Remaking Water Legible: A Prototype for a Communicative Landscape

In contemporary American cities, the hydrology of the place has been largely ignored. Drainage systems have been put underground unnecessarily or channelized with concrete, erasing the visual and spatial logic of the region.

—Gary Strong "Infrastructure as Landscape"

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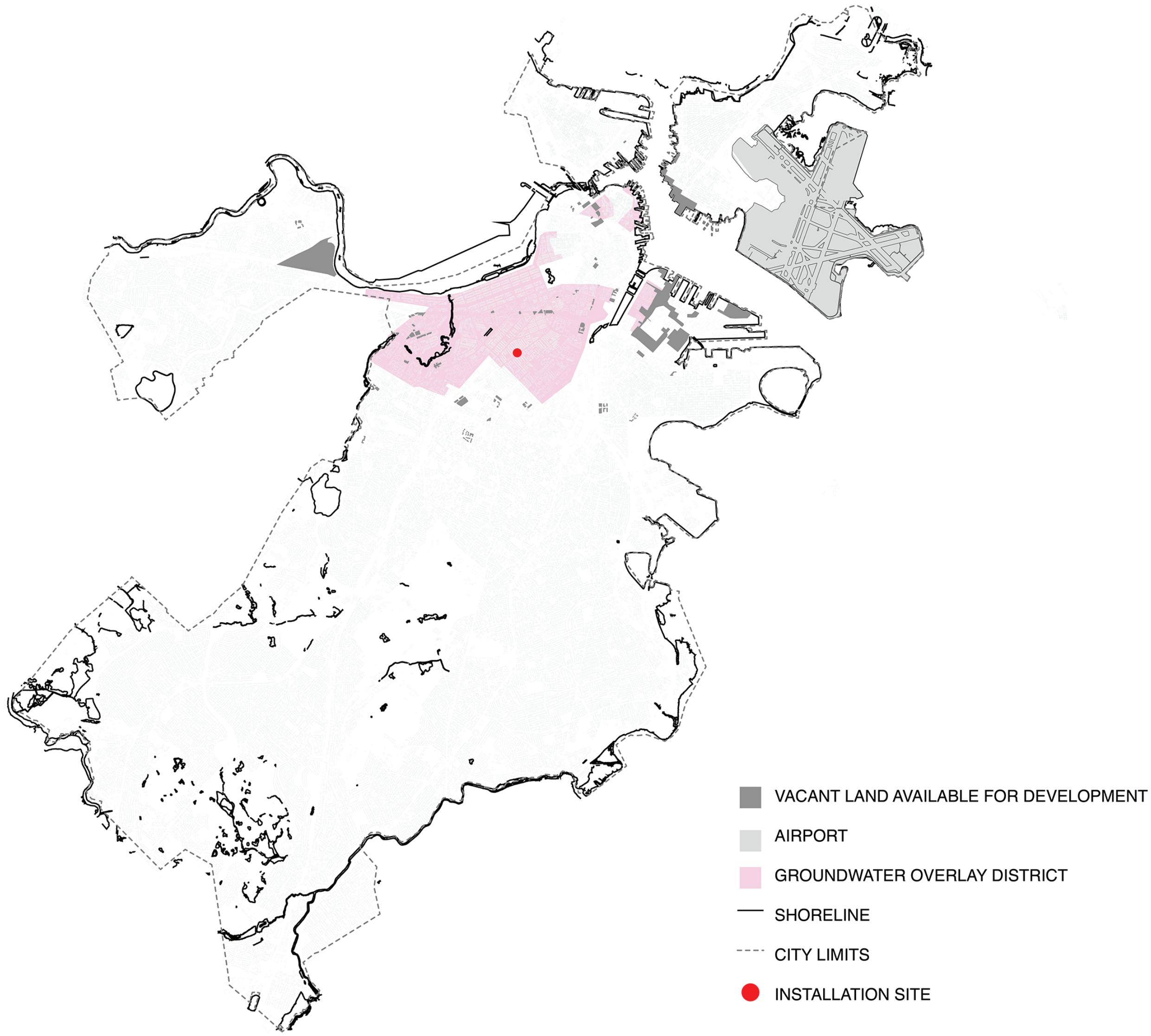
THE SCALE OF THE WATER PROBLEM

