A Downtown Reimagined – Visions and Strategies to Restore Vibrant, Safe, and Memorable Connections to Historic Squares, Districts, and Public Spaces of Downtown Santa Rosa, California

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ABSTRACT

The City of Santa Rosa, California, U.S.A., like many cities throughout the world, has a larger core downtown area that is divided practically and psychologically by physical man-made barriers. In the case of Santa Rosa, these barriers are an elevated highway, U.S. Highway 101, and a regional shopping mall, the Santa Rosa Plaza mall. Collectively, this "elephant in the room" at Santa Rosa's center separates two key districts, Historic Railroad Square and Courthouse Square. The highway was first built at-grade in 1949 and elevated to address pedestrian and traffic safety concerns in 1966. The Santa Rosa Plaza mall was opened in 1983. These barriers disrupt and adversely impact social connections, functional circulation, and commerce, capping the potential for greater vibrancy, sense of place, and community pride and identity.

The focus of this paper and supporting presentation is the topic of reconnecting Santa Rosa's larger downtown area. Building on IMCL's principles of True Urbanism, the authors will leverage an innovative mix of urban planning, urban and landscape design, architectural expression, development strategies, and supporting policies and regulations. The target is a Downtown grounded in walkability, richly mixed land uses, enhanced public transit, protected historic and natural resources, and abundant connections to nature, fueling the flourishing health and well-being of residents and visitors alike.

Santa Rosa's challenge, "elephant in the room", is not unique! The ideas and lessons in this paper and presentation and suggested readings will be of benefit to all cities beset by seemingly intractable physical barriers that block the fulfillment of urban visions and possibilities.

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I. INTRODUCTION

Santa Rosa – "Out There. In the Middle of Everything"[1]

The City of Santa Rosa is located approximately 55 miles north of San Francisco in central Sonoma County. Santa Rosa is 42.7 square miles in size and has a population of about 180,000. Even with this size of population, Santa Rosa has maintained a small-town feel. Santa Rosa has varied topography, with large expanses that are more level together with rolling hills scattered throughout its area. Santa Rosa has several creeks, including Santa Rosa Creek, Matanzas Creek, Spring Creek, and Brush Creek.

The larger County of Sonoma is about 1,768 square miles in size with a population of 494,336. Santa Rosa is located inland by about 20 miles from the Pacific Ocean. Santa Rosa is the county seat of Sonoma County and the largest city between San Francisco and Portland, Oregon. Santa Rosa is one of eight incorporated cities in Sonoma County.

Santa Rosa is not only close to the ocean and beaches but also a gateway to a world-renowned wine region in Sonoma Valley, historic Redwoods in nearby Armstrong Woods, the Russian River that extends to the Pacific Ocean, several State Parks (including Jack London State Park) that offer a variety of hiking and recreational opportunities, a broad range of dining options, and the Charles Schulz Museum in the hometown of the revered "Peanuts" cartoonist. Within the immediate downtown area are the Luther Burbank Home and Gardens, beautiful Julliard Park, and historic residential neighborhoods.

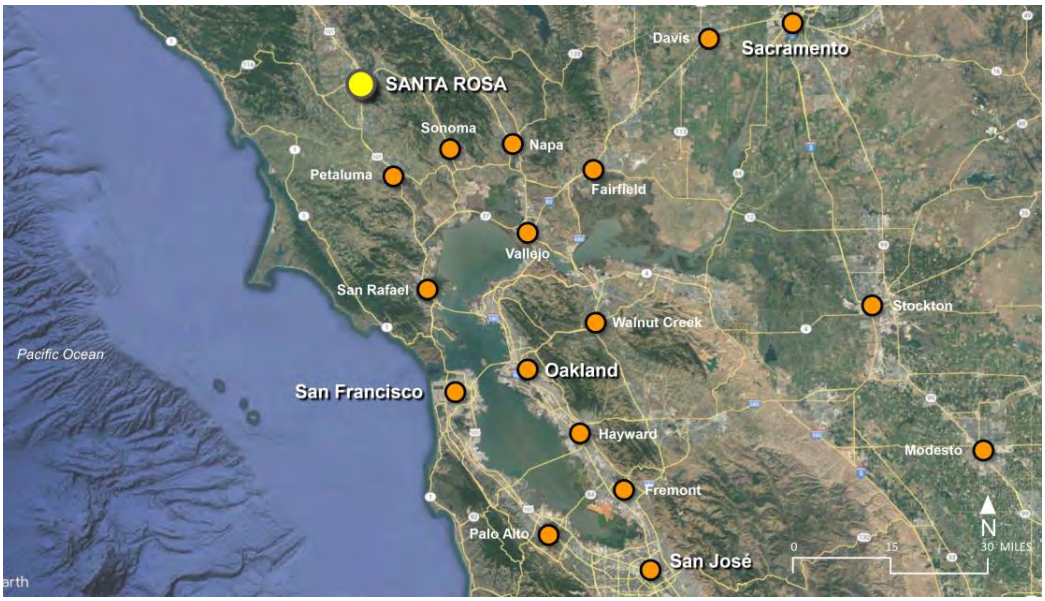

Figure 1 – City of Santa Rosa, in the north Bay Area region of Northern California.

[1] "Santa Rosa: Out There. In the Middle of Everything" is the motto of the tourism marketing campaign of the City of Santa Rosa's Economic Development Division.

Historic Background

Prior to European settlers coming to this area of "Alta California"[2] that is now Santa Rosa in the early 1800's, it was inhabited by members of the Southern Pomo Native American Tribe. Among the founding settlers was the Carrillo family. The City of Santa Rosa was originally mapped in 1854, with a rectangular street grid around a town plaza. That plaza has become known, today, as Courthouse Square, located within the Downtown District.

Figure 2 – Sanborn Fire Insurance Map of downtown Santa Rosa in 1904, showing historic street grid, Courthouse Square, railroads, and Santa Rosa Creek.

Santa Rosa was formally incorporated as a city in 1868. In 1871, the first train arrived at Railroad Square, located west of what is now Courthouse Square. Initially, the town's economy was strongly based on agricultural trade. Several railroad lines were extended to various locations within Santa Rosa in the latter half of the 19th and early 20th centuries to support this trade. Over time, the two squares, Railroad Square and Courthouse Square, became important commercial centers. Housing, financial institutions, government institutions (including the County Courthouse located in the Square), and retailing came together to form a loosely knit development pattern to form Santa Rosa's downtown.

The pattern of development of Downtown Santa Rosa has been impacted by many significant events, circumstances, and actions over time. Among these are:

- The devastating 1906 earthquake that also leveled downtown San Francisco, during which the original Sonoma County Courthouse was destroyed.
- The movement in the USA towards more decentralized, auto-dependent development patterns, generally during the latter part of the 20th century.
- Constructing in 1949—then elevating in 1966—U.S. Highway 101 through the center of the larger downtown area.

[2] Prior to 1848, "Alta California" was part of Mexico, becoming USA territory following the settlement of the Mexican-American War.

- Urban renewal in the 1960s leading to clearing of 40 acres of downtown urban fabric, clearing the way for the construction of the expansive Santa Rosa Plaza mall.
- Channelizing and burying Santa Rosa Creek through downtown in the 1960s.
- Extension of Mendocino Avenue through Courthouse Square in 1967, made possible by demolition of the County Courthouse in 1965 due to structural concerns.
- Another substantial, damaging earthquake in 1969.
- Completing Santa Rosa Plaza mall in 1983.

Figure 3 – Railroad Square, the Santa Rosa Plaza mall, and Downtown.

Although these events, circumstances, and actions have had a multitude of impacts on Santa Rosa's downtown and the wider community, two actions stand out: the development of Santa Rosa Plaza mall and construction of the elevated US 101 freeway. The combination of these urban barriers has interrupted social interactions and commercial flows between the eastern area of downtown associated with Courthouse Square, and the western area associated with Railroad Square.

II. ASSESSMENT

"Planning Mistakes" and Plans

Downtown Santa Rosa has been the subject of many studies and plans over time to determine how to address and remedy the impacts associated with what have been identified as past "planning mistakes", including some of those mentioned above: decentralization of the downtown, division of the downtown by the Santa Rosa Plaza mall and U.S. Highway 101, loss of Santa Rosa Creek as a natural amenity, and the splitting of Courthouse Square by Mendocino Avenue in 1967. Collectively, these planning mistakes have broadly impacted the essential realm of community

social and commercial connectivity, critical to successful "placemaking" and creating a vibrant and thriving place where people want to be.

Among the studies and plans completed are the R/UDAT[3] report *City Vision – Santa Rosa Urban Design Project*, completed in 1998, and the *City of Santa Rosa Downtown Station Area Specific Plan*, originally adopted in 2007 and then updated and re-adopted in 2020. Both of these planning documents have been guides for the City in addressing the "planning mistakes" of the past and bringing vibrancy to Santa Rosa's downtown, a 720-acre area as defined in the Station Area Plan that includes Courthouse Square, Santa Rosa Plaza mall, and Railroad Square. Following is a selection of key recommendations and guiding principles of these Plans.

Figure 4 – Looking west: Courthouse Square (bottom), Santa Rosa Plaza (center), the US 101 freeway and Railroad Square (top).

From *City Vision – Santa Rosa Urban Design Project* R/UDAT Report[4]:

- Establish and maintain a positive planning approach as opposed to reactive project based planning.
- Encourage and support center city housing and mixed-use projects.
- Reunite Courthouse Square.
- Reconnect 4th Street through the Plaza from downtown to Railroad Square.
- Celebrate and market Santa Rosa as the "Food and Wine" capitol of California.

[3] R/UDAT (Regional/Urban Design Assistance Team), a program of the American Institute of Architects (AIA), brings together outside and local experts and stakeholders to convene highly-focused design and planning workshops, or "charrettes", to assess challenges and develop visons and strategies.
[4] Source: *R/UDAT, City Vision – Santa Rosa Urban Design Project*, November 16, 1998, page 5.

- Develop a pedestrian system to link the parts of the central city and the adjacent neighborhoods.
- Illustrate a system of bicycle lanes and paths to provide access to the central city and surrounding recreational destinations.
- Adopt a general policy supporting limited, quality growth.
- Implement and maintain a program of participatory planning providing for broad community input.
- Encourage and support the performing and visual arts as an integral part of the city.

From the *City of Santa Rosa Downtown Station Area Specific Plan*[5]:

- Downtown is safe and friendly for people of all ages, income levels, and cultures.
- Downtown's streetscape is active and comfortable day and night, with pedestrian-scale lighting, street trees, landscaping, seating, and other coordinated amenities that establish a distinct identity.
- A successful Downtown is a driver of Santa Rosa's economic health and quality of life.
- Downtown values its historic buildings and encourages compatible, high-quality new construction.
- A diverse array of distinct neighborhoods with vital business activity, housing options, and multimodal connections to each other and the greater region is essential to Downtown Santa Rosa's success.
- Meaningful and visible communication about Downtown Santa Rosa's heritage can link past, present, and future, and it can contribute to Downtown's evolution.
- Downtown will safely accommodate many modes of travel – pedestrians, bicycles, rideshare, and transit – with the easiest choice being foregoing a personal car entirely.
- Downtown's network of public parks, plazas, trails and recreational spaces is enhanced and interconnected.
- Increasing active lifestyles is Santa Rosa's greatest opportunity to improve the health of its residents.
- Downtown continues to serve as an economic engine for the City and region, promoting a diverse economic environment that supports both local entrepreneurial ventures, as well as larger businesses.
- Downtown provides economic opportunity for all residents.
- Downtown is comprised of successful, desirable, and complete neighborhoods with a variety of housing choices and mix of uses.
- Downtown has a thriving cultural and arts community and its lively public spaces are local and regional destinations.
- Downtown's network of public parks, plazas, trails and open space is enhanced and interconnected.

[5] Source: *City of Santa Rosa Downtown Station Area Specific Plan*, October 2020, pages 1-7.

- Santa Rosa's arts and cultural scene offers opportunities that can enrich everyone's lives.
- Active celebration of Santa Rosa's diversity will help ensure economic and social success.
- Downtown protects and restores natural resources and incorporates environmentally friendly elements into new projects.

Interviews With 10 Key Individuals – Accomplishments and Observations

In addition to extensive site visits and reviewing the Santa Rosa R/UDAT Report and the City's Downtown Station Area Plan, the authors interviewed 10 key individuals—covering elected officials, City staff, a key downtown developer, a development consultant, merchants, newspaper reporters, and local historians—about accomplishments and key actions needed to create the vibrant downtown desired that has a sense of place, generates community pride, and has a clear, positive identity.

Among the accomplishments mentioned were the following:

- Initial phase (2007-2008) for restoring the channelized portion of Santa Rosa Creek in Downtown, including the opening of the Prince Memorial Greenway creekside multi-use trail, connecting Downtown and Railroad Square.

Figure 5 – Images of Santa Rosa Creek, along the Prince Memorial Greenway.

- Reunification of Courthouse Square in 2017, accomplished by removing the Mendocino Avenue bisection of the Square, followed by other improvements.

Figure 6 – Celebrating the reunification of Courthouse Square.

- In the early 2000s, successful City/Developer collaboration to facilitate an increase in housing unit starts in the greater Santa Rosa Downtown Area.

Figure 7 – Multi-family residential projects under construction in downtown Santa Rosa.

Suggestions and themes offered by the individuals the authors interviewed included:

- Need a broader mix of uses in Downtown, including core uses like grocery, pharmacy, and daycare.
- City Hall needs to provide leadership, capacity, urban planning expertise, commitment, continuity, availability, and passion.
- Need to "daylight" the covered sections of Santa Rosa Creek—need "eyes on" development and activities along the creek to assure it's a safe place.
- Need substantially more housing downtown that mixes incomes and types.
- Need to improve the public realm so that downtown is a desirable and a safe place to be.
- Need regularly scheduled programs and activities to attract a broad range of community members and visitors to downtown: Wednesday night market and winter ice arena in Courthouse Square are good examples.
- Vision, champions, and timing all matter!
- Past mistakes: U.S. 101 bisecting downtown, Santa Rosa Plaza mall location and design dividing downtown, current City Hall location and design, Urban Renewal clearing of 40-acres of downtown urban fabric.
- Downtown development needs to be encouraged and efforts should include:
    - Enhanced Infrastructure District
    - Business Improvement District
    - Reduction in fees
    - Action Groups
    - Beautification of key corridors: Santa Rosa Avenue and Mendocino Avenue
- People need to desire to live, work, and play in downtown Santa Rosa.
- Need to re-establish and improve connectivity in and around downtown.
- Need to have active ground floor land uses—activity begets more activity!
- Need to create "community" and deepen culture; culture is weak and poorly defined.
- Need to address homelessness.

- Need to upgrade facades, have hanging flower baskets—downtown needs to be clean and inviting, show pride and stewardship.
- Need to address parking demand.
- Need to promote downtown's attributes: parking availability, events, safety efforts, accomplishments, etc.
- Need to extend 4th Street through Santa Rosa Plaza mall.
- Need dramatic statement and attractor(s) to downtown Santa Rosa.
- Need to establish east-west connections.
- Need a sense of urgency about improving the downtown—Downtown needs to matter!
- Need to maintain and support the uniqueness of various districts, such as the Railroad Square Historic District, within the larger downtown area; need to develop and enforce Design Guidelines.
- Need to "promote, promote, promote", as there is so much here: Luther Burbank Home and Gardens, Schulz Museum, Wine Country, the Redwoods, the Coast—Santa Rosa is close to everything including San Francisco.
- Improved stewardship needed to maintain streetscapes, remove graffiti, foster substantially higher quality outdoor dining areas, parklets, etc.
- Downtown should be clean, safe, and positive—it needs to "sparkle"!
- Need better wayfinding: review and update downtown's sign program.
- Need to reduce the cost of developing housing downtown.
- Further develop and finish Courthouse Square.

Implementing most if not all of these suggestions will be necessary to manifest the vision we feel is possible for Santa Rosa's downtown. However, most critical to overall success will be creating or restoring key urban connections—most urgently between downtown and Railroad Square—to establish social and commercial integration, sustainability, and vibrancy, the qualities of a place where people want to be! In the next section, the authors describe an energetic and innovative approach to establish this critical connectivity.

III. VISION

"The Elephant in the Room"

The urban planning and design strategies proposed in this section are predicated on our assessment that removal of the "elephant in the room"—the physical isolation of Railroad Square by the Santa Rosa Plaza mall and the elevated US 101 freeway—is the first and highest priority in restoring the health and vitality of downtown Santa Rosa. First, the barrier must be breached. Then, other strategies to further vitalize Downtown can follow, filling-in and completing Downtown's urban potential.

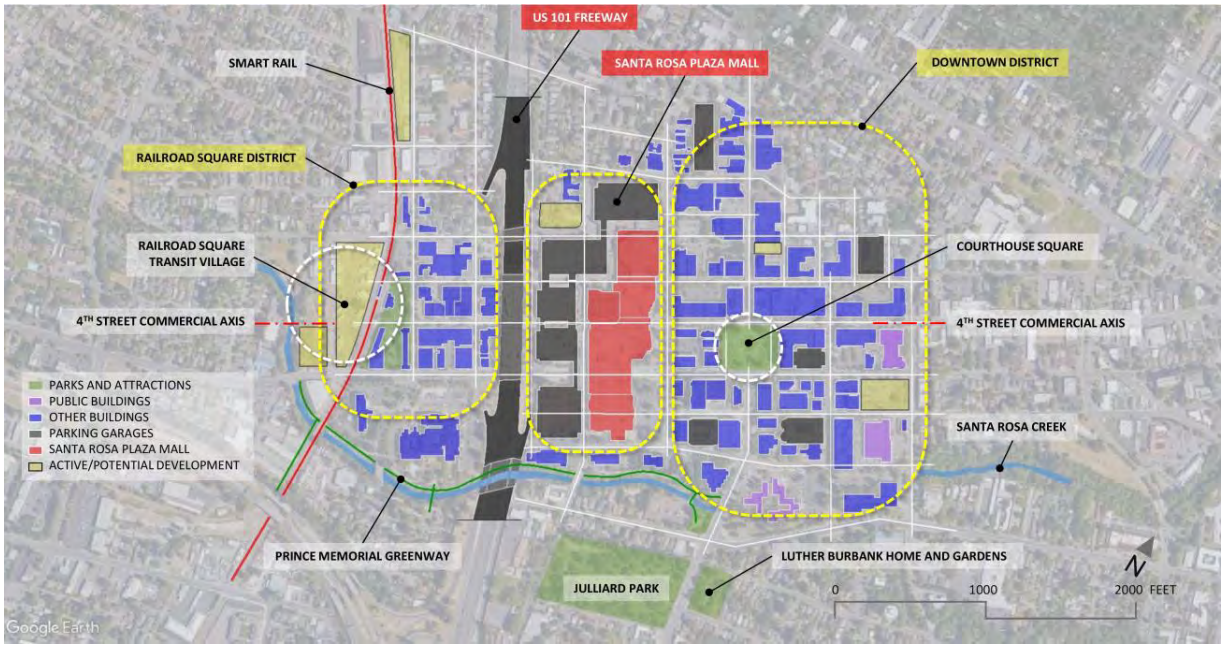

Figure 8 – The Elephant in the Room: Barriers between Railroad Square and Downtown.

Figure 8 is a stark illustration of the walls that separate Downtown from Railroad Square. Opened in 1983, the Santa Rosa Plaza is a blandly suburban 2-3 level fully enclosed shopping mall stretching over 4 blocks and 10 acres of historic urban fabric. The mall is wrapped on two sides by a connected chain of low-level parking garages, displacing an additional 5 city blocks. At over 27 acres, the combined "footprint" of mall and parking occupies a significant portion of Downtown's overall area.

Pedestrians can enter the mall's "front door" at the west end of 4th Street in Downtown, pass through the mall and between parking garages, reemerge on 4th Street, and walk under the freeway to reach Railroad Square – however, this passage is circuitous, unpleasant, and constrained by the mall's hours of operation. Although public and relatively short, 4th Street's passage under the freeway is dark and featureless, albeit somewhat mitigated by recent urban design improvements.

Figure 9 – Mall entrances from 4th Street in Downtown (left), and through garages from 4th Street in Railroad Square (right).

In breaking down the wall of the mall and freeway, we have organized our ideas into three "connections", or semi-independent packages of land use and design strategies applied to three urban corridors that link Downtown and Railroad Square. What links these packages is that each involves changes to the layout and function of the Santa Rosa Plaza mall. One theoretical scenario could involve complete removal of the mall and undergrounding of the elevated freeway—opening up the possibility of simply restoring the city's historic street grid—however, we have chosen instead to work with the mall as an acceptable, settled land use and explore how it can best support Downtown's transformation.

The "Three Connections" are:

- **The 4th Street Corridor** – the historic commercial axis connecting Downtown and Railroad Square, currently blocked by the mall (see Figure 10).
- **The 6th/7th Street Corridor** – north of 4th Street, a minor street providing vehicular access between Downtown and Railroad Square, around the mall's north end (see Figure 12).
- **The Prince Memorial Greenway** – A multi-purpose trail along historic Santa Rosa Creek, linking Downtown and Railroad Square, around the south end of the mall (see Figure 14).

In addition, we are proposing key urban design improvements within the core of Downtown: to historic Courthouse Square, at the center of Downtown's walkable retail/commercial district along the 4th Street corridor, and to the intersecting north-south commercial corridor of Santa Rosa and Mendocino Avenues, the historic route of US-101 prior to its realignment in the 1940s. Finally, to explore the possibilities of enhanced mobility, we are proposing the conceptual routing of a local circulator transit system, albeit as a service model, not a technology recommendation.

At this visionary stage in our process, we are focused on principles, not details. Mixing conceptual land use and urban design, our proposals are introduced here at a diagrammatic level, as a "big picture" launch pad for what happens next as the ideas are shared, explored, challenged, and developed through further study and expanding community participation.

Connection 1 – Restoring the Blocked 4th Street Corridor

Restoring the 4th Street connection between Downtown and Railroad Square (see Figure 10) is the cornerstone strategy in our overall vision—in nothing else is completed, this alone would be transformational. The concept is to revitalize both retail and connection into a signature experience that attracts and sustains vibrant urban activity by resident and visitor alike.

- **The Grand Arcade** – Passing through the mall itself, the Grand Arcade creates a 500-foot-long arcaded pedestrian shopping street along the 4th Street axis, inspired by traditional 19th Century models such as London's revered Leadenhall Market (see Figure 11). Although conceived as a mall improvement, it would function as if a public street, requiring a special public/private partnership between the mall and the City to maintain security, urban amenity, and unimpeded public access.

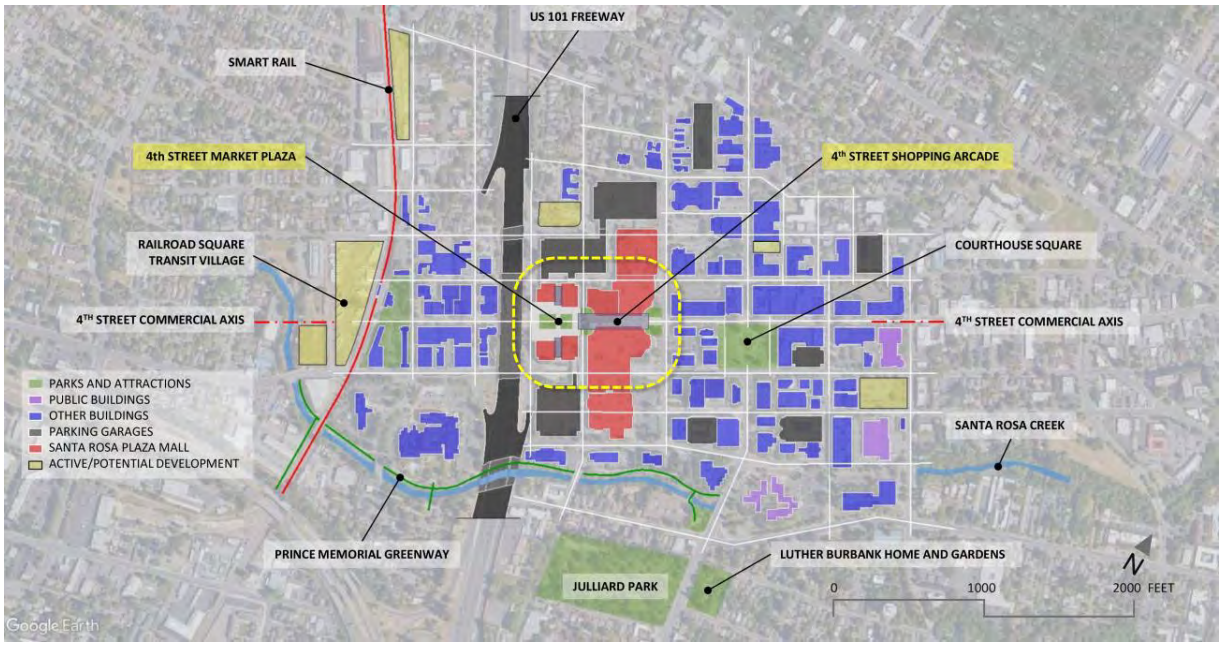

Figure 10 – Concept Plan: Connection 1, the 4th Street Corridor.

- **Market Square** – Passing through the mall, the Grand Arcade opens up into Market Square, a new urban plaza framed by ground-level retail and mixed-use development. In terms of urban design, the plaza provides an expansive spatial opening between the enclosure of the Arcade and the passage under the freeway. The plaza and new development would displace the two existing low-level parking garages that flank the 4th Street axis.

Figure 11 – Shopping Arcade in London's Leadenhall Market (left), 4th Street passes under the US 101 freeway (right).

- **Under the Freeway** – Current conditions under the freeway, recently enhanced by a palette of "complete street" improvements (see Figure 11), can further be improved through better top-lighting and the introduction of programmed fronting activities. Caltrans (the state transportation department) typically prohibits permanent enclosed development under its structures—however (in addition to storage and parking), temporal activating uses are possible, such as food trucks, farmer's markets, and varieties of "pop-up urbanism."

Connection 2 – Transforming the 6th Street/7th Street Corridor

Railroad Square and the US 101 freeway are linked functionally to Downtown by two local streets that pass around or under the Santa Rosa Plaza mall, 3rd Street and 6th Street (4th Street and 5th Street pass under the freeway but are blocked by the mall). To pass around the north end of the mall's garages, 6th Street traffic is routed north to 7th Street along a 1-block section of A Street. Although functional, the 6th Street/7th Street Connection lacks amenity and distinction. We propose (see Figure 12) to enhance this connection while expanding the possibilities of Downtown north of the mall, a neighborhood of growing residential and cultural activity.

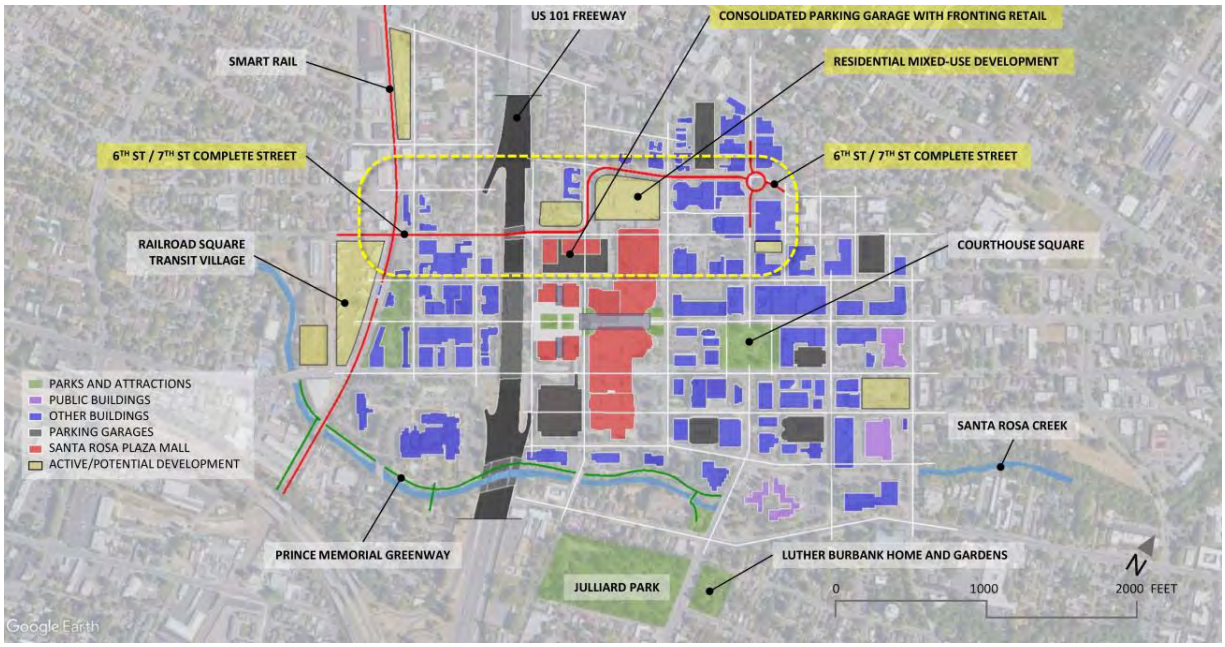

Figure 12 – Concept Plan: Connection 2, 6th Street/7th Street Corridor.

- **The 6th Street/7th Street Complete Street** – From a gateway roundabout at 7th Street and Mendocino Avenue to its termination at the future Railroad Square Transit Village, a tree-lined multimodal boulevard provides a distinctive connection between Downtown and Railroad Square. As a "Complete Street" (see Figure 13) serving equally the needs of pedestrians, cyclists, and motorists, features include right-sized traffic lanes, wide sidewalks, separated cycle tracks, and decorative streetlighting.
- **A Special Housing/Retail Opportunity** – Replacing the mall's northernmost parking garage, the street is anchored by an iconic multistory residential mixed-use development featuring major retail and services along its A-Street and 7th Street frontages. Addressing a local "food desert", a vibrant farm-to-table supermarket—perhaps modeled on Berkeley, California's famous "Berkeley Bowl" (see Figure 13)— serves as the anchor tenant.

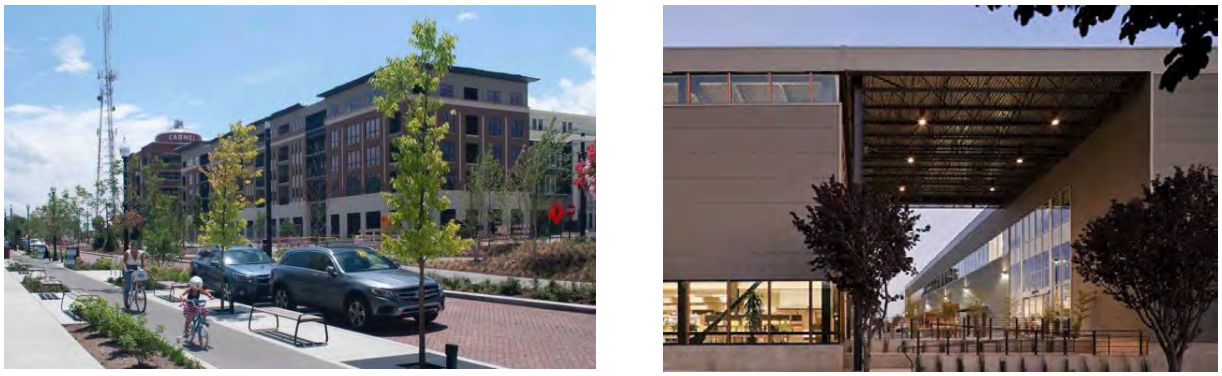

Figure 13 – A Complete Street in Carmel, Indiana (left), the iconic Berkeley Bowl West (right).

- **Consolidated Parking … and More Retail!** – Between 5th Street and 6th Street, the existing low-level parking garage is replaced by a high-level garage absorbing much of the parking capacity lost to other garage displacements. Along its Morgan Street and 6th Street frontages, retail uses activate the sidewalks, leading south to Market Square and the Grand Arcade.

Connection 3 – Activating Santa Rosa Creek

South of the 4th Street commercial corridor are two additional connections between Downtown and Railroad Square (see Figure 14). Passing under the Santa Rosa Plaza mall in a shallow tunnel, 3rd Street is the major arterial connection between Downtown and the US 101 freeway. South of 3rd Street is the Prince Memorial Greenway, an iconic restoration of the downtown segment of historic Santa Rosa Creek, featuring a richly landscaped and detailed creek-side trail at the core of the City's expanding network of pedestrian paths and bikeways.

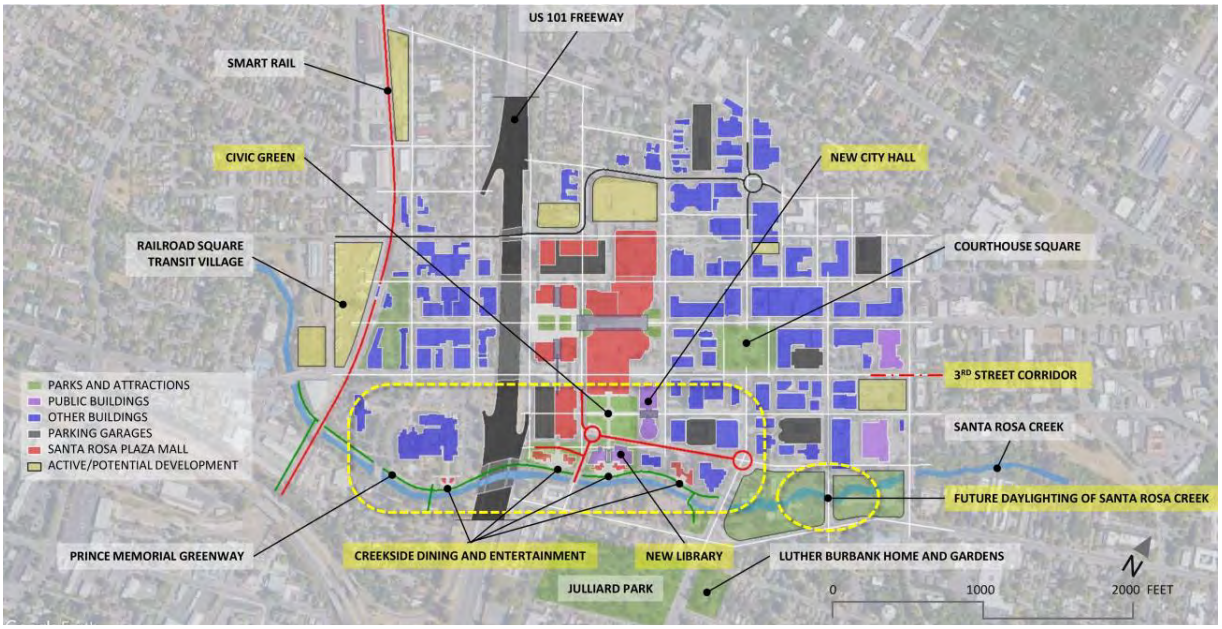

Figure 14 – Concept Plan: Connection 3, Prince Memorial Greenway.

Despite its vision and beauty, the Greenway's potential is underutilized due to widely held, legitimate concerns for safety and security. In contrast to successful urban river transformations such as San Antonio, Texas's world-famous *Paseo del Rio*, Santa Rosa backs-up to the Greenway with no visual oversight or activating public or private activities.

Our proposals for the south sector of Santa Rosa Plaza mall (see Figure 14) combine public/private activation of the Greenway with a vision of a new Civic Center and community gathering place. A new City Hall is currently being considered, and our vision has precedent in a recently considered proposal by SonomaCounty: replacement of the mall's southern anchor, a failed Sears department store and auto center, with a public-facing County administration and service center.

- **Creek-facing Activities along the Prince Memorial Greenway** – A promenade of active uses—principally outdoor/indoor dining and entertainment venues—are spaced along the north bank of Santa Rosa Creek, incorporating and overlooking the Greenway, reinforced by active mixed-use urban development connecting city and creek. Key sites include the fronting Hyatt Regency Sonoma Wine Country hotel and conference center south of Railroad Square, and three locations fronting 1st Street in Downtown: between US 101 and A Street, A Street and B Street, and B Street and Santa Rosa Avenue. The sites between US 101 and B are vital elements of the Civic Center vision at the south end of the mall.

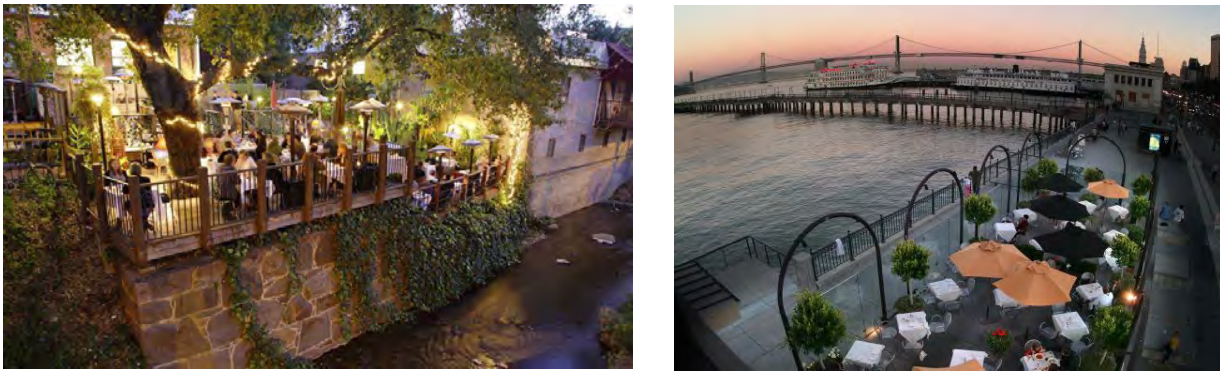

Figure 15 – Creekside dining in San Luis Obispo, California; dining by the Bay in San Francisco.

- **A New Civic Center** – The former Sears department store is replaced by the Civic Green, a central gathering place framed and activated by the mall to the north, a new City Hall on the east (on axis with 2nd Street, Downtown's bus transit center), new mixed-use development and parking to the west, and a new City Library across 1st Street to the south, opening up to Santa Rosa Creek and the active uses along the Greenway. 1st Street is realigned on a diagonal, opening-up space for the Library and formalizing the south entry of A Street into Downtown.
- **Daylighting the Creek from Santa Rosa Avenue to E Street** – Before creation of the Prince Memorial Greenway, Santa Rosa Creek passed through Downtown in a concrete-lined channel. The next possibility, a long-discussed City vision, is to "daylight" the creek, undergrounded in a culvert through two contiguous city blocks east of Santa Rosa Avenue.

City Hall occupies the block between Santa Rosa Avenue (east end of the Greenway) and D Street, and moving City Hall to Civic Green initiates the first opportunity to realize this vision.

Visons for a daylighted Santa Rosa Creek could range from open parkland to fronting mixed-use development, including continuation of the Greenway lined with vibrant creek-side activities. The City Hall block could transform first, followed by a long-term possibility of daylighting the second block (occupied by a major Federal office building)—however, a masterplan covering both blocks would ensure the highest ultimate outcome.

