

Creative Infrastructure: Dynamic Intersections of Urban Ecology and Civic Life

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Infrastructure • Structure + Process

Like many designer/citizens, I am concerned about the ecological degradation of biotic systems, particularly the natural systems of which cities are parts.¹ Many have enriched the instrumentalist discussion of ‘sustainable’ design discussion and enlisted a review of urban ecology’s potential role as an infrastructure, urging that the relationship demands new urban forms.² These expressions indeed reveal the workings of the city and demonstrate how natural and engineered systems can be synthesized into new aesthetics and territories for reinvigorated meaning in built landscapes.³

I join them and simultaneously depart from them by underscoring the limitations of the predominant view that attempts to translate ecological *structure* into built form. Ecological structure is the momentary organization of an ecosystem. It is the static organization of the landscape: the size of trees, the placement of elements in space, the physical relationships between organisms and food sources and the like. And while these expressions of ecological structure are worthwhile, they do not tap the full potential of ecological understandings. For the more we learn about ecology, the more we understand that the ecological structure is merely an artifact of much more important ecological *processes*. These largely unseen operations that create a landscape’s structure—erosion, reproduction, mutualisms, herbivory, predator-prey relationships, and biochemical reactions—are the vital forces that drive natural systems and continue to influence the infrastructure of cities, no matter how altered and managed.⁴

I propose that we build upon these investigations of ecological process and infrastructure by proposing a direction for reimagining infrastructure. By focusing on one municipal infrastructure, stormwater, I will build an argument for a *creative civic infrastructure*. It is an ecological infrastructure that taps the ongoing phenomena and activities that make the city alive and pulsing with not only biotic nutrients but also social interaction and civic imagination.

Civic Meaning

In exploring how ‘civic’ might be expanded, I begin with ‘civic’ in its broadest sense as it relates to the activities, needs, and concerns of the general public. Eschewing private interests, it is that which serves the common good.⁵ In the history of municipal stormwater systems, the examples of infrastructure serving the common good have reflected or re-presented the city. From the public squares of Rome to Haussmanian streets to 19th c. parks, municipal stormwater infrastructure has intentionally expressed societal values about nature and its attendant ecologies and the relationships of both to the city. In other words,

these infrastructures have signified the city itself, that which is the common territory of all citizens. And as Hannah Arendt has described, that expression relies on the simultaneous presence of innumerable perspectives, demanding that its common identity be discerned by all but also be without common measurement.⁶ Unfortunately, “common” has become debased to lowest denominator, and urban infrastructure has become a socially neutral act of economic efficiency. They have been standardized to the point of banal, relegated to the forgotten margins of projects, and obliterated any relationship to the natural infrastructure from which the city has emerged. Consequently, municipal infrastructure may be public works that serve the common good—in the abstract—but also strip from the city one of its most important opportunities for civic expression.

This essay explores how ecology might be used as a vehicle for reinvigorating civic expression and consequently civic life. It challenges conventional notions of static municipal infrastructure, first, by distinguishing between realizations that involve ecological processes, those that are merely “dynamic,” and those where dynamism is more encompassingly “creative.” Throughout the argument we discover how ecology both expands current meanings of civic and revives forgotten meanings to re-emerge. And we realize how infrastructure’s creative aspects might be extended from formal considerations to its potential as a place for civic transformation.

Challenges to Fixed, Conventional Infrastructure

Mill Creek Canyon Park (1982) remains a watershed design in the transformation of stormwater infrastructure into meaningful civic space. Designer Herbert Bayer makes a park that not only repairs a badly eroded canyon (his primary charge) but also doubles as stormwater detention. The design transcends the static nature of standardized “fixed” public works by stressing the *works*, the action. Here, water acts as a moving, lyrical melody. A series of earth frames detain the water and offer structures which register the water’s changing levels. The flooding of the clearly incised geometrical forms permits changed readings of these forms, as demonstrated by the accompanying computer animations.

The park’s reading of process is not dependent upon the presence of water. Through the careful orchestration of the small, base-flow creek and the various heights of the landforms, the volumity of water is inflected. Citizens’ imaginations can empty and fill the park with water and allow water to circumnavigate their experiences.