The past, the present and the future of Boston are tied to water. Pushing into the harbor, covering tidal flats and filling vast areas of new land defined many of the city's boundaries for more than two centuries.[1] Many of Boston's public spaces are organized in great part by Frederick Law Olmstead's principles of city planning, that transformed salt marsh landscapes of the Fens into an infrastructure to regulate tidal flows, control floods and associated storm and sewer overflows.[2] Today, large-scale restoration projects in the Muddy River attempt to reactivate the capacity for flooding control and water quality of Olmsted's landscape systems by daylighting the river, removing invasive species and removing obstructions created by pipes. On the other hand, the underground construction of buildings and infrastructure, coupled with the increase in impervious cover, has reduced the ground water levels in historic districts now threatened by rotting wooden pile foundations that were left exposed to dry. And at the same time, the future of the city is increasingly shaped by the threats of sea level rise on low lying areas and the harbor, but also by the projections of increased frequency of extreme rain events that can cause inland and riverine flooding. From the Living with Water design competition, to the city's plans on climate resilience and adaptation, every aspect of future city planning involves a conversation about water.

Boston's relationship with water is very legible from a bird's eye view. The Fens, the airport and the Harbor are the most recognizable physical attributes of the legacy of water-based large scale planning. Evaluating vacant land available for development in the city of Boston reveals that most of the future new development within city limits will likely happen along coastal or riparian areas (Figure 1). Architects and landscape architects in practice and academia often study the physical form of Boston, its relationship to water, and its urban ecology, when engaging in speculative projects about the future of large new developments, attempting to find responses to the question of how these may be designed to coexist with water. However, when observing maps of future flood projections (Figure 2), we can see that much of the already existing fabric of Boston, where the past relationship to water can only be seen in historical maps of land making or in maps of Combined Sewer Overflows (CSO), is



