STREAM BANK REVITALIZATION IN SOMERVILLE, NEW JERSEY:

A CASE STUDY IN PLANNING STRATEGY FOR THE INTEGRATION OF

ECOLOGICAL AND SOCIAL NEEDS IN PUBLIC OPEN SPACE

By

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ABSTRACT OF THE THESIS

Stream bank revitalization in Somerville, New Jersey:

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In an urban environment, the establishment of a sense of place and values is directly related to the surrounding natural landscape. A community must find sacredness in its environment in order to embody the feelings of pride and appreciation that will allow it to properly relate to, and, by extension, care for, its surroundings. Public open space in an urban community is key to that sacredness. These are places that manifest the best of both human and ecological values; and yet, the interaction between humans and the ecology of these spaces is often insufficiently supported to produce the desired connection between the community and the landscape. This study, therefore, investigates the potential to integrate ecological and social values in public open space. As a case study, the research is focused on a stream and associated riparian corridor that connects a series of public outdoor spaces in the Borough of Somerville, New Jersey, exploring strategies for enhancing both stream ecology and the relationship of the community to the water. Specific issues addressed include recreational access, community connection, water quality, flooding, riparian habitat, and erosion and bank stabilization. The result is a

proposed municipal level planning strategy for the revitalization of this stream corridor to accommodate a stronger connection between the ecology of the riparian system and the community it serves by enhancing both ecological integrity and human value.

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Introduction

The integration of ecology and social science is a challenge for landscape architects. Establishing and maintaining ecological integrity in the landscape is a complex scientific process, as is the social connection of a landscape to the community it serves. It is often difficult to successfully implement either one of these processes, and the integration of both into one landscape is even more challenging. It is, however, critical to do so, particularly in the urban context, where ecological systems that have already been disrupted need support, and diverse human populations struggle to connect with their surroundings.

Randolph Hester has begun to address this challenge with his theory of ecological democracy[1]. This theory provides a framework for urban design that promotes a strong connection between a city and its inhabitants, with a focus on creating a sense of place in the landscape. In an urban setting, a connection between the community and the natural landscape of public open spaces becomes critical.

There is a historical conflict between managing land for public use and the perpetuation of ecological integrity, which was best exemplified in the late nineteenth and early twentieth centuries in the contention between conservationist and preservationist[2] ideals. These movements, led by Gifford Pinchot and John Muir, respectively, both sought to protect public land, but with differing values.

> "Muir fought against destruction of wild nature and the attitude that had allowed legitimate use to be perverted into rampant abuse. Pinchot fought against inefficient development of natural resources, the political corruption that such development so often entailed, and the inequitable distribution of wealth and power that both allowed and followed unrestrained exploitation."[3]

In essence, Muir argued for the ecological value of uninterrupted nature, as well as the aesthetic, psychological, and spiritual benefits of experiencing wilderness. Pinchot, on the other hand, saw greater value in the strategic development of nature for human benefit, particularly for the efficient farming of natural resources. Both sides were arguing for a treatment of natural public land that provided equitable benefit to the people, but with very different sets of values.

The efforts of Theodore Roosevelt worked to bridge the gap between these two schools of thought by advocating a careful combination of development and protection of public land.[4] Finding the proper balance between the preservation of nature and development for equitable access and enjoyment for the public can be equally as precarious at the site scale as they were at the national scale during this time, and the concept of ecological democracy is well positioned to achieve a viable union of these two sets of values.

Equally important is the inherent nexus between public land and democratic process. From public land acquisition like the Louisiana Purchase of 1803 to the land grants that established public institutions like Rutgers, the State University of New Jersey, the exchange and management of public land has played a significant role in American history. More specifically, democratic decisions involving public land have paved the way for explorations of the aforementioned integration of ecological integrity and human use in the natural landscape. The National Forest Service and the National Park Service, both established during the height of the conservation versus preservation debate, led to great opportunities for federal public land management that would serve to benefit both human and ecological use, although they were, at first, at odds over these values. “The heightened visibility of recreational values also raised the status of wilderness protection within the Forest Service, ratcheting up the level of competition between the Forest Service and Park Service over control of potential park and recreation lands."[5] Today, the lands held by these organizations function to serve both the native ecology and the many recreational visitors that they serve.[6]

Just as equitable access to the resources of public land is important, democratic participatory process in urban planning and design is a viable means of facilitating the connection between the people and the natural landscape of public open spaces, and it is a right of the community that should be honored. The National Environmental Policy Act of 1969 (NEPA) requires public participation in the planning process for all projects that are federally funded, but no such regulations apply to municipal level planning. Translating the intentions of NEPA to the municipal level and incorporating the participatory process into urban landscape planning is necessary for the integration of democratic process with environmental design, which is a functional necessity that Randolph Hester alludes to in *Design for Ecological Democracy.*

According to Aldo Leopold, "We abuse land because we see it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."[7] This is the common goal of ecological democracy, conservationism, and NEPA - a relationship with public land that enhances quality of life for both the human and ecological communities that value the land. This study, which focuses on an urban riparian corridor, questions the current level of integration of ecological and human value in public open space design in an urban context. How can ecological and social needs be integrated to develop a municipal level planning strategy for the revitalization of public open space to enhance both ecological integrity and sense of place for the surrounding urban community? With this question in mind, this project is a case study in the application of ecological landscape planning strategies that revitalize both the ecological integrity and the community integration of the Peter's Brook linear park system in Somerville, New Jersey.

Conceptual Framework

The conceptual framework for this research builds on two existing ideas – Randolph Hester's concept of Ecological Democracy, and the National Environmental Policy Act of 1969 (NEPA). While ecological democracy is a discussion of the value of place making and stewardship in creating a relationship between the natural landscape and the urban community, NEPA addresses government involvement in environmental projects and the right to public involvement in the planning process.

Hester's ecological democracy builds upon fifteen design and planning principles which fall into three categories, with the goal of creating landscapes that are impelling, resilient, and enabling, thereby creating a sense of place within an urban community. These fifteen principles are in herently interconnected, with sacredness being the crux of the theory, and what Hester calls the "integer" of the fifteen principles.[8] Sacredness is the representation of the values of a community that gives worth and meaning to a place (Figure 1).[9]

NEPA, which establishes a process for assessing environmental and community impacts of federally funded projects, can be broken down into several process-oriented goals, which, it can be argued, are equally interconnected with the principles of ecological democracy. Using these two structures together as one conceptual framework, this project seeks to show how a planning-oriented process can be used to integrate ecological integrity and community place making in public open space at the municipal level.

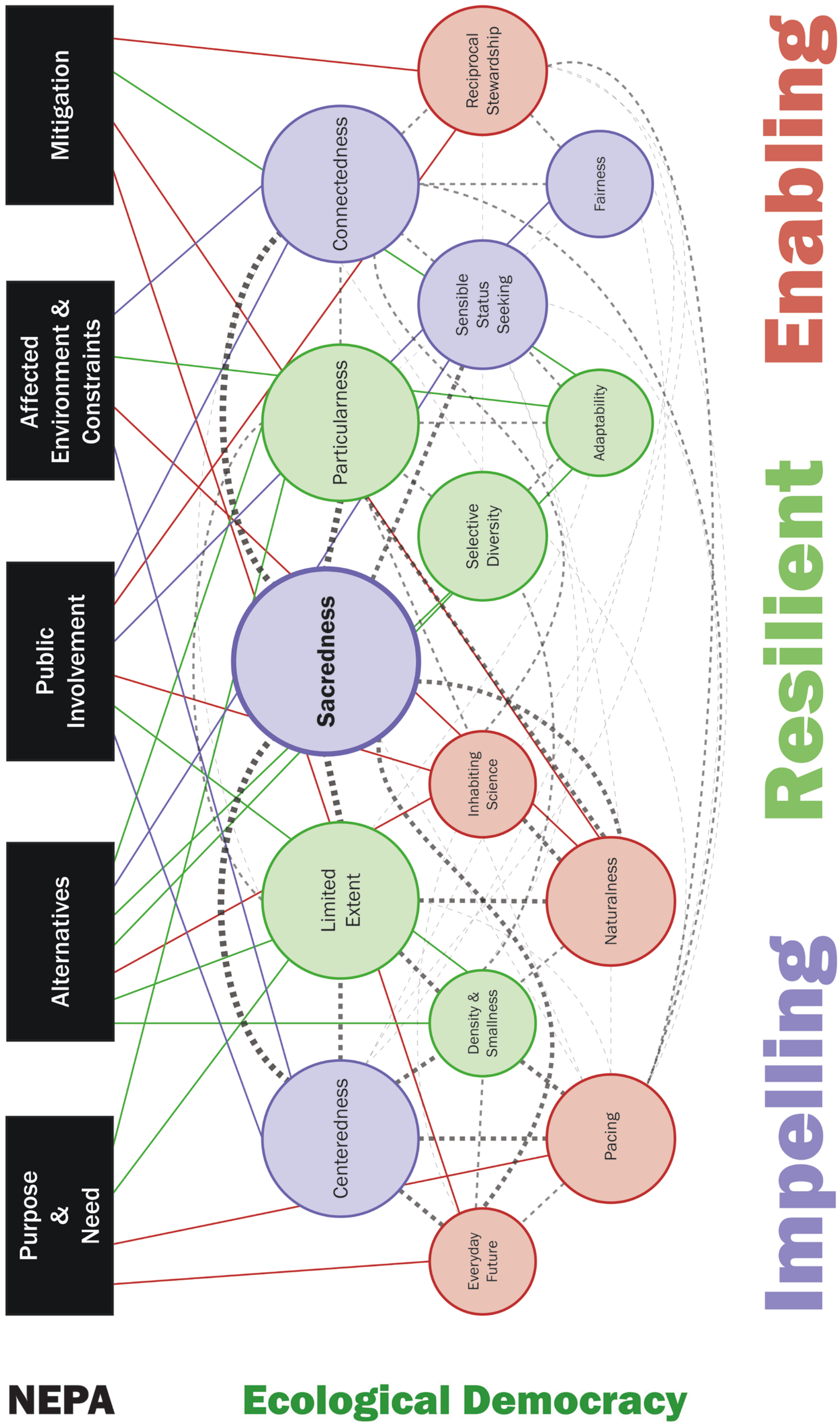


Figure 1. Diagram of conceptual framework for research, incorporating elements of Hester's Ecological Democracy and NEPA.

Ecological Democracy

In his book *Design for Ecological Democracy*, Randolph Hester discusses the current state of American cities and the concept of urban sustainability. To summarize the problematic state of the current urban system, he states that “The vicious iterative cycle in which insecure and unrooted individuals make insecure and unrooted cities, which make even more insecure and unrooted individuals, was generations in the making and will be generations in the undoing. Shifts that disrupt the unhealthy cycle are essential. This is the great challenge of our time.”[10]

Hester goes on to propose the theory of ecological democracy to address this issue, noting that it is not meant to be a quick fix to societal problems, but a long journey toward the best possible life we can achieve. It is a marriage of applied ecology (defined as the study of the relationships between organisms, including people and their environments) and direct democracy (government by the people). The resulting definition of ecological democracy is “ […] government by the people emphasizing direct, hands-on involvement. Actions are guided by understanding natural processes and social relationships within our locality and the larger environmental context.”[11] *Design for Ecological Democracy* proposes the application of this concept to urban form, as a means of seeking the roots and foundations for the American city that support a resilient society of satisfied and fulfilled individuals.

Hester identifies and defines fifteen principles of ecological democracy for cities. These are organized into three fundamental categories – Enabling Form, Resilient Form, and Impelling Form. Enabling Form is the characteristics of the city which allow it to function as a community rather than a divided society. It promotes connections and facilitates a working democracy that allows neighbors to share their environment. Resilient Form refers to the ecology of the urban system and its ability to sustain itself. It promotes a balanced and complex system of biological and cultural diversity that is capable of responding to the surrounding ecology adaptably (for example, climate change or catastrophic events), in turn providing a certain level of economic security to the system. Impelling Form is that which brings joy to everyday life. It invites inhabitants to act on happiness and pride rather than fear and insecurity, creating a sense of identity with the landscape and an uplifting everyday experience.[12]

The five qualities of ecological democracy in the category of Enabling Form are centeredness, connectedness, fairness, sensible status seeking, and sacredness.

Centeredness is the "[…] aggregate of shared experiences, activities, and interests and of associated settings."[13] In the landscape of the city, it is found in the places that draw people together for face-to-face engagement. This quality is essential for economic efficiency, local identity, physical legibility of the landscape, and rootedness.

Connectedness "[…] encompasses the mutual dependence and appropriate relationships of parts of an ecosystem, including human and nonhuman aspects, which need to be reflected in physical arrangements."[14] In an urban environment, this quality expresses the fundamental associations between the parts of the ecosystem, heightening public understanding of the interrelatedness of society and its environment and maximizing social and ecological benefits.

Fairness promotes accessibility, inclusion, and equal distribution of resources and amenities. This is "[…] critical for creating legitimate involvement and a well-informed public."[15] The form of the city communicates complex information to its inhabitants in a way that facilitates the perception of fairness.

Sensible status seeking refers to progress. Status allows a city to know its place in society, gives order, and satisfies the need for recognition. It is important, however, that progress be sought because of genuine need, and not because of community insecurity. In the context of design, this means making accurate assessments of local resources and understanding the consequences of alternative actions.[16]

Sacredness in the context of urban form is the manifestation of convictions, values, and virtues through the ritual use of places. It is not rational or mechanical, and is lost when form too strictly follows function. It is created through tradition, participation, history, and cultural identity.[17]

The five qualities in the category of Resilient Form are particularness, selective diversity, density and smallness, limited extent, and adaptability.

"Particularness refers to the distinctive adaptations of human habitation that have been made to fit especially well into the unique natural ecosystem of which that habitation is a part."[18] It is a quality that allows a city to react resiliently to natural disasters and the disruption of economic shifts, while simultaneously giving the landscape unique character that makes it memorable and distinguished.

Selective diversity is complex. "Cities that are diverse are more resilient but only when that diversity is within a framework that is delineated by the particularness of the given regional landscape, social respect, and cooperation. Healthy diversity is tempered by limits of locality."[19] Diversity that promotes resilience is not indiscriminate diversity seeking, but the careful selection of diversity in areas that are basic to long-term sustainability, which is dependent upon the place, but generally involves a balance of biological diversity, cultural diversity, and mixed economies and land uses.

Density and smallness is the counter to low density urban sprawl. It is the quality of a city that concentrates population density in a smaller area, promoting resiliency by protecting regional biodiversity, providing access to nature, and reducing transportation costs.[20]

Limited extent is closely linked to density and supports the same beneficial outcomes. It involves elements of the landscape that limit the spread of a city; for example, cities with greenbelts that limit their outer boundaries.[21]

"Adaptability is the capacity of an ecosystem to adjust for changing conditions with the minimum of unhealthy stress or expenditure of essential resources."[22] It is flexibility – an overall structure that accommodates change while maintaining its fundamental form. In an adaptable environment, many spaces serve more than one purpose, are suitable for new uses, and are flexible without being entirely open-ended. Spatial configuration is capable of supporting many functions over time.

Finally, the five qualities in the category of Impelling Form are everyday future, naturalness, inhabiting science, reciprocal stewardship, and pacing.

Everyday future is the concept of meaningful urban metamorphosis. It contends that the transition of a city into one that supports ecological democracy must accommodate everyday patterns of life. "Innovative transformations, even radical ones, that are recognizable and that accommodate and champion valued ways of living are more likely to be successfully implemented."[23]

Naturalness is exactly what it sounds like – the presence of nature within the urban environment. Hester looks specifically at the design aspects of feelings that are associated with nature, and the "subconscious, emotional influences that nature has on human beings."[24] The value of this quality is in the pleasure and sense of identity that humans take away from interaction with it.

Inhabiting science is a complex interpretation of the way a city's inhabitants understand and interact with the city itself. "A city will impel us only if we comprehend and truly understand it, know our place in it, and know how to be meaningfully engaged in the decisions that create it."[25] The knowledge necessary to make prudent design decisions based on this relationship between the city and its inhabitants includes native wisdom and a working understanding of urban ecology.

Reciprocal stewardship, according to Hester, is a logical outcome of naturalness and inhabiting science. It occurs when the interconnectedness of people and place results in voluntary action beyond self-interest. Urban design can facilitate stewardship by removing obstacles in the everyday landscape and making impelling alternatives.[26]

Pacing is the quality that brings the dimension of time into the urban landscape. "Urbanity is immensely more impelling when it is experienced at tempos that vary like the rhythms of life itself."[27] The fast pace of city life is alluring and stimulating, but without a balancing slower tempo, becomes rushed and hasty. In fact, unbridled hurry detracts from several of the qualities of ecological democracy. "Frantic speed renders centeredness obsolete, precludes sacredness, transforms particularness into sameness, disconnects even as it deludes us into believing that it provides convenience over great distances. Frenzy makes it impossible to inhabit science, and the benefits of naturalness cannot be absorbed when hurried. Speed has no time for deliberative decision making. It debilitates ecological democracy."[28] Design to accommodate a slower pace allows calmness to permeate the city and promotes the valuable qualities previously described.

With the incorporation of these fifteen principles, Hester contends that a city can evolve to be enabling, resilient, and impelling, offering its inhabitants a lasting and fulfilling future. He points out that each of these principles is a discrete entity that can be analyzed individually, but that they are tightly intertwined and influence one another.[29]

NEPA

The National Environmental Policy Act of 1969 (NEPA) is a prime example of the function of direct democracy within the concept of ecological democracy. Signed into law in 1970, NEPA is an act that requires federal agencies to assess the environmental effects of proposed actions prior to making decisions. These assessments are typically presented as Environmental Impacts Statements (EIS) or Environmental Assessments (EA).

NEPA specifically states that all concerned parties, both public and private have the right to be involved in this process, with the goal of creating conditions in which a community and its surrounding nature can coexist in a mutually fulfilling manner:

> "[…] it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to us all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."[30]

This federal act, however, does not apply at the municipal level unless a project is being funded either partially or in full by federal funds.[31] Translation of the intentions of NEPA to municipal planning projects, such as stream bank revitalization in public parks in the Borough of Somerville, would contribute significantly to the successful implementation of ecological democracy.

Site Selection

This project started with the site. The researcher grew up in Somerville[32] and is very familiar with most of the town, including its parks and open spaces, and has noticed a change in the way people appreciate and use those spaces. The parks were once important places that were valued by the community, but today the public open space in town is generally underutilized and much less maintained. The experience of this trend sparked an interest in exploring the possibility of revitalizing these spaces.

In particular, this research is focused on a series of parks and open spaces that follow a stream called Peter's Brook through town. The nine segments of this linear system will henceforth be referred to by their common names - Brookside, Flockhart Park, Exchange Field, Van Fleet, William/Cliff, Cliff/High, Park Ave., Lepp Park, and Chambres Park.[33] There are other small parks, but this linear system encompasses most of the borough's park space, and has a certain amount of potential for social connection and ecological integrity because of it's unique form and location (Figure 2).

Somerville is a town of approximately 2.4 square miles with a population of just over 12,000 people.[34] Land use is mostly urban residential, with a downtown commercial core on Main Street. The largest piece of open space is a former landfill, which is currently not publicly accessible and will soon be redeveloped with mixed commercial and residential use. Somerville is a transit village, which is a designation by the New Jersey Department of Transportation for a municipality that is working to redevelop and revitalize in a way that creates a walkable community oriented around public transportation.[35] In this case, Somerville takes advantage of its downtown core and train station (which provides direct transportation to New York City), and is focusing its revitalization efforts around this area. The projects completed so far have been very well received by the public, but this focus is resulting in an unintentional abandonment of the linear park system, which is equally valuable to not only the walkability of the town, but also to the sense of place for the community and the ecological integrity of a functioning riparian corridor within an urban context.

