12-2014

Thickening: A 21st century approach for resilience in infrastructure

Marco Antonio Ravini

THICKENING

A 21st century approach for ~~permanence~~ [resilience] in infrastructure

Syracuse University School of Architecture

ARC 505 Thesis Prep
Fall 2014
Primary Advisor: Julie Larsen
Committee: Theodore Brown and Lawrence Chua

The twentieth century was witness to both an infrastructure boom and bust. It is the twenty-first century that will need to determine not only how to address crumbling infrastructure but also how to position new ones.

—Lateral Office/InfraNet Lab, Pamphlet Architecture 30

CONTENTS

CLAIM

Infrastructure should be designed for higher RESILIENCE, not permanence. Rather than over-engineer to resist the inevitable failure of individual components, the next generation of public infrastructure needs to exceed its technical specifications and seek opportunistic hybridity between systems. In doing so, new possibilities for multi-layered use/outputs emerge which contribute to a more productive and resilient infrastructural lifespan.

SITUATION

Designing for permanence and single use has burdened many developed/underdeveloped countries with ineffective and aging infrastructures. Coupled with increased urbanization, the rate at which these vital frameworks deteriorate has produced pervasive phenomena with social, economic and environmental ramifications.

Fig 1.0 Sewage overflow in the River Thames. During times of heavy rain, storm water runoff and raw sewage get dumped into the river.

Fig 1.1 The Northeast blackout of 2003 affected more than 65,000,000 people. The malfuction began from a software bug.

Fig 1.2 Floods in Pakistan and India. Their systems were not designed to handle monsoons.

In transport infrastructure, as the lifespan of highways, tunnels and bridges is approached and exceeded, failures become inevitable. These unexpected events generate systematic inefficiencies that if ignored, can escalate to a full-system breakdown. Less tragic occurrences however come in the form of frequent delivery setbacks, traffic and increased fuel expenditure. By extension, they affect everything and everyone; from urban and economic productivity to civic health and social interaction. As a result, governments are in a perpetual dilemma whether to repair or replace aging structures in order to mitigate the constant pressures of a growing population.

Fig 1.3 Typical rush hour in Lagos, Nigeria. Population density exceeds the capacities that the infrastructures were designed for.

Fig 1.4 Drivers are forced to re-route due to schedule road work/bridge maintanance

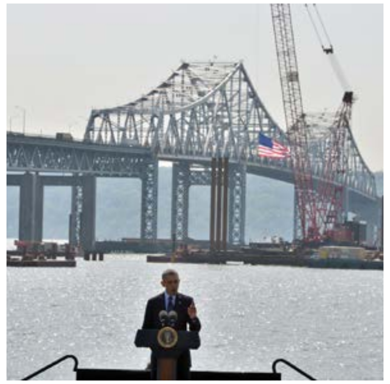


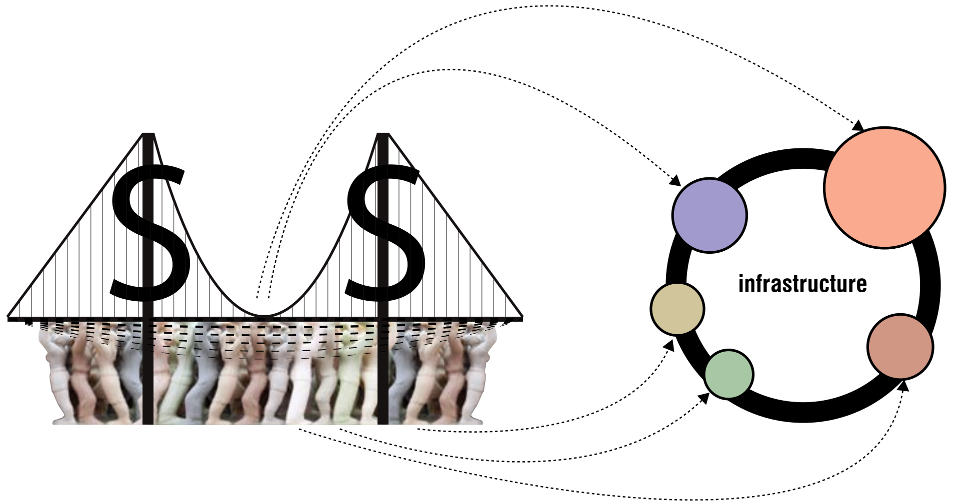
Fig 1.5 Obama delivers a speech on funding policy for infrastructure. In the background, the Tappan Zee Bridge is preparing for dismembering.

RECONSIDERING (*n*): INRASTRUCTURE

Aging transit systems cost billions of taxpayer's money to remain operational. In the context of competing political interests and limited financial resources, this perpetual process demonstrates the burden of designing infrastructure through the lens of permanence and singular use. As we transition into the next chapter of public works, it is necessary to agree on a collective approach that can translate high public expenditure into greater service output.

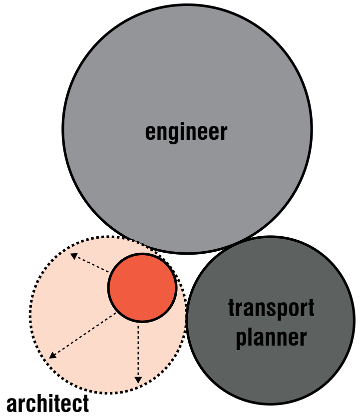
By arguing for higher public use as a way to compensate for the financial burden associated with failure, future infrastructures can be positioned both as a collective good and a resilient service. This offers an opportunity to reconsider the premise and scope of infrastructure in cities, as well as their relationship with the larger ecological systems of our landscape.

Architects can intervene in this process by expanding their marginalized niche in infrastructure and deploying "architecture" in collaborative discussions with engineers, ecologists, historians and transport planners.



High public expenditure to keep problematic infrastructure operational

Infrastructure as a collective good rather than a collective burden



Architects need to expand their niche as aesthetic advisors

Re-introducing "*architecture*" in Architecture

During the 20th century, engineers and transport planners were generally the main authorities responsible for the production of public infrastructure; architects were utilized mostly as aesthetic advisors.

In the essay Formatting Contingency, InfraNet Lab/Lateral Office (IN/LO) critiques this marginalization and asserts that the discipline would benefit from a reintroduction of "architecture" as it has evolved in other fields.

Co-opted in 1960s Business and Computation theory, "architecture" came to signify a systems-thinking practice that dealt with multilayered processes and organizational complexity. This produced a new breed of architect that ventured away from the constraints of walls and zoning regulations into the ephemeral field of data and frequencies. By extension, the design agenda entailed the production of services through the coordination and assembly of systems.

As the information services began expanding, the operational interdependencies and perpetual increase in user volume led to greater complexity within the system. With this came more opportunity for failure. Realizing these occurrences are inevitable, business and computation architects infused failure in the structure of the code. This radically shifted the conventional mindset that equates reliability with permanence. Rather than arguing for a resistance to failure, systems architects designed systems that anticipated and accepted the possibility of such events occurring. In doing so, the architects were able to minimize the inefficiencies thus, yielding a more resilient service capable of addressing a greater number of stakeholders.

Today, as architects seek ways to intervene in the production of infrastructure, a similar systems-thinking approach could prove strategically productive. In doing so, architects will be able to utilize infrastructure not only to deviate from the confines of buildings but also as a means to reconcile the disciplines historic relationship with the city and the environment.

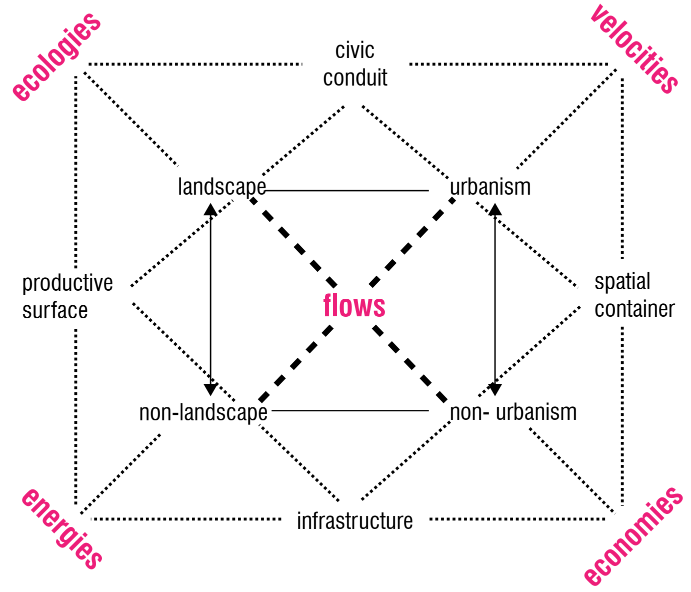
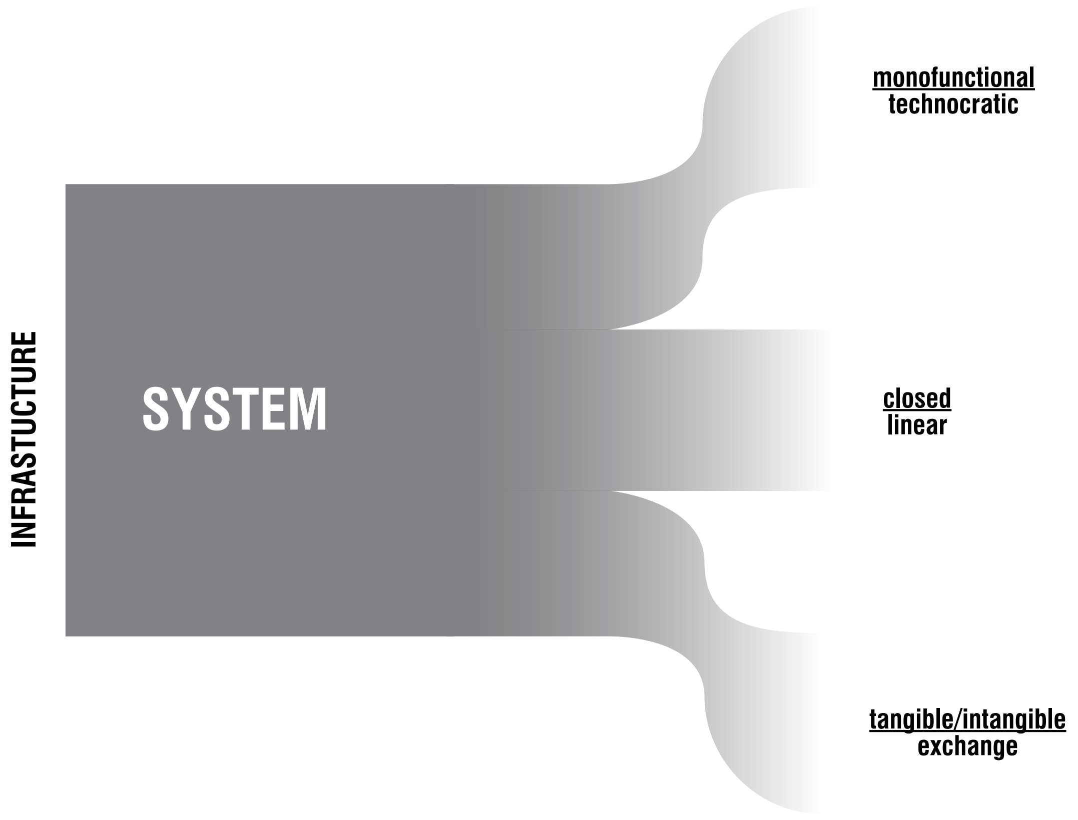


Fig 2.0 Architecture in the Expanded Field by InfraNet Lab/ Lateral Office
Architecture as a *systems thinking* practice

Infrastructure in the context of *Engineering*

The fundamental issue with public infrastructures is that they are engineered with closed system logics. This means that the connections and transfers between various nodes are optimized to accommodate specific uses and capacities. If a closed system exceeds its limits or is met by a force that disrupts its balance, it will fail and, by default, subside into the realm of an 'engineering problem'.



Infrastructure in the context of *Architecture*

Infrastructure and architecture haven't always dissimilar. Predating the semantic period of postmodernism, a substantial number of architects explored hybrid relationships between the fields of infrastructure, architecture and urbanism.By revisiting some of the seminal projects of the 20th century, it is possible to begin speculating on the role of infrastructure beyond that of a closed system.

Early utopian proposals, such as Edgar Chambless' Roadtown and Le Corbusier's Plan Obus for Algiers, attempted to fuse the formal characteristics of infrastructure with the spatial content of architecture. Through this, a set of linear volumes emerged that embodied spatial and programmatic diversity. By weaving together geographically disparate systems such as agriculture, live, work and transit, the architects were able to produce a multilayered conduit of interdependent social, economic and cultural exchanges. The overarching theme was to juxtapose the inefficiencies associated with sprawl by clustering all the essential functions of society into a single continuous volume.

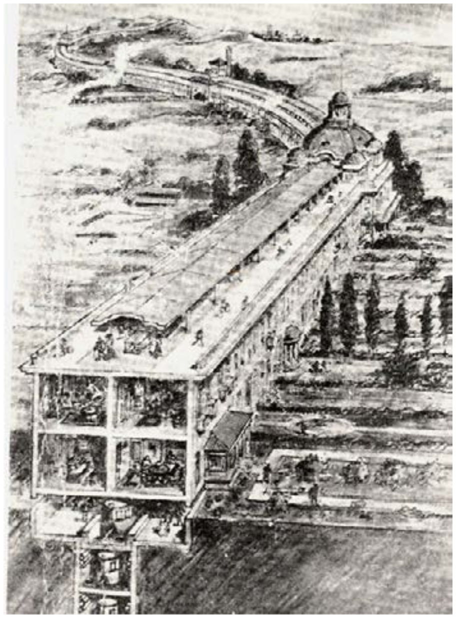


Fig 2.1 Edgar Chambless: RoadTown, 1910

Fig 2.2 Le Corbusier: Plan Obus for Algiers, 1933

Latter proposals like Kenzo Tange's Tokyo Bay Project and Peter Cook's proposal for a Plug-in City—respectively part of the Metabolist and Avant-garde movements in the 60s—deployed infrastructure as an adaptive and resilient 'superorganism'. By utilizing common techniques of mass production, the architects developed city-like megastructures that could reconfigure their spatial content by adapting to various inputs and outputs. These transformations were facilitated by plug-in structures that enabled the standardization, and at the same time customization, of systemic growth.

Despite the clear differences—formal and conceptual—these projects share a number of distinct similarities. In each case, the architects utilize infrastructure to create an object composed of aggregate spaces and processes. Secondly, unlike traditional architecture where the building site is delineated by property lines and zoning regulations, these objects employ infrastructure to operate at a territorial scale, thus becoming inextricably linked with the larger social, ecological and political systems in our built environment. Respectively, the architects also challenge the conventional logics of closed systems by infusing the architectural object with open systems of operation. This mindset introduces reciprocity between programs and functions which in turn yields valuable output.

Collectively, the proposals inform various roles that infrastructure could embody. Rather than remain confined to the operational limitations of closed systems, infrastructure, through the lens of architecture, has the potential to be understood as a [open] system, a [continuous] resource, a [expanding] territory and an [reconfiguring] object.

Fig 2.3 Kenzo Tange: Tokyo Bay Masterplan, 1960

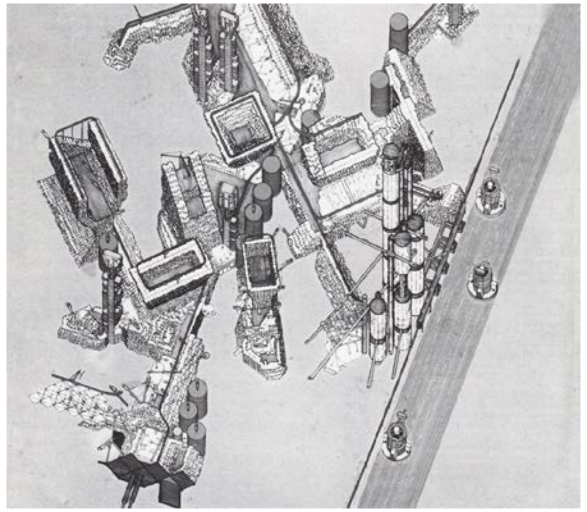
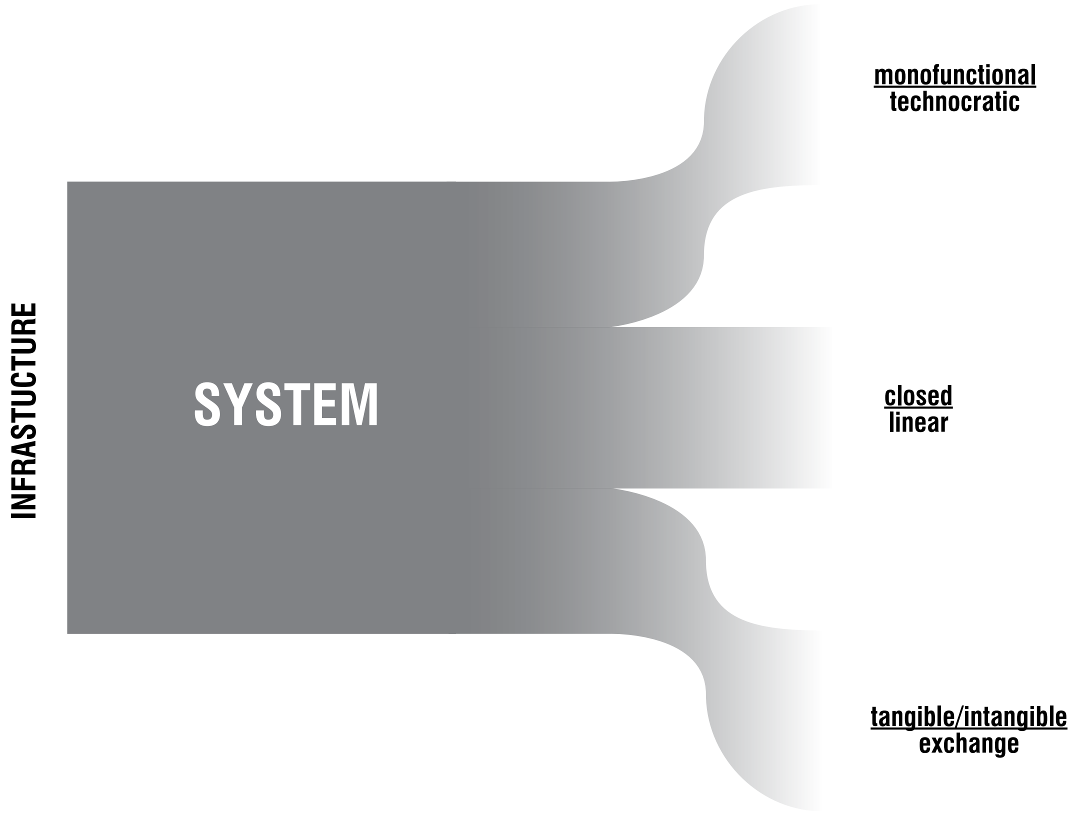
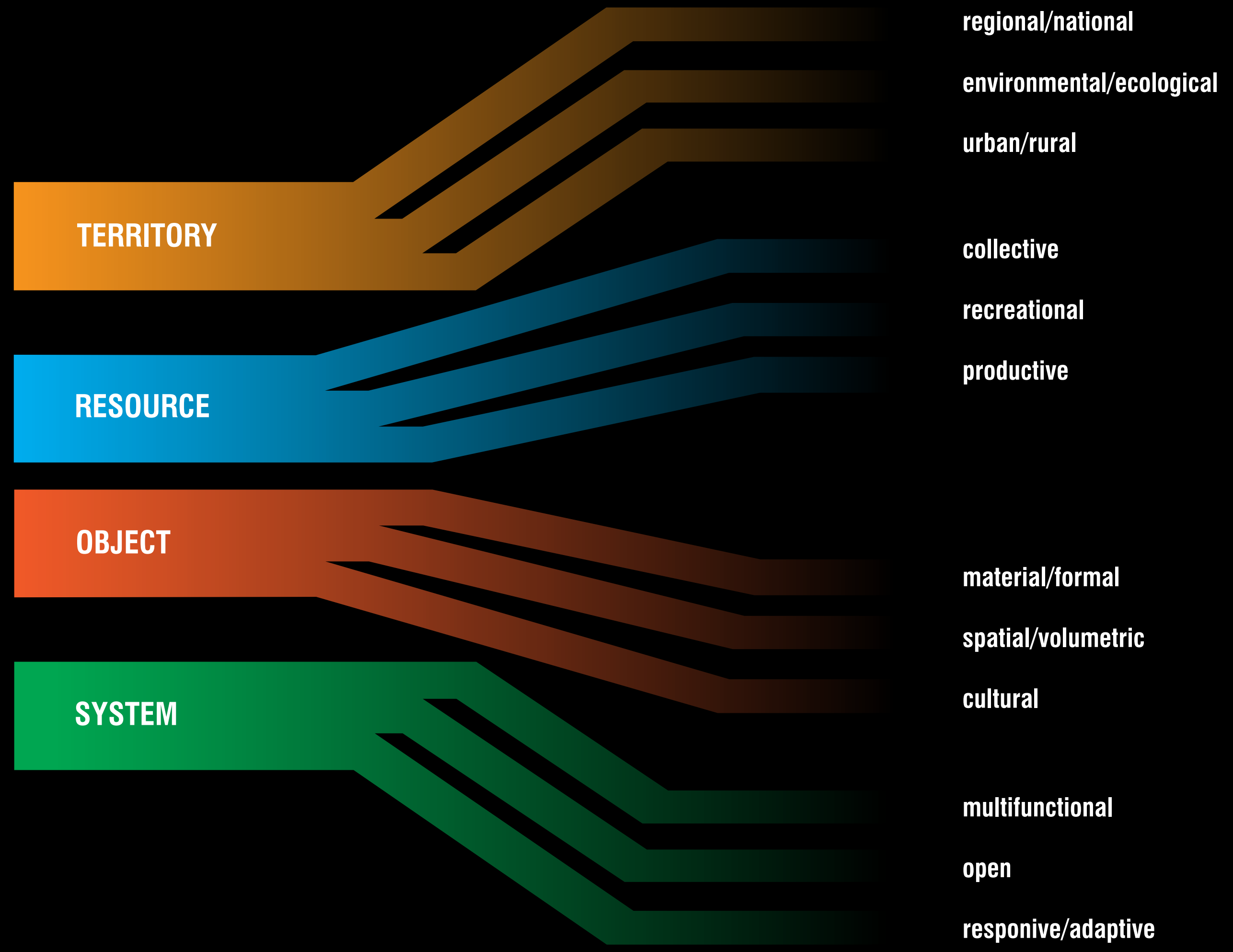


Fig 2.4 Sir Peter Cook; Archigram: Plug-In City, 1964

INFRASTRUCTURE IN THE CONTEXT OF ENGINEERING



INFRASTRUCTURE IN THE CONTEXT OF ARCHITECTURE

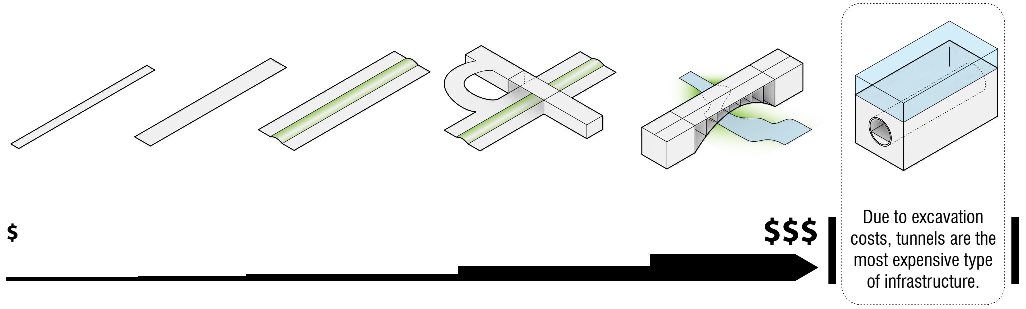


THE BRIDGE PROBLEM

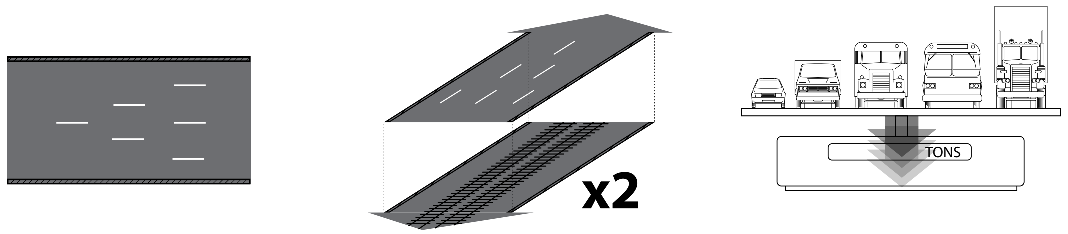
The bridge is a key element within the network of highways. Optimized—exclusively—to service the continuous flow/distribution of people and goods over physical obstacles, the present state of bridges forecasts a future of systematic disfunction.