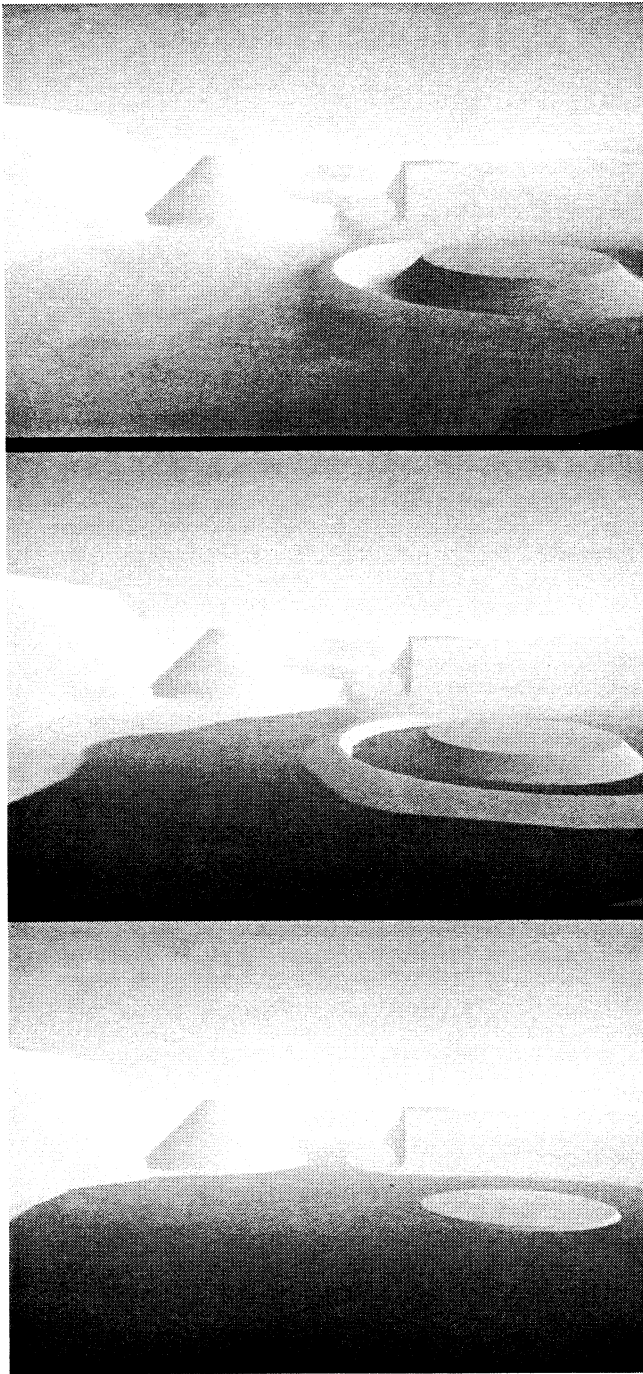


Fig. 1. Mill Creek Canyon Park: dry, flooded, inundated (Computer animations by Ben Logan)

The park's design gives physical form to civic's Latin roots, *civitas*, which referred to citizenship as a collection of individuals "united in a community, the body-politic, the state...as this consists of one city *and its territory*."⁷⁷ [emphasis mine] It is set within a specific topography, a canyon that is incised into citizens' memories. And its processes are composed of particular structures and dynamics. At Mill Creek, stormwater is given civic presence beyond its usual public service function. It is a physical expression that deepens and clarifies for the town's citizens their places within this city of Kent, Washington.

Distinguishing Between Process and Dynamics

While clearly dependent upon hydrological process for its conceptual meaning and its forms, Mill Creek Canyon Park demonstrates the limitations of relying on ecological process for design content. It remains static in the sense that it does not engage them beyond being a fixed form *upon which* a phenomenal element, water, reacts.

Attempts like Mill Creek Canyon to use ecological process tend to reduce biological activities to simple and discretely understandable interactions; they are oriented towards systems' self-regulation within a relatively stable equilibrium. The designs may "reveal" or "celebrate" the underlying, unseen ecological functions, but they remain focused on a discrete process and treat it deterministically, as if a known set of behaviors will definitely occur. "Dynamics," on the other hand, includes process and much, much more. Where processes are simply the mechanistic operations that drive ecology, dynamics is the complex interaction between all the processes. It is the force that creates opportunities for evolving and changing over time. Analogously, process versus dynamics is the difference between having merely chemistry and suddenly having life.⁸

Revitalizing Civic Hydrology

Shop Creek Park in Denver, Colorado is an example of stormwater infrastructure that enlists more complex ecological dynamics rather than simply process. William Wenk Associates' rammed earth drop structures have repaired an ecological disaster of a channel, and they control flooding by impounding water. Their plunge pools slow sediments, effectively cleansing the runoff from the adjacent housing development. Their earthen sides and initial plantings create wetlands that filter pollutants and provide wildlife habitats.