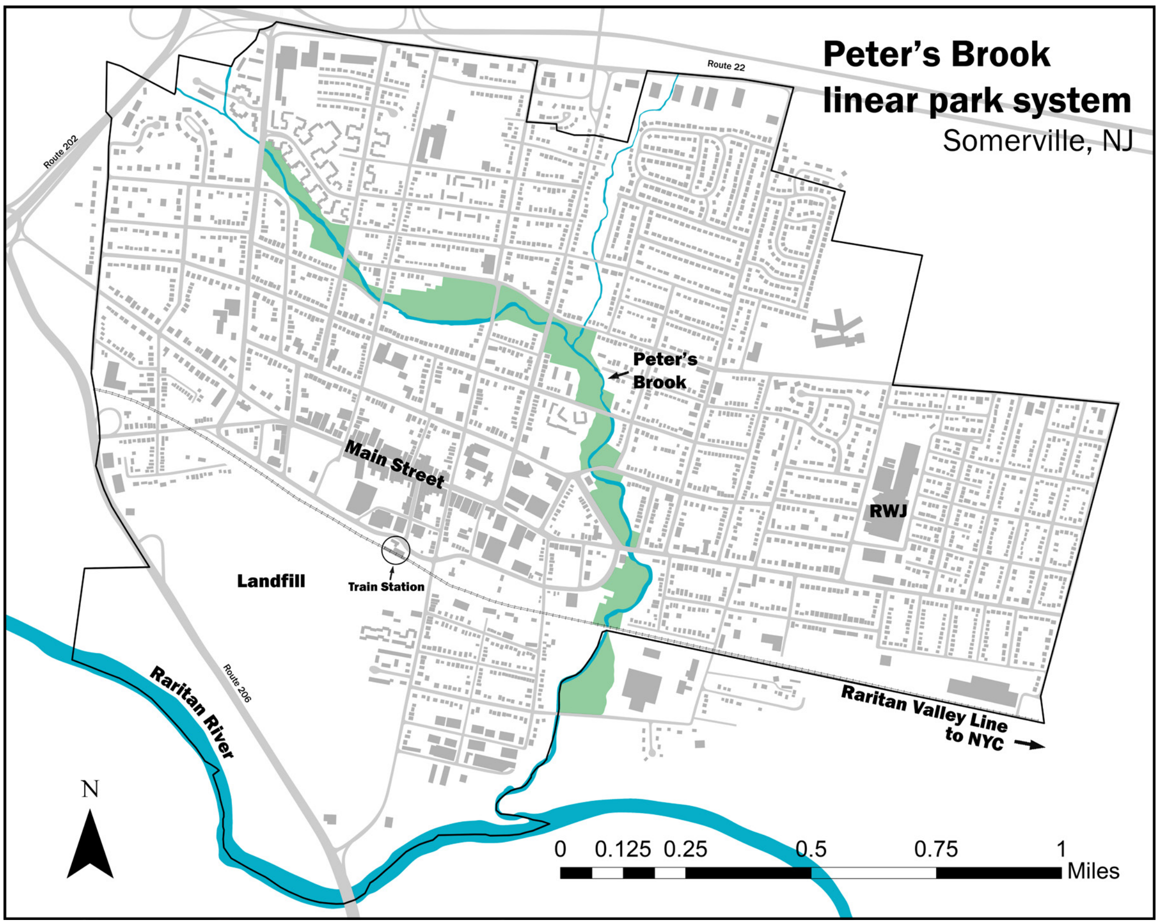


Figure 2. The Peter's Brook linear park system within the context of the Borough of Somerville, New Jersey.

The spaces within this linear system range in character from heavily programmed parks with ball fields and playgrounds, to open spaces that are maintained only by mowing the lawn. The nine segments of the system are connected by the stream and associated riparian corridor, as well a pedestrian greenway that follows the stream for one and a half miles. Located central to most of the community, these spaces and the greenway have the potential to function as a unifying element of the landscape, bridging gaps between diverse neighborhoods and providing significant access to both recreation and nature for users. However, many of these spaces are often empty or underutilized (Figure 3).

Meetings with Kathy Gerndt, Director of the Somerville Recreation Department, and the Somerville Environmental Commission identified several overlapping priorities for the future of the town's public open space, including flood control, erosion of the stream banks, integrity of the riparian corridor, increased usership, and improved connection between users and the environment. Identification of these priorities led to the decision to focus this research on the stream banks within the Peter's Brook linear park system, seeking strategies for revitalization that address these issues while also working to create more of a social connection to the water.

With that in mind, this research looks for opportunities to revitalize the stream banks within this linear system of public open space in terms of both social and ecological integrity focusing specifically on issues of recreational access, community connection, water quality, flooding, riparian habitat, and erosion and bank stabilization.

Figure 3. The Peter’s Brook linear park system.

The goal of this project is to develop a planning model for the revitalization of the banks of Peter's Brook in Somerville's public open space to enhance ecological integrity as well as value to the community, fostering the goals of ecological democracy. Focus on strategic planning specific to the troubled stream banks can help to address almost all of Hester's principles of ecological democracy. Additionally, experimentation with methods of community input in the planning process will address the need to incorporate the values of NEPA into municipal level planning for public open space.

Site Background & Context

History

Somerville was founded in the 1750's by primarily Dutch colonials who established their church in the vicinity. The Old Dutch Parsonage, which still stands as a historic landmark, was the residence of church ministers (including Reverend Jacob Rutsen Hardenbergh, a founder and first president of Rutgers University, then called Queens College). Until the completion of the railroad in the 1840's, the town was a farming community. It was a Revolutionary War encampment in 1778-79, and George Washington was headquartered in the Wallace House (which is now a site on both the National and State Registrar of Historic Places and is part of the New Jersey Divison of Parks and Forestry). Somerville became the seat of Somerset County in 1799. The railroad began service in 1842. By the 1850's water power had been developed along the Raritan River, and along with the railroad, brought the industrial revolution to Somerville. Brick making was the town's major industry, as it was built on plentiful red clay and shale.[36]

Somerville became a cultural, commercial, and educational center for the county in the early 1900's. It was almost fully developed by 1950, and boasted a wide range of architectural styles, including Victorian, Georgian, Greek Revival, Italianate, and others, much of which survives today, and multiple sections of the town are proposed historic districts. The National Historic Preservation Act of 1966 established a federal policy of preserving the country's heritage, and seven sites in Somerville have been registered as historic sites.[37]

Peter's Brook, the Raritan River tributary central to the research site, was named for Peter Van Nest, who fought in the Revolutionary War under the command of Jacob Ten Eyck.[38]

Demographics

Somerville is a diverse community with a wide range of demographics. With a population of approximately 12,160 in 2012, the town has a population density of about 5,151 people per square mile. The population is 53% male and 47% female, with a median age of 35.5 years, which is six years lower than the median age for the state of New Jersey. Residents are 57% white, 19.8% Hispanic, 10.9% black, and 9.5% Asian.

As of 2012, the estimated median household income was about $70,000, and the median home value was about $288,000. The cost of living index is 123.9, which is higher than the national average of 100.0.[39]

There are four census tracts in the Borough of Somerville. The southern-most tract includes the empty landfill area, and it should be noted that this may result in a misrepresentation of density. Based on demographic data from the 2010 census, this southern most tract, which includes neighborhoods south of the train tracks as well as the downtown area, has the lowest average household income, and the highest densities of both children and Hispanic residents.

The northeast census tract boasts the highest average household income, as well as the highest densities of White and Asian residents and senior citizens. Black residents are highest in density in the same census tract that has the highest overall population density (Figure 4).

This data shows that there are tangible differences in demographic composition of the neighborhoods of Somerville. Located centrally and reaching across town from the northwest to the south, the Peter's Brook linear park system is accessible to many diverse neighborhoods, and offers an opportunity to connect these areas and bridge gaps in social equality by providing equal access to outdoor spaces, recreational facilities, and the benefits of experiencing nature and the outdoors. With increased use and community appreciation, this system could become a strong unifier for this community, and a valuable tool for the implementation of ecological democracy.

Interestingly, looking at demographic data in this form makes it seem like the riparian park chain might be functioning as a separator rather than a unifier. It must be noted that when looking only at the raw data, experiential perception is not represented. In fact, these spaces, although underutilized, do function very democratically, but because the census tract boundaries follow the stream, that unifying potential is misrepresented. As a resident and regular user, the researcher can see the opportunity for revitalization in a way that enhances the connecting quality of these spaces.

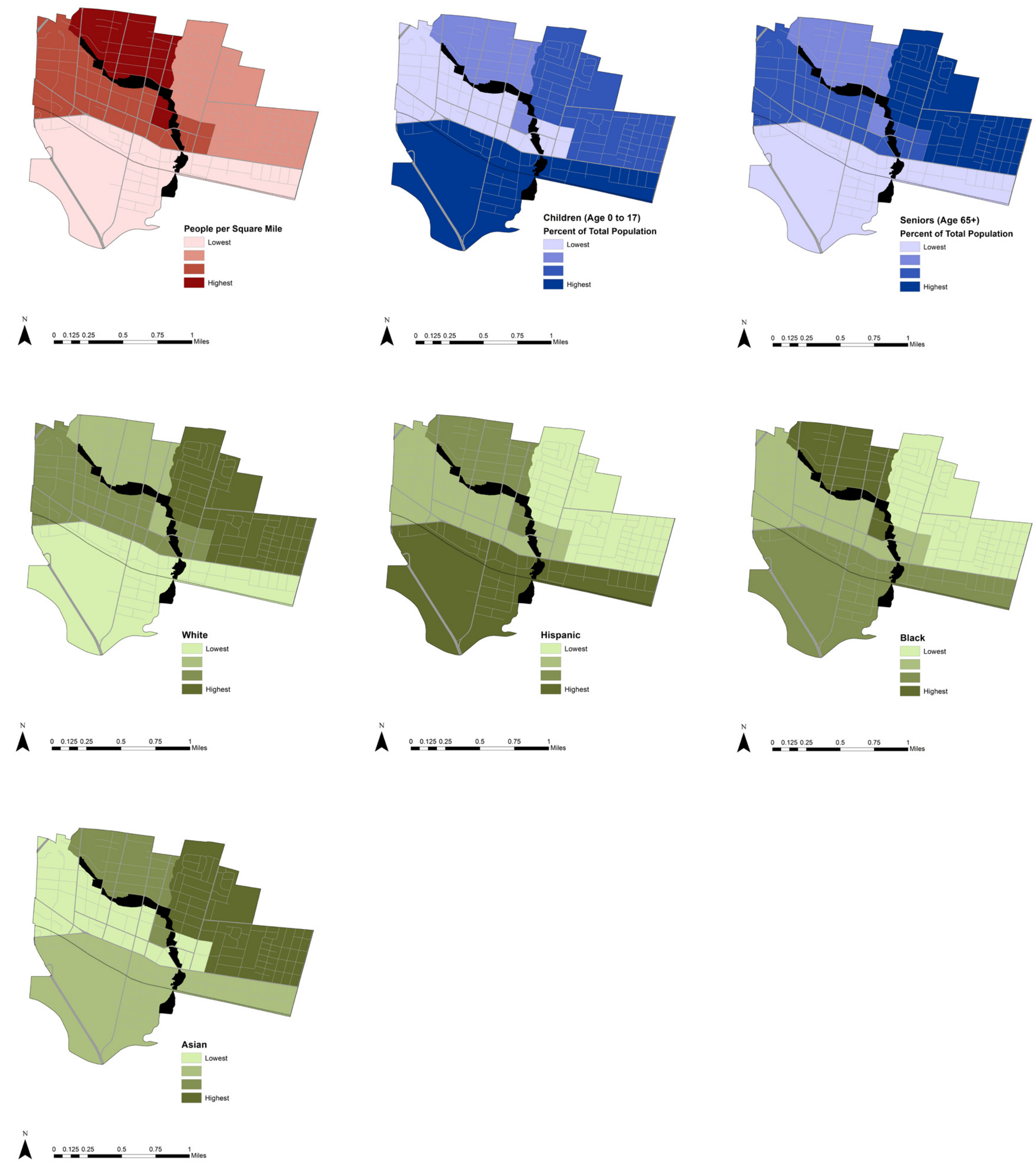


Figure 4. Somerville demographics. (From top left: total population density, density of children, density of senior citizens, density of White residents, density of Hispanic residents, density of Black residents, density of Asian residents.)

Downtown & Redevelopment

The relationship between these green spaces and Somerville's downtown corridor is also an important part of the context. Although the ball fields are used during Little League season and a few playgrounds have regular visitors, the majority of the spaces in the Peter's Brook linear park system are frequently empty, even on beautiful summer days.[40] Conversely, the downtown area, which includes commercial Main Street and the recently redeveloped pedestrian-only Division Street, are almost always full of people on an average day or summer night, and very crowded during the many events held there throughout the year, including parades, street fairs, and the world famous Tour of Somerville bicycle races (Figure 5).

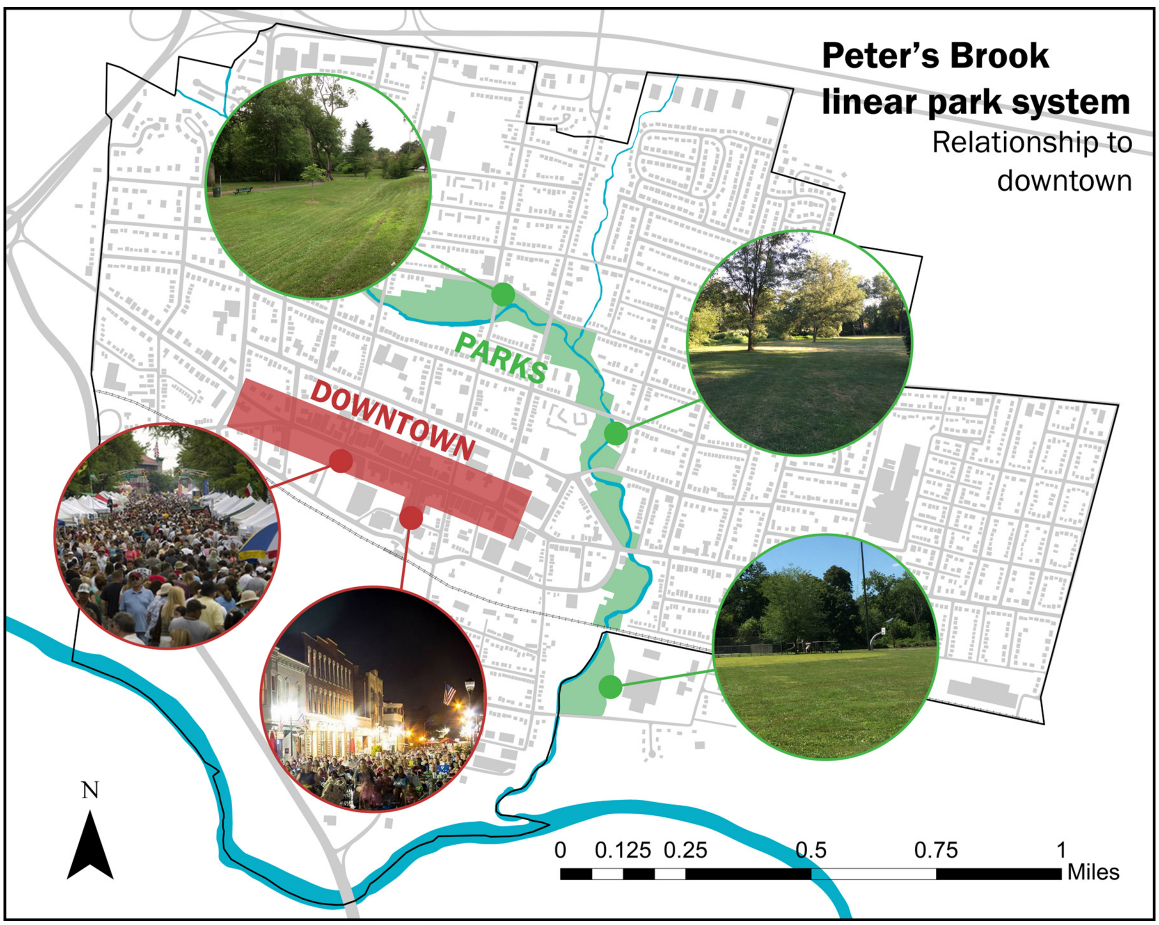


Figure 5. Relationship of Peter's Brook linear park system to downtown.

That tendency is only likely to increase, as Somerville is currently riding a wave of redevelopment, which is focused primarily on its downtown area, taking advantage of the town's status as a transit village. Downtown is a beautiful historic corridor that draws people from all over town, which is a wonderful thing. However, while the recent and proposed redevelopment projects are poised to add more than 500 new luxury apartments to the downtown area,[41] likely shifting the social structure of the community, the beautiful park system and its ecologically valuable riparian corridor have fallen off the town's radar (Figure 6).

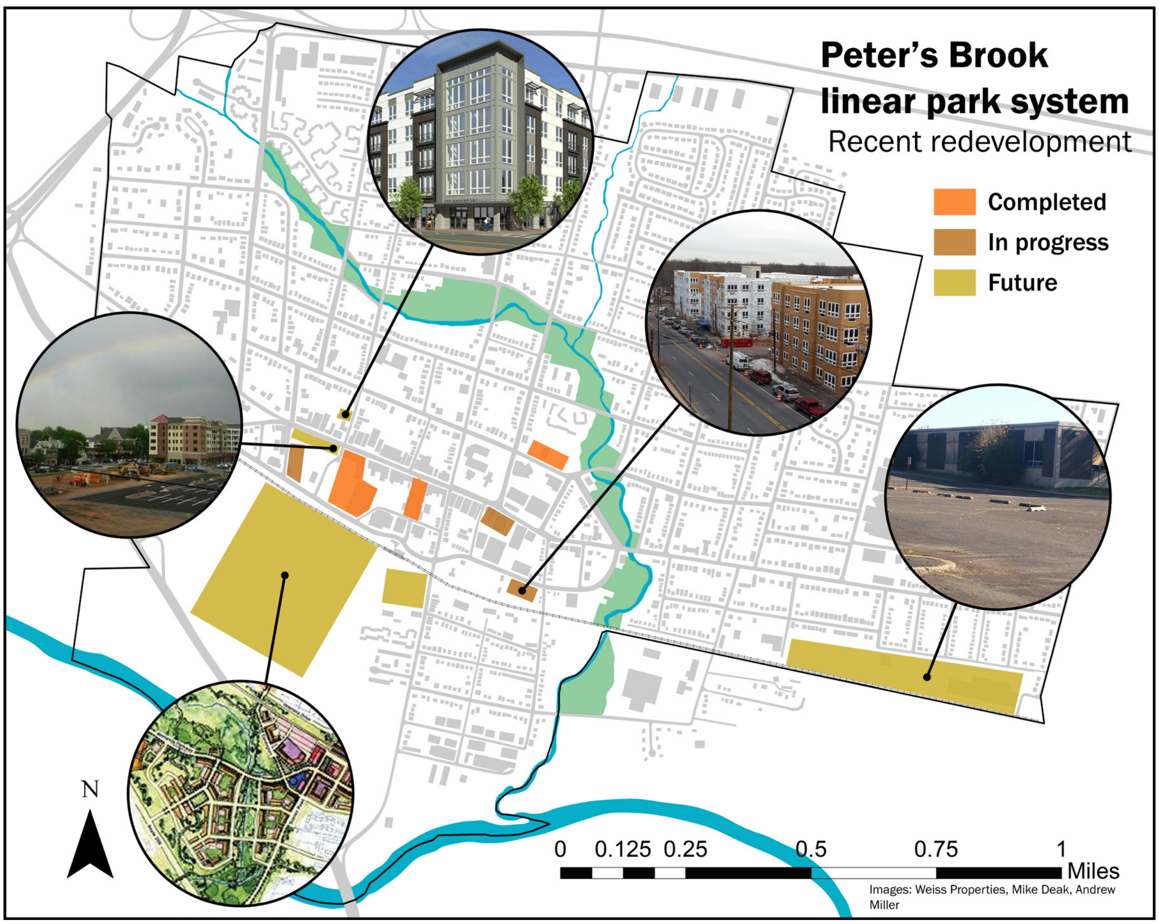


Figure 6. Recent redevelopment.

Community Perception

One of the less commonly noted goals of NEPA is the inclusion of public participatory process in decision making for any project that might impact the ecological environment. This act, of course, applies only to federal projects. In an attempt to translate that goal to the municipal level and include participatory process in this research in Somerville, an experiment was conducted on the use of social media for public participation. A mental mapping exercise in which participants were asked to get creative and depict “their” Somerville, without being led too much in the direction of the parks (Figure 7). The goal was to see how the parks were represented in their overall view of their town. Participants were asked to share their maps on social media with the hashtag *#MyVilleNJ*, making the results easy to search and collect using the hashtag display platform www.tagboard.com.

The mapping exercise was distributed throughout town, in cafes and local businesses, the YMCA, town hall, library, and to friends and family of the researcher, as well as being shared digitally on social media with the help of a very active group of downtown businesses (the Downtown Somerville Alliance). Despite this wide distribution, very few responses were actually posted with the hashtag. Discussions with participants revealed that many of them did not know how to use a hashtag, which was an unexpected problem with the survey method.

Ultimately, the most responses came from an important subpopulation of the community - the students at Somerville High School. Response via social media within this group was higher than that of the greater population, but still lower than expected. Only 15% of the high school students used the hashtag to share their maps on

Figure 7. Mental mapping exercise.

social media. The most common reasons given for not using the hashtag were that the students had shown the location of their home on the map and didn't want to share that information publicly, and that they did not use Twitter so they thought they couldn't use the hashtag. This proved to be a common misconception, as a hashtag can be used on any social media platform, including Facebook, Instagram, and even the professional network, LinkedIn. Of the students who did use the hashtag, 92% had done so using Twitter. This supports the hypothesis that there was a general misunderstanding of the hashtag method of social media participation, and if this experiment were to be repeated, more specific instructions on the use of the hashtag might be required.