Over the past decade, bridges in the United States have become significant players in the growing crisis of public infrastructure. Built using logics of singularity and economy of scales, when the growth of transportation networks was less of an expansion and more of an explosion, many of the bridges are inadequately redundant to handle current/future traffic loads and densities. Several of them in fact lack redundancy altogether. The truss bridge is a prime example of this situation. With a structural body assembled entirely from fracture critical members it poses the risk that if one member fails, the entire structure will collapse.

WHY THE BRIDGE?



It is the highest cost per mile of the system (after tunnels)

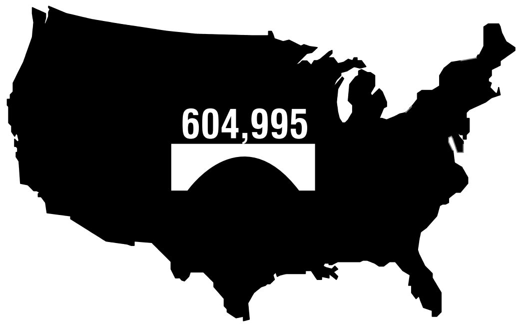


It controls the capacity of the system (Type, Weight and Volume)

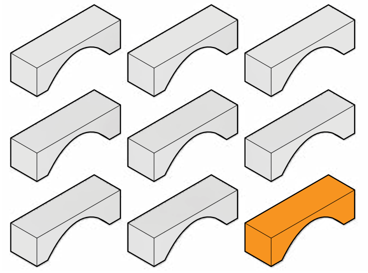
If the bridge fails, the system FAILS

Bridge Crisis in the US

Currently, the National Highway System (NHS) has an inventory of over 600,000 bridges. A study conducted in 2012 estimated that one in nine bridges has exceeded its 50-year designated lifespan and, by engineer's standards, suffers from 'structural deficiency'. This indicates that imminent failure is not a primary concern BUT RATHER the bridge's design no longer meets current highway standards. As a result, the US Congress, alongside the American Society of Civil Engineers (ASCE) and various other state-related transportation authorities, is faced with a strategic dilemma of whether to repair OR replace these problematic structures.



National Highway System Bridge Inventory



1/9 Ratio bridges is structurally deficient (SD)

Average Age of Bridges (yrs)

* Data accumulated from reports provided by *Transport for America* 2013 (www.t4america.org)

Looking beyond the *'Engineering Problem'*

Following two consecutive bridge collapses in 2007 and 2013, the general consensus advocates that future structures need to be stronger and more reliable. This mindset, similar to repair, will only postpone the effects of failure in the short term by means of 'technical optimization'. As architects, we need to deviate from the the realm of strictly an 'engineering problem' and instead seek ways to yield higher resilience through productive moments of reciprocity/hybridity between our current infrastructural systems.

2007

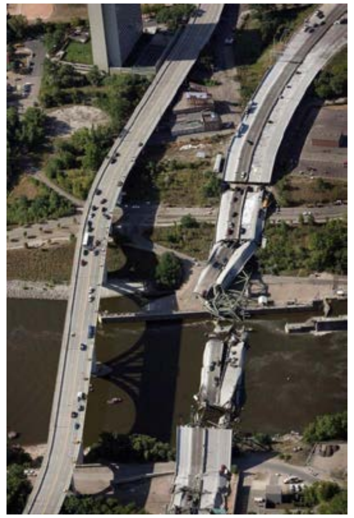


Fig 3.0 I-35W Mississippi River bridge

2013

Fig 3.1 I-5 Skagit River Bridge collapse

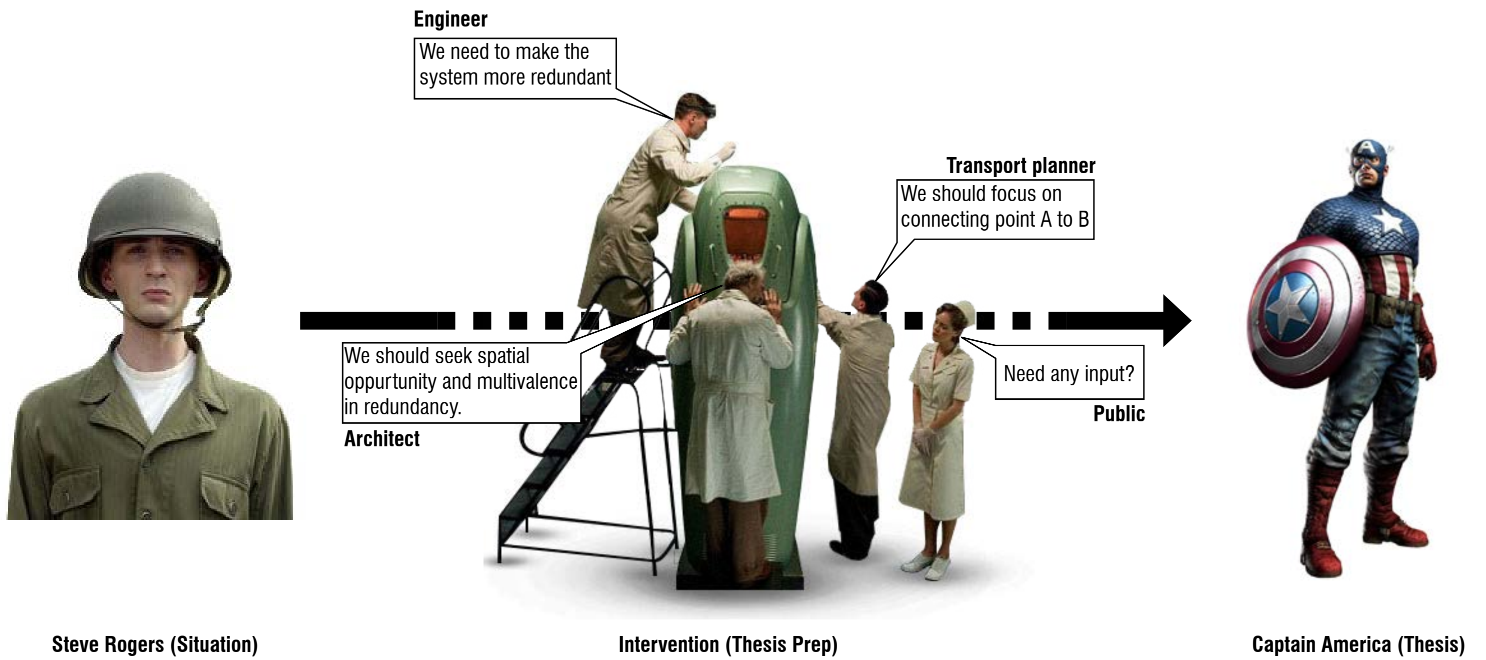
CONTENTION

Architecture can participate in the discussion of bridge resilience by approaching the issue through THICKENING: a strategy that aims to modify the spatial utility of the bridge from a LINE to a VOLUME. This is achieved by infusing the structure with:

1 social, environmental and economic vibrancies

2 multivalent redundancy

3 reciprocity between systems



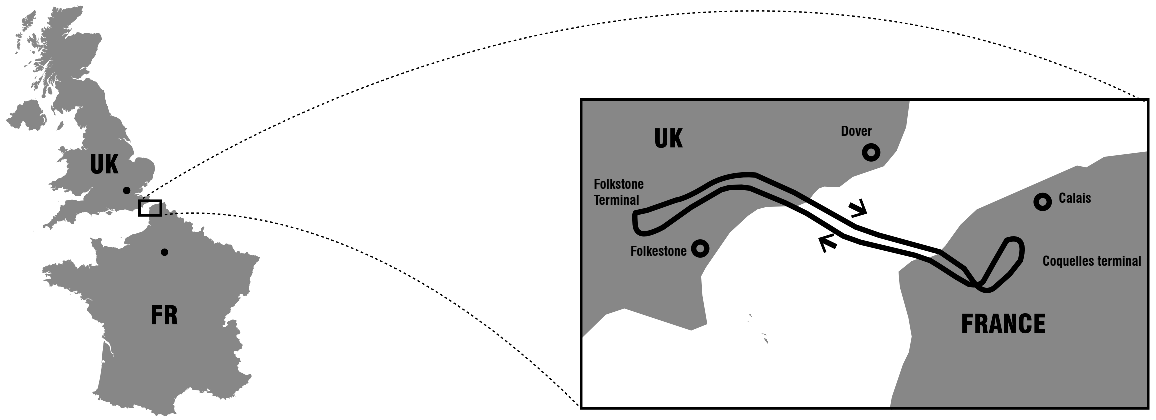
Resilience through Redundancy: The Chunnel

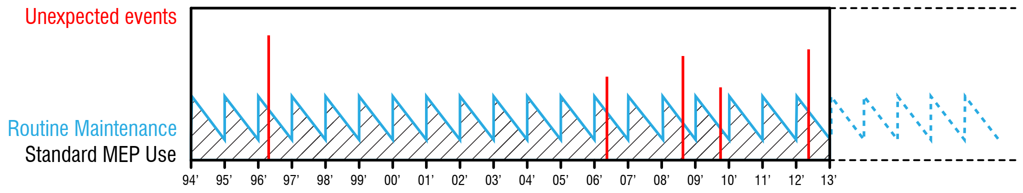
As demonstrated in business and computation architecture, permanence yields unreliable systems. Redundancy however does NOT.

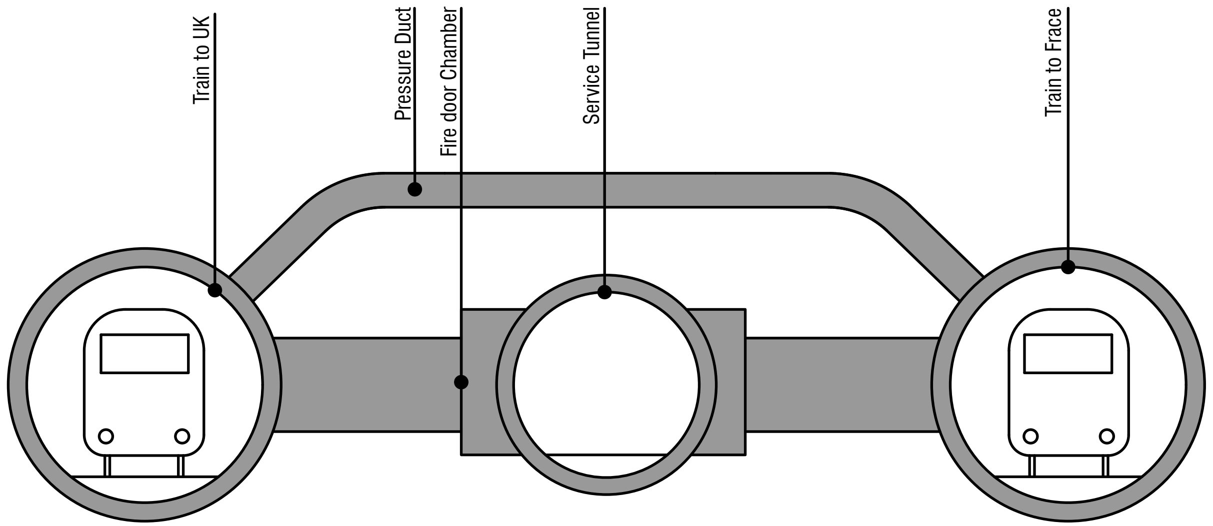
Redundancy in infrastructure typically materializes in the form of added structural/tectonic insertions. The purpose of this engineered measure is to minimize the effects of failure if one of the components is compromised. Although it enhances the resilience and reliability of the system, it is by no means necessary for the system to function. A notable application of redundancy is demonstrated in the design of the Chunnel; an underwater tunnel system that enables locomotives to cross the English Channel and connect France to the UK. Instead of ensuring the resilience of the systems through added structure, redundancy in the Chunnel is spatially articulated.

In order to deal with a high volume of shipments and passengers, the designers and engineers had to acknowledge the potential failures of individual components. They compensated for these events by deploying three interconnected tunnels; two for locomotive traffic and one redundant service tunnel for routine maintenance/potential escape route.

Since its opening in 1994, the service tunnel has been used in five instances for purposes of evacuation. The rest of the time it remains idle, contributing neither to the utility of the system nor its structural integrity.







Redundancy beyond idleness

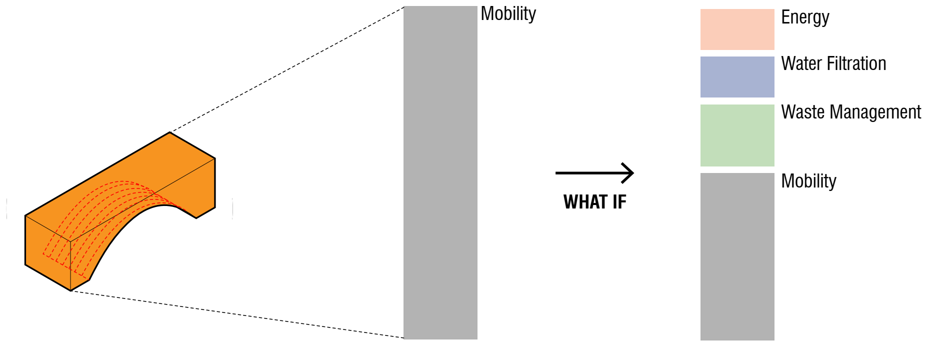
It is without question that the implementation of redundancy is vital to ensure public safety. The Chunnel serves to validate this but also, demonstrates that rendundancies can be articulated spatially, not only structurally.

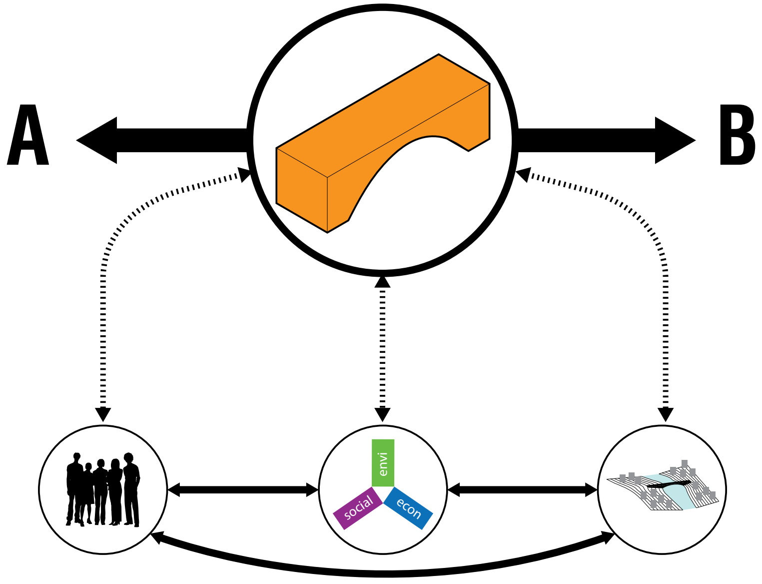
As architects, can we utilize the idleness to our advantage? Can we design redundancy to be more active rather than passive, both structurally and spatially? Can it embody multiplicity rather than singularity? Can redundancy address stakeholders and contexts beyond the system itself?

Unlike the Chunnel, bridges utilize redundancy passively as counter measures for structural failure. In suspension bridges for example the numerous cables are a form of redundancy. Other redundancies exist such as road barriers, joint bearings, drainage systems etc, but they are less vital to the integrity of the system. Nevertheless, their collective existence is inextricably linked to mobility. Although this seems obvious, it exemplifies the inefficiencies of closed system ideologies.

WHAT IF architects could articulate redundancy spatially in order to mediate issues like water filtration, waste management and/or energy production?

A bridge infused with multivalent redundancy would have the potential to fulfill its primary purpose as well as become a resilient system within its context—a facility for subjects (users/public), objects (inputs and outputs) and ground (urban fabric) to engage in a mutually reactive dialogue.





DESIGN TECHNIQUE

By delaminating the bridge into its basic subdivisions—superstructure, substructure and foundation—architects can seek ways to productively 'de-optimize' the redundancies of various components into scenarios/oppurtunities for inhabitation, participation and added value.

Take for instance road barriers. Their utility is irrelevant to the structural integrity of the superstructure. Rather, road barriers ensure driver safety by providing a redundant boundary between opposing flows of traffic and/or extreme changes in elevation. Through de-optimization, architects can thicken the singular use of the barrier to generate additional utility as a sound dampening device, a storm water collection tank, a multimodal circulation corridor etc. By employing this technique, engineered redundancies can become spatial articulated thus, providing new opportunities for public use.

Therefore, literacy in the tectonics of bridges, the inherent structural forms and the passive systems embedded within the structure become imperative components in this investigation. Collectively, they will determine the type, scale and context of potential intervention.

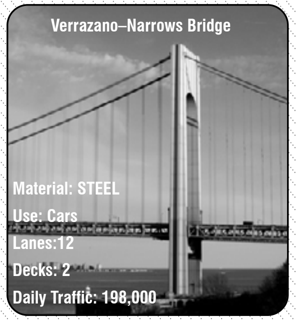
(delaminate / de-optimize)

TYPES

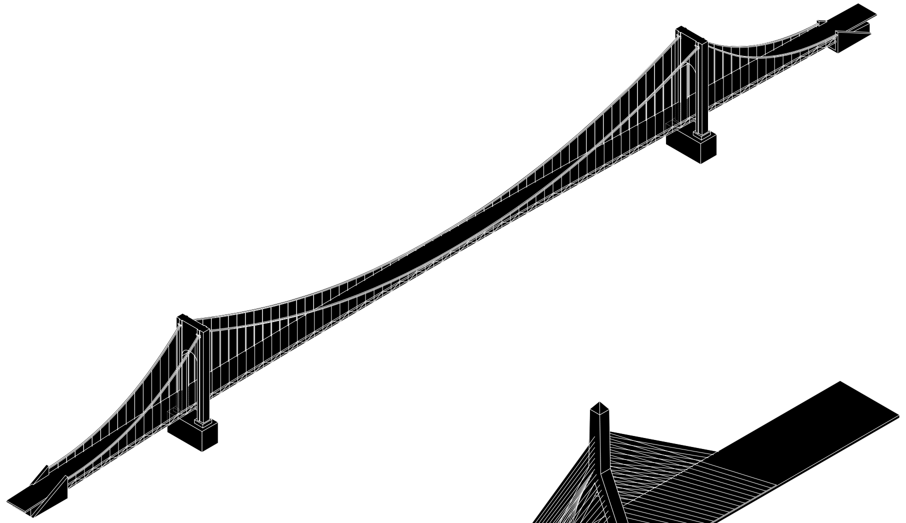
BRIDGE MATRIX
AXON

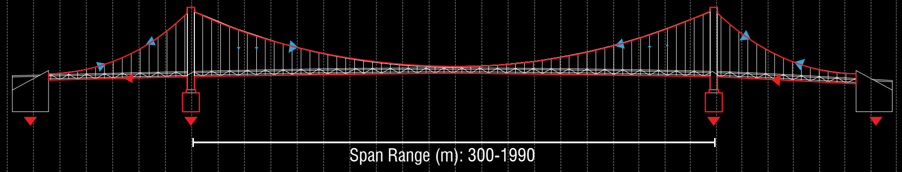
STRUCTURE
LONGITUDINAL ELEVATION

USE
CROSS SECTION

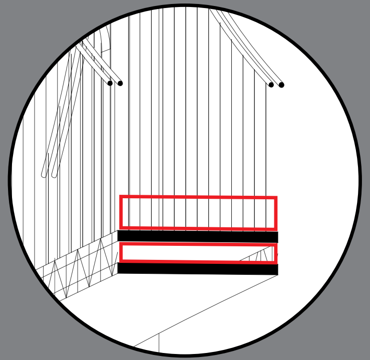


SUSPENSION

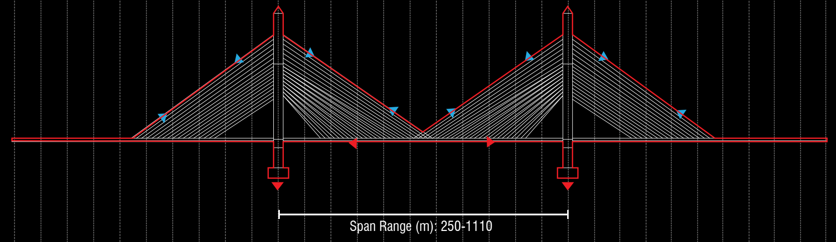




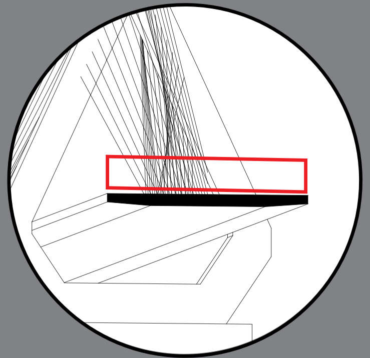
The suspension bridge is one of the most notable forms within the highway system. Due to its structural, material and cost efficiency, this type of bridge is very cost effective for spanning over extreme physical obstacles such as large bodies of water and/or mountain ranges. A deck supported by girders or stiffening trusses forms a large part of the superstructure which is then gracefully hung from the main cables via hangers. These cables are then fixed to the each substructure component - towers and anchorage - on either side.



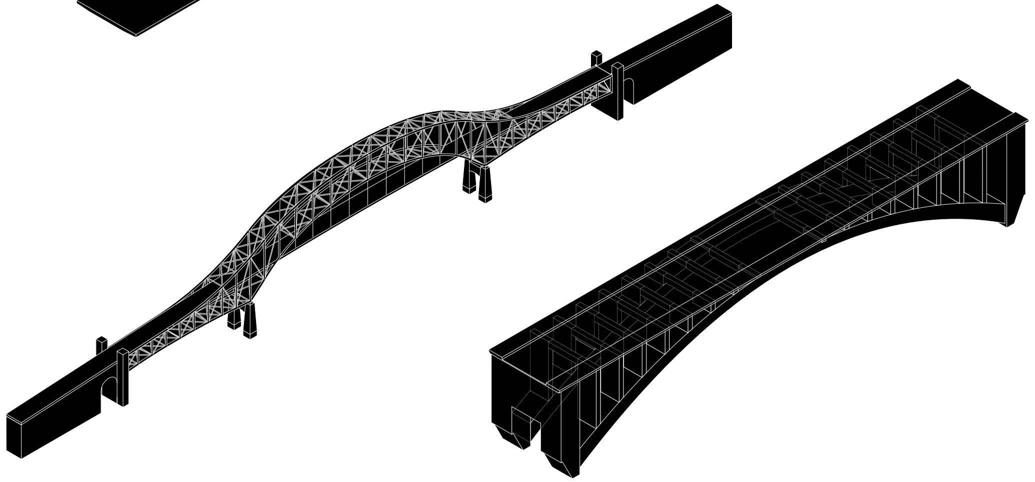
CABLE STAYED

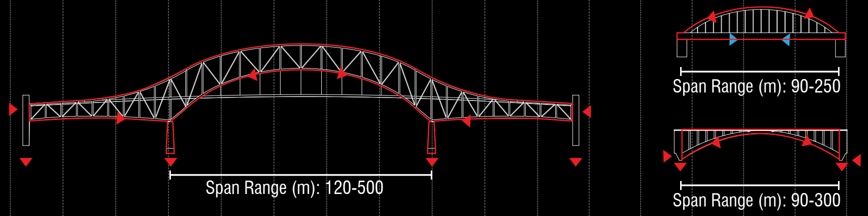


The last 50 years has seen a rise in the construction of cable-stayed bridges. Its popularity can be attributed to low cost, ease of construction, and minimal aesthetics as well as for its structural ability to accomodate medium and lond spans. The deck superstructure is assembled with multicell girders using the balanced cantilever method, thus greatly reducing construction costs due to lack of falsework. In addition, the monumental substructure - the pylon - is built solid or hollow, depending on the tower size and the loads from cable stays.