Shop Creek also gives a revitalized expression to civic infrastructure through the initiation of ecological dynamics. Wenk's landscape began as a relatively pristine set of constructed pools. As the processes of sedimentation and nutrient loading were introduced, the landscape has taken on a dynamic of its own. In part this is due to the natural temporal qualities of living things, vividly changing with the seasons and the fluctuating amounts of rainfall and groundwater. And in part, it is due to the intentional lack of "sanitizing" maintenance that characterizes most stormwater infrastructure projects. However, this is also due to the design. The coursing and pooling forms give metaphoric fullness to the ebb and flow of water. Complex ecosystems, their murky bottoms allow participants to immerse their imaginations in the unknown, the wonder, of life. These wetlands represent the indeterminacy, the unpredictable, and the marginal of our world. They are spaces between actual and imagined worlds.⁹ They are reflexive vessels, able to reciprocally respond to biophysical ecological processes and human interventions. Consistent with dynamic's definition of "marked by continuous pro-

ductive activity or change,”¹⁰ the project is resistant to any fixed aesthetic or civic meaning.

Distinguishing Between Dynamic and Creative

Shop Creek extends the use of ecological process to engage the dynamic. Yet, its formal dynamism is limited. The project is, in fact, relatively discretely contained and its behavior largely predictable. Its ability to continue its dynamic evolution is limited. Plus, it will inevitably have to be dredged at some point resetting the evolutionary clock back to its original beginning state. Therefore, it leaves us with some nagging issues. Specifically, while it engages the processes of urban ecology and gives aesthetic form to living systems’ dynamics, it stops short of fully embracing ecological dynamics’ most important aspect—that living systems’ very essence is “creativity.”

Living systems do not passively respond to events the way a leaf blows in a windstorm. They actively turn whatever happens to their advantage, constantly redefining themselves, operating under their own self-defined behaviors. They have a structure, coherence, and self-regulation that allows them to bring order and chaos into a special kind of dynamic balance.¹¹ Creative differs from dynamic in degree by taking it one step further. But it is a big step. Dynamic systems are those that allow complex processes to engage the ongoing expression of the artifact through time, but their expressions are largely predictable because the probability of behaviors is well known. Creative systems are those that continue to respond to the constantly changing variables, each time making something new of itself. Therefore, it is operating within complex dynamics, the behaviors of which are unknown let alone predictable.

Once extrapolated to urban design, a creative infrastructure is one that is constantly making something new of itself long after the designers have left the scene. Its ‘ultimate’ outcome is unknown. And it is not an infrastructure that operates on its own. Instead, it engages other forces and physical expressions. Where dynamic infrastructure changes through time, creative infrastructure’s formal relationships are determined by the reciprocating acts of human intention and biological process—where the components never quite lock into place and yet never quite dissolve into turbulence, either.

The most compelling example of creative infrastructure applied to stormwater is in an effort by architect and landscape architect Keith McPeters.¹² He has created a landscape that is truly “evolutionary,” combining conventional municipal stormwater techniques with the dynamism of the River’s geomorphology to strategize a creative form of infrastructure.

The site straddles the Anacostia River at the northeastern border of the District of Columbia near Bladensburg, Maryland. For over 250 years of European inhabitation, the River has been continually engineered, first through the filling of riparian marshes and then through the dredging of a harbor for a thriving tobacco trade. The Army Corps of Engineers’ levee efforts



Fig. 2. Shop Creek Park aerial (Courtesy William Wenk).



Fig. 3. Shop Creek Park vessels (Courtesy William Wenk).

have effectively controlled any dynamic processes, whether biotic or social. The adjacent neighborhoods have been visually and physically severed from the civic body of the River, and the biotic complexity has been reduced to trash species—and literal garbage. It has 50 times the normal sediment load, demanding a 24-hour a day dredging operation.

McPeters’ design will extend the history of culturally induced form. Released from its constriction of being only of the natural realm, the River is reframed. Neither aqueduct nor canal nor pastoral visual body, the river is less redefined as restructured as a series of baffles.