Results were still gathered, however, by collecting the paper copies of the mapping exercise (Appendix I). As the largest group of respondents (211 responses), the high school student subpopulation responses were analyzed, and some interesting things about the students' perception of their town were learned.

As suspected, the responses showed a much stronger representation of the downtown area than the parks. Besides the High School, the most frequently mentioned places were the downtown area and places to get food. 17% of the students mentioned downtown as a place, and 60% mentioned specific businesses downtown. The routes most commonly drawn on the maps generally led to the downtown area as well. 24% of respondents mentioned parks or open spaces, which is equal to the percentage that mentioned Starbucks. Of the mentions of parks, 52% were of parks located within the Peter's Brook linear park system, and of those, 73% referred to one park in particular (Exchange Field), and many referred to it as "the park," which suggests that this space is part of their sense of place within the community (Figure 8).

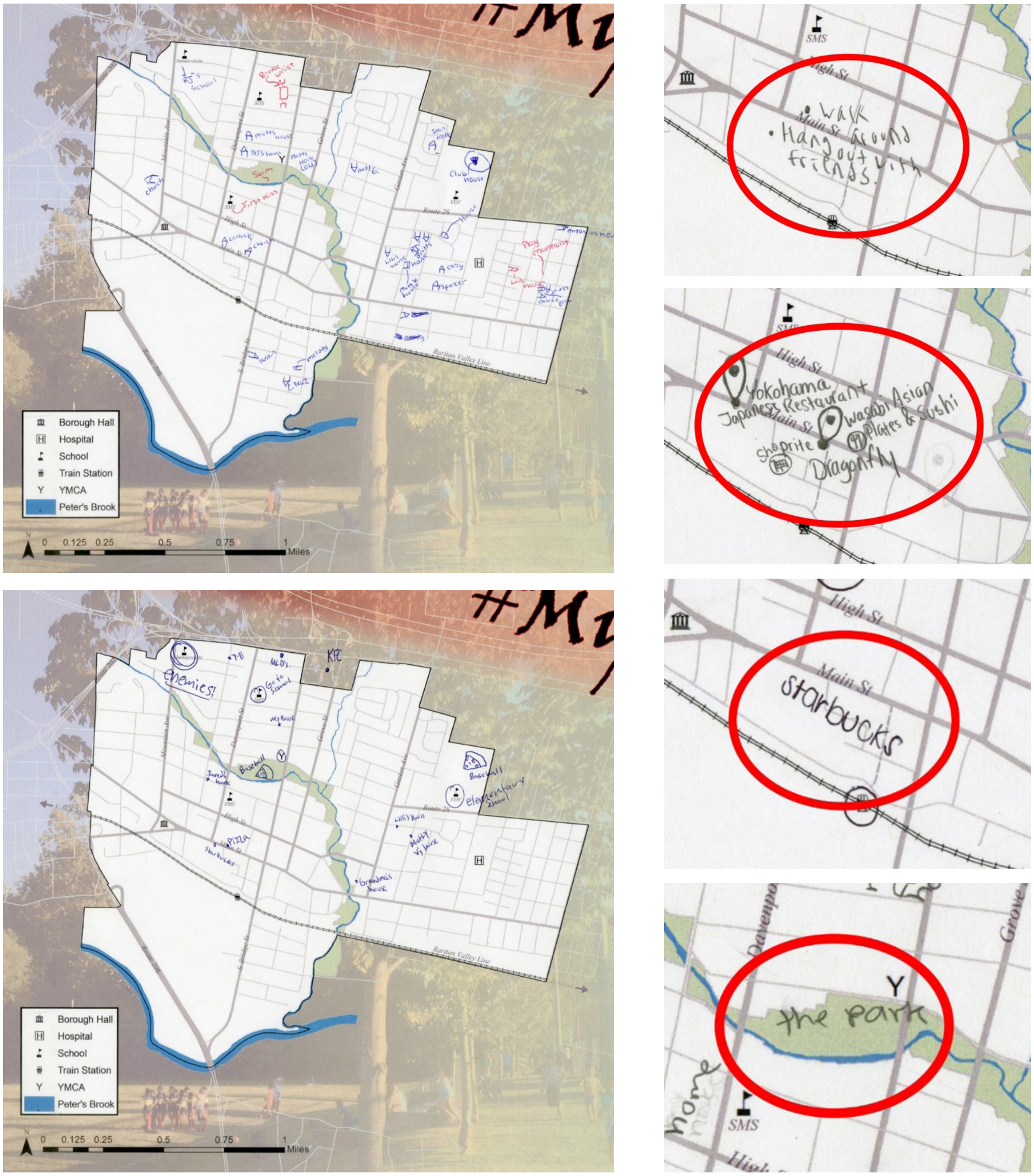


Figure 8. Mental mapping exercise results from high school students. Left: sample responses. Right: examples of commonly mentioned places (Top to bottom: downtown as a place, downtown businesses, Starbucks, Exchange Field).

Overall, it is clear that while there certainly is some interest in the parks, the downtown area is still the main focus for this subpopulation, even if they live in other neighborhoods. Mentions of downtown outnumber mentions of parks three to one (Figure 9). This information about how the community perceives and values its public spaces supports the hypothesis that the downtown area is significantly more appreciated than the Peter's Brook linear park system, and provides strong support for the need to engage the community more directly with these green spaces in order to support a connection between the people of Somerville and its remaining natural landscape, thereby revealing the potential sacredness of the site and pushing forward the progression of ecological democracy.

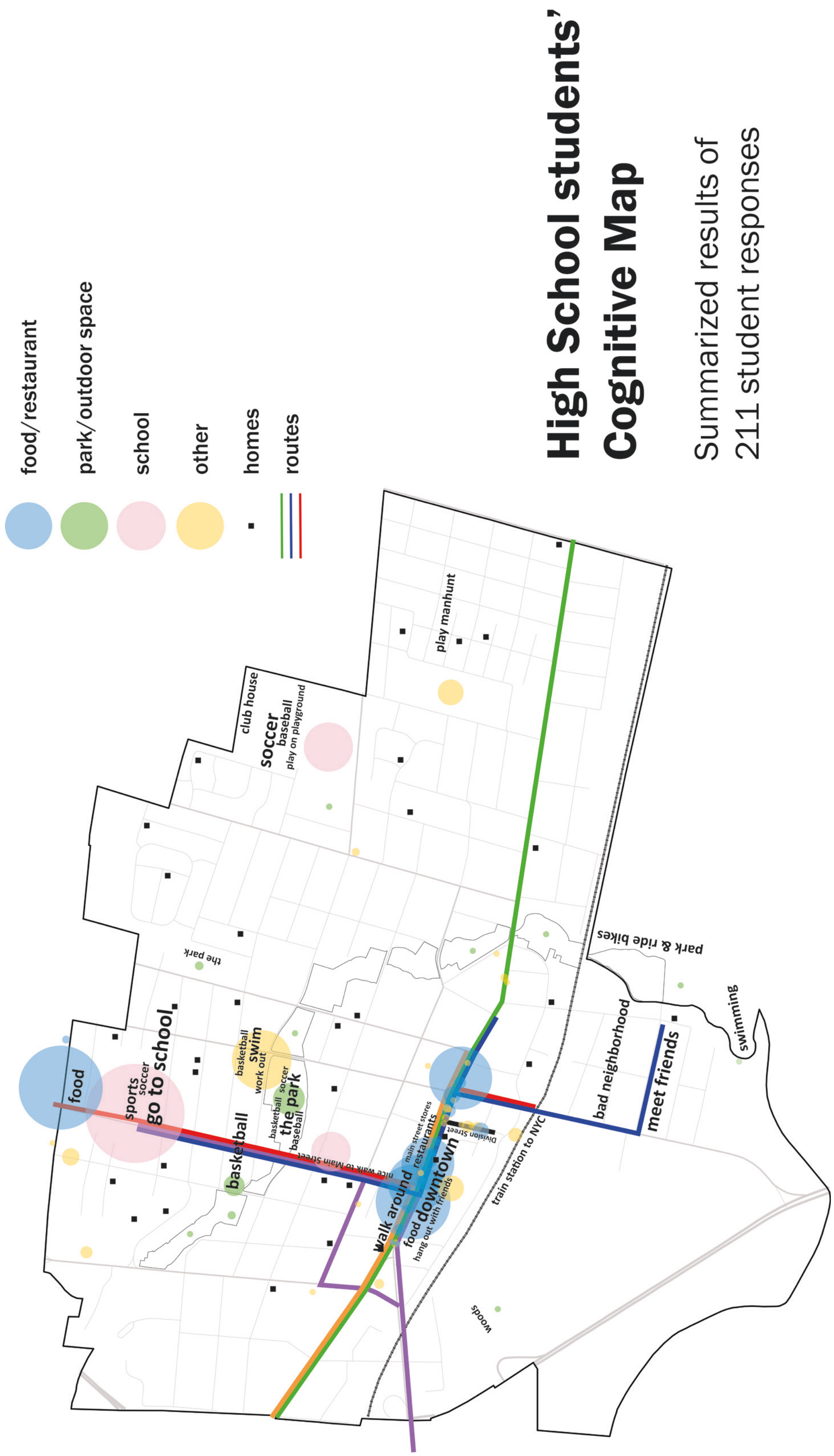


Figure 9. Graphic summary of responses from high school students to mental mapping exercise.

Existing Stream Condition

While the nine segments of parks and open spaces in the Peter's Brook linear park system are very different, the stream and riparian corridor provide a shared characteristic and a certain amount of consistency between spaces. There are certainly differences even within the riparian system, but the overall condition of the stream system is consistent.

The stream bed consists of gravel and rock substrate that is significantly embedded in finer sediment in some areas, usually pool zones (Figure 10), but in most areas riffles are frequent enough to support stream health (the ratio of the distance between riffles divided by width of the stream is generally 7:1 or lower) (Figure 11).

Water quality is moderately impaired due to intense runoff from the high percentage of impervious surfaces in town and direct inflow from storm drains. Specifically, the New Jersey Department of Environmental Protection developed a total maximum daily load (TMDL) of fecal coliform for the stream that requires a 98%

Figure 10. Stream bed substrate in a pool zone significantly embedded in fine sediment.

Figure 11. Stream health. (Left: a riffle zone. Right: foamy residue along bank).

decrease in levels. The source is identified as primarily suburban stormwater runoff.[42]

Because of the combination of intense flooding and impaired water quality, Chambres Park (at the south end of the linear system) is technically closed due to environmental contamination and health risk, although access is not prevented. Warning signs have been posted and maintenance operations have temporarily been ceased (Figure 12). There are plans for a stormwater bypass system that is not yet operational.[43]

Soils are primarily a moderately well drained silt loam with a parent material of reddish brown shale.[44] Erosion and channelization vary but are present throughout the system (Figure 13). In some areas, aging bank stabilization structures are slowly beginning to fail (Figure 14). In areas with no stabilization efforts in place, banks are continuing to erode and recede (Figure 15).

Riparian habitat in the stream corridor ranges in width and diversity, with some

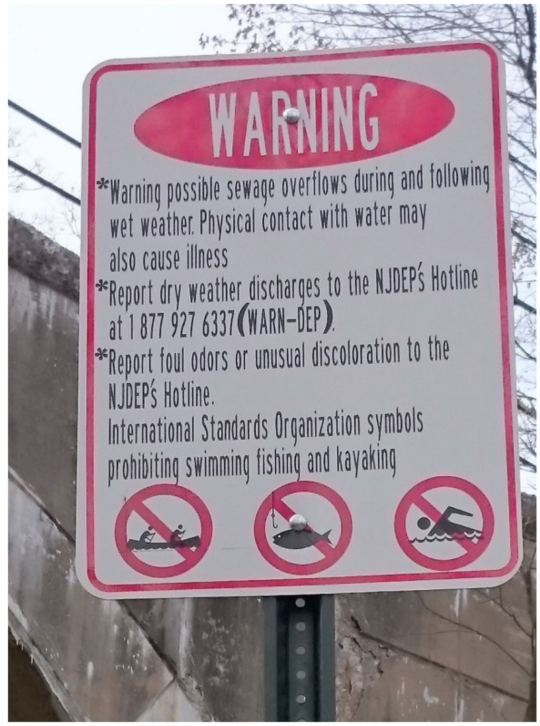


Figure 12. Chambres Park. (Left: Ceased maintenance of recreational facilities. Right: Warning sign, health and environmental risk).

Figure 13. Soils, erosion, and channelization.

Figure 14. Existing gabion wall beginning to fail.

Figure 15. Fallen tree due to unstable bank. (Left: February 6, 2016, Right: March 7, 2016)

areas relatively lush and others dominated by invasives (Figure 16). Plant species identified near the stream include several maple, oak, and ash species as well as American Sycamore, Black Walnut, Honeylocust, Black Locust, Elm, Black Cherry, American Hophornbeam, and other trees. Understory includes a mix of native and invasives, such as Japanese knotweed, goldenrod, poison ivy, mugwort, pokeweed, marsh marigold, mile-a-minute, common hibiscus, multiflora rose, fall blooming asters, and several grasses. A number of animal species have also been observed in the riparian corridor, including a pair of great blue herons, hawks, ducks, several woodpecker species, many songbird species, groundhogs, raccoons, skunks, red fox, and large colonies of bats in the summer months. There is certainly existing value and potential for the riparian habitat of these spaces.

There are several areas where informal paths and breaks in vegetation allow access to the water, although there are no purposely maintained access points. Crumbling walls and discarded concrete help to create some of these access points (Figure 17). At most of these informal access points there is evidence of use, which often includes litter and bottles. Between parks, the stream flows under road bridges, and the greenway and stream both pass under the train tracks through a frequently flooded and muddied underpass between Lepp Park and Chambres Park (Figure 18).

Overall, the stream and riparian buffer within the Peter's Brook linear park system is a beautiful corridor that is not yet realizing its full potential, both socially and ecologically. It is a public site in an urban context with great potential for achieving the goals of ecological democracy.

Figure 16. Examples of existing riparian habitat and vegetation.

Figure 17. Examples of existing access to the stream.

Figure 18. Greenway and stream under train tracks.

Methodology

Data Collection

Several types of social and ecological data were collected on site over the course of about nine months, including current recreational use, visual and physical access points, flood risk, geomorphology, and riparian habitat condition (Appendix II).

Data on the current recreational use of the site was collected using the social observation methods of Jan Gehl.[45] Understanding current social use of a site is imperative before making decisions that will change the way users interact with the site. "The core of the matter is to get the large volumes of life in public spaces to function in a way that allows daily life to take place under decent conditions and partner with the physical framework instead of fighting against it."[46] The methods described by Gehl that were used include Counting, Mapping, Tracing, and Looking for Traces.

The Counting method provides a tally of types of users observed on the site. The site is observed from a selected vantage point during a selected time period (morning, afternoon, or evening). Users are watched and counted for ten minutes every hour.
The following types of users were counted and tallied: Total number of people; males; females; children; teenagers; adults; seniors; moving; staying; alone; in pairs; in groups; on phone; dogs; bicycles.

The Mapping method records the locations of stationary activities on site. The site is observed from a selected vantage point for one hour during a selected time period (morning, afternoon, or evening). All stationary activities observed are recorded on a map of the site, using different symbols to denote type of activity.

The Tracing method records the routes of users moving through the site. The site is observed from a selected vantage point for one hour during a selected time period (morning, afternoon, or evening). The movement patterns of users are recorded on a map of the site, noting walking sequence, direction, flow, use of entrances, etc.

The method of Looking for Traces makes use of indirect observation. The site is examined for evidence of past or recent use, and the evidence is photographed and recorded on a map of the site. Examples of evidence of use include footprints, trampled paths, things left behind, or things used in ways not originally intended.

For the purposes of this project, so as not to confuse Tracing with Looking for Traces, the Looking for Traces method will henceforth be referred to as Evidence.

Each of the four chosen methods of user observation was completed at each segment of the site once during the time period of July 2015 through February 2016 (Figures 19 & 20). It is important to note that differences in the time of year that each observation was completed may account for differences in results, and further observation might be needed (for example, over the course of a full year) to gain an even better understanding of use patterns.

Points of access, both visual and physical, to the stream bank were recorded on a map of the site. Visual access points are areas where a potentially enjoyable view of the stream is visible from the public space, and some of these are large segments of space. Physical access points are often represented by a single point, and are areas where the edge of the stream bank can be physically accessed by users. Already existing visual and physical access points reveal areas where users already access the stream for recreational use (Figure 21).

Flood data came directly from FEMA flood maps,[47] and includes the location of the existing flood plain as well as the extent of flooding for one-hundred and five-hundred-year storm events. Areas where these flood zones overlap with existing development outside of the parks were also noted.

Geomorphology of the stream banks in the project site was assessed using parameters adopted from the Rosgen Stream Classification Technique,[48] which is frequently used by the United States Environment Protection Agency. The full technique is extremely comprehensive and technical, and classification using this methodology would not have been possible with the available time and resources. Classification parameters that were possible to assess were chosen, including bank slope and channel depth, and pool and riffle zones within the channel.

Segments of the stream banks were mapped and classified as follows based on these parameters: bank slope was classified as Shallow, Moderate, Steep, or Vertical. Channel depth was classified in increments of six feet. Pool and riffle zones within the channel were mapped by visual observation (Figure 22).

The habitat value of each segment of stream and its banks was assessed using the EPA's Habitat Assessment for High Gradient Streams[49], which is based on visual observations and provides a habitat score to each segment. Based on the value of the score, the habitat of each segment can be rated as optimal, sub-optimal, marginal, or poor.

Figure 19. Examples of social observations recorded. (Top to bottom: Mapping, Tracing, Evidence).

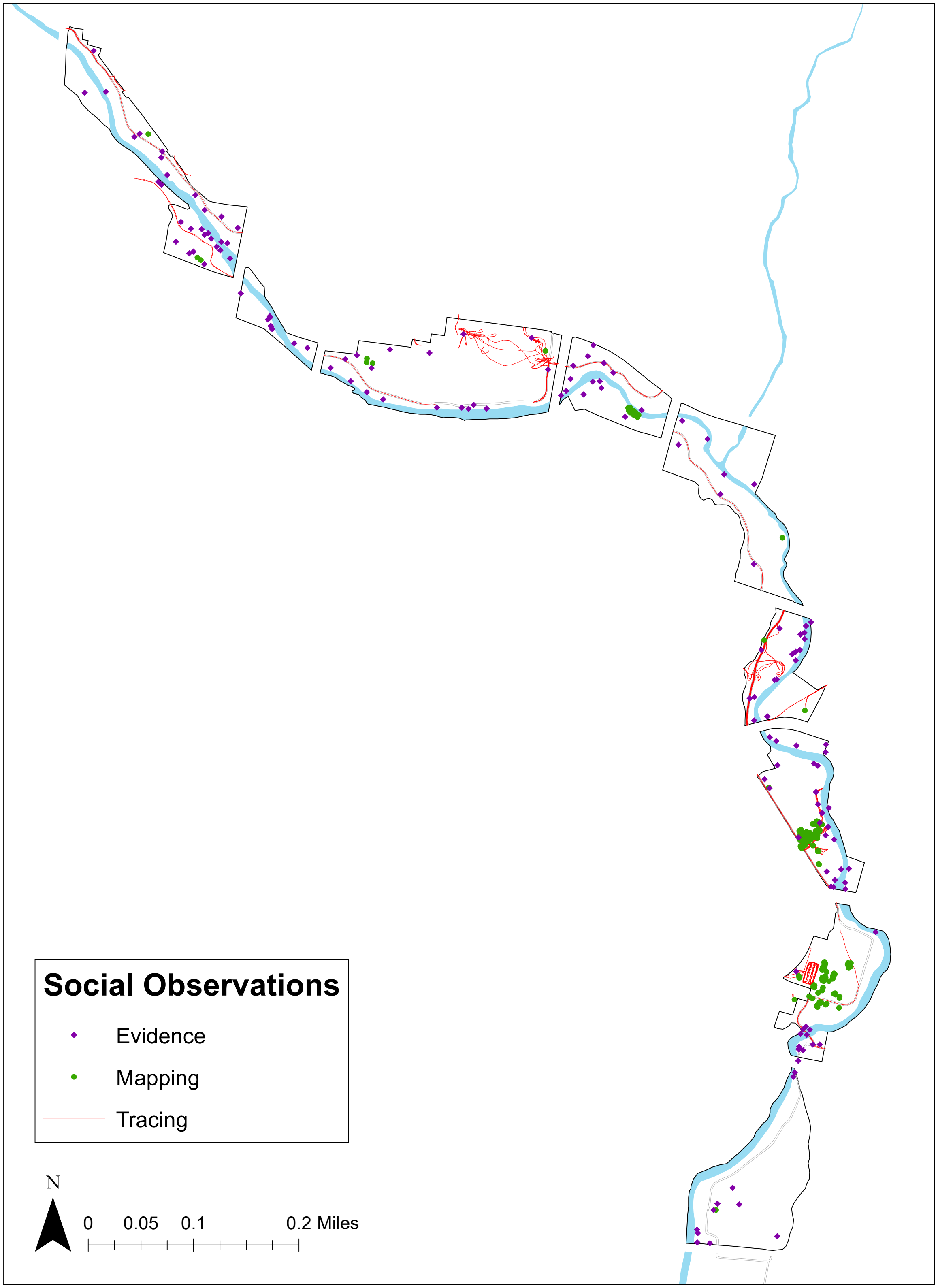


Figure 20. Spatial representation of social use observations (Evidence, Mapping, and Tracing).