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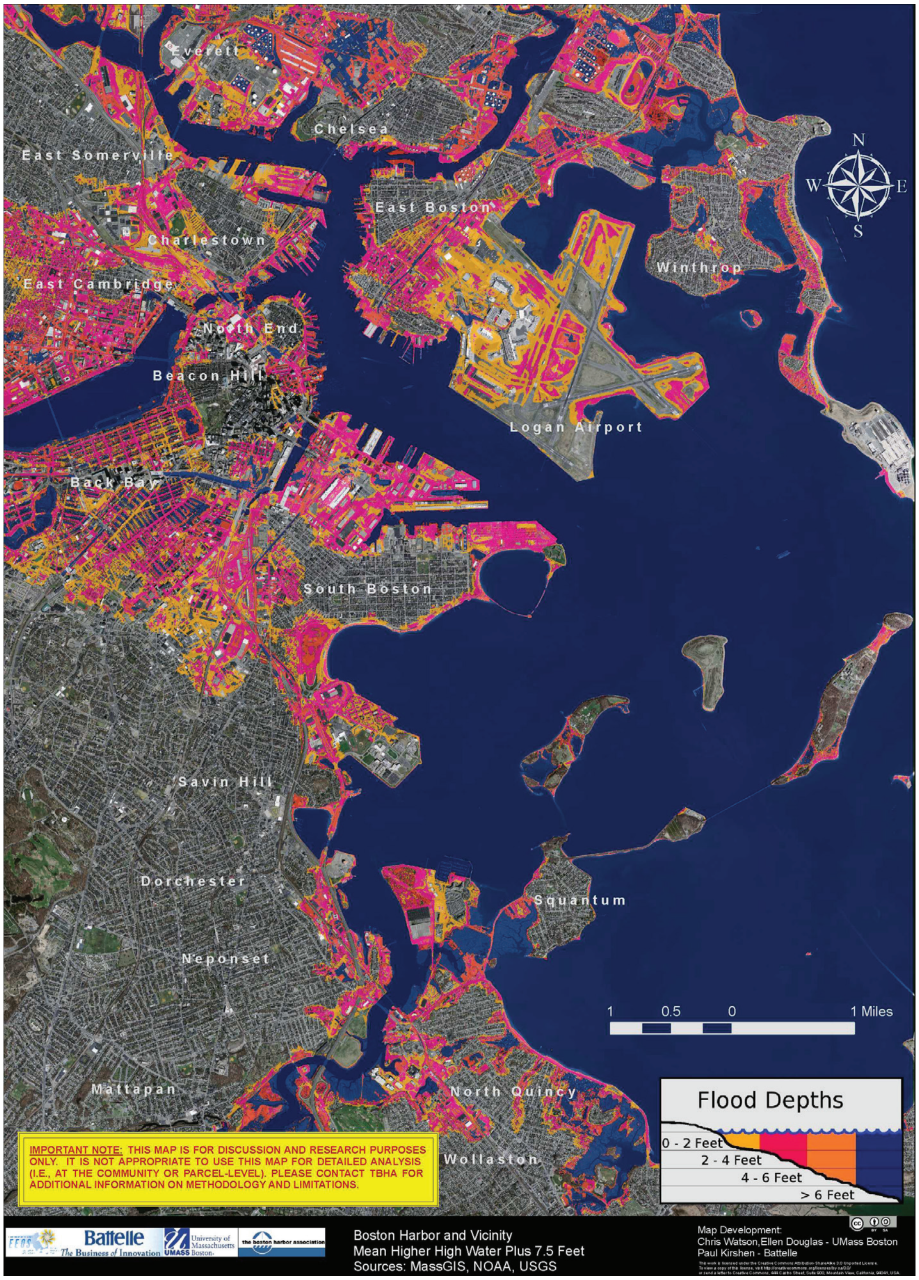
a fabric that is both vulnerable to the threat of water, and at the same time responsible for the increased stress on infrastructure created in these urban areas during large rain events.

The relationship to water, so evident in the morphology of the city when seen from a bird's eye view, is lost at a human scale. The experience at the ground in many parts of the city does not include the presence or consciousness of water, its history or its process. With the exception of the harbor or a few culturally significant spaces in the historic fabric that are visibly connected to Olmsted's landscape infrastructure of the Emerald Necklace, the only visible reminder of the role of water in the urban environment can be seen near street drains that say: "DON'T DUMP, drains to the Charles River" (Figure 3). Water, and its legacy, is invisible in most of Boston, except when it suddenly is not. In many urban environments, water quickly and violently becomes visible when it is overwhelming urban infrastructure and interrupting daily lives. As a subject matter in urbanism, water seems to exist between two extremes: it makes urban space and it threatens to destroy it. Architects and landscape architects must ask: can we develop a productive and more inspired relationship with water by making it a visible and active part of daily urban life? Would a landscape where water and its processes are more legible and culturally significant change public engagement with this ecosystem?

Figure 1: Map of Boston showing vacant land area, most significant land making project (Logan Airport), and the groundwater conservation overlay district, which covers most neighborhoods built on fill before the 20th century. The site of the installation is indicated. *Credit: image by author.*



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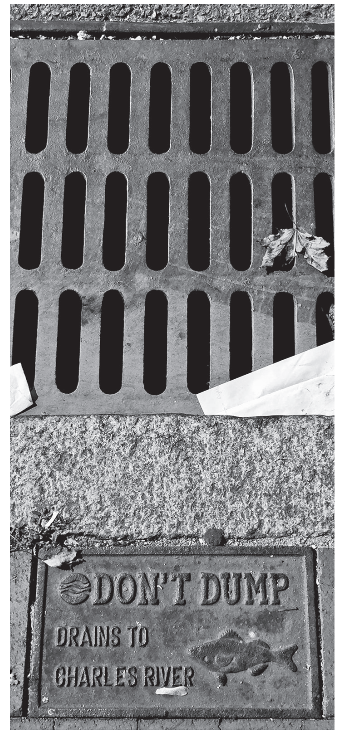