Refined Design – Courthouse Square and the Santa Rosa/Mendocino Corridor

In recent years, improving the urban design of downtown Santa Rosa has focused on the City's historic central plaza, Courthouse Square (originally occupied by a courthouse), and the streets that frame it, including 4th Street, Downtown's most activated and walkable shopping and dining corridor. Recent, ongoing, and planned improvements to the Square are informed by a strong and visionary conceptual master plan completed in 2016, supported by new fronting mixed-use development and creative adaptive use of historic structures—a great example is the transformation of the treasured, ornate Empire Building into the trendy boutique Hotel E.

However, full activation of the Square's potential is challenged by minimal pedestrian activity around the south quadrants of the square fronted by bland banks and office buildings with little or no ground-floor penetration, a condition that continues south on Santa Rosa Avenue as it leaves Downtown. Our proposals (see Figure 16) are focused on these issues.

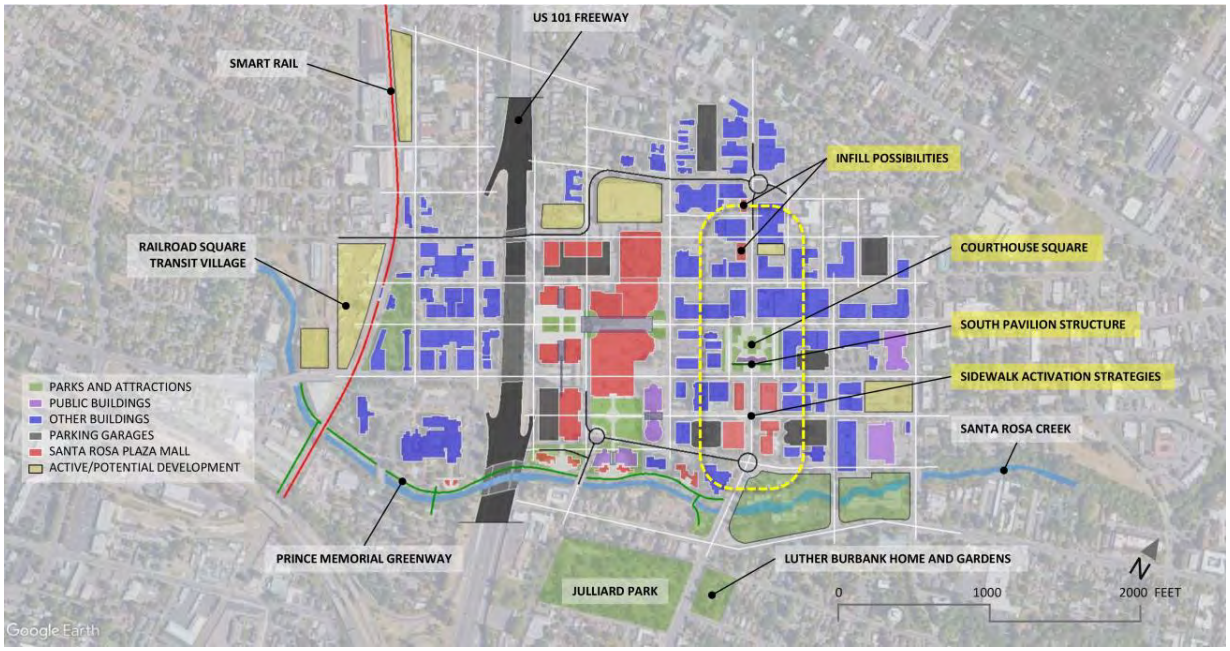

Figure 16 – Concept Plan: Activating Courthouse Square and the Santa Rosa/Mendocino Corridor.

- **Completing Downtown's Living Room** – The northern half of Courthouse Square, activated by 4th Street (see Figure 17), enjoys significant public use, and this half has the feel of an open space right-sized to the buildings and activities that frame it. By contrast, the "wide-open" southern half may sit in limbo for many years waiting for fronting land uses to become more pedestrian-friendly. In the interim, we recommend structural elements placed in the southern half that support attractive, programmed public activities while enhancing the square's spatial definition and iconic sense of place. One such possibility (see Figure 17) is a glazed and latticed open Pavilion inspired by the great train sheds of 19th Century railway stations, under which many activities can be held: farmer's markets, craft fairs, sporting events, and sheltered seating for outdoor concerts, to name but a few.

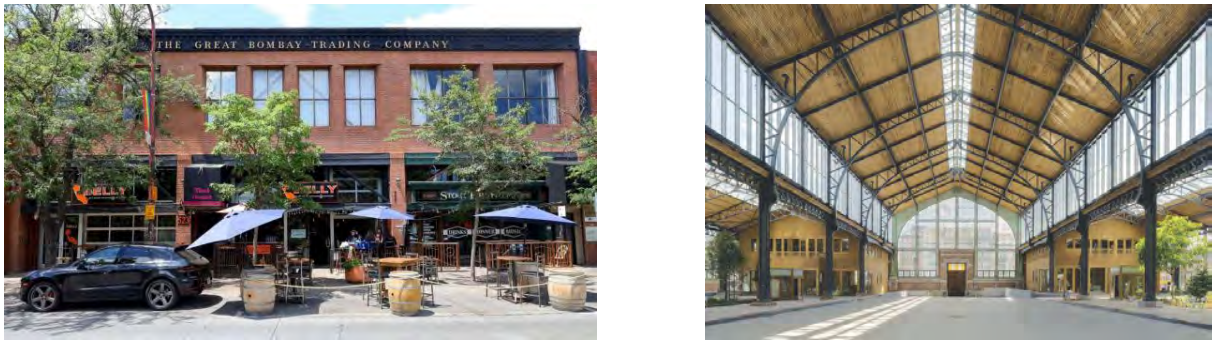

Figure 17 – 4th Street near Courthouse Square (left), Belgium's Gare Maritime train shed (right).

- **Mixed-use Infill and Sidewalk Activation** – Relying on redevelopment, infill development, and the incremental adaptive use of existing properties, sidewalk activation is a "long game", yet still essential for Downtown's ultimate expression of urban livability. The most visible gap in sidewalk activation is the reach of Santa Rosa Avenue between Courthouse Square (3rd Street), and Sonoma Avenue, south of Santa Rosa Creek. The buildings indicated in red on Figure 16—banks, office buildings, a shuttered multiplex cinema—are all potential candidates for various strategies to introduce ground-floor pedestrian-friendly activities and businesses along the corridor that links Courthouse Square to the Prince Memorial Greenway, historic Julliard Park, and the Luther Burbank Home and Gardens.

Enhanced Mobility – A Downtown Transit Circulator

Our final recommendation recognizes the importance of micro-mobility alternatives in even the most walkable urban settings. Although the compact area of Railroad Square and downtown Santa Rosa is inherently walkable, distances between key attractors—for example, the future Railroad Square Transit Village and Courthouse Square—exceed the commonly-accepted walkability measure of a quarter mile (0.4 km). Moreover, this measure applies to active adults without mobility challenges, such as Hidden Mobility Disability (HMD), which can limit walking for many people to very short distances, even (as in the case of HMD) to as short as 50 feet between long resting intervals. Ideally, a micro transit service (see Figure 18) can bridge such gaps, allowing residents and visitors of all ages and physical conditions to enjoy full access to all the district's many attractions.

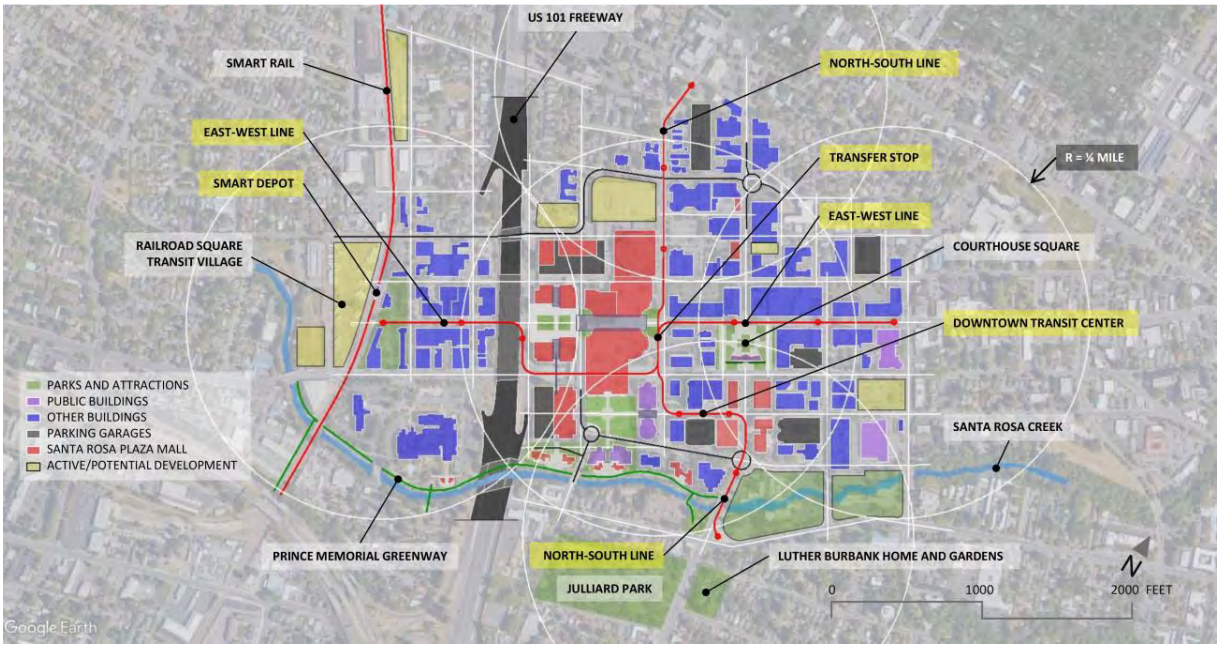

Figure 18 – Concept Plan: A Downtown Transit Circulator

At this stage in our study, we are considering the Transit Circulator as a service model, not a specific transit technology. Tech options (possible "modes") abound: mini-buses (driven or autonomous) and "modern" streetcars (line or battery powered) are strong contenders. Ideal characteristics of a local circulator include an understood and predictable route, a reliable short-interval schedule, bi-directional operation, ease of boarding and exiting, and—of particular importance to disabled patrons—the ability to make frequent stops-on-demand.

A system that meets these requirements (see Figure 18) features two intersecting lines that meet to exchange passengers on 4th Street near the east portal of the Grand Arcade:

- **East-West: The 4th Street Line** – Connecting with the regional SMART rail service at the Railroad Square Transit Village, the line follows the 4th Street corridor through Downtown, with a deviation to 3rd Street to pass under the Santa Rosa Plaza Mall.
- **North-South: The B Street Line** – Following B Street, 2nd Street, and Santa Rosa Avenue, the line connects the growing mixed-use area north of Downtown with key attractions south of Santa Rosa Creek, connecting with regional buses at the Downtown Transit Center.

Figure 18 also proves the intentions of such a system: quarter-mile radius walkability circles are placed at the four extremities of the lines and where they intersect in Downtown, showing the comprehensive and convenient access provided by this network.

IV. NEXT STEPS

In this paper, the authors have shared a circumstance in the California city of Santa Rosa, in which a downtown is divided by the location and design of a shopping mall and a highway. These barriers have not only physically and psychologically divided the downtown but precluded the downtown from realizing its greater urban potential, capping the downtown's potential for greater vibrancy, sense of place, and community pride and identity. The authors believe that breaching the barriers and establishing multiple safe and inviting corridors connecting Downtown and Courthouse Square with Railroad Square are the vital, catalytic moves by which Santa Rosa's downtown will realize its greatest urban potential.

At the IMCL conference in Le Plessis-Robinson, the authors will share this paper and related information and perspectives and invite additional thoughts and ideas to use in further developing their strategies regarding the "elephant in the room", then bring these thoughts and ideas back to Santa Rosa towards helping Downtown reach its greater urban potential and become that thriving place where people want to be!

APPENDICES

Attached to this paper is a list of references that include books, articles, and information that contribute to understanding and addressing the topic of this paper, a urban planning and design strategy based on restoring and providing vibrant, safe, and memorable urban connections. A foundation used by the authors in developing their ideas, approach, and recommendations is IMCL's Principles of True Urbanism. The 4-part IMCL strategy to achieve True Urbanism is described in IMCL Co-founder Suzanne H. Crowhurst Lennard's paper, *A Healthy City for All,* which she presented at the 56th IMCL conference in Portland, Oregon, in 2019.

A. IMCL Principles of "True Urbanism"

1. **Facilitate COMMUNITY SOCIAL LIFE**: "Wellbeing and quality of life are experienced primarily as a result of rewarding face-to-face interaction…The most essential task, therefore, is to make it possible for people to come together, form friendships and face-to-face social networks, and develop social capital and community. Public places, streets and squares must be designed to facilitate these social interactions." [6]
2. **Facilitate CONTACT WITH NATURE**: "There are many reasons why we need contact with nature in our cities, ranging from fundamental health issues to our intrinsic need to be connected to a living environment greater than ourselves." [7]
3. **Facilitate INDEPENDENT MOBILITY**: "A healthy, balance transportation policy must place first priority on walking, second on biking, third on public transit, and lastly on the car.

[6] Lennard, Suzanne H. Crowhurst, *A Healthy City for All*, International Making Cities Livable, 2019, page 11.
[7] ibid, page 16.

Taking the trips made by children, elders, the poor and disabled as seriously as trips made by working adults helps to prioritized healthy, ecological transit models." [8]

4. **Ensure Healthy URBAN FABRIC**: "Strong and diverse social life, and commercial diversity flourish best within a compact, human scale, mixed-use urban fabric. Contiguous buildings form continuous walls enclosing streets and creating squares. When many errands and trips can be accomplished by foot within a small radius, community networks develop. A compact urban fabric makes viable a good transit system." [9]

B. Conversations (Interviews) Conducted in Support of this Paper

- Jeff Elliott, City of Santa Rosa Historian, February 2, 2022.
- Gaye LeBaron, Santa Rosa Newspaper Columnist/Local Historian, February 4, 2022.
- Hugh Futrell, CEO of the Hugh Futrell Corporation, and Property Developer, February 4, 2022.
- Chris Coursey, Supervisor, Sonoma County Board of Supervisors, 3rd District (includes Downtown Santa Rosa), February 11, 2022.
- Chris Rogers, Mayor, City of Santa Rosa, February 18, 2022.
- Bernie Schwartz, California Luggage Retail Store, Santa Rosa, California, April 8, 2022.
- Dee Richardson, Co-Owner, Whistlestop Antiques Store, Member of Railroad Square Association, Santa Rosa, California, April 13, 2022.
- Keven Brown, Owner, Corrick's Stationery and Art Retail Store, Santa Rosa, California, April 20, 2022.
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- Figure 5, 6, 7 – D. Woltering.

- Figure 9 – left: Simon Property Group, right: D. Woltering.
- Figure 11 – left: Time Out Group, right: D. Woltering.
- Figure 13 – left: City of Carmel, IN, right: Tierney Connor Architects.
- Figure 15 – left: Novo Restaurant & Lounge, right: The Waterfront Restaurant.
- Figure 17 – left: The Press Democrat, right: AMC Architects.

Bangkok New Urban Agenda Through Urban Living Lab Model: Case Studies of Urban Studies Lab

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Abstract
In Thailand, the urban population reached 51.34% in 2020 (O'Neill, 2021). Like other megacities, the capital, Bangkok, faces immense urban and global challenges – aging society, climate change impacts, PM2.5 pollution, urban mobility, urban inequality, etc. – and the government cannot overcome these challenges alone. Most efforts to implement urban change in Bangkok come in the form of top-down policies or private-driven projects, and many are inefficient, lack adequate data, and fail to engage local communities. Moreover, academic research in the field of architecture and related fields often goes unnoticed by decision-makers, leading to a large gap between good urban policies and practical implementations for Bangkok's urban development. One solution to this problem is the urban living lab concept, a model that aims to include academic experts, government agents, and private enterprises to work directly with urban communities to achieve more sustainable and equitable urban development. This paper introduces the urban living lab (ULL) model actively applied by Urban Studies Lab (USL), a team of diverse academic experts and professionals based in Bangkok, Thailand. The model places local communities as equal partners in the planning, design and transformation of their cities, and strategically convenes a broad range of actors to test new methods of neighborhood-scale urban development. This focuses on co-creation aiming to expand the organizational capacity of the city, sharing the responsibility that falls on government, and makes a direct impact by changing urban policy, enhancing community power, applying practical and theoretical knowledge, and actively employing a bottom-up approach. By exploring example projects that have resulted from the ULL approach, including placemaking interventions, a social innovation hackathon, and an ongoing COVID-19 relief effort, the authors will demonstrate and evaluate the urban living lab concept as a new tool and mechanism for Bangkok and other cities to achieve the new urban agenda.

Keywords: New Urban Agenda, Urban Living Lab, Place Making, Urban Studies Lab, Bangkok

1 Introduction

The 21th century is the world urbanization. Like many megacities have become the major magnet of opportunity, Bangkok is the capital and primate city of Thailand drawing population of more than 10 millions living in Bangkok or 13% of the total national population (World Population Review, 2022). This causes the increase of populations and urban sprawl development through the past decades. In 2020, Thailand urban population reached 51.34% (O'Neill, 2021). These result in many challenges for the government and citizens to face immense urban and global challenges – aging society, climate change impacts, PM2.5 pollution, urban mobility, urban inequality, etc (see figure 1 and 2). Even though, urbanization can be viewed as the cause of the problems, it should be viewed as the potential and opportunity for solving the world problems (United Nations, 2017).

Figure 1. Flooding problems in Bangkok during the heavy rain days due to the lack of sewage system maintenance. (photo source: https://www.siamnews.net/environment/19862-four-factors-blamed-for-flooding-problem-in-bangkok/)

Figure 2. Bangkok sky on the serious PM 2.5 pollution conditions. (photo source: https://www.it24hrs.com/2018/bangkok-air-pollution-pm25-warning/)

Thai government has also launched the Thailand's 20-year National Strategy aiming to promote sustainable and continuation of the policy to ensure that the political party will continue along with this path of development. However, due to the process of developing this strategy, the citizens have not participated. This is top-down process of military government. Similarly, the development plans lack the citizen's participation (iLaw, 2017). Most efforts to implement urban change in Bangkok fall in the form of top-down policies or private-driven projects, and many are inefficient, lack adequate data, and fail to engage local communities. Thus, the government cannot solve these urban challenges alone, but stakeholders, professionals, academia, privates and communities must synergize to the encounter these urban challenges.

In addition, the Thai academic researches, especially architecture and related fields, go forward to understand the urban phenomena and to propose urban solutions. However, the data and knowledge are somehow either obsolete when the research project is done, or undergone without being realized by the policy makers or public awareness. Furthermore, the government or university research data has not been consolidated so it is hard to search for and access to the information (Shinpong, 2015). As a result, the research on the urban phenomena and solutions has a large gap between urban research policies and practical implementations.

To suggest urban solutions and promote the New Urban Agenda in Thailand, especially, Bangkok, the study reviews and focuses on the case study of the Urban Studies Lab (USL) which applies Urban Studies Lab (ULL) model as the team approach. The model aims to include academic experts, government agents, and private enterprises to work directly with urban communities to achieve more

sustainable and equitable urban development. Thus, the USL's goal, operation, approach, and activities are investigated and evaluated, especially, the impacts and applying of Urban Living Lab model for further suggestion on the urban Bangkok development.

2 Urban Living Lab (ULL)

The New Urban Agenda (NUA) aims the spatially efficient sustainable urban development and lays the action-oriented plan and strategy for assuring the SDGs implementation in all levels (UN Habitat, 2021). However, the NUA, as blueprint for states to adapt, could not be one size fit all, especially the developing countries. As the urban development has hardly dealt with the professional urban designers' or planners' action; on the other hand, it evolves and is organically developed by the informal settlements or local communities (Caprotti et al., 2017). Furthermore, Caproitti et al. (2017) argues that NUA focuses heavily on the measurable city data and indicators. Therefore, the role of citizens and behavior are often reduced to measurable data for policy making.

Therefore, Von Wirth et al. (2018) argues that the technological innovation is inadequate but socio-technological innovation is more appropriate. Thus, the open platform for solution experiments on an impermanent, adaptable, revisable, vibrant, and open methods is demanded. Moreover, the local communities have knowledge and experience to identify what suits the localities and their people. They know best of what action directly implies to their local conditions and context comparing to the top-down policies and procedures. The ULL model is then an approach to bring the stakeholders to act, experiment, and learn from the urban challenges to seek dynamic and specific site solutions through participation, experimentation and learning on the specific urban area.

However, the challenge for the ULL is how the ideas and solutions can be replicated and reapplied to other places. Thus, there are three stages of ULL: embedding, translating, and scaling. The embedding focuses on the design or application of the existing local context. The translating is an expansion of the knowledge or replication of the design or solutions somewhere else and/or different actors. This stage involves different stakeholders and networks to assist the learning process. The scaling is the application of the experiment on a the different scale (Von Wirth et al. 2018).

3 Urban Studies Lab, Bangkok

Urban Studies Lab (USL) was found in 2018 as a living lab in Bangkok. The USL is a center of independent researchers from various universities and urban practitioners. They focus on inclusive urban development and the impacts on community's lives. Besides from the multidisciplinary and diverse team members, USL divides its teams into four pillars: resilient urban system, urban classroom, inclusive placemaking, and socio-cultural heritage. Through ULL, USL promotes solutions through facilitating collaborative activities to construct a understanding of the urgent issues among the stakeholders and locations while focusing on three impacts areas: direct design or policy interventions, open data and knowledge sharing, and new urban leader education (see the figure 3).

Figure 3: The conclusion of the area of interests, impact areas, and organization activities. (photo source: USL Impact Report 2021)

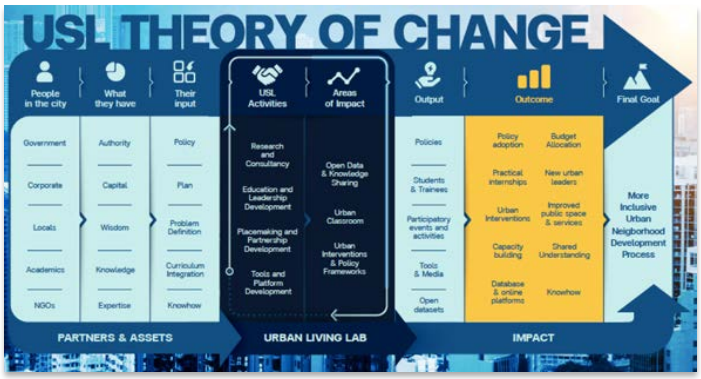

Figure 4: The diagram presents the USL theory of change: who, how, and what to achieve the goal of New Urban Agenda. (photo source: USL Impact Report 2021)

In Thailand, there are other urban changing agents who apply different urban development models. However, USL applies the ULL model to create an approach and platform for collaboratively innovative urban socio-economic, environmental and political solutions. The ULL offers the experimental areas with stakeholders' participations in real time situation. This plays a key role in USL's idea on who, how, and what of the urban problems should be reacted and urgently responded in order to receive the solutions and urban impacts (see figure 4).

4 USL Case Studies Reviews

4.1 Nang Leong Pocket Park

The project is the first placemaking project involved with USL. It was initiated from the International Program in Design and Architecture (INDA), Chulalongkorn University. The studio under the subject of Urban and Architecture was conducted during the summer school. The studio was to understand the urban context while implementing the design-built project intertwining in the urban setting. Through the network, the INDA staff and USL discussed an opportunity for the students to learn about the urban community conditions; cultural, social, and economic conditions (see figure 5 and 6). As working with the community at Nang Leong Community, one of the oldest markets community in Bangkok, USL discussed this opportunity with local leaders and the Pomprabsatrupai District vice officers for the operation and management. Therefore, a committee of park management with representatives from both the district and community was established. As a result, this committee was promoted and supported by a written policy of the Bangkok Metropolitan Administration (BMA).

The supports from various parties has been accounted. The studio students were interested in the empty space nearby the market with ideas of creating the shaded pocket park for community's activities and social events (see figure 7). FREC offer the operational space and labor forces. SOS Foundation proposed plants and gardeners. USL, in this project, acts as a front-end facilitator to the District, the Crown Property Bureau (CPB: landlord), and Nang Leong community.

Figure 5-6: (above left and right images) USL team briefed the INDA students for the community background and answer to the students' question while they provided the students' community trip. (photo source: Pongpisit Huyakorn)

Figure 7: The final proposed design by the INDA students; however due to the CPB's restriction, the roof structure were eliminated causing problematic BMA's registration. (photo source: Pongpisit Huyakorn)

However, with the CPB's regulation control, the original pocket park with the roof to prevent the excessive heat has been cancelled. Unfortunately, as the roof has not been built as a permanent structure, the park could not be registered with BMA for water and electrical supply. This causes problematic issues to the park committee. Finally, the issue was solved by the community. A resident living nearby the park helps supply the water while suing the solar cell system to produce lighting system. The BMA regulation is inflexible to permit the community-based project to be registered.

4.2 Mahanak Canal Wall Painting.

In further collaboration with the District, during the pandemic decease, the Covid-19 and lockdown in Thailand, USL has collaborated on a project, Mahanak Canal Wall Painting, under FREC and the Pomprapsatrupai District, Bangkok. Since the BMA has focused on developing the canals in old town Bangkok, the District also focused on Mahanak Canal to promote the BMA's policy. The project aims to activate/reactivate the abandon canal sidewalk along Mahanak Canal through community participation and engagement. The operation of this project was supported by the District with funding support from FREC. USL worked as a facilitator and ran the engagement process with 3 Muslim communities and schools along the canal.

For this project, USL fulfilled the role of facilitator in order to know the community's requirements and the District's goal through community participation. However, the process was uneasy since during the pandemic and lockdown period. People could not gather and meet in a group according to the government policy. Therefore, the challenge of the project is how USL overcome this unfortunate incidence. Otherwise, the project would have been proposed and unfinished. The USL team decided to have an online meeting instead, send tool boxes to the kids and teenagers in the community, and

invite them to share their ideas and imaginary wall with the USL team. The children in the community are pleased with the process as, as it was a good activity at home (Pin, 2020).

Figure 8: Community children participated in wall painting with the team. (photo source: Pin Udomcharoenchaikit)

Figure 9: During the Covid-19 lockdown, the artists and team continued the painting from the community ideas. (photo source: Pin Udomcharoenchaikit

Both USL and community youth discussed the ideas behind those images, related to their beliefs in religion mostly. The USL team collected and selected those sketches and drawings from the community youth. Finally, three images from each community were chosen for the final wall painting under the theme of dream, toy, and home. Before the lockdown, a group wall painting with the school kids were conducted (see figure 8). They painted the wall by their hands, after lockdown, the artists using the selected images to continue and finished the project (see figure 9). The flexible of the participation process and tool are the key success in this project to work under the uncertain conditions – Covid-19 lockdown.

4.3 UK Hackathon: Nang Leong Community

In 2020, during the Covid-19 situation, British Council Thailand and USL organized and facilitated the "Social Innovation Hackathon: Creative Placemaking in Nang Loeng. The hackathon emphasized the collaboration between different stakeholders, specifically, the local community and UK creative hubs aiming for social innovations on the local level. This encouraged the community's participation in Nang Leong community. USL also provided community baseline study. The hackathon invited four Thailand creative hubs (Weave Artisan Society, Factopia, Prayoon for Art, and E-Learng) to receive input from more than 100 local participants with various backgrounds: market community, local district agencies, school students, local leaders in art and craft, new generation business owners, and FREC staffs.

The project offered the participants to explore their ideas and involved first-hand experiences with the community (see figure 10). This process supports each team to validate their propositions. Furthermore, USL provided and trained them to apply the USL's Social Impact Assessment toolkit to their projects. The proposed projects included a local enterprise digital platform, a virtual tourism experience and local heritage treasure hunt, development of a local pocket park and community center, and a plastic upcycling station for street shading device. There were four criteria for the project: viability, impact, sustainability, creativity, and implementation plan. As a result, the winning team was the Weave Artisan Society with the idea of plastic upcycling bank to create a job on drapery shading device production. The result of the project not only created an urban phenomenon impact on public space, but also supported the job opportunity and reduced plastic waste in the community (see figure

11). The project is also ongoing in the community. However, the rest of the proposal projects were still collected as project banks for the future community development.

Figure 10: The UK Hackathon participants interviewed with one of the Nang Leong Market leaders. (photo source: USL Impact Report 2021)

Figure 11: The proposal design of the plastic bank in the Nang Leong Market. (photo source: USL Impact Report 2021)

The diverse group of participants are very helpful. With the healthy debate and ideas from various professions. It brings out the good lesson from this project. While, the engagement is the main key, the data and information sharing among the participants are also exceedingly important. Moreover, FREC is the physical platform for an idea and information sharing. It provides the neutral ground for all parties to freely share ideas without political and social pressures. In addition, the Covid-19 could be the main obstacle for the participatory workshop causing the expansion of the hackathon; somehow, it prolongs the ideas to be nurtured and customised for the suitable solution based on the local context and experiences they had.

4.4 Covid 19- Relief Bangkok

During 2020, the city lockdown impacted all the people in Thailand. Many voluntary parties and government parties launched the activities to assist effected people. There were vulnerable groups without registration to BMA, so they could not access the public health facilities and living supports. USL, as a co-founder of the Covid Relief Bangkok (CRB), operated with partners from NGOs, academia, privates, and government agencies (SATI Foundation, SOS, Ford Fund, Social Giver, Public Health Center and Local Health Volunteers, Bangkok 1899, RISE Impact, Community Organization Development Institute (CODI), and Brandthink) to aid these afflicted groups.

The USL approach was gathering consensus data and analysed them to identify the vulnerable groups from Covid-19 within Bangkok. This urban data analysis assisted the Public Health Center with crowdfunding (4,000,000 Baht or 150,000 USD.) to initiative aids for these groups (see figure 12). Furthermore, the initiative plan has developed into phase two and three; training mental health first aid for public health volunteers; community base booster camp with CODI focusing on food enterprises (see figure 13).

The ULL framework benefits the urban impacts during the pandemic. The risk management is crucial in this situation. All parties share their skills, expertise, knowledges which offers dynamic coordination among teams. The decision of the team is critical; thus shared data and knowledge assured the team's procedures. Furthermore, the ULL model provides the flexibility and adaptability in real-time and crucial pandemic situations. Moreover, the community also feedbacks the live data to the team after the remedies are applied. This is valuable to evaluate the processes and products; thus, the responses

and remedies are specific and redirect to the current community conditions. The USL is continue collecting and analysing the data from the vulnerable communities with local volunteers in Bangkok for further health and well-being community statistics and relief development plan in the future.

Figure 12: USL and partners are preparing the Covid Relief packs at FREC before sending to the vulnerable communities. (photo source: USL Impact Report 2021)

Fi**gure 13**: The phase 2 and 3 of the Covid Relief Bangkok are to promote the community food businesses developing from one of the community's skills. (photo source: USL Impact Report 2021)

4.5 Urban Classroom

One of the USL activities is Urban Classroom aiming to be a channel for the public and academia that are interest in urban issues to explore and learn their potentials, and be part of the solution provider for urban development opportunities. This Urban Classroom is in collaborated with School of Architecture and Design (SoA+D), King Mongkut's University of Technology Thonburi (KMUTT); Faculty of Architecture, Chulalongkorn University (CU), Urban Design and Development International Program (UDDI), Thammasat University (TU) during the summer period. The USL's Urban Classroom now mostly focuses on the university level from various built environmental design; landscape design, architecture, and urban design. The projects or ideas from this Urban Classroom are collected as USL's project bank for the future use.

The activities raise the pressing urban issues in specific areas as the main learning issues. One of the projects in Nang Leong community was tentatively evicted due to the new transportation system development in Bangkok; the orange line subway. The architecture students from KMUTT investigate the cultural, social, and economic conditions of the area in order to propose the projects and programs. The final projects were also exhibited and presented to Ford Foundation for the urban classroom and placemaking projects in the community (see figure 14). Another urban Bangkok development issue is Hua Lampong Station (HLS) (or Bangkok Station) by the State Railway of Thailand (SRT). As the completion of the new Bangkok station at Bang Sue Station, the HLS operating for over 100 years with an area of 192,000 m^2. is preparing to change the programs and renovation. However, the program and area changes affect the nearby communities which working and doing businesses for generations. USL with TU and KMUTT students also proposed the study of the program and activities for the master plan of the new renovation of HLS. The process used data from the main government research included the SRT officers' interviews, the public participations from the communities and school

nearby, a live online on Facebook for public hearing, online media collaboration, and a design completion (see figure 15).

Figure 14: The students are presenting their design proposal for Nang Leong Community development to the Ford Foundation team. (photo source: Chamnarn Tirapas)

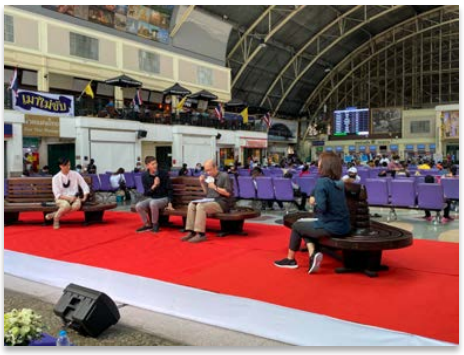

Figure 15: The USL team and research team setting up the online live session on the HLS renovation at its main hall. (photo source: Chamnarn Tirapas)

The Urban Classroom is the activity that USL applies the ULL with academic realm linking the theories and researches into the current urban issues. The participating students learn the impact of the data towards design decisions. Besides, they learn great deal on urban issues and understanding the impacts of the urban development on the communities. In addition, the partners or stakeholders reviewed the proposed projects and were inspired by the possibilities of the projects.

5 Conclusions

The reviewed projects illustrate how the ULL model promotes the inclusive urban development. The ULL model opens to different parties to engage together on the pressing urban issues. Similarly, the USL approach of ULL tackles the urban issues on the specific areas and engage the stakeholders, government agents, academia, privates, NGOs, and especially the community to participate on the project. The projects achieved their goals at different level. Like the Nang Leong pocket park, ULL encourages the top-down policy makers to realize and raise awareness on the constraints and BMA opens the opportunity for the first time to promote the co-operation between the community and district over the public space. The Mahanak Canal Wall Painting suggests the flexibility of approach and methodology of community engagement. The communities also raise the sense of belonging of the space along the canal. The UK Hackathon workshop promotes the collaboration of the local and international points of view to respond to the local urban conditions. Furthermore, its results create new urban job and public space phenomenon. The Covid Relief Bangkok integrate the various skills of experts and using the urban data to identify the sensitive area in Bangkok. From the data, it supports the team to tackle the vulnerable areas more precisely. The Urban Classroom is the activity that opens to the participants to learn and raises the urban awareness. Moreover, the activity enhances the students to explore their design possibility.

To sum up, USL case study has shown that the ULL model emphasizes local communities as the main equal partners in the planning, design and transformation of their cities, and strategically convenes a broad range of actors to test new methods of neighborhood-scale urban development. The model is still in the embedding stage, however, the successful cases are now recognized from the various parties viewing that engagement and participation are the key of the urban sustainable development. This is a

good opportunity to promote the model to be one of the key models of driving urban solutions to respond to Bangkok New Urban Agenda.

Acknowledgement

All successful projects have to thank the various supports from our partners: Nang Leong Community, International Program in Design and Architecture (INDA), Ford Resource and Engagement Center (FREC), Ford Funds, UK Creative Hubs, SATI Foundation, SOS, Social Giver, Public Health Center and Local Health Volunteers, Bangkok 1899, RISE Impact, Community Organization Development Institute (CODI), Brandthink, Pomprapsatrupai District, Bangkok Metropolitan Administration (BMA), School of Architecture and Design (SoA+D), King Mongkut's University of Technology Thonburi (KMUTT); Faculty of Architecture, Chulalongkorn University (CU); and Urban Design and Development International Program (UDDI), Thammasat University (TU).

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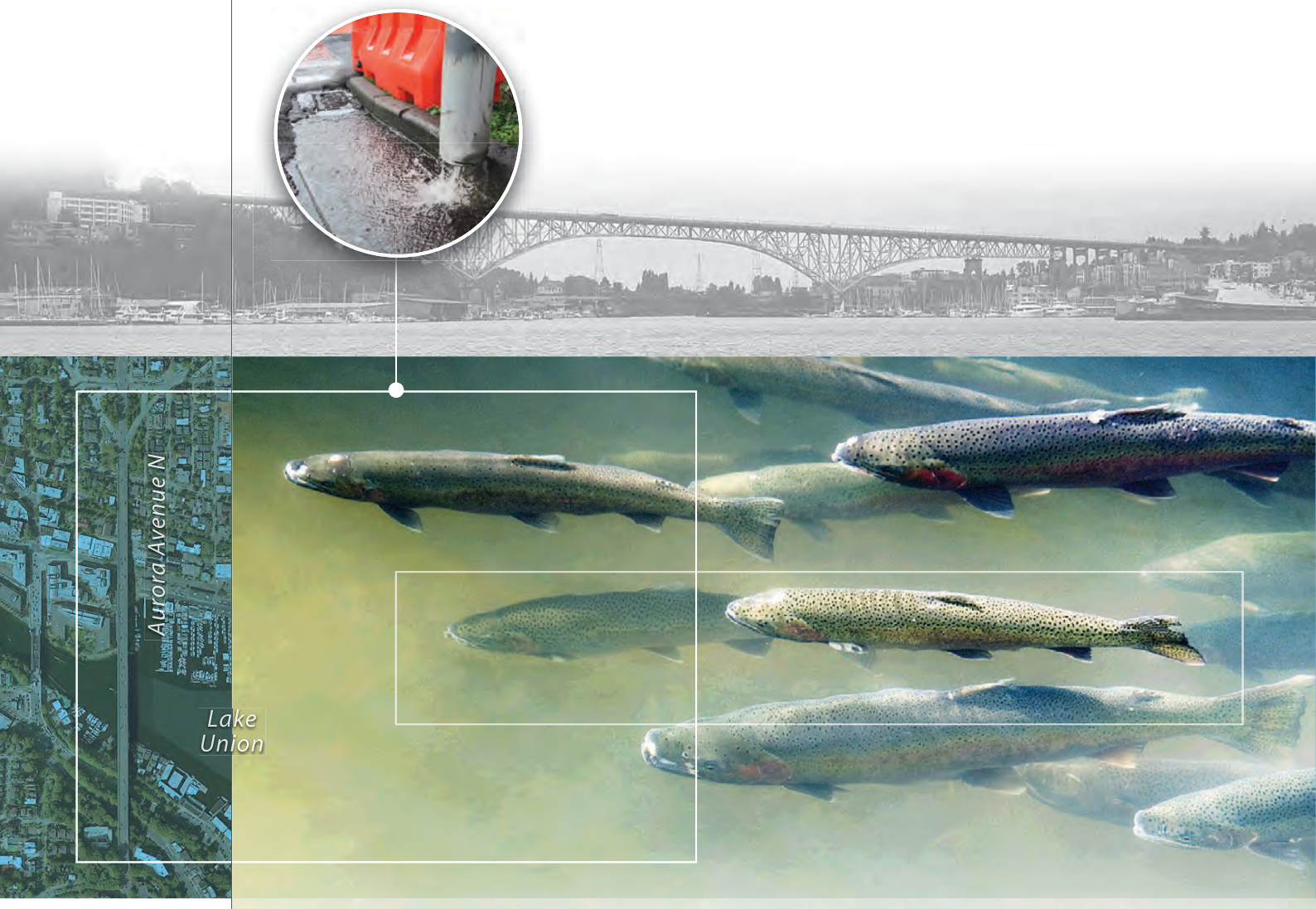
SALMON-SAFE INC.