Through a few strategic gestures, he creates a design that, in essence, forms itself. By building a wall in the present river on the western edge of Bladensburg, McPeters establishes an edge behind which sediment collects along concrete and steel “ribs.” Using common water filtration technology, the process of *creating* land is set in motion. Acting as a sand filtration lens for the city’s storm water and a “trap” for an upstream gravel mining operation, this skeleton becomes a “gill” for the city’s water, cleansing it of toxins and, eventually, breathing new life into this near-dead city.

On the west side of the present River, McPeters has reestablished one of the natural meanders of the Anacostia. The resultant island begins as a perfectly formed geometry, resembling an inverted ship’s hull. It is a beginning field upon which to register the fluctuations of tide, deposition, and erosion—consequences of the seasons of this place. It is a creative schematization rather than an explicit design, responding to the reciprocating forces of (what I can find no better term for) a “built natural landscape.”



Fig. 4. McPeters model of 'ship hull' island and 'gill'.

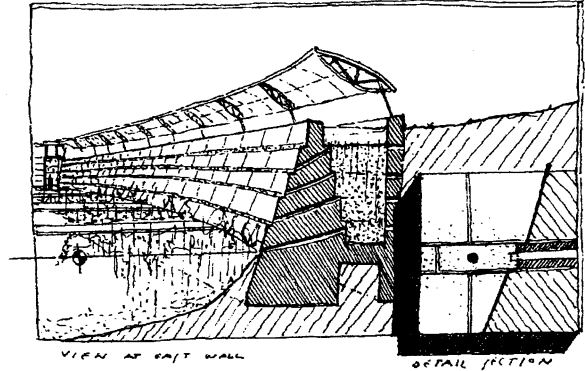


Fig. 6. McPeters speculation of city/filtration edge

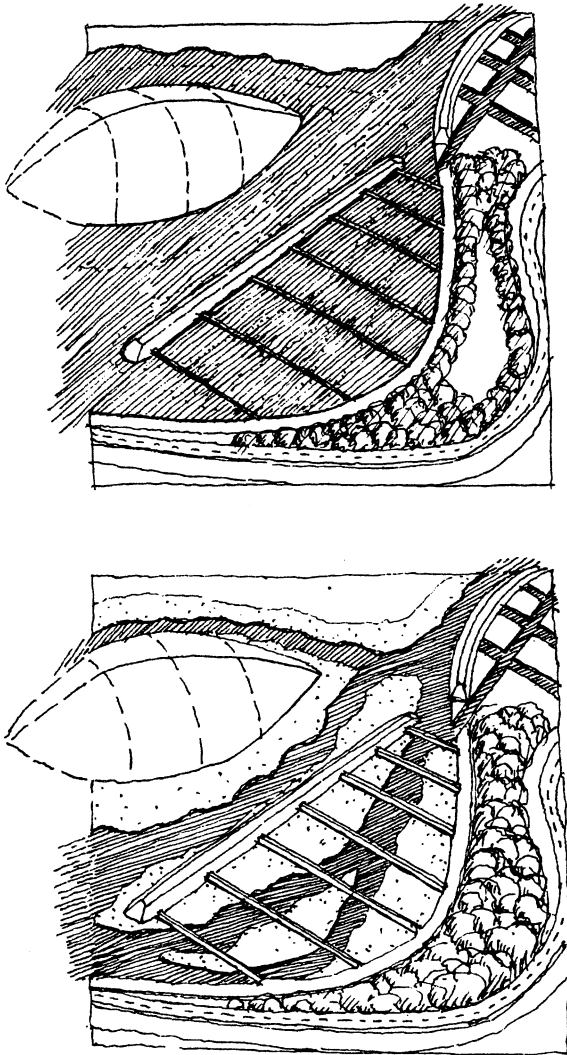


Fig. 5. McPeters diagram of strategy at installation and accreting 'land.'

Beyond Formal Considerations: Creative Civics

McPeters' design illuminates critical issues that are paramount in any discussion of dynamics. Primarily, it demonstrates why the task of reframing infrastructure as a creative activity *must* extend beyond *formal* considerations. To limit our consideration of creative infrastructure to *form* risks reducing the role of infrastructure design to a mere study of phenomena. Such a 'giant science experiment' approach would hardly be more creative than contemporary standardized solutions. The primary task of reframing infrastructure as a creative activity is also one of re-evaluating our notions of civic.