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WATER, REGIONAL LANDSCAPES AND THE LANGUAGE OF CITY MAKING

When we think about living with water, Venice comes to mind. An extremely unique example, Venice exemplifies the simultaneous adaptation and vulnerability of a place. The experience of water in Venice is both formative and destructive, but it is also a daily occurrence that becomes part of the cultural identity and production of a place. The design project of city making and architecture is found at multiple scales. In Venice, the large infrastructure project attempts to resist and protect the entire city from the destructive power of water, while other meaningful small projects exploit the creative potential of absorbing water into its internal organizational logic, and turning water into the main narrative of the spatial and tectonic experience. The urban scale project that is Venice's relationship with water today developed the unique and powerful aquatic sensibility of the architect Carlo Scarpa.[3] The design of the Quarini Stampalia Foundation, which allows water into the entry sequence of the building and turns it into a phenomenological experience, a narrative for both building

Figure 2 (left): Sea level rise flood projections for Boston. Impact of 7.5 feet of flooding above mean high tide on the Boston Harbor coastline, produced through one or more of three reasons: sea level rise, storm surge or astronomical high tide. Developed in 2010 by Dr. Paul Kirshen, Dr. Ellen Douglas and Mr. Chris Watson. *Image credit: The Boston Harbor Association.*

Figure 3 (right): Street drain in Boston. *Image credit: by author.*

and landscape, could not be conceived were it not for the impact of water on the collective consciousness and the place identity of Venetians, including agents like Scarpa operating in the physical environment.

In many other places around the world, contemporary cities are engaging with water at a large scale to address environmental issues associated with older infrastructure that combined storm and sewer systems, and to face a changing climate that brings the destructive and constructive potential of water into the public consciousness. The contemporary context of landscape or ecological urbanism emphasizes restoration of natural processes and hydrological cycles as a new form of infrastructure—while engaging the role of water in place identity cultural production—inviting architects, landscape architects and urban designers to see and engage water as more than a technical or environmental challenge, but also as a creative source of place making. The range of strategies found in current practice operates between a naturalized and structured approach, often based on the nature of the site, and the historical legacy of the regional landscape.

The Netherlands is well known for national efforts in land making, and a structured approach to city making where water is a force to protect from but also a generative and beautiful part of urban space and daily life, with parks over dikes, canals and channels organizing urban space. Most notably, the Delta city of Rotterdam, like most of the Netherlands is challenged by sea level rise around low land that lies below sea level, as well as high density and extensive impervious cover. In recent years, the dramatic increase in rainfall creates a bigger challenge than the sea, with the city estimating a needed retention capacity of 600,000 m^3 (160 million gallons) or a 80 hectares (200 acres) lake.4 With large retention projects under a limited number of new garages and other large structures proving insufficient and unfeasible in the existing dense city center and 19th century neighborhoods, rainwater storage needs to be collected across a wide network, and preferably closer to where it falls.[5] The current focus operates on a range of scales, from replacing pavement with gardens in front yards, to green roofs, and multi-use retaining basins distributed throughout small plazas and open spaces. The Waterplein (Water Square) Benthemplein project by De Urbanisten emerged from a design competition to design for floods, and provided a model for the current plan for the city of Rotterdam.[6] The plaza between a few large urban buildings harvests water from green roofs and impervious surfaces, to harness the natural rain water cycles in a constructed hardscape of blue-painted concrete basins and stainless steel gutters that articulate and express the infrastructural functions of the space, exposing how the landscape captures and stores water after large rain events and letting it infiltrate into the ground shortly after (within 36 hours).[7] The uniquely Dutch landscape transforms hard plazas into overtly designed elements of the city's ecology that accommodate temporality, integrating recreational public space and events with stormwater management infrastructure that floods. This approach celebrates the infrastructural nature of the landscape and makes the cycles of water visible to and generative of place identity.