THE AURORA BRIDGE MITIGATION PROJECT



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PUGET SOUND BUSINESS JOURNAL

How dying baby salmon inspired these developers to build a better building for Tableau

Headline from a Puget Sound Business Journal online news story published January 14, 2016.

Introduction | Baby Salmon Spawn Urban Intervention

The Aurora Bridge Mitigation Project was spawned from the brain trust of the Center of the Universe LLC partnership and their approach to developing two new projects at the corner of 34th and Troll Avenue known as the Data 1 and Watershed Buildings.

Stephen C. Grey & Associates (SGA) is developing the new commercial projects with First Western Development Services. Mark Grey of SGA and Mike Hess of First Western said a video of dying baby salmon inspired them to build a fish-friendly project. "Mike and I saw a video showing baby salmon being put in water runoff from the State Road 520 Bridge and instantly dying," said Grey. "And then the developers showed them surviving after they were put in water that had been passed through soil a few times."

With the two new buildings designed to capture water runoff from the Aurora Bridge and pass it through soil cells, cleaning it before it makes its way to Lake Union, they decided to take a proactive approach by building a bioswale under the bridge across North 34th, adjacent to Lake Union and the mouth of the Fremont Canal, which leads to Puget Sound for further intervention. The bridge's stormwater runoff at this site impacts a critical migration route for salmon. Chinook, Coho, sockeye and steelhead trout all swim from the Pacific Ocean and Puget Sound back through the canal and Lake Union to reach their spawning grounds in the upper watershed. Working with Salmon-Safe, the design team of KPFF Engineers and Weber Thompson Architects and Landscape Architects is trying to establish a ground-breaking effort to treat nearly two million gallons of polluted bridge runoff and create a replicable model of private-public partnerships for the future.

Samples of bridge runoff were taken in the winter and spring of 2017 to determine what pollutants were evident in the water and provide a water quality baseline for testing bridge runoff and treatment over the next five years. The water quality reports and their comparison to the SR-520 Bridge runoff results are featured in the supporting materials that follow.

THE PROJECT AND DESIGN OPPORTUNITIES

The Aurora Bridge Mitigation Project presents a new opportunity for innovative water quality treatment of polluted stormwater runoff. Currently, runoff from the Aurora Bridge is polluted by vehicular traffic. It is then partly discharged as untreated stormwater to a Ship Canal outfall. The rest is discharged to Seattle's capacity-constrained combined sewer system. During periods of wet weather and/or equipment malfunctions, untreated sewage and stormwater from the combined sewer system is released into surrounding Puget Sound water bodies, which are referred to as combined sewer overflows (CSO's). The following table describes the outflow of the catch basins:

Table 1. Catch basin outflows

Project Basins	Description	Bridge Area (sq ft)	Number of Bridge Down-spouts	Average Annual Discharge (Gallons)
A	Untreated stormwater runoff is discharged from a bridge downspout to the curb on Troll Avenue, where it is collected and conveyed through the municipal storm sewer system to a culvert outfall at the Ship Canal.	9,000	1	175,000
B	Untreated stormwater runoff is tight-lined from bridge downspouts directly to the municipal storm sewer system discharging by culvert to the Ship Canal.	25,000	2	450,000
C	Untreated stormwater runoff is tight-lined from bridge downspouts to the municipal combined sewer system with ultimately connects to the King County Metro trunk line in North 34th Street conveying sewage to the West Point treatment plant.	30,000	2	580,000
	Total	64,000	5	1,205,000

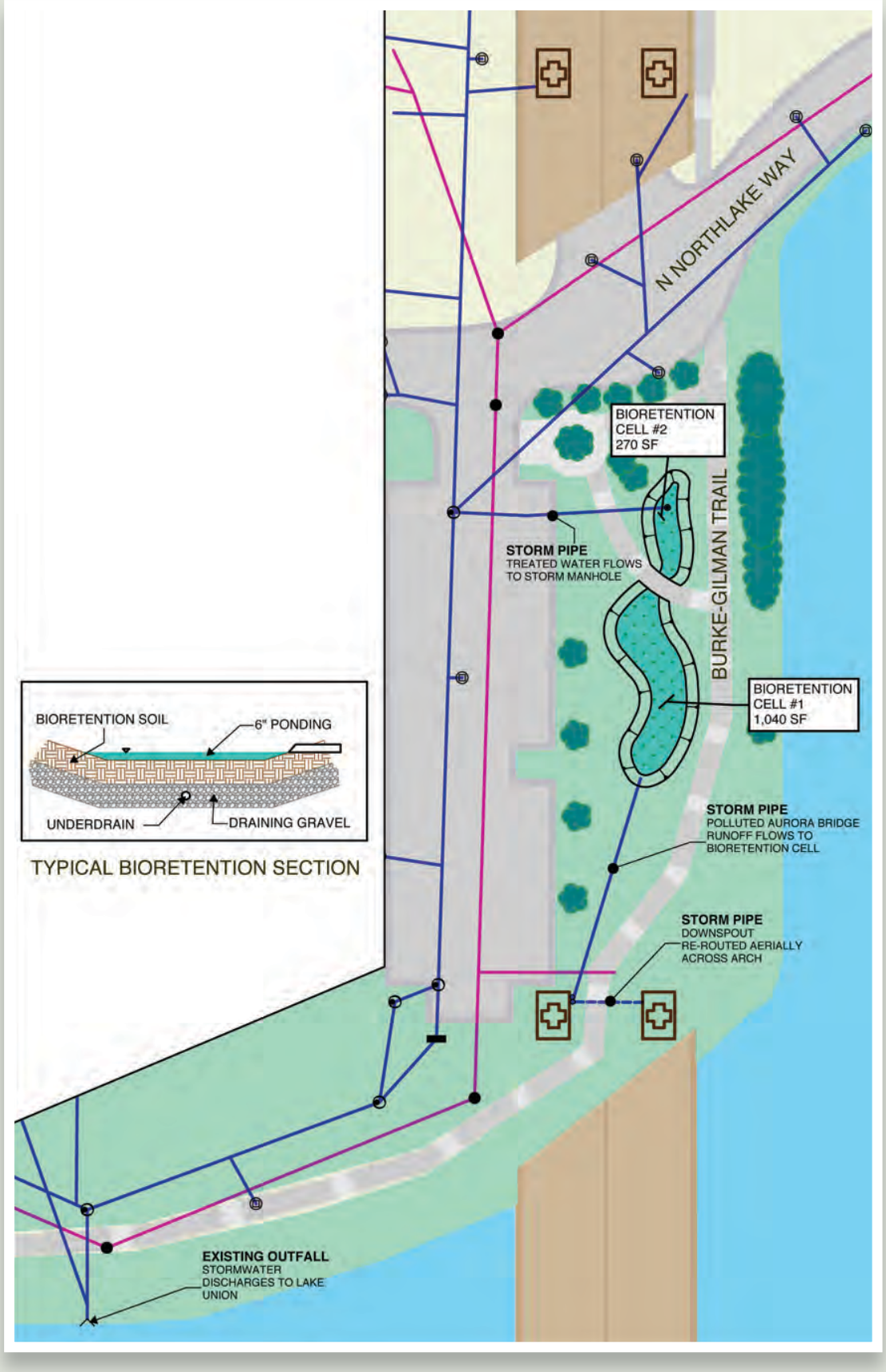

Figure 1. Aurora Bridge bioretention site locations

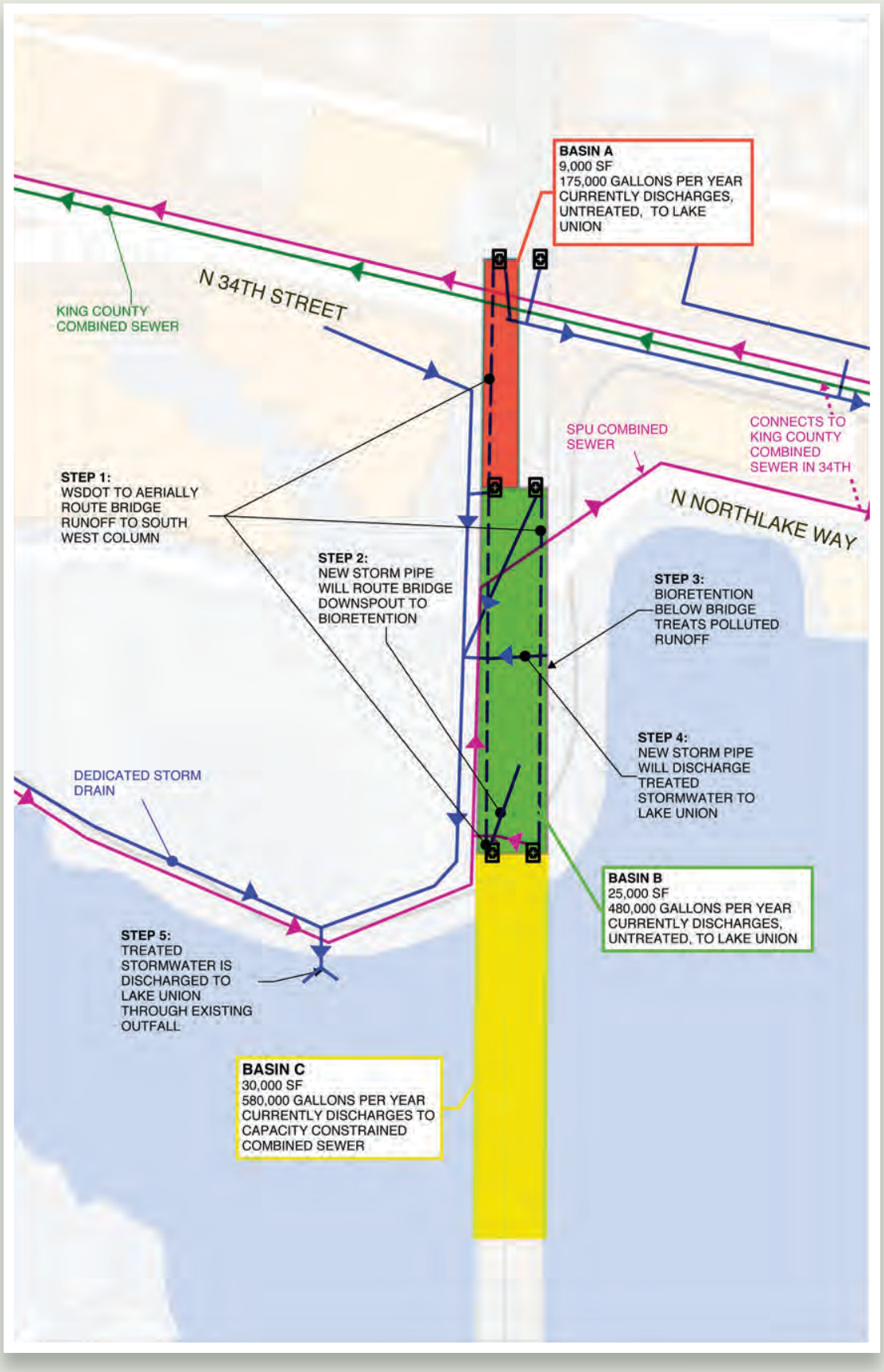

Figure 2. Aurora Bridge mitigation map as prepared by KPFF Engineers

This project proposes to intercept stormwater runoff from all five subject downspouts and route previously untreated stormwater runoff to a bioretention facility constructed in the open green space below the Aurora Bridge, adjacent to the Burke Gilman Trail (see Figure 1 and 2). The facility will be designed to meet or exceed the 2016 City of Seattle and Washington Department of Ecology standards for basic water quality treatment. Preliminary designs for the facility indicate the following geometry:

- infiltration rate through amended soils — 6 inches / hour
- bottom area (infiltrative surface) — 1,310 square feet
- amended soil depth — 2 feet
- ponding depth — 6 inches
- freeboard — 6 inches

The facility was modeled using MGSFlood continuous rainfall-runoff modeling. The results of this model indicate that the bioretention facility will provide enhanced water quality treatment for approximately 98% of all stormwater the facility receives based on the model's 158-year record. This exceeds the City of Seattle standard of treating 91% of the total runoff volume based on the same record. Enhanced treatment is intended to remove 80% of total suspended solids (TSS's), 30% of dissolved copper, and greater than 60% of dissolved zinc.

Table 2 below provides an executive summary of the preliminary engineer's estimate for construction. An important percentage of the costs are in the conveyance and rerouting from the bridge downspouts to the bioretention facility. WSDOT (Washington State Department of Transportation) has expressed some openness to aerially reroute stormwater from four of the rain leaders to a designated fifth rain leader for simplified conveyance to the bioretention facility. There has also been some discussion with the City of Seattle (COS) regarding waiving permit fees. The cost estimate below does not assume WSDOT or COS assistance.

Table 2. Preliminary cost estimate

Hard Costs	Cost
Division 1 — General	$ 21,000
Division 2 — Temporary Erosion Control	13,000
Division 3 — Site Preparation & Earthwork	32,000
Division 4 — Aggregate & Surfacing	12,000
Division 5 — Pavement Replacement	22,000
Division 6 — Bioretention Facility	49,000
Division 7 — Drainage & Utilities	37,000
Division 8 — Miscellaneous (includes interpretive signage)	22,000
Sales Tax @ 10%	22,000
Subtotal	$ 238,000
Soft Costs	
Design & Consultant Costs @ $15%	$ 37,000
Public Agency Fees @ 5%	13,000
Construction Management @ 8%	20,000
Salmon-Safe Certification, Assessment & Monitoring	15,000
Water Quality Testing (5 Years)	6,500
Subtotal	$ 85,000
15% Contingency	50,000
Grand Total	$ 380,500

NEIGHBORHOOD CONTEXT & GROWING MOMENTUM

The Aurora Bridge Mitigation Project is located adjacent to Lake Union at the southern point of the Fremont canal leading to the Ballard Locks. It is just below the intersection of 34th and Troll Avenue where cascading bioswales and rain gardens are being built to treat the runoff from the new Data 1 Building and the future Watershed Building across the street. Both projects are owned and being developed by Center of the Universe LLC and managed by Mark Grey, who is proposing the Aurora Bridge Mitigation Project.

The urban intervention sites present learning opportunities for pedestrians to better understand the importance of watershed health in urban environments.

With the installation of the bioswale, our team saw an opportunity to link to the larger context of the neighborhood. Inspired by Salmon-Safe certified parks in the Pearl District of Portland, we have identified a three-site link to habitat and natural areas that are currently not part of the built environment along Troll Avenue. Fremont, like the Pearl District, is going through a resurgence of development and experiencing exponential growth. Although the Pearl sites, including The Fields Park, Tanner Springs Park, and Jamison Square, are larger in scale, they do provide a similar trilogy of an urban walking experience. The Fields Park is programmed as open space and play area for kids. Tanner Springs Park is a site for treating urban runoff. Lastly, Jamison Square provides an open space area with a water feature. Our Fremont trilogy could begin at the popular Troll's Knoll, a site that is being revitalized as an active park space and community garden presenting opportunities for habitat and ecological function adjacent to the Fremont Bridge; walking west to the canal, pedestrians can enjoy the open plaza and bioswales of the Data 1 and Watershed Building on either side of the street, ending at the Aurora Bridge Mitigation Project along the Burke Gilman Trail, where one could venture even further throughout Seattle. These three sites will all feature interpretive signage for interactive engagement of visitors (see Figure 3). They also present teaching moments in terms of better understanding urban watershed health, the impacts of polluted runoff impacting Puget Sound, and the wellbeing of salmon and other aquatic species.

The neighboring urban villages of Ballard and the University District have recently inventoried open space planning and green infrastructure sites. Precedence was set

The new Troll's Knoll Park is located in the right-of-way at the north end of the Aurora Avenue Bridge and could be a future site for stormwater treatment of bridge runoff.

in these communities where key stakeholders and the public identified right-of-ways as a priority opportunity for bringing urban habitat into the neighborhoods, treating stormwater and providing a more livable experience for the people that reside there. Although the Fremont neighborhood has not yet conducted a similar process, the Seattle Department of Neighborhoods is seeing the same interest from a multitude of other urban villages. As density influences Seattle's growing neighborhoods there is an increasing need for these types of urban interventions to fill a gap for green space and habitat.

In addition to the individual neighborhood inventories, public private partnerships are also becoming more common in our region. The Swale on Yale serves as a great example of private investment for the common good. When completed, the project will treat an average of 190 million gallons of stormwater flowing from Capitol Hill into Lake Union annually, greatly reducing the amount of pollution flowing into the lake. The Swale on Yale anchors the runoff at the southern end of the lake while our project in Fremont is treating runoff at the northern end. Together the aggregate outcomes are an important step to further restoring water quality in Lake Union.

The new Data 1 and Watershed Buildings will provide learning experiences for pedestrians with a series of interpretive signs that identify native plants and the importance of treating stormwater runoff in the urban environment. Their plazas also offer new found open space at the intersection of N. 34th and Troll Avenue.

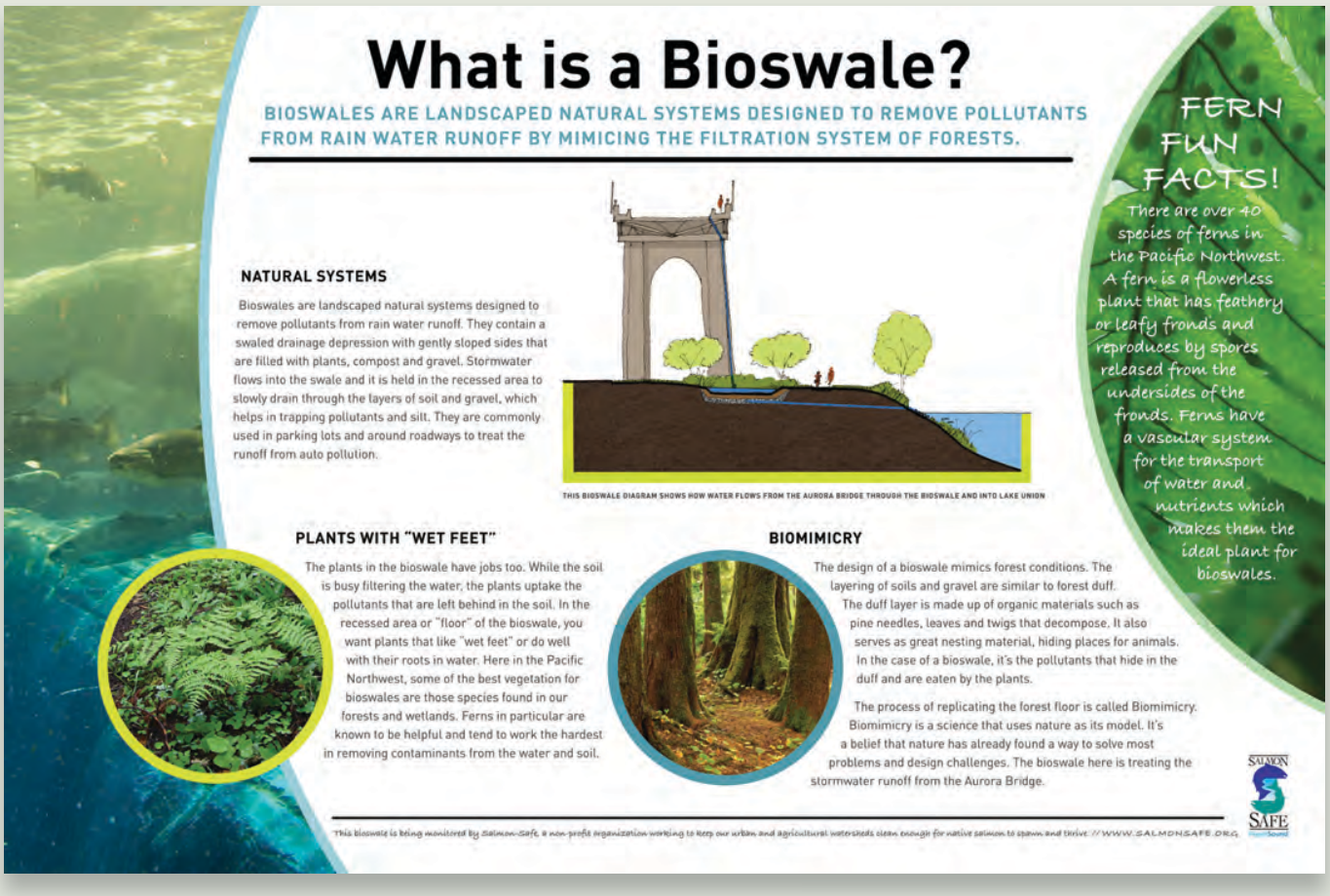

Figure 3. An example of interpretive signage installed at Fremont Bioswale

GOVERNANCE CONUNDRUM

At the beginning of the Data 1 project (Phase 1), KPFF reached out to Seattle Department of Transportation (SDOT) and Seattle Public Utilities (SPU) to share the team's trepidation with entering into the typical permitting regime with the project's innovative stormwater approach. The team earnestly believed in its idea, but feared that the typical review process would put up roadblocks

This bridge aerial illustration shows where the bridge downspouts and mitigation project are located and where runoff will be contained and treated through bioswales.

to anything out of the ordinary. SDOT responded by assigning an SIP reviewer who was willing to put in extra time to understand the proposal and who allowed the project team to step outside of the normal 30%, 60%, 90% review process with additional meetings and coordination. Additionally, SPU assigned a dedicated engineer to help with permit review and expediting. This cooperative effort continued into the Watershed project (Phase 2). We made similar attempts to engage Washington State Department of Transportation (WSDOT) with phases 1, 2, and 3, as their infrastructure is the source of the polluted runoff. WSDOT participation in Phases 1 and 2 was to communicate to SDOT that they had no objections to the proposal. The team is in initial discussions with WSDOT regarding rerouting storm

THE SWALE ON YALE EXAMPLE

Using the Swale on Yale example as a private public partnership example, the Swale on Yale, also known as the Capitol Hill Water Quality Project, is an innovative collaboration between Vulcan Real Estate and Seattle Public Utilities (SPU) to reduce the amount of pollution flowing into Seattle's Lake Union. The project incorporates a natural drainage system of four biofiltration swales set along two Vulcan-owned blocks in South Lake Union at Yale and Pontius Avenues North treating polluted runoff from 630 acres of land on Capitol Hill. The total cost of this project is approximately $11 million.
SPU received a $1 million storm-water grant from the Washington State DOE's FY2011 Stormwater Retrofit and Low Impact Development (LID) Competitive Grant Program and a $1.8 million loan from the Washington State Water Pollution Control Revolving Fund Loan Program. SPU is actively working with Vulcan Real Estate, a local Cascade Neighborhood Partner, in developing and funding the Swale on Yale. Vulcan Real Estate has provided technical and professional services and will be funding $1.2 million of the design and construction costs of the two-phase project.

leaders to help accomplish Phase 3 at less cost than the prior phases. It remains to be seen if WSDOT will assist with the endeavor. WSDOT Bridge Repair Engineering Division has indicated willingness to reroute four bridge downspouts to the Fremont Bioswale on the condition that they do the work themselves following approval from SPU and SDOT. WSDOT has said that they intend to charge Stephen Grey and Associates (SGA) for their services and are requiring that SGA assume liability and achieves approval from SPU and SDOT. The design team has requested a cost from WSDOT and they have yet to provide that information. The team has also met with the Department of Ecology (DOE) Water Quality and Non-Point Pollution team. DOE is in favor of the project and at one point had hopes to help fund its construction through two potential grant programs. As of June 2017, those funding streams are on hold until there is further clarity of overall EPA funding distribution for Washington State.

Based on RC 47.24, the Aurora Bridge section of SR-99 is a Managed Access Highway within the City of Seattle city limits. As such, drainage responsibility and right-of-way are vested with the City. WSDOT has a Maintenance Agreement (GM20) with the City of Seattle for this area and has identified the City of Seattle as the lead agency for projects such as this. WSDOT does not intend to maintain the proposed facility.

WHAT'S IN THE WATER?

Introduction

Property redevelopment at the northwest corner of N 34th Street and Troll Avenue N in Seattle is incorporating bioretention-type green stormwater infrastructure (GSI) to treat runoff from approximately 8,000 ft^2 of the Aurora Avenue N Bridge (State Route 99) passing over Troll Avenue N. The project has received Salmon-Safe certification because of its overall practices beneficial to salmon, including reaching beyond its own site boundaries to mitigate a major neighborhood water pollution source. In planning are additional GSI facilities on other properties in the vicinity to treat more of the bridge surface runoff. To form a baseline of the highway runoff water quality prior to the installation of treatment, samples of the flow from the bridge were collected on five occasions during February–April 2017. The intention is to monitor discharges from the eventual treatment facilities for comparison with this baseline.

Sampling and Analysis Methods

Sample containers were obtained from Fremont Analytical, Inc., located less than 1/4 mile from the sampling location. The containers were cleaned as required for the analyses to be performed and preservatives were added as necessary. Samples were collected directly into the containers from a vertical downspout draining the Aurora Bridge near the northwest corner of N 34th Street and Troll Avenue N. Sampling was timed to occur as soon after the onset of runoff as logistically possible to represent the "first flush" of pollutant transport.[1] The samples were transported to the Fremont Analytical laboratory immediately upon completing collection. They were placed under temperature control until the beginning of analytical

[1] Sampling was planned using the website *https://weather.com/weather/hourbyhour/l/USWA0395:1:US* (last accessed on 4/13/17), which gives hour-by-hour forecasts of precipitation probability for Seattle.

procedures, which were completed within five business days. Table 3 lists the analyses performed, the methods used and the quality control checks applied.

Analytical Results

Table 4 presents the pollutant concentrations measured in each sample and the rainfall recorded on the sample collection date and the preceding day. Most of the quantities are consistent in being in the same order of magnitude in the respective samples. Others differ more substantially (TSS, DPb, TPH-Dx and TPH-heavy oil). TPH-Gx was not detected in any sample.

All quality control checks are within acceptable limits with the following exceptions. Dissolved copper and total recoverable zinc appeared in the method blanks run on the 2/15/17 sample, whereas they should have been undetectable. The quantities are just above the reporting limits, however, and are only 2.4 and 1.0 percent of the respective DCu and TZn concentrations measured in the sample.

Table 3. Analytical methods

Water Quality Variable (Abbreviation)	Method	Quality Control[a]
Total suspended solids (TSS)	Standard Methods 2540D[b]	MB, LCS, Dup
Total recoverable copper (TCu)	EPA Method 200.8[c]	MB, LCS, Dup, MS, MSD
Dissolved copper (DCu)		
Total recoverable lead (TPb)		
Dissolved lead (DPb)		
Total recoverable zinc (TZn)		
Dissolved zinc (DZn)		
Total petroleum hydrocarbons-gasoline (TPH-Gx)	NWTPH-Gx[c]	MB, LCS, LCSD, Dup
Total petroleum hydrocarbons-diesel (TPH-Dx)	NWTPH-Dx/Dx Ext.[d]	
Total petroleum hydrocarbons-heavy oil (TPH-heavy oil)		

[a] MB—method blank, LCS—laboratory control sample, Dup—duplicate, MS—matrix spike, MSD—matrix spike duplicate, LCSD—laboratory control sample duplicate

[b] American Public Health Association, American Water Works Association and Water Environment Federation. 2016. *Standard Methods for the Examination of Water and Wastewater.* APHA, AWWA and WEF, Washington, DC.

[c] U.S. Environmental Protection Agency. 1994. *Method 200.8, Revision 5.4: Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma – Mass Spectrometry.* Environmental Monitoring Systems Laboratory, Cincinnati, OH.

[d] Washington Department of Ecology. 1997. *Analytical Methods for Petroleum Hydrocarbons.* Washington Department of Ecology, Olympia, WA.

Table 4. Analytical results and rainfall records

Variable (unit)	Sample Date				
	2/8/17	2/15/17	3/24/17	3/29/17	4/5/17
TSS (mg/L)	1890	370	630	319	567
TCu (µg/L)	471	344	311	200	251
DCu (µg/L)	32.8	21.8[a]	25.8	14.4	25.1
TPb (µg/L)	301	447	319	690[a]	345
DPb (µg/L)	ND	2.41	3.30	6.64	4.28
TZn (µg/L)	2520	1910[a]	1570	1440	1410
DZn (µg/L)	255	271	218	149	270
TPH-Gx (µg/L)	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]
TPH-Dx (µg/L)	ND[b]	339	284	503[a]	436[a]
TPH-heavy oil (µg/L)	11100	13300	3310	7890	5600
Time rainfall began[c]	6:00 AM–12:00 PM	12:00 AM–6:00 AM	6:00 AM–12:00 PM	12:00 AM–6:00 AM	12:00 AM–6:00 AM 4/4/17
Sample Collection Time	11:40AM	9:35AM	9:11AM	9:15AM	9:10AM
Rainfall on Sampling Day (inch)[d]	0.70	1.63	0.52	0.44	0.53
Rainfall on Preceding Day (inch)[d]	0.01	0.23	0.18	0.07	0.07

[a] A quality control check was outside of established limits. See discussion below.

[b] ND—not detected

[c] From *https://www.timeanddate.com/weather/usa/seattle/historic?month=2&year=2017* (last accessed 4/13/17), which reports rainfall occurrence in 6-hour intervals.

[d] From *https://www.wunderground.com/history/* (Historical Weather for Zip Code 98103; last accessed 4/13/17).

Matrix spike (MS) and matrix spike duplicate (MSD) checks on TPb and TPH-Dx in the 3/29/17 sample and TPH-Dx in the 4/5/17 sample are outside of the designated limits in initial and repeated tests, indicating possible matrix interferences. The term matrix refers to the components of a sample other than the analyte of interest. MS involves adding a known concentration of the analyte to the sample and determining the degree of agreement in the analytical result with the expected concentration. MSD is a repetition of that procedure. Matrix interference refers to sample characteristics that interfere with the test method execution. Examples include extreme pH, high alkalinity or acidity, and chemical constituents that react

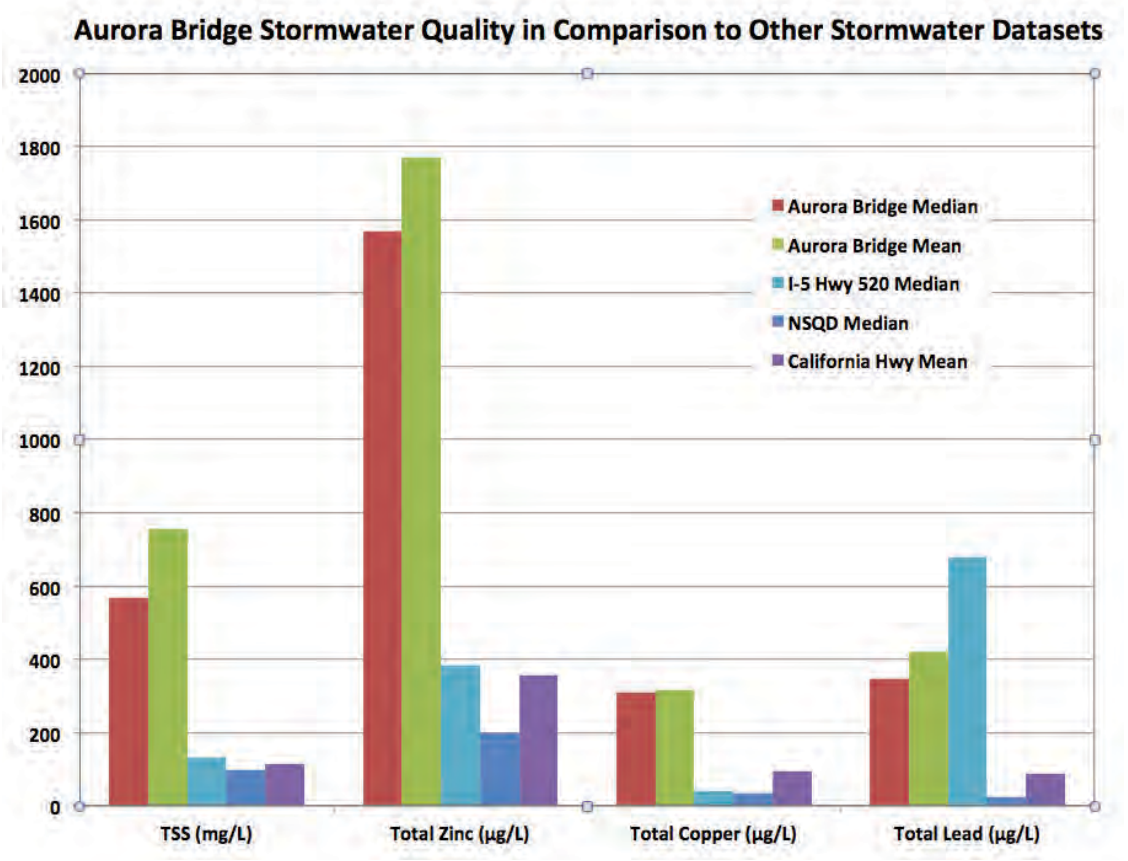

Figure 4. Aurora Bridge stormwater and other stormwater datasets compared

with target analytes. The latter is the most likely cause in this case. Measurements in the affected samples do not differ substantially from those in the samples taken on other dates not having indications of matrix interferences.

Sampling generally occurred relatively soon after the onset of runoff, as planned. Antecedent dry periods were not long, however, generally less than 24 hours. Seattle was experiencing almost daily rainfall, totaling near record amounts for the months of February and March 2017. Thus, the study does not represent the build-up or pollutants that may occur with extended antecedent dry weather. It rained 122 continuous days in the first four months of 2017—the rainiest period on record in the history of Seattle.

The Results in Context

The municipal permits under which the Washington State Department of Transportation (WSDOT)[2] and City of Seattle[3] drainage systems operate state no numeric limits on pollutants in stormwater discharges. To put the Aurora Bridge results in context, the National Stormwater Quality Database (NSQD)[4] provides data from a representative number of municipal stormwater permit holders across the nation. To date it serves as the largest urban stormwater database ever developed and includes data from freeway sampling. Median freeway concentrations as reported in the Fact Sheet for the WSDOT permit for pollutants also measured in the Aurora Bridge runoff appear in Table 5 in comparison to this study's results. The median is the number at which half of the measurements fall above and half below.

Excepting DPb, even the minimum Aurora Bridge concentrations are far above the nationwide medians. The Aurora Bridge TCu, TPb and TZn medians are a full order of magnitude higher than the same statistic in the national data. The TSS and dissolved metal medians are as much as five times as high.

Table 5. Median freeway pollutant concentrations from the National Stormwater Quality Database (NSQD) compared to Aurora Bridge results

Variable (unit)[a]	NSQD Freeway Median	Aurora Bridge Median	Aurora Bridge Minimum	Aurora Bridge Maximum
TSS (mg/L)	99	567	319	1890
TCu (µg/L)	35	311	200	471
DCu (µg/L)	10.9	25.1	14.4	32.8
TPb (µg/L)	25	345	301	690
DPb (µg/L)	1.8	3.30	0.25	6.64
TZn (µg/L)	200	1570	1410	2520
DZn (µg/L)	51	255	149	271

[a] The database does not report TPH fractions.

[2] National Pollutant Discharge Elimination System and State Waste Discharge Municipal Stormwater General Permit No. WAR043000A (2014).

[3] National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Discharges from Large and Medium Municipal Separate Storm Sewer Systems (2012, as modified 2015 and 2016).

[4] NSQD Version 4.02 (last updated January 2015). *http://www.bmpdatabase.org/nsqd.html* (accessed on March 16, 2017).

The Washington State Highway Runoff Water Quality research project performed by the University of Washington from 1977 to 1982 provides another frame of reference. This study collected 653 stormwater samples from nine highways across the state, including 283 from Interstate 5 and SR-520 in Seattle.[5] Table 6 presents median concentrations for some pollutants measured on these two high volume-highways near Aurora Avenue N. The medians are in the same general magnitude as those in the NSQD data set, except for TPb, which is much higher and also generally higher than the Aurora Bridge median. The latter result is understandable, in that lead was not banned from gasoline until the 1990 amendments to the Clean Air Act, which did not take effect until 1995. The large majority of the NSQD data points are from after the phase-out date.

Table 6. Median pollutant concentrations in stormwater runoff from I-5 and SR-520 in Seattle measured in the 1977-1982 Washington State Highway Runoff Water Quality Research Project[6] compared to Aurora Bridge results

Variable (unit)[a]	1977-1982 Median[b]	Aurora Bridge Median	Aurora Bridge Minimum	Aurora Bridge Maximum
TSS (mg/L)	130	567	319	1890
TCu (µg/L)	40	311	200	471
TPb (µg/L)	680	345	301	690
TZn (µg/L)	385	1570	1410	2520

[a] The study did not measure dissolved metals and the TPH fractions.

[b] Based on data from Western Washington monitoring stations on I-5 and SR-520 lanes carrying 42,000-53,000 average vehicles per day. The Seattle Department of Transportation's *2014 Traffic Report* gives the volume as 37,950 vehicles per day on Aurora Avenue N south of N 145th Street.

Excepting TPb, the Aurora Bridge minimums exceed the more than 35-year old median concentrations by percentages of 250-500. The medians range up to more than seven times as high.

Another contextual illustration can be drawn from an extensive study of stormwater best management practices (BMP's) suitable for application on highways performed by the California Department of Transportation from 1999 to 2004.[7]

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[5] Mar, B.W., R.R. Horner, J.F. Ferguson, D.E. Spyrikakis and E.B. Welch. 1982. Summary—*Washington State Highway Runoff Water Quality Study, Report No. WA-RD-39.16*. Washington State Department of Transportation, Olympia, WA.

[6] Horner, R.R. and B.W. Mar. 1982. *Guide for Water Quality Impact Assessment of Highway Operations and Maintenance, Report No. WA-RD-39.14*. Washington State Department of Transportation, Olympia, WA.

[7] California Department of Transportation. 2004. *BMP Retrofit Pilot Program Final Report*. California Department of Transportation, Sacramento, CA.

Table 7 presents the arithmetic mean concentrations of pollutants common to both that study and the Aurora Bridge monitoring. These numbers are from sampling of highway drainage (prior to its receiving treatment) at a number of sites in Los Angeles and San Diego Counties, on urban freeways carrying higher traffic loads than Aurora Avenue.