Figure 21. Access points. (Left: visual access, Right: physical access).

Figure 22. An example of varying geomorphology. A deeply channelized vertical bank on the left and a minimally channelized shallow bank on the right.

Data Analysis

After the data was collected, it was analyzed as seven distinct sets, which represent specific parameters of ecological and social value.

Data from the Counting exercise of social observation showed certain trends in use. Throughout the linear system, 65% of users are male and 35% are female. Almost half of users (46%) are adults, while 35% are children, 18% are teenagers, and less than 1% are senior citizens. About 41% of users are moving through the space, while 59% are staying. About half of users (51%) are in groups of three or more people, while 26% are alone and 23% are in pairs. The observed ratio of dogs to people is 1:6.5, and the ratio of bicycles to people is 1:15.

On each remaining set of social use data, including Mapping, Tracing, and Evidence, a point or line density analysis was run in ArcGIS to create separate maps of density for each type of use. With the three resulting density maps, an overall use analysis was done using a simple multicriteria overlay analysis technique, with Mapping and Tracing weighted slightly higher than Evidence. The result shows several hot spots of human use based on the data recorded (Figure 23).

Visual access to the stream was analyzed on site by mapping areas within each space where the water is visible (Figure 24).

Physical access was analyzed by creating a cost surface, classifying the amount of resistance of each surface in the parks, and then running a cost distance analysis in ArcGIS. For example, the densely vegetated areas along the banks were classified as higher resistance than lawn. The result is a hot spot map of areas where physical access to the stream is possible (Figure 25).

The flood data from the FEMA maps was overlaid with areas where development outside of the parks is affected by flood risk (Figure 26).

Erosion data was also analyzed using a simple multicriteria overlay analysis, including the bank slope and channel depth data with equal weighting. The result is a map of relative erosion within the site (Figure 27).

Channel geomorphology, represented by the mapped pool and riffle zones, is representative of both geomorphology and stream habitat, and is therefore included as a separate layer of analysis (Figure 28).

Finally, habitat value of each segment of stream bank was characterized based on the habitat assessment data. As the different stream banks scored within a relatively limited range on the habitat assessment, mostly falling into the category of Marginal, the scores only reflect that range (Figure 29).

These seven layers of data analysis were overlaid and examined together (Figure 30), and the result is the classification of each segment of stream bank into five distinct typologies (Figure 31).

Typology 1, Flood-prone Natural, includes segments with high flood risk that see little recreational use and have little connection to the community (in other words, low human value), but have high ecological potential. Typology 2, Natural, is similar to Typology 1 but with significantly lower flood risk. Typology 3, Flood-prone Social, includes segments with high flood risk that have values opposite those of Typology 1. Recreational use and community connection are high, and ecological potential is low. Typology 4, Social, is similar to Typology 3 but with significantly lower flood risk. Finally, Typology 5 includes small pockets of space with little value, either socially or

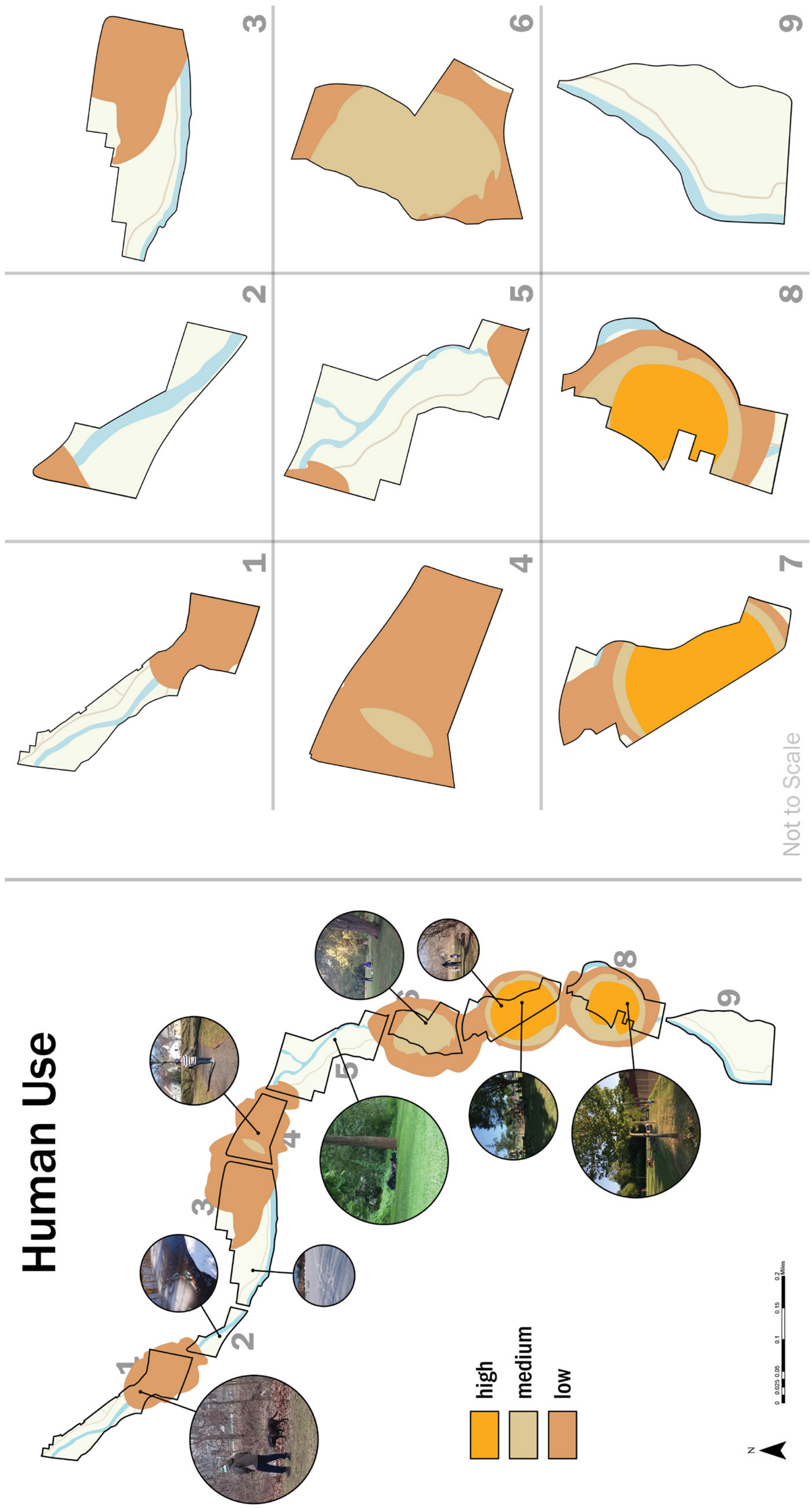


Figure 23. Results of use data analysis.

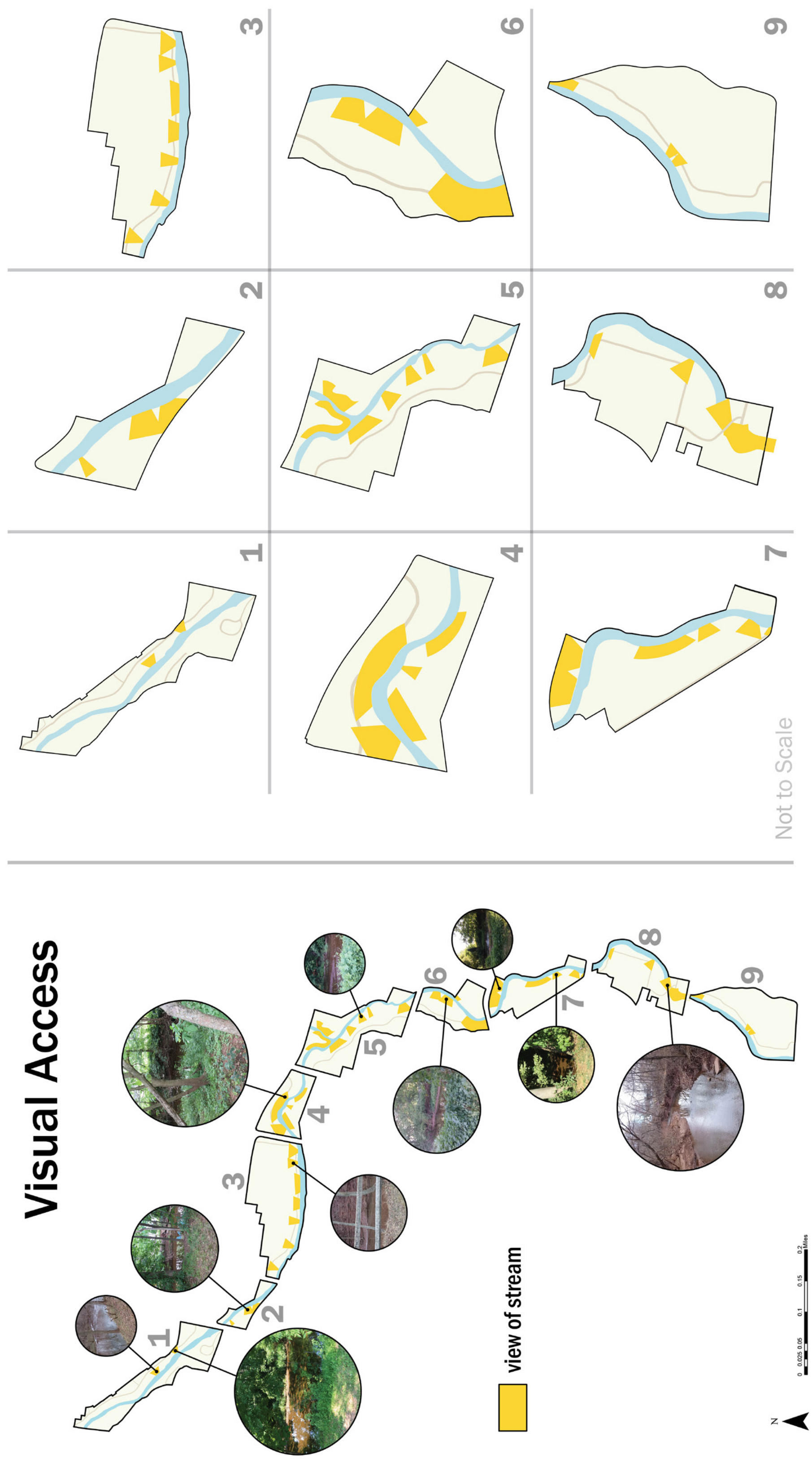


Figure 24. Results of visual access data analysis.

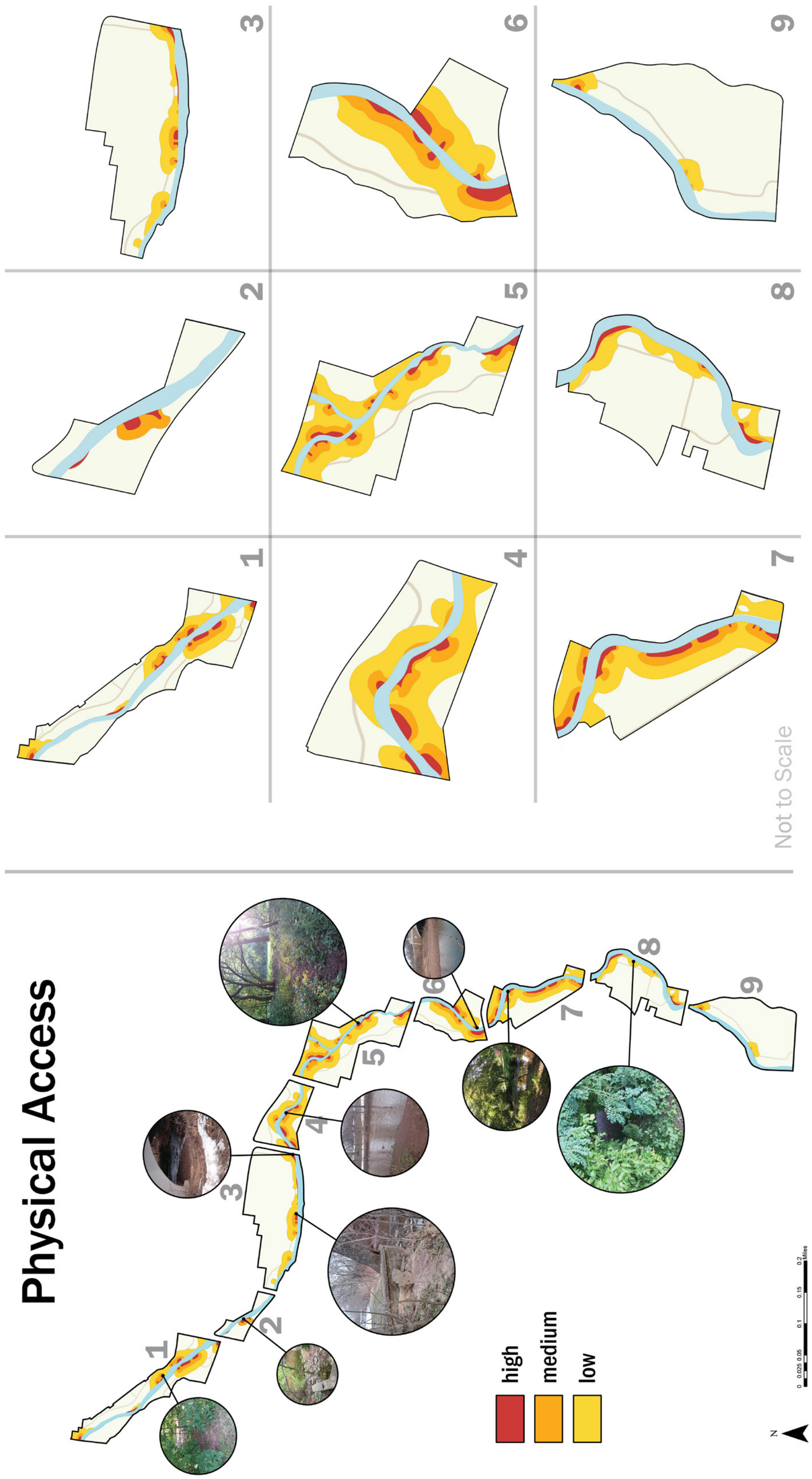


Figure 25. Results of physical access data analysis.

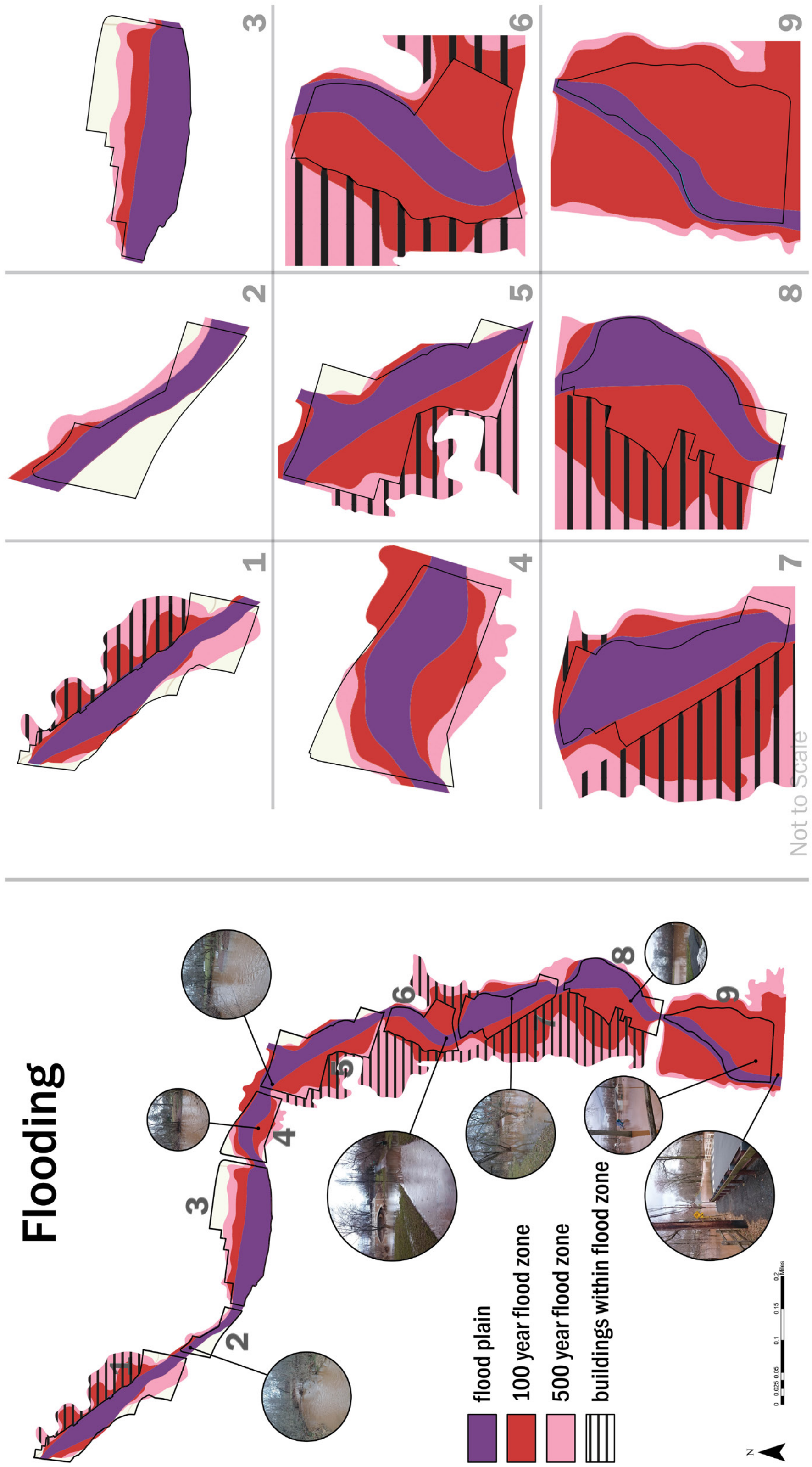


Figure 26. Results of flood data analysis.

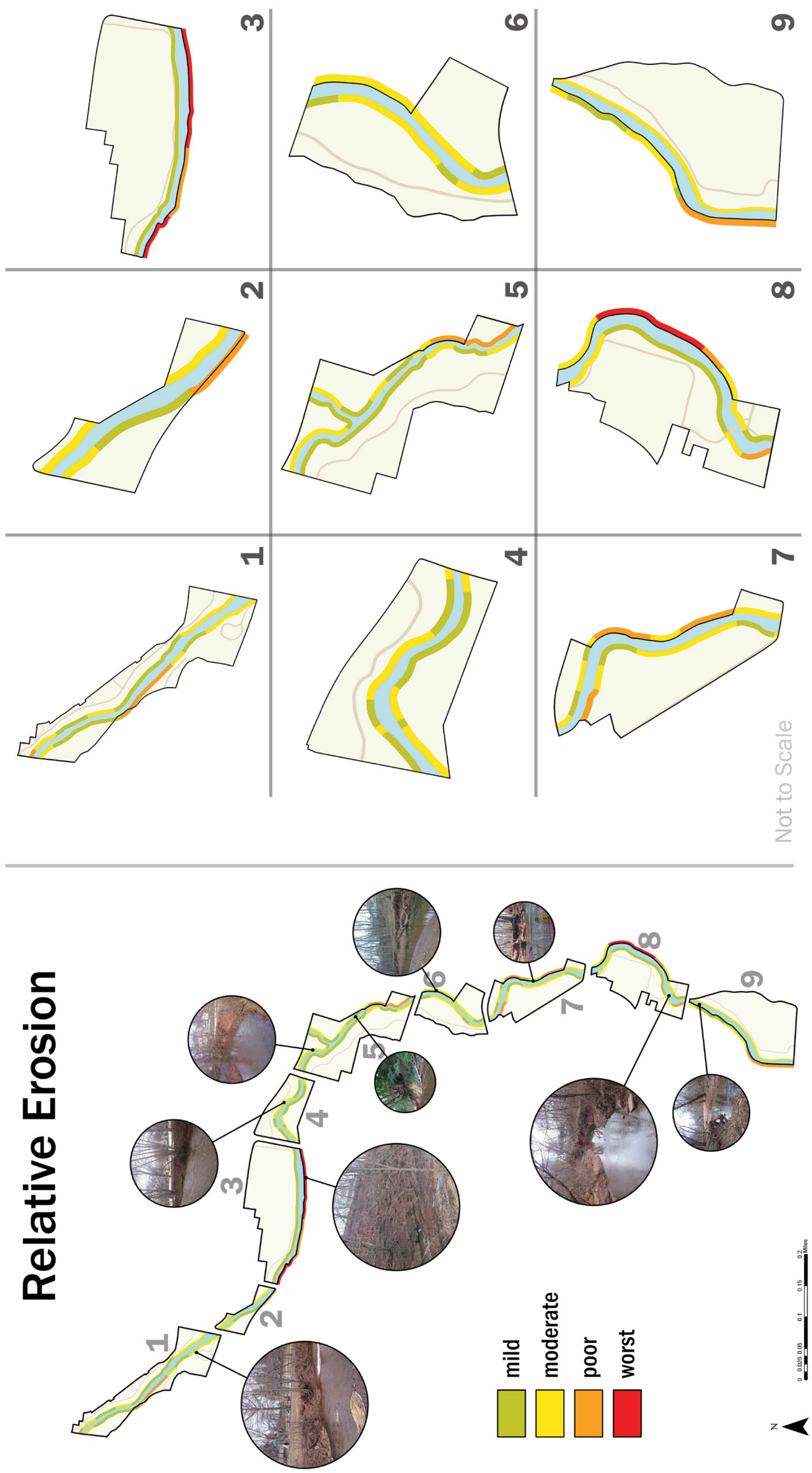


Figure 27. Results of erosion data analysis.