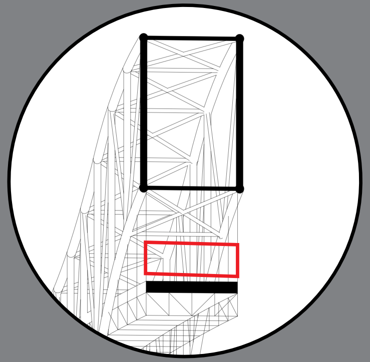


ARCH

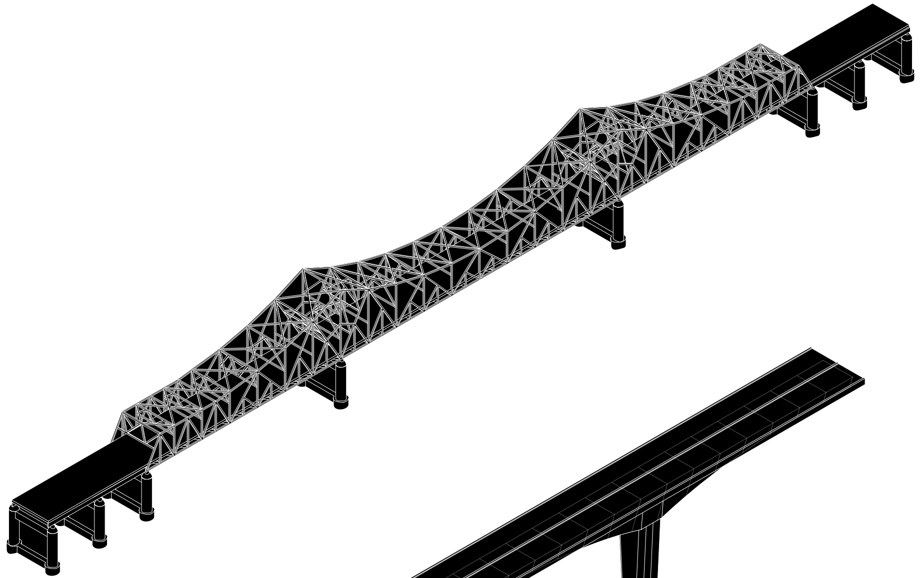


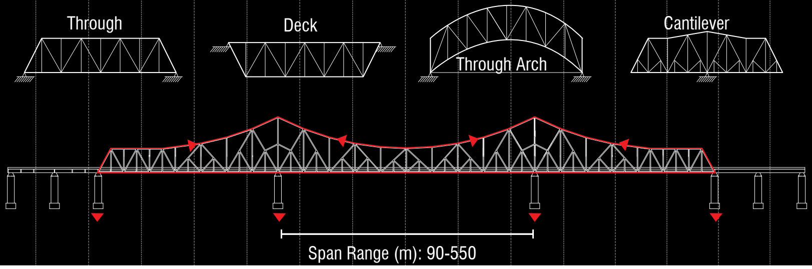


The arch bridge is a structure derived directly from the bending moment diagram. Its form eliminates the need for a pier in the river, which in the case of suspension bridges can be a problematic and expensive task. The large horizontal forces exerted by the superstucture (i.e. deck and arch) are resisted by the vertical members of substructure (i.e. abutment and spandrel columns). In terms of construction, engineers use either the cantilever method with falsework or a prefab assembly of steel girders. Albeit the aesthetic qualities, the bridge is one of the most expensive structures in the highway system.

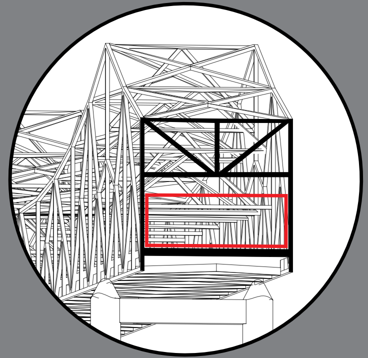


TRUSS

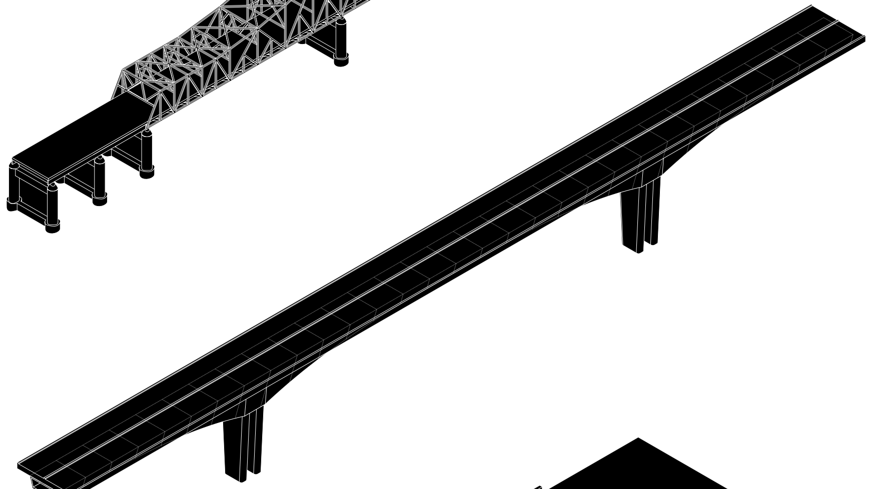


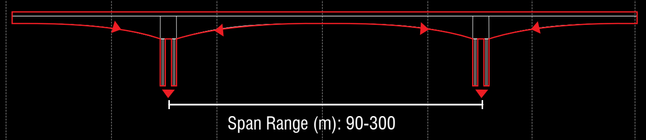


Truss bridges spawned during the 19 c. and extended well into the 20 c. Nowadays, the era of the truss as a bridge typology has come full circle. The change of heart can be attributed to the fracture-critical nature of its members meaning that if any member were to fail, the entire structure would collapse (notable examples are the 2007 and 2011 bridge collapses in the US). Another reason engineers deviate from this typology is due to the high maintanence costs. However, the use of trusses as bridge components is still very popular. The decks of suspension bridges are a prime case of their ubiquitous use as deck superstructures.

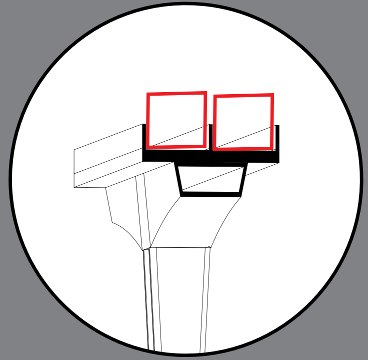


BOX GIRDER

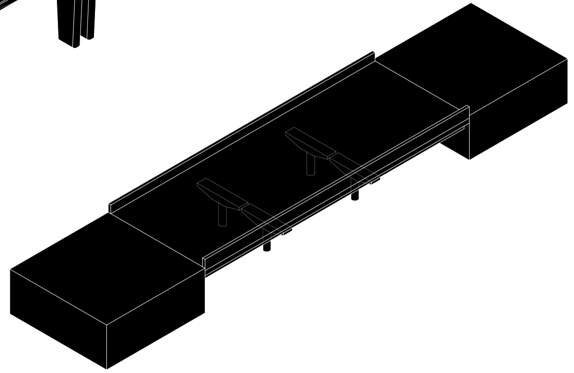


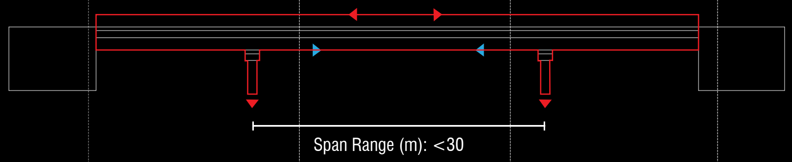


Box girder bridges, albeit high construction costs, are aesthetically pleasing solutions to bending moment and torsion. Although the similarity with arched bridges is evident, the lack of standardization restricts the use to medium and semi-long spans. The concrete box girder is employed heavily for this type of bridge construction and typically uses precast or cast-in-place members. With longer spans, engineers resort to the balanced cantilever construction method to build the superstructure.

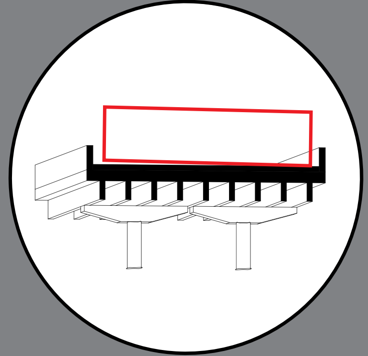


SLAB-ON-GIRDER

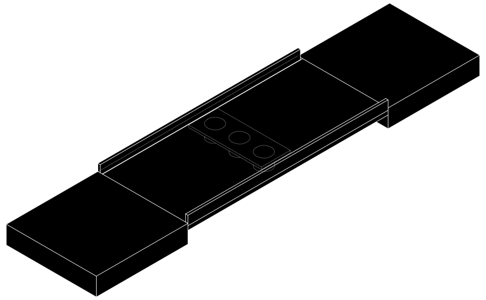


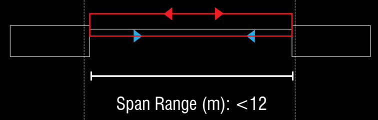


The slab-on-girder is the most standardized and uniformly designed superstructure in the highway system. It is comprised of a concrete slab resting on a set of steel or pre-stressed girders. Uniformity also means that consistent, and therefore economical, methods can be employed in repairing deteriorated structures as well as expanding them in size if times deem it necessary. This type of bridge is ubiquitous along highway networks and in many cases can be found within urban centers.

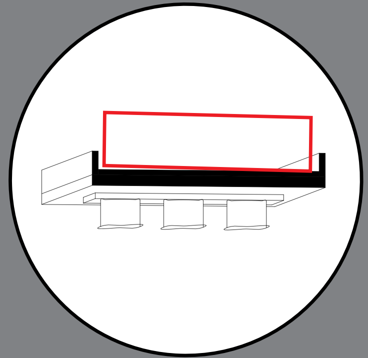


ONE WAY SLAB





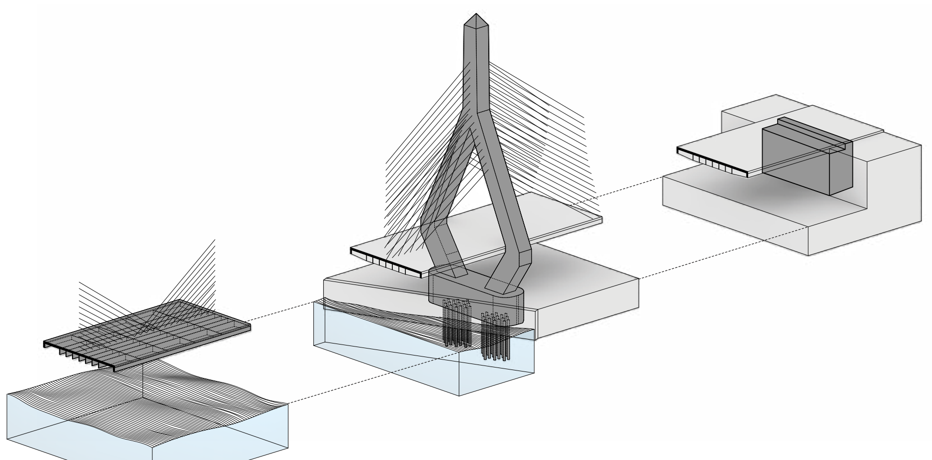
A one way slab is a popular and economical bridge for extremely short spans. Typically precast, the bridge's deck is re-inforced concrete supported on either end by small abutments and bearing. Often, circular voids are sometimes used to reduce the dead load of the slab.



BASIC SUBDIVISIONS

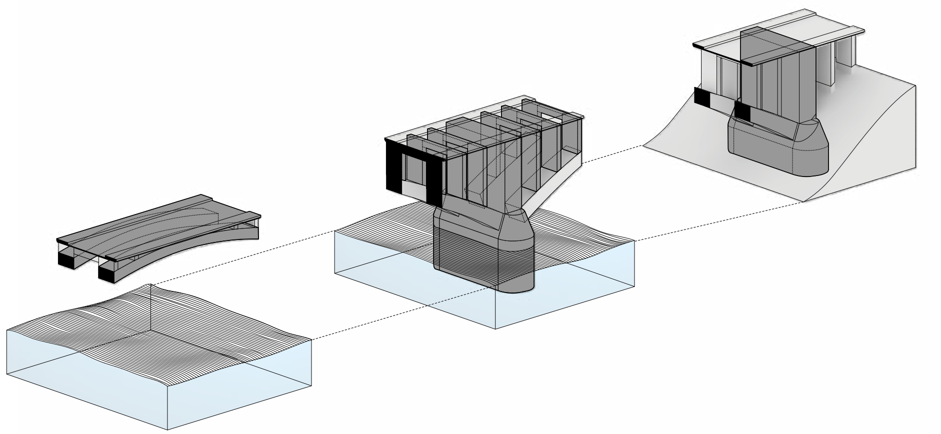
[SUPER]structure. [SUB]structure. Foundation

Cable Stayed Multicell Deck



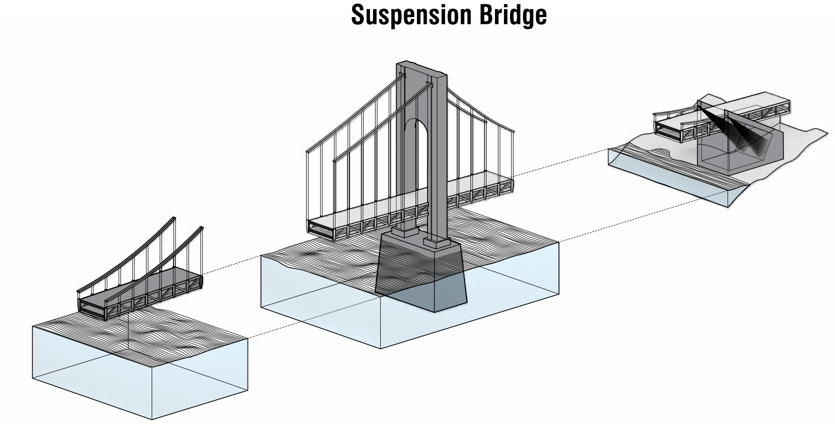
Deck suspended from arch — Pylon and Foundation Piles — Abutment

Open Spandrel Concrete Arch



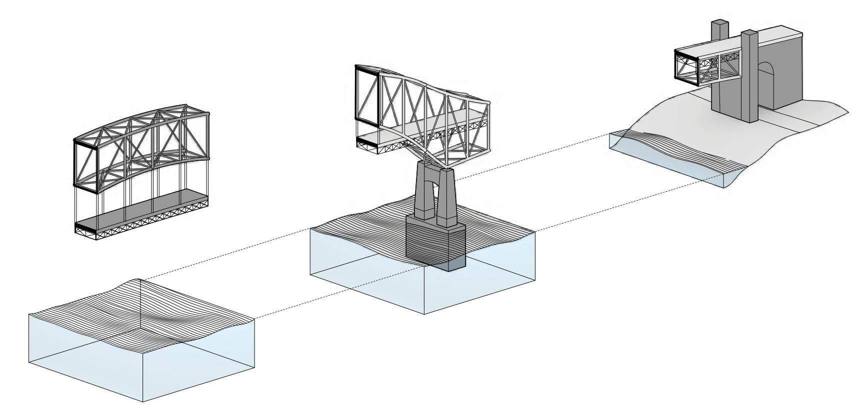
Crown — Water Pier +Spandrel Columns — Abutment

Suspension Bridge



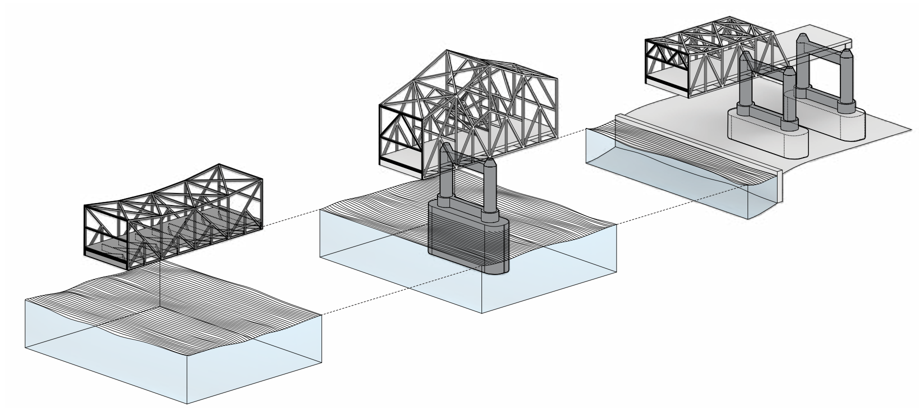
Deck suspended from cables — Pier Tower — Anchorage

Suspended Deck Through Arch



Deck suspended from arch — Deck through arch — Truss fixed to Viaduct

Single Deck Cantilever Truss Bridge



Suspended Span — Cantilevered Arms + Single Deck — Back span +Piers

SITE

Overview

Flows along the borders of **SIX STATES (IL,WV,OH,KY,IN,PA)_**

MAJOR CITY adjacencies(Cairo, Evansville, Conisville, , Wheeling and Pittsburgh)_

Consists of 100+ medium to long span bridges (mostly truss type bridge made of steel)_

Contains a system of infrastructures (locks & dams for water stairway)_

The River is the source of drinking water for more than **3 million people_**

Strong interest to rehabilitate, reclaim and promote the river front, particularly in Cincinnati, Pittsburg and Louisville_

Ohio River is considered the MOST polluted river in the United States due to high industrial discharge_

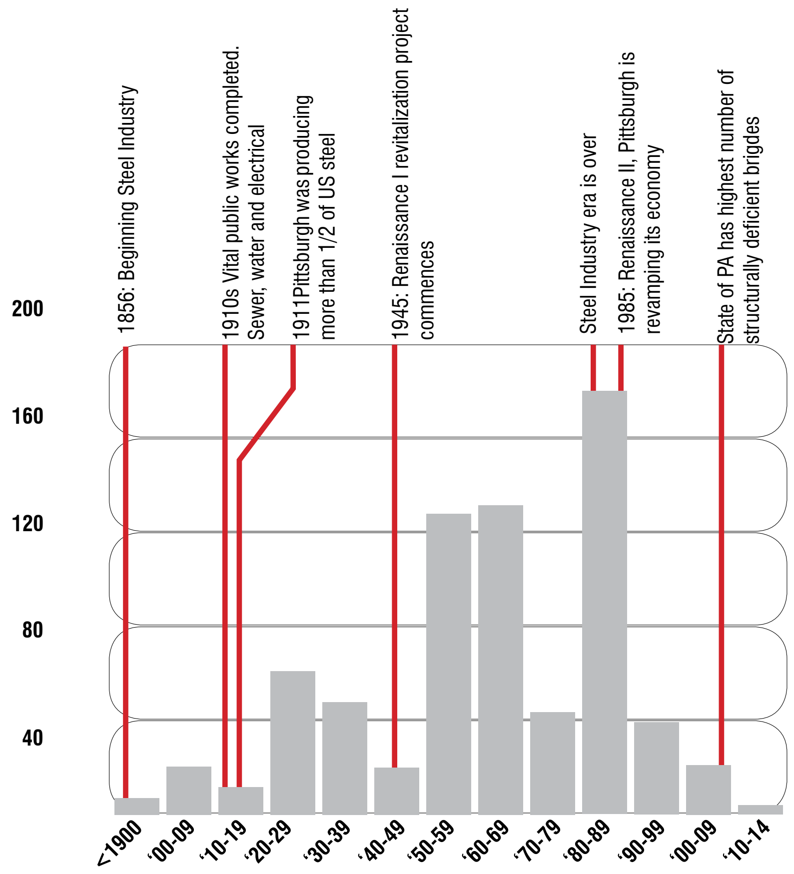
Sites Considerations

Louisville, KY

Cincinnati,OH

Pittsburgh, PA

Pittsburgh is situated where the Monongahela and Allegheny Rivers join to form the Ohio River. Known for pioneering the mass-production of steel, the city owes much of its fortune to the three rivers that flow through it. By extension, a rich infrastructural palette was implemented to provide a fluid distribution of goods and resources. This resulted in the production of over 400 bridges within the span of 100 years; each one with its own history, structural typology and use.



Today, these bridges still remain vital components for the city to function. They connect railways, highways and tunnels, providing direct passage between the working class neighbourhoods and the inner city/ downtown. It is within this context that a new bridge prototype could be deployed.


Fig 4.0

Birmingham Bridge

Built: 1977

Use: connects Uptown, Oakland, the Hill District and South Side Neighbourhoods

Type: Tied arch bridge

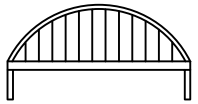



Fig 4.1

Three Sister Bridges

Built: 1926 -1928

Use: Connect to Downtown Parking
Sports Arenas
Local neighbourhoods

Type: Self-anchored suspension

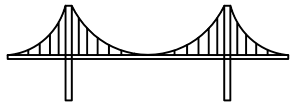



Fig 4.2

Fort Wayne Railroad Bridge

Built: 1904

Use: Two train tracks
Norfolk S. and Amtrak traffic
Lower deck is 'unused'

Type: Double-deck steel truss

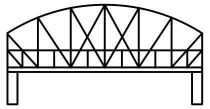



Fig 4.3

Liberty Bridge

Built: 1928

Use: Connects downtown
Liberty Tunnel, Int. 576
South Hill Neighbourhoods

Type: Steel cantilever w/ concrete piers

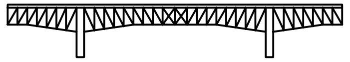



Fig 4.4

Veteran Bridge

Built: 1987

Use: Carries Interstate 579
Connect to Downtown

Type: Steel and welded girder


Fig 4.5

West End Bridge

Built: 1932

Use: Connects the West End to the Chateau neighborhood on the North Side of Pittsburgh

Type: Steel bowstring arch bridge

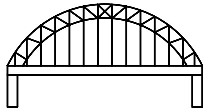


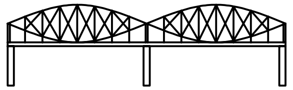

Fig 4.6

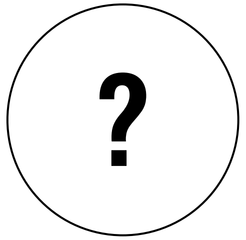
Smithfield Bridge

Built: 1883

Use: Connection to Mellon Park Sq.
Downtown Center
Art institutes and Culture centers

Type: Steel Lenticular Truss





What's next?

Built: -

Use: Transport +

Type: Concrete/Steel

Built in 1928, the Liberty Bridge connecting Downtown Pittsburgh with Liberty Tunnel is being prepped as a poster child for an advertising campaign that hopes to pressure Congress into passing a long-term funding bill for infrastructure repair and replacement.

Over the past decade, the bridge has shown significant signs of deterioration. Despite plans to rehabilitate this againg structure, the general public, alongside various labor unions, namely the Laborers' International Union of North America (LIUNA), advocate that the time has come for the Liberty Bridge to be replaced.

Similar to many rust-belt cities, Pittsburgh is constantly seeking ways to reinvent/rebrand its image.The last two decades have seen the city undergo two significant changes. The first involves the shift from a manufacturing based economy to a high tech industry specializing in the fields of robotics, medicine and computer science. The second planned for the revitalization of post-industrial waterfront property. Several projects have been implemented to rekindle the city with its rivers. The aim is to re-activate dormant sites along the riverbanks into animated spaces for recreation and leisure.