Table 7. Arithmetic-mean pollutant concentrations in California highway runoff compared to Aurora Bridge results

Variable (unit)[a]	California Study Arithmetic Mean	Aurora Bridge Arithmetic Mean	Aurora Bridge Geometric Mean	Aurora Bridge Minimum	Aurora Bridge Maximum
TSS (mg/L)	114	755	603	319	1890
TCu (µg/L)	94	315	302	200	471
DCu (µg/L)	18	24.0	23.2	14.4	32.8
TPb (µg/L)	87	420	400	301	690
DPb (µg/L)	8	3.38	2.24	0.25	6.64
TZn (µg/L)	355	1770	1727	1410	2520
DZn (µg/L)	122	233	227	149	271

[a] The study did not measure the TPH fractions.

While the California means are higher than the freeway values in the NSQD, they are in every case lower than any statistic in the Aurora Bridge data set, except for DPb. Aurora Bridge geometric means are included in the table, because this statistic moderates for the effect of a relatively few values that may be well outside the predominant range. In this case, though, the geometric and arithmetic means do not differ substantially, indicating that concentrations in various Aurora Bridge samples are relatively uniform. The difference in the two means is greatest for TSS, where one sample measured three times as high as any other and, for DPb, for which one sample was below detection.

Although the operative permits do not put numeric limits on highway discharges, the study's results can be placed in further context by comparison with benchmarks issued to industrial stormwater dischargers under Washington's Industrial Stormwater General Permit (ISGP), given in Table 8.

Table 8. Washington Industrial Stormwater General Permit (ISGP) benchmarks compared to Aurora Bridge results

Variable (unit)[a]	ISGP Benchmark[a]	Aurora Bridge Median	Aurora Bridge Minimum	Aurora Bridge Maximum
TCu (µg/L)	14	311	200	471
TPb (µg/L)	81.6	345	301	690
TZn (µg/L)	117	1570	1410	2520
TPH-Dx (µg/L)	10,000	339	24.9	503

[a] Benchmarks are not set for TSS, dissolved metals, TPH-Gx and TPH-heavy oil.

Even the minimum Aurora Bridge metals concentrations are far higher than the amounts set for industrial discharges. According to the ISGP, a benchmark exceedance requires a review of best management practices and specification of additional measures to attempt to meet the benchmark. Only TPH-Dx in the Aurora Bridge runoff would not be subject to that provision if the flow were coming from a permitted industry.

SUMMARY AND CONCLUSIONS

Concentrations of solids, total metals and dissolved metals measured in runoff from Seattle's Aurora Bridge are markedly much higher overall than those found in extensive highway runoff studies performed in the region and nationwide over many years. While only five samples have been collected at the bridge in this study, the results are consistent in this pattern, as demonstrated by the minimum values usually exceeding the medians or means in other studies and the relative congruity of the arithmetic and geometric means. There is definite concern with this finding, since the bridge's runoff flows into the Lake Washington Ship Canal, a key salmon migration corridor and, from there, to Puget Sound. Research studies have extensively established negative impacts of the contaminants measured in this study on aquatic ecosystems in general and salmon in particular, as briefly summarized in the appendix of this report.

The question arises, of course, as to why the Aurora Bridge runoff is so contaminated relative to many other examples of stormwater from high-traffic highways. The reason is probably not found in the quantity or composition of traffic. Aurora Avenue carries less traffic and probably also less heavy truck traffic, than the highways in the 1977-1982 Washington research and the 1999-2004 California study. Other possible reasons are atmospheric deposition and deterioration of the highway and bridge structures. Atmospheric deposition is not likely the explanation, as Aurora Avenue is in the same vicinity as I-5 and SR-520 studied earlier. There are less industrial air pollution sources in the air basin now than there were 35 years ago, when industries operated in the near and far field and have since shut down. The road is 85 years old and it is possible that deteriorating structural integrity is involved in what this study has shown. Whatever the reason, treating the runoff with the planned green stormwater infrastructure can only make a positive contribution to water quality and aquatic biotic health in the Ship Canal and Puget Sound.

APPENDIX A | Summary of Negative Effects of Measured Pollutants on Salmonid Fish

There is a large amount of literature on the specific lethal and negative sub-lethal effects of metals on fish and other aquatic life. Copper, especially, has received a great deal of attention in the Puget Sound region for its inhibition of various salmon physiological processes, to the detriment of migration, feeding, reproduction and rearing.

Short-Term Impacts of Metals

As just one example, Baldwin et al. (2003)[1] used coho salmon olfactory capacity, a reliable indicator of sublethal toxicity, in a series of studies. Exposure to 10 µg/L of copper for 30 minutes reduced responses to three odorants by 35-67 percent and the reduced olfactory function persisted for hours. Impairment was evident within 10 minutes for exposures ranging from 2 to 20 µg/L. The researchers defined the threshold for sublethal, copper-induced coho neurotoxicity to be 25 percent reduction in olfactory responses. They found the threshold to be 2.3-3.0 µg/L (depending on odorant) above the 3.0 µg/L background in source water; i.e., the presence of approximately 5-6 µg/L of copper reduced olfactory function by 25 percent. For context, the geometric mean total recoverable and dissolved copper concentrations measured in the Aurora Bridge samples are 302 and 23.2 µg/L, respectively.

Zinc concentrations as low as 93 µg/L have been found to be lethal to 50 percent of juvenile rainbow trout in 96 hours of exposure.[2] Sublethal effects at even lower concentrations include avoidance of rearing habitat and inhibited immune response.[3] Such negative effects interfere with growth, ability to avoid predators and resistance to disease. Geometric mean total recoverable and dissolved zinc in the Aurora Bridge samples measure 1727 and 227 µg/L, respectively.

Lead concentrations as low as 8-14 µg/L cause chronic sub-lethal effects on salmonids.[4] This threshold compares to 400 and 2.24 µg/L of total recoverable and dissolved lead, respectively, measured in the Aurora Bridge samples.

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[1] Baldwin, D.H., J.F. Sandahl, J.S. Labenia and N.L. Scholz. 2003. Sublethal effects of copper on coho salmon: Impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. *Environmental Toxicology and Chemistry* 22(10):2266-2274.

[2] Chapman, G.A. 1978. Toxicities of cadmium, copper and zinc to four juvenile stages of Chinook salmon and steelhead. *Transactions of the American Fisheries Society* 107: 841-847.

[3] Price, M.H.H. 2013. "Sub-lethal Metal Toxicity Effects on Salmonids: a review". Report prepared for SkeenaWild Conservation Trust. Smithers, BC, Canada. 64 pages.

[4] Price, *Ibid.*

In this case the dissolved quantity appears to be safely below the toxic level, if no more lead is solubilized in the receiving water. While lead is a relatively insoluble metal, there is still the possibility of release into the dissolved form.

Long-term Impacts of Metals

The negative effects of metal toxins are not necessarily limited to short-term, acute lethal or medium-term sublethal impacts. Over time an organism can accumulate metals in tissue, a process known as bioaccumulation. When predators consume organisms with bioaccumulated metals, they concentrate them in their tissues. The top predator in an aquatic ecosystem tends to have the highest concentrations, through biomagnification up the food chain. The salmonid fish of the Puget Sound tributary ecosystem are subject to these impacts.

Aquatic sediments become repositories for particulate metals through gravity settling and for dissolved metals through various adsorption and ion exchange processes. In addition to their toxicity to bottom-dwelling organisms, these captured metals can become remobilized into the water column by disturbance and dissolution and thus harm pelagic aquatic life long after their initial release.

Impacts of Particulates

Solids transported in flow are an instrumental feature of water quality because of their numerous ecological consequences, including:

- Covering and seeping into coarse bed materials where fish spawn and eggs develop; in filling the pore spaces, sediments restrict the flow of water carrying dissolved oxygen, resulting in asphyxiation of the young;
- Covering the surfaces serving as habitat for fish food sources (e.g., insects, algae);
- Filling deeper areas, tending to produce a more homogeneous bed and less habitat diversity and specifically reducing pools where fish rest and seek refuge from predators;
- Reducing visibility, making it harder for fish to find food and avoid predators;
- Reducing light penetration to underwater plants and algae;
- Abrading the soft tissues of fish, especially gills; and
- Transporting other pollutants present in the soil or picked up in transport.

Regarding the latter impact, sediments are a transport medium for many contaminants in other categories of water pollutants: metals, organic chemicals, nutrients and pathogens.

Impacts of Petroleum-Based Materials

Petroleum-based materials contain many chemicals, certain ones of which are toxic to aquatic life. They produce harmful sublethal, if not immediately lethal, reactions negatively affecting reproduction, development and behavior. These materials decompose relatively slowly and tend to accumulate in the aquatic environment. The gradual decomposition reduces the oxygen supply needed by aerobic water life, from fish to the microorganisms responsible for the breakdown themselves. The total petroleum hydrocarbon-heavy oil fraction that was measured at relatively high concentrations in the Aurora Bridge samples is especially subject to comparatively slow decomposition and extended presence in the environment.

Naphthalene is an important component of the total petroleum hydrocarbons and has been studied more than most of the many constituent chemicals. Laboratory bioassays have shown that naphthalene is moderately toxic to rainbow trout (*Onchorynchus mykiss*), bluegill sunfish (*Lepomis macrochirus*) and fathead minnows (*Pimephales promelas*). In Coho salmon (*Onchoryncus kisutch*) chronic naphthalene exposure resulted in reductions in feeding, growth and survival rates.[5] Naphthalene and methyl naphthalenes are among the most water soluble and toxic components of petroleum and are accumulated by marine organisms.[6]

In the aquatic environment, naphthalenes are especially hazardous compounds due to their particular combination of mobility, toxicity and general environmental hazard. In fact, some studies have concluded that the toxicity of an oil appears to be a function of its di-aromatic hydrocarbon (that is, two-ring hydrocarbons such as naphthalene) content. Environmental effects of such compounds often are the result of exposures to complex mixtures of chronic-risk chemicals.[7]

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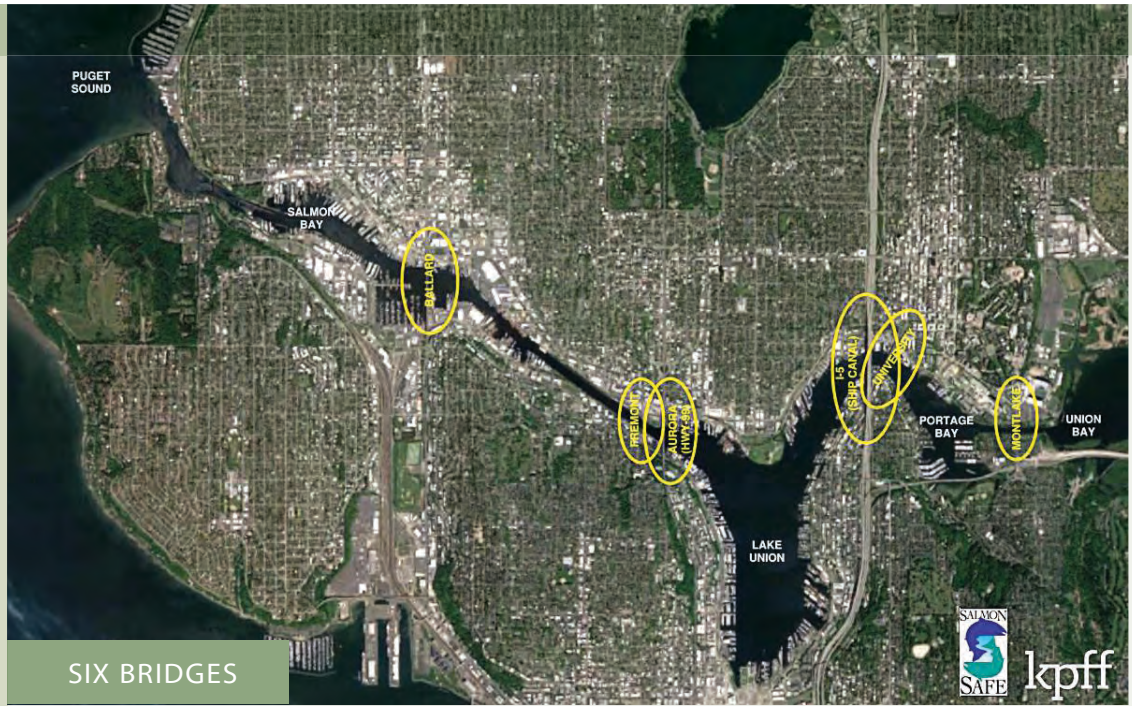
[5] From National Pesticide Information Center, *http://npic.orst.edu/factsheets/naphtech.html.*

[6] Liu, D. and B.J. Dutka (eds.). 1984. *Toxicity Screening Procedures Using Bacterial Systems,* (p. 392). Marcel Dekker, Inc., New York, NY.

[7] Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. *http://www.nature.nps.gov/ water/ecencyclopedia/assets/contaminant-pdfs/nap2met.pdf* (accessed September 15, 2016).

APPENDIX B | Green Bridges Pilot Study

The Green Bridges Pilot Study is an outcome of the original Aurora Bridge Report. In the Fall of 2017, following a presentation by The Nature Conservancy regarding the research conducted for the Aurora Bridge, a private anonymous donor offered to fund a brief study to determine if the other five bridges that impact the Lake Washington Ship Canal had the potential for green infrastructure to mitigate storm-water runoff from the bridge deck spans. Salmon-Safe retained KPFF Engineers to conduct the feasibility study and calculate the runoff. The runoff calculations are based on Seattle's annual rainfall of 38 inches. In addition, KPFF identified a composite bridge deck material which could be used to replace the grating on four of the draw bridges and collect additional contaminated runoff that may have normally fallen through the grates. The product, Fiber Span, has been used in other parts of the country.

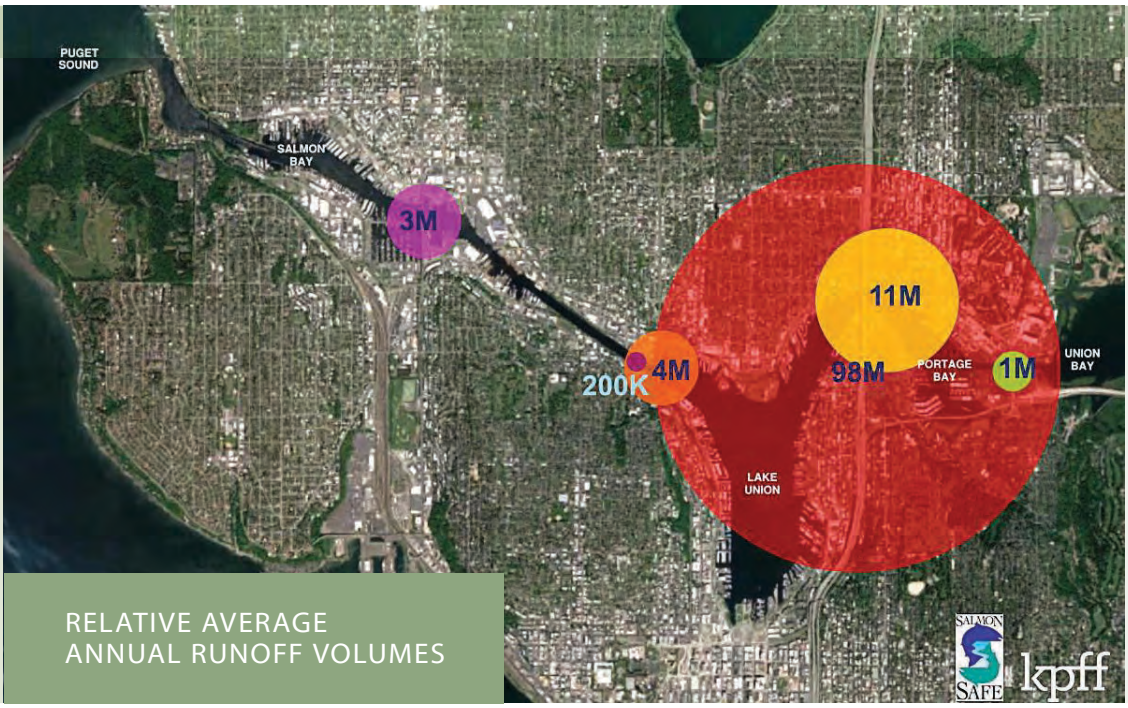


SIX BRIDGES

There are six bridges spanning Lake Washington ship canal, a key salmon migration corridor into the North Lake Washington and Lake Sammamish watersheds.

Pilot Study Findings

This study included the Ballard Bridge, Fremont Bridge, I-5 Bridge, University Bridge and Montlake Bridge. The scope of work was to determine the functionality of the existing runoff collection system, to quantify the extents of the collection basins, to develop new runoff collection and treatment strategies, and to locate adequate treatment sites. City of Seattle utility maps and record drawings were the key sources used to gather information about each bridge and provided the means to create feasible runoff mitigation solutions. Once the initial background information was obtained for each bridge, an approximate ratio of the bioretention area required to treat subsequent basin areas was used to size the treatment facilities. This ratio was approximated during the study of the Aurora Bridge stormwater runoff mitigation.



RELATIVE AVERAGE ANNUAL RUNOFF VOLUMES

If we were able to redirect runoff from all six bridges, we could mitigate 98,000,000 gallons of polluted stormwater from entering Puget Sound.

The investigation into the bridges crossing the ship canal revealed that the I-5 Bridge and its surrounding areas contribute the largest amount of untreated stormwater runoff out of all the bridges. The runoff from the bridge deck and contributing areas of the I-5 Bridge is almost five times that of the other four bridges combined. The cause for this extensive impact is not only the size of the I-5 Bridge but is also due to the layout of the surrounding stormwater

infrastructure. The large outfall that carries runoff from the I-5 bridge deck has been utilized to serve the surrounding neighborhoods creating a substantial collection basin that has a singular discharge point. This is also the case for the University Bridge, which is the second largest contributor of runoff. In total, all five bridges contribute approximately 113,000,000 gallons of untreated stormwater runoff per year. However, treatment solutions can be achieved for each of these bridges by investing in rerouting of stormwater to bioretention facilities. These bioretention facilities would not only serve to treat stormwater, but also serve as an improved green park space for public benefit and public awareness of stormwater mitigation.

A brief summary of each bridge condition can be found in Appendix C of this report.

Montlake Bridge

AHJ's: WSDOT[1] — Bridge and ROW[2]
SPU[3] — Combined Sewer

Drainage Area: 1± Acre

Connects to: SPU Combined Sewer

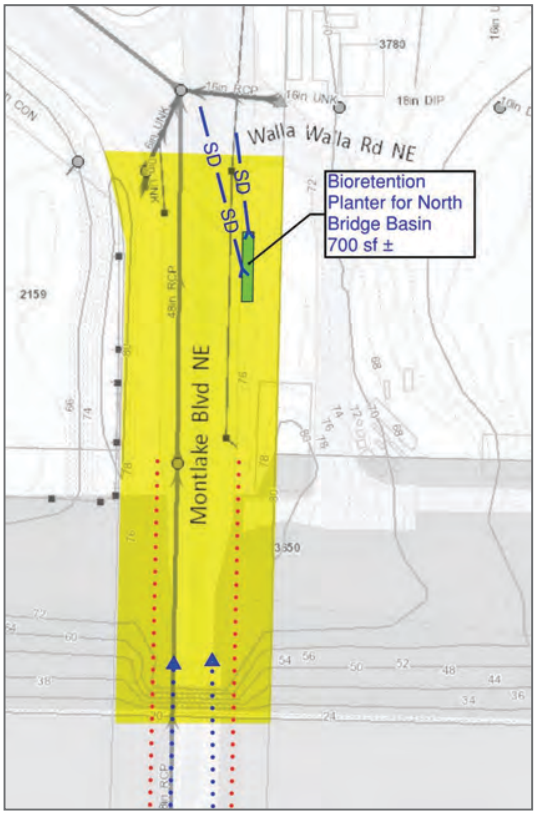
North Mitigation

Reroute storm pipe conveyance for approximately 0.5 acres of north approach to a 700 square foot ± bioretention area in the right-of-way adjacent to Montlake Blvd NE and connect the existing SPU drainage lateral to the bioretention.

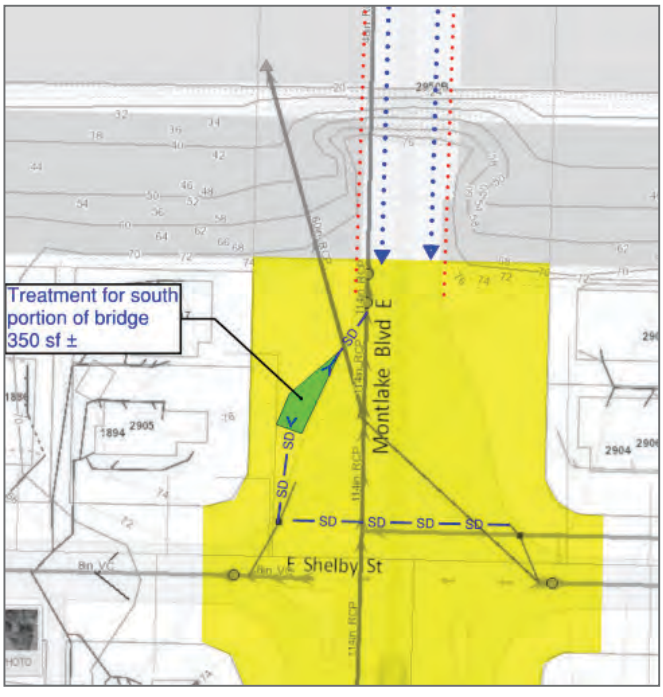
South Mitigation

Replace grated bridge panels with composite panels with runnel and route approximately 0.5 acres of bridge deck and south approach area to a 350 square foot ± bioretention area in the right-of-way adjacent to Montlake Blvd NE and connect the existing SPU drainage lateral to the bioretention.

North



South



[1] Washington State Department of Transportation
[2] Right of Way
[3] Seattle Public Utilties

University Bridge

AHJ's: SDOT[4] — Bridge and ROW
SPU — Storm and Combined Sewer Mains

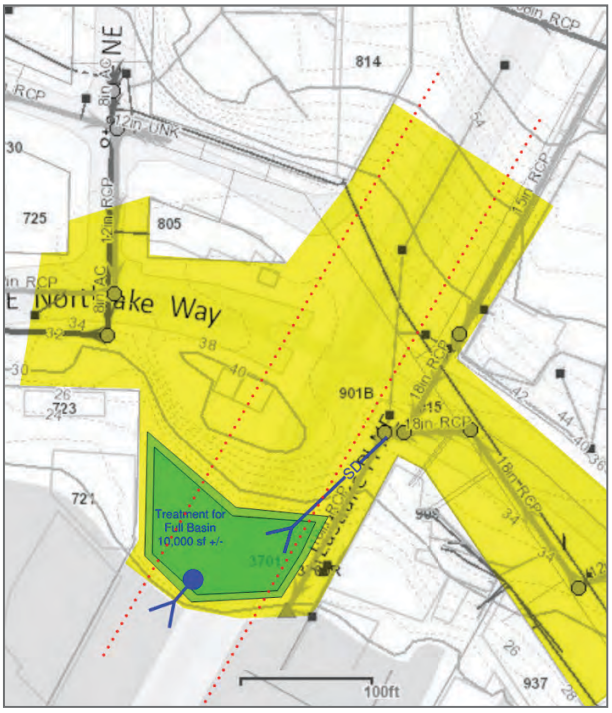
Connects to: SPU Dedicated Storm (North)
SPU Combined Sewer (South)

North Mitigation

Reroute bridge downspouts from approximately 1.7 acres of north bridge deck and approach, and daylight the dedicated storm main collecting runoff from approximately 10 acres of adjacent neighborhood into a 10,000± square feet bioretention area in the SDOT right-of-way beneath the bridge. Connect bioretention outfall to existing 18" RCP[5] culvert. Design challenge will be even distribution of a large volume of water.

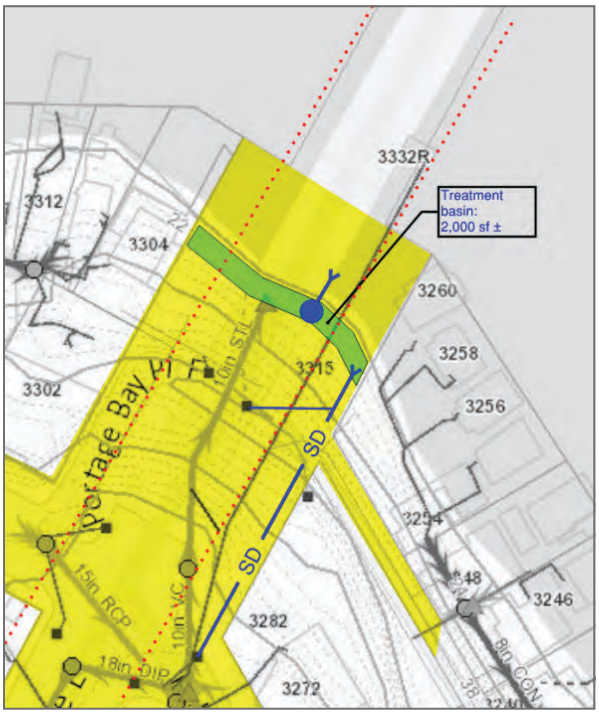
South Mitigation

Replace grated bridge panels with composite panels with runnel and route approximately 1.0 acres of bridge deck and south approach and an additional 1.0 acres of right-of-way road runoff area to a 2,000± square foot structured bioretention planter box in SDOT right-of-way beneath the bridge. Repurpose an existing 10" RCP combined sewer overflow as the outfall.



North

South



[4] Seattle Department of Transportation
[5] Reinforced Concrete Pipe

I-5 Ship Canal Bridge (North)

AHJ's: WSDOT — Bridge and Storm Main
SPU — Drainage to WSDOT Main
SDOT[6] — ROW at ground plane
Seattle DPR[7] — North Passage Point Park

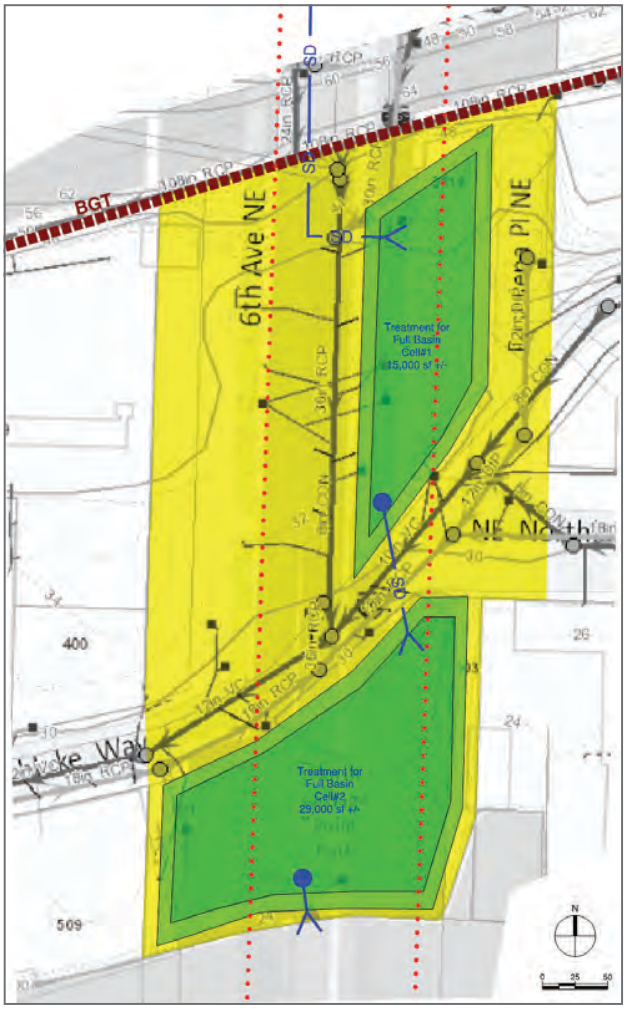
Drainage Area: 21± Acres
(5 Ac Bridge and 16 Ac Approach);
65± Acres Neighborhood Adjacent

Connects to: WSDOT 36" Storm Culvert

North Mitigation

Daylight the existing 36" RCP outfall to a large multi-tiered bioretention area in the SDOT right-of-way and a Seattle Parks parcel. The approximate bioretention size is 60,000 square feet, and would require multiple level pools, even distribution of large volumes of water, and culverting under Northlake Way.

The bioretention would outfall to the existing culvert. The SDOT right-of-way may have an existing lease with Lincoln Towing. The Seattle Parks portion of the treatment area would require a more intensive design creating public recreation space over and around the stormwater treatment.



[6] Seattle Department of Transportation
[7] Seattle Department of Natural Resources

I-5 Ship Canal Bridge (South)

AHJ's: WSDOT — Bridge and Storm Main
SPU — Drainage to WSDOT Main
SDOT — ROW at ground plane
Seattle DPR — South Passage Point Park

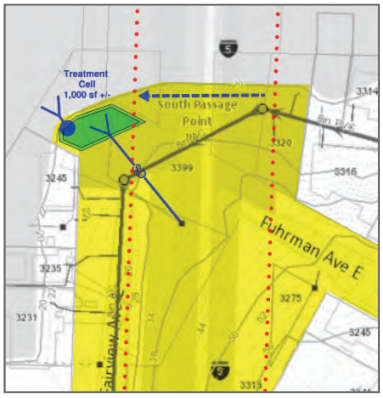
Drainage Area: 31± Acres
(7 Ac Bridge and 24 Ac Approach);
1± Acre Neighborhood Adjacent

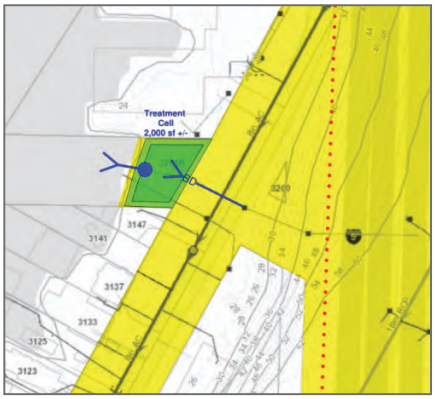
Connects to: 6" PVC at terminus of Fuhrman Ave E
18" pipe within pocket park adjacent to Fairview Ave E
30" RCP at terminus of E Allison St

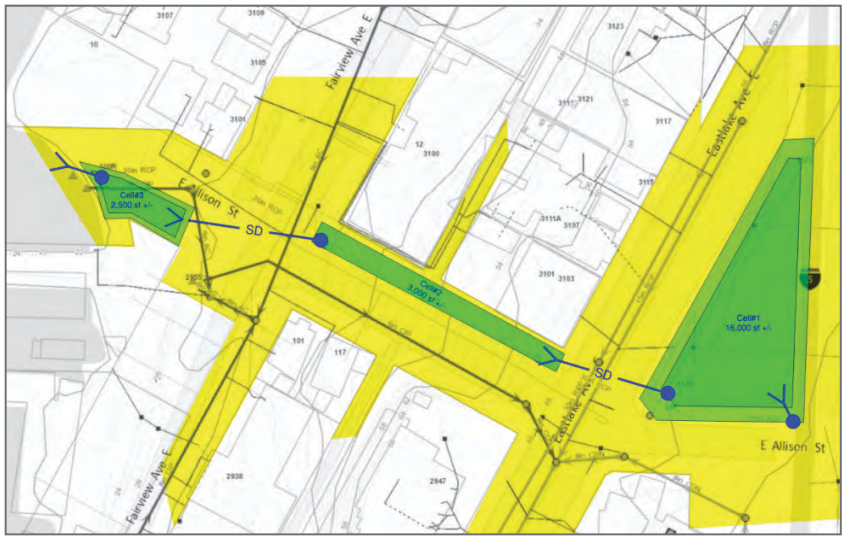
South Mitigation

Daylight the existing outfalls to multiple bioretention areas in the SDOT right-of-way. Mitigation areas appear to all be in the SDOT right-of-way, but portions may be maintained by Seattle Parks and coordination with DPR may be necessary. The 6" and 18" daylighting areas would be single-cells of approximately 1,000 and 2,000 square feet respectively. The 30" daylighting area would have an approximate bioretention size of 21,000 square feet, and would require multiple level pools, even distribution of large volumes of water, coordination with existing driveways and culverting under Eastlake Way and Fairview Avenue.

The bioretention areas would utilize the existing outfalls.



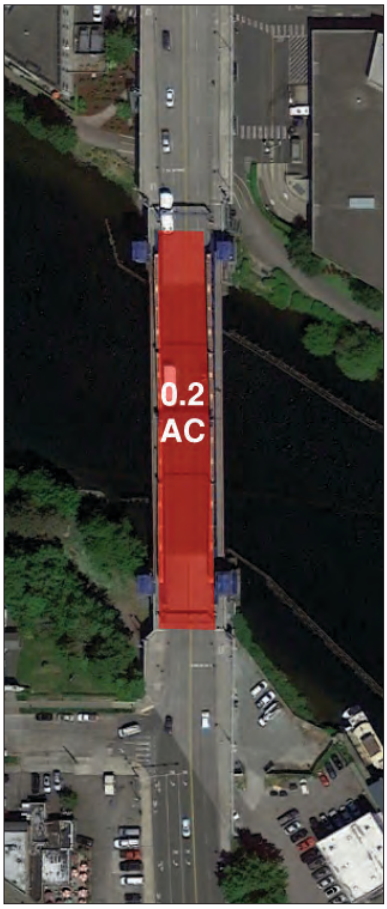




Fremont Bridge

AHJ's: WADNR[8] — Shoreline
SDOT — Bridge and ROW
SPU — Storm and Combined Sewer Mains

Connects to: SPU Dedicated Storm (North)
SPU Combined Sewer (South)



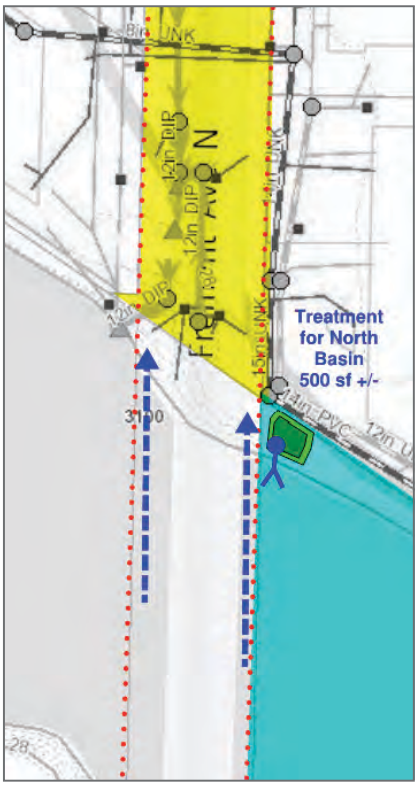
North Mitigation

Replace grated bridge panels with composite panels with runnel and route approximately 0.1 acres of bridge deck and north approach to a 500± square foot bioretention area on DNR land adjacent to the bridge. Outfall from the bioretention area would be routed to an existing SPU 12" DIP outfall on the west side of the bridge.

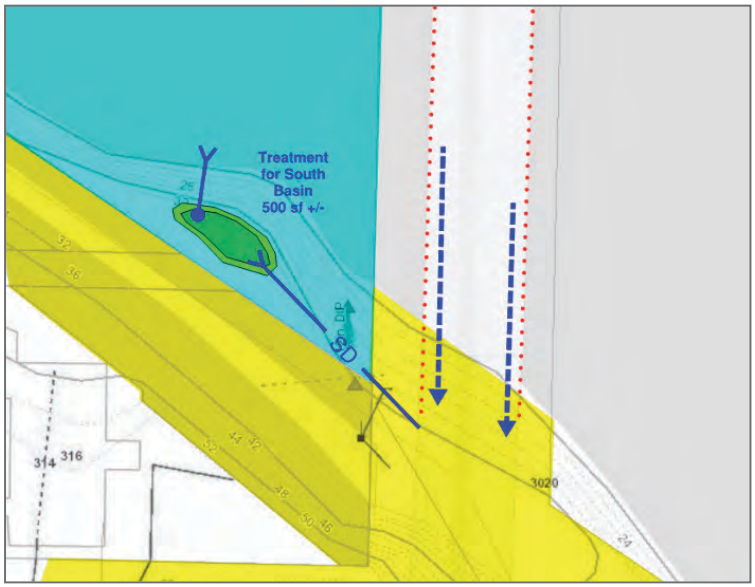
South Mitigation

Replace grated bridge panels with composite panels with runnel and route approximately 0.1 acres of bridge deck and south approach to a 500± square foot bioretention area on DNR land adjacent to the bridge. Outfall from the bioretention area would be routed to an existing SPU 12" DIP outfall on the west side of the bridge.

North

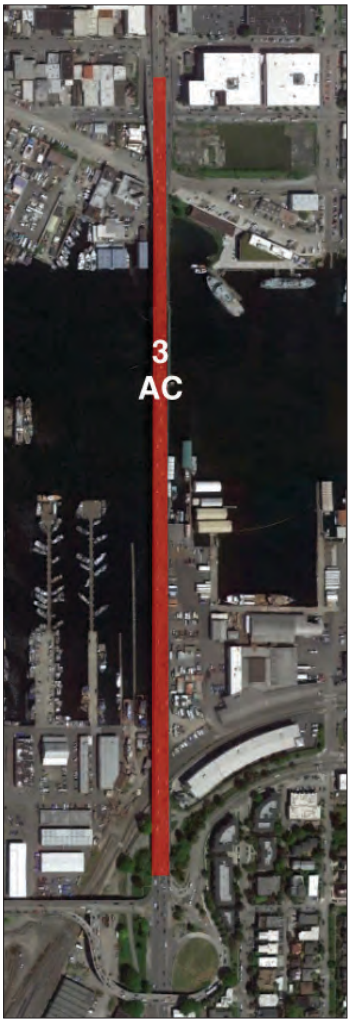


South



[8] Washington Department of Natural Resources

Ballard Bridge



AHJ's: SPU — Storm and Combined Sewer Mains
SDOT — Bridge and ROW
USACE[9], Ecology, and WDFW[10] if new outfall required

Connects to: SPU Dedicated Storm (North)
SPU Combined Sewer (North & South)

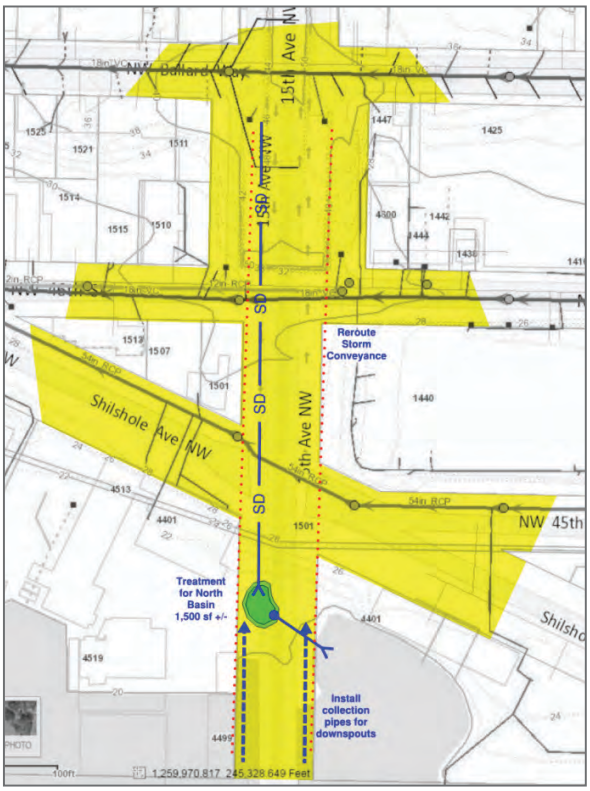
North Mitigation

Intercept the existing open downspouts and construct a suspended storm main on the bridge joining with the rerouted storm main on the north approach collecting an approximately 1.0 acre area going to a 2,500± square foot bioretention area in the SDOT right-of-way beneath the bridge. There is no existing culvert outfall, and so a new culvert or spillway discharge would be required.