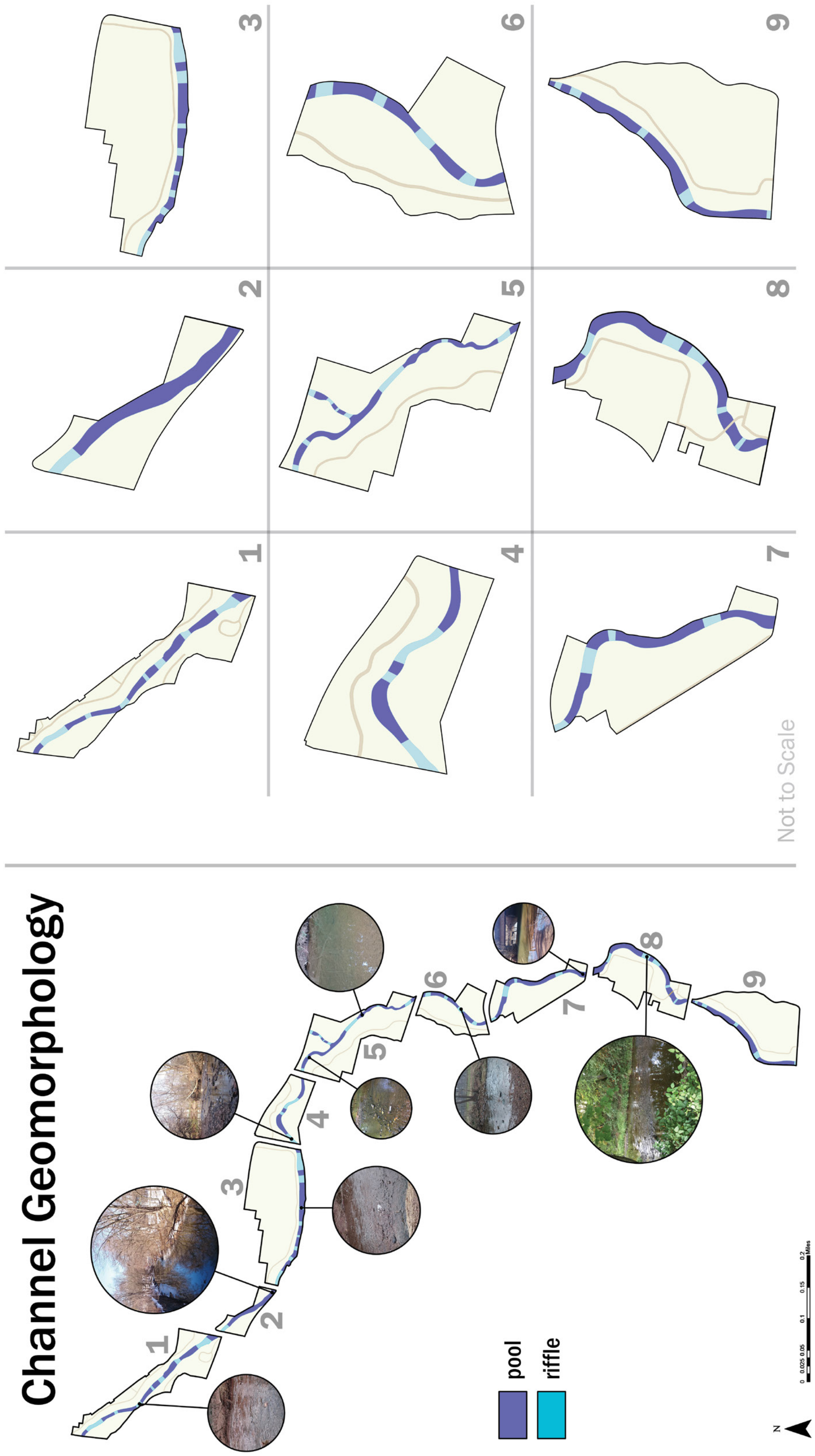


Figure 28. Results of channel geomorphology data analysis.

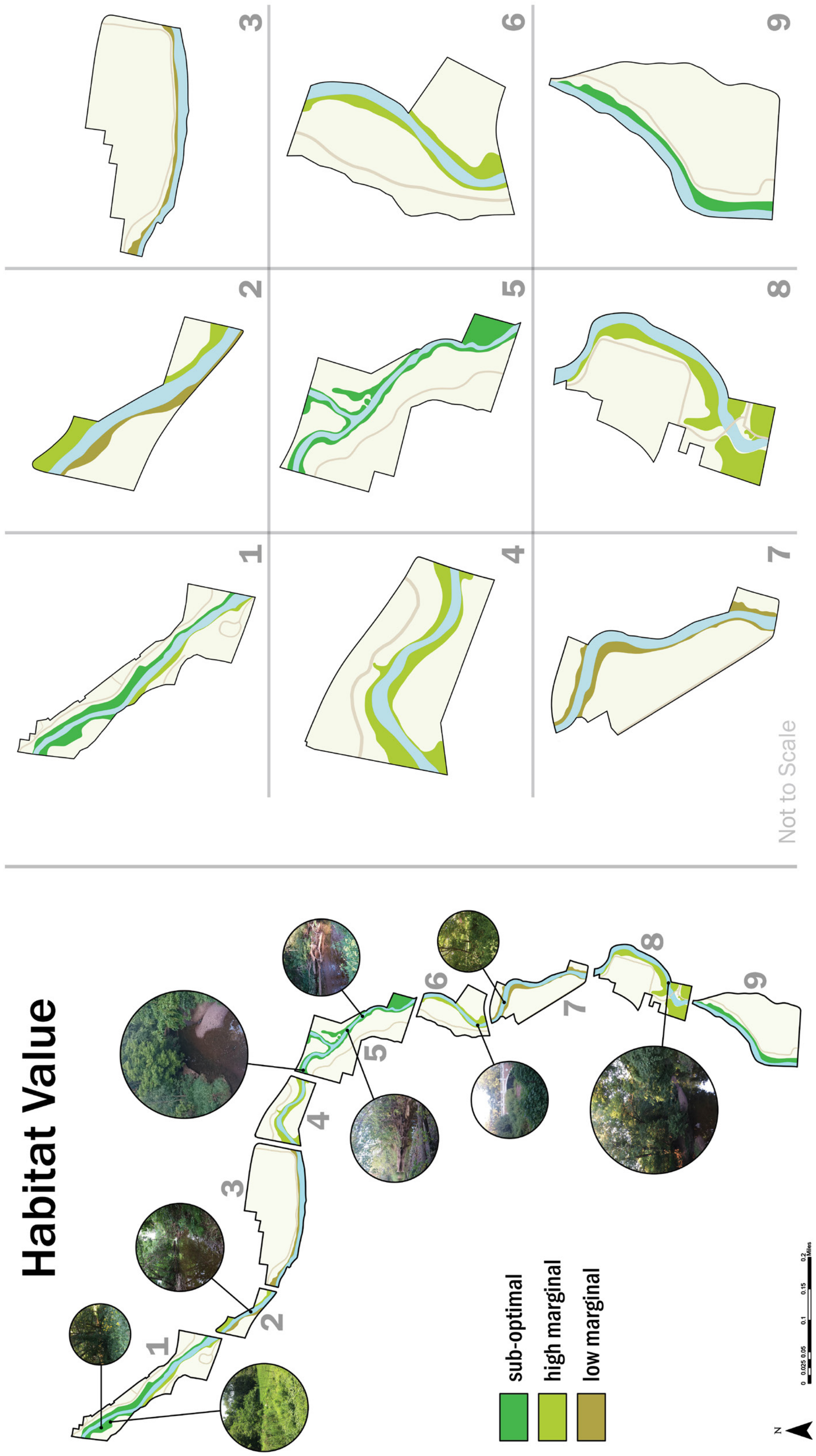


Figure 29. Results of habitat data analysis.

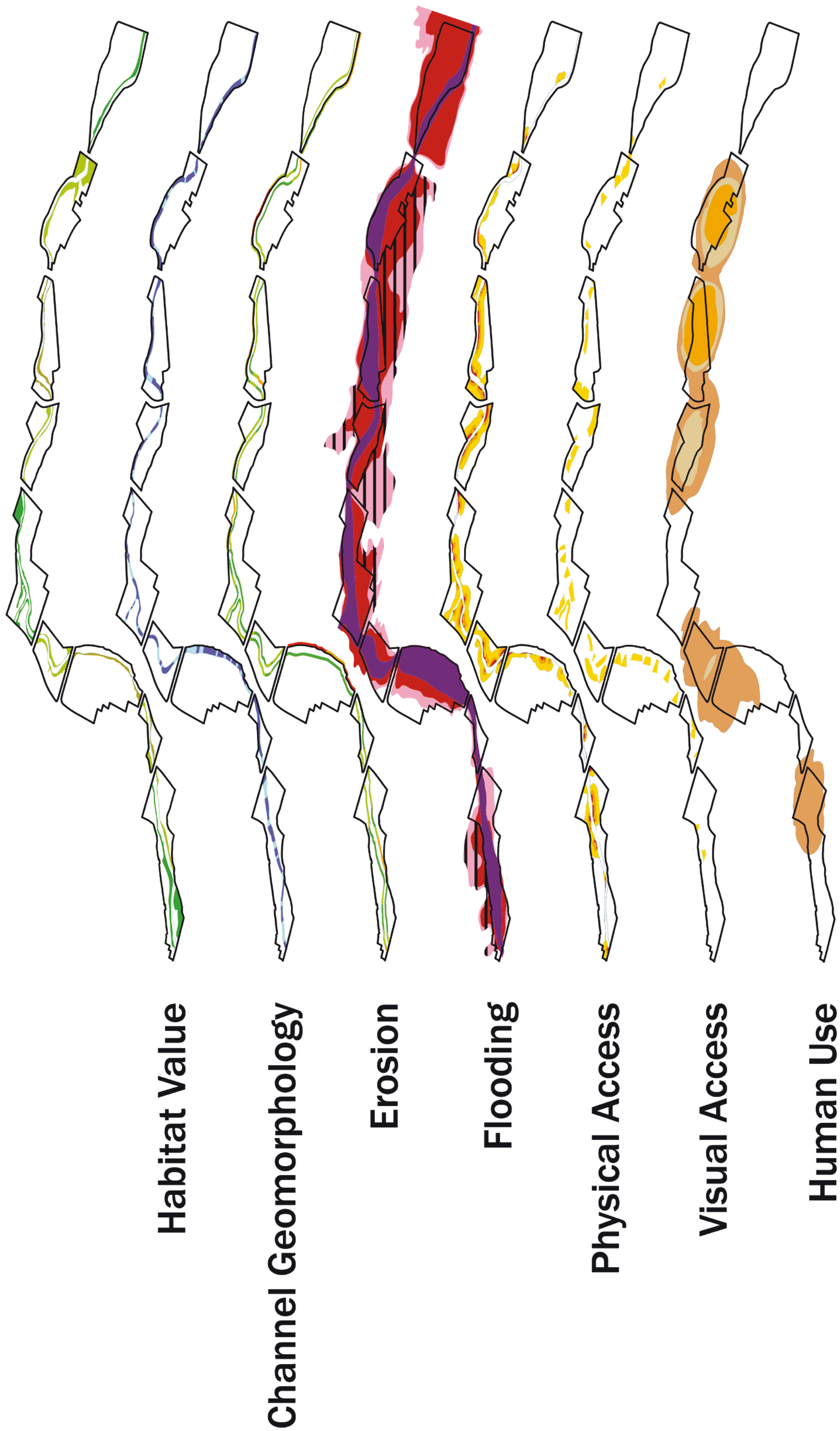


Figure 30. The seven layers of analysis.

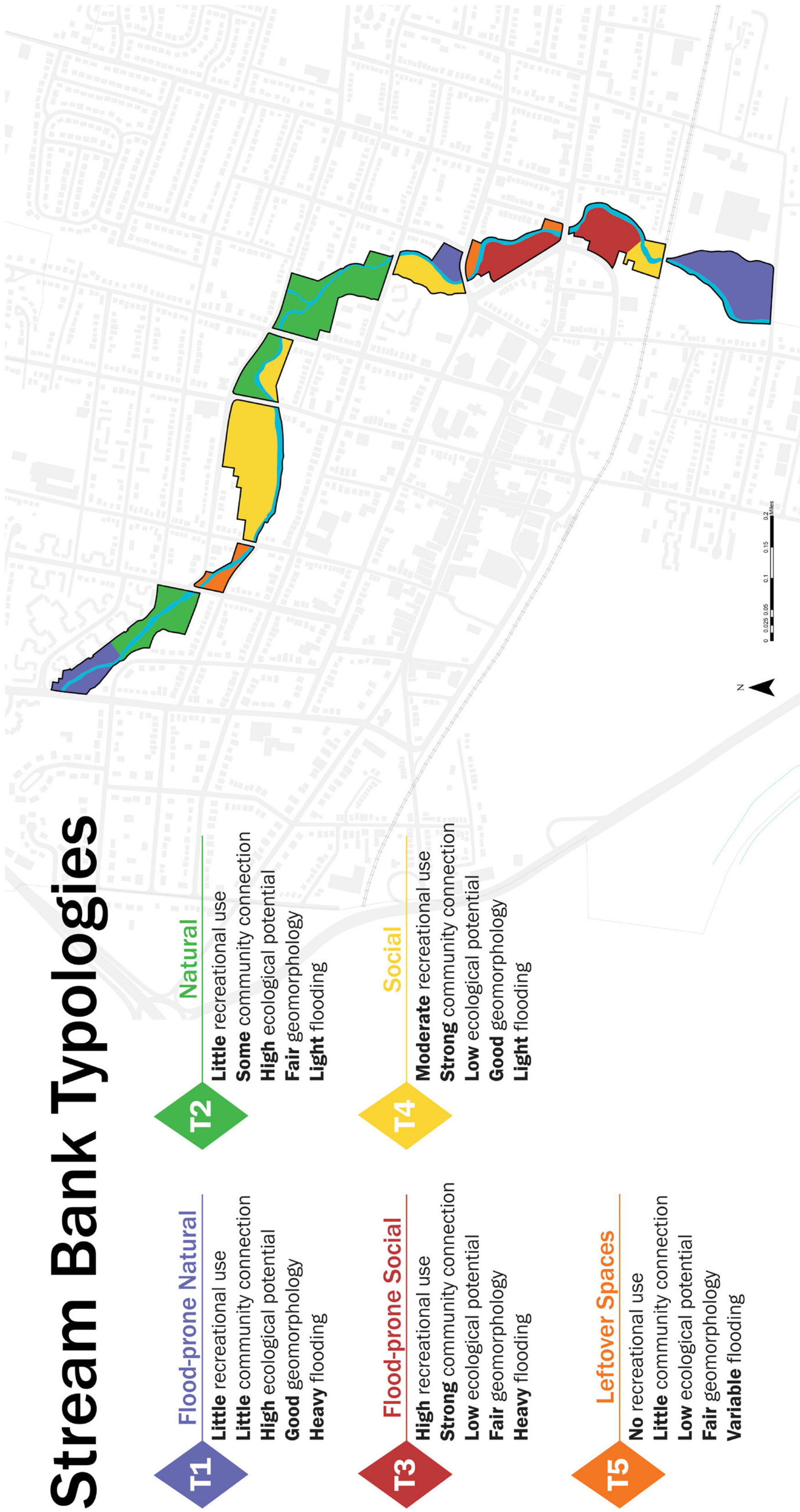


Figure 31. Stream bank typologies resulting from data analysis.

ecologically.

If we look at these resulting stream bank typologies in terms of ecological value and human value, we can see that they are polarized on opposite ends of the spectrum, with Typology 5 as an outlier with little value on either axis (Figure 32). To achieve ecological democracy, revitalization efforts would ideally work to move the stream banks toward the area of the graph where they would be achieving relatively high levels of both social and ecological value (Figure 33).

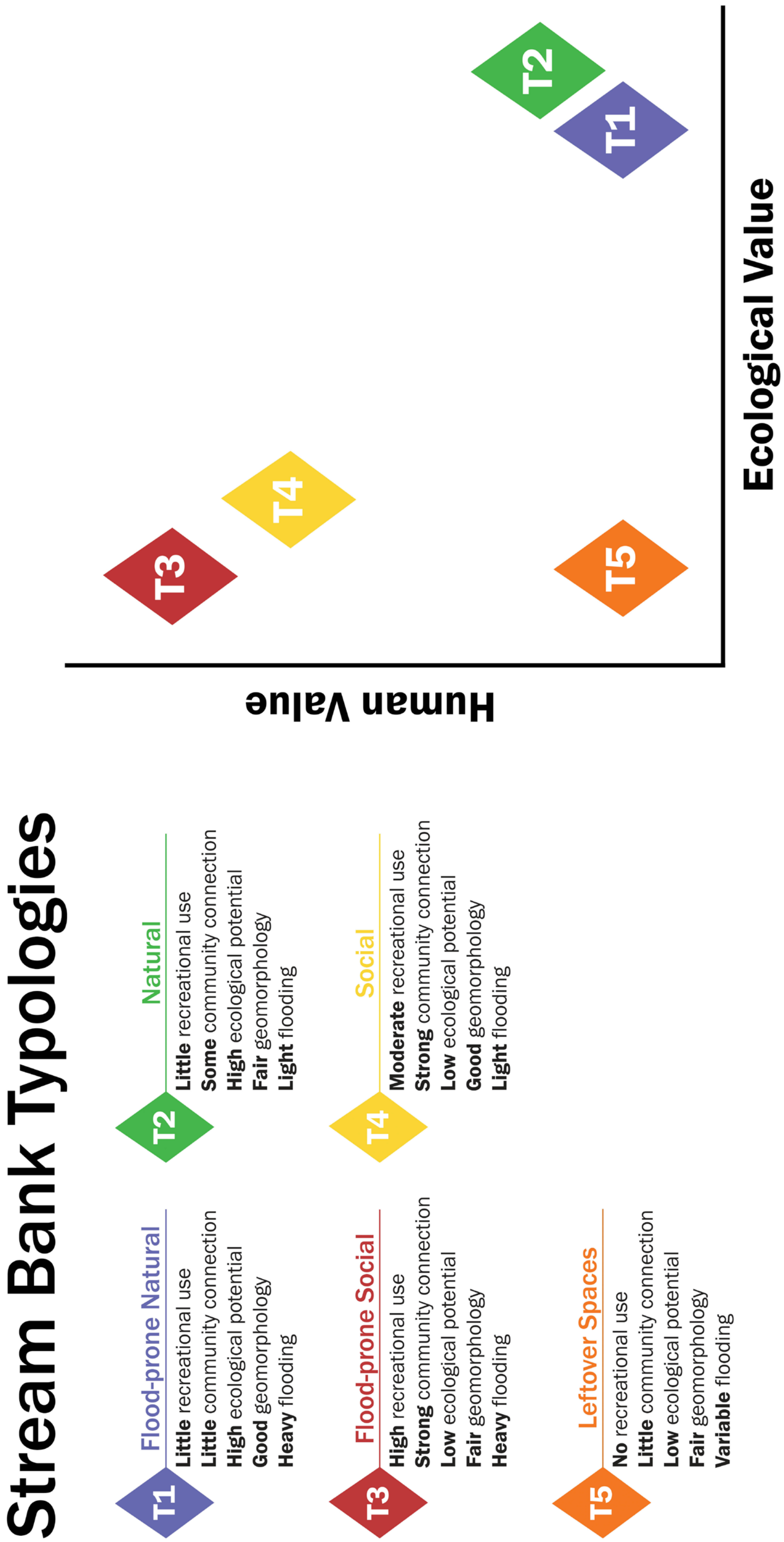


Figure 32. Existing human and ecological values of stream bank typologies.