In Germany, a more naturalized approach to the hydrological cycle has focused on a network of multi-scale and multi-function ecological, vegetated systems such as swales and constructed wetlands, which evolved from experiments to standard practice by building on lessons learned from pilot projects. The city of Hamburg has worked on coupling streets, parking, gardens, and park spaces with natural open space to create a network of multi-functional spaces that manage water, improve micro-climate and create open public space.[8] In the city of Emscher, subsidizing pilot projects at multiple scales harnessed citizen engagement in smaller projects to foster acceptance of the investment in larger projects, by implementing grant programs for landscape-based infrastructure that prioritized surface area disconnection, and making them visible by strategically dispersing these pilot projects over a large area, organized throughout public open space that is well connected with bike paths, and publishing a map of projects as well as guidelines with best practices learned.[9] In the city of Berlin, building on the closed water systems developed in the pre-unified West Berlin, subsidies and flexible regulations incentivize the increase in green spaces, decrease impervious cover in the dense city center and improvement of evapotranspiration through measures such as greened courtyards, green facades and green roofs.[10] Designing with vegetated and porous surfaces, and emphasizing the management of rainfall at its point of origin, connect building and landscapes visually and performatively as part of a single hydrological and ecological system. This supports an ecological view of architecture and urbanism—one where buildings, cities and constructed landscapes are living and dynamic components of natural systems.

In the United States, the idea of green infrastructure has been around for a few decades, consisting of approaches and technologies that utilize, enhance and/or mimic the natural hydrological cycle, to restore natural processes required to manage water and create healthier urban environments.[11] Most stormwater management practices or green infrastructure strategies rely on soil, underground storage, and plantings to filter, treat and infiltrate, employing a naturalized aesthetic that blends into the general vegetated urban landscape. The examples discussed illustrate that natural processes can also be harnessed in structured and multi-use approach that combines gray and green infrastructure, and makes water a visible and important aspect of urban spaces in ways that are more legible and didactic. Yet even in water-sensitive projects, so much of the water cycle in existing cities remains highly invisible to users, and the disconnect between buildings or public space and the hydrological cycle represent a barrier to implementing transformative, adaptive and decentralized small-scale solutions critical to the solve the crisis-centered relationship cities have with water. The apparent invisibility of the naturalized and the visibility of a structural approach to stormwater storage can be bridged through design and technology that communicates the location and water levels of underground systems in ways that engage public space.

Working in the dense fabric and historic landscape of Boston, this design research project engages with a number of questions: how can we make more sustainable processes of water visible in daily urban life? How can water once again become a force to productively shape the human experience of urban space? How can water connect cultural and ecological systems? This project tests how can one of the most invisible processes in urban landscapes, ground water recharge, can be engaged in the poetics of public place making, how technology can be coupled with natural systems in public space, and how can design communicate information on essential ecological services and processes that not only becomes useful, productive and essential to building resilient urban environments, but also transformative of the cultural identity of a community.