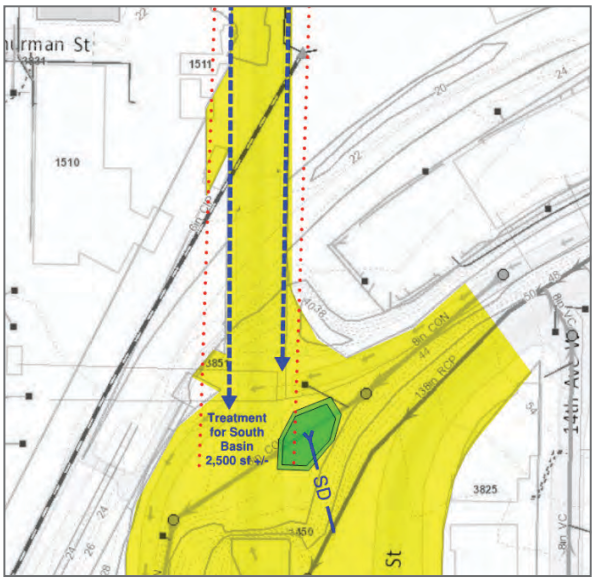
South Mitigation

Replace grated bridge panels with composite panels with runnel and route runoff from approximately 2.0 acres of bridge deck and south approach to a 2,500± square foot bioretention area in SDOT right-of-way. The outfall would connect to existing combined sewer mains.

North



South



[9] US Army Corps of Engineers
[10] Washington Department of Fish and Wildlife

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www.salmonsafe.org

Empowering children through co-creation: writing a book with and for children about their first steps towards urban independence

Beata Patuszyńska
cityforchildren.pl, Warsaw, Poland

Abstract

Children are largely absent from Polish social discourse, a fact which is mirrored in urban planning processes. Their absence creates a vicious circle – unfriendly urban space discourages children from going outside on their own, meaning adults do not see a need to make spaces more friendly for a group not present. The pandemic and lockdown, with their closed schools and temporary ban on unaccompanied minors on the streets, have only reinforced this.

The project – co-writing with children a book concerning their first steps into urban independence - aims at empowering children, enabling them to find their voice when it comes to urban space. The foundation for the book was data collected during research and workshops with children from Warsaw primary schools, aged 7-10 - the age they begin independent travel in the city.

The project was carried out with the participation and involvement of children at each creative step. Children were (1) models: the narrator is an 7-year-old boy, getting ready for urban independence. He shares his experience as well as the experience of his school friends and his 10-year-old sister, who already travels on her own. Children were (2) teachers: the book is based on authentic children's stories and experience, along with the author's findings from research undertaken with children. The material was extended by observations and conclusions made during the pandemic. Children were (3) reviewers: a series of draft chapters from the book underwent review by children during workshops performed in a school.

The process demonstrated that all children experience similar pleasures and worries when it comes to interaction with urban space. Furthermore, they also have similar needs that need satisfying. In my article I will discuss; (1) the advantages of creating together with children; (2) my conclusions on how to work with children in participatory processes; (3) research results: perceptions of urban space by children age 7-10, when they begin their independent travel in the city; the barriers to and pleasures derived from independent urban travel; the influence of the pandemic on children's feelings and their behaviour in urban spaces.

1. INTRODUCTION

Children are largely absent from Polish social discourse, a fact which is mirrored in urban planning processes. I discovered this when my daughter was 8 years old and she could already legally travel in the city on her own. She declined to go alone to school, even though she was more than familiar with the way. Having been professionally involved in the property sector and having an interest in urban issues, I wanted to find out more about what lay behind her reluctance. The first findings led to more detailed research, workshops in schools, writing articles, speaking at conferences and, more recently, a project aimed at empowering children in the urban space through co-creation.

In this article I will describe how a simple family inquiry has developed into a project aimed at acknowledging children's rights to feel comfortable in the urban environment. I will cover the results of my research - the perception of urban space by children aged 7-10, when they start their independent travel in the city; the barriers to and pleasures derived from independent urban travel for those in that age group; the influence of the pandemic on children's

feelings and behaviour in urban space. Finally, I will share my views on the advantages of creating in partnership with children and my conclusions on how to work effectively with children in participatory processes.

2. THE SITUATION IN POLAND - BACKGROUND

While researching the topic of children's participation in society I came across a poll, dated May 2013[i], concerning the role of children in the purchasing decisions of their carers. It revealed that children had a big influence on what their parents were buying. The list of items included some obvious goods; those typically associated with children such as sweets, toys and clothes. To my surprise, however, a large group of respondents admitted consulting their children on the purchase of much more expensive goods, such as the choice of holiday destination (60.2%), apartment (23.1%) or car (16.7%). I believe that, with the changes visible all around us and having observed how assertive schoolchildren can be, these percentages might well have increased.

Parents consult their children about major purchases as they are to serve the whole family and all members need to participate. This idea, however, can become lost somewhere down the line. The same people who acknowledge and respect the role of children in the decision making process, a group that most assuredly includes parents, when they get to work and start doing their "adult things", can easily forget that children have the same right as they do to feel comfortable in urban space - they fail to remember that urban space is as much a "child thing" as an "adult thing".

As a result of excluding children from decisions about urban space, the space fails to meet their needs and expectations and, especially at the beginning of their urban independence, many children cannot enjoy using and experiencing public space on their own. Their absence creates a vicious circle – unfriendly urban space discourages children from going outside on their own and, as the lack of independent children outside means adults do not feel the need to make the space more child-friendly, they do not perceive children as equal and proper users. The resulting exclusion concerns a large group of society; according to Statistics Poland census data[ii], those aged 7-17 years old (the age at which independent travel is allowed by law) make up over 10,6% of the population of Polish cities.

The lockdown that we observed in Poland marginalised children even further. The world - both inside and outside - turned hostile. A lot of children experienced a form of house arrest, as there were temporary bans[iii] on children going out into the streets without adult supervision. According to a report of the Empowering Children Foundation[iv], over 27% of respondents aged 13-17 experiencing domestic confinement were exposed to various forms of violence and harm at home. Outside, adults were masked and children could not see their smiles or read their emotions; the plethora of newly-introduced rules left many youngsters feeling somewhat lost. Schools and playgrounds were closed, so children couldn't meet their peers; they were declared a danger to their elderly family members. The public perception of children as a threat went as far as one office building manager announcing that, after the strict lockdown ended, tenants were safe to return to the workspace because safety measures had been implemented in the building[v] - one of the measures being, alongside upgraded ventilation systems and safer car parking regimes, a ban on children entering the building.

3. FROM RESEARCH TO WORKSHOP

I started researching the subject of children in urban space 5 years ago with my daughter, who was then 8 years old. She could legally travel on her own - she knew how to make the journey to school, although she declined to do it. To find out what the actual barriers were to a

child's independent travel in a big city, I started to conduct "accompanied interviews" with my daughter and her younger brother.

I became interested in the extent to which urban space was welcoming to children, and decided to concentrate on the journey to school, as it was something my daughter experienced daily. It was repeatable and familiar, and therefore easy to be taught and practiced. It included, for example, such familiar aspects of the route as which tram goes to school and where care was needed in specific places. I followed my children. I observed them, asking questions, and discussing things that were funny, pleasant and easy, as well as difficult and scary. I also asked them to take photos, so I could get a child's-eye view of the city.

Eventually, my investigations developed into a larger research project, where I conducted workshops for 7 to 10-year-olds in school. Initially, I had planned to analyse the inclusive nature of urban infrastructure – the pavements, crossings, road lights, bicycle paths, and city transport. I soon noticed, however, that although infrastructure was very important, it was not a key factor in my daughter's dislike of independent travel in the centre of Warsaw where we lived and where school was. Even when the infrastructure presented challenges or appeared illogical, I could teach her where to exercise caution or prepare her for possible deviations from normality. Talking to children during my research, I became fascinated with their perception of the city, and I discovered a whole range of other issues, most notably concerning how children's developmental needs regarding safety and play are translated into the urban space.

3.1 MENTAL MAPS

During the workshops, I realised it was difficult for 8-year-olds to use regular maps; they explained their perceptions to me by drawing their own maps and describing how to get from one place to another. Their city maps were not made up of a network of named streets, but rather a system of orientation points and experiences, as well as collections of smells, sounds, views and textures[vi]. This, perhaps, should come as little surprise, given that street nameplates are placed too high for them to read.

My children, when asked how to get from home to a certain tram stop did not say that "it is on a square north of our building," as I might; they explained that "you need to go past a bakery which smells nicely of cakes, then pass a bank with big doors that slide open every time someone passes, then turn and cross the street where there's always a little puddle from where the fire engines are washed and which has ice to break in the winter, and lastly you have to go past the cafe where we usually have our birthday breakfasts".

3.2 THE NEED FOR SAFETY

Children need to feel safe, and in the urban space safety means friendly and pleasant surroundings. This conclusion is confirmed by what I have heard from researchers all over the world. Children, regardless of where they live, inevitably talk of the same likes and dislikes. They enjoy green spaces, places where they can meet and interact with others and have the freedom to discover things; they dislike cars on streets, vandalised spaces, aggressive adults, and rubbish.

Another aspect of feeling safe is predictability; the world, including adults and non-living things, needs to follow pre-established rules. Unfortunately, often the first rule that children in Warsaw learn is: there are no rules. During workshops, they pointed out the lack of security resulting from adults themselves not observing the rules which children are taught at home or school. This includes; parents and delivery vehicles driving across, parking on, and reversing over zebra crossings outside schools; cars driving through green lights for

pedestrians; the inability to cross a street or get off a tram or bus because adults are not observing the conventions of walking on the right or letting people exit before entering. Children, additionally, also expect predictability and regularity from non-living things such as city lights or transport systems.

During one of her independent trips to school, my daughter noticed that, due to a system fault, a digital board at a tram stop was announcing the incorrect arrival times of many different trams. She chose to walk to school instead of waiting for her tram. For adults, these boards are mere representations of timetables, but in a child's world, especially in situations where children have only themselves to rely on, a single faulty element can render the whole system unsafe.

Safety also means feeling included and welcomed. In Warsaw, children often receive the message that they are not important in an urban space. Warsaw is a city dominated by adults who are not accustomed to looking down to notice children, and who, by their rule breaking, exercise their physical dominance. The children I spoke to talked of adults either blocking them from getting off a crowded bus or, when cycling, from starting first when a light turns green, even when they were first in line. Another common complaint was that of traffic lights prioritising drivers. A child's perception is that it takes an age for lights to change, and that sometimes they must take more than one traffic cycle to fully cross the road because big road crossings are often divided into two or three sections, making them impossible to cross during a single green light cycle. Children also pointed out that trams and buses with steep steps (although such vehicles are in the process of being replaced by low floor versions), are difficult to enter, especially while carrying a heavy school bag.

3.3 THE NEED FOR PLAY

Another core need of children is the need to play – something they also contribute to the urban space. Children are in a constant dialogue with urban space, either when using the city's infrastructure as a playground, or via storytelling and building connections with places.

The most obvious way for children to introduce play into the urban space is in response to the infrastructure. Watching children on streets, it is easy to see that they use benches, walls and steps as opportunities for physical exercise, climbing, jumping, and running. Other parts of the urban infrastructure also offer invitations to play. My children, for example, used to play a game of avoiding broken paving slabs or the black stripes of a zebra crossing. Non-typical situations also create opportunities for play; a green man on a crossing light turned 30 degrees presents a challenge to a child to negotiate the crossing in a way mimicking the pictogram.

Another component of play in urban space are "tales and magic spells", which give a sense of control. My children love to use "magic" to change things they do not like – they feel it is an effective way for them to gain a sense of influence over the city. For example, spells can accelerate the changing of lights or speed up the arrival of buses.

Apart from helping to establish where places are, stories are also important in making sense of the incomprehensible organism that the city can be. Sometimes the stories are of the past; sometimes they involve the animation of non-living objects to build connections with places; sometimes they are stories of places children find scary.

4. MAKING USE OF MY FINDINGS

Equipped with my findings and the thoughts they stirred, and regularly listening to children's voices, I realised youngsters often have no channel into adult consciousness. It is true not only in the case of planners and decision makers, but also of those closest to the children - their carers. Parents and teachers do not always know how to support children in their first independent steps in the city and, what is even more important, they often do not recognise the

child's need for support. The adult perspective of looking and experiencing things from their 1 metre 60+ vantage point leads to a very different worldview[vii]. Adults do not see so much rubbish on the ground; they breathe in fewer exhaust fumes; they can more easily read street signs; they can see the actual faces of drivers, rather than just the bumpers of their cars; they can look others in the eyes to confirm they have been noticed. From such a vantage point it can be hard to appreciate or evaluate a child's fears. For an adult, travelling from A to B is a result-centred mission rather than a process. For a child it is neither so simple nor obvious - with their fresher view and their need to understand and learn how the world is organised, travel is more of an experience.

4.1 TALKING TO ADULTS

Aware as I was of children's difficulties in being listened to by adults, I adopted the role of intermediary - as both an adult and someone who listened to children, I was connecting the two worlds. I started sharing my findings in articles and presenting them at conferences devoted to placemaking and children in cities.

Through my encounters with adults during my activities I realised that, even though every adult had been a child themselves, many of them remembered little of those times. The children's stories that I related often recalled their own past urban traumas. I heard childhood stories from adults praying that some adult would push a stop button in the bus as it was too high for them; stories of entering shops and seeing only the rears of adults; recollections of being unable to buy things in shops because the counters were too high. Such challenges have changed little and are familiar to today's children.

Many adults did not get support themselves in their childhood years. Today they tend to romanticise their experiences, proudly remembering times when they were left on their own with a housekey hanging on a thread round their neck, or had to find ways to deal with the often violent and twisted world of adults. Today's cities present more difficulties and challenges; there are more cars on roads[viii], the cities themselves are bigger[ix] and, as a result, people care less about each other.

During the conferences I had the chance to learn about the view from other countries and to exchange opinions. It proved both very inspiring and served as confirmation of my own perceptions and findings. I realised, however, that it was not bringing about any real, sustained change, nor could it actually help children within a reasonable time period. Observing the social discourse in Poland, and with my experience working in the property sector and dealing with local government institutions, I well knew how slow real, meaningful change could be. I realised that, especially in Poland, by the time adults started incorporating a child-friendly perspective into their thinking and activities, many of today's children would have become adults themselves. The beginning of the pandemic and the way children were treated at the time in Poland only served to reinforce these observations.

4.2 WORKSHOPS

A further focus of my activities were workshops in schools for children aged 7-10; workshops which also played a therapeutic role for children. They were a place and time where the children could talk freely about their feelings without being judged. During such sessions, the youngsters were listened to and their feelings were acknowledged, giving them the opportunity to discuss a variety of situations. In one of my workshops a girl told me a story of how, on the way to school, she had fallen over on a big Warsaw street and hurt her knee. She was sitting there, crying with blood on her knee and the only adult who actually spoke to her was an elderly man, who did no more than tell her to stop crying, before leaving her. The first

adults to offer actual help were in school, where she was comforted and had her wound dressed. It is only one example of the stories I had related to me during the workshops with children.

Although the workshops were undoubtedly helpful for the children, their scale presented some limitations. In reality, they were a support, albeit it a valuable and interesting one, to my research, rather than a way to make fundamental changes to the journeys and experience of children as a whole – a group which in Warsaw alone numbers some 75 thousand individuals[x].

4.3 A BOOK

Seeing that talking to adults and workshops with children – at the scale I was able to perform it – would not permit significant change, I realised I needed something that would give many children the right to have their own experience of travelling in urban space - a tool to manage their experience, which could empower the children of today, as well as the children of yesterday, to find their voices concerning the pleasures and limitations of urban space. By reminding adults how they once felt I could foster more empathy and understanding in the carers themselves and create common ground for different generations to talk and understand each other. This is especially true given the common features I noticed of the stories coming from the same age groups, and from different generations. To widen the scale, I needed to share out my role as 'therapist' with other adults – these caregivers can inspire children to share their own experience with trusted people, and they can ensure that the experiences – both good and bad – are shared more widely. I understood that I needed something that could be of help to both children and their carers in the present and future, which is how I decided upon the idea of co-writing a book with children concerning their first steps into urban independence. The project was carried out with the participation and involvement of children at each creative step – children as both models, and teachers and reviewers.

4.3.1 CHILDREN AS MODELS

Firstly, children were my models. The narrator is a 7-year-old-boy, who is getting ready for urban independence. He talks about his urban adventures, what he likes and dislikes about the city, sharing his own experience as well as the stories of his friends and his 10-year-old sister. He is accompanied to school by his mother. While on the street he plays urban games: other people, streetlights, trams, and even little stones on the ground, are all part of those games, helping or preventing him from winning points. The rules in the game are decided by adults and he does not always like to follow them, so together with other children they develop their own rules and ways to enjoy themselves in the city.

Another character is my narrator's 10-year-old sister. She already travels to school on her own and knows almost everything about how to get there. Still though, every time she has the chance to go to school with him and their mother, she chooses that way over independent travel, since she gets bored alone.

The children's mother is their guide through urban life. She deals with urban space in her professional life and researches how well it meets the needs of its users. She wishes that children are happy in the city, so when they encounter problems, she listens, explaining things to them, and together they look for the best solutions.

4.3.2 CHILDREN AS TEACHERS

I would not be able to create such things without accepting the role of children as my teachers. I have put in practice things I have learnt whilst working with them - their authentic

stories, the urban pleasures and fears they shared with me, their understanding of things, the great wisdom they had in finding solutions and expressing their feelings

4.3.3 CHILDREN AS REVIEWERS

And last, but definitely not least, children were my reviewers; they checked the language, looked over the plot, and calibrated my understanding of what their voice was. The first review step was for the book to be read by 8-year-olds. I initially wanted to make sure everything was clear to them, whether they understood all the words and approved of the stories. I carried out this step during the pandemic lockdown, so out of necessity my readers were children I knew, who had often been involved in the creative process from the very beginning. I felt the need to also have the book read by children who had no previous connection to me or the stories. When the schools reopened after lockdown, I organised a workshop and took the draft for the consideration of more children, showing them the initial illustrations and reading them the first chapters. I answered all their 'why' questions, explaining my point of view and listening to their reactions. The book met with a positive response; my reviewers liked that the characters were their age, and they could identify some stories as being similar to their own.

Such a way of doing things also turned out to be an effective icebreaker for the children participating in the workshops. Once they understood they were not the only ones to feel a certain way, it was easier for them to talk about their own experiences without the initial filter I often encounter in schools - the 'what would the lady like to hear from me' filter. Listening to the experiences of the characters that they themselves could relate to, enriched the communicative process. Reading a book about the urban adventures of children their own age, freed the children from the answers they thought I expected, giving way to more authentic answers underpinned by their real feelings.

5. CONCLUSION

Entering the child's world is for me starting an adventure without end; one that takes me further and deeper. My work with children started from researching urban infrastructure and its (un)suitability to the needs of young urban travellers. What followed has tested my pre-conceived ideas and assumptions on the themes I have met along the way. I discovered, or perhaps rediscovered, the role of the need for safety and play, and the need to be listened to. Children are excluded, through a lack of empathy and understanding, from the work of planners and decision makers, and they often do not receive an appropriate level of recognition from their caregivers. In line with the old Polish proverb, which translates as "children and fish have no voice" and is trotted out every time an adult wants to remind a child that they have no right to express their opinion, children are not asked about their needs and expectations, nor are they included in the planning process.

I could summarise the lessons I have learnt over the last 5 years with the 3 Ls. The first L stands for "learn". When you work with children remember to enter the room with no agenda or assumptions, without an attitude of "knowing better" than the children what they experience. The truth, put simply, is that you have little clue. The reason you are in that room is for the second L – "listen". Listen to what children want to share, what are the pleasures and problems they encounter. Listen to validate their experience. Your gain will be learning from them; their gain will be to learn that their voice matters. It will be a lesson of democracy and we will all benefit from it as a society.

The third L stands for "love". It is the word I often hear in children's mouths, their simple solution to many things and, the more I think about it, the more I suspect it is the ultimate answer to the many questions raised by urban space - love turns your empathy on, helps you

notice and include the needs of others and respect their rights. When you listen, you want to learn about the other person and their needs, to make the world easier and more pleasant for them. That is the key to why parents, as I noted at the outset, involve their children in decisions about big purchases. Love brings people together, allowing them to change things for the better, keeping danger and fears at bay.

Meeting the needs of children in a city will make the city a richer environment for all its inhabitants. Child-friendly cities have much to offer, their benefits including; improved health and well-being, a stronger local economy, better safety, stronger communities, enhanced nature and sustainability, more resilience, and being a catalyst for improving cities[xi]. By challenging our assumptions and engaging with children, we can more fully realize their prospects, allowing us to create more accessible and healthier cities for all of us.

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The research covered children at the age of 13-17. The researched problems were violence from close adults (physical and psychological), witnessing violence between parents or siblings, peer group violence (physical and psychological).
- 15.8% respondents experienced one, 6.2% − two, and 5.2% at least three forms of harm.
- 15% of respondents experience violence from their peer group, 10.8% from a close adult. 5.4% witnessed violence towards a parent or child.
- 10.2% respondents experienced sexual abuse, 9.2% without physical contact, 2.6% with physical contact.

[v] Gawrońska, A., Biura szykują się na wielkie powroty, Rzeczpospolita daily, 16.04.2020, https://www.rp.pl/nieruchomosci/art770181-biura-szykuja-sie-na-wielkie-powroty (accessed April 2, 2022)

[vi] This is not much different from the way streets were originally named – after landmarks, typographic features or the places they led to.

[vii] There is an easy way to experience some of what children feel to connect with them more deeply. There is an exercise proposed by the Bernard van Leer Foundation (https://bernardvanleer.org/) where participants go out into the city space with 95 cm long sticks, which mark where their eye level should be to experience the city from that height. Staying at this level for a minute in different places helped me experience what I knew from children's stories: to sense how bad car exhausts smell, how dirty streets are and how scary grown-up people might look.

[viii] According to the Statistics Poland – 795.5 passenger cars per 1,000 inhabitants in 2020 compared to 547.9 in 2010. Passenger cars per 1000 population in Category, K8: Transport and communication, Group, G239: Vehicles, Subgroup, P2420: Road vehicles and tractors – indicators; retrieved from: https://bdl.stat.gov.pl/bdl/metadane/cechy/2420 (5 April 2020)

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buildings

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Article

The Impacts of Symmetry in Architecture and Urbanism: Toward a New Research Agenda

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Abstract: Architecture has an ancient relationship to mathematics, and symmetry—in the broad sense of the term—is a core topic of both. Yet the contemporary application of theories of symmetry to architecture and built environments is a surprisingly immature area of research. At the same time, research is showing a divergence between the benefits of and preferences for natural environments on the one hand, and built environments on the other, demonstrating relatively deleterious effects of many contemporary built environments. Yet the research cannot yet pinpoint the actual geometric factors of architecture and urbanism that could produce such an important divergence. This paper explores this research gap, surveying the literature across a range of fields, and assessing current evidence for the impacts of symmetry in the built environment upon human perception and well-being. As an emerging case study, it considers the recent work by Christopher Alexander and Nikos Salingaros, two trained mathematicians who have made notable contributions to architecture and urbanism. The conclusion proposes a new research agenda toward further development of this immature subject area.

Keywords: symmetry; aesthetics; geometry; biophilia; environmental preference

1. Introduction

The application of mathematics to architecture is very likely as old as architecture itself [1]. From the use of arithmetic to measure lengths, to the calculation of squares and angles, to the complex analysis of structural loading capacities, mathematics has served architecture as an essential toolset to improve quality and performance. The improvements sought have not only been in construction soundness and utility—famously termed by the Roman architect Vitruvius as "firmitas" and "utilitas"—but also in aesthetic character, or what Vitruvius called "venustas" or beauty. Over many centuries, scores of theories have been developed and applied in search of the most beautiful (judged by most people) proportions, scales, patterns and relationships [2]. In this discussion, the topic of symmetry has also been a core interest [1].

In the modern era, when aesthetics has come to be seen as relatively plastic and subjective, the role of mathematics in architecture has shifted to producing more sheer varieties of aesthetic expression, with a notable emphasis on artistic novelty [3]. This dominance has come at the expense of improving the desirable aesthetic quality and performance of a building as seen by most users (whether incorporating novelty or not). Indeed, even the possibility of "improving" aesthetics is often regarded by many architects and planners as merely a matter of subjective taste, or a matter that is merely conditional on one's own individual and highly variable aesthetic goals [4].

However, as this paper will discuss further below, a different perspective is coming from the social and medical sciences, where the impacts of varying environmental characteristics have begun to be measured, including psychological impacts (e.g., calmness, pleasure, excitement, fear, etc.) and even medical impacts (e.g., stress levels, restorative health effects, speed of recovery from surgery, etc.)

It seems the geometric properties of environments do indeed carry predictable and largely shared impacts for those who experience a given environmental structure [5].

At the same time, there is an important gap in the literature that still needs to be addressed. While there is ample evidence for the strong preference of a large majority of people for natural environments over built environments, especially contemporary ones [6,7], and ample evidence for the relationship between this preference and the psychological and physical health benefits of these environments [5,8], there is only weak evidence for the precise geometric characteristics that produce these benefits, or conversely, the relatively negative impacts of built environments. Such an understanding could guide researchers and practitioners to identify the specific factors that produce these beneficial effects within natural environments. In turn they might be better positioned to incorporate more of these factors into built environments, thereby producing greater beneficial effects for their users.

There have indeed been preliminary efforts to connect the specific geometries of natural environments with their beneficial characteristics. Dosen, Ostwald and Dawes [9] investigate the hypothesis "that certain spatial and formal features may not only influence psychological wellbeing but also our aesthetic preference for environments" and go on to seek "a mathematical basis for the analysis of human perceptual responses to space." Hagerhall, Purcell and Taylor [10] examine the fractal geometry of natural environments as a predictor of their preference by subjects, and find "that there is a relationship between preference and the fractal dimension, which in turn gives rise to the hypothesis that the fractal dimension could provide part of the explanation to the well-documented connection between preference and naturalness."

Yet the age-old topic of symmetry in architecture, curiously, has been overlooked as a fertile subject of research in bridging this gap [11]. The purpose of this paper, then, is to explore the literature, to assess the potential for new research, and to outline a new research agenda. The methodology will be to conduct a literature review, drawing conclusions for further research. The paper will begin with a review of the concept of symmetry, proceeding to examine its history in architecture, to examine more recent research findings in biology, medicine, psychology and other fields, and then turn to new frontiers, before proposing tentative conclusions and hypotheses for further research.

2. Definition and Background

Before undertaking this research survey, the first task is to clarify the working definition of "symmetry." While many people focus almost exclusively on so-called reflectional or "mirror" symmetry, wherein one side of an object is a mirror copy of the other, the concept is vastly broader. Most readers will be well aware that the word originates with the Greek *sym* (together) + *metron* (measure), and thus refers to a correspondence between different forms with similar measurements or shapes. In geometry, the "symmetrical" form in question is said to be invariant under a given transformation, which may include reflection, rotation, translation, scale changes, or other changes. When the transformed form is compared to the original form, the correspondence is said to be a symmetry [12].

Symmetry is also an important concept in other forms of mathematics, where similar transformations can occur in non-geometric elements, and symmetries can be described more broadly as structural invariances through transformation [13]. In a fundamental sense, an "equation" is nothing other than an expression of a symmetry between the two formulae being equated.

More recently, the concept of symmetry has also played an important role in information theory [14]. What is called "information" could also be thought of as nothing other than a symmetrical relationship between any two structures in the world that are of interest to us; all that is required is that one structure is capable of transforming into the other while preserving some symmetrical aspect, e.g., in the transformation of a sound wave into its digital representation, whose measurement preserves a symmetrical relationship to the original wave [15]. While one thinks of information as symmetry that is of interest to human beings, it can be applied more broadly to phenomena in nature, such as the "information" contained in DNA [16]. Once again, the symmetrical structure is an invariance through

transformation, and in the case of DNA, the invariance is in the pattern of proteins that is expressed by the transformations of a given sequence of DNA, repeated (with perhaps some natural variation) by symmetrical copies of the DNA sequence in other cells.

Some theorists have proposed that "information"—understood in this way as symmetrically related structure—is the fundamental structure of the Universe [17]. That is, the structures of the Universe transform and differentiate from one another, but preserve some symmetric relationships in combination with various forms of "symmetry-breaking," or differentiation into other structures with new symmetries. In a sense, this is the "really real" structure of things, without which the Universe would be an undifferentiated homogeneous field. Indeed, some propose that it may have been precisely so prior to the initial "symmetry-breaking event" of the Big Bang, and subsequent differentiation processes [18].

This broader perspective helps to set the context for the exploration of symmetry as a phenomenon of both process and product. Here, however, the narrower focus is upon the role of symmetry within the human environment, including buildings, and in their specific geometric properties as well as the transformations that generate them.

3. Classes of Symmetry

As a preface, this section includes, for the unfamiliar reader, a brief review of the classes of symmetry as applied later to the human environment, from the most straightforward to the most complex, and the most concrete to the most abstract [12,19].

Perhaps the most familiar class of symmetry is **reflectional** (Figures 1a and 2a), in which one geometric configuration is reflected across an axis. For example, in many Classical buildings, the axis is the centreline of the building, and the façade as it appears on one side of the axis is exactly reproduced on the other in a matching progression (identical geometries moving to left as moving to right). It is common to say that one side is the "mirror image" of the other. In nature, a reflection in a body of water has a vertical reflectional symmetry with the scene above it, across the axis of the horizon.

(**a**) (**b**) (**c**) (**d**)

Figure 1. Examples of (**a**) reflectional, (**b**) rotational, (**c**) translational and (**d**) scaling symmetries in natural forms (tiger face, sun corona, mother and baby ducks, and fern leaves). Left image: S Taheri via Wikimedia Commons. Other images in public domain.

Another familiar class of symmetry is **rotational** (Figures 1b and 2b), in which a configuration is symmetrical as it rotates about a point. A perfect circle has a rotational symmetry about the centre point of the circle. Many structures in nature have rotational symmetry at least in part: planetary bodies, the iris of the human eye, an inflated balloon (except where its nozzle distorts the shape) and so on. In the case of the inflated balloon, the symmetry of its shape is a product of the symmetry of the pressures radiating outward from within the balloon.

A **translational** symmetry (Figures 1c and 2c) is a correspondence between different shapes that may not be otherwise symmetrical about an axis. For example, a repeated figure has a translational symmetry with itself. In architecture, one part of a repeated motif has a translational symmetry with another part. A child's blue eyes can be said to express a translational symmetry with its parents'

identical blue eyes (and the child may have partial translational symmetries in other respects, e.g., shape of the face, etc.)

(**a**) (**b**) (**c**) (**d**)

Figure 2. Examples of (**a**) reflectional, (**b**) rotational, (**c**) translational and (**d**) scaling symmetries in human architectural forms (Classical façade, stained glass window, archway tile motif, repeating arch shapes at different sizes). Images: Ryan Kaldari (left) and Thomas Ledi (second from left) via Wikimedia Commons. Other images in public domain.

A **scaling** symmetry (Figures 1d and 2d) is similar to a translational symmetry, but instead of symmetry across positions, the symmetry occurs also across sizes. The most familiar example is the so-called fractal pattern, in which the same geometry is visible at multiple scales.

Symmetry breaking, though not strictly speaking a class of symmetry in its own right, is an important process of symmetry formation and transformation, and therefore it is included as an important element in this list. When existing symmetries are perturbed or "broken," they often produce new symmetries at smaller scales, or new compound structures combining smaller symmetries and partial asymmetries (Figure 3). For example, a tubular structure, which is symmetrical about its axis, may break at some point along the axis, producing a new form of mirror symmetry. It is now understood that many classes of biological morphogenesis rely on broken symmetries to generate new compound symmetries, and importantly, complex body geometries as well as functionalities in organisms [20]. Symmetry breaking also plays a large role in recent theories of physics and cosmology [21,22]. It may be that symmetry, together with the process of its breaking and recombining into new complex forms, is a fundamental aspect of the evolving structure of the Universe at many different scales.

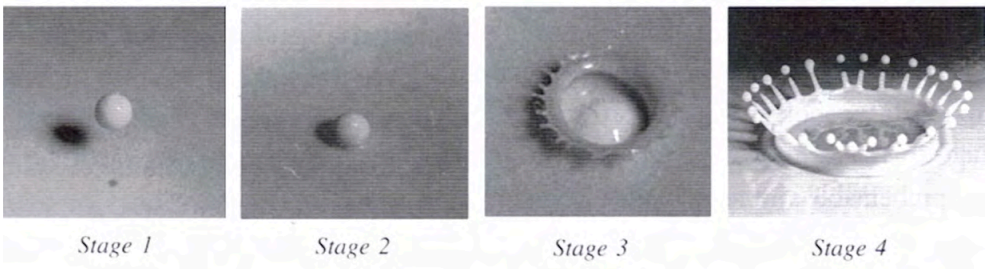
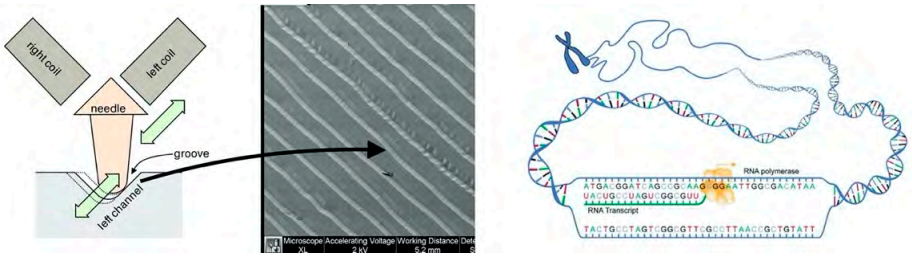


Figure 3. An example of symmetry breaking in a drop of milk as it collides with a thin sheet of milk, shown in a famous series of photos by Harold Edgerton. The new structure is not a disordered mess, but in fact exhibits new forms of symmetry at smaller scales. Such processes are thought to be fundamental to the generation of structure in biological and natural systems. Images: courtesy of the Edgerton Digital Collections.

An **information** symmetry is a symmetry that is not per se between geometric forms, but has some other more abstract correspondence. At its most fundamental level, mathematics is a representation of symmetries, or preserved correspondences, in the transformation of mathematical constructs [23]. The familiar "equal" sign in a formula expresses just such a symmetry. As forms of information, these constructs can therefore be described as a major class of "information symmetry." One can also describe an "information symmetry" between the pattern of a DNA sequence and the complex protein that it

generates, which in turn allows the "information" to be further transmitted, e.g., through inheritance. In the realm of human technology, one could describe an information symmetry between the pattern of grooves in a vinyl audio recording and the changes in air pressure at the microphone or speaker, corresponding to the sounds that are made or heard (Figure 4). Any language or code can be said to contain information symmetries as well, for example, the symmetries between a symbol and its referent, or a map and its territory. In the case of literature, information symmetries can take the form of analogies or metaphors. In the case of the built environment, they can take the form of literal signs or symbols.



(**a**) (**b**)

Figure 4. Two examples of information symmetries, one in human technologies—the encoding of audio information on a vinyl record (**a**), and one in biological systems—the genetic code for the synthesis of proteins and other complex molecules in an organism (**b**). Images: MIK81 (left), TBraunstein (center) via Wikimedia Commons. Image on the right in public domain.

Compound symmetries, which combine other kinds of symmetry into more complex forms, are what is experienced most commonly in natural and human environments. Many classic tile patterns and motifs combine reflectional and translational symmetry, in what is known as a glide reflection (Figure 5): a figure is repeated, then reflected across a glide axis [24]. The three basic plane symmetries, plus their 14 possible combinations, form 17 symmetry groups in two dimensions (called "wallpaper groups"). The familiar kaleidoscope pattern is also a compound symmetry in two dimensions (Figure 6).

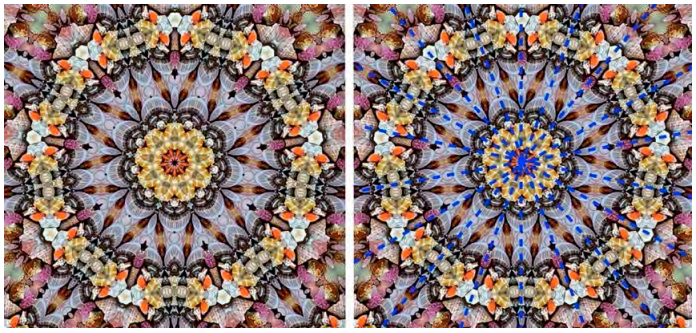
(**a**) (**b**)

Figure 5. A simple glide reflection (**a**), and a more complex "wallpaper group" (**b**). A figure is repeated, then reflected again along a glide axis. This process may be repeated to produce larger groups. Images: Kelvinsong and Martin von Gagern via Wikimedia Commons.

Three-dimensional symmetries are even more complex, and are common in human experience. For example, a sunset on the water may combine a radial symmetry of the Sun, a reflectional symmetry of the sun as reflected in the water, translational symmetries in the ripples of the water, and scaling symmetries in the self-similar patterns of clouds (Figure 7).

Broken symmetries are often seen compounded with other symmetries in the irregularities of our world, which embody the complex processes of their breaking. For example, a street grid which

breaks in response to terrain can help to reveal the pattern of the terrain in a way which is aesthetically pleasing. This is because the resulting pattern is not more disorderly, but perhaps paradoxically, more orderly. It reveals a deeper level of compound, complex order in the human environment. Finally, one can see many information symmetries in the symbols and metaphors of art, particularly in its most abstract aspects.