From luminaries such as Patrick Geddes, Daniel Burnham, Werner Hegemann, Elbert Peets, City Beautiful era figures, and a host of neoclassical designers, we have inherited a classical notion of civic as a *permanent* exhibition of culture for the education *of* and transmission *to* the masses. The implication is the existence of a constant and exemplary civic paragon, an interpretation that is often laced with elitist or paternalistic connotations.

A more creative civics suggests that the most effective and meaningful civics is one that is *in flux* over time and in response to various conditions. Just as creative ecological systems are constantly reorganizing themselves in seemingly chaotic yet delicately ordered ways, creative civic infrastructure is a reflexive structure that, in response to its changing context, can undergo transformation. This metaphoric and corporeal ground is an expression of the potential of citizens' creativity. Where classical civic infrastructure is a static entity within the city that serves the common good, creative civic infrastructure serves the common good by providing an ever-changing, catalytic forum that citizens have the power to participate in forming.

Citizens' participation *may* be in the form of becoming more involved in the political activities of the city. Clearly, citizens can be catalyzed into participation through other means—education, solicitation, gathering around a cause, to name a few. And by embracing biological systems and their evolutionary creativity, there is opportunity for demonstrating more responsible environmental practices, "sustainable" techniques and the like. And it *may* be a means of getting people to "behave" more responsibly towards the larger environment. Yet, this is the very moralizing and social engineering that creative civics seeks to

avoid. Creative infrastructure's metaphors of malleability and latent invention are important for capturing the imaginations of citizens. It is through these metaphors that citizens become *interested* in the workings of the city, *captivated* by what it means to be a citizen of a place, and *absorbed* in the possibilities of what the city can become.

Such a social conception of infrastructure demonstrates the limitations of too-heavily relying on a singular form to express civic potential. It demonstrates how a more productive way of regarding infrastructure is to view it as a reciprocating relationship between dynamic built constructions and the civic realm. It is both reactive and catalytic in inviting us as citizens to continuously redefine the city, our places as urban inhabitants, and our perceptions of ourselves.

Infrastructure in the name of civic or creative does not necessarily make it so, and McPeters's design shows one approach to strategizing the processes that are necessary for the infrastructure to continue to be civic. If, as I have argued, creative infrastructure is dependent on the reciprocation between citizens and ecological forces, then engaging people in the continued making of these landscapes is vital. Eventually, the dynamic will form the new ground of the city. The concrete footholds will constitute the new "bedrock," the organic geology for the city's future development. The citizens of Bladensburg and Colmar Manor, the adjacent communities, will witness a transformed understanding of their citizenship. Not only will they regain part of the territory that defines their relationship with the River, they will be a part of its continual development and imagination—the forms of which they will create and destroy along with the dynamics of the River. From this perspective, infrastructure is what "civic" means as a momentary organization and as a dynamic entity that must continuously recreate itself. Ultimately, the most significant civic infrastructure reveals itself as *our imagination* of what "civic" might become.

Creative Strategies

We express those things that we value: the things that touch our hearts, the ideas that spark our intellects, and the concepts that unite us as a community. And our physical expressions, in turn, spur our imaginations about *potential* relationships with the city and fellow citizens.

This reciprocating relationship prompts us to ask whether creative municipal infrastructure may be more a question of creating *strategies* or making *instruments* than of prescribing any particular design form. Rather than "designing" structures that are capable of acquiring different characters (as in Shop Creek Park) or creating built/natural relationships that can infinitely evolve within natural processes (as in the Anacostia), the designer's task might be redefined as defining initial parameters, relationships, and interactions that then take on a life of their own. While the designer may "equip" the landscape to accommodate particular programmatic activities, social relationships, and even meanings, the physical field has the freedom to

gather, improvise, and transcend those original intentions in ways that the designer may or may not—in her singular mind—have yet imagined.

This tactic of design strategies has clear precedence in the work of a few contemporary urbanists, most notably in two. Landscape architect Michel Desvigne proposes landscapes that are more mediums than compositions. His gridded and lined landscapes hover between figure and field, inviting other elements—whether programmatic or physical—to interact with his plantings and indeed alter his original plantings. Furthermore, he intentionally overplants the landscape with trees that fill the space when they are young but will need thinning as they mature. In this way, the continued transformation of the landscape is necessitated.