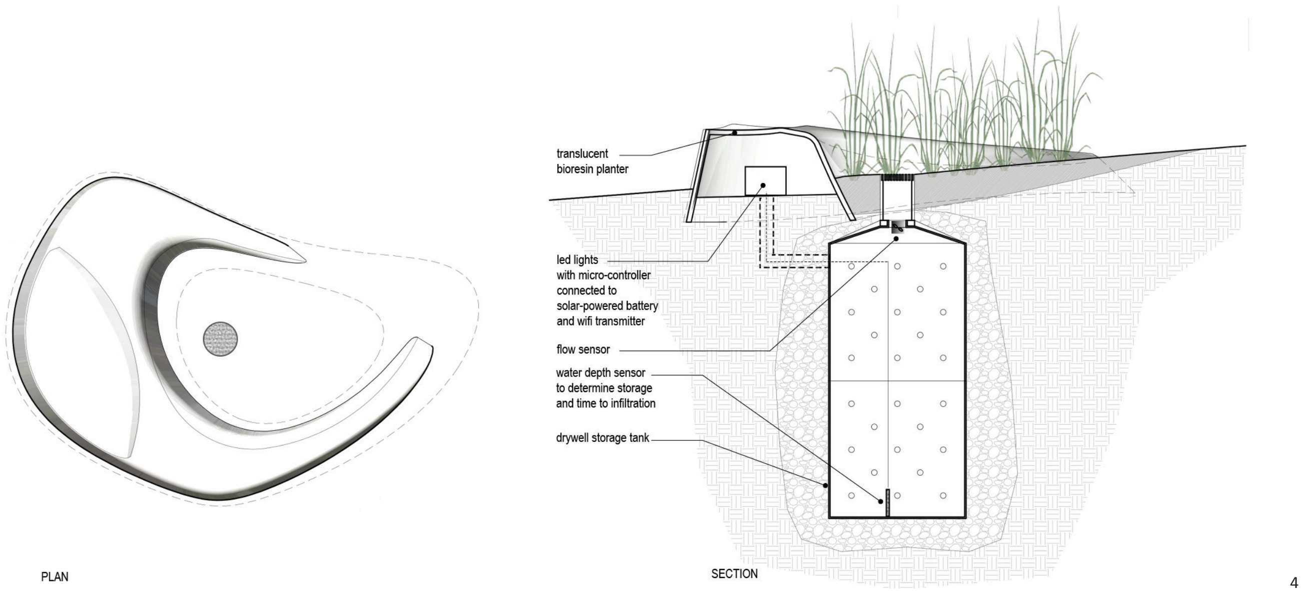
A PROTOTYPE FOR COMMUNICATIVE LANDSCAPES

Threatened with a ground water problem, the city of Boston has created a Groundwater Overlay District where it regulates the implementation of ground water recharge installations in large projects (Figure 1). Although most threats and solutions of resilient cities are very local, the power to take action does not always reside locally. Municipalities like Boston can regulate water much easier than they can regulate energy. Water in Boston is a utility that can be regulated as a zoning code issue through writing ordinances. Energy on the other hand is a building code issue, and building code officials, whom operate at the state level, are protective of their sole role to regulate it. When a building project within this overlay district is large enough, the zoning code requires installation of storm water management strategies such as drywells, porous pavement, or pervious pipes that can keep on site at least the first 1 inch of a rain event to recharge the ground water levels.[12] This ordinance is enacted based on the belief that the collection of many small interventions can have great impact in their cumulative effect. It is an ecological proposition: many actors providing an ecosystem service locally, as an integral part of a larger ecosystem. However, must of this area is comprised of mostly built historic neighborhoods, and because there is a threshold of project size, the result is that many projects in this district are small enough to avoid this requirement. Nonetheless a few projects have had to address this. The accepted strategies are simple enough but invisible. Furthermore these are never monitored, and their impacts are neither quantified nor perceived. If their function and process became visible in public space, water could become a part of the collective consciousness, and may demonstrate the power of individual action in ecosystems.

Boston is the city of transcendentalists, of thinkers that formulated the unique meaning of the American landscape, and one of Olmstead's greatest city plans. This city invites us to revisit the notion of "communicativeness" that is embodied in Olmstead's work, driven by his belief in the restorative value of landscape, and in the social agenda of design that connects human beings to nature.[13] A contemporary reevaluation of these ideas, as presented by James Corner, is that "more than aesthetic and representational spaces", the most important aspect of many traditional landscapes, such as Olmstead's infrastructural landscapes of that time, is that they "function as important ecological vessels and pathways".[14] Within this intellectual context, architects and landscape architects must question how and why should urban landscapes be "communicative" of ecological process and of the dynamic relationships of culture and the environment. A challenge is forming a landscape that is representational of ecological process and that engages both the large-scale project and the cumulative effects of individual actors.