(**a**) (**b**)

Figure 6. A view through a kaleidoscope, which seems to exhibit rotational symmetry (**a**) In fact, it exhibits a compound form of reflectional symmetries (**b**) created by mirrors within the kaleidoscope tube, which together form multiple reflectional planes (blue lines on the right). When aggregated together, they appear as rotational symmetry, also compounded together with many translational symmetries as well. This example also cleverly makes use of the reflectional sub-symmetries in the shell patterns, also producing scalar symmetries. Such patterns are widely regarded as beautiful. Images: public domain.

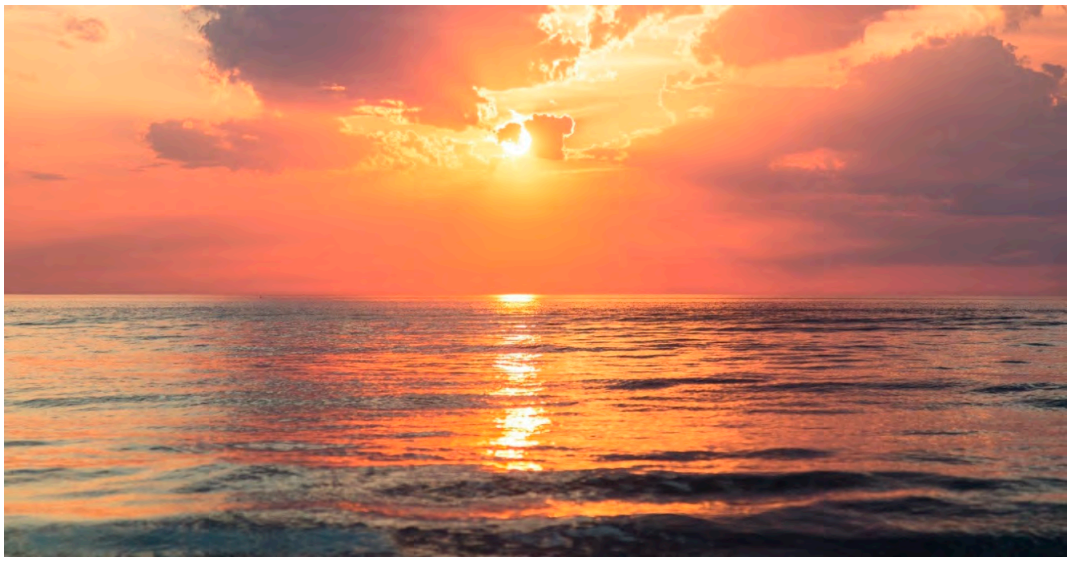


Figure 7. Most environments exhibit compound symmetries, including reflectional, rotational, translational, scaling, and broken symmetries. Humans are adept at perceiving these symmetries and the order that they manifest. Image: Sebastien Gabriel via Unsplash.

Many daily experiences involve exceedingly complex forms of these compound and broken symmetries, which nonetheless help reveal important overall structural characteristics within human environments. This "deep symmetry" helps one to understand, navigate, and interact with one's world, with important implications for health and well-being, as subsequent sections of the paper will further examine.

4. Theories of Symmetry in History

The pursuit of symmetry in human structures stretches back to antiquity, and even deep into prehistory [25]. As Salvadori [1] has documented, there is ample evidence of complex forms of symmetry in ancient Chinese, Indian, and American pre-Columbian architectures. The symmetric proportions and geometries of ancient Egyptian structures, including the Pyramids of Giza, have also been described at length [26], although there is considerable debate over the degree to which the Egyptians were consciously aware of the mathematics involved. Perhaps the earliest explicit and written theory of symmetry in mathematics, as it is known today, came from Pythagoras roughly 2500 years ago, and his familiar "Pythagorean theorem" [27]. The influence of his ideas played a major role in the thinking of later Greeks, including Plato, about the importance of symmetry in the world [28].

Perhaps the most influential Western thinker on symmetry in architecture was the Roman Marcus Vitruvius Pollio, known more commonly as Vitruvius. In his writings of about 2000 years ago, his "symmetry" was a fundamental concept. However, it was less focused upon the more common reflectional or rotational classes of symmetry, and more focused upon translational and scalar symmetries, and to some extent, information symmetries, or correspondences under transformation. He defined symmetry as:

> *" . . . a proper agreement between the members of the work itself, and relation between the different parts and the whole general scheme, in accordance with a certain part selected as standard. Thus, in the human body there is a kind of symmetrical harmony . . . and so it is with perfect buildings."* [29] (Book 2, Chapter 2)

Thus, a "certain part selected as standard" may be transformed through a change in size (scalar symmetry) or repetitive position (translational symmetry), or through the formation of new proportional groups (informational symmetry). Once again, one can see the importance of compound symmetries in the human environment, and moreover, a proposal for their application as a normative standard.

It was not until after the seminal Renaissance architect and writer Alberti (1404–1472) that reflectional symmetry began to dominate theories of architectural design. Alberti's own theory of symmetry was much more nuanced, and in fact the Latin phrase used by Alberti was "ita ut mutuo ad speciem correspondeant," or "so as to correspond to one another as a species," which only later came to be understood as (reflectional) symmetry [30]. For Alberti, symmetry was moreover an inter-relationship of parts and wholes, or a kind of harmony (which he termed "concinnitas"). In this respect, Alberti continued to echo Vitruvius' and Pythagoras' broader concept of symmetry.

Indeed, Alberti's writings on this topic reflect a rather modern view of the complex interplay of part-whole relations:

> *"Beauty is a kind of concord and mutual interplay of the parts of a thing. This concord is realized in a particular number, proportion, and arrangement demanded by harmony, which is the fundamental principle of nature . . . There are three basic things which contain everything that we seek: number, what I have called proportion, and arrangement (numerus, finitio, collocatio). But besides these there is something else which originates from the linking and mutual relationship of these things, and which makes the surface of beauty glisten with a marvelous brilliance; this thing we call harmony (concinnitas)."* [31] (Book 9, Section 5, pp. 337–340)

5. Modern Developments

As noted previously, symmetry (in its varied forms) plays a major role in the contemporary history of mathematics and physics. In a number of notable cases, these lessons were applied to aesthetics. For example, the mathematician George Birkhoff [32] developed a proposed mathematical measure for the aesthetics of an art object, expressed as M = f (O/C), where O stands for order and C for complexity. For Birkhoff, order "O" was intimately related to symmetry, as when an object "is characterised by a

certain harmony, symmetry, or order (O), more or less concealed, which seems necessary to aesthetic effect" [32] (pp. 3–4).

Several years later, Eysenck [33] proposed a major modification to Birkhoff's theory, arguing that O/C (order divided by complexity) should be replace by O × C (order times complexity). In other words, the complexity of a structure magnifies its perceived order. This revised formula seems to better capture the increased attractiveness of compound symmetries.

More recently, Mandelbrot [34] described scalar symmetries in self-similar objects in Euclidean space, which he termed "fractals". These recursive patterns can be quite beautiful (Figure 8). These self-similar objects at a variety of scales have been described as expanding symmetry or unfolding symmetry. It is now understood that many structures in nature have this "fractal" form of scalar symmetry, including clouds, landscapes, plants, and other structures. In fact, fractal mathematics has been used in a powerful form of image compression and regeneration, even producing quite convincing synthetic images [35].

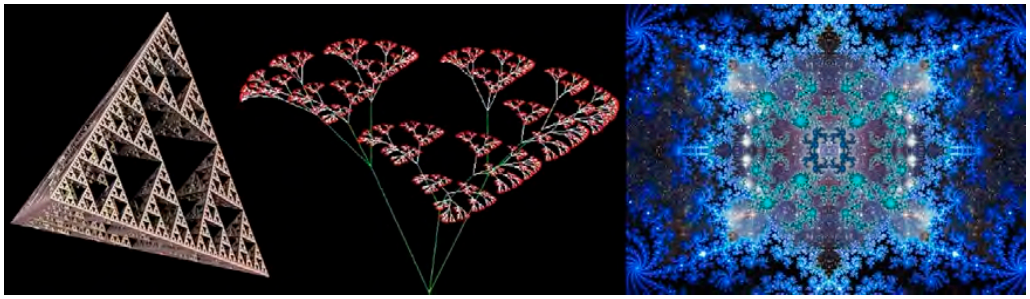


Figure 8. Fractal patterns generated by remarkably simple recursive mathematical formulas. Images: public domain.

6. The Role of Symmetry in Biology

One of the most common occurrences of symmetry in nature is in biological structures, and in particular, the forms of plants and animals. Everyone is familiar with the reflectional, rotational, translational, and scaling symmetries in beautiful flower patterns, for example. There is some evidence that the symmetrical patterns of flowers serve as innate attraction signals for pollinator insects [36] and that the specific configuration of flower symmetries guides specific insect pollinator behaviour such as landing [37].

The symmetries of flowers and other organisms are not only devices to attract insects, of course, but have their roots in the morphogenetic processes of growth, including folding, rotating, replicating, and so on [38,39]. Once again, one can see the essential relationship between process and product, allowing the transmission of information about the potential benefits of biological structures.

More broadly, symmetry has been advanced as a form of biological signalling, conveying the signaller's health and genetic quality [40]. There is also evidence that the ability to perceive characteristics of symmetry regardless of orientation enhances object recognition and is strongly related to aesthetic preference [41]. It may be that the ability to perceive symmetry aids in the ability to "read" the structures of the environment and their likely impacts on the health and well-being of the organism.

Here too, "broken symmetry" plays an important role in biological morphogenesis, as noted previously [20]. However, a broken symmetry in the environment is not a mysterious form of disorder if its breaking can be perceived—for example, if a mainly symmetrical animal is lounging on an irregular surface, causing its apparently symmetrical parts to present asymmetrically. The work of Enquist and Arak [41] suggests that the ability to perceive both unbroken and broken symmetries is key to object recognition.

7. The Role of Symmetry in Human Biology

A related hypothesis has been advanced about the human body, and in particular the perceived attractiveness of the human face (Figure 9). Males and females find each other more attractive in the presence of higher degrees of facial symmetry [42]. They also find more symmetrical features more desirable when considering the suitability of a life partner [43].

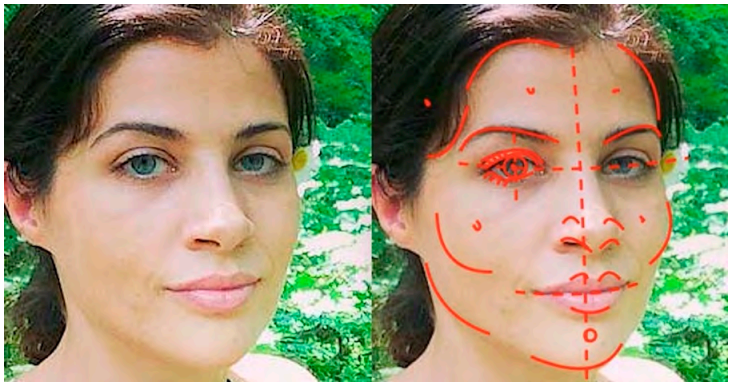


Figure 9. The human face incorporates many classes of symmetry in compound and interrelated forms, as can be seen in the markings at right. Reflectional symmetry occurs across the dotted lines, rotational symmetry occurs in the circles or arcs around the points, translational symmetry occurs in the repeated curve patterns, and scalar symmetry occurs in the repetition of patterns at smaller scales, e.g., hairline-eyebrow-eyelash, etc. Finally, information symmetry occurs between the subject and the viewer's instinctive ability to read biological signals of health (e.g., in clear skin, etc.) Images: the author.

The evidence presented by Enquist and Arak [41] that the ability to perceive symmetry aids in structural legibility also applies to humans, they note. This heightened structural legibility appears to apply not only to biological structures but to other forms of environmental structure, which need to be made legible in order to assess their capacity to support human well-being. They suggest that the pleasurable experience of this legibility may well be an important component in what is experienced as "beauty." Indeed, functional MRI studies have found evidence to support this view [44].

Thus, a growing body of recent evidence is clarifying the role of symmetry (in its many forms, both broken and unbroken) as an essential biological attribute for sensing and seeking the conditions of health and well-being. Importantly, one can see that the ability to perceive symmetries conveys otherwise hidden information to an organism about both the morphology and morphogenesis (that is, product and process) of the structures it encounters, both biological and non-biological. When it comes to an organism's interest in the impact of a structure on its well-being—whether it be finding food, choosing a mate or settling in a salubrious environment—this information is invaluable.

8. Evidence for the Health Impacts of Symmetry and Its Absence

Evidence has been growing in the literature that the presence of natural forms and geometries, including their fractal and symmetrical properties, have remarkably positive effects on human health and well-being. Ulrich [45] showed a positive relationship between recovery from surgery, including reduced morbidity and length of hospitalization, and the ability to view a natural environment. Other investigators have since shown similar properties, which have come to be referred to as "biophilia" [46]. Further work has shown that not only natural environments, but buildings and other built environments, can confer important benefits to users through biophilic geometries and related characteristics [47].

The specific geometric characteristics of beneficial natural environments, particularly their characteristics of symmetry, have also been recognised. As noted previously, Hagerhall, Purcell and

Taylor [10] investigated the fractal dimension of landscapes—a form of scalar symmetry—as a factor in human preferences, and found a correlation. The previous discussion has also illustrated that natural environments typically contain abundant forms of symmetry, strongly suggesting that symmetry is a factor in both environmental preference and in the benefits of natural environments. As this paper has already noted, more research is needed on this topic. However, already there is tantalizing research evidence emerging from a number of fields.

At the same time, evidence has been accumulating that a deficit in the experience of natural environments and their forms can be harmful, especially to children. The journalist Richard Louv [48], citing this evidence, coined the term "nature deficit disorder" to describe the adverse impact upon children who are deprived of regular contact with natural environments. Grinde and Patil [49] also found negative impacts on health and quality of life from environments devoid of nature, while Kellert [50] surveyed the literature and found evidence that "children's emotional, intellectual, and values-related development, especially during middle childhood and early adolescence, is greatly enhanced by varied, recurrent, and ongoing contact with relatively familiar natural settings and processes" [50] (p. 146).

Here it must be noted, however, that not all built environments must be assumed to be uniformly deleterious. Stamps [6] noted that, just as natural environments are preferred over built ones, old buildings are typically preferred over new ones. These structures, and the urban environments they comprise, often possess explicit characteristics of natural environments, including literal plant forms, but also geometric characteristics like reflectional, translational, and scaling symmetry (Figure 10).

Figure 10. Two urban environments in London, UK. The environment on the left includes literal natural forms as well as their properties, notably reflectional, scaling, translational and scaling symmetries. The environment on the right has few such characteristics. Images: the author.

Zeki [51] surveyed neurological research (including his own) and concluded that "mathematical principles of symmetry, harmony and proportion . . . are part of the cognitive apparatus of all brains" and that these principles "have to be respected" in order for a structure such as a human face to be perceived as beautiful [51] (p. 19).

Moreover, the experience of beauty is a neurological requirement of healthy brains: "In our daily activity, we search for and seek to satisfy that quality; in simpler terms, we seek the beautiful to nourish the emotional brain since, from a neurobiological point of view, all areas of the brain must be continually nourished in a way that corresponds to their specific functions . . . Hence, whatever other demands go into architectural design, beauty must be a central element. Its experience adds to the health of its individuals and thus to society's wellbeing. It is not a luxury, but an essential ingredient in nourishing the emotional brain" [51] (p. 19).

There is also an important distinction to be made between "artifactual" and "biological" perceptions of beauty, according to Zeki et al. [52]. While the former are highly variable between people based upon their different life experiences (for example, professionals with specialised training), the latter are more dependent upon inherited responses to invariant mathematical relationships that are widely

shared among populations. Even though these relationships are a form of information which may be manipulated as constructs within art, their roots are in innate and shared ways of experiencing the world. In that sense, the innate and the constructed are not opposites, but exist within an overlapping continuum of the artifactual and the biological—the world of art, and the world of life.

9. Applications of Symmetry to Built Environments: Art in Service to Life

Echoing the distinction made by Zeki and his colleagues, the urbanist Jane Jacobs [53] famously pointed out that although art and life are interwoven and overlapping, they are not the same thing. Confusion between these two realms of experience causes immense problems for city planning and design, she argued, resulting in neither art nor life, but what she called "taxidermy"—a result that is lifeless: "All this is a life-killing (and art-killing) misuse of art. The results impoverish life instead of enriching it . . . Instead of attempting to substitute art for life, city designers should return to a strategy ennobling both to art and to life: a strategy of illuminating and clarifying life and helping to explain to us its meanings and order—in this case, helping to illuminate, clarify and explain the order of cities" [48] (pp. 373–375).

Thus, the "artefactual" has its place, but it is to serve the meaning and order of life, and of the "biological." Using the language of symmetry outlined herein, the construction of artificial information symmetries can indeed enrich life and well-being—but only if they are serving to engage and enrich the natural symmetries of the physical and biological world.

The mathematician and design theorist Nikos Salingaros [54] has assessed evidence that human perception relies upon combined symmetries to reduce information overload and to group architectural elements into larger wholes. These perceptions of symmetry have their roots in what is biologically useful, Salingaros has noted, and what is inherent in the structure of matter and life itself. Drawing on the work of Christopher Alexander [55], Salingaros concluded that symmetry conveys a "structural meaning, rooted in our biological selves and in the natural world" [54] (p. 233).

For Salingaros, these symmetries can be generated in methodical ways. Citing Alexander, Salingaros proposed "tools to organize complexity, including,

- *"Create many linked symmetries of different types as a response to activities on distinct scales (but don't impose a global overall symmetry) . . .*
- *"Implement approximate spatial correlations using similarities at a distance and scaling symmetries (i.e., similarity under magnification)..." [56] (p. 52)*

The critical factor, according to Salingaros, is adaptation. Even asymmetry is pleasant when users are able to perceive its adaptive origins: "When asymmetry arises from adaptation . . . the configuration may be surprising but it is 'comfortable' to our perceptual system" [24].

The aforementioned Christopher Alexander, an architect with previous training in physics and mathematics, also proposed an extensive theory of geometric properties of "order," in Birkhoff's sense, in his four-volume work *The Nature of Order* [55]. In the first volume, Alexander reported his observation of "fifteen properties" (Figure 11) which he found repeatedly in his own surveys of many structures in human history. Alexander proposed that all structures with characteristics of life have these properties in them—not only literal organisms, but what he referred to as "living structure" with the characteristics of "wholeness" [55] (p. 80).

In this work, Alexander drew on insights of modern philosophers like Alfred North Whitehead [57,58] who argued for the primordial nature of life as an inherent structural potential of nature. Yet there was also a strong echo of the ideas of Pythagoras, Vitruvius and Alberti about the importance of interrelatedness, correspondence, harmony, and indeed, symmetry in the broader sense.

Alexander's fifteen properties are geometric configurations of space, as seen in Figure 11:

1. Levels of Scale (similar figures at a range of scales)
2. Strong Centers (prominent geometrical zones in between others)

3. Boundaries (geometrical zones that bound others, e.g., centers)
4. Alternating Repetition (patterns that repeat with some alternating variation)
5. Positive Space (a geometric region that does not have excessively acute sub-regions)
6. Good Shape (a geometric region that is coherent and interrelated)
7. Local Symmetries (groups of regions that are internally symmetrical but may not be externally symmetrical)
8. Deep Interlock and Ambiguity (patterns that inter-relate in complex ways)
9. Contrast (adjacent figures that are starkly different from one another)
10. Gradients (figures whose characteristics gradually transition)
11. Roughness (figures with many small-scale asymmetrical characteristics)
12. Echoes (figures that repeat some aspect from other figures)
13. The Void (areas where few or no figures are present)
14. Simplicity and Inner Calm (overall figures that are highly unified and harmonious)
15. Not-separateness (connectedness of all figures to one another and to the viewer)

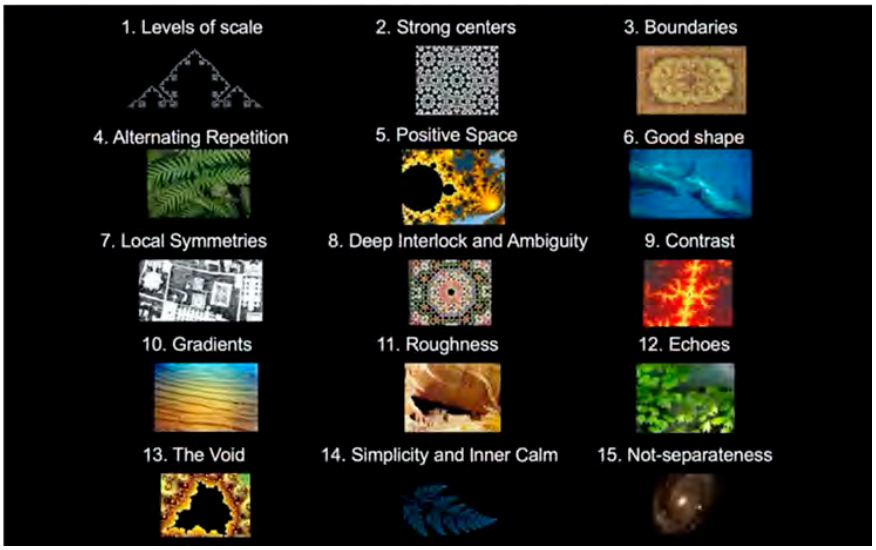


Figure 11. Alexander's "fifteen properties" of geometric order in human and natural environments. Illustration: the author.

Following the earlier discussion of classes of symmetry, one can also describe each of Alexander's fifteen properties as some class or combination of symmetry, as follows:

1. Levels of Scale (scaling symmetries)
2. Strong Centers (rotational, reflectional symmetries)
3. Boundaries (rotational, reflectional symmetries)
4. Alternating Repetition (compound symmetries)
5. Positive Space (net convex symmetrical spaces)
6. Good Shape (coherent symmetrical shapes)
7. Local Symmetries (reflectional symmetries within symmetry breaking)
8. Deep Interlock and Ambiguity (translational symmetries)
9. Contrast (reflectional symmetries)
10. Gradients (translational symmetries)
11. Roughness (translational symmetries)

12. Echoes (deep translational symmetries)
13. The Void (symmetry void)
14. Simplicity and Inner Calm (symmetry simplicity ratio)
15. Not-separateness (ultimate symmetry, with symmetry breaking, of all things)

These fifteen properties (symmetries) also have their counterparts in the physical processes by which they are generated, through what Alexander called "wholeness-extending transformations." The symmetries of experience arise as the result of coherent processes of formation. Human beings, with their highly evolved capacities of perception, can detect these symmetries, and sense the biologically relevant characteristics of the processes that formed them (healthy, beneficial, dangerous, etc). Once again it is clear that the perception of symmetry is biologically useful.

Alexander's work also reinforces the conclusion that the world is shot through with symmetry and its transformations, in many different forms and deep combinations. One can tease out these symmetric properties, understand and work with them, and in the act of design, create more of them. In a basic sense, this is what the act of design must do: create and shape symmetries, in effect weaving them together in a way that is most beneficial for human beings.

Alexander argued that these symmetric properties are abundant in high-quality human environments. Conversely, he argued, in those environments where the properties are not abundant, there is a negative impact upon human well-being. Here, there is a normative implication for practice: the designer has a professional duty to create more of the symmetric structures characteristic of the left-hand image in Figure 10, and fewer places like that of the right-hand image.

Elsewhere in *The Nature of Order,* Alexander also drew upon the work of Salingaros [59], building upon the earlier work of Birkhoff [32] and Eysenck [33] to propose a mathematical theory of beauty. However, rather than using the term "beauty," Alexander and Salingaros referred to "life," or "living structure," described extensively throughout Alexander's 2002 book:

> *" . . . life, as I have defined it, is mathematical. By this I mean that it arises because of the mathematics of space itself. Since living structures arise primarily as symmetries and structures of symmetries, their presence and their density can, in principle, be calculated for any given configuration."* [55] (p. 469)

For Alexander, living structure produced an experience of beauty, but was not itself an experience. Rather, it was a physical structure in the world, with mathematical properties that could even be expressed (or at least approximated) in a formula.

Salingaros proposed the formula L = T × H, where L is "life" in the Alexandrian definition, T is "temperature," which "estimates the density of occurrence" of Alexander's properties (which as can be seen are classes of symmetry), and H is what Salingaros called "harmony," described by Alexander as "the number of local symmetries present in a configuration" [55] (p. 469). Salingaros then applied the formula to a number of famous buildings, generating results that Alexander found to be rough but promising approximations of what could be observed. He concluded that "Salingaros' work opens the door to a rich field of study" [55] (p. 472).

10. A Basic Distinction

From this discussion it can readily be seen, then, that symmetry permeates the structures of the world, and also the structures of experience and thought—indeed, of brains and their patterns of activity [44,52]. But these different realms of symmetry should not be confused. Drawing on Zeki, Jacobs, Salingaros and Alexander, one can now make a fundamental distinction between three overlapping but separate phenomena:

1. The immense structures of the physical world, with their vastly complex geometric properties;
2. One's innate experiences of these structures, which are conditioned by humans' evolution as complex neurological organisms; and

3. One's own synthetic mental constructs, which sometimes interact with these physical symmetries and one's experiences of them, and sometimes go into other directions, creating linguistic or artistic symbols, metaphors, allegories, artworks, and other constructions.

The first two categories are widely shared between individuals and across cultures, whereas, as research has shown [52], the third category can vary widely between individuals, depending upon their language, culture, life experience, and other factors.

One should note that the synthetic mental constructs of the third category also often have their own physical counterparts, but these are often incidental to the expression of the mental constructs. For example, a work of literature may also exist as a physical pattern of printed marks on pages bound in a printed volume. However, the work of "literature" as such is in the realm of concepts, not the realm of the printed marks on the pages. (At the same time, the printed volume may itself be widely experienced as beautiful, perhaps containing many compound forms of symmetry.)

This distinction between the conceptual and the physical is fundamentally important. It must be recognised that while there is a relationship between the two (and between the abstract and the concrete, or the urban and the artistic) they are distinct, and it is dangerous to confuse the two.

To be able to clearly identify these two realms, one may refer herein to symmetries in the physical world using the Latin term *"structura naturalis"*—that is, the immense range of concrete, physical, and natural structures that surrounds us in daily life.

However, when one thinks about these structures, or form abstractions, or uses language to describe them, one is generating a *"structura mentis"*—a mental structure—with powerful capacities to extend and compare these and other structures of the world. Indeed, these great capacities are a defining trait of the human species, extending its further capacities of language, art, and culture.

As Jacobs pointed out, each of these is a vital component of human experience. Indeed, many important aspects of literature and other arts occur in the domain of *structura mentis,* including symbolism, metaphor, and allegory. These structures also go on to produce *structura naturalis*, in the form of the structures of the world. But planners and designers in particular must be clear about the relation of the two, and the coherence—or less happily, the discord—between them.

11. Tentative Conclusions and Hypotheses for a New Research Agenda

It is clear from the literature that symmetry is a central component of human perception and understanding, and one with its roots in the biological need to apprehend the structure and meaning of the world. From these insights, one may now formulate a series of tentative conclusions or hypotheses, already tentatively supported by evidence, that can be further tested and evaluated through a new research agenda.

The hypotheses are:

Hypothesis 1. *Symmetry, particularly compound symmetry, is an essential attribute of human environments that helps one to comprehend, navigate within, and interact successfully with one's world, including fostering aesthetic enjoyment and well-being*.

Evidence is mounting that people find structures with high levels of symmetry, especially compound symmetry, preferable to those with low levels of symmetry. Nor is this merely a matter of preference, as evidence shows it is tied to mental and physical health. It may also be tied to other forms of social and economic interaction (for example, the willingness of people to walk and encounter one another within public spaces) which in turn are related to health and well-being.

Hypothesis 2. *The origin of this aesthetic enjoyment and well-being—of the craving for deep symmetry—lies in these biological roots*.

Humans are order-seeking or "ordophilic" creatures, whose well-being depends on their ability to detect the complex forms of order represented by nourishing food, suitable mates, salubrious environments, and other beneficial structures that they encounter or create. Symmetry, in its many forms, is an expression and a manifestation of this order. In particular, humans crave highly complex forms of compound symmetries with deep coherent inter-linkages, or what one may call "deep symmetry."

Hypothesis 3. *There is an important distinction between symmetries within structures in the physical world, and symmetries between the mental structures of human beings, sometimes expressed symbolically or metaphorically through structures in the physical world.*

These different forms of symmetry are themselves related through structural symmetries—that is, language and art bear a symmetrical relation—but not an identical one—to the physical world. This view of the relation of language to reality suggests a kind of "symmetric structuralism" [60].

Hypothesis 4. *To confuse these realms, and to allow mental symmetries to supplant physical ones, can be damaging to human well-being.*

The evidence for this proposition is growing, as the research discussed here has described. One likely reason that many people judge contemporary structures to be disordered and unattractive (and therefore degrading to their enjoyment and, as research shows, even harmful to their well-being) is that architects are over-focused upon their own, often private, mental symmetries, and have diminished the importance of the more shareable physical symmetries. There is abundant research to describe this divergence in aesthetic judgment between architects and non-architects (Gifford et al., 2000), with implications for the failure of architects to understand and respond adequately to user needs. Some of the most compelling research substantiating the biological basis of this need comes from neuroscience [52,61].

Hypothesis 5. *The cause of the prominence of this confusion in the modern era can be understood as a fateful consequence of multiple historical forces.*

Zeki [51] described "other considerations to which beauty becomes hostage, such as social or financial constraints, or the projection of power in the design." To those one could add functional requirements of transportation including automobiles, the short-term dictates of capital, technological imperatives and constraints, and other consequences of the exploitation of "economies of scale and standardization" at the expense of "economies of place and differentiation" [3].

At the same time, architects and planners are hardly free of responsibility. It has been alleged that architects in particular became complicit in a kind of marketing or commodification regime [62]. The allure of their fine art—their *structura mentis*—together with the pedigree of the fine universities at which they endlessly discussed these abstractions with connoisseurs and critics, served as a kind of "product packaging" over what were, it now seems, toxic industrial products. This was a fateful combination of architects' cognitive biases with the dictates of a relatively primitive technological era.

Hypothesis 6. *There is an important implication for professional practice and policy: today's built environments may be damaging human health and well-being through a "symmetry-deficit disorder".*

Following Richard Louv's "nature-deficit disorder," one can now postulate (sufficient for further research) a related disorder that evidence suggests is produced by a deficiency of symmetry in the human environment—one manifestation of which is a lack of contact with nature and its complex symmetries. This deep symmetry, and the experience of beauty that it produces, is nothing less than "an essential ingredient in nourishing the emotional brain" [51]. Yet too often it is displaced by what

one may call "shallow symmetry"—few or disordered forms of symmetry—often left as a residual by-product from displaced attention to the deep symmetry of *structura mentis*.

12. Discussion

Clearly there is, and should be, no constraint on *structura mentis* as a matter of free expression (except perhaps as has been decided by courts on various grounds of public safety, i.e., the proverbial shouting *fire* in a crowded theater, and so on). Clearly, too, *structura mentis* is a potentially infinite domain of creative expression and culture, and should be celebrated as such. *Structura naturalis* is, however, a much more concrete structure, with more specific and predictable human effects and consequences. It follows that, whatever other forms of *structura mentis* they may employ, architects and planners have a primary duty to support the emotional and physical well-being of users with a sufficient level of deep symmetry in the human environment (*structura naturalis*). What that level is and how it can be ascertained is another, larger subject for further research; but as of now, the basic conclusion stands.

Some architects will protest here that their role as artists supersedes their professional responsibility to ensure the enjoyment and well-being of users. After all, is it not the case that some of the greatest art shocks and disturbs? In a gallery or private residence, such an argument has merit. However, in the public realm, where users are forced to experience the work of architects, there is a matter of professional responsibility to promote public health and well-being.

Few architects would question their basic professional duty to serve the needs of their clients and users. After all, the profession does maintain clear professional responsibilities, with penalties (even criminal ones) for malpractice. This is clearly understood in the case of Vitruvius' *firmitas* and *utilitas* (firmness and commodity). What remains insufficiently examined (particularly in light of evidence discussed herein) is the question of *venustas*: that is, do the impacts on health and well-being of a *structura naturalis* imply the need for a normative theory as well? As the evidence indicates, it appears they do.

This is true not only of clients and users of a building, but of the general public who are impacted by a building's exterior and its contribution to shaping the public realm. In particular, architects have a duty not to impose their constructs of *structura mentis* where they have the capacity to be harmful, in place of beneficial forms of *structura naturalis*. As discussed previously, while the two are naturally related and supportive aspects of a continuum, they are not the same, and the tendency to impose the latter onto the former—especially by specialists whose mental symmetries have become divorced from the symmetries experienced by most people—may well be the cause of negative impacts on the human experience and well-being of a majority of the population.

There are many aspects of this issue that are beyond the scope of this paper, but several warrant a mention. One is the implication of "construal level theory" [63], which describes the potentially negative impacts of psychological distance from the actual experiences of those to whom professionals are responsible. In place of effective responses, professionals often insert their own "construals"—which in this case become forms of *structura mentis*. A related phenomenon is the occurrence of "geometrical fundamentalism" by architects, described by Mehaffy and Salingaros [64]. The strong and simple mental symmetries they admire come from relatively primitive geometric characteristics, which result in denuded, low-symmetry structures in place of the symmetry-rich environments that promote enjoyment and well-being for the vast majority of the public.

In architects' partial defence, this is often not a wilful act. Mehaffy and Salingaros [65] describe the divergence between architects' and laypersons' judgments as "architectural myopia"—that is, architects literally cannot see what non-architects see in the physical world, because their mental associations, symbols, metaphors, fondness for geometrical fundamentalism—their *structura mentis*—dominates their view. What is needed, then, is something like a set of "corrective lenses"—new forms of normative guidance, provided and supported by a maturing body of research.

13. Conclusions

A key gap has been identified in the research, namely in understanding the geometric factors that influence environmental preference and well-being in architectural and urban environments. This survey research has assessed the evidence, and explored a hypothesis that the characteristics of symmetry do have significant impacts on users. This hypothesis, if further validated, will help to account for the divergence in preference for natural versus contemporary built environments, and secondly, the divergence in judgment between professionals and users as to desirable environmental characteristics. That in turn will carry normative weight regarding important but unmet obligations of professionals toward users' well-being.

None of this discussion is meant to suggest that the theoretical and normative framework of deep symmetry outlined here is the only important factor in the human experience of built environments. On the contrary, there are surely many other important factors that support well-being and delight, among them novelty, contrast, drama, and the many deep mental symmetries within artistic structures and others—some of which can be experienced by broad sections of the public too—that is referred to above as *structura mentis*. Rather, the argument made here is merely that physical symmetry in the environment—*structura naturalis*—has been overlooked and diminished, with fateful consequences for human well-being.

To assist in rectifying the problem, a new agenda is needed for research. It must have the normative aim of guiding a reformed professional practice—exactly as Alberti, Vitruvius, Pythagoras, and innumerable other scholars have sought to do over for many centuries, with manifest benefits to public welfare and city life. Such an agenda might include the following key elements:

1. A clarified understanding of the ways that people are impacted by buildings and urban environments containing varying forms of symmetry under varying circumstances, and the lessons to draw about likely shared reactions and evaluations.
2. A clarified understanding of the measurable impacts of symmetry on different aspects of human health and well-being, and the conditions under which these impacts occur.
3. A clarified understanding of the role that symmetry might play in achieving other urban goals, including walkability, active public space, social capital, urban resilience, low-carbon living, and mitigation of loneliness.
4. A better articulated understanding of the different forms and combinations of symmetry, including "deep symmetry" (as initially outlined herein), and how they combine and interact to produce human impacts.
5. New methods for defining and measuring these forms of symmetry, building on the work of Alexander, Salingaros, and others, and providing useful diagnostic and design guidance tools.
6. Articulation of the philosophical framework of "symmetric structuralism" described herein, in order to provide a comprehensible and useful model of the relationships between these issues.
7. Finally, and perhaps most controversially—but supported by evidence—new normative and practical guidance for inclusion of these geometric characteristics in building design so as to enhance positive user impacts and attenuate negative ones, as part of responsible professional practice.

In the end, such a research agenda must have a practical aim, to aid practitioners (and secondarily, policymakers and educators) to produce environments that users find more satisfying, more beautiful, and more salubrious. The aid must include specific guidance on the weaving together of more coherent patterns and spaces—including especially public spaces—that are better able to support human flourishing.

To accomplish this exceedingly ambitious goal, such a research agenda must reflect and build upon the very forefront of findings in environmental psychology, neuroscience, healthcare, biology, mathematics, and other related fields. As the research surveyed herein suggests, it must be more

firmly rooted also in the evolutionary history of humanity, its biology, and the nature of the physical universe itself.

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Bicycle nodes as urban acupuncture: Surgical planning from private to public towards promoting cycling across Ain Sohkna, Red Sea

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Abstract
Fourteen new cities are growing in Egypt rapidly along Cairo's desert edge, the Mediterranean coast, the Nile Delta, the Red Sea, and Upper Egypt. In Cairo, the New Administrative Capital alone is built to accommodate 6.5 million inhabitants. Most of these projects are private sector and mixed-use developments. At such instances of mega-planning and urban growth, little attention is given to the small details of connectivity, micro-mobility, and the question of advancing public space. This paper adheres to the forces on the ground. It argues for the need to adopt change at the edge of things, from within the private sector to the outside. The argument envisions a surgical planning that tactically catalyzes private projects — their edges, boundaries, and walls. The profusion of activities from the private sector to the public space may eventuality re-produce nuances and points of contact, thus increasing porosity and proliferation. This paper reflects on a consultancy project through the American University in Cairo during 2021, where the author served as the principle urban designer for retrofitting the masterplan adjacent to the New Galala City to become bike-friendly. The objective was to envision a strategy of bridging the walls through cycling and bike nodes. The paper demonstrates the design intervention and action areas with the positioning of bicycle nodes on natural contours, where the activity of cycling would act as "urban acupunctures" (Lerner 2016 [2003]). The broader impact is to expand sustainable transportation and multi-modal mobility integrating the inside-out along the Red Sea network. Such pilot project and strategy of intervention is itself an act of operating at the edge of publicness; when there is little left, yet, we have to act, improvise, experiment, and explore.