Perhaps best-known is OMA/Rem Koolhaas who has been noted for its methods of *assembling* urban components in a way that allows both for the play of chance elements and for formal interventions.¹³ Despite the projects' employment of multiple geometries and resistance to *singular* diagrams of order, concept, their groundedness in a reading of the city allow unexpected orders to emerge. They are orders that participate and even catapult the contemporary city's continual diversification and breakneck-speed evolution.¹⁴

The creative infrastructure proposed here is indebted to these thinkers but departs from them in two significant ways. The approaches are synchronous in that they resist reinventing or rebuilding *tabula rasa* style. They reframe existing contexts with infrastructure that provides alternative and fresh ways of viewing oneself within the city. Yet, where others propose an infrastructural framework that enables social, economic, and political acts, creative infrastructure seeks forces that will necessarily bring about the eventual *physical* overhaul of that infrastructure. Just as creative infrastructure is a physical metaphor for catalyzing socio-political ideals, the abstract ideals are meant to reciprocally manifest themselves in physical form.

And second, where others propose infrastructural strategies that will facilitate creative acts by other institutions, all of which are powered by people, creative infrastructure enlists both people *and* processes beyond human creation, that is, the biophysical ecology of the city. Creative infrastructure continues to welcome and thrive on reciprocation between human and non-human forces: human action alters the non-human, "natural" world that, in turn, alters the human creation; each entity simultaneously alters and creates a vital city.

Static Creative Infrastructure

Having taken the argument through its rigors, we must ask the question of whether an infrastructure *must* evolve through time. Santiago Calatrava's Alamillo Bridge in Seville (1987) demonstrates how infrastructure can be creative by moving only as much as necessary for structural deflection. Rather than move with the Meandro San Jeronimo, the dynamic is inflected. The bridge responds to the ecology of the river in its placement of

the pylon on the depositional (and not erosional) bank. Anchored firmly to this accreting ground, the 656 foot span seems as if in a flood it might float on the water's surface. The fifty-eight degree inclination makes the cables seem to exert energy, to be pulled to their limits. Built as part of Expo '92, the bridge and attendant viaduct were always envisioned as a civic improvement for the town and surrounding areas. But Calatrava delivers a structure that is a civic monument, a soaring vision to which the city might *aspire*. In short, it begs for civic action.

Had the project been completed as originally designed, its creative civics would have been redoubled. Since the river is crossed twice, Calatrava designed two symmetrical bridges, 1.5 kilometers apart, to mirror one another. They would have implied a huge triangle whose apex was in the sky.¹⁵ The two points would have strategically identified a space between for citizens to use their imaginations and energy to begin recreating the city. The processes of the river are not physically engaged, only implied. Though the bridge, as an infrastructure, is static, it is no less creative. Because it will continue to interact with the natural processes of the river and because it will continue to resonate in the city's future making of itself, the bridge strategizes a city that Calatrava neither imagined nor needed to imagine. His creative infrastructure set in motion a series of reciprocating acts whose ultimate outcome is unknown but exciting.

Nonsentient Infrastructure

Since my argument is rooted within nonhuman systems, nature, it goes without saying that nonsentient systems—those that are not conscious of sense impressions or themselves—are creative. Yet, it is important to note that once applied to infrastructure—a basic component that allows congregated living—the issue takes on a different cast. And it demands that we ask whether interaction with natural systems is necessary. In other words has the consideration of natural systems' processes, dynamics, and creativity been a useful process for deriving design theory but their actual engagement in a design ultimately unnecessary once the potentials are exposed?

A mere glance at the history of water infrastructure attests to the fact that nature need not be part of design content for creative infrastructure to emerge. Yet, at this moment in history when we are struggling with how to employ ecologically positive water strategies that can support healthier cities for all urban residents, human and otherwise, the potentials for engaging natural systems' creativity is pressing. Otherwise, ecological understandings could be expressed instrumentally, in ways that are no better than current standardized engineering solutions. And more ecologically-concerned infrastructures might contribute nothing to civic life other than making citizens feel good about protecting a common resource, which currently is often little more than a private sentiment being superimposed on public space.

I would argue that to continue to engage natural systems will continue to enrich infrastructure design in part because they will always be part of cities' physical and conceptual content and

their health will always be inextricably linked to the "common good" of cities. Plus to actively engage natural systems will help rectify the current situation of our segregating ecology into its own realm—outside civic or any other realm—seemingly considering it good in its own right, a situation that stakes ecology and nature on moral high ground. We have failed to recognize that ecology is essentially a social construct and removed it from its cultural frames. To reframe ecology *within* a rich history of urban infrastructure, the expressive potentials will never be fully exposed. The synthesis will continue to be creative.