The ***why*** is an ethical question. Boston, like many other cities along the east coast, will be dealing with many water issues in the not so distant future, threatened with having too much water everywhere and yet a dropping ground water table. And yet when it rains water goes from roofs and impermeable surfaces through pipes into water bodies that are being polluted by many forms of human activity, from fertilizing to cleaning to driving. This process is so normalized, and engrained in the physical and experiential qualities of the urban landscape, that the consequences end up far removed from the people and spaces where this path of water starts, where the source of the problem originates. This is neither sustainable nor resilient. The simple process of slowing water down, letting it stay on the site, and allowing it to infiltrate into the ground needs to happen in many places, everywhere we can: from backyards and front yards to large public spaces. Transforming these spaces into vessels for socio-ecological integration, displaying natural process and the communicative potential of sustainable systems, can be a powerful way to achieve the integration of cultural and environmental goals.

The ***how*** is a design question. Technology can be a powerful tool to demonstrate how a simple old concept of water storage and recharge can have cumulative effects, by turning it into something beautifully visible and interactive. The objective of this prototype installation, sponsored by the City and a research grant received by this author is not only to test the effectiveness of common sustainable systems such as drywells, but also to explore ways that they become visible and didactic. The first installation of this solar-powered, internally lit urban object in the park of the public library (which in addition to providing light doubles as a seat and a planting edge) makes the systems of groundwater storage and recharge visible and active parts of the urban landscape. The integration of digital sensor technology and data visualization into an artifact in public space augments public experience by allowing the physical object to express the dynamic changes in ground water levels and to communicate real data. Studying the performance-driven integration of building and landscape systems, technical and natural systems, this prototype is part of a larger research project on the cumulative effect of small-scale ecologically restorative projects, exploring the power of design to



not only solve pragmatic problems but also to engage in a cultural dialogue, communicate information about natural systems and transform urban spaces.

In a drywell water follows gravity to enter a storage space underground, where it has time to slowly infiltrate into the ground water table. It is indeed a simple idea that has been in use for a long time. Like many ecological processes in the natural and designed environment, we never experience this, and we have little data in its effectiveness. The idea for this project was to mark its location in space with a public artifact that communicates information about an otherwise invisible process. An equally important goal is to test its effectiveness in improving the sustainability of public spaces and in building a consciousness about water through the design of information in an aesthetic spatial experience. Drywells are typically very low tech. But this prototype employs quite a bit more technology than a traditional drywell (Figure 4). Clearly, technology was used to model the shape of the part, and to convert it from a digital model to analog methods of fabrication. Most importantly, technology is used to test the effectiveness of this tool for recharging water, and to communicate the fluctuations of this process through innovative interface of light and color that activates and transforms an otherwise marginalized public space.

There are two analog water sensors in each well. The first is a flow sensor that can measure when runoff is flowing into the well, and provides data on the flow rate. The second sensor is a water pressure sensor at the bottom of the storage tank. This sensor provides data on how much water is stored at any given moment. A weather station logs data on rain events. An Arduino tool receives data from the sensors, and communicates the data wirelessly to a remote web server. A custom program interprets the data and sends directions to the microcontroller at dusk to power and change the color of 300 LED lights located inside the translucent artifact, which change color to indicate the amount of water infiltrated that day. A QR code on the artifact allows the public to immediately access the meaning of data being communicated in a simple interface, and more in-depth historical data is being logged and displayed on a project website for anyone who wants to see patterns emerge from the information. Batteries charged by solar panels power these lights, sensors, wifi transmitters and microcontrollers. The sensors in the prototype tells us how much water runoff moves into each location, and allows us to determine how long it takes from a rain event until the water is slowly infiltrated into the ground. Most importantly the technology communicates that information to the public that goes by the park, or to the project website, through