Keywords: urban acupuncture, tactical urbanism, micro-mobility, bikes infrastructure, Egypt

Introduction

Tourist resorts play a significant role in developing the Red Sea coast; however, they are growing as an urban sprawl at Ain Sokhna area (Mahgoub, 2022; Gohar and Kondolf, 2020). Currently, the state is interested in transforming the region and build a new satellite city, *Galala City,* on a mountain top that is 650 meters above sea level and transform Sokhna port into mega port hub in the region (www.english.ahram.org.eg; www.sczone.eg; egypttoday.com). Massive urbanization at remote areas is one of the characteristics of the twenty-first century. According to the UN-Habitat, by 2050 nearly 70% of the global population is projected to live in urban areas (UN-Habitat World Cities Report, 2020). Massive urbanization often leads to fragmented settlements and self-enclosed privatized developments specially in the Global South (Lobao et al., 2020; Brenner and Theodore, 2010; Pinson and Journel, 2016; Parnell and Robinson, 2013). There is a delayed response in integrating a collective strategic plan and overall vision for sustainable urban mobility at non-city hinterlands. The way Ain Sokhna's urbanization emerges pose serious questions related to car-dependency through: 1) reliance on planning models of fragmentation and urban sprawl in new developments, and 2) lack of a sustainable mobility infrastructure to retrofit the past resorts growing over 30 years and connect the ongoing mixed-use developments. The sole dependency on cars in these urban agglomerates will adversely affect urban health and individual health. Promoting active transport through cycling and walkability coupled with non-motorized vehicles would decrease 20% of such mortality rates (Mueller et al., 2017). Multiple

researches have highlighted the urgent role of sustainable mobility in enhancing the quality of life, physical health, well-being and mental health in cities (Hare et al., 2012; Scheerper et al., 2014; Labee et al., 2022; Dacko and Spalteholtz, 2014).

This paper analyzes the underlying possibilities of a micro-mobility design experiment inside one of the resorts built on the mountain at Ain Sokhna region that took place from March 2021 to April 2022. The Ain Sokhna region with the New Galala City is expecting to inhabit a population of 1.5 million (ref). The micro-intervention inside the resort aimed at rethinking the possible linkages along the Ain Sokhna region to link the fragmented region through points of junctures at the edge of the private-resorts. The intervention is based on a request by a real-estate developer facing engineering difficulties in urbanizing the mountain along the Red Sea coast, hence requesting micro-design solutions. This opportunity generated a wider discussion to rethink how to utilize such challenge of mountain urbanization to collectivize energies towards creating a common shared infrastructure facility for bike-stations along the Red Sea shoreline. The discussions swayed the proposal into urban acupuncture solutions that address social sciences and behavioral aspects beyond just traffic engineering and feasibility studies. The design discussions led to a proposal of opening up the resorts and create a quasi-public space for a shared micro-mobility facility, that would serve the region and act as a micro-infrastructure. The marketing team of the real estate developer denoted that such approach aligns with a diverse pool of users such as youth, mixed gender and mixed-class towards savvy and nuanced ways of inhabitation. Similar research asserted this aspect where active transport and e-scooters attract youth (Abduljabbar et al., 2021; Scheepers et al., 2014). The paper argues for urban acupunctures that develop solutions from inside the neoliberal setting and privatized-enclaves. It follows what Donna Haraway articulates as “staying with the trouble” (2016), and what Lindblom denotes as “muddling through” the super-structures of planning (1959). These “disjointed incremental” solutions may help the overarching goal of sustainable urban mobility through the utilization of active-transport and promotion of connectivity, physical activity and healthy living.

The 70-kilometer stretch of Ain Sokhna comprises more than 100 resorts stacked beside each other (Figure 1). Gated and disconnected, they create a fragmented mode of urban sprawl. A highway of 12 meters wide along the coast divides the resorts from the mountain. Developers used to build resorts along the waterfront giving their back to the mountain. That pattern changed in 2007 with the relative success of a tourist complex named “Porto Sokhna.” Borrowing its architectural style from Las Vegas, Venice and Dubai’s iconic Jumeira building, it gained popularity with its massive architecture constructed on top of the mountain tempting investors to rethink the mountain as a surplus value for future development. These resorts are booming at an accelerating rate and in ways that defy nature. They flatten contours to create speculative golf courses, swimming pools, residential villas and touristic chalets. Some of the newer resorts denote their commitment to sustainable development and responsible architecture, yet each project stands separately without a collective vision.

By mapping 100+ resorts along the Red Sea coast of Ain Sokhna, and tracing the new state-led development of Galala City (Figure 2), the paper investigates the following question: how to induce an active-transport system into an urban sprawl of car-dependent gated resorts through micro-design to promote active transport from within the self-enclosed tourist resorts? What are the possibilities of urban-mobility retrofitting in a highly fragmented region that is dispersed over the mountain and by the shore?

The paper advocates for small-scale focused interventions of micro-mobility inside the privatized resorts through: 1) applying urban acupuncture of micro-mobility strategy at the highly populated resorts, and

2) promote incentives for using active-transport while moving along the sea-coast and by the mountain through communicative, economic and physical infrastructure tools. The objective of this paper is to investigate an urban design experiment of micro-mobility that began at a nuclear unit in a privatized tourist village, and reflect on the private developer's engagement with the proposal. The nuanced solution of "urban acupuncture" was inspired from the fragmented nature of Ain Sokhna, with the target of expanding and rescaling the initiative at a larger neighboring scale. The paper's results would benefit private developers, city planners and decision makers who aspire to address sustainable urban mobility in fragmented regions.

The argument hereby is that as the competition increases in the real estate industry to tame nature and urbanize the mountains, each enclave is attempting to align itself with new solutions for tackling sustainability and accessibility resulting in acupunctural interventions to remedy the problems of fragmentation. The solutions of each resort are sporadic and market-based with special interests an can hardly serve under a general scheme *yet* they can still be manipulated. These practices do not necessarily complement each other and can be hardly framed as an alternative mode of planning. They operate with higher degrees of unknown variables and uncertain future. They however fall under "soft planning" (Cavaco et al., 2022; Sager, 2016; Raws, 2017) or "tactical urbanism" (Webb, 2016; Wohl, 2017; Parker et al., 2012) with short-term actions that yield in long-term impact.

The contradictions of urbanizing nature often create challenges to the real estate industry that lead to opportunities in addressing broader aspects in the built environment. The paper intends to capitalize on the contradictions of the self-led problems of neoliberalism and find solutions from within these cracks. Building on top of the summit for scenic views generates profit but also natural destruction. It is difficult to surpass such fact. Those privatized developments are however increasingly growing. Developing a middle agency to work them creates a possibility for transformation. It is a risk worth taking than condemning the status quo. Currently to move from one plateau to the other relies on cars. To circulate and bypass the splintered highway dividing the mountain resort with the beachfront relies on car. During this design proposal, the intention is to address sustainable mobility per resort and rethink the collective linkages of the whole Ain Sokhna coast from the small-scale to the regional-scale.

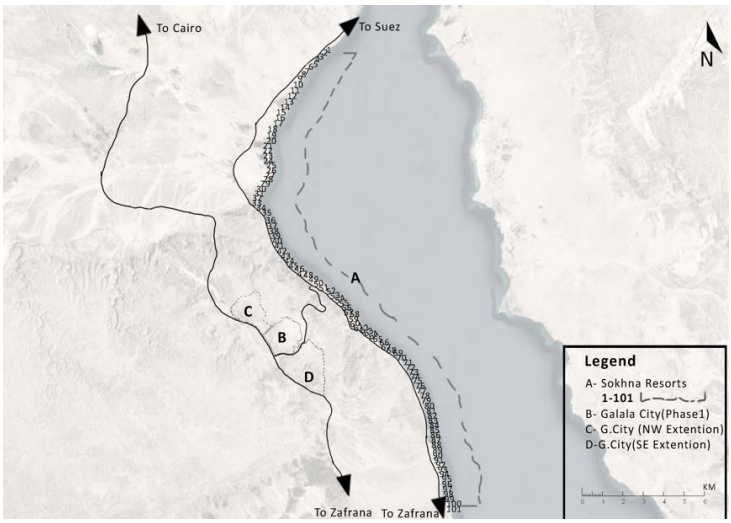

Figure 1. Ain Sokhna regional development with the 101 resorts overlooking the Red Sea and the mountain urbanization of the New Galala City. (Author, 2022)

Figure 2. Elevation profile of New Galala City at a mountain summit of 650 meters above sea level. (Google Earth Pro, 2022)

Literature Review: Urban acupuncture and a Private Pathology of Intervention

The concept of urban acupuncture is linked to a sustainable principle of healing the city's energy – environmentally, socially and economically (Lerner, 2016 [2003]). Borrowed from clinical surgery, urban acupuncture deals with the city as a living organism searching for hotspots to activate the blockages and energizes the city. It works through analyzing the potential problems and offering scalable solutions that starts with micro-interventions. Jaime Lerner tells us that a "true urban acupuncture" stimulates improvement and chain reactions (2016, p.1). A good acupuncture is one that understands that every city is like no other and understands what is missing before designing. Lerner points out that an intervention is all about revitalization, creating catalytic-intensive intervention in the urban fabric. It is an alternative deign path to *urban renewal* and *top-down planning* approaches. It is a strategic healing, where parts of the city act as a heart that gradually heal the whole.

Problem-based Acupuncture: Identifying, Intervening and Rescaling

Casagrande (2020) proposes an approach for rescaling experiences. He describes the city as "complex beings of energy, with different overlapping layers," where spaces learn from each other, exchange experiences, and influence the city at large. There is a power for small-scale interventions to transform the energy of the larger urban context. Any selected site for intervention is chosen through a comprehensive analysis of social, economic and environmental factors, developed through a dialogue between stakeholders, designers and society (Casagrande, 2012). Centering people's interests at the heart of the design process is the objective of urban acupuncture. Without understanding the place, context, its people and politics, any planning attempt becomes merely a technocratic tool.

Some interventions have a temporary or limited effect in a very specific area, while others have a wider scope; they can be individual and/or integrated interventions. In general, there are four types of acupuncture interventions (Daugėlaitė A and Grazuleviciute-Vileniske, 2018, p.8-10):

1. Intangible interventions: these do not have a permanent physical form but leave a major impact on the site's liveliness and vigor (for example, yoga sessions, brisking and street artists).
2. Local impact interventions: they affect the surrounding environment only.
3. A broad-based intervention: while they are localized, they affect a wider surrounding (for example, the Bilbao Museum's impact on boosting the economic and political status of the Basque region).
4. Systematic interventions constitute a specific network of spaces in order to influence the whole city (for example: the ten grand projects proposed by Francois Mitterrand for Paris).

Focused interventions can happen at the level of transport system such as Curitiba, a single building that catalyzes an industrial city gone into ruins such as in Bilbao (Hemingway and De Castro Mazarro, 2022), and a network of interventions at the historic core revitalizing buildings, nodes and axes such as in Kampung (Harjoko, 2017), Taipei (Chan, 2017), Baghdad (Al-Hinkawi and Al-Saadi, 2020), and Caracas (Bueno and Lanng, 2019). Urban acupuncture emerges as a strategy for development. It can create an atmosphere of affect and place-attachment at times of uncertainty in informal settlements. The impact of the small-scale intervention in the case of Tepito in Mexico is quite evident, where enhancing a physical space in the informal settlement alleviated stress than the direct efforts of political organizations, that often negotiate something in return from residents (Lastra and Pojani, 2018). Urban acupuncture heals the urban fabric through exerting pressure at specific points to generate a catalytic chain reaction. It can also work through incorporating hybrid tools deployed at the physical space and virtual sphere as in the case of Brisbane's Festival of 2012, where co-planning, co-organizing and mobilizing the masses take place on social media and realized in the physical space (Houghton et al., 2015).

Every City has a Separate Pathology: Engaging the private-sector in Sokhna

These interventions are effective because they are place-specific with every city achieving its path of "sustainable healing" according to its people, place and politics. When it comes to Ain Sokhna, it is mostly private resorts with no public space or a shared domain. Fragmentation and urban sprawl of privatized and gated architecture is a serious concern. Therefore, a nuanced solution towards sustainable urban mobility needs to come from within the touristic private-resorts and create a ripple effect at the larger urban context. Applying sustainable mobility in the region will take a different path than other cities such as Curitiba with its linear solution of bus-rapid transit. Therefore, I propose an additional type of acupuncture intervention to the previous four types of Daugėlaitė A and Grazuleviciute-Vileniske, to tackle fragmentation and privatized gated communities, and that is creating points of influence that emanate the from private-developing and transcend to the public sphere.

The significance of this research is that it draws attention to remedy the neoliberal condition of our built environment. The expansive urbanization of the hinterland, appropriating nature, increase of new private developments and speculative urbanization that persuade the state to participate in strategic plans around these private-led developments. Planning scholars denoted the problems of neoliberalism and strategic planning. Lindblom mentions the need to muddle through the vectors of power by initiating other ways of planning. Recent research called the alternative ways of planning, "tactical urbanism" and "soft planning." How to penetrate into a neoliberal built-environment and apply a guerilla approach of intervention that would address the public and the collective inside a context that is heavily-oriented to private-ownership and self-interests. The incursion of micro-mobility as "disjointed incrementalism" as a parasite feeding off the spillover and wasted consumptive landscapes that are underutilized, however they can be retooled.

Multiple researches have highlighted the urgent role of sustainable mobility in enhancing the quality of life, physical health, well-being and mental health in cities (Hare et al., 2012; Scheerper et al., 2014; Labee et al., 2022; Dacko and Spalteholtz, 2014). The significance of this intervention is that it attunes with The World Health Organization estimates that 40.5 million deaths per year are the result of non-communicable diseases NCDs, meaning around 71% of the global mortality resulting from stress, diabetes, obesity or lack of physical activity (WHO report, 2019). The transport behavior of car-dependency contributes to the habit of non-physical activity of citizens. Congestion and traffic reduce the citizens' energy and desire to practice after long trips in the car. How we urbanize our cities and expand their growth have a direct impact. Promoting active transport through cycling and walkability coupled with non-motorized vehicles would decrease 20% of mortality rates (Mueller et al., 2017).

Urbanizing Mountains at times of Change

Urbanizing the mountains at times of transformation and the strategic development across the Red Sea region entail two aspects: 1) taming nature and mountain-reshaping (this has been dominantly used for aesthetics purposes), 2) repositioning the resort at the intersection of new geopolitics of internationalization (resorts are catering for a cosmopolitan clientele with a new international marina), and transgress the walls of resorts and open to public access (mixed-use hubs open for Sokhna visitors).

Taming Nature

The taming of nature, shuffling of rocks, cut-and-fill, and pavements of asphalt roads up the mountain are undeniably non sustainable. The state and private sector are urbanizing nature through building resorts, industrial complexes and a new city 650 meters on top of the Galala mountain. Bulldozers are flattening and reshaping topographical contours at the service of a real-estate boom. An indigenous fauna is being replaced by new ecosystems of an urban world still unknown and uncertain yet in the making. After occupying the 70-kilometer stretch of the Red Sea shoreline with fragmented and self-enclosed resorts over the past 30 years, there is an urban encroachment crippling up the mountains. The future of this speculative boom may turn into bust becoming ghost towns that are entirely empty or at best half-empty/half-filled developments unless a set of interventions that focus on day-to-day sustainable practices take place to redress some of the unsustainable impact of mountain urbanization.

The selling point for the massive reshaping of nature and rebuilding a new modal of inhabitation is the view from above. Landscapes of remote wilderness are usually sites of capital accumulation. Nature-based real estate development has a tendency to foresee, embrace and extract profit from occupying the unruly nature. It follows a display of power, showcasing what capitalism can do to transform the abstract space to frame beauty in mind-blowing cadres seen from the window. Technically, the mountain plateaus are hardly inhabitable, yet these plateaus are forged for habitation in exchange of profit.

Maven Developments prides itself to make "bold new direction" in the Egyptian real estate market by identifying "already stunning locations" and turning them "spectacular"; the vision is to "design living environments that embrace and enhance the natural landscape that surrounds them" (Figure 3) – for Maven these are "the things that matter" (https://baymount.mavendevelopments.us/#masterPlan).

In her seminal book *This Changes Everything*, Naomi Klein (2015) tells us that there are already signs for contradictions where major contributors to the earth's destruction collect something called "carbon credits" in exchange of their damage. There are signs where the manipulation of nature is seized upon

and handed over yet more resources to the 1 percent. The Earth is colonized and dispossessed from its basic form to become habitable. The deviations that occur between re-morphing nature and inhabiting it contribute to the climate change crisis. With the ongoing urbanization of nature, some sort of contesting practices needs to intervene and subsume a radical position towards change with voices from within the neoliberal organizations. This is where Labao (218, p.389) argues that the state is incapable of leading change and develop a socially-democratic program. Nation-states have been dwarfed with a smaller and weakened public sector and forgone infrastructure projects. As such Olesen (2013, p.29) suggests that we have to find a way to engage with the neoliberalization of planning and production of unruly projects.

The *Baymount* resort is a 76.6 acres project constructed at a pristine location in Ain Sokhna, Suez, Egypt. There are two parts for the resort with the main part resting on the Galala Mount at a plateau that is 240 m above sea level. The second part is a beach area that is approximately 9.4 acres with 300m beach frontage and separated by a highway road infrastructure.

The units at the mountain plateaus are arranged in a linear configuration for maximum exposure to the sea. The plateaus organize the form, shape and spatial organization of the resort. Each plateau embodies a set of functions to include mixed-used developments such as: hotel, hotel serviced apartments, mountain cabins, stand-alone villas, single floor twin houses, double floor twin houses, chalets and lofts buildings, studios. Facilities include a club house, a mountain hub, kids park, bay hub, a camping center, a spiritual relaxation zone & yoga, family gaming rooms, sea view piazzas, an amphitheater, pets' area, mosque, pedestrian walkways and a stargazing zone. There is also a walkway at the edge of the mountain hub with a distinctive panoramic view.

In the brochure, *Baymount* promotes itself through its geographical positioning at the heart nature; "Between the summit and the sea"; "With dazzling sea views on one side and spectacular mountain landscapes on the other" (https://baymount.mavendevelopments.us/#masterPlan); "*Baymount*'s magnificent elevation positioned on one of the highest mountains in Sokhna provides unparalleled views and a calm peaceful environment, *but with the best facilities on every doorstep"* (italic added); "Infinity. Infinity view. Infinite pools. Infinite happiness. Outdoor terraces and infinity pools immerse you in the jaw-dropping vistas and the sound and smell of the sea." The "mountain hub" is a mixed used commercial and recreational activities occupies on one of the natural plateaus inside the resort, close to the mountain summit. Another intervention to the resort is the "mountain elevator" where the developer justifies using it stating that:

> "[We have the] Mountain Elevator. Because transportation can be fun. Taming the natural topography, *Baymount*'s mountain elevator system brings all of its facilities together, ensuring that its homes, hubs, the hotel and clubhouse are all within reach of each other for superior convenience for its guests and residents" (https://baymount.mavendevelopments.us/#facilities)

Here the mechanical transportation is used for fun. The employment of electro-mechanical means of transport at the midst of nature shows a break from the ecolodge culture of touristic villages that were prevailing over the past decade and constantly attributed to not altering the natural context. As Gohar and Kondolf (2020) tell us, all attempts of eco-lodges are far from adopting an ecological sustainable mode of development. The resorts at the Red Sea misuse the incorporation of ecology, nature and sustainability, undermining their potentials and restrict their usage to mesmerizing views and aesthetic

scenery. In Delhi's enclaves, Devra Waldman articulates how real estate developments carefully position each dwelling unit with its windows to aim for the views of the green golf courses while blocking off unwanted views of the urban poor (2022). At Egypt's Sokhna, developers carefully position units and frame their windows to aim for the sea and a human-made nature.

Repositioning the resort towards internationalization and Public Access

The new resort positions itself within the new political ecology of the state with the investment for the new city and public amenities in Ain Sokhna and Cairo; "*Baymount* is located in the Red Sea area [..] within easy walking distance of the new International Marina in Galala city":

> "The welcoming, cosmopolitan atmosphere is sure to attract the residents and visitors from the world over: those arriving by yacht will be able to dock at the magnificent Al Galala Resort and Marina, which is just a short walk from *Baymount*. And with Cairo just 90 minutes away by car, access from the city and its airports couldn't be easier." (Ibid)

The "Bay Hub" is pronounced as a space not exclusive but rather a hub catering for the public sphere. In the brochure it says: "The Bay Hub welcomes all visitors to Sokhna. Located close to the *Baymount* entrance at the lowest level of the development" with restaurants, cafes, mosque, business hub, public seating areas and a mountain elevator station.

In the *Baymount*'s brochure, there is an emphasis on becoming at the intersection of a changing political landscape for urban growth and development. The correlation with cosmopolitanism and publicness draws on an aspiration to situate the project across the changing forces shaping what can be analyzed as both local and global, natural and urbanized, calm and bustling with facilities. It builds on the aspiration of *becoming* a non-metropolitan *worldly*-city, something that is beyond a resort. This is what Ananya Roy and Aihwa Ong (2011) framed as "the art of being global", where the city is viewed "as a milieu that is in constant formation, drawing on disparate connections, and subject to the play of national and global forces" (Roy and Ong, 2011; p.3).

These projects engage in remaking the area and its unforeseen possibilities despite of the uncertain claims about the future. The area is changing and the resorts are repositioning themselves in this non-fixed atmosphere of public-oriented projects. The formation of a metropolitan region with the naming of a new city implies public spaces and engagement with amenities beyond the touristic resorts. As such, the metropolitan formation is viewed not as a locality, but as a nexus of situated and transnational ideas, institutions, actors, and practices that may be variously drawn together for solving particular problems. These ideas are experimental in nature. Roy and Ong tell us that: "World-aspiring projects are experiments in that they put forth questions, initiatives, and procedures in the midst of uncertainty, without guarantees about successful outcomes" (Jacob 1998 in Roy and Ong, 2011, p.4). In such globalizing atmosphere and transformative urbanizing regions, situated experiments take place and the neoliberal project of privatized boundaries may as well be pushed to address the general public's concerns.

Figure 3. Baymount resort resting on the topography with a beach front area separated by a highway road infrastructure. (https://baymount.mavendevelopments.us/#masterPlan. Retrieved April 28, 2022)

Promoting Micro-mobility

Multiple developers use their "research and development units" to advance their designs within a competitive real estate market. One area of development that became center-stage is "Sustainability and Accessibility." Such aspect is critical in new tourist resorts on the Galala Mount. The steep mountains represent a challenge for mobility. The idea of mountain elevators was proposed to improve the mobility and accessibility from the mountains to the beach front and within the resort to overcome the high elevations. Two mountain elevators were initially conceived. Their engineering solutions are however expensive and unreliable and cannot be promoted as an everyday practice for short and quic mobility trips.

Other solutions of micro-mobility can be more feasible, practical and sustainable. The inclusion of active transport as a strategy for intervention can refine movement inside the resort and across the neighboring resorts (Figure 4). Connectivity is much needed in this area. Such micro-initiative has a potential to expand and become a leading pilot project along the Red Sea coast. These microscopic interventions would act as urban acupuncture to heal the car-dependent problem. The devices of micro-mobility have less carbon footprint and greenhouse gas emissions than using cars and inclined elevators within the resort. Borrowing ideas from competing projects within the real estate market is a common practice. Tapping into such practice of "borrowing ideas" by encouraging sustainable mobility, elucidates a positive impact that would migrate to neighboring resorts leading to an urban spillover of *disjointed incrementalism* towards "sustainable urban transformation" (Levin-Keitel et al., 2018; Nielsen and Farrely, 2019; Ryan, 2012; Truffer et al., 2015).

According to Abduljabbar et al. (2021), "Micro-mobility is an innovative urban transport solution aimed at providing short-distance travel options including first and last kilometer trips" (p.1). Micro-mobility involves a range of small, lightweight devices operating at speeds typically below 25 km/h and can increase to 45 km/h as top speed, and is ideal for trips up to 10 km. These devices include bicycles, scooters, skateboards, segways and hover-boards, they can be human-powered or electric (Dia, 2019). The appeal of micro-mobility is that it can be privately owned or shared (Dia, 2019), making it flexible,

sustainable, cost-effective and on-demand transport alternative (Shaheen et al., 2016). These devices are space efficient, can be emplaced anywhere and at any urban infill or space between buildings. They are transportable devices that can be uninstalled and re-installed anywhere where there is demand. They are also attractive across the different age groups regardless of social class and gender. Moreover, they reduce reliance on using private vehicles for short-distance travel (Tiwari, 2019), and promote a sharing economy model (Liyanage et al., 2019; Machado et al., 2018; Shaheen et al., 2016).

The adoption of micro-mobility has physical health benefits for individuals and the city's social sustainability. They encourage social class mix as well as promoting an important mix in the smart urban mobility ecosystem by linking the physical realm of sharing devices with applications on smart phones. All these registers support a new creative economy based on the premise of sharing amenities, which may salvage a neoliberal setting based on exclusivity and private-ownership. As such, inserting micro-mobility as a plugin strategy, as if a virus that infiltrates into the veins of a privatized built environment may have a role in subverting the fundamental ethos of neoliberalism. Marco Casagrande (2020) calls the infiltrating approach of acupuncture "parasite urbanism" and "3-generation city" (Hemingway and Mazarro, 2022, p.2). "Privatized acupuncture" has the ability to feed on the composts the neoliberal city through their tempting appeals and attractive branding, hence infiltrate into the structure of privatization and re-institute a new ecosystem that is based on sharing and physical activity. Casagrande envisions small-scale interventions as a potential method of renewing and recovering the city, a form of "bio-urban healing."

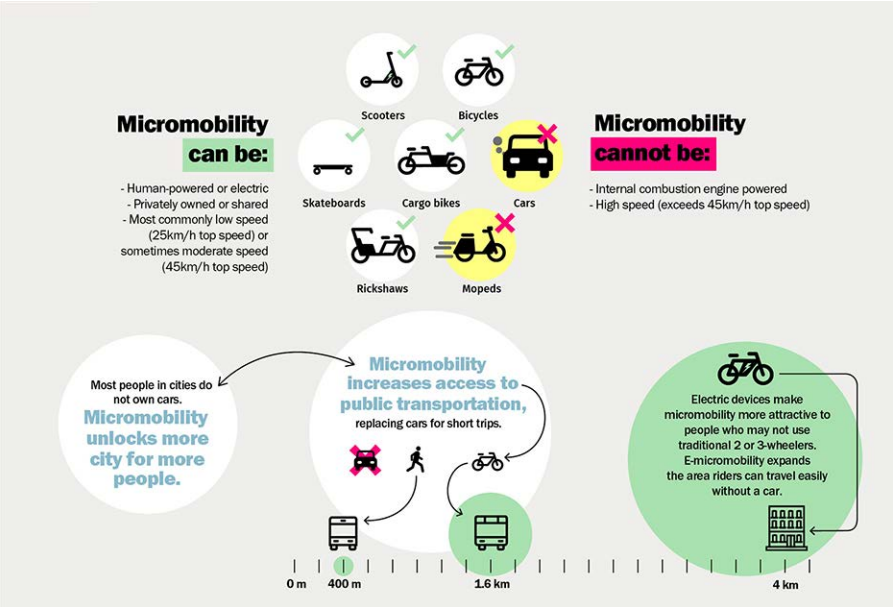

Figure 4. Defining what is micro-mobility, Institute for Transportation Development Polciy Report. (https://www.itdp.org/multimedia/defining-micromobility/. Retrieved April 28, 2022)

Micro-Design: Plateau by Plateau

A number of factors contribute to the distribution of micro-mobility stations such as density, popularity, safety, and demand and usage. A feasibility study conducted in US and European city-centers indicate that an average of 1 station is placed every 300 meters to ensure a uniform coverage (ITDP report, 2014, p.57); this ratio may vary according to population density and usage demand.

Allocating the micro-mobility stations has to be strategic on the mountain plateaus. Most research done on the distribution of active-transport stations is conducted on cities. Research on developing guiding principles for active transport stations in urban communities on mountain plateaus is still to be done. In the city center, researchers tell us that stations should be adjacent to mass-transit stops to help passengers connect more easily and quickly to their destinations. Whenever possible, stations should be located along existing bike lanes or on streets that are safe and accessible for bikes. Stations are best situated on or near corners, so that users can access and egress from multiple directions. Stations are ideally located between multiple uses that generate activity at different times of the day. This ensures that bikes will be used from morning to night. Moreover, stations should not be placed next to barriers like train tracks, or single-use areas such as a large gated park or factory (ITDP report, 2014, p.57).

There is little research on the factors affecting the distribution of bike station in mountain settlements. Elevated topography and irregular steep gradients have an impact on the allocation and distribution of stations. Change of weather season per day, oscillating between extreme hot and cold temperatures, play a factor as well. Any feasibility study would fail to predict residents' behavioral choice of cycling and physical activity on mountain settlements. Experimentation, ideation, feedback loop then prototyping would help in such obscure conditions. This design approach requires a different mindset from the strategic planning approach, which rely on clear achievable goals and objectives. Lydon and Garcia (2014) called this experimental approach the "design thinking loop"; they referred to it as "tactical urbanism" in contrast to the engineering science and economic feasibility models of transport predictability.

At *Baymount*, the context was divided into three plateaus depending on counting the number of dwelling units and estimated population (Figure 5). According to the New Urban Communities Authority, an estimate of 4.3 family member would reside per unit. By multiplying this standard number with the number of housing units, the upper zone would be inhabited by around 560 persons, the middle zone would be inhabited by around 4,250 persons, and the lower plateau would be inhabited by 1,650 persons. This calculation led to proposing a bigger hub station in the middle zone with a larger social gathering space that would act as a node. The middle e-hub is located besides a children and youth park called "central park" and would include 18 bicycles and 10 e-scooters. Previous research tells us that e-scooters are more popular to be used than bicycles, thus it is suggested to have them more than bicycles. Yet, e-scooter are three times more expensive than bicycles in Egypt. Hence, balancing out the factors of price cost and usability at the early experimentation phase is recommendable. That is why more bicycles were installed. The lower zone includes a mixed-use commercial zone called "Bay Hub" at the edge of the project and is open to public access. The location of the e-hub beside the road and a protected bike lane by the high road is strategically proposed to encourage the neighboring resorts to follow suit and develop another bike station. The Bay Hub station includes 12 bicycles, 5 e-scooters and 2 golf-carts (Figure 6).

The flexibility of station type and design would support the unclarity surrounding users' behavioral choices and demand rates for active transport. The changing modularity of the station for addition and subtraction was used in the project. Each e-hub station was accompanied by a small café, seating area, gathering spots and a plugin for charging electronic devices with the aim of attracting youth, residents and strangers to meet, talk and encounter each other. Promoting the culture of active transport requires the utilization of multiple incentives and tools towards an effective behavioral change towards less-car dependency. At least at for those who may end up working, living and residing at the New Galala City,

such behavioral transformation will impact the growth of the region to embrace active transport as a means of transportation along the Red Sea region.

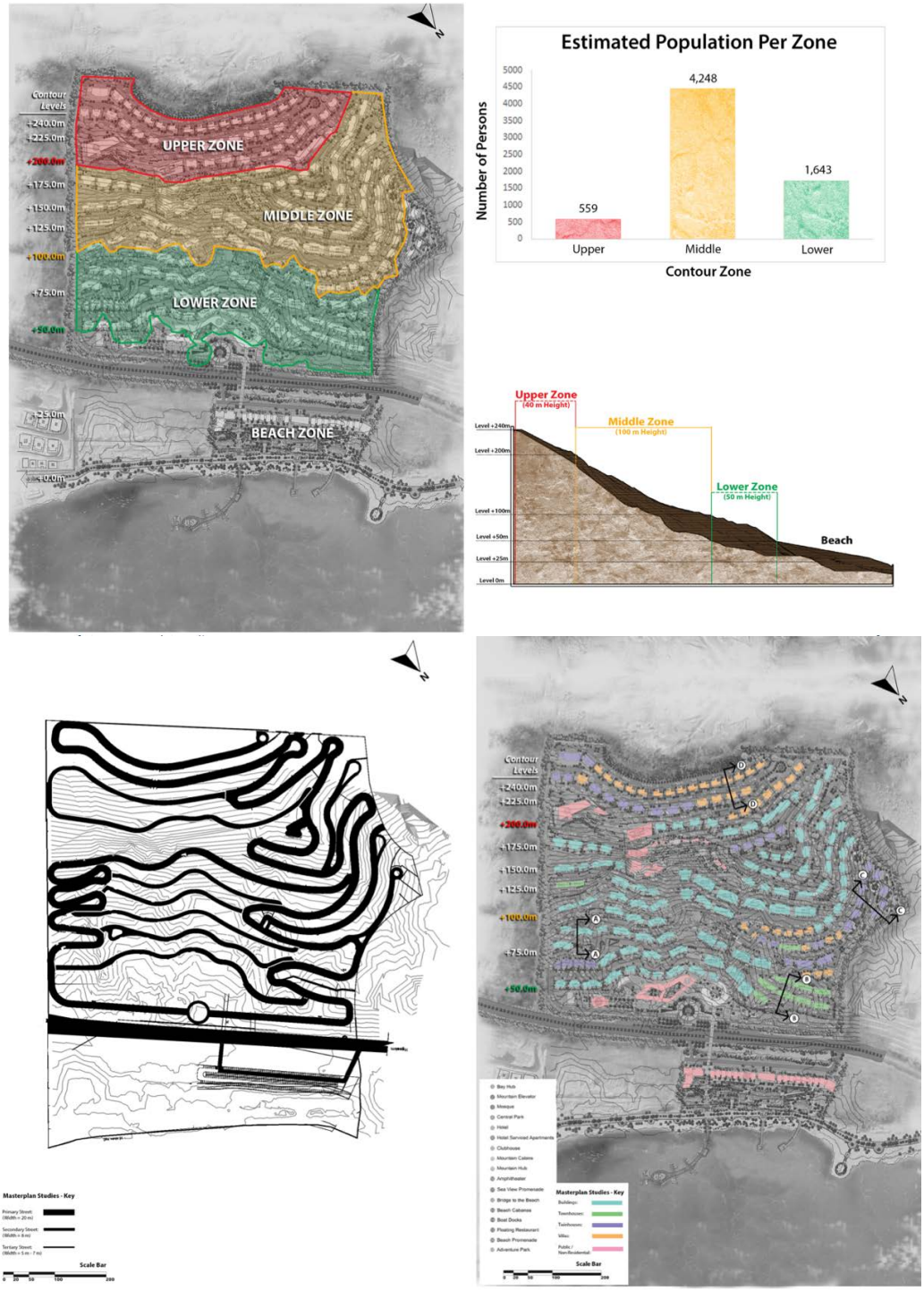

Figure 5. Generating three topographical plateaus for lateral mobility developed as a ratio between population density, steep elevation and mixed-use social nodes. (Author, 2022)

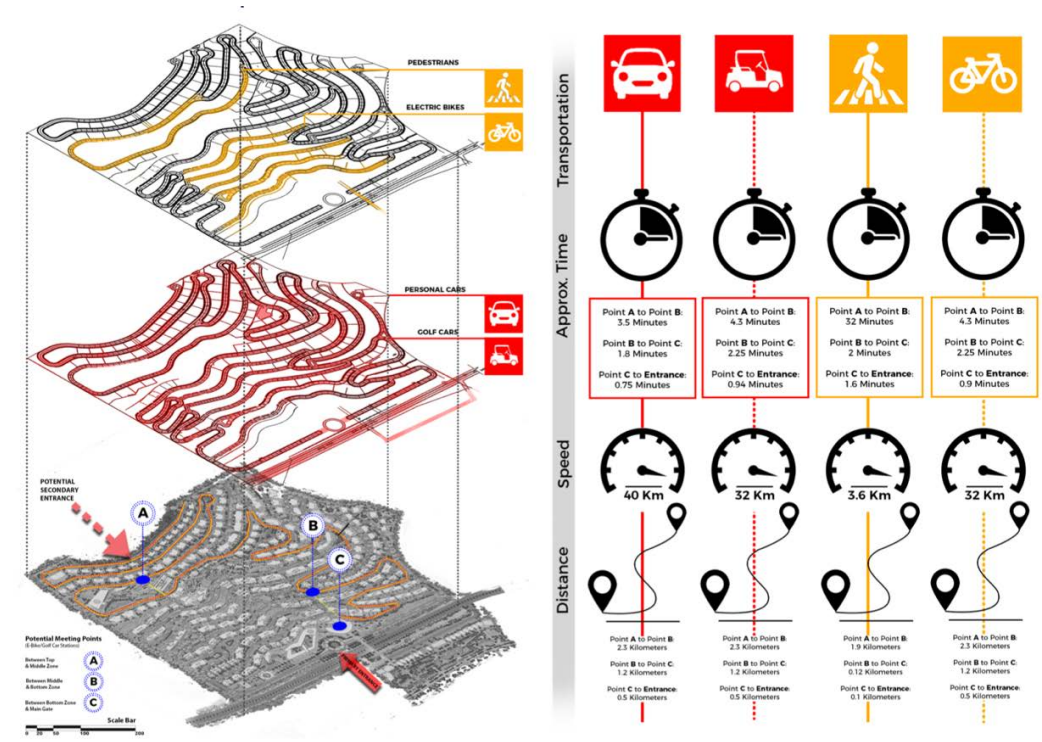

Figure 6. Distribution of micro-mobility hub stations, estimated time travel and number of active transport devices. (Author, 2022)

Discussion

Along the Red Sea shore of Ain Sokhna, *Baymount* resort is one of the 100+ fragmented resorts along the coastline encountering an urban transformation to create a new regional masterplan. The state is working around the fragmented privatized land of resorts to develop a strategic development for the region. The future of these seasonal residences remains uncertain. The increasing interest of the state is creating a speculative boom. However, the new private development projects "muddle through" the fragmented urbanization and uncertain future. The state's strategic planning for the region includes a new city with international and local universities, industrial complexes for mining and fertilizers, military investment projects and a new international port. Real estate developers are torn between developing resorts for *seasonal* tourism or a *year-round* settlement complimenting the strategic masterplan. New resort projects are currently mediating a middle position between creating residences for temporary inhabitation versus permanent settlements.

An integrated plan for sustainable mobility that connects the fragmented sprawl of enclaves stretched along the coastline and over the mountain is extremely needed. What is clear is the increase interest of private sector to open up their exclusive resorts to heterogenous target users. Active-transport stations that promote micro-mobility can be a convincing strategy for generating nodes of common interest at the edge of each resort. Generating an incremental, step-by-step micro-mobility infrastructure along the Red Sea shore would reduce the rates of car-dependency in the area.

Understanding the situated politics of the region, the diversity of stakeholders, and the uncertain venture of urbanizing on top of the mountain result in a muddling through approach of planning (Lindblom, 1959). Using urban acupuncture is a mechanism for healing the built environment through surgical focused and small-scale interventions, especially at times of incoherence, unclarity and lack of a collective body for mitigating risks. Due to the lack of resources, there is an impracticality to propose a state-led grand scheme for a sustainable mobility infrastructure that connects the fragmented resorts. Accordingly, this paper proposes a micro-mobility approach inside the fragments to work inside-out the resorts through micro-designing plateau-by-plateau leading to a spillover effect. The paper calls this form of planning *disjointed incrementalism* towards making change at times of incoherence.

Planning the position of micro-mobility stations with intertwined spaces of social nodes plays a role in exacerbating the frequency of using them. Factors such as visibility, legibility, safety and lighting at night represent key aspects to encourage utilization of active-transport stations across gender, age, and social class. This shift of studying *mobility* is called "mobilities turn" (Greico and Urry, 2011), and is defined by the inclusion of human agency in recent years and it was followed by a further focus on the non-human element of mobility, which is the design materiality of mobility's infrastructure that impact people's desire and affect (Jensen and Lanng, 2016). All such factors of the physical, economic and policies influence people's behavioral choices and attitudes from car dependency (Scheepers et al., 2014). The insertion of "situated practices," "social life" and "mobility design" is now contributing to our broader understanding of *sustainable mobility* making those aspects the center-stage of many research endeavors related to travel and transport. The design of social nodes and the material configuration of its place-making to the areas adjacent to the hub stations plays a factor in incentivizing people to use active-transport devices (Figure 7).