Redefining Infrastructure

In the context of stormwater, then, infrastructure becomes less a physical entity than a *portal* from which to re-view what we regard as the underlying structure of the city. Indeed, this exploration of creative infrastructure, as an expression of public space, should be regarded as a portal that opens new avenues of investigation, without diminishing others.

A pulsing, dynamic, and alive creative infrastructure offers an environmentally-positive way of thinking that allows a forgotten meaning of civic to be resurrected, that of the "freedom of the city."¹⁶ It is a freedom that embraces numerous kinds of public and civic experience. As a freed infrastructure, it promotes our congregation as citizens to both celebrate and contest our collective and private identities. Acknowledging that we are now a public composition of constantly shifting, overlapping, and disjunct groups, it is a freed infrastructure that allows indeterminacy, creative uncertainty, healthy competition, and spontaneity. The freely creative civic realm is "where new ideas and innovative genotypes are forever nibbling away at the edges of the status quo,"¹⁷ where infrastructure is constantly illuminating alternative visions for understanding the city and our places within it. Like the social environment that it is meant to foster, creative infrastructure is a metabolic strategy that cannot be predetermined, only speculated.

This is not to suggest that a creative civic infrastructure defines a context of "anything goes." This would amount to utter chaos. The important matter is that by aggressively engaging the biophysical ecology of the city, we discover a way to value not only the natural systems but also the social systems that had previously been excluded. And by engaging and expressing biological processes, the metaphor of change and flux is made manifest, and the idea of citizenry is extended beyond accepted monolithic, status quo definitions.

Hannah Arendt reminds us that it "is the publicity of the public realm which can absorb and make shine through the centuries whatever men may want to save from the natural ruin of time"¹⁸ The challenge is to give physical form and social opportunity to those things which we hold common while simultaneously encouraging citizens to continue the project. It is a formidable challenge to establish such a dynamic equilibrium and complexity that can flexibly resonate despite the "nibbling away" of time and those that it catalyzes. Yet, it is a worthwhile en-

deavor. For if we can provide forms and strategies in which citizens can exercise more aspects of their citizenship, then we will significantly contribute to reinvigorating civic life.

ACKNOWLEDGMENTS

I am grateful to those who have graciously commented on this essay and its associated talks, particularly Kenneth Helphand. Their challenges have made it better, though its faults are my own. I extend special thanks to Robin Dripps whose insights and care for the civic realm have refueled my passion and clarified my understandings of the roles that design might play.

NOTES

- ¹ Robert Hough's *City Form and Natural Process: Towards a New Urban Vernacular* (New York: Van Nostrand Reinhold Company, 1984) and particularly Anne Whiston Spirn's writings have articulated how natural systems are urban systems and that to engage them is to demand new realms of content and aesthetics. Their work has helped spur the recent flurry of ecological infrastructure, that is, infrastructure that does not damage natural ecosystems. Anne Whiston Spirn, *The Granite Garden: Urban Nature and Human Design* (Basic Books, 1984) and "The Poetics of City and Nature: Towards a New Aesthetic for Urban Design" in *Landscape Journal* vol. 7, no. 2 (1984):108-126.
- ² The discussion of ecology's relationship to design has too often been left on a technical level that fails to consider the larger cultural, political, and aesthetic aspects that are critical to successful urban design. Our situation is not much different than that of Colin Rowe's description of early 20th c. modern architecture's failure to reconcile dual myths of scientific allegiance and philanthropic idealism. He contended that the lack of reconciliation had stalled the project of making the modern city. Today we are trapped by the same dual and simultaneous threats of ecology's allegiance to science and attributing nature a moral authority that is rarely more than naïve idealism. We may use ecology to get all the parts right, that is, get Humpty Dumpty back together again. But in the process, we have debased ecology's cultural importance and allowed its creative use in urban design to stagnate except in the fewest of examples.
- ³ See Gary Strang, "Infrastructure as Landscape" in *CELA 1992: Design + Values*, pp. 93-102, and Elissa Rosenberg, "Public Works and Public Space: Rethinking the Urban Park" in *Journal of Architectural Education* vol. 50, no. 2 (1996):89-103.
- ⁴ A few designers and critics have proposed more provocative and promising questions for the role of ecology in infrastructure design by enlisting processes. Most notably, Hargreaves Associates not only acknowledges the inevitability of landscape change like growth, death, and seasonality but gives expressive form to the unseen forces that generate those processes, particularly erosion, hydrology, and the change of the landscape over time. And James Corner has argued persuasively for more creative approaches to incorporating ecology in design. Despite this work, few designs have contributed to the larger issues and content of making cities.
- ⁵ David Gobel, "Introduction" in *Modulus 17: The University of Virginia Architectural Review* (New York: Rizzoli, 1986), p. 1.