Fig 4.7

Fig 4.8

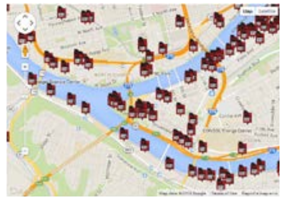
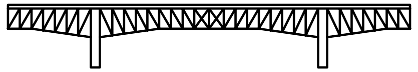


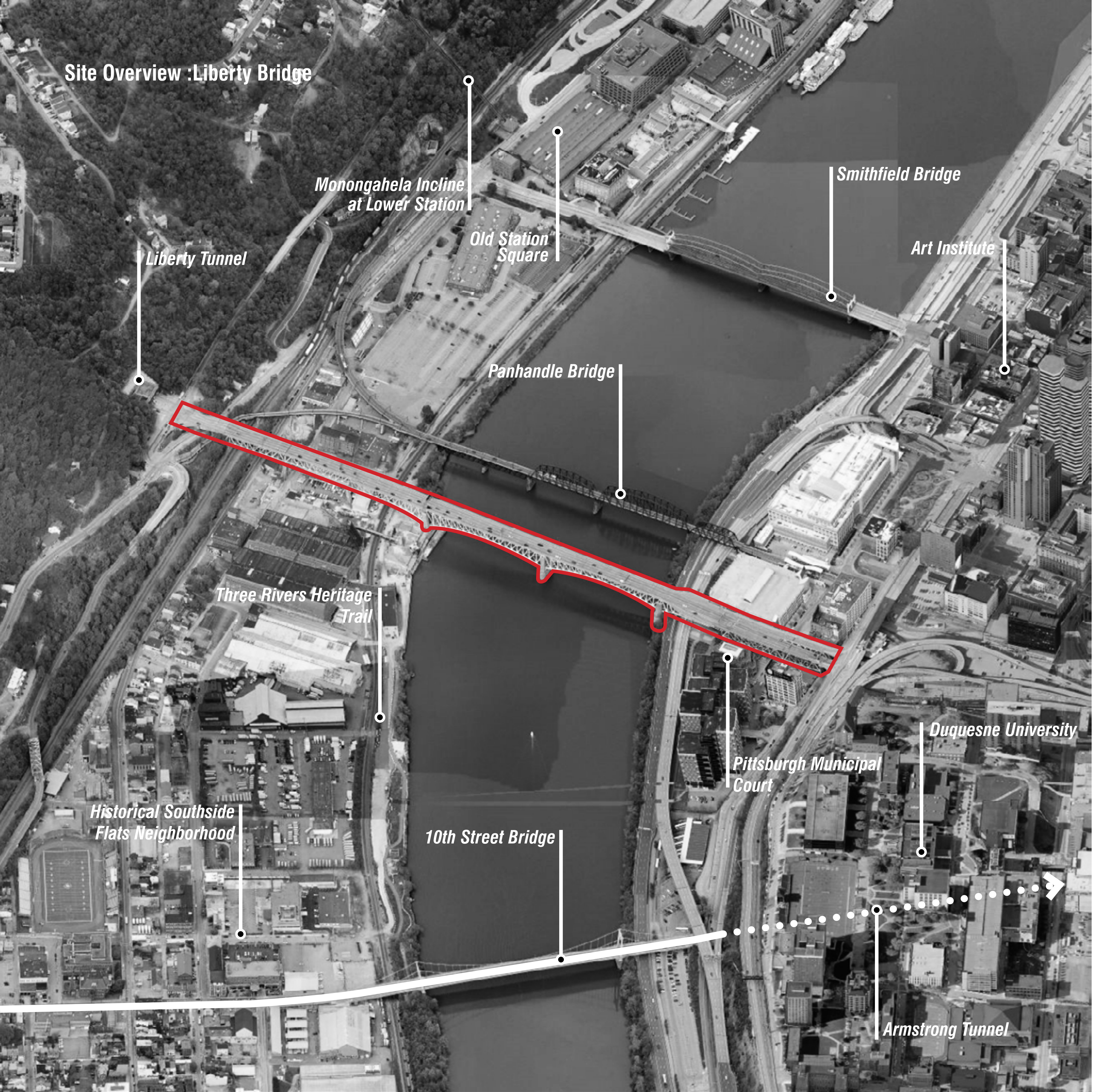
Fig 4.9

Fig 4.10

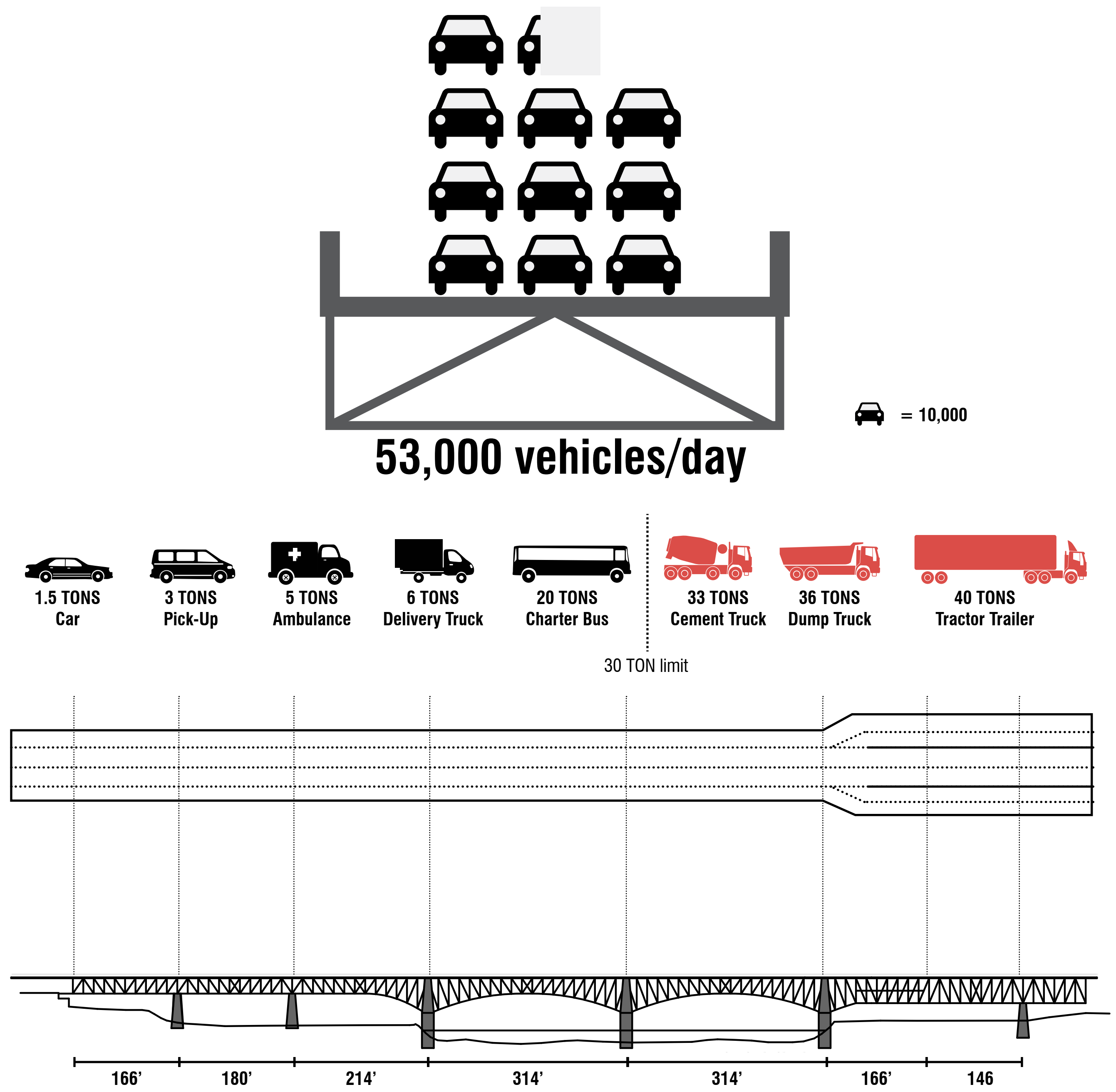


?????

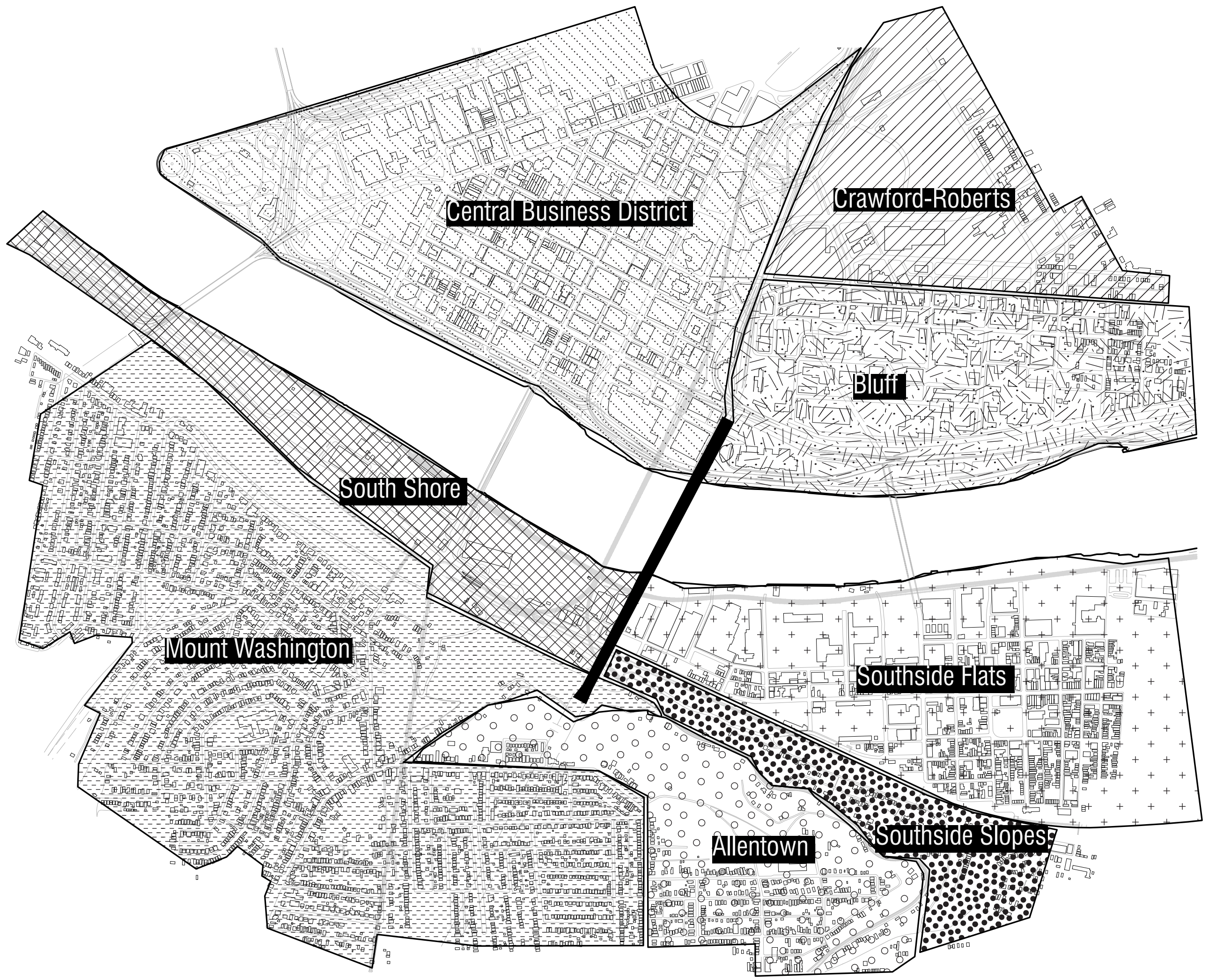
Could the prototyping of a new bridge inform the next wave of change?



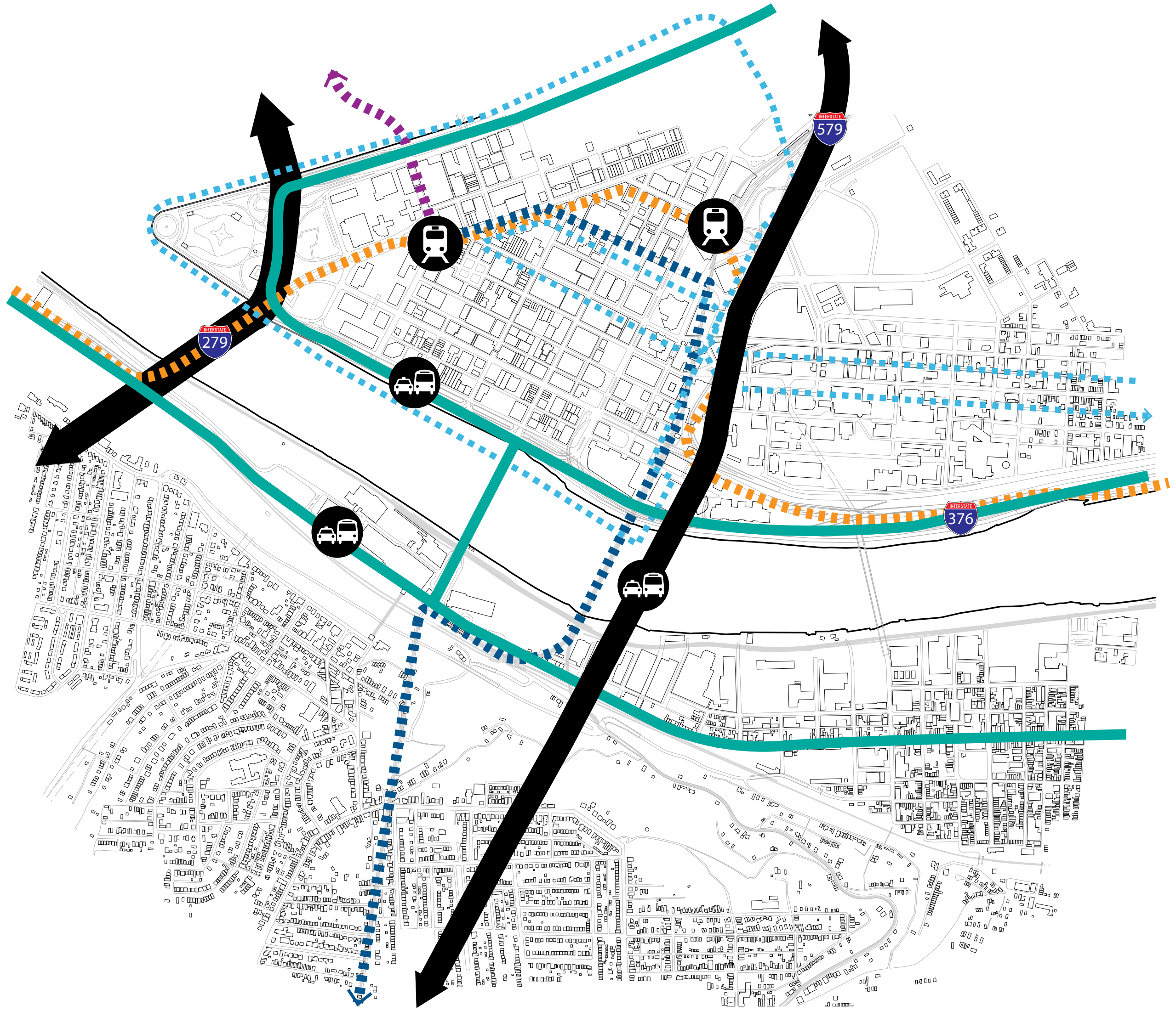
Bridge Overview



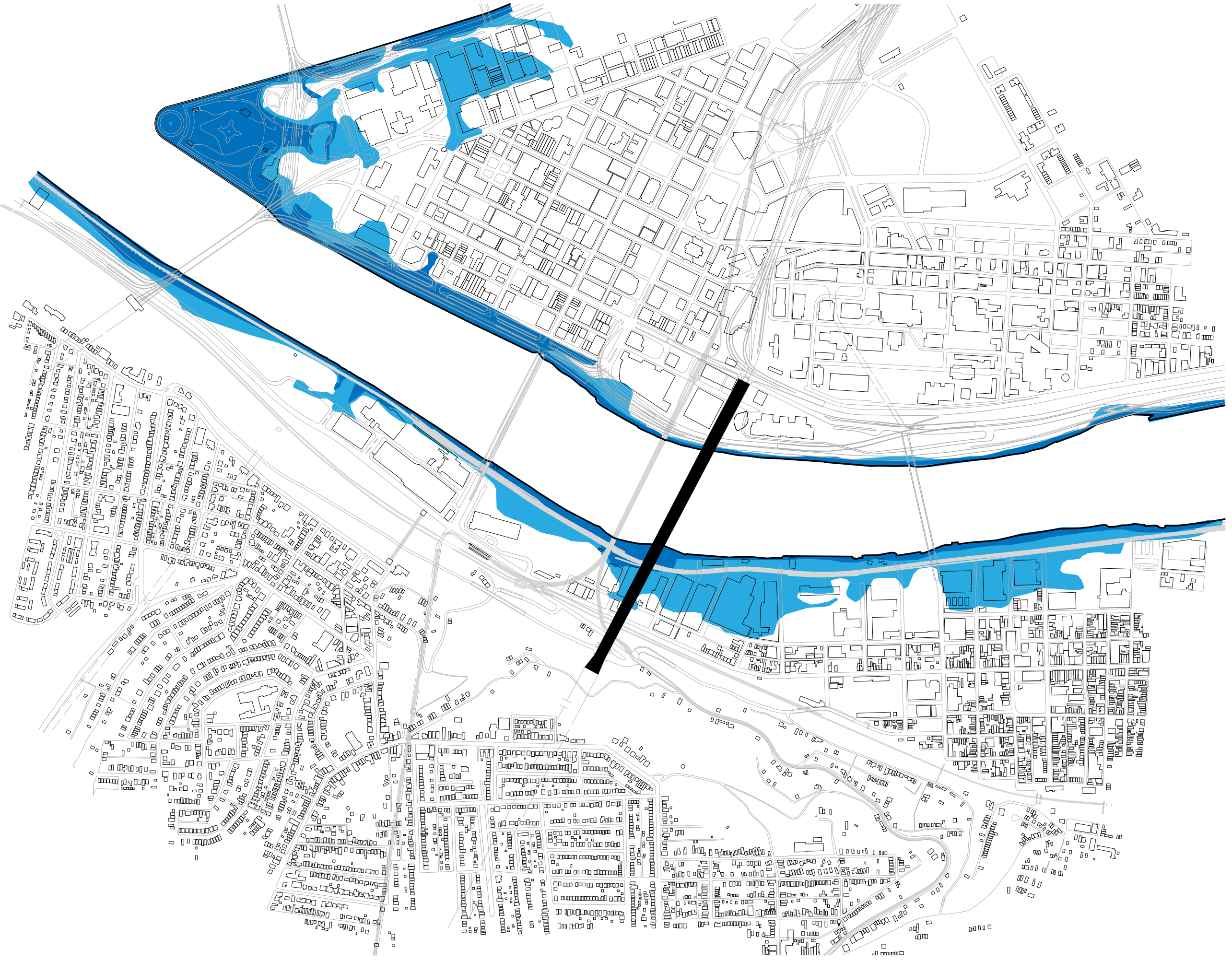
Site Mapping



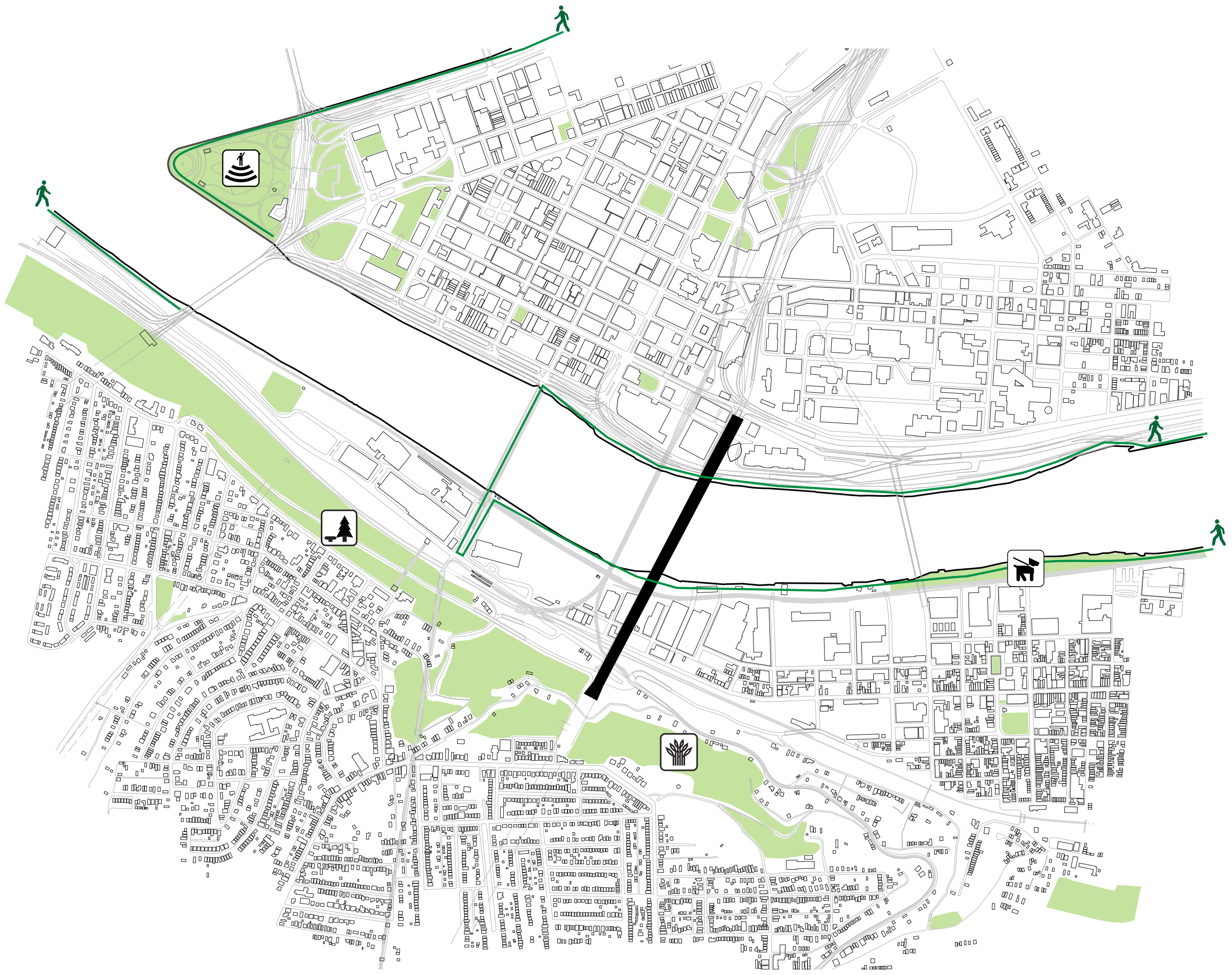
Adjacent Neighbourhoods



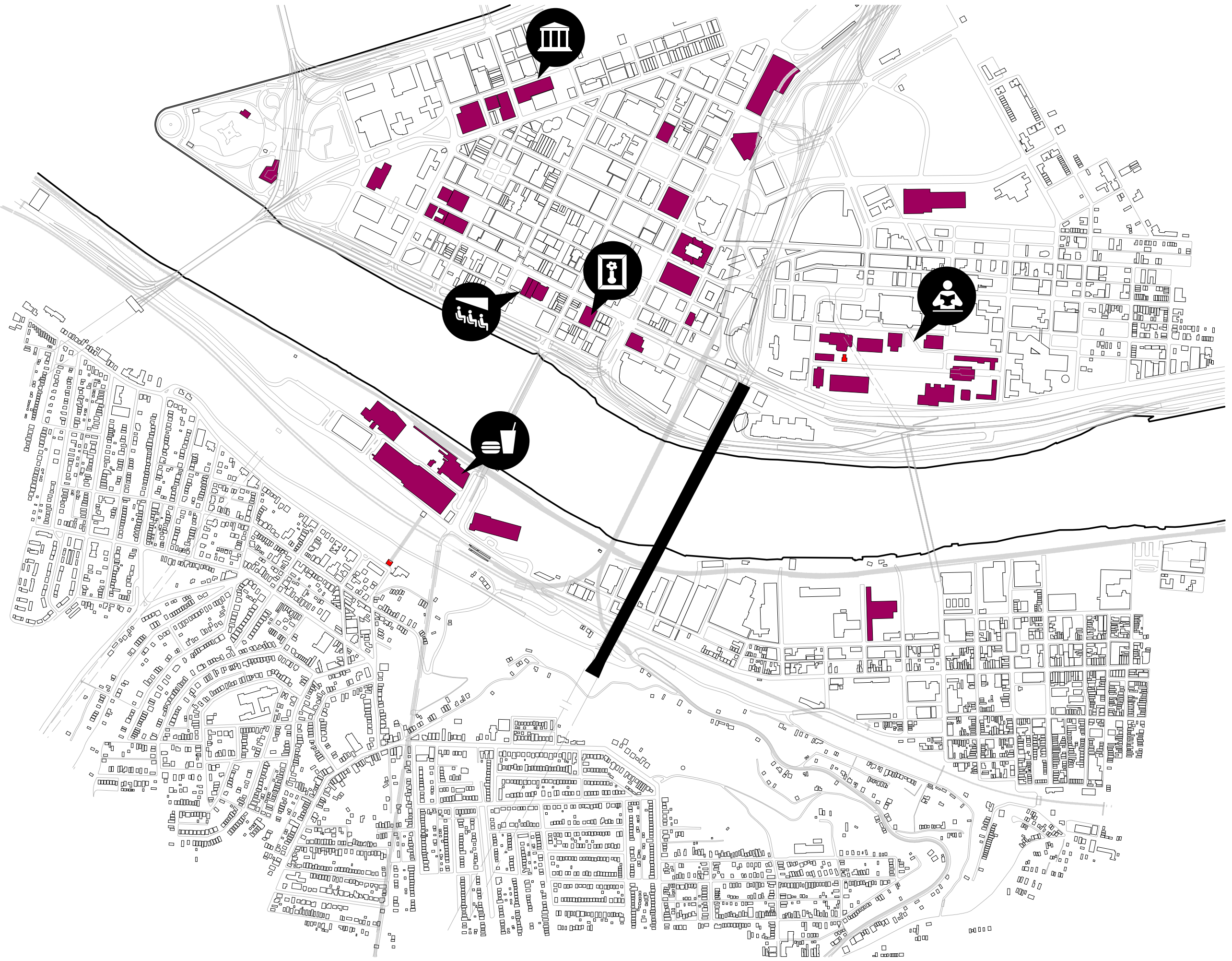
Infrastructural Network



Flood zones



Parks and Public Space



Cultural and Academic Institutions

Population Activity

Corporate Offices and Impervious Surface Parking

Annual discharge frequency of CSO into the Three Rivers

Pittsburgh's antiquated Combined Sewer and Overflow (CSO) System

When it storms in Pittsburgh, rainwater frequently exceeds the designated capacity of the outdated sanitation sewers forcing raw sewage to spill into the rivers at a rate of ~1 billion gallons per year.