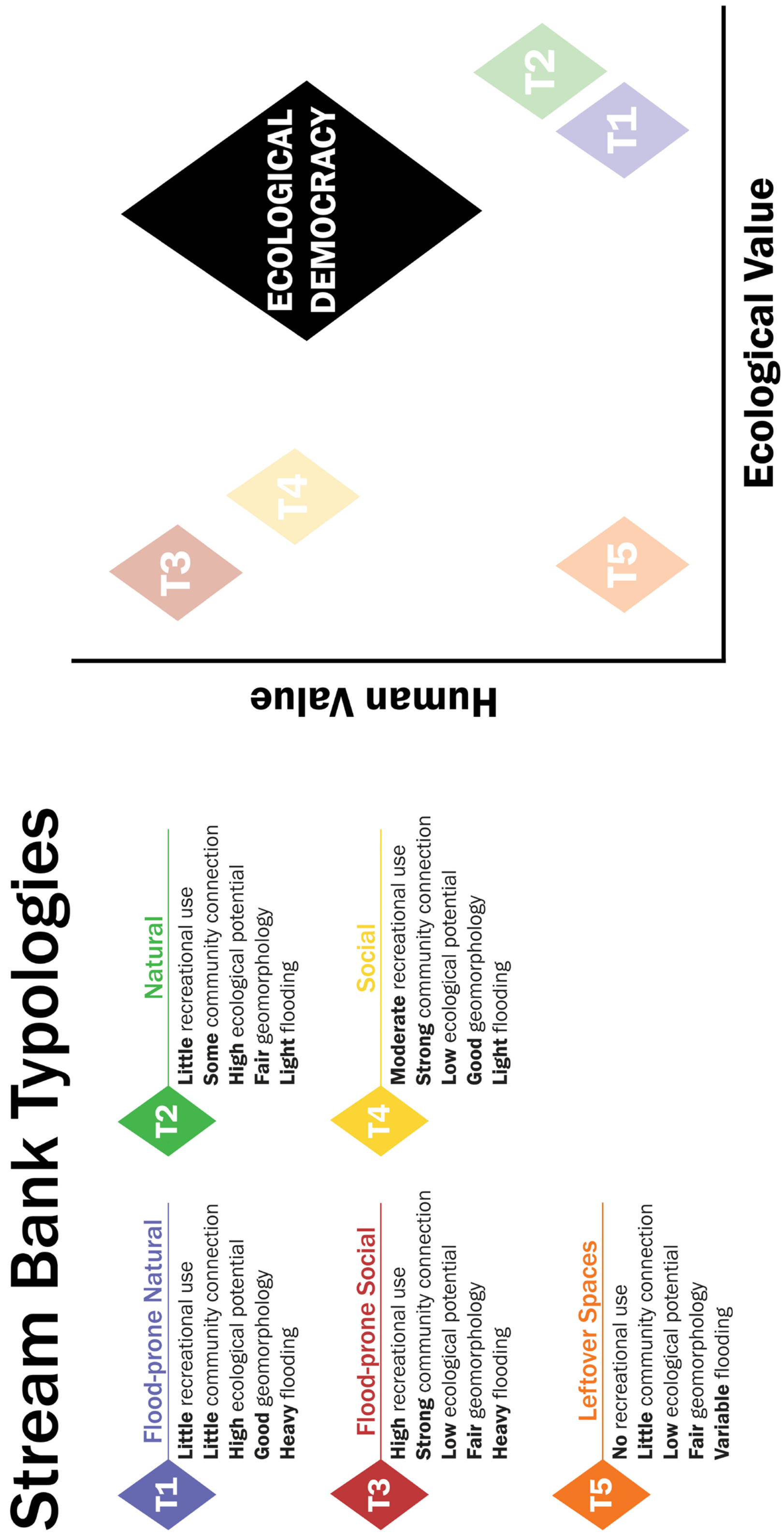


Figure 33. Ideal relationship of human and ecological value to achieve ecological democracy.

Precedents

A review of precedents was used to identify possible design and management strategies for accomplishing the goal of revitalizing the stream banks in an effort to achieve ecological democracy. Precedents studied include five case studies and a guide to Best Management Practices for stream restoration and stabilization. From each precedent, specific intervention strategies have been extracted that might be applicable to the project site, addressing the identified primary concerns of recreational use, community connection, water quality, flooding, riparian habitat, and erosion and bank stabilization.

The first case study is the competition-winning design for Waller Creek in Austin, Texas (Figure 34).[50] Waller Creek is a narrow stream that runs through downtown Austin, Texas. This urban riparian corridor is of historical significance to the surrounding city, but has become physically and culturally isolated from the community due to lack of maintenance, as well as problems with flash flooding, erosion, and invasive species. In 2011, the Waller Creek Conservancy announced a design competition for the revitalization of this urban stream system. The winning design, which is still in the process of implementation, was presented by Michael Van Valkenburgh Associates, Inc. and Thomas Phifer & Partners.

The design celebrates the connective quality of the stream, which is remarkably similar to that of Peter's Brook. The one-and-a-half-mile creek connects several parks and public open spaces of varying character. "Waller Creek is too long, and its condition too varied, to be resolved with a single sweeping design gesture. What was called for, rather, was a sensitivity to the particulars of the remarkably heterogeneous site."[51] Just like the Peter's Brook system, the Waller Creek project sought to restore the ecological integrity of an urban riparian corridor that connects a series of public spaces, while simultaneously creating a connection to the surrounding community.

Possible design strategies from the Waller Creek case study include Bridges, Streamside Grove, Green "Island," and Lifted Lawn (Figure 35).

A lattice of trail bridges and a floating pontoon bridge create linkages between downtown Austin and the creek. These provide easier pedestrian and bicycle access to the stream and associated parks, as well as enticing views to draw users to the space. The riparian ecosystem is preserved below the bridges, which are of lightweight construction and can be easily built and adjusted to meet future needs of the changing community.

The Streamside Grove in the Waller Creek system incorporates a shaded grove that increases recreational access to the creek, engaging the community. The Grove is a cool, shaded area, planted with stands of new shade trees, with paths and seating, creating spaces for outdoor socialization.

Taking advantage of a bend in the creek, the design creates a green "island" with a relatively level grade, which allows people to interact directly with the creek ecosystem in a serene environment. This space includes open lawn with the slopes of the creek graded back, leaving the space at creek level and providing great opportunity for environmental education, as well as a restored floodplain.

In an effort to control flooding, the Waller Creek design proposes a widened channel near an existing park. To prevent losing park space, the design compensates by lifting a segment of lawn out over the water, creating a dramatic open event space and a unique view of the landscape.

Figure 34. Waller Creek case study design plan. (Image: Michael Van Valkeburg Associates, Inc.)

Figure 35. Waller Creek case study strategies. From top left: Bridges, Streamside Grove, Green "Island," Lifted Lawn. (Images: Michael Van Valkeburg Associates, Inc.)

The second case study is Rockefeller Park in Cleveland, Ohio.[52] Rockefeller Park is a 200 acre park on the east side of Cleveland which includes the Doan Brook and much of its watershed. Although this park is one large space as opposed to a chain of public open spaces, it's size still allows it to create connections between diverse urban communities. The stream within the park is heavily channelized and is characterized by flood and erosion issues, which are exacerbated by excessive runoff associated with urban impervious surfaces and an outdated combined storm and sanitary system.

This master plan project for Rockefeller Park aims to restore the ecology of the park and improve the health of the watershed by addressing flooding issues and stream restoration, as well as to improve connectivity and access for the community. According to Siteworks, who won an ASLA Honors Award for this project in 2009, "The Park is an interwoven set of ecological and human systems that extend far beyond the boundaries of the areas of investigation," and "the strategies described here primarily address the major edges and intersections of these complex natural and human systems."[53]

Possible design strategies from the Rockefeller Park case study include Streamside Terrace Gardens, Neighborhood Edge Parks & Rain Gardens, and Infrastructure Garden Gateways (Figure 36).

Areas of the streambank with significant erosion are designated as potential sites for Streamside Terrace Gardens. These terraced areas, constructed from on site or local stone, are meant to function as a built extension of the floodplain, allowing the brook to expand and contract into gardens that can not only tolerate flooded conditions, but help to purify the water they take in. Plantings in these areas are intended to create a visual connection to the stream while simultaneously maintaining a strategic physical barrier.

A system of small spaces placed along the upper edges of the floodplain, where the park meets the neighborhood, known as Neighborhood Edge Parks & Rain Gardens are intended to create a seam between the community and the park which provides a variety of passive and active programmatic opportunities. Rain gardens and bioretention areas within this seam would help to intercept runoff to the brook, slowing flooding during storm events. The designers hope that this edge would also help to create a stronger definition for the edge of the park and a sense of connection for the local neighborhood.

Infrastructure Garden Gateways are another series of spaces throughout the park, which could vary in scale and form, are proposed to help manage stormwater while also providing recreational opportunities. These spaces could involve landform designed to move water strategically, as well as more bioretention areas. The designers propose that combinations of these techniques could create larger gathering spaces that can act to mitigate downstream flooding and reduce the occurrence of combined sanitary and stormwater overflow. These spaces are meant to be connected with a path system and placed within a restored native riparian forest.

Figure 36. Rockefeller Park case study strategies. From top: Streamside Terrace Gardens, Neighborhood Edge Parks & Rain Gardens, Infrastructure Garden Gateways. (Images: Siteworks)

The third case study is a section of the Peapack Brook located in Rockabye Meadow Park in Gladstone, New Jersey.[54] The restoration of this section of the Peapack Brook was a project completed in 2007 by Amy S. Green Environmental Consultants, Inc. for the Upper Raritan Watershed Association. This segment of the brook's banks experienced severe bank erosion and changes in morphology due to erratic flow associated with storm events. The project area is about 135 feet of stream bank located within the 100 year flood plain, and includes some wetlands and wetland transition areas.

Possible strategies from the Peapack Brook case study include Live Cribwalls and Native Riparian Planting via live stakes, both of which are also included in the Best Management Practices guide[55] (Figure 37).

Because of the severe erosion conditions and high flow rates during storms, which are similar to some of the conditions of nearby Peter's Brook, the Peapack Brook project utilized relatively permanent structural interventions. The bank was stabilized with a Live Cribwall, which provides protection for the banks and facilitates the establishment of riparian vegetation.

The restored banks were replanted in order to restore the ecosystem of the stream corridor. Live stakes of Black Willow, Pussy Willow, Silky Dogwood, and Red-osier Dogwood were planted along the face of the cribwall, and native trees and shrubs were planted on the top. The species selected for the face of the cribwall are ones that grow quickly from cuttings, creating root structures that will secure the bank by the time the cedar logs of the cribwall begin to deteriorate. Although live stakes were used in this project, any method of Native Riparian Planting can be a possible strategy.

Figure 37. Peapack Brook case study strategies. From top: Live Cribwall, Native Riparian Planting via live stakes. (Images: Amy S. Greene Environmental Consultants, Inc.)

The fourth case study is Boneyard Creek in Urbana, Illinois[56] (Figure 38). Boneyard Creek runs through the cities of Champaign and Urbana. Like many urban streams, the creek was channelized for flood control in the early 20th century. The city of Urbana underwent significant redevelopment in the early 21st century, focused at first primarily on a renewed downtown, much like the recent redevelopment strategy of the Borough of Somerville.

In 2006, a master plan for the revitalization of Boneyard Creek was begun. The goals of the plan included improving flood control and water quality and protecting and enhancing wildlife and habitat, in addition to providing spaces for active and passive recreation and enhancing the local community. The master plan divides the creek into distinct segments, similar to those represented in the Peter's Brook system, and prescribes solutions for each based on its unique character and needs.

Possible design strategies from the Boneyard Creek case study include Terrace Steps, Elevated Deck Overlook, Steps & Ramps, and Weir Structures (Figure 39).

Terraced Steps near the stream banks provide both access and seating for enjoyment of the water, while also helping to accommodate flood conditions (especially when used in conjunction with a restored riparian buffer to widen the floodplain).

An Elevated Deck Overlook constructed over a portion of the stream creates a gathering space overlooking the stream that interacts directly with the riparian ecosystem. This space allows users to experience and enjoy the stream corridor with opportunities to learn about the value of its ecological function, without directly interrupting that function.

Steps & Ramps to the creek create access points in areas of significant grade change, including locations near road bridges.

The strategic placement of Weir Structures within the stream, which function in the same way as those described in the Best Management Practices guide, creates backwater areas and drops in the stream during low flow periods, in addition to directing the flow of the water. These Weir Structures can also function as stepping stones for access and connection to the water. An additional benefit of these structures is that they increase the sound of running water, creating a pleasant experience for visitors, and help to establish good conditions for aquatic life and bank vegetation.

Figure 38. Boneyard Creek case study design plan. (Image: Wenk Associates, HNTB)

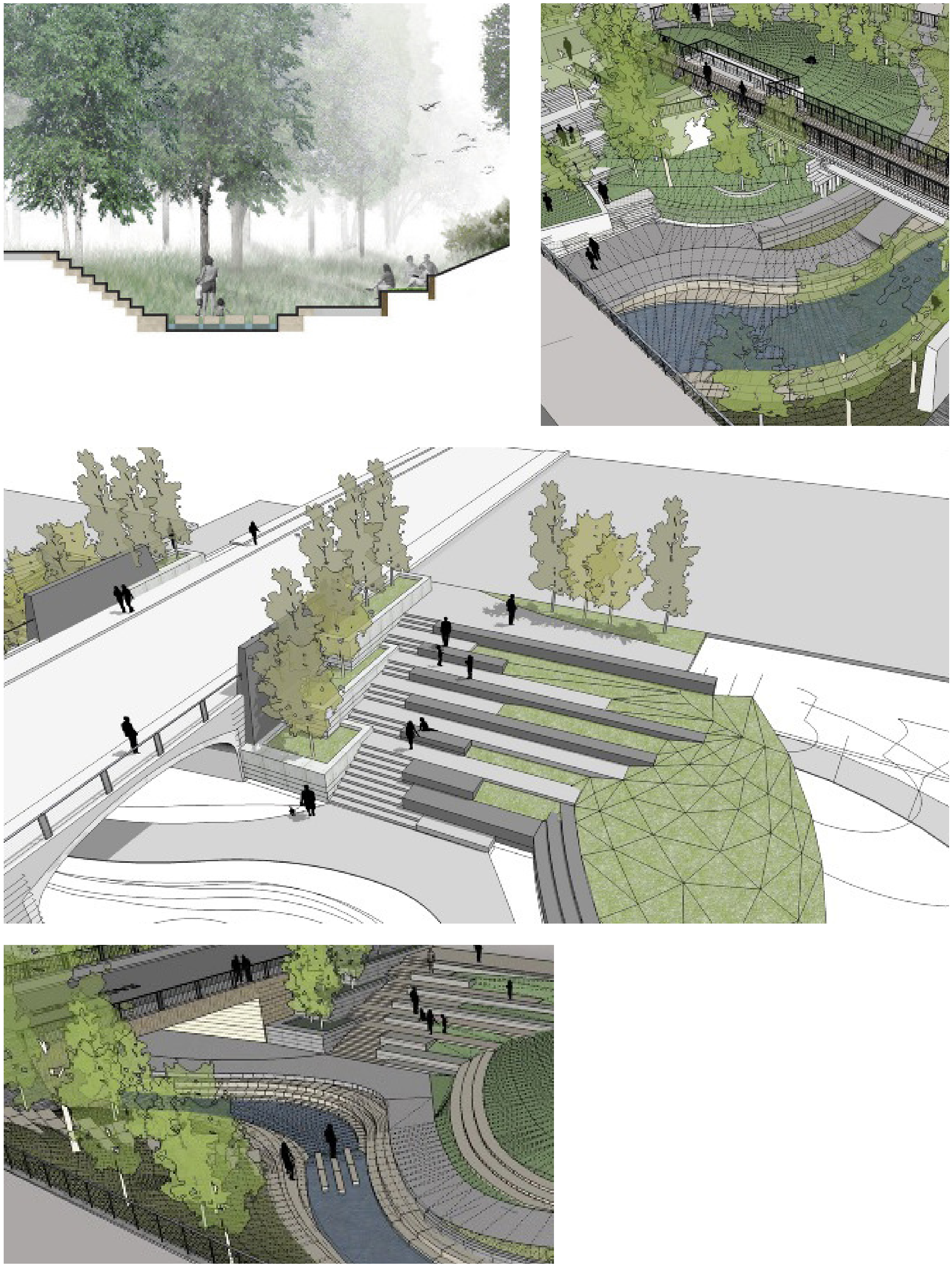


Figure 39. Boneyard Creek case study strategies. From top left: Terrace Steps, Elevated Deck Overlook, Steps & Ramps, Weir Structures. (Images: Wenk Associates, HNTB)

The fifth case study is a segment of Beaver Run located within Chamberlain Park in Springdale, Ohio.[57] The Beaver Run Riparian Corridor Restoration Project was completed in Springdale in 2012. Like Peter's Brook, Beaver Run was a beautiful stretch of stream that suffered from continuous bank erosion and downstream sediment deposits. The 1,600 feet of bank in question was deeply channelized, resulting in a thirty-foot vertical bank, much like some that exist on the project site. The stream is accessible to the community, and although the restoration effort did not specifically aim to enhance recreational use, it did seek to maintain accessibility while restoring ecological function.

Possible strategies from the Beaver Run case study include Terrace Walls and the Plunge Pool, which is also a Best Management Practice[58] (Figure 40).

The construction of a gently sloped Terrace Wall on a deeply channelized, eroded stream bank stabilizes the bank and increases the capacity of the stream to hold flood waters. The terrace walls are composed of soil lifts encapsulated in coir matting, and are planted with native riparian vegetation to further enforce the bank's stability and provide valuable habitat.

A Plunge Pool constructed of rock and gabion walls serves to dissipate the velocity of the stream, especially during storm events or periods of intense water movement.

Figure 40. Beaver Run case study strategies. From top: Terrace Walls, Plunge Pool. (Images: Mill Creek Watershed Council)

In addition to the strategies pulled from the five case studies, there exist many Best Management Practices for stream restoration and stabilization. Several of these proven physical practices might be applicable for the Peter's Brook system, helping to address issues of erosion, flood control, and water quality (Appendix III).

From The Virginia Stream Restoration and Stabilization Best Management Practices Guide,[59] this project considers the use of Rootwad Revetments, Stacked Stone, Natural Fiber Rolls & Matting, Rock Cross Vanes & W-Weirs, Rock Vanes & J-Hook Vanes, and Wing Deflectors (Figure 41).

Rootwad Revetments are a technique for bank protection which utilizes the rootwads of already fallen trees. The rootwads are placed in a series along the outer meander bend of a stream bank where rigid protection strategy is needed. They are braced on a footer log and anchored with large boulders or riprap, and the bank behind them is backfilled. This technique provides protection for the bank as well as sediment trapping and high habitat value, and is often used in combination with a vane device.

Stacked Stone is another technique for bank protection which is highly durable, and often used in areas with steep slope where the potential for vegetative establishment is low or woody vegetation is undesirable. It involves layers of stacked angular rock built into the streambank with gravel backfill behind.

Natural Fiber Rolls made from coir fiber and netting can be used to stabilize banks in areas of low stress. The fibers promote the trapping of sediment and also provide a medium for vegetative growth. They can be used in conjunction with more rigid protection techniques, like those listed above. Natural Fiber Matting is placed on a gently graded slope for stabilization, and allows the growth of trees and shrubs.

Rock Cross Vanes & W-Weirs are stone structures constructed within the stream in a way that directs erosional forces away from the streambanks, providing grade control and reducing bank erosion. Sediment accumulates behind the structure, and flow is directed over the cross vane, created a scour pool downstream of the structure. This technique not only helps to stabilize banks with grade control, but enhances fish habitat and can potentially enhance recreational opportunities.

Similar to Rock Cross Vanes and W-Weirs, Rock Vanes & J-Hook Vanes are in-stream rock structures that deflect erosional forces away from unstable streambanks, and also create aquatic habitat through the formation of scour pools.

Wing Deflectors are in-stream structures can be made of rock or logs. They provide a narrower base in the channel, accelerating flow through the constricted section. This provides improved function of low flows and improves habitat conditions.

Figure 41. Best Management Practices strategies. From top left: Rootwad Revetment, Stacked Stone, Natural Fiber Matting, Rock Cross Vane, J-Hook Vane, Wing Deflectors. (Images: Salix River Restoration Specialists, Montgomery County, Maryland DEP, Mill Creek Watershed Council, Minnesota River Basin Data Center, Aquatic Resource Restoration Company, New Mexico State Forestry)

Twenty-one total strategies were extracted from the precedent studies (Figure 42). Each of these strategies contributes to improving one or more of the issues hoping to be addressed with this project, including recreational access, community connection, water quality, flooding, riparian habitat, and erosion and bank stabilization (Figure 43).

