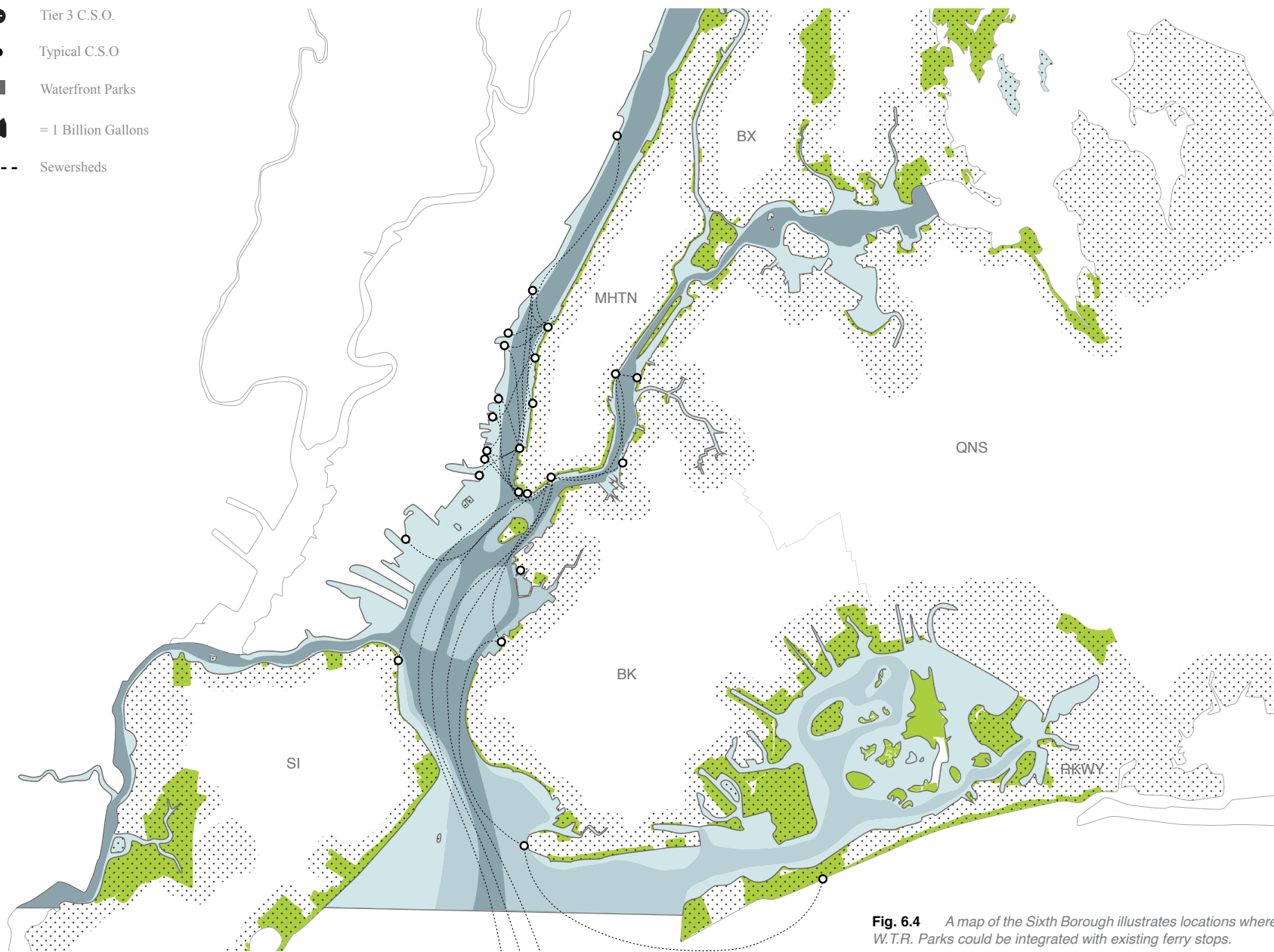


Fig. 6.4 A map of the Sixth Borough illustrates locations where W.T.R. Parks could be integrated with existing ferry stops.



Fig. 6.5 *An aerial photograph of the East River shows the waterway as the connective tissue between the urban fabric.*

and into other regions of the New York Harbor. With 450 combined sewer outfalls located along the city's 500 miles of urban waterfront, outfitting all of them with W.T.R. Parks is an impossible task so with this in mind, choosing specific locations for implementation requires a strategy that considers the larger objectives of the systems design. The W.T.R. Park system is not proposed as a supplement to the city's existing wastewater infrastructure but rather as an upgrade that can improve the social performance of the of the larger sewage network by operating as the public interface of the invisible systems that are unable to attract public investment. With this in mind it would be most beneficial to construct W.T.R. Parks

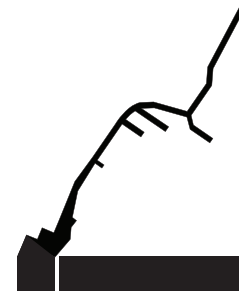
at locations where there is a great deal of public activity to maximize the number the system's effect and also its capacity to be used. REvision 2020 proposes that these locations be existing ferry terminals which would ensure that the parks are well connected to public transit, and regularly used. Placed at these locations, the parks would serve as didactic installations that precipitate awareness and interest by engaging New Yorkers in the enterprise of water pollution control.

Given the W.T.R. Park's capacity to address all of the challenges the Bloomberg Administration will face in convincing its constituents to finance the renovation and repair of New York City's sewer system, it would offer

a more sustainable and robust alternative to the conventional cisterns proposed in "Vision 2020." With this understanding, the W.T.R. Park is not meant to be a final solution but merely the first step in opening a discourse about how the design New York City's next generation of wastewater infrastructure can be explored as opportunity to confront the larger social, economic, and environmental challenges underlying the post-industrial revitalization of the our cities. As Scott Lloyd suggests, "...responding to local, social, aesthetic, and ecological conditions produces resilient forms of urbanism that are appropriate for the given conditions."²

² Stoll, Katrina , and Scott Lloyd. *Performance As Form. Infrastructure As Architecture*. Berlin: Jovis , 2010. 4-8. Print.





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