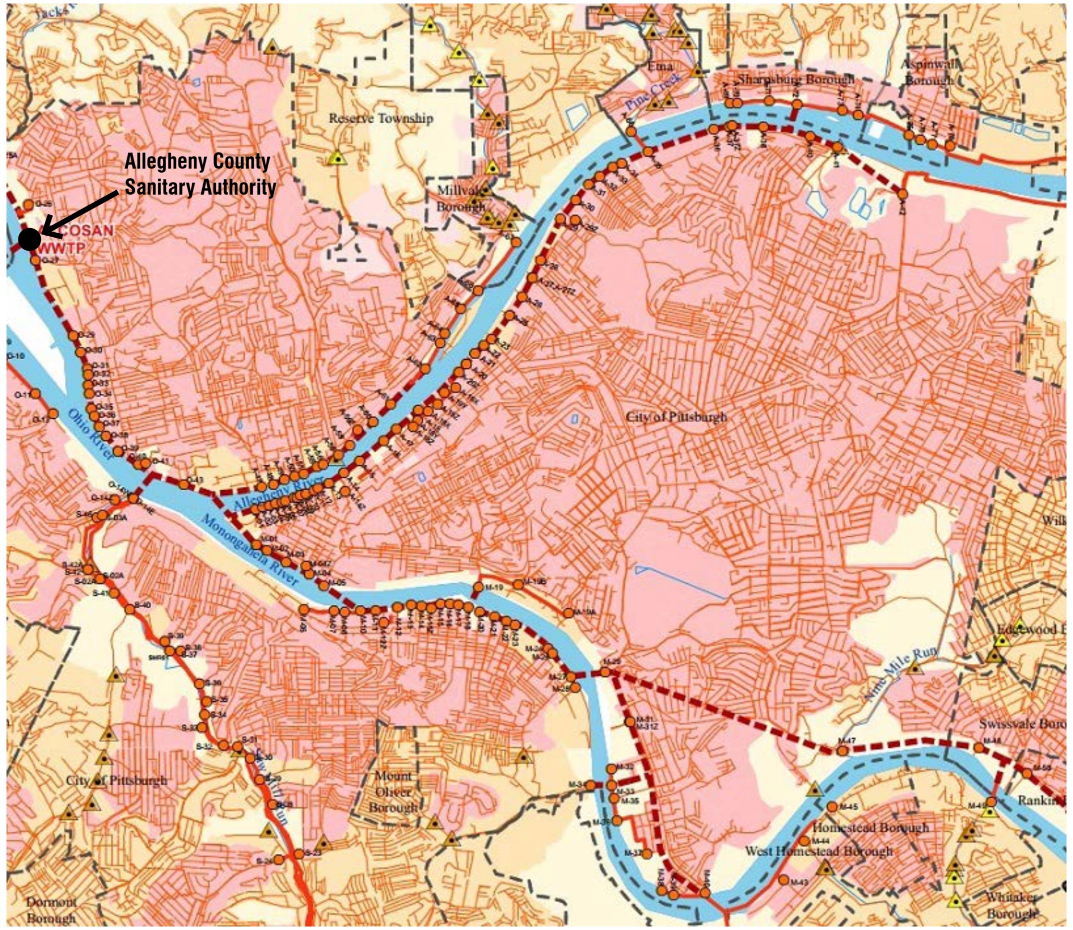
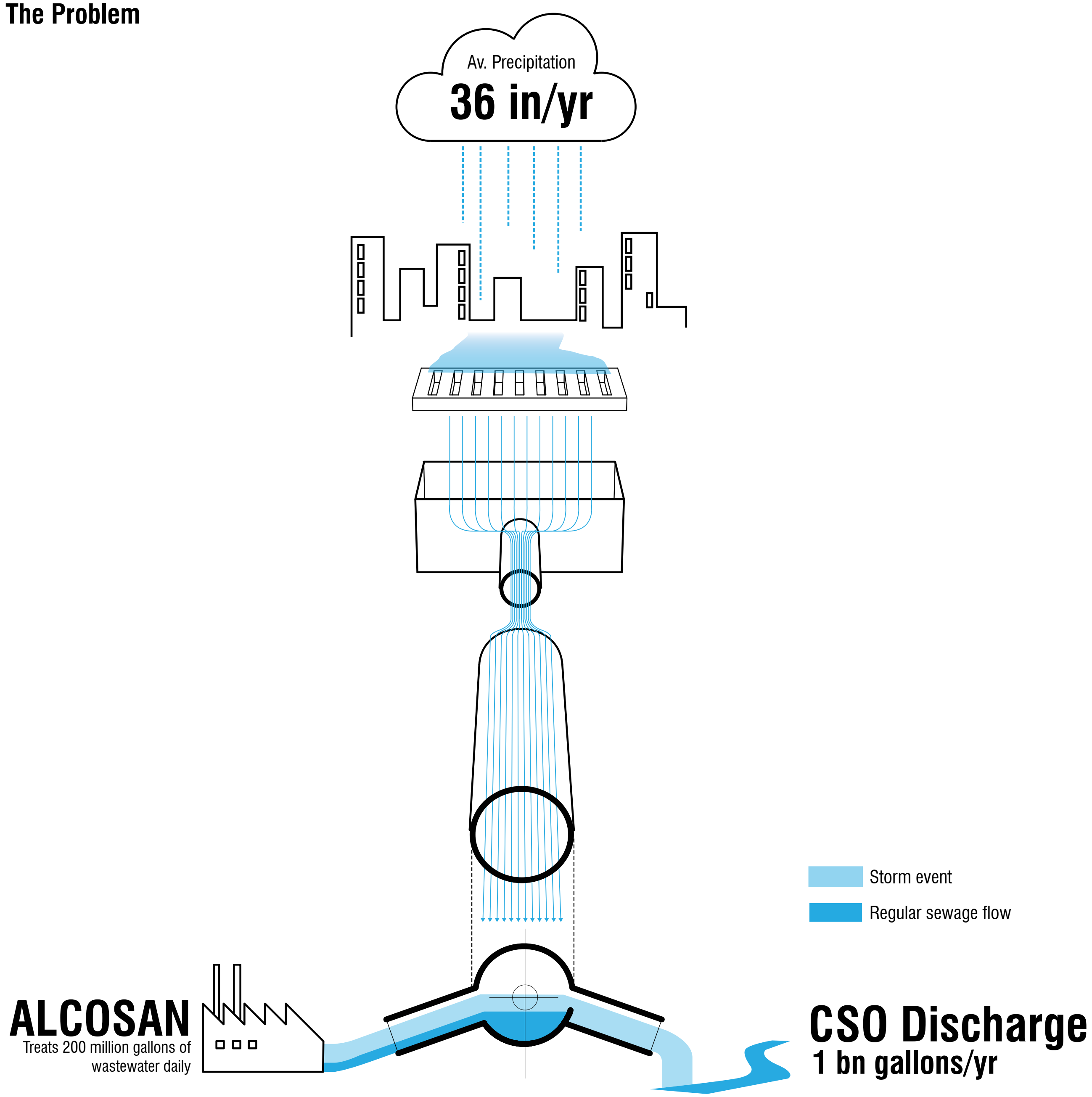


Fig 5.0 ALCOSAN's map of combined sewer overflow locations around Pittsburgh

As a result of this perpetual process, the river is fouled with waste and thus deemed unsafe for the better part of the boating season.

The Problem



Proposal for gray water infrastructure

As of 2008, the Environmental Protection Agency (EPA) has given Allegheny County Sanitary Authority (ALCOSAN), the municipality for waste and water management in Pittsburgh, until 2026 to meet the Clean Act Standards.

Fig 5.1 Warning sign declaring the river receives sewage from overflows

Fig 5.2 A proposed gray water solution (Deep Tunnel)

In order to meet this deadline, the municipality proposed a 2bn $ sewer plan that would utilize gray infrastructure to mitigate 60-70% of the overflow. This plan was rejected by the EPA declaring it deficient and far too costly.

Pervious Green Infrastructure

As a reaction to ALCOSAN's gray infrastructure proposal, a group of designers and engineers conducted a design charrette to test the potential application of green infrastructure along a half-mile site in the Southside neighbourhood. The aim was to investigate how best to capture the volume produced by a 1-inch storm event close to where it lands.

Fig 5.3 Testing Site for design charrette

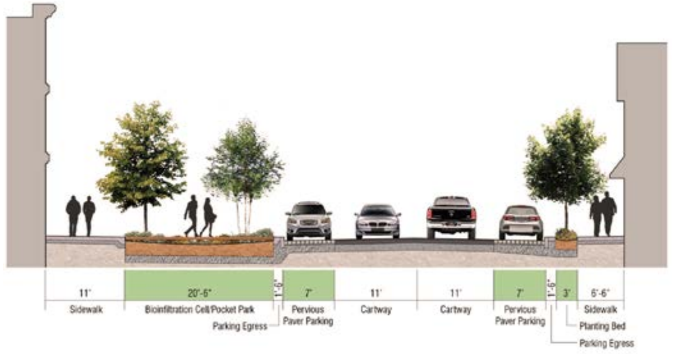


Fig 5.4 Section through 21st Street Corridor

Fig 5.5 Perspective View of 21st Street Corridor

Most of the teams advocated installing "pervious elements" along the street edge and building rooftops in order to soak up the rainwater before it enters the sewers. This approach would help mitigate the flow to Alcosan as well as the pollution that would otherwise be overflowing into the river.

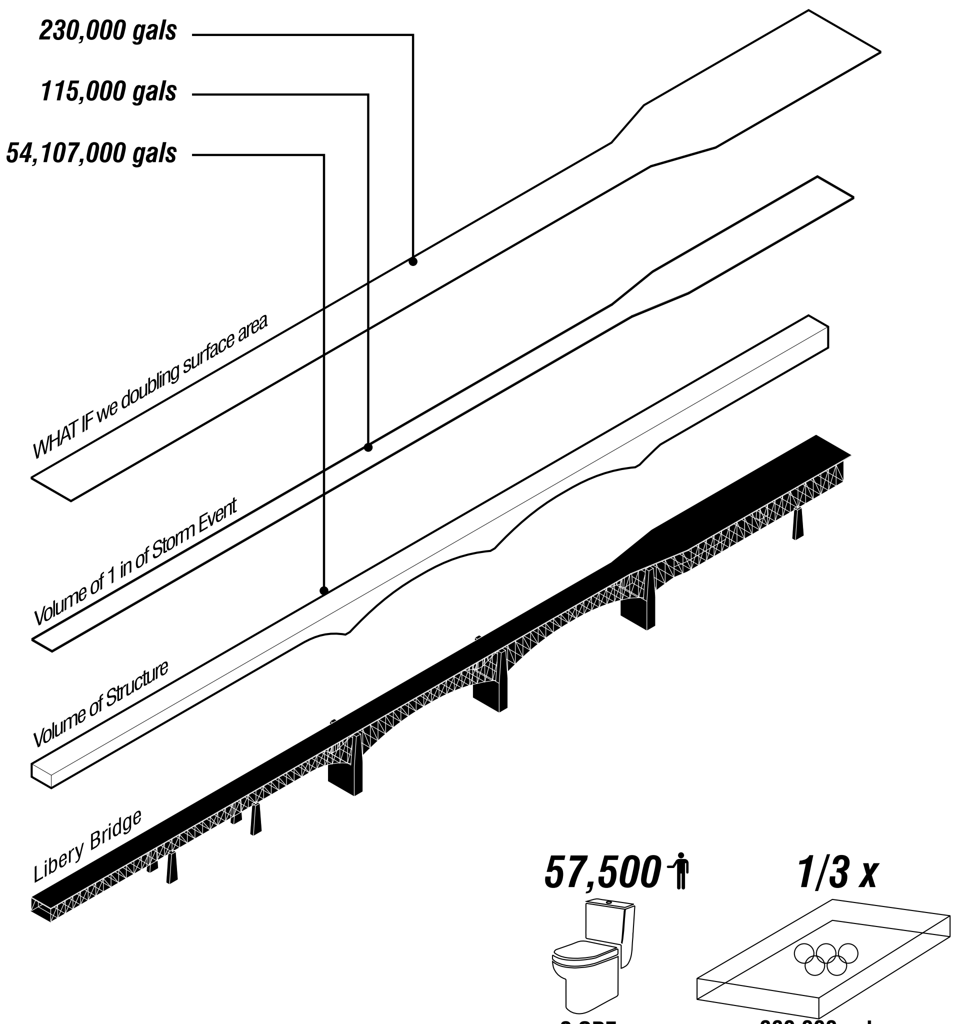
THICKENED VISION

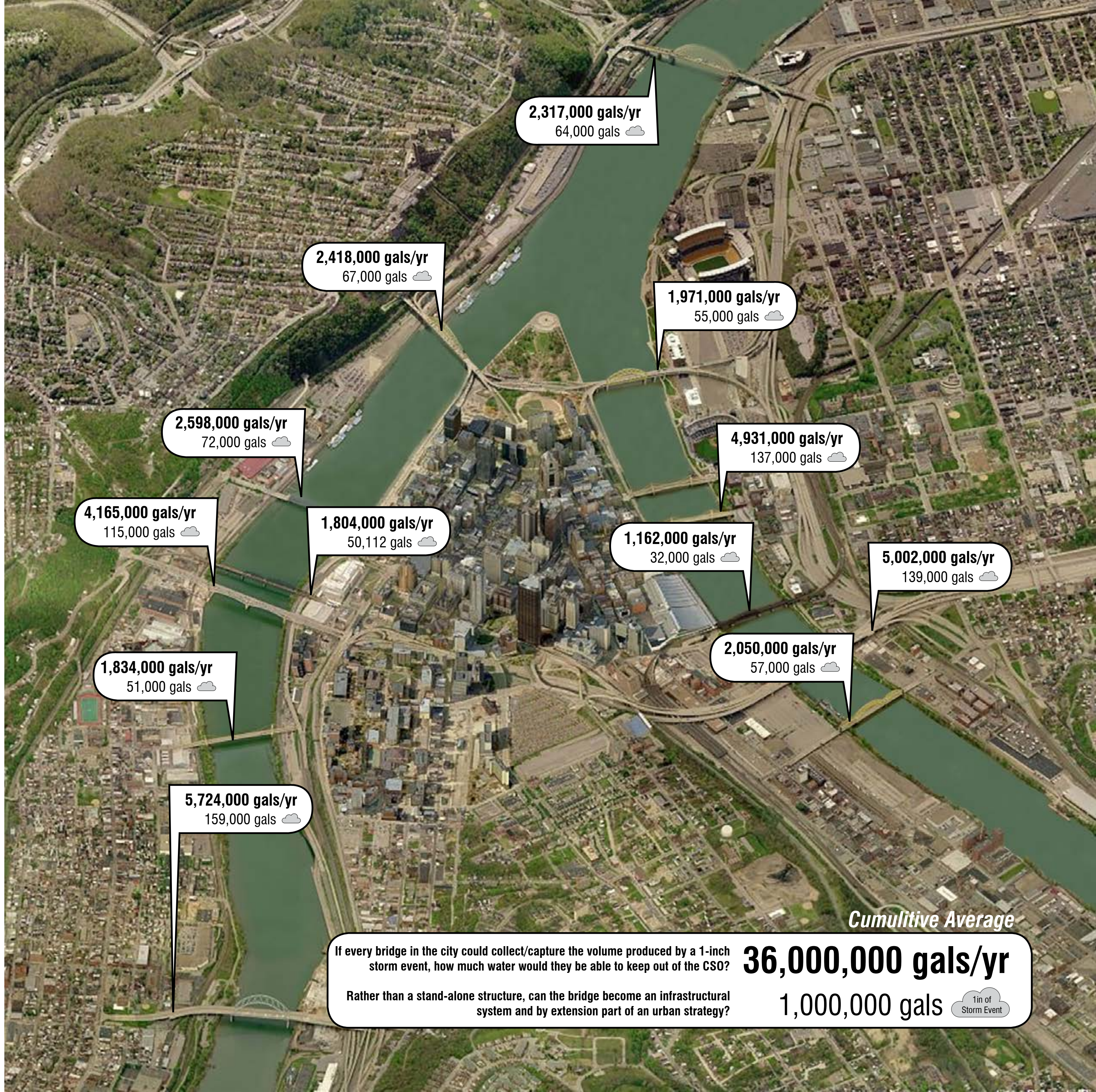
Could we imagine the bridge serving dual interests?

*1) **WASTE/WATER:** Could it harvest rainwater during storm events in order to unburden ALCOSAN and the CSO?*

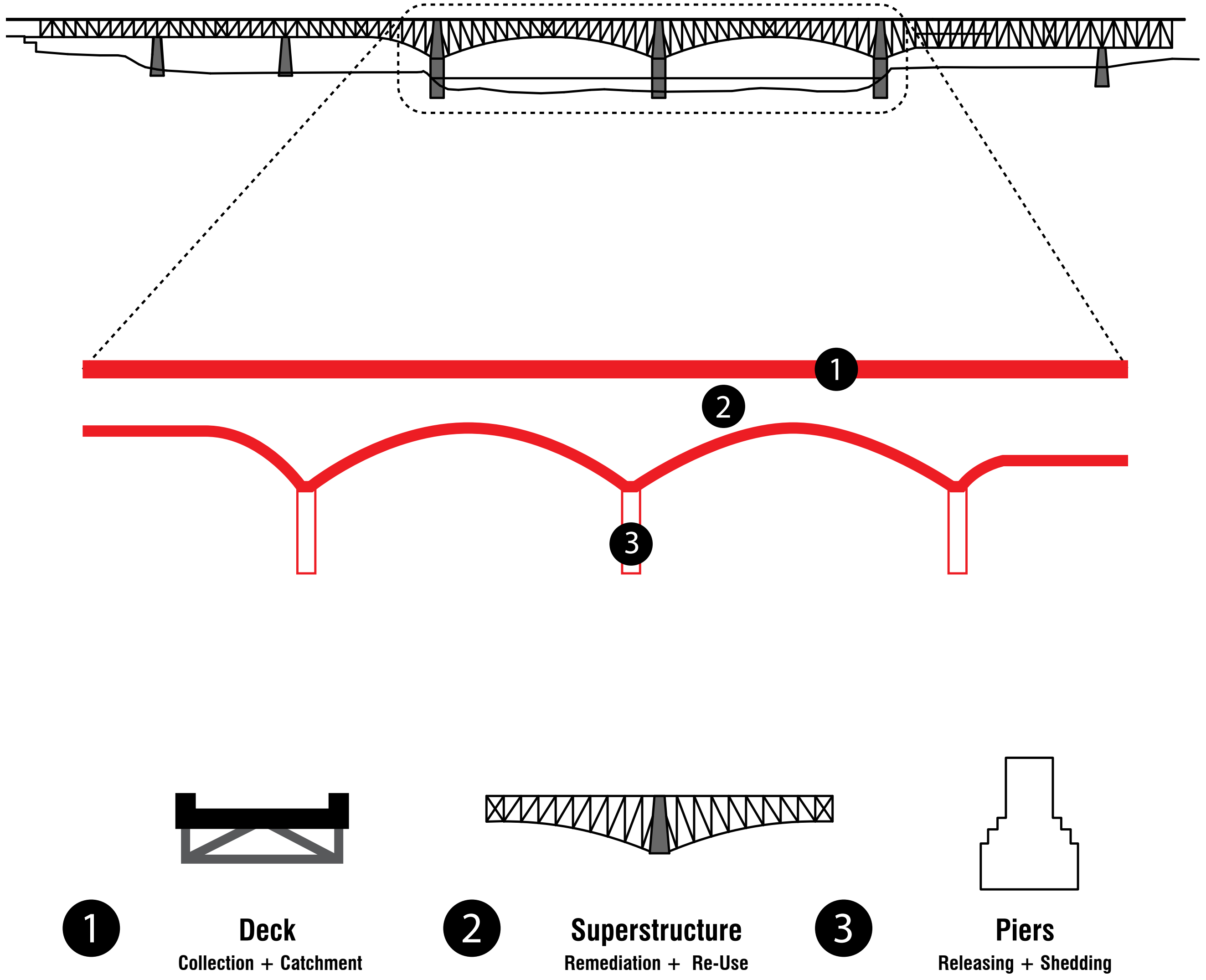
AND

*2) **MOBILITY:** Can it become a prototype of how to rethink Pittsburgh's aging bridge infrastructure?*





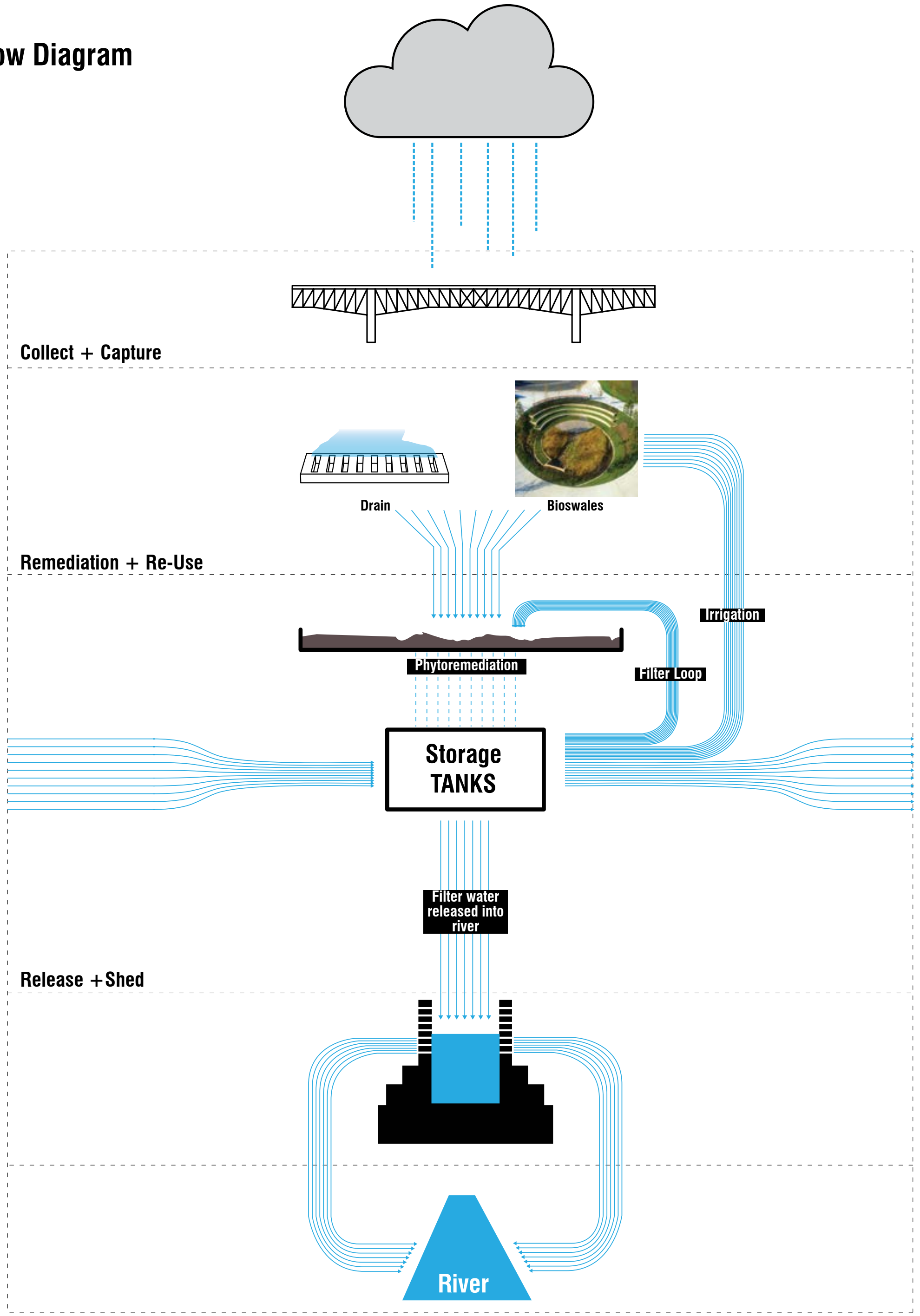
Conceptual Layering: Rainwater Harvest



During periods of high precipitation, the bridge can utilize its redundancy to help unburden the out-dated sewer system by capturing and remediating storm-water run off before it enters the CSO and the Ohio River.