When the twenty-one strategies are arranged on the same graph of human and ecological value on which the stream bank typologies were visualized, we see an arrangement that reflects the same polarization as the existing typologies (Figure 44). When implemented together, however, these strategies can begin to pull those typologies toward the goal of ecological democracy, maximizing and balancing human and ecological value.

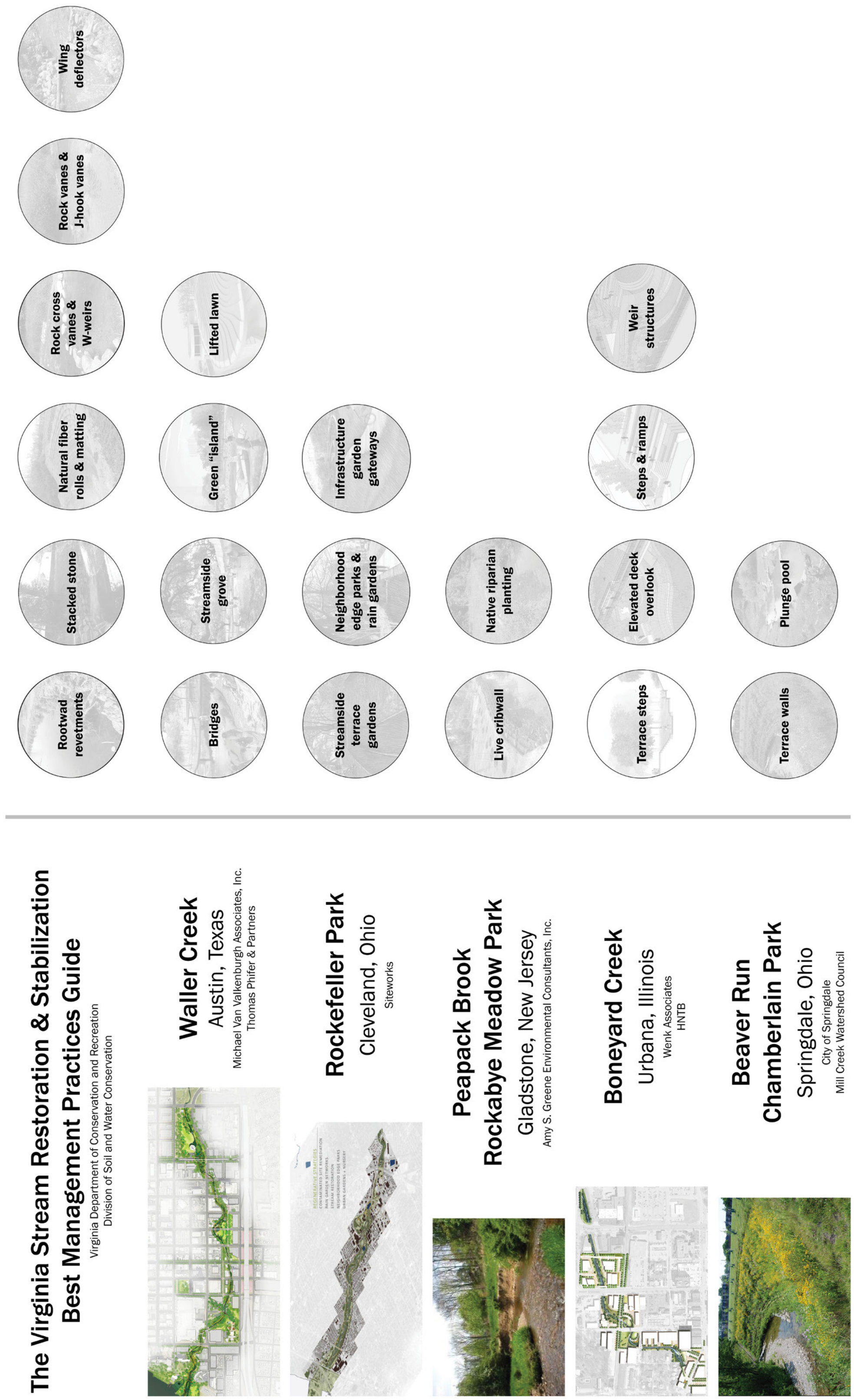


Figure 42. Twenty-one strategies extracted from precedent studies.

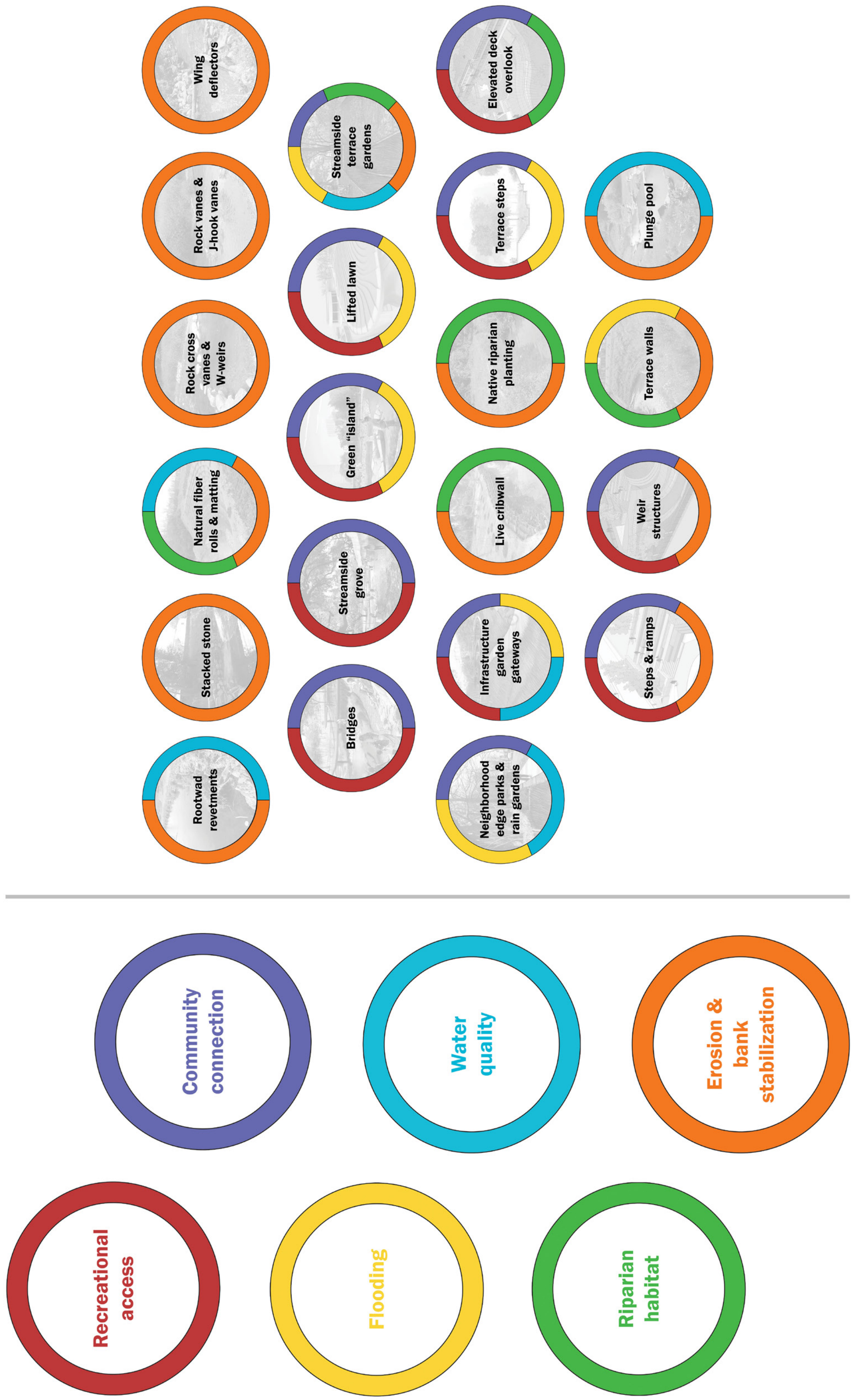


Figure 43. Issues addressed by the identified strategies.

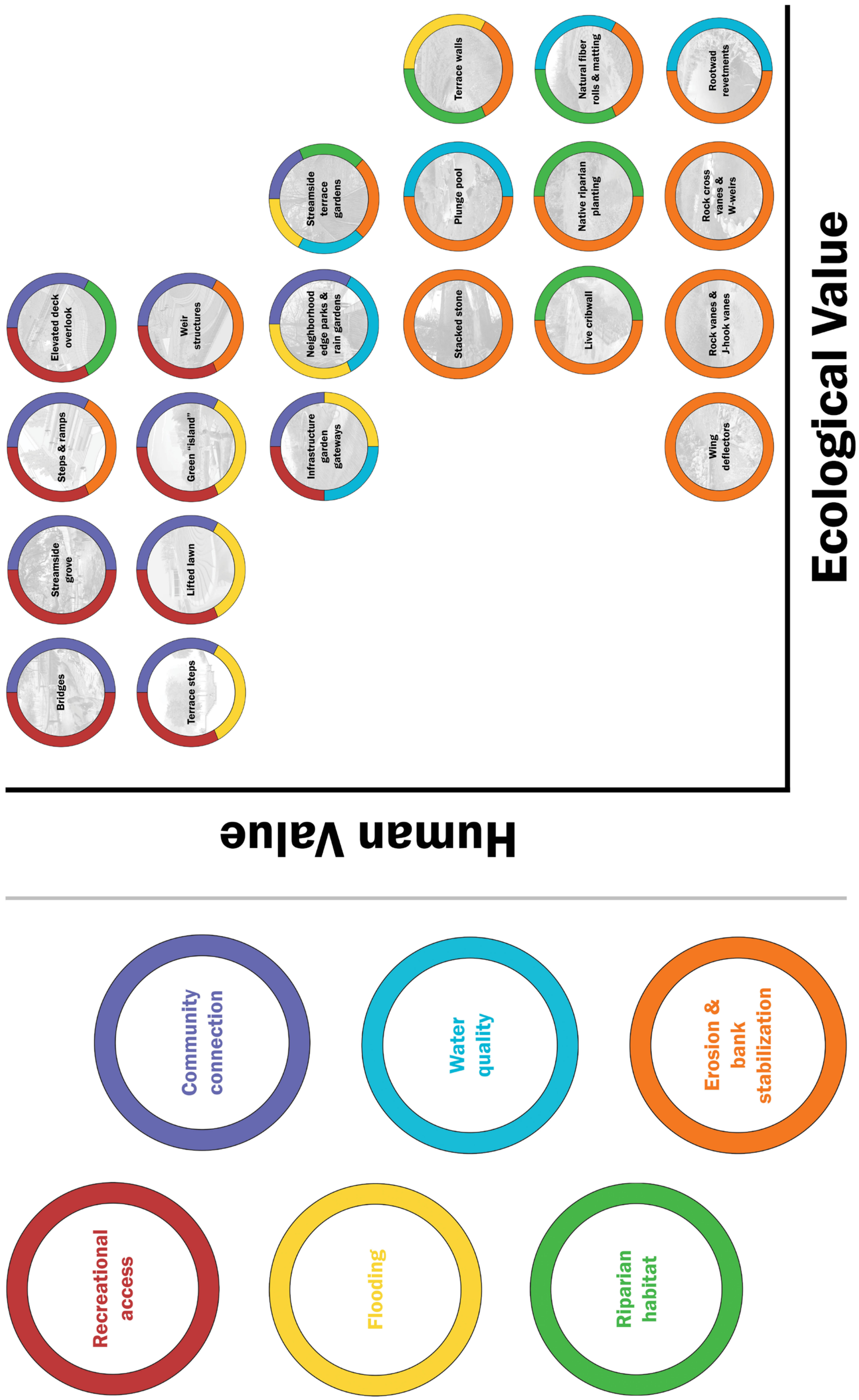


Figure 44. Human and ecological value of the identified strategies.

Results & Implementation

The result of this analysis is a set of strategies that would satisfy the needs of each stream bank typology, based on both the values it lacks and those it has that need to be supported. Native Riparian Planting and the structural channel morphology techniques can be applied to any of the typologies where appropriate (Figure 45).

Typology 1, the Flood-prone Natural spaces, could benefit from increased recreation use and community connection provided by Bridges, Terrace Steps, Green “Islands,” or Streamside Terrace Gardens. Several of these would also function as flood control elements. The Streamside Terrace Gardens, along with bank stabilization strategies such as Live Cribwalls, Rootwad Revetments, and Natural Fiber Rolls & Matting, would also address water quality and riparian habitat function when combined with supplemental Native Riparian Planting and the optional Best Management Practices for channel morphology.

Typology 2, the Natural spaces, have less need for flood mitigation. Recreational and community connection options for these spaces include Terrace Steps, Steps & Ramps, Weir Structures, Elevated Deck Overlook, and Infrastructure Garden Gateways. These, in conjunction with similar bank stabilization techniques to Typology 1, would enhance the human value of these spaces while also supporting and enhancing the existing ecological integrity.

Typology 3, the Flood-prone Social spaces, could see improved flood conditions through the use of Terrace Steps, Lifted Lawn, Streamside Terrace Gardens, or Terrace Walls. Several of these strategies would also supplement existing social access, as would Bridges. The Terrace Walls and Streamside Terrace Gardens, along with expanding the

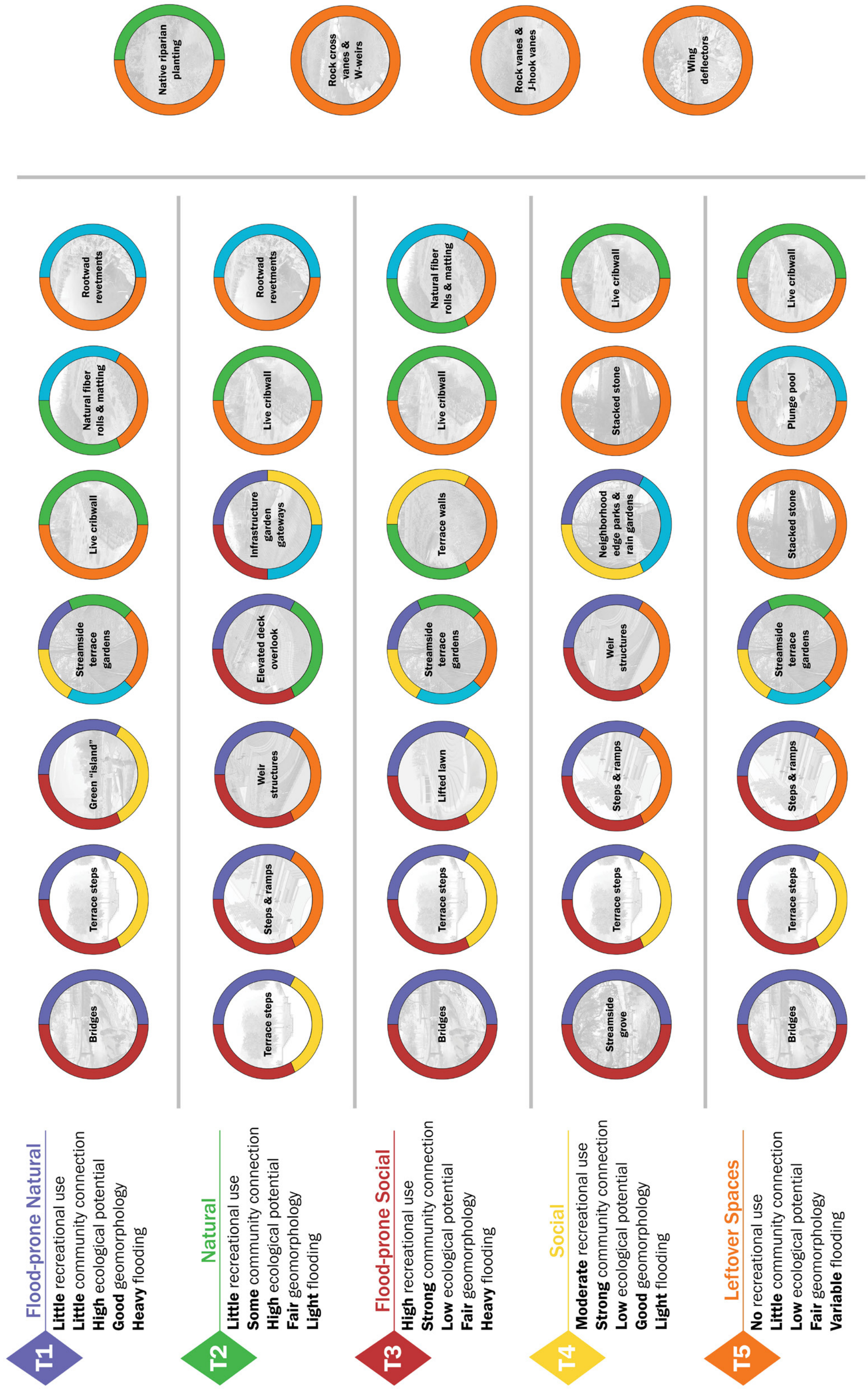


Figure 45. Strategies appropriate to each stream bank typology.

flood plain, would help to stabilize the stream banks and enhance water quality and riparian habitat when combined with Native Riparian Planting and bank stabilization techniques.

Typology 4, the Social spaces with less of a flooding concern, could take advantage of several strategies that would function to support use and community connection while also improving the ecology of the riparian system, including Streamside Grove, Terrace Steps, Weir Structures, and Neighborhood Edge Parks & Rain Gardens.

Finally, Typology 5, the Leftover Spaces, require a combination of strategies that will significantly increase both human and ecological value. Bridges, Terrace Steps, and Steps & Ramps are proposed as options for access within these smaller edge spaces, with the goal of connecting them to both the stream and larger nearby spaces. Streamside Terrace Gardens, Plunge Pool, and several bank stabilization techniques, combined with supplemental Native Riparian Planting, would help to enhance and connect the ecology of these small areas within the larger corridor.

As examples of implementation, two segments of the Peter's Brook linear park system have been looked at more closely (Van Fleet and Park Ave). Van Fleet represents the Natural typology (Typology 2) on one side of the stream and the Social typology (Typology 4) on the other, with not much of a flood issue. Placement of several bank stabilization techniques combined with supplemented riparian planting will help to support and increase ecological value on both sides (Figure 46). A Streamside Grove is proposed within the bend of the stream on the side that currently sees more social use, which would be connected by a stepping stone Weir Structure to Terrace Steps on the other side, helping to accommodate mild flooding while also improving recreational use and community connection in the area that currently sees little use (Figure 47).

The Park Ave. segment is primarily the Flood-prone Social typology (Typology 3), with two pockets of Leftover Spaces (Typology 5) on the other side of the stream. The area between those Leftover Spaces is private property. Again, bank stabilization techniques and planting will help to increase habitat value on both sides. A Plunge Pool constructed in a stretch of the stream that is currently stagnant would help to handle periods of intense water flow, and a combination of Terrace Steps and Streamside Terrace Gardens would widen the flood plain while also providing access and community connection in the pockets of Leftover Spaces (Figure 48). In the bend of the stream at Park Ave., perhaps the channel could be widened by removing some of the built up sediment deposits to allow a greater capacity for handling water during storm events. Placing a Lifted Lawn over this widened channel, as in the Waller Creek case study, would prevent the loss of park space and create an additional connection to the stream. Opposite the Lifted Lawn, vegetated Terrace Walls going around the outer edge of the bend would do even more to accommodate flooding and might create an interesting visual juxtaposition to the protruding lawn (Figure 49).