The recognition of the "social" and "situated contingencies" in organizing mobility has been widely ignored within the study of transport until the advent of the "activity" approach at the Transport Studies Unit in Oxford (Jones at al., 1983). The study of agency and "multiple mobilities" generated a paradigm

shift towards the inclusion of heterogenous devices for mobility trips. Travel is *not just* a derived demand; the choice of how to travel and why accounts for the atmosphere surrounding people and their built environment, the natural setting and urban morphology, and the geopolitics of urban growth (Banister, 2008; Greico and Urry 2011; Jansen, 2017).

Figure 7. The social articulation for the design of space adjacent to the micro-mobility station. (Author, 2022)

Conclusion

This paper started with a simple question, what are the possibilities of healing a region from inside the resorts that created a problem in the first place? The case study showed that the resorts can be re-instrumentalized to initiate a new type of "privatized urban acupuncture." The usual interventions of urban acupuncture take place around public amenities through unblocking the points of stress in the built environment. At Sokhna region, there is an absence of spaces for publicness, where everything is private-owned. And the average rate of travel will increase as a result of the anticipated urban sprawl in the region. Cars remain the only means of travel along the coast and by the mountain settlements. These variables threaten the increase rates of carbon footprint and greenhouse gas emissions. Adopting "active transport" and non-motorized devices is becoming an essential approach for sustainable urban mobility. To accelerate having micro-mobility stations beyond the slow-pace state-led projects of infrastructure, requires the incorporation of the private-sector investing in the region. Thus, the "privatized urban acupuncture" can aid in developing new stakeholders in the field of healing the region.

Linking the 100+ resorts through mass-transit infrastructure requires time, funding and new legislations. With the New Galala City and the inclination to internationalize the region and become a world-city, fragmentation and segregation will only exacerbate and more self-enclosed archipelagos will grow. A quick reproach would be to install micro-mobility devices that operate up to 45 km/h and focus on the first and last kilometer trip of any travel journey.

The new resort developments are crippling over the mountains. The urbanization of nature, cut-and-fill stones and reshuffling of rocks follow the logic of creating dwelling units stacked beside each other, with every unit having a sea view from above. The topographic contours are the organizing principles in such

parallel linear arrangement. This is followed by stacking homes and units in a linear arrangement for maximum seafront exposure and better framing of views. Developers promote mountain elevators as the mean of connectivity between the plateaus. It is a touristic device to capture the scenic views, but these devices can be only occasionally used and will not replace using cars. Travel trips from the top of the mountain to the beachfront will become a hassle. Hence, an active transport system with micro-mobility stations that promote e-bicycles, bicycles, e-scooters and golf cars can be more practical and reasonable for quick everyday travel trips.

Adopting micro-mobility stations would mend the fragmented neoliberal urbanism in two aspects. First, they would normalize the culture of sharing devices amidst an elite social class that is heavily invested in private-ownership. This shift may be gradual but essential. Second, the development of a bike-sharing hub at the edge of each resort will lead to the normalization of public access thus the gradual transgression of walls along the gated resorts of the Red Sea coast.

This approach of planning practice follows the genre of "soft planning", "tactical urbanism" and "guerilla architecture", which stand in contrast to state-led strategic planning. This paper contributes to this genre of alternative modalities by proposing "privatized urban acupuncture" that engage the private sector and develop "disjointed incremental" interventions towards achieving the sustainable urban transformation in an extremely fragmented region that is about to grow even more, and become a world-city region.

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REINVENTING PUBLIC HOUSING:
Restoring the Infrastructure of Community that Modernism Left Out

Frederick Biehle, Pratt Institute

Abstract
The quiet successes and loud failures of New York City's Housing Authority are well known. Recent criticism has identified bureaucratic management as the true catalyst for failure, giving the architects a pass. But doing so has required apologizing for design positioning now recognized as fundamentally anti-urban. Today, as public housing has only continued to grow old, the city that surrounds it has become more robust. The impending collision between the extravagance of private markets and the neglect of the public may yet prove to be fortuitous.

Two circumstances have altered the calculation. First is the dramatic fall of in crime. Second is a recent accusation that redefines New Deal public housing policy as race biased. By conjoining 'slum clearance' with the construction of public housing, the federal government ended up legislating a form of institutional racism. Slum clearance destroyed not only the physical but the social fabric of those communities. The anti-urbanism of the projects that replaced them was really a second act to guarantee they would never return.

The result is that the federal government has not only an opportunity to introduce change, but an obligation. Taking advantage of the excess open space on over 150 NYCHA estates is really a chance to reimagine our cities by engaging best practice conclusions for new affordable, equitable, and environmentally sustainable housing, thus improving the quality of life for tenants and city dwellers both. Based on the work of seven successive research studios, this paper will present a series of tactical strategies for breaking up super block sites by re-streeting and then re-urbanizing them by introducing and shaping a new fabric.

Introduction
In his 2008 publication *Public Housing that Worked* Nicholas Bloom offered an in-depth critique of low-income, high-rise public housing that turned conventional wisdom on its head. His thesis was that, while most of America's superblock public housing was, in fact, a disaster, New York City's was not. New York City was different. This was a city whose Housing Authority had created, overseen, and maintained a product of twenty-six hundred buildings and a system that could, and continues to, satisfy the housing needs for over 400,000 tenants. In short, it worked.[1]

To stake this claim, however, Bloom had to redefine the frame through which affordable housing would be evaluated. His new position promoted bureaucratic workability over issues related to its actual architecture. He could only get to his conclusion by defending the assumptions institutionalized by NYCHA under Robert Moses:

First, that the decongestive action of "slum" clearance was always a net positive; second, that the superblock's exclusive residential zoning, as well as physical disassociation from its surrounding fabric, was an acceptable, even more efficient idea; third, that the decision to construct housing intended to look poor, entirely absent of any sense of architectural detail was also acceptable; and lastly, that not shaping the residual space opened up by smaller lot coverages and taller buildings was equally preferable, thus elevating abstract aesthetics over social concern.

In short, Bloom tells us that we should accept the NYCHA's public housing 'project' for what it was, and still is- those 2600 buildings and 154 multi-block locations whose tenants live with "well maintained brick buildings, mature plane trees and green lawns…(which) have made NYC public high-rise housing a smashing success."[2]

As positive as this assessment may be, it disregards the fact that the superblock sites have become stigmatized by their spatial isolation from the larger public realm. Their 90% black and brown tenantry have been physically partitioned behind a second ghetto appearance. The future that NYCHA thought it was constructing has now become a series of island wastelands, anti-cities within the city. Certainly, a decent home and suitable living environment[3] was an important objective, but how was it that achieving that goal came to require such antipathy toward the city's foundational urban fabric.

It has never been clear just what can be done about New York City's vast public housing legacy. But, with NYCHA currently insolvent and facing a capital improvement and maintenance shortfall of over 34 billion dollars, the city must address it. In his concluding sentence to *Americans against the City,* Steven Conn laid down the challenge- "the problem of the 21st century will be how we re-urbanize, that is, how we fix the mistakes of our anti-urban 20th century."[4] It will be no small undertaking.

Fixing the Mistakes of our Anti-Urban 20th Century

Four events have coincided to disrupt the long-standing laissez-faire perception of public housing and create what may be a truly honest opportunity for change. First, the progressive and steady decline in the crime rate. Second, a building boom centered on market rate housing that has run out of empty lots to build on. Third, introducing the idea of exploiting or monetizing the excess open space[5] present within the housing estates. And fourth, an existential and financial crisis at NYCHA that cannot continue as is.

The city and its Housing Authority have recently unveiled NYCHA 2.0, a comprehensive plan to raise 24 of the needed 32 billion dollars to repair, restore and rebuild NYCHA housing. The program, called "Build, Transfer and Fix to Preserve,"[6] has three parts, of which the most important is to lease out underutilized open space from the superblocks for the construction of new market rate and affordable housing. Profits would go toward paying the maintenance and repair shortfall. Ambitious as the program is, its failure is preordained. NYCHA housing is not something any reasonable planner or urbanist would consider proposing today, so the intention to preserve its proven anti-urban and destructive ideas must be questioned. This is a crisis that needs to become an opportunity, to "fix the mistakes of our anti-urban 20th century," and not just repeat them.

For the past seven years, the Pratt Institute's UG Architecture has been offering an urban design studio intended to do just that- fix the mistakes. It begins with the question- what if we see the superblock as simply unfinished? Can NYCHA 2.0 unwittingly be the catalyst that finally allows for the necessary urban transformation? The work I am going to show you seeks to prove that, from a design perspective, it very much can.

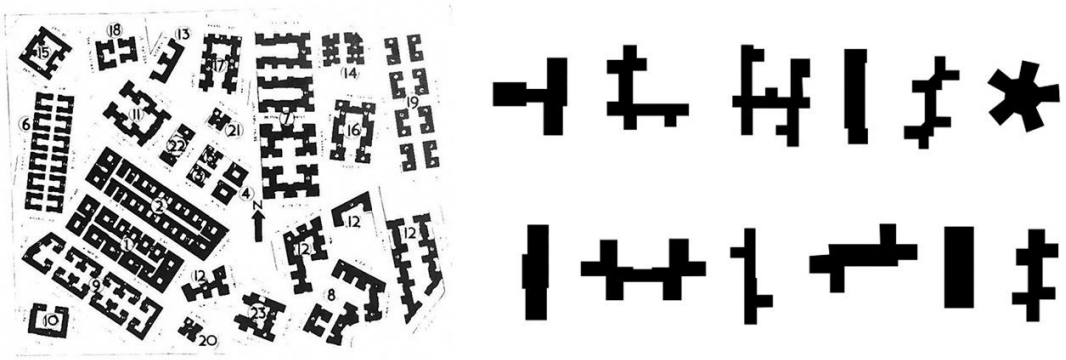

Figure 1: Perimeter Block Housing Projects identified as models for future NYCHA housing by the original design director Frederick Ackerman (L) and actual NYCHA housing tower and slab templates (R)

The studio began with New York's uniquely dialectical history of affordable housing (see Fig. 1) Asking each student to comparatively analyze a pre-NYCHA and a post-NYCHA project. The result was a gained awareness of how housing reformers, philanthropists, and architects had worked to create a new type of housing that both fit anonymously into the city's gridiron pattern and provided a unique new amenity, the collective garden. Richard Plunz even described the garden apartment type as "setting a standard for urban housing that has remained unmatched since".[7]

But then, how Post-NYCHA, the authority became an instrument of urban renewal, conjoining affordable housing with slum clearance to forcibly destroy lower middle-class neighborhoods, doing irreparable damage to the lives of the very citizenry it had been created to serve. NYCHA's failure was both social and architectural. Introduced as a lower-rise idea modelled on suburban German planning, it increased in scale to become a uniquely American version of a utopian European idea: the tower-in-the-park superblock housing estate.[8] With this comprehensive understanding of the social, political and architectural context, the studio moved to an examination of superblock sites.

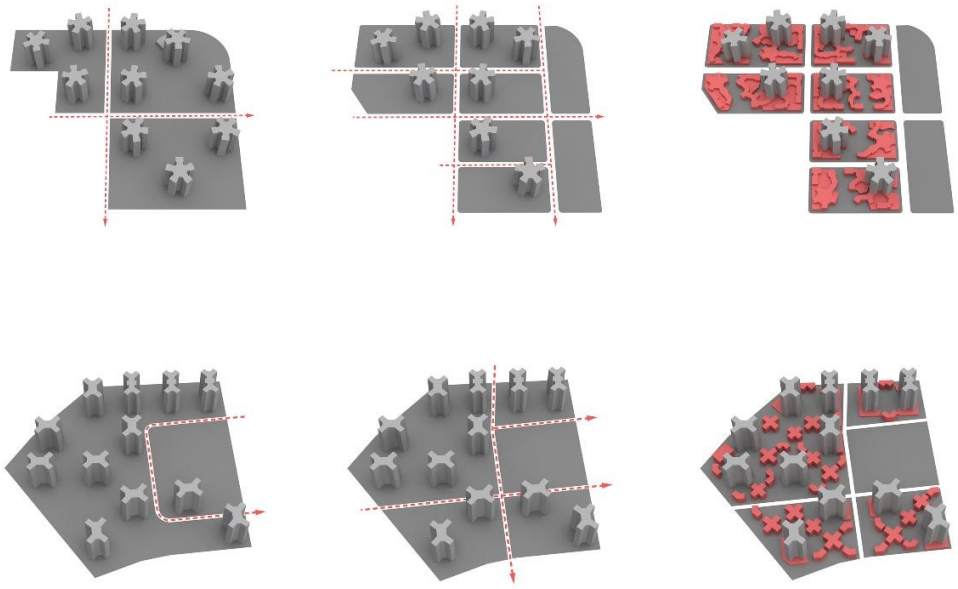

Figure 2: Two existing superblock sites restreeted and overlaid with a new low-rise fabric

Tactical Strategies
To date, the studio has engaged seven different sites in three boroughs (see Fig. 2). For each site the students address two fundamental issues- first, restoring the idea of the street. The superblock eliminated not only the actual streets of the historic gridiron, but the very idea of the street- as something that has a sectional, spatial presence, and frames the collective activity of the neighborhood. By subdividing the superblock into smaller pieces again, re-streeting as it were, there is an opportunity to restore that activity by introducing vehicular and pedestrian porosity.

And then second, the re-shaping of an urban fabric in relationship to the altered street pattern. Introducing a lower-rise, high density infill architecture to shape the residual space specifically. The existing tower or slab cores can then be integrated into this new urban pattern. The result is a figure-ground plan in which the footprint of the towers disappears.
The existing towers maintain their "access to light, air, and health", but the architecture of the street has reintroduced the absent urbanism- retail shops, restaurants and cafes, small business opportunities, and community facilities. The superblock becomes its own 15 minute or even 10 minute neighborhood.

The solutions that have emerged from these studios, 75 projects for seven sites, can be categorized into distinct typologies. Here they are:

Micro block
Perhaps the most obvious solution is the micro block which involves identifying each freestanding NYCHA building as the centerpiece for what will ultimately be an independent block surrounded by streets on all four sides. Five of the seven sites developed a version of this typology. It resembles the contemporary zoning strategy referred to as "vancouverism" where tall towers are required to be designed with lower rise skirts, often made up of three to four story townhouses, that explicitly fill out the city block perimeter.[9]

Figure 3: Micro block A (Ingersoll-Whitman Houses) Hillary Flannery and Kai Fang

With Micro block A (see Fig. 3), each of the 35 existing buildings for Ingersoll-Whitman Houses was provided with a new low-rise base or skirt that becomes the basis for new individual blocks. The sites minimal architectural footprint is completely reversed, with the added form generating a dense urban fabric. In this case the density was aerated by the inclusion of smaller internal courtyards around which a variety of institutional, retail, and community programs were distributed. The agitated grid pattern generates a street system without through traffic, making it function as a safer, pedestrian friendly, neighborhood.

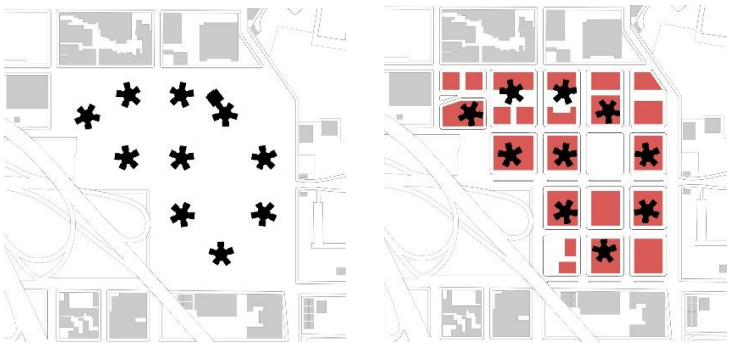

Figure 4: Micro block B (Farragut Houses) Eunsoo Choi

At Micro block B (see Fig. 4) the generous spacing of the point towers allows for a restoration of the original Brooklyn gridiron. These blocks are then filled by a surrounding apron with different types of programming- institutional, commercial and residential. The low-rise structures define the quality of the street while the towers occupy their own intermediate zone above. One block is left empty to serve as a public park which gives the new neighborhood a central focus.

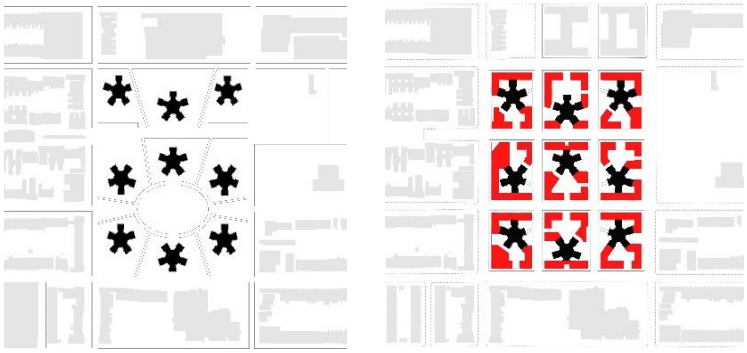

Figure 5: Micro block C (Albany Houses) Cierra Francillon

For Micro block C (see Fig. 5), a new 200’ x 200’ block street grid is able to be established. But it is the internal interconnected courtyards that distinguish the new neighborhood.

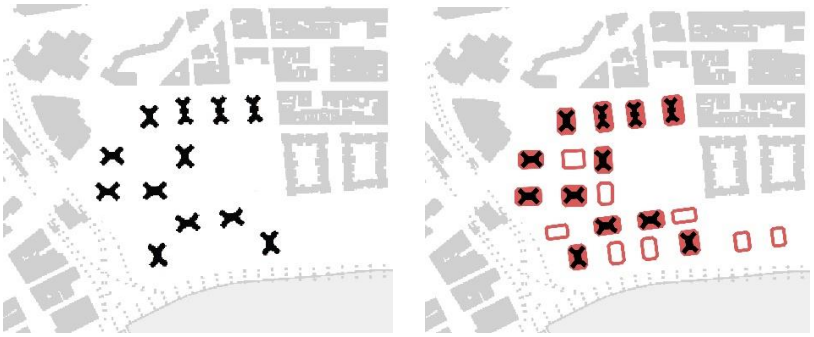

Figure 6: Micro block D (Alfred E. Smith Houses) Zaki Zhang

At Micro block D (see Fig. 6) each tower is surrounded by a low-rise ring. Additional open rings, more typical perimeter block units, are added to fill in and complete a loosely agitated overall grid.

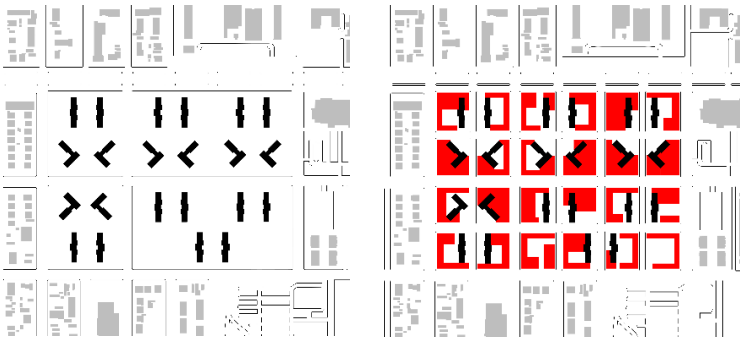

Figure 7: Micro block E (Pink Houses) Mackenzie McCrane

At Micro block E (see Fig. 7), the new blocks are able to accommodate a variety of different infill strategies with ease. The new fabric is intended to be introduced over time and so as to emphasize its differences.

Perimeter Block

Perhaps the most pedagogically driven solution to the problem is the generation of a new urban street pattern that is defined by low-rise Perimeter Blocks that can integrate with the existing NYCHA towers.

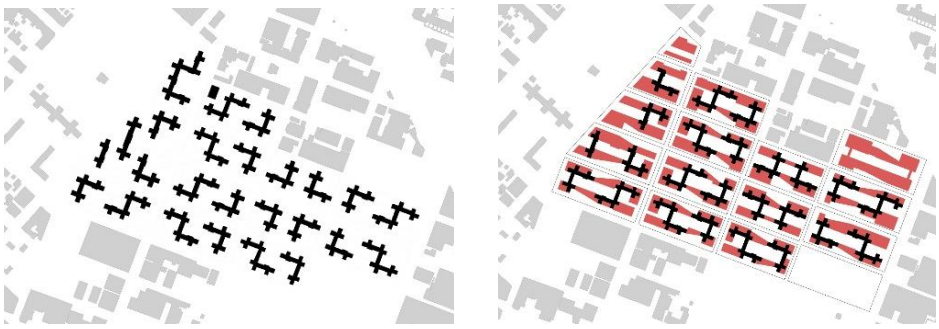

Figure 8: Perimeter Block A (Red Hook Houses) Dafne Lum

Perimeter Block A (see Fig. 8) at the Red Hook Houses, one of NYCHA's earliest projects, 15 of the original 17 blocks were restreeted to restore an urban sensibility. A one-story commercial base consistently repeats a diagonal indentation to widen sidewalks and allow for social outdoor use. The interior of these new blocks is imagined as a semi-private landscaped garden with circulation accessible by residents only.

Figure 9: Perimeter Block B (Red Hook Houses) Peter and Han Kim

For perimeter block B (see Fig. 9) individual buildings are clustered into clever, more comprehensible groups to generate garden courtyards between them. New vehicular streets run north-south between the clusters to break up the superblock and are crossed by a green promenade that links the neighborhood more coherently to its pre-existing institutions of school, library, church and hospital. The shaping of the clustered courtyards is achieved by adding a two-story apron that connects the existing taller buildings together and offers street-front commercial space.

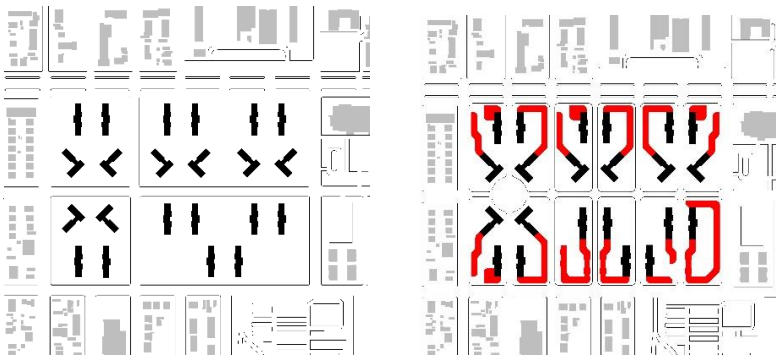

Figure 10: Perimeter Block C (Pink Houses) Bing Li

At perimeter block C (see Fig. 10), the existing slabs are linked into a set of diagonally indented perimeter blocks with courtyards that allow for three differentiated uses- private, semi- private, and fully public. The result is a mostly porous neighborhood but with greater spatial differentiation.

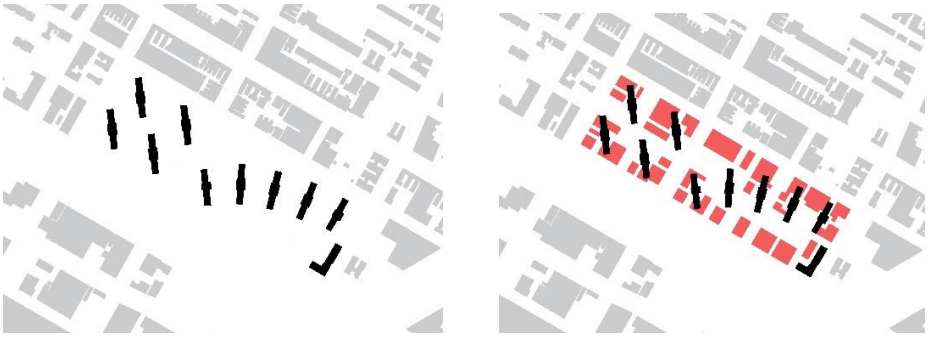

Figure 11: Perimeter Block C (Mill Brook Houses) Mary Anne Barone and Carly McQueen

For perimeter block D (see Fig. 11) the smaller Mill Brook Houses site is converted into a single large perimeter block cut through by two vehicular streets and a wide variety of public interior access that makes for an highly activate pedestrian core.

Replicating Block

A third type is the Replicating Block. In the three examples shown there is a clear desire to generate a different type of public space by replicating aspects of the more idiosyncratic NYCHA building template.

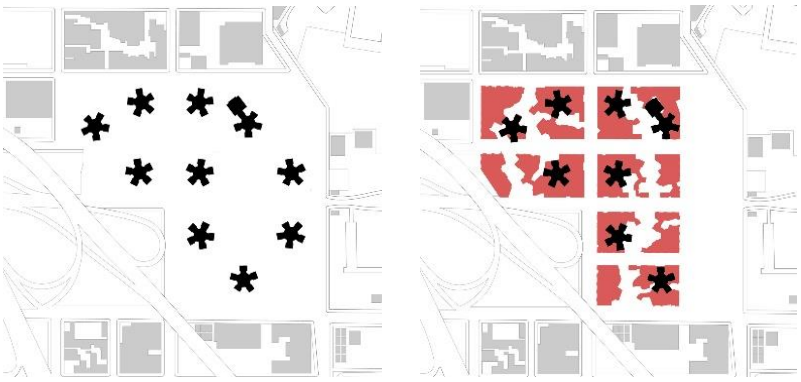

Figure 12: Replicating Block A (Farragut Houses) Laura Longhitano and Kelly Haughy

For Farragut Houses (see Fig. 12), following the restoration of the original street grid, a one-story commercial base was added to fill out the block, shaping a generous hardscaped pedestrian passage through it. On top of that base the arms of the original star shaped towers extend, mutate, and proliferate as new additional affordable housing.

Figure 13: Replicating Block B (Alfred E. Smith Houses) Emma Stephens

At the Smith Houses (see Fig. 13), the designer used a five-story cross-shaped housing block not so dissimilar in plan to the original towers to introduce and generate a pattern of repeating diamond figures. This in-between public realm takes on a variety of programs depending on the adjacent ground floor commercial or institutional use.

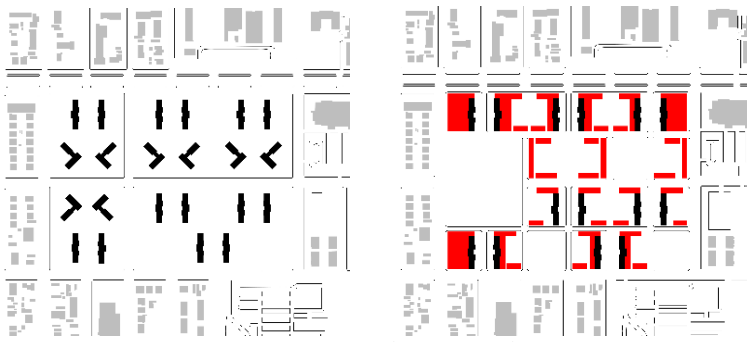

Figure 14: Replicating Block C (Pink Houses) Raymond Yu

Replicating Block C at the Pink Houses (see Fig. 14) the designer set up a kit of parts- a matching slab tower, a slightly lower point loaded slab and an underlying base building with occupiable roof and

different depths. The idiosyncrasies of the site relationships effectively determined a response that results in a richly porous public realm of landscaped squares.

Labyrnthine Block

The fourth type is the Labyrinthine Block which uses strategies of interconnection to achieve a spatial intensity that links up the free-floating NYCHA fragments into a more agitated set of shaped figures. Rather than being manifested with a low-rise apron, these projects have specifically chosen to operate at matching heights, whether that is 6 stories or 16. The result in each case is to generate a kind of city within a city that the public can now engage.

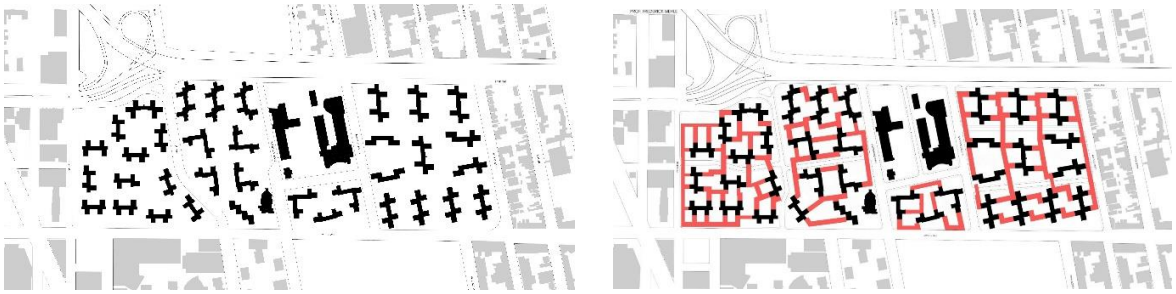

Figure 15: Labyrinthine Block B (Ingersoll-Whitman Houses) Michael Rosen and Yuli Huang

At Ingersoll-Whitman (see Fig. 15) again the extensions grow, aggregate, and ultimately metastasize into a honeycombed fabric of courtyard-oriented spaces. New streets sometimes pass under and sometimes through. The character of the site has been shifted from a collection of objects in a field to a maze of interior spaces.

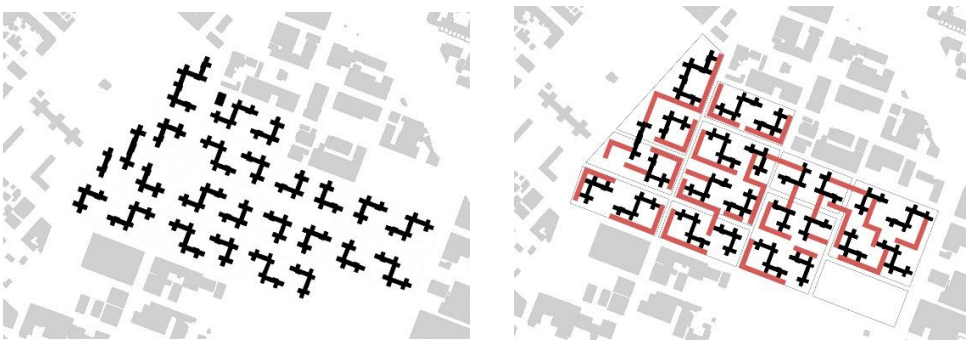

Figure 16: Labyrinthine Block B (Red Hook Houses) Doug Forscino

At Red Hook Houses (see Fig. 16) something similar was engineered, this time repeating the linearity of the original housing blocks to double the square footage, tighten the relationship to the street, and urbanize the interior spaces within as well. The decision to strip out the ground floor exposing the existing column structure and encasing entrances in glass intentionally contrasts with the figured spatial order.

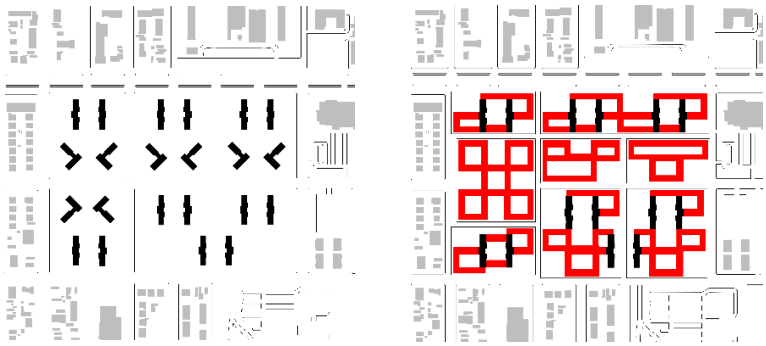

Figure 17: Labyrinthine Block C (Pink Houses) Izrael Shmuckler

For Pink Houses (see Fig. 17) the designer has worked with overlapping courtyard housing. The courtyards vary in size and in public accessibility and thus generate two distinct pathways through the neighborhood, one that adheres to the street and block and one that digresses from it and passes through the courtyards where accessible.

Freestyle Block

The fifth type is simply Freestyle Block or non-categorical. One academic goal of the studio was to take full advantage of the superblocks open ground and produce urban forms and public spaces that might not otherwise be possible.

Figure 18: Freestyle Block A (Mill Brook Houses) Anna Dwyer and Simon Huang

For the Mill Brook Houses (see Fig. 18) this project proposed expansions at two different scales. First, it followed the studio formula of introducing a set of apron structures to fill new blocks and shape spaces into three overlapping ribbons of differentiated usage- residential, commercial, and institutional. Second, it added bridges and extensions onto the 16-story slab buildings, shaping the urban space at a much grander scale. Its triumphal arches both create expectations and provide a gentle monumentality. Because most of the streets are short single block excursions, they will be low in traffic and slower in speed while restoring the sectional quality of the more traditional public realm.

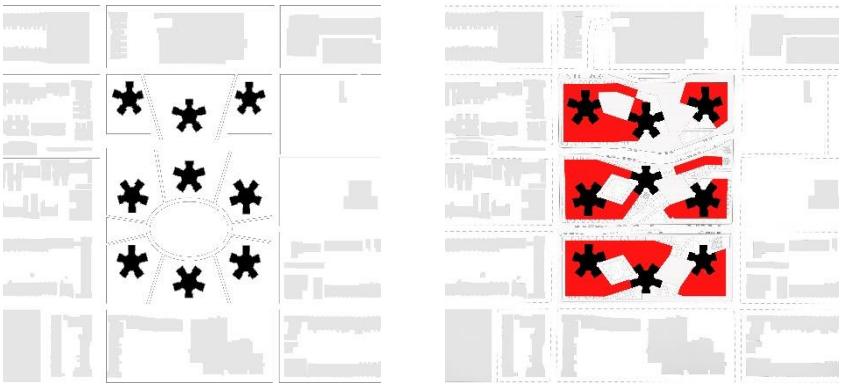

Figure 19: Freestyle Block B (Albany Houses) Joseph Shiveley

At Albany Houses the superblock has been restreeted picturesquely and the perimeters reshaped by new lowrise point loaded housing that offers a repeating array of stoops, a primary feature of the larger neighborhood. The three longer blocks are further broken up by a meandering public plaza that is a new kind of defined space.

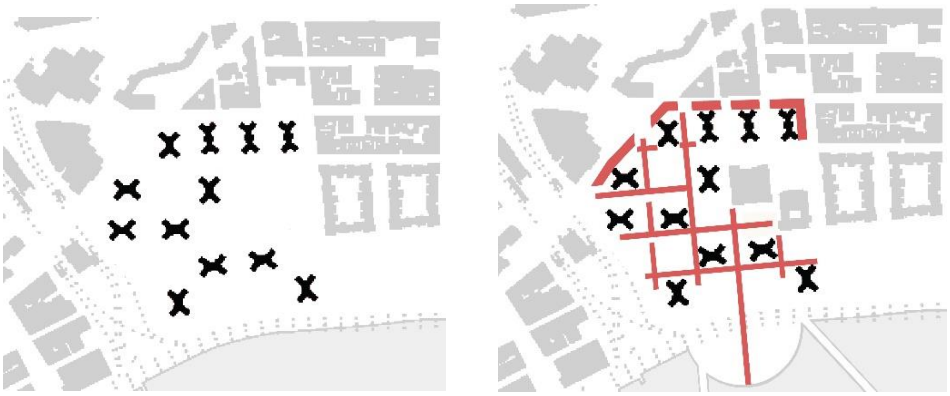

Figure 20: Freestyle Block C (Mill Brook Houses) Jason Kim

The last project, for Smith Houses (see Fig. 20), performs a kind of critique of the entire enterprise. Recalling perhaps Aldo Rossi's San Rocco Monza, it superimposes a low-rise grid of brutalist courtyard-based housing onto the Smith House towers, encasing each within an individual frame. It specifically does not resolve or change the freestanding character of the original, and the majority of its courtyards are formally compromised by the presence of a tower in their midst. Nonetheless, the museification of the original still manages to resolve the sites boundary by fully integrating it with the surrounding fabric.

It has been quite some time since public housing carried the flag of the future by replacing what was then a discredited prior housing model, the tenement house, by condemning it as a slum and tearing it down to make way for that future. But perhaps its time has come again.
As the superblock public housing estate has itself now been universally discredited as fundamentally anti-urban, can we identify a way and a means to transform it, only this time without the wrecking ball. The most environmentally responsible decision we can make today is to retain the architecture that is in place rather than raze and have to rebuild it over again. And the more socially responsible decision is not to preserve the relics from what was an authoritarian vision of our future, but to transform them. The premise of the *Reinvention of Public Housing* studios was to look at the public housing legacy, not as

a failure to be erased (as has been done in Chicago, Baltimore and New Orleans), but as an idea left unfinished. Thus, the best sense of this work is in providing tactical prototypes, the templates that are necessary to transform other sites so that we might make our cities whole again.

End Notes

1 The shift of responsibility for the failures of public housing away from architects and planners to the bureaucratic managers has been more recently repeated. See Chad Friedrichs, dir., The Pruitt- Igoe Myth (Unicorn Stencil Documentary Film, 2011).

2 Nicholas Dagen Bloom*, Public Housing That Worked: New York in the Twentieth Century* (Philadelphia: University of Pennsylvania Press, 2009), 4.

3 The stated goal of the original 1949 Federal Housing Act legislation allowing for the use of eminent domain to clear urban slums and replace them with new housing.

4 Steven Conn, *Americans against the City – Anti-Urbanism in the Twentieth Century* (Oxford, UK: Oxford University Press Inc, 2016), 306.

5 FAR or Floor Area Ratio is the principal bulk regulation controlling the size of buildings. FAR is the ratio of total building floor area to the area of its zoning lot. Each zoning district has an FAR which, when multiplied by the lot area of the zoning lot, produces the maximum amount of floor area allowable on that zoning lot. See *Zoning glossary NYC Department of City Planning.* https://www1.nyc.gov/site/planning/zoning/glossary.page

6 NYCHA 2.0. see https://www1.nyc.gov/assets/nycha/downloads/pdf/NYCHA-2.0-Part1.pdf

7 Richard Plunz*, A History of Housing in New York City: Dwelling Type and Social Change in the American Metropolis* (New York: Columbia University Press, 1990), 209.

8 My recent paper discusses how the proliferation of the tower-in-the-park mandate could have taken a very different path. See Biehle, Frederick Chaffee, Fast Forward into the Past: Frederick Ackerman's Radical Banality and the Affordable Housing Future That Could Have Been. https://doi.org/10.1080/20507828.2020.1792126. Architecture and Collective Life Vol 8_issue 3+4, forthcoming.

9 Vancouverism has come to mean a number of different things reflecting the development of Vancouver, Canada, but from an urban form standpoint means tall slim towers for density, widely separated for light, air and views, complemented by low-rise buildings, often townhouses, that fill out the blocks and maintain a pedestrian scale.