Conceptual Flow Diagram

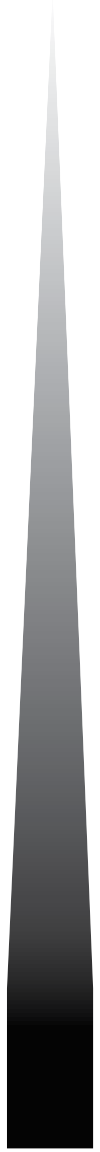
During storm events the city can utilize its bridges as a storage basin to try to unburden the CSO



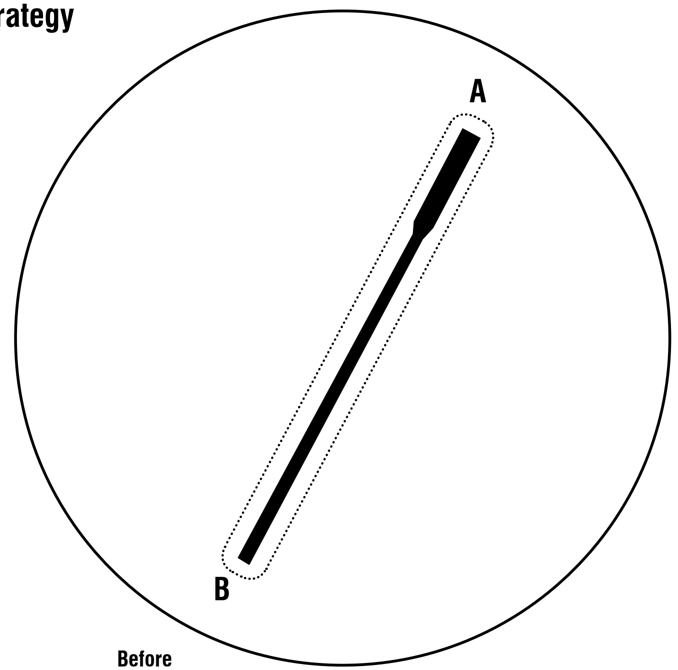
After storm event, the bridge can pump the water back into the city for graywater and irrigation use

Conceptual Bridge Strategy

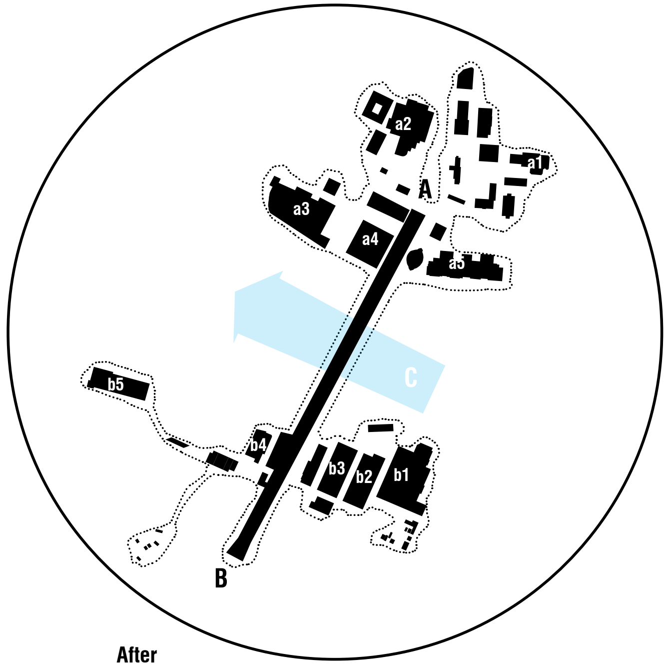
Stand alone Structure



Infrastructure System



Before



After

1.

Fig 6.0 Former Site of Demolished Civic Arena

2.

Fig 6.1 Crosstown Park

3.

Fig 6.2 Boulevard of the Allies and Crosstown Boulevard Intersection

4.

Fig 6.3 Mckean St. Industrial sites

Conceptual Urban Strategy

Programmatic & Tectonic References

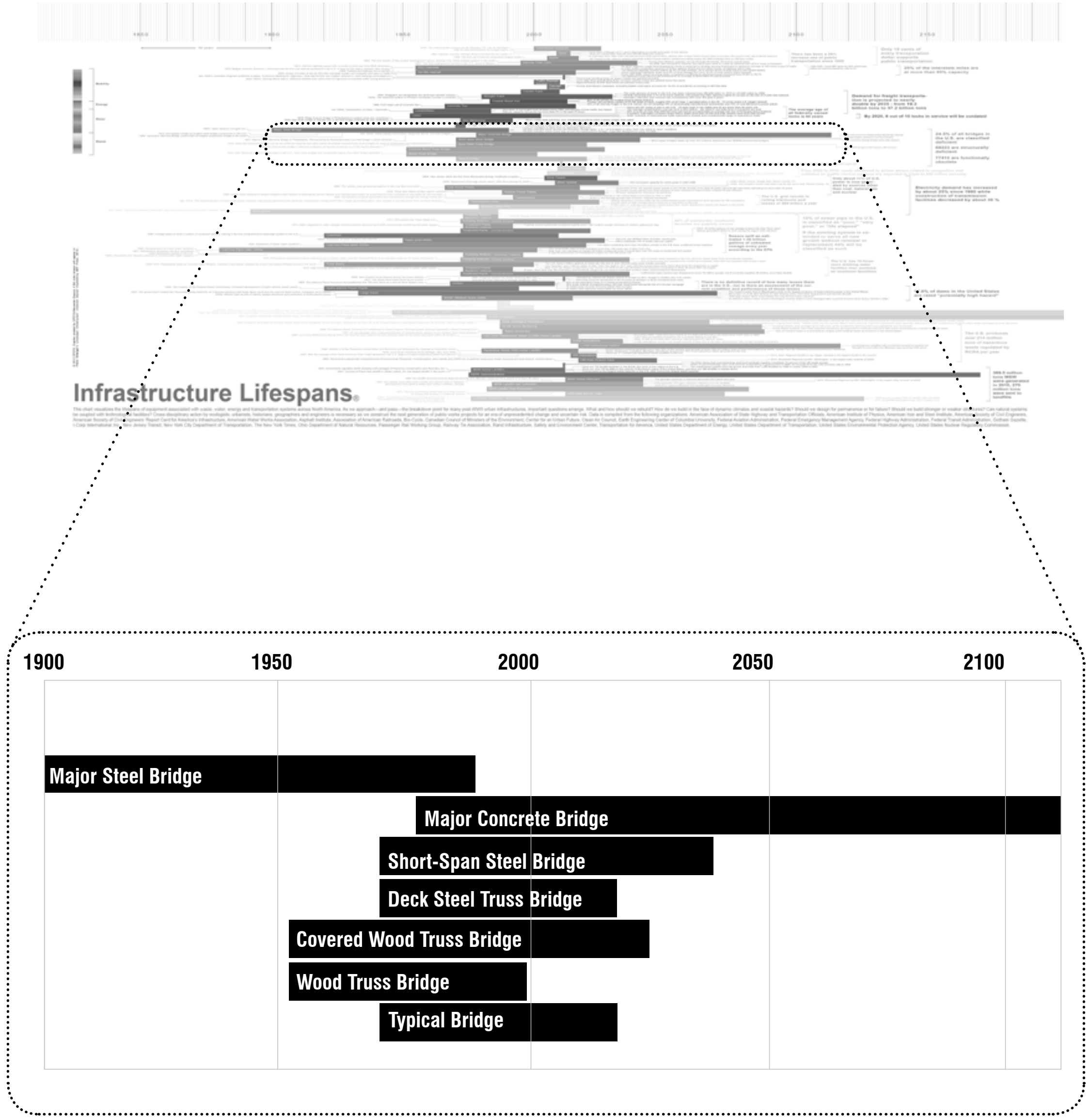


Fig 6.4 Harvard GSD Symposium *Landscape Infrastructure: Systems and Strategies for Contemporary Urbanization*
Event Poster: Infrastructure Lifespans

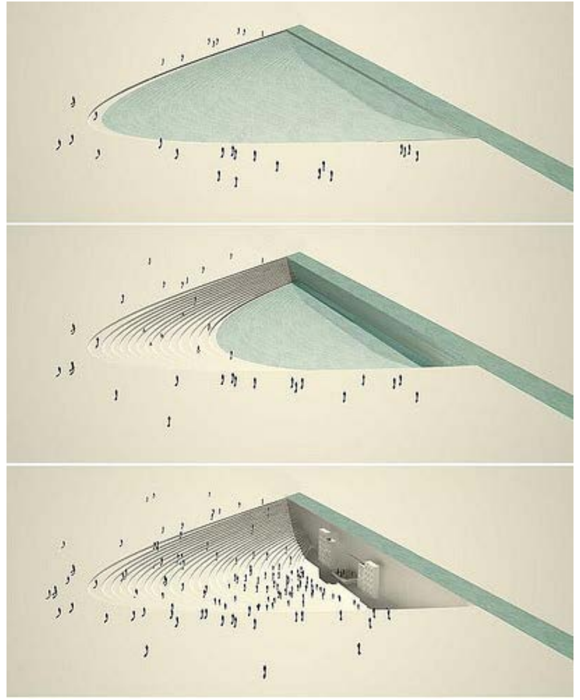


Fig 6.5 Anonymous Competition Entry: Half Rainwater Tank, Half Theater

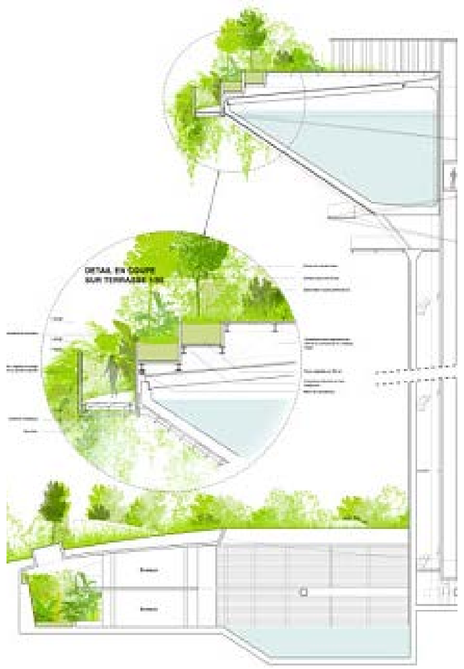


Fig 6.6 Atelier Ramdam: Castle in the Sky Water Tower

Fig 6.7 Bioswale amphitheater

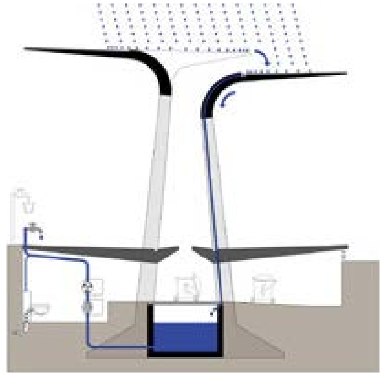


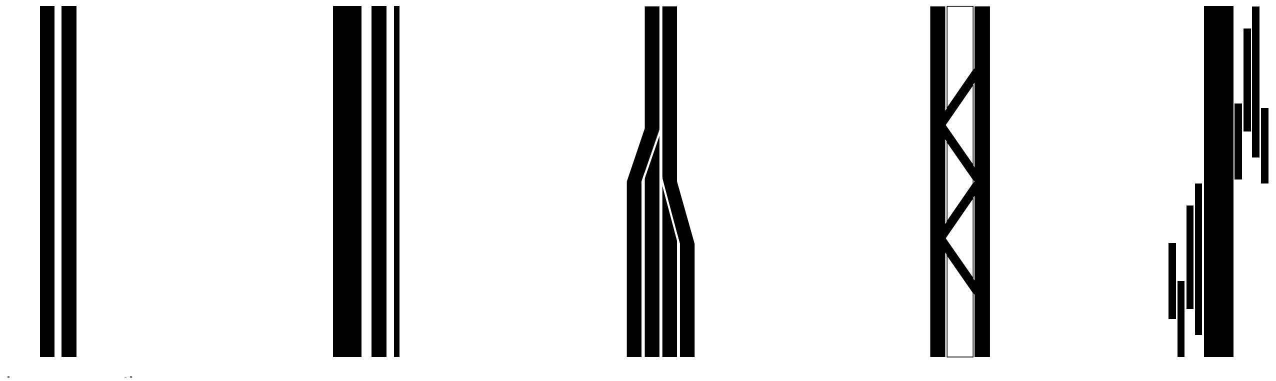
Fig 6.8 TomDavid Architecten: Rainwater Harvesting Leaf Pavillion

CONCEPTUAL STUDIES

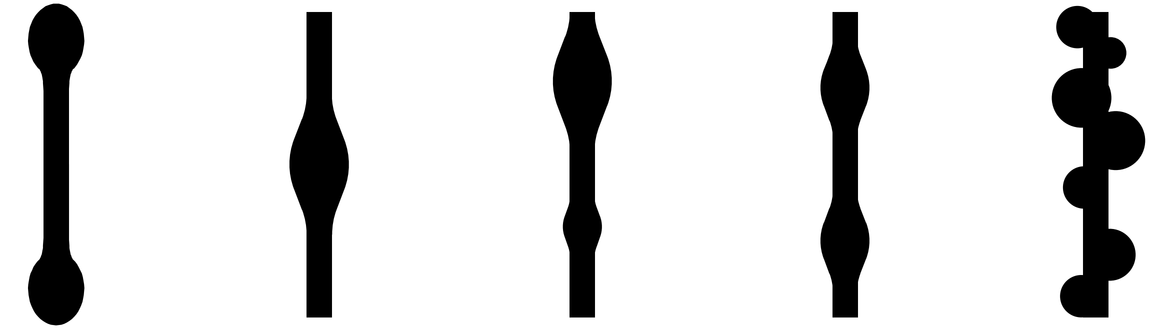
*The bridge is a **linear plane** supported by a repetitive **assembly of structural components.** Its purpose is to facilitate, consolidate and augment the **continuous flow** of vectors and processes between **two nodes** separated by a **physical boundary**.*

By defining the bridge through its basic features (i.e. shape, structure, function and context), we can begin to de-optimize the critical elements that lend to its strict function. Exaggerations in scale, plasticity, repetition and aggregation will form the basis of de-optimization . In doing this, there is potential to inspire a new understanding of the bridge and allow for productive discoveries/interpretations to emerge.

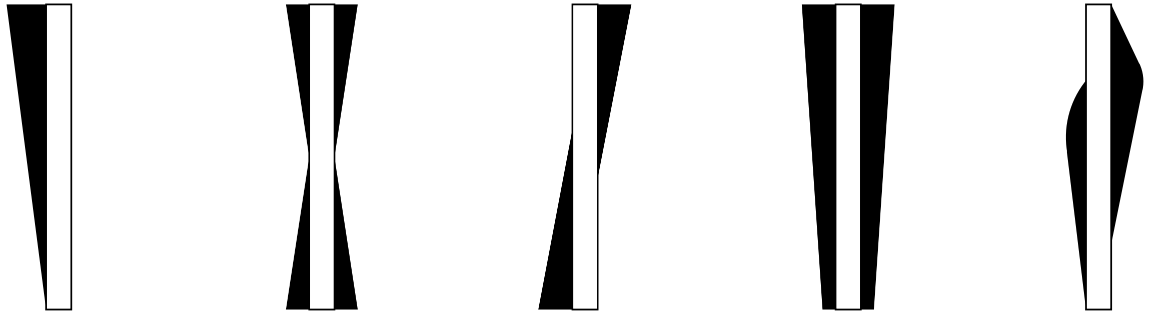
The plane will serve as the basis of this conceptual exercise.



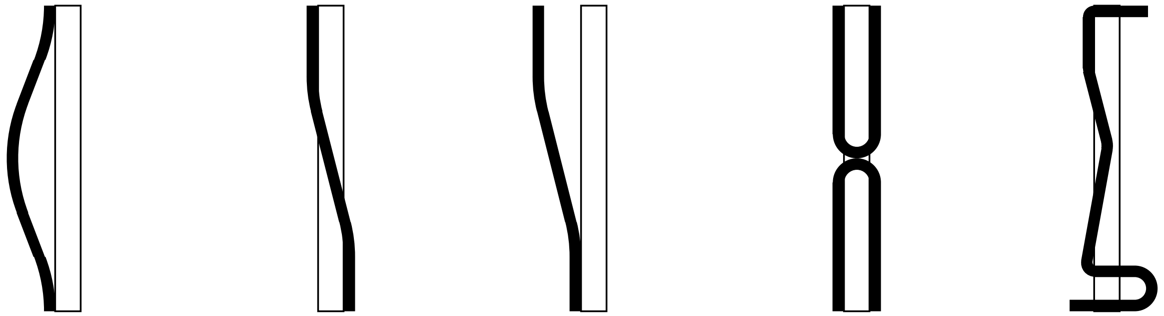
Planar Aggregation



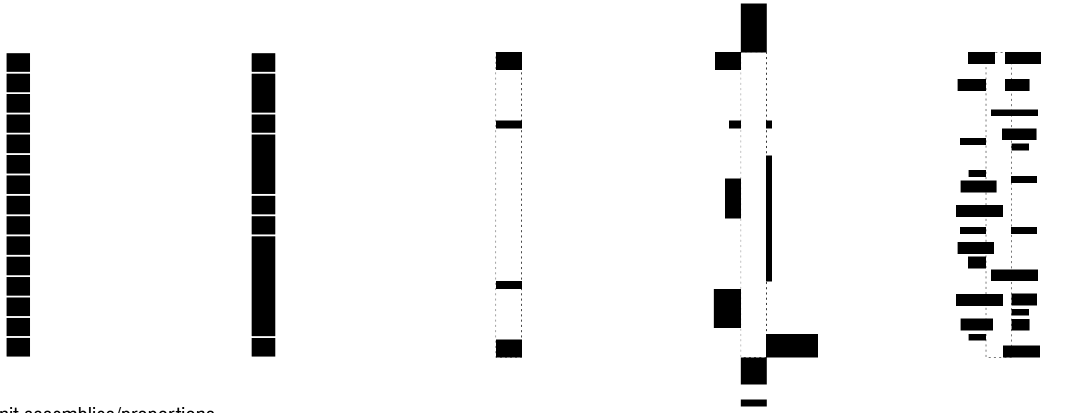
Nodes/Intensities



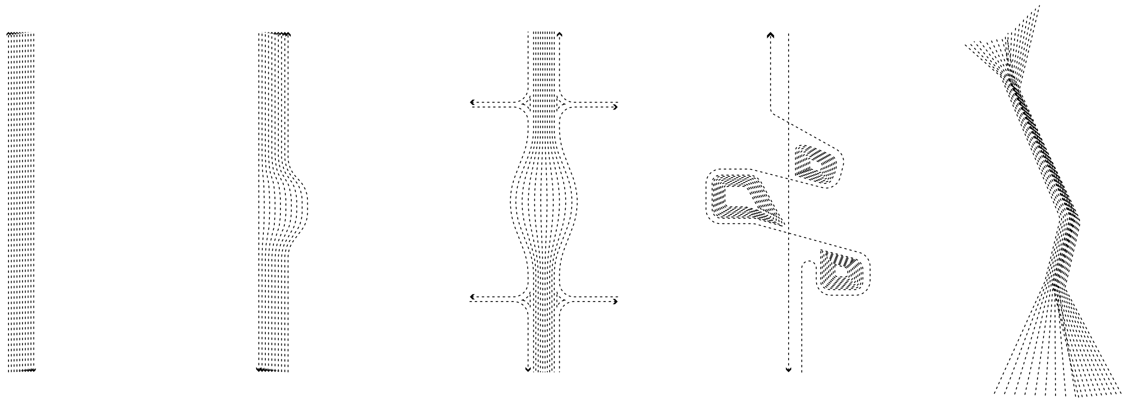
edges/vertices



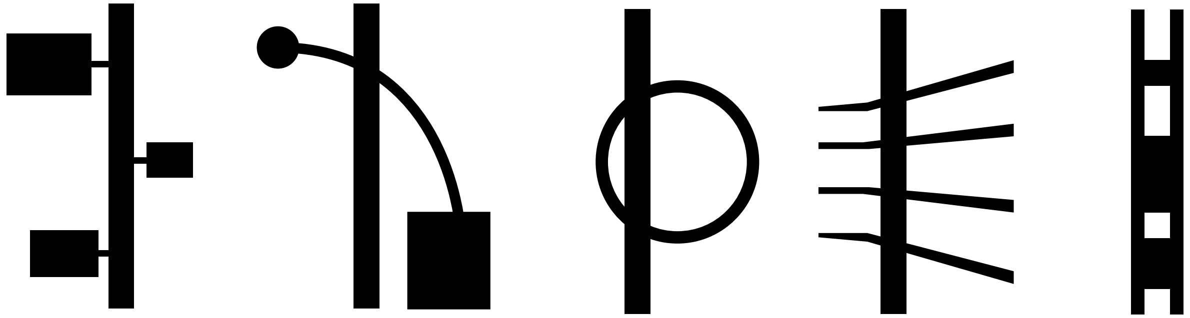
Secondary 2D path



unit assemblies/proportions

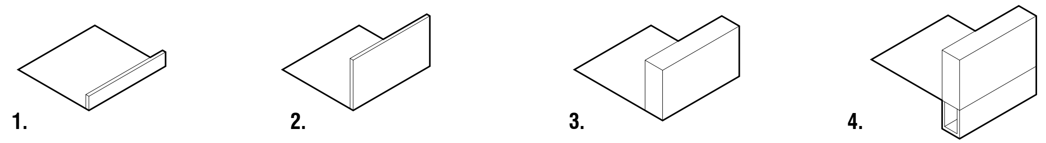


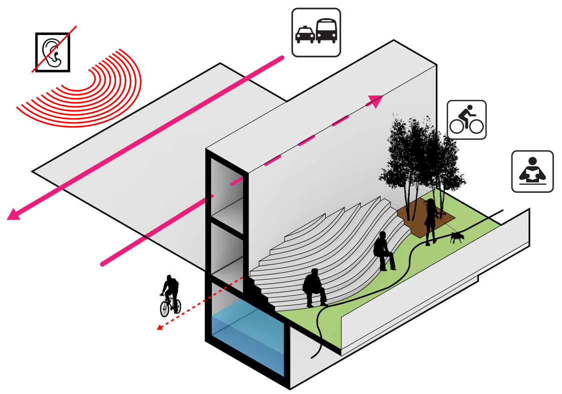
processes/flows



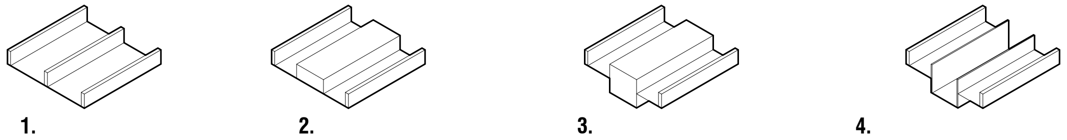
Planar composites

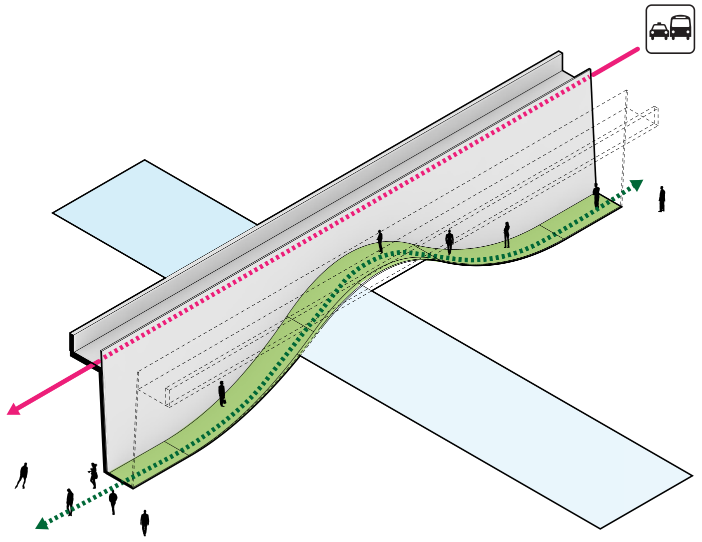
De-optimize Rear Road Barriers



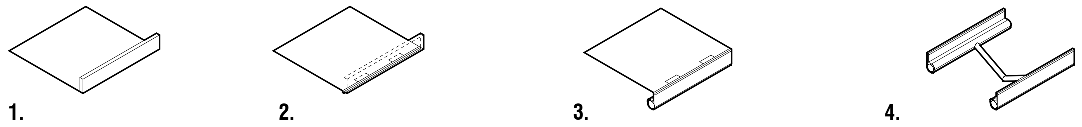


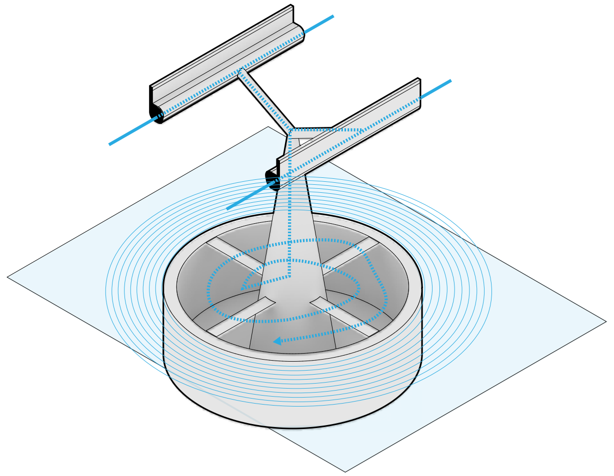
De-optimize Middle Road Barriers



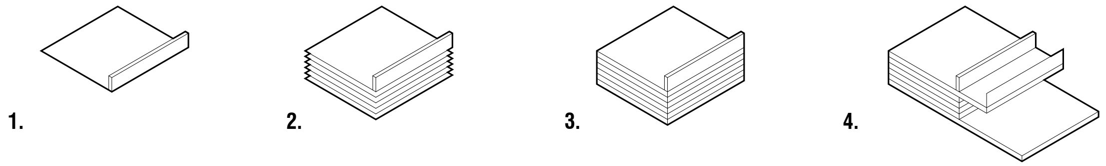


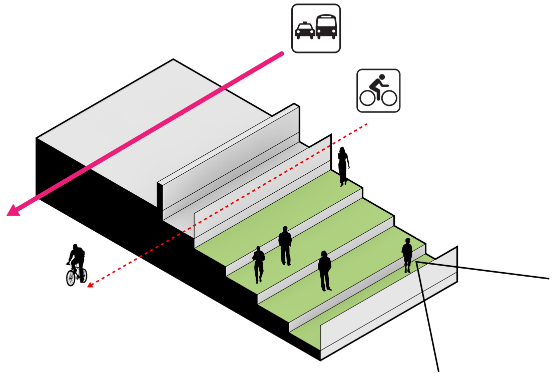
De-optimize Drainage System





De-optimize Deck structure





AIM(s)

Thickening

…advocates for a critique of infrastructural practice; not a definitive solution.