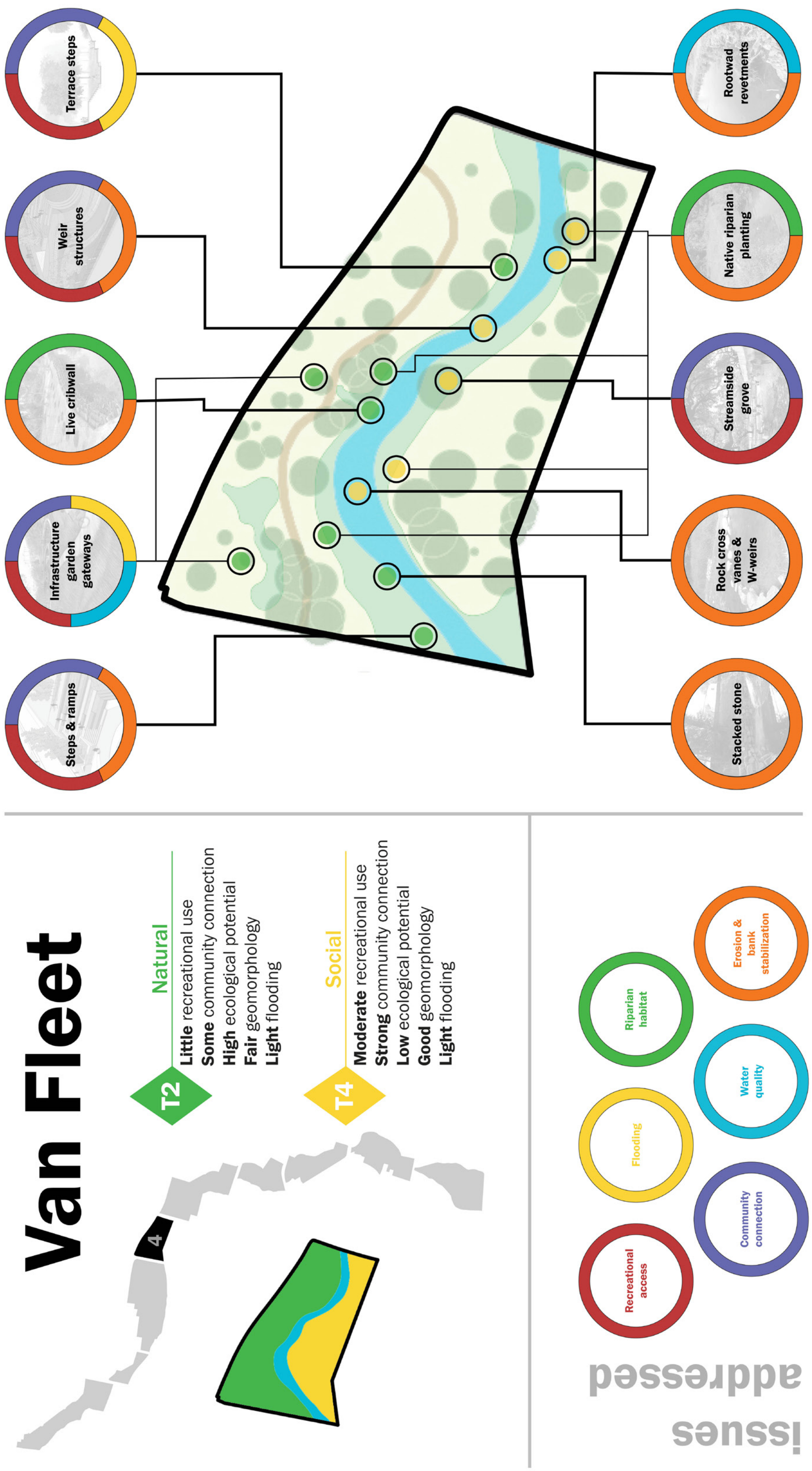


Figure 46. Example of implementation for the Van Fleet segment.

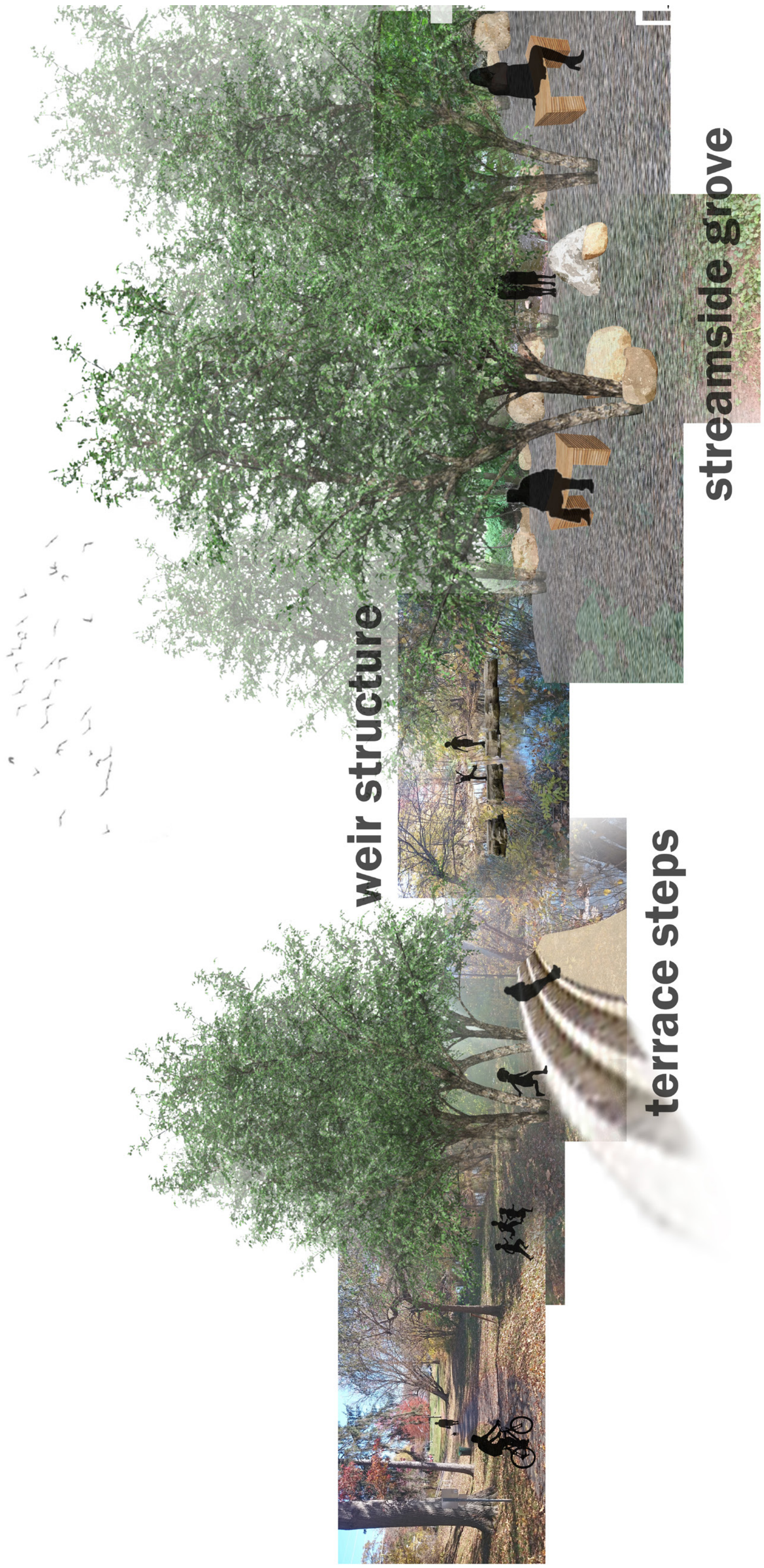


Figure 47. Conceptual section of implementation for the Van Fleet segment.

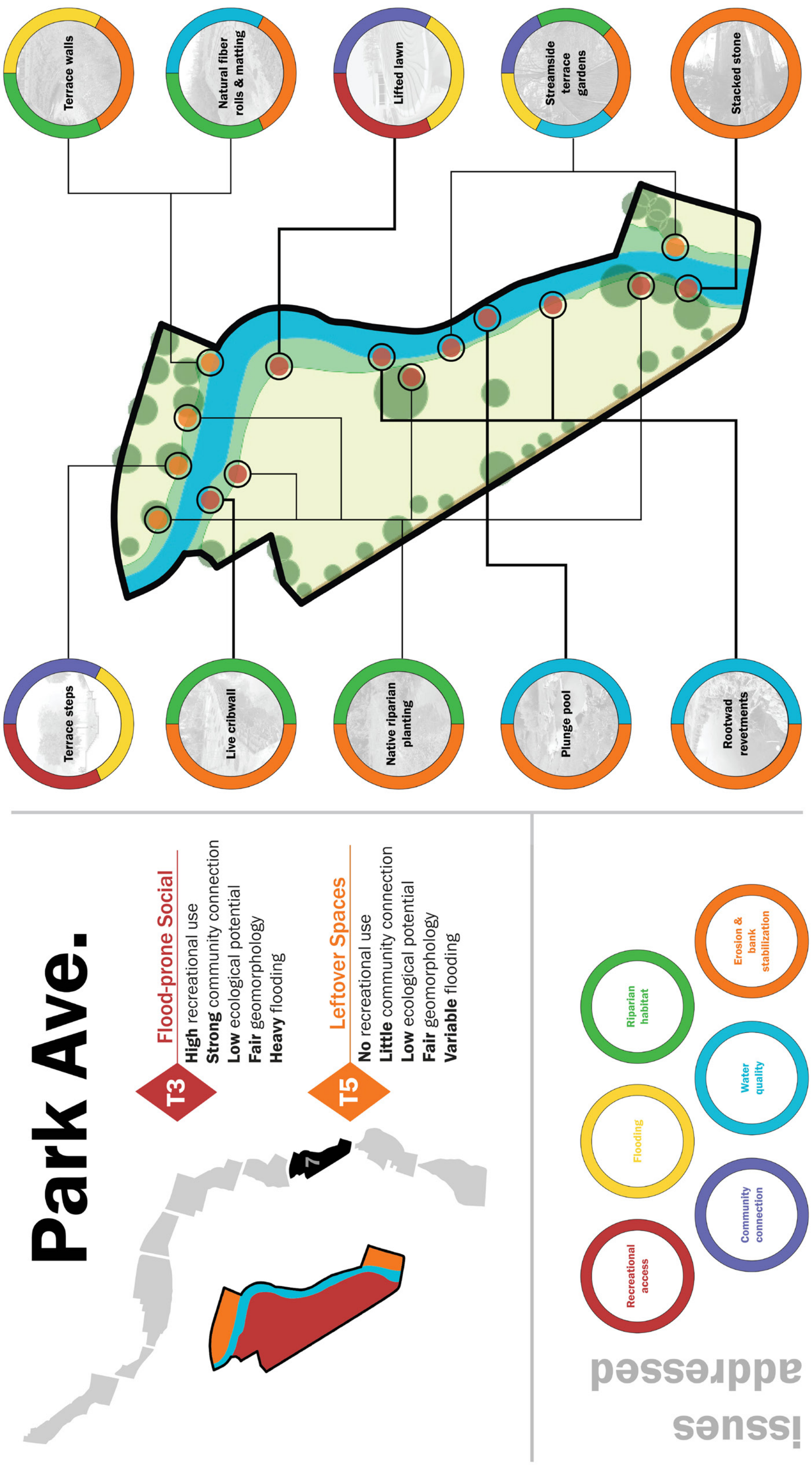


Figure 48. Example of implementation for the Park Ave. segment.

Figure 49. Conceptual perspective (before and after) of implementation for the Park Ave. segment.

Conclusions

The result of this study is the framework for a planning strategy that integrates ecological and social needs in public open space. The first step of this strategy involves the collection and analysis of data pertaining to the specific goals of the project. In this case study, the goals for the Peter's Brook linear park system were to address the issues of recreational use, community connection, water quality, flooding, riparian habitat, and erosion and stream bank stabilization. Driven by these goals, the data analyzed for this site included human use, visual access, physical access, flood risk, erosion, channel geomorphology, and habitat value. Data analysis resulted in the classification of spaces into typologies with different needs and strengths.

The developed planning strategy continues with the study of precedents, including case studies and Best Management Practices, and the identification of potential strategies for addressing existing issues and concerns.

This strategy can be applied to other projects with the goal of integrating ecological integrity and human value in any public space, particularly at the municipal scale. Research on the Peter's Brook linear park system functions as an example of the process. A stream and riparian corridor is only one example of a site that could benefit from this type of planning process, which is adaptable based on specific needs and goals.

Needs and goals should be identified via careful analysis of site context and conditions, as well as input from users and the community. The layers of data collected and analyzed can vary based on those goals, and the selection of potential intervention strategies would follow based on the result of data analysis.

For local government, this planning strategy provides a plan for intervention that is supported by both contextual research and data collected on site. This ensures that the goals being addressed are truly those that are important to the community and the site, and that the developed plan for intervention does, indeed, address those issues. By using this planning strategy to adopt a plan for revitalization of public space, ecological and social interventions chosen are supported by research and data.

Such a strongly supported revitalization plan might have a better chance of receiving funding from sources such as local governments, state grants, or watershed associations, as well as mitigation credits from the Environmental Protection Agency.

This research has been primarily data driven and has not yet crossed over into addressing specific design questions. From a planning perspective, it provides a possible strategy for the incorporation of the principles of ecological democracy into the revitalization of a system of public open space. Perhaps this case study will offer the Borough of Somerville, New Jersey the opportunity to establish a plan from which the design phase may proceed.

Recommendations for Further Study

In order to be truly dependable, the data collected in this project should be supplemented. For example, both the geomorphology of the site and the structure and diversity of the riparian plant communities should be researched in greater detail. Additionally, the human use data collected using the methods of Jan Gehl should be repeated to improve accuracy, as each type of observation was only conducted once at each of the nine segments in the site.

The next step for the Peter's Brook linear park system case study is to move to the design phase. The data collected and analyzed thus far has provided a framework for planning strategy. Next, a more specific site analysis should be conducted for each segment of the system to determine appropriate use and placement of selected strategies for intervention. Greater attention should be paid not only to site specific conditions, but also to historical and cultural context, when making design decisions including materials, construction methods, plant selection, form and function of structures, and intended use.

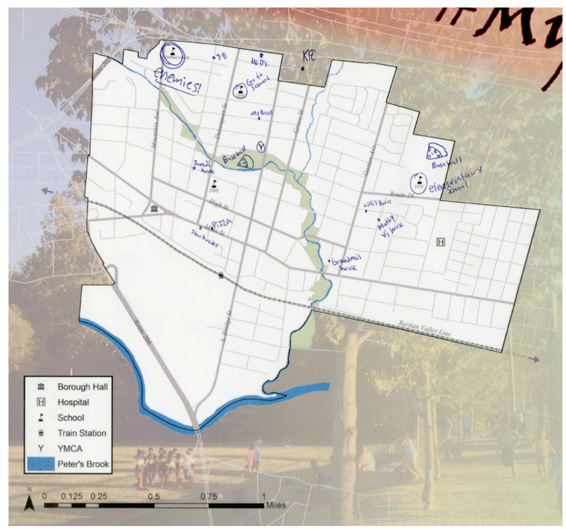
In addition to a more focused design approach for each segment of the linear system, the connection of the system to the greater context of the community should also be considered. Specifically, the establishment of a direct connection between the Peter's Brook linear park system and the popular downtown area should be a priority, as it would bridge the gap between the more social urban core of the community and the more natural green spaces. A connection to the soon to be developed landfill area is also advisable.

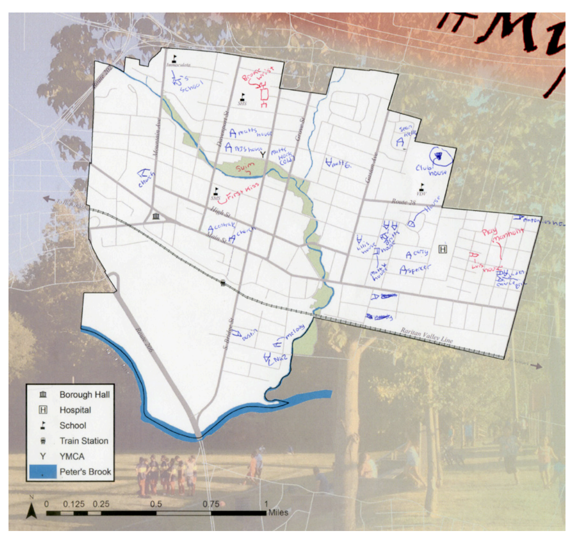
Moving into the design phase for this site will provide a true vision for the revitalization of the spaces and the value they can have for the community, both ecologically and socially. It will be in this vision that the resulting ecological democracy can finally be seen and appreciated.

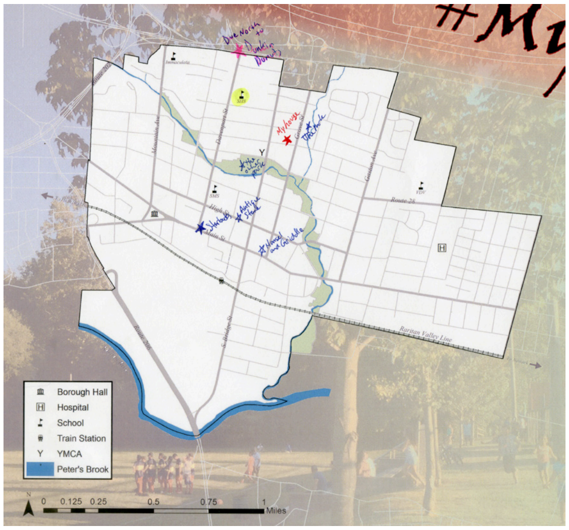
With that appreciation will come the opportunity for implementation. A vision for a truly functional ecological democracy within the Peter's Brook linear park system has the potential to attract support, and even funding. With that in mind, the final recommendation of this project is for the Borough of Somerville to seek possible sources of funding for the strategic and viable revitalization of its valuable public open spaces.

Appendices

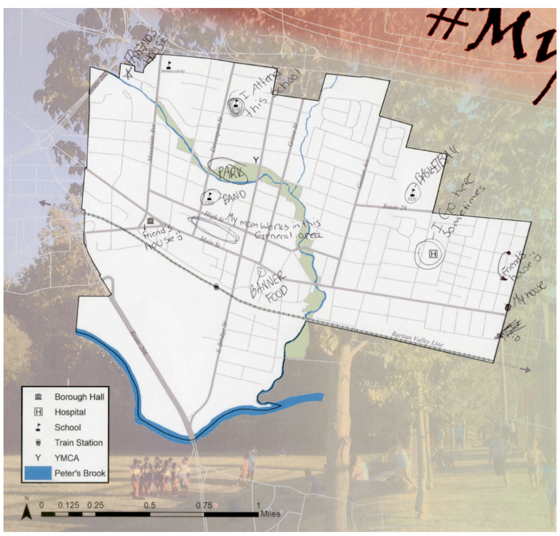
I. Appendix: Examples of mapping exercise responses






Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles

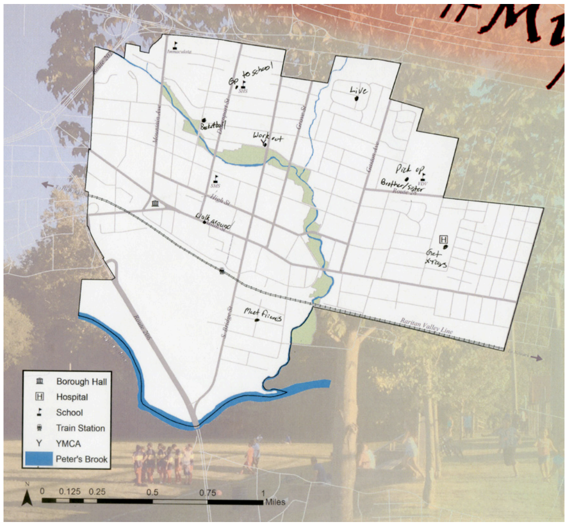

School
go to mall
I didn't go here
Route Home
Route School
Food
I Never go here
Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


I Attend this School
PARK
BAND
My mom works in this General area
BANNER FOOD
Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles

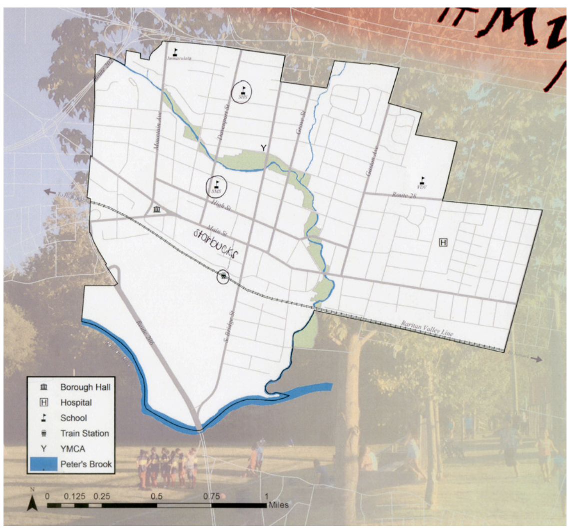

my school
the park
Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


Sport
Swim here
Restaurants
Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


School
Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles

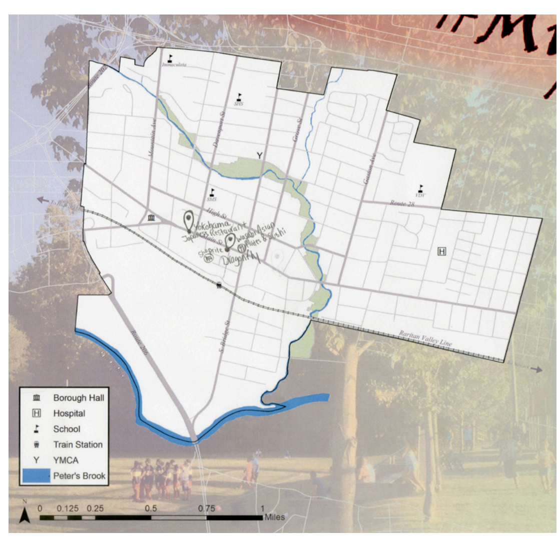

Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles