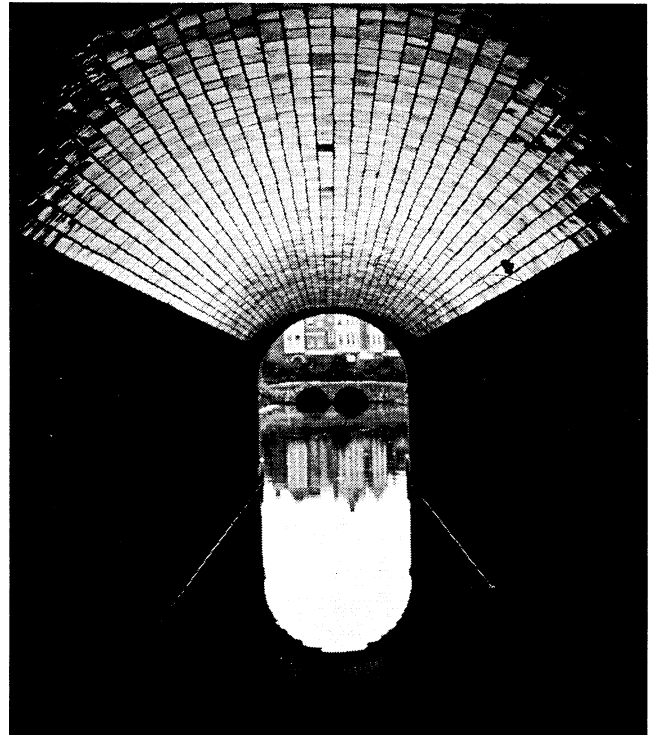


Fig. 7. Portal to re-viewing infrastructure: View from inside culvert (Courtesy Olmsted National Historic Site).

- ⁶ Hannah Arendt, "The Public Realm: The Common," in *The Public Face of Architecture: Civic Culture and Public Spaces*, eds. Nathan Glazer and Mark Lilla (New York: Free Press, 1987), pp. 5-12.
- ⁷ Charlton T. Lewis and Charles Short, ed. *A Latin Dictionary Founded on Andrews' Edition of Freund's Latin Dictionary*. Revised and enlarged edition (Oxford: Clarendon Press, 1969).
- ⁸ Thanks to Dr. Jean Marie Hartman, who helped me understand this concept and articulate it in scientific terms.
- ⁹ William Howarth, "From Swamp to Marsh: The Evolving Literature of American Wetlands." Paper given at the Society for Ecological Restoration 1996 International Conference, Rutgers, State University of New Jersey, New Brunswick, New Jersey.
- ¹⁰ *Webster's New Collegiate Dictionary* (Springfield, Massachusetts: G. & C. Merriam Company, 1977).
- ¹¹ M. Mitchell Waldrop, *Complexity: the Emerging Science at the Edge of Order and Chaos* (New York: Simon and Schuster, 1992), p. 5.
- ¹² McPeters completed the project in a graduate landscape architecture studio "Civic Ecology" at the University of Virginia. The author was the instructor.
- ¹³ Jacques Lucan, OMA-Rem Koolhaas: Architecture 1970-1990 (New York: Princeton Architectural Press, 1991), pp. 14-16.
- ¹⁴ As Sanford Kwinter has so aptly described, "It is never a question of organizing a space at the outset, but rather of unleashing, triggering, or capturing larger any already existing processes." Sanford Kwinter, "Rem Koolhaas, OMA : Urbanism After Innocence: Four Projects," *Assemblage 18: The Reinvention of Geometry* (1992): 83-113.
- ¹⁵ Kenneth Frampton, Anthony C. Webster, and Anthony Tischhauser, *Calatrava Bridges* (Zurich: Artemis, 1993).
- ¹⁶ Lewis and Short, op. cit.
- ¹⁷ Waldrop, op. cit., p. 12.
- ¹⁸ Arendt, op. cit, p. 10.

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