Figure 4: Diagrammatic plan and section of prototype. *Credit: Image by author.*

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inventive forms of information design. Through photography, the lighting variations, and the interactions of the public with the installation, are being documented (Figure 5). Starting with one location as prototype, the goal was to expand this project at multiple other locations within the groundwater overlay district. Securing additional funding from a research grant from AutoDesk, the project is beginning a new phase of development intended to expand the program, scale and scope, engaging industry, the municipality and water organizations in the process. The concept is tethered to existing infrastructure and urban data, installing new sensors and leveraging existing data monitoring infrastructure, such as the 962 groundwater monitoring wells of the Ground Water Trust. The next phase of the project will include mapping, modeling, gathering and communicating stormwater data points at the city scale, and to make these visible and engaging elements in public space. At the urban scale the project is conceived as a constellation of glowing objects, ranging in scale from markers of existing groundwater monitoring wells to urban furniture, creating a network of installations to display the ecological performance of urban systems.

Designers would likely agree that integration of aesthetic and high performing design is of paramount importance. What is not often recognized is the need for gathering data on actual performance of design strategies to support future evidence-based design. Digital technologies for sensing, monitoring and communicating information about the environmental and cultural performance of design empower design disciplines to communicate its ecological value, and to make decisions that strengthen the performance or urban landscapes. This is of critical importance in this moment of ecological crisis. Communicating to the public the dynamic process of ecologies is challenging and imperfect, but experiments to uncover this potential are essential to begin to build resilience at multiple scales through redundancy, robustness and resourcefulness. Much of the discussion on resilience in cities is centered on the physical improvements to energy, water and infrastructure systems. However, a part of resilience is inextricably tied to socio-ecological systems: the organizational and communication structures that couple humans with natural systems. To build resilience in communities requires the engagement of the public in understanding the natural systems that support them. When water becomes invisible, taken away into hidden networks, or recharged into the ground, there is not much opportunity or potential to make it part of the narrative of a space and its collective consciousness. This premise of this project is to uncover and explore that potential.

Figure 5: First two installations of prototype, illuminated at night. South End Public Library Park. *Image credit: by author.*

AN ECOSYSTEM PERSPECTIVE: CUMULATIVE EFFECTS

> "A single drop of water in the uplands of a watershed may appear and reappear as cloud, precipitation, surface water in creek and river, lake and pond or groundwater; it can participate in plants and animal metabolism, transpiration, condensation, decomposition, combustion, respiration and evaporation. This same drop of water may appear in considerations of climate and microclimate, water supply, flood, drought and erosion control, industry, commerce, agriculture, forestry, industry, commerce, agriculture, forestry, recreation, scenic beauty, in cloud, snow, stream, river, and sea. We conclude that nature is a single interacting system and that changes to any part will affect the operation of the whole."
>
> —Ian McHarg, *Design with Nature*

Ian McHarg's ecological view introduced designers to the relational and dynamic nature of systems, which are made of many smaller and interdependent systems.[15] Large scale infrastructure planning is important, it is necessary and unavoidable, but it can also maintain a passive citizenship that expects large solutions to come from elsewhere. On the other hand, small-scale interventions that demonstrate the significance of individual contributions as part of a network of systems, although limited in their relative individual impact, are not only essential to solve a large problem of infrastructural scale, but also conducive to an empowered and active citizenship. Work at this scale, especially as it multiplies throughout the spaces of daily urban life, become a reminder that ecosystems are about dynamic relationships of many actors at many scales. Making sustainable systems, their functions and processes, visible and engaged in cultural production, is an imperative for designers of the urban environment. When we connect ecological process with cultural process, the landscape becomes an instrument and signifier of collective action.

ENDNOTES

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