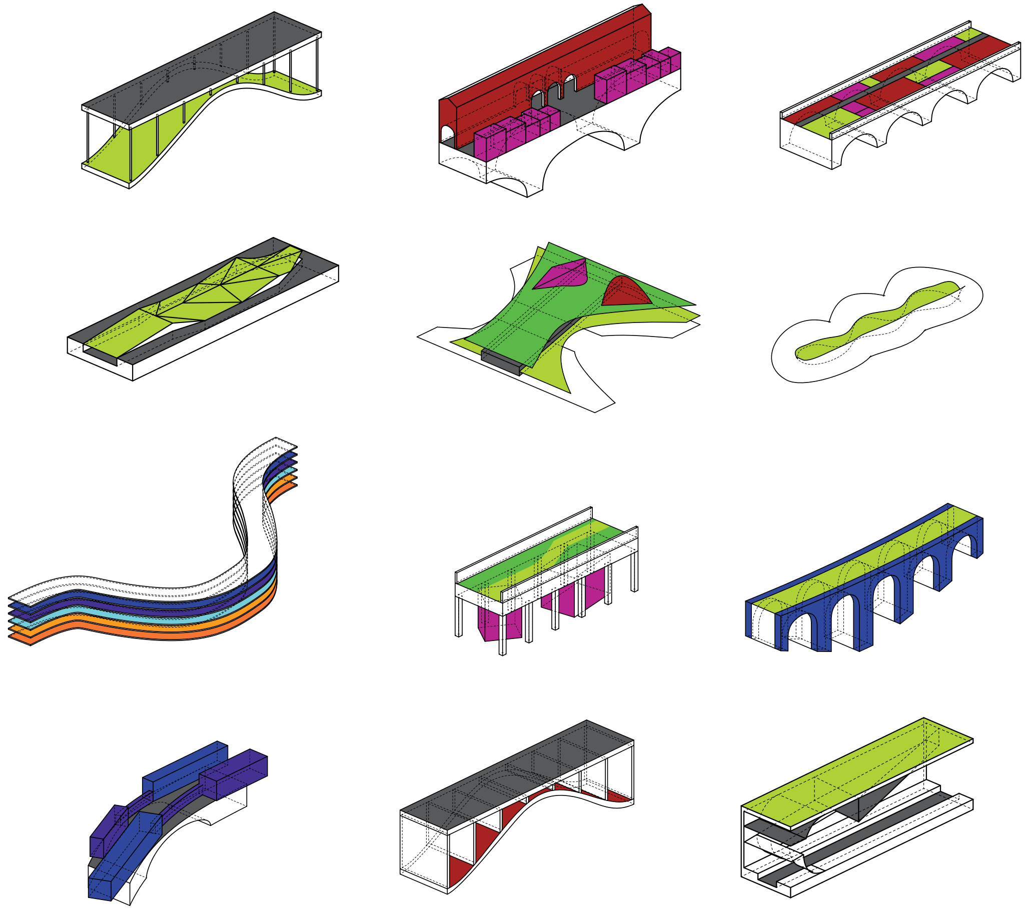
…demonstrates how infrastructure can benefit from "architecture" as a systems thinking practice. It encourages architects to deviate from the role of aesthetic advisors and intervene in infrastructure as coordinators and designers of resilient systems.

…leverages redundancy to create new architectural prototypes that deal with several variables and exchanges: social, environmental, ecological and tectonic.

…scrutinizes the closed system mindset of 'singular use'. By focusing equally on the structure and its adjacencies there is potential to create stronger reciprocity between systems, ecologies and infrastructure. Thus producing systems with resilience lifespans.

…argues for an infrastructural system; not a stand-alone structure.

APPENDIX



Could the bridge be informed by a diagram like this?

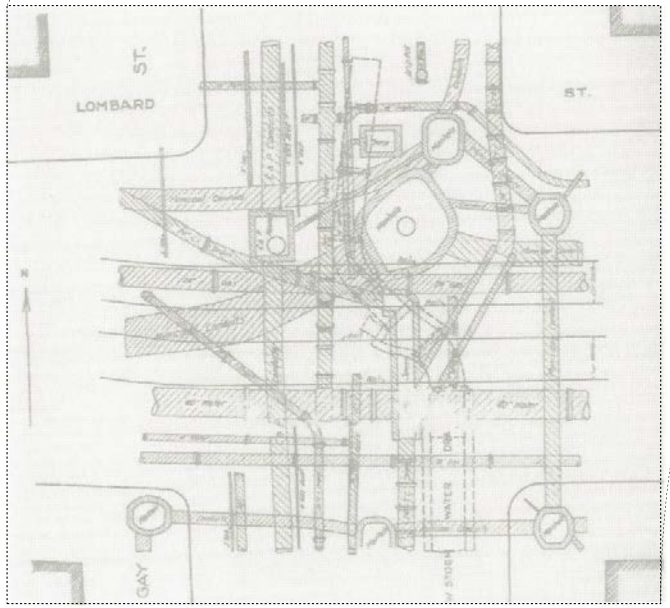
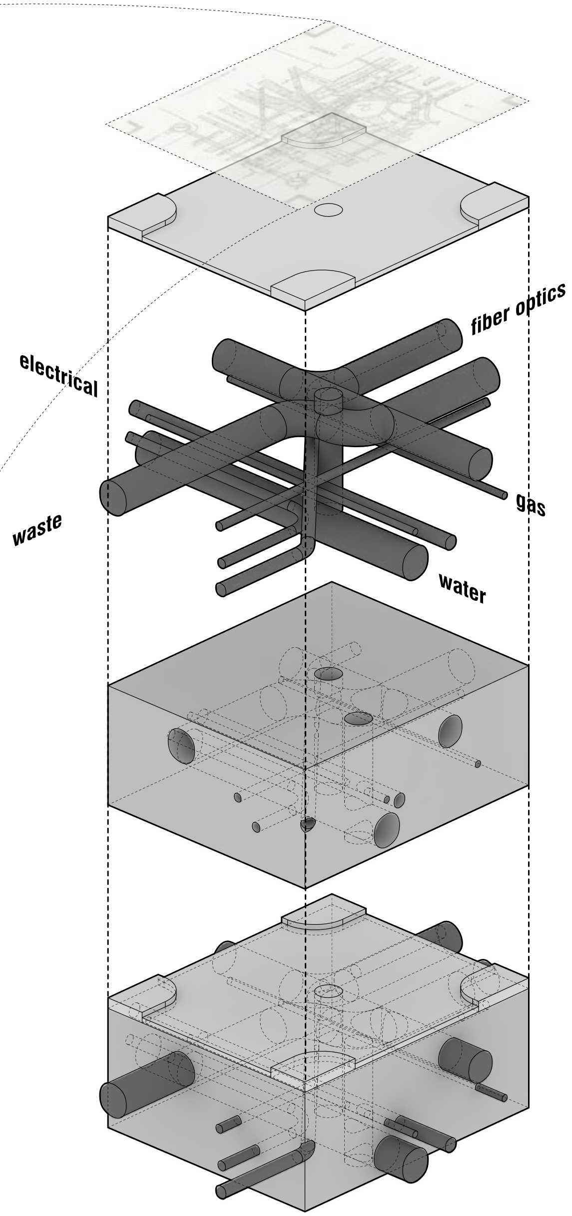
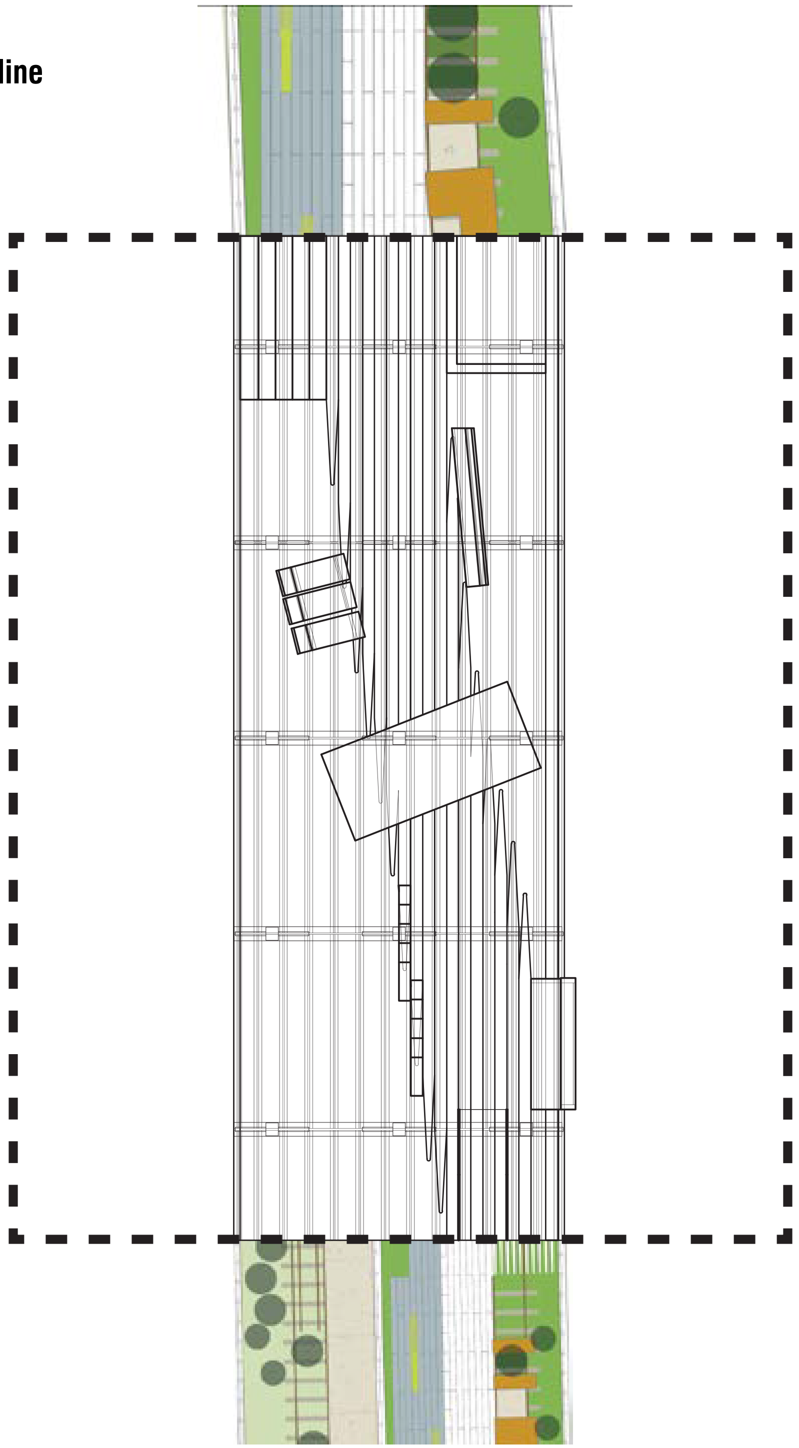


Fig 7.0 Lewis Mumford's Invisible City (*note: The hidden pipes and conduits at the junction of Gay and Lombard Streets in Baltimore, 1908)

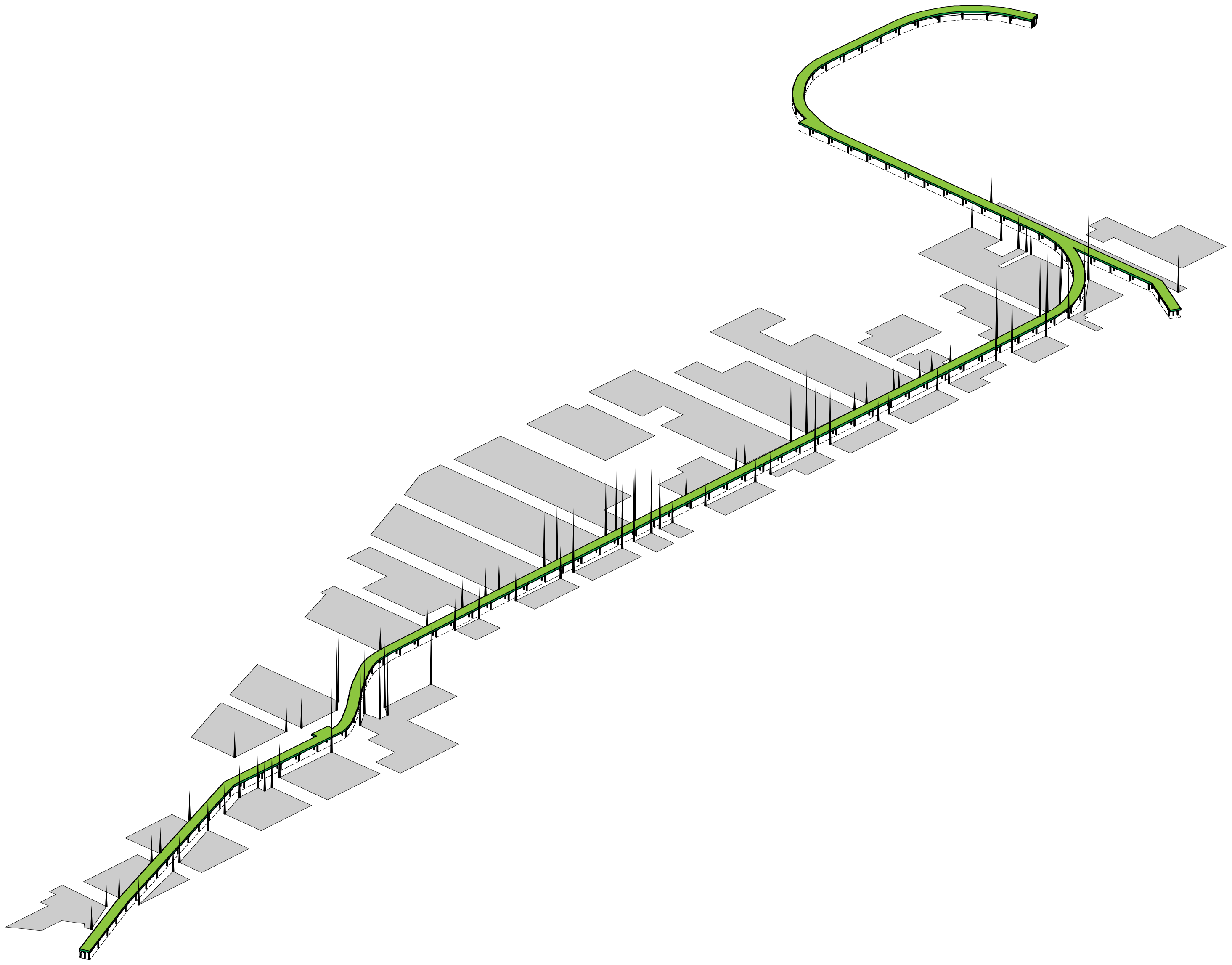


Mumford's Invisible Highline



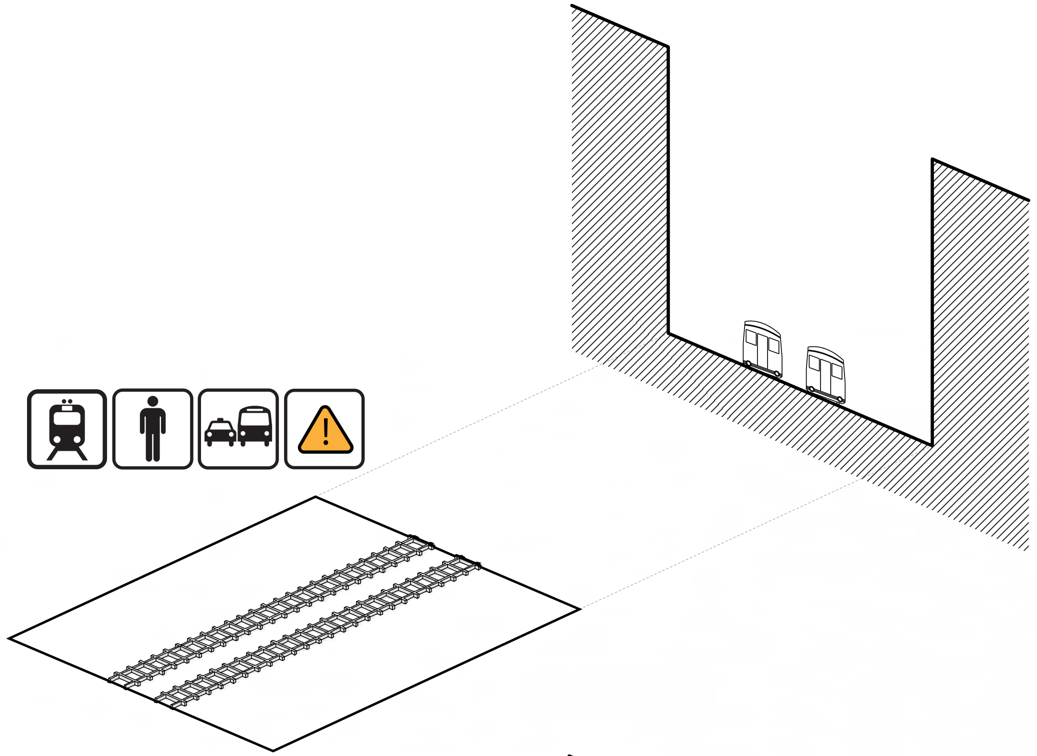
Site:Macroscale

The Line

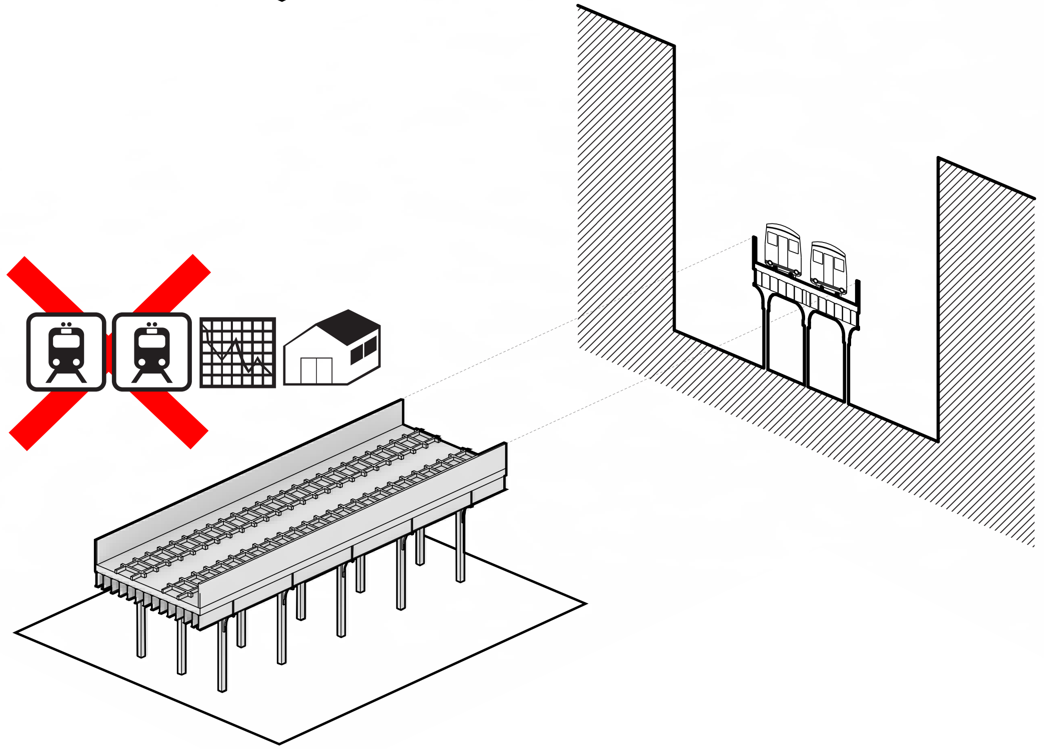


Site:Microscale

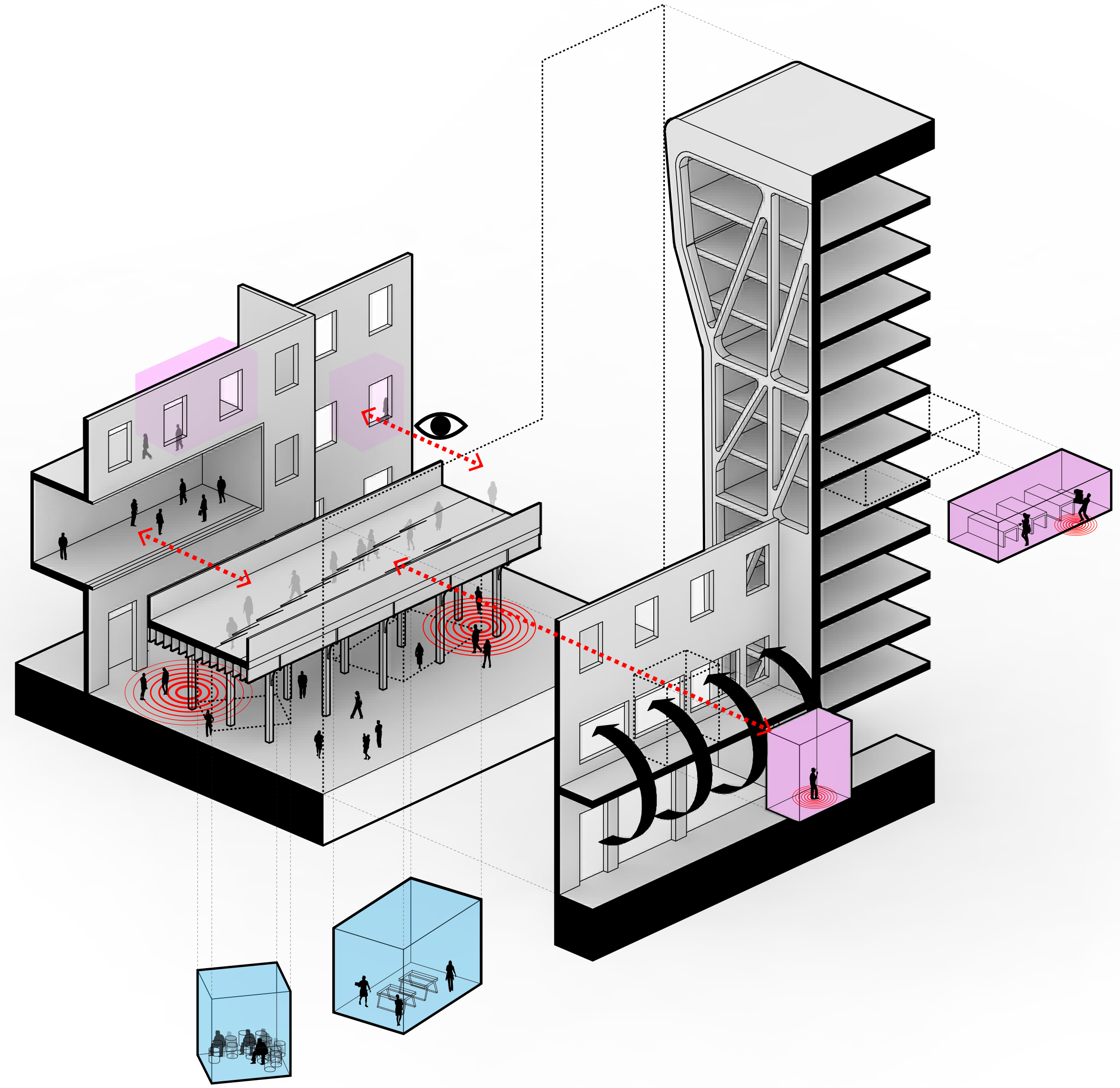
History & Motivation



1847...

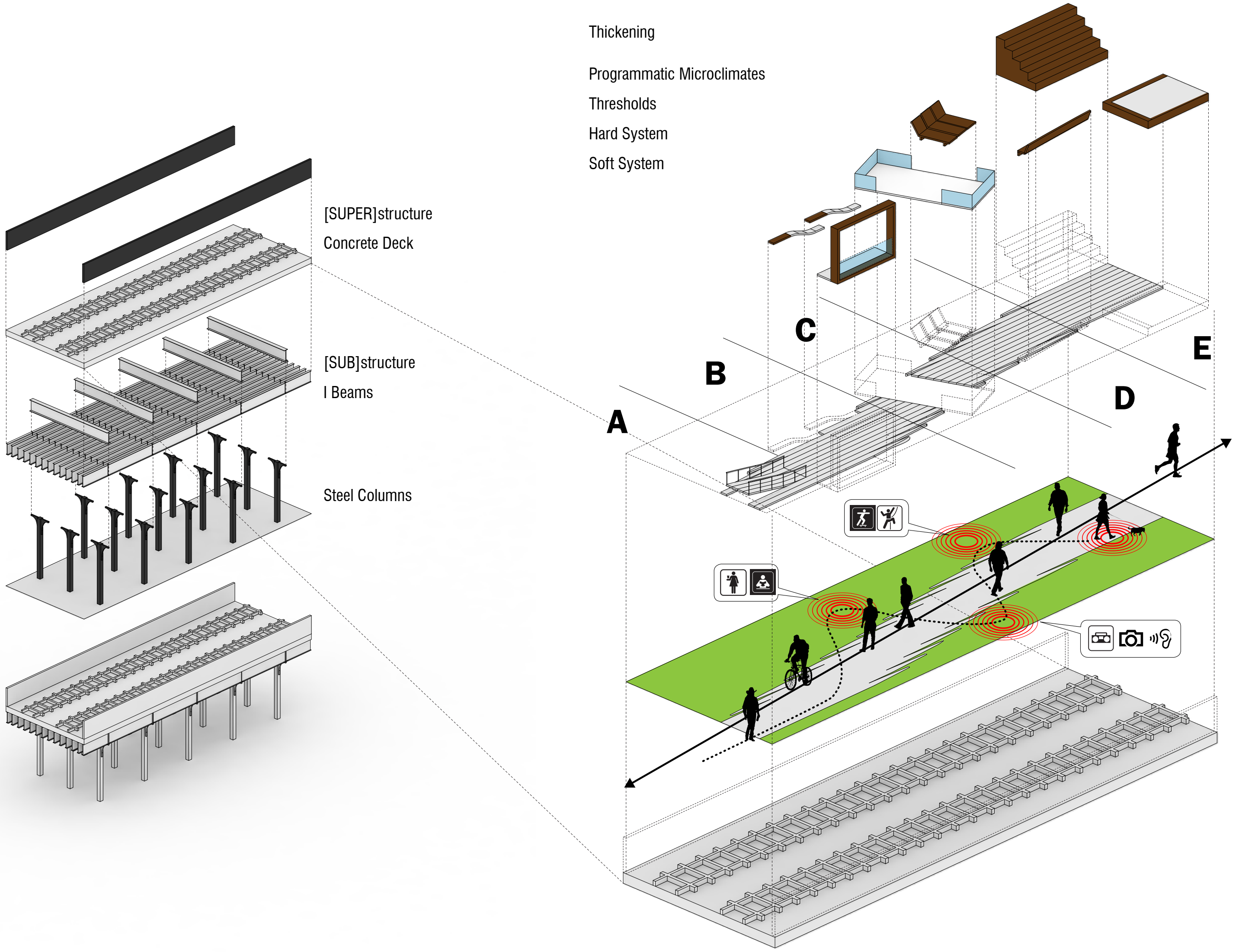


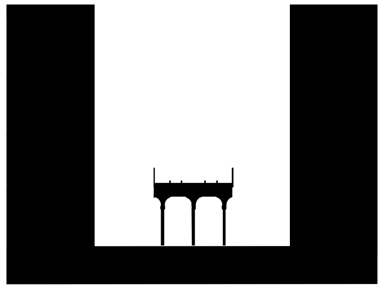
1930...



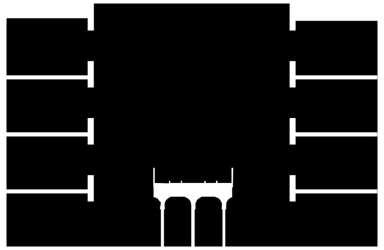
2009...

Site:Microscale
Thickening the [SUPER]structure





Positive

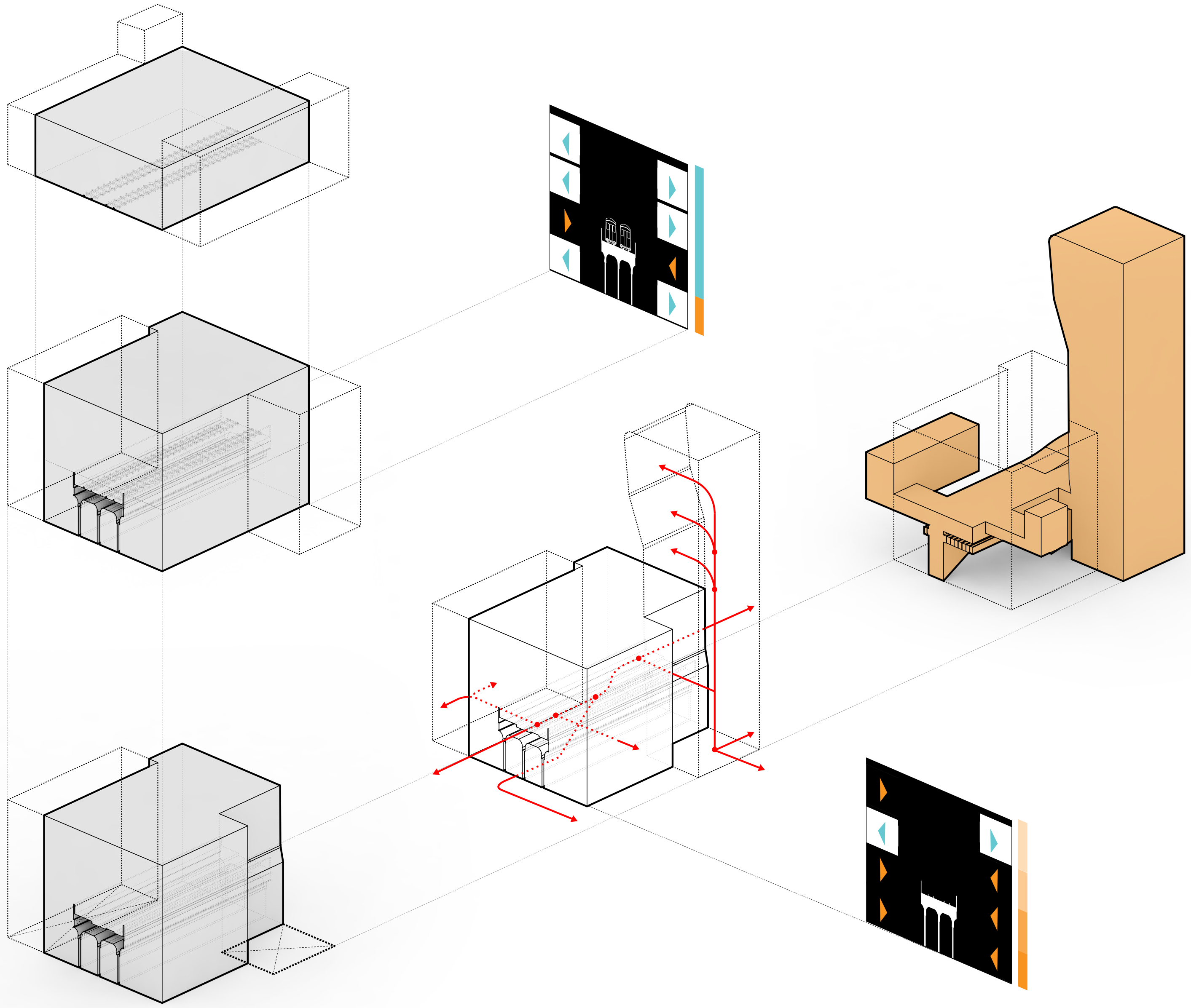


Negative

Activating the Negative

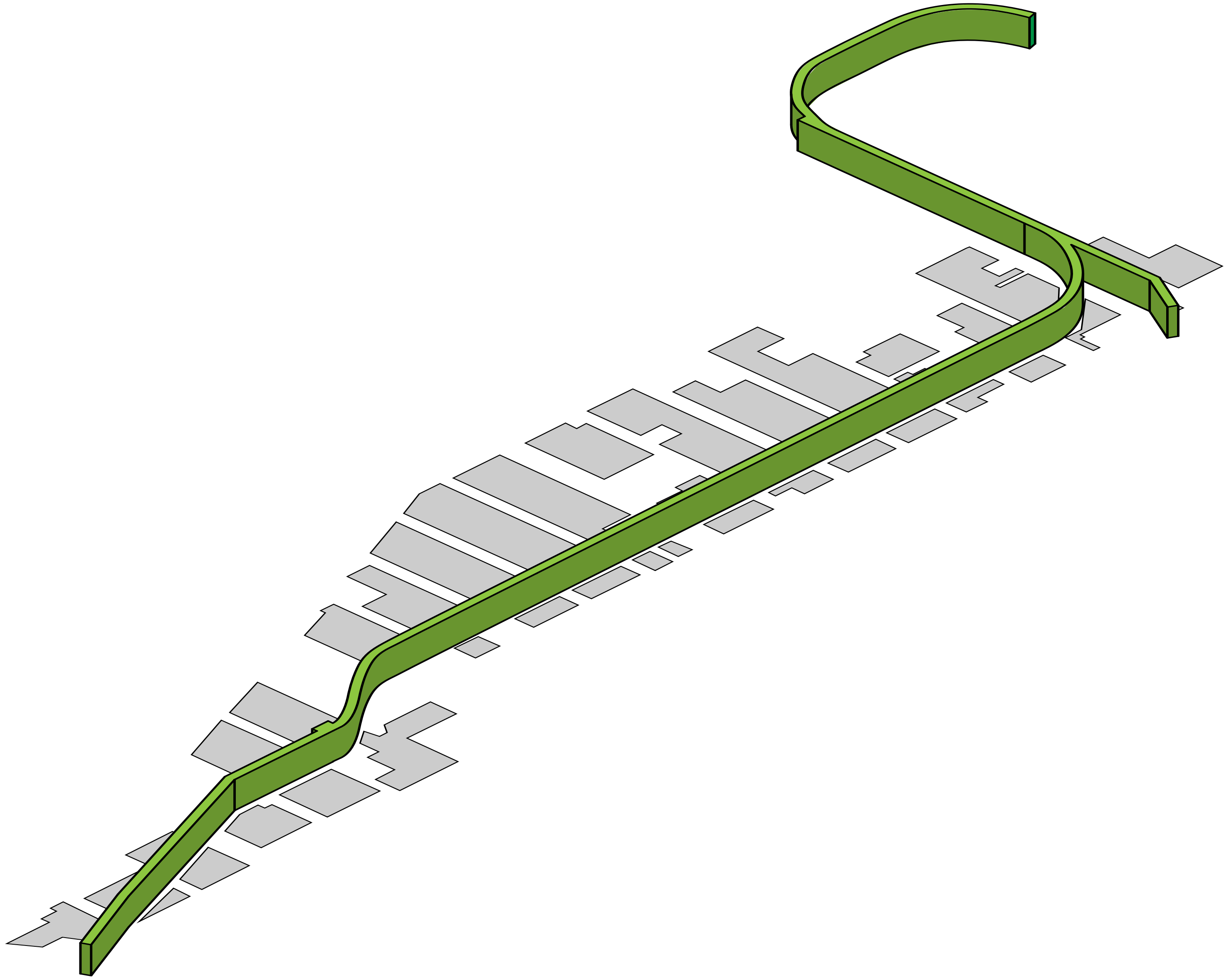
Site:Microscale

Thickening the [SUPER]structure



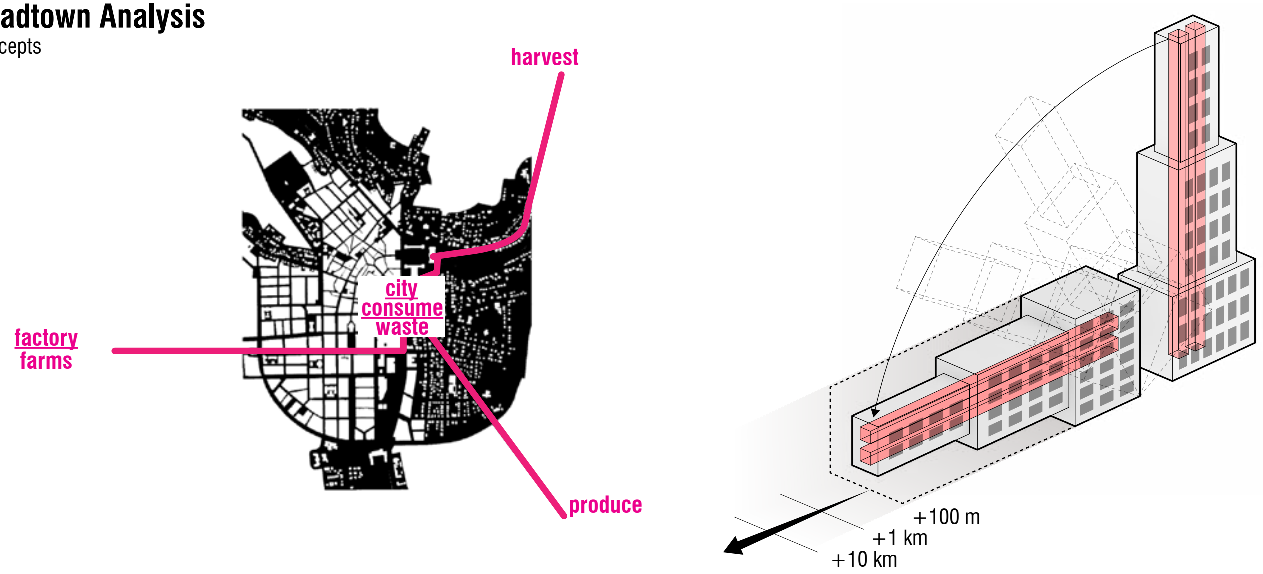
Site:Macroscale

The Volume



Roadtown Analysis

Concepts



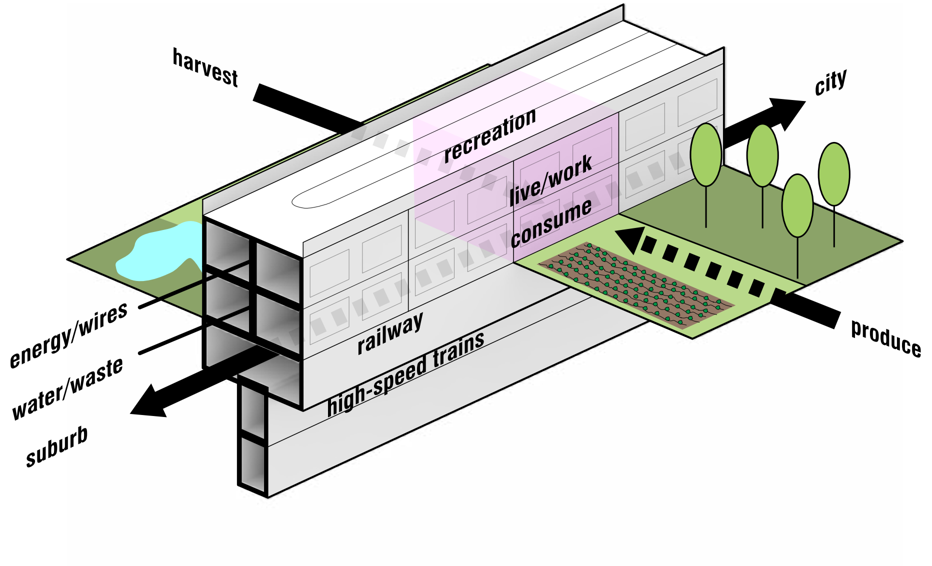


Image Credits

PAGE 9 **Fig 1.0** "London sewer: Milwaukee residents warn of flooding". *BBC News*. Web. 7 Oct. 2014<http://www.bbc.co.uk/news/uk-england-london-14348485>.

Fig 1.1 "Japanese ponder options to cope with energy shortage". *International Business Times*. Web. 9 Oct. 2014<http://www.ibtimes.com/japanese-ponder-options-cope-energy-shortage-277249>.

Fig 1.2 "Pakistan floods: Thousands flee after dyke breached". *BBC News*. Web. 8 Oct. 2014<http://www.bbc.com/news/world-asia-india-29137789>.

PAGE 11 **Fig 1.3** "Nigerian Startup Wants To Outsmart Traffic Chaos". *The New Africa*. Web. 4 Nov. 2014<http://www.thenewafrica.info/nigerian-start-wants-outsmart-traffic-african-cities/>.

Fig 1.4 "Ballard Bridge stuck, out of service". *Seattle Post Intelligencer*. Web. 5 Nov. 2014< http://www.seattlepi.com/local/article/Ballard-Bridge-stuck-out-of-service-4907230.php>.

Fig 1.5 "Obama Announces Infrastructure Plan During Tappan Zee Bridge Speech". *CBS New York*. Web. 5 Nov. 2014<http://newyork.cbslocal.com/2014/05/14/obama-visiting-tappan-zee-bridge-to-ask-congress-for-cash-for-roads-bridges/>.

PAGE 15 **Fig 2.0** "Architecture in the Expanded Field". *Infranet Lab/Lateral Office*. Web. 15 Oct. 2014<http://infranetlab.org/blog/feedback-architecture%E2%80%99s-new-territories>.

PAGE 19 **Fig 2.1** "Roadtown". *Art History UPenn*. Web. 19 Oct. 2014<http://www.arthistory.upenn.edu/spr01/282/w4c3i19.htm>.

Fig 2.2 AlSayyad, Nezar. "Le Corbusier and Algiers: The Plan Obus as Colonial Urbanism." *In Forms of Dominance on the Architecture and Urbanism of the Colonial Enterprise*. Aldershot: Avebury, 1992: pg 185. Print.

Fig 2.3 Sadler, Simon. *Archigram: Architecture without Architecture*. The MIT Press. 2005: 16. Print

PAGE 21 **Fig 2.4** Sadler, Simon. *Archigram*. 14. Print

PAGE 29 **Fig 3.0** "The 9 Most Devastating Man-Made Disasters". *American Profile*. Web. 21 Oct. 2014<http://americanprofile.com/articles/the-9-most-devastating-man-made-disasters/>.

Fig 3.1 "Bridge collapse in Washington state blamed on tractor-trailer". *CBS News*. Web. 20 Oct. 2014<http://www.cbsnews.com/news/bridge-collapse-in-washington-state-blamed-on-tractor-trailer/>.

PAGE 46 Images acquired via Google Earth

PAGE 47 Aerial Image extracted from Bing Bird-Eye View

PAGE 49 **Fig 4.0-4.6** "Pittsburgh Bridges". *Historic Bridges* Web. 20 Nov. 2014 <http://www.historicbridges.org/bridges>

PAGE 51 **Fig 4.7** "Rivers of Steel National Heritage Area". *Rivers of Steel* Web. 25 Nov. 2014 <http://www.riversofsteel.com/>

Fig 4.8 "Nerdvana". *Pittsburgh Technology Council* Web. 24 Nov. 2014 <http://www.pghtech.org/2014-15-teq-pittsburgh-techmap.aspx>

Fig 4.9 "Steel Footprints". *Rivers of Steel.* Web. 25 Nov. 2014<http://www.riversofsteel.com/map/category/all/>

Fig 4.10 "Highlights of Riverlife's work in 2013…and what's on the horizon". *River Life.* Web. 27 Nov. 2014 <http://www.riverlifepgh.org/blog/a_riverlife_year_in_review/>

PAGE 62 **Fig 5.0** "ALCOSAN's map of combined sewer overflow locations around Pittsburgh". *Project15206* Web. 7 Dec. 2014<http://www.project15206.org/publicpolicy/>

PAGE 64 **Fig 5.1** "Advocate: Stopping CSOs Worth the Investment". *The Allegheny Front.* Web. 8 Dec. 2014 <http://www.alleghenyfront.org/story/advocate-stopping-csos-worth-investment>

Fig 5.2 "Deep Tunnel's Deep Problems". *Chicago Mag.* Web. 8 Dec. 2014<http://www.chicagomag.com/Chicago-Magazine/The-312/June-2013/Deep-Tunnels-Deep-Problems/>

PAGE 65 **Fig 5.3 - 5.5** "Browse the Designs: S. 21st Street, North of Carson to Southside Riverfront Park". *The Southside Green Infrastructure Charette.* Web. 6 Dec. 2014 <http://www.southsidegreen.com/study-area/>

PAGE 70 **Fig 6.0** "Mellon Arena". *Ballparks, Arenas and Stadiums* . Web. 12 Dec. 2014 <http://www.ballparks.phanfare.com/5276299>

Fig 6.1 "Brian O'Neill: Building park over I-579 could cap rebirth of Hill". Pittsburgh *Post Gazette.* Web. 12 Dec. 2014<http://www.post-gazette.com/opinion/brian-oneill/2014/04/13/Brian-ONeill-Building-park-over-I-579-could-cap-rebirth-of-Hill/stories/201404130064>

Fig 6.2 "Crosstown Blvd". *Brookline and Pittsburgh Historical Facts and Remembrances.* Web. 12 Dec. 2014<http://www.brooklineconnection.com/history/Facts/Facts.html>

Fig 6.3 Image acquired via Google Earth Street View

PAGE 72 **Fig 6.4** "Infrastructure Lifespans". *GSD Symposium.* Web. 20 Nov. 2014<http://m.ammoth.us/blog/2012/03/expiration-dates/>

PAGE 73 **Fig 6.5** "Anonymous". *City Planning.* Web. 7 Dec. 2014<http://www.cityup.org/case/garden/20090527/49052-3.shtml>

Fig 6.6 "Atelier Ramdam: Castle in the Sky". *Designboom.* Web. 12 Dec. 2014<http://www.designboom.com/architecture/atelier-ramdam-architects-castle-in-the-sky/>

Fig 6.7 "Bioswale". *Manassas Park Elementary School & Pre-K* . Web. 12 Dec. 2014<https://www.honestbuildings.com/project/#!/view/72414/manassas-park-elementary-school-pre-k>

Fig 6.8 "Leaf Rain Harvesting Umbrella". *tomdavid architects: sustainable market square in casablancas.* Web. 12 Dec. 2014<http://www.designboom.com/architecture/tomdavid-architects-sustainable-market-square-in-casablanca/>

BIBLIOGRAPHY

1. Allen, Stan. “Infrastructural Urbanism.” In *Scoope* 9. Cambridge: Cambridge University Architecture School, 1998: 71-79. Print.

2. AlSayyad, Nezar. “Le Corbusier and Algiers: The Plan Obus as Colonial Urbanism.” *In Forms of Dominance on the Architecture and Urbanism of the Colonial Enterprise*. Aldershot: Avebury, 1992: pg 183-210. Print.

3. Balmori, Diana, and Michel Conan. *A Landscape Manifesto*. New Haven: Yale University Press, 2010. Print.

4. Bangash, M. Y. H. *Prototype bridge structure: analysis and design*. Thomas Telford Publishing. 1999

5. Barker, Richard and Jay Puckett. *Design of Highway Bridges.* John Wiley & Sons, Inc. 1997. Print.

6. Bhatia, Neeraj, Maya Przybylski, Lola Sheppard, and Mason White. *Coupling: Strategies for Infrastructural Opportunism*. New York: Princeton Architectural Press, 2011. Print.

7. Brown, David J. *Bridges: Three Throusand Years of Defying Nature.*Mitchell Beazley Publishers Limited. 2005. Print.

8. Cuff, Dana; “Architecture as Public Work.” In *Infrastructure as Architecture: Designing Composite Networks*. Berlin: Jovis, 2010. Print.

9. D’Hooghe, Alexander; “Objectification of Infrastructure.” In *Infrastructure as Architecture: Designing Composite Networks*. Berlin: Jovis, 2010. Print.

10. Habraken, N. J. *Supports, an Alternative to Mass Housing*. London: Architectural Press, 1972. Print.

11. Hung, Ying Yu, Gerdo Aquino, Charles Waldheim, Julia Czerniak, Adriaan Geuze, Matthew Skjonsberg, Alexander Robinson; *Landscape Infrastructure: Case Studies by SWA*. 2nd ed. Basel: Birkhäuser, 2013. Print.

12. Koolhaas, Rem; “Whatever Happened to Urbanism.” In *S,M,L,XL*; New York, NY: Monacelli Press, 010 Publishers, 1998: pg 961-971. Print.

13. Koolhaas, Rem, Nobuyuki Yoshida. “Junkspace.” In *OMA@work.a U*. Tokyo: U Publications, 2000. Print

14. Larsen, Julie. “For + Against: Designing for Failure.” In *Enclaves / Territories + Expanding Megalopolises*. ACSA 101: NEW CONSTELLATIONS / NEW ECOLOGIES. California College of the Arts. 2013. Print

15. LeCavalier, Jesse; “Let’s Infratecture!” In *Infrastructure as Architecture: Designing Composite Networks*. Berlin: Jovis, 2010. Print

16. Mayne, Thom. *Combinatory Urbanism: The Complex Behavior of Collective Form*. Culver City, CA: Stray Dog Café, 2011. Print.

17. Sadler, Simon. *Archigram: Architecture without Architecture*. The MIT Press. 2005. Print

18. Shannon, Kelly, and Marcel Smets. *The Landscape of Contemporary Infrastructure*. Rotterdam: NAi Publishers, 2010. Print.

19. Tschumi, Bernard, and N.Y. York. *Event-cities: Praxi*s. Cambridge, Mass.: MIT Press, 1994: 11-13. Print.

20. Wall, Alex. “Programming the urban surface.” *Recovering Landscape: Essays in Contemporary Landscape Architecture.* Princeton Architectural Press, 1999: 234.

21. Zhao, Jim J and Demetrios Tonias. *Bridge Engineering: Design, Rehabilitation and Maintenance of Modern Highway Bridges*. 3rd ed. McGraw-Hill Professional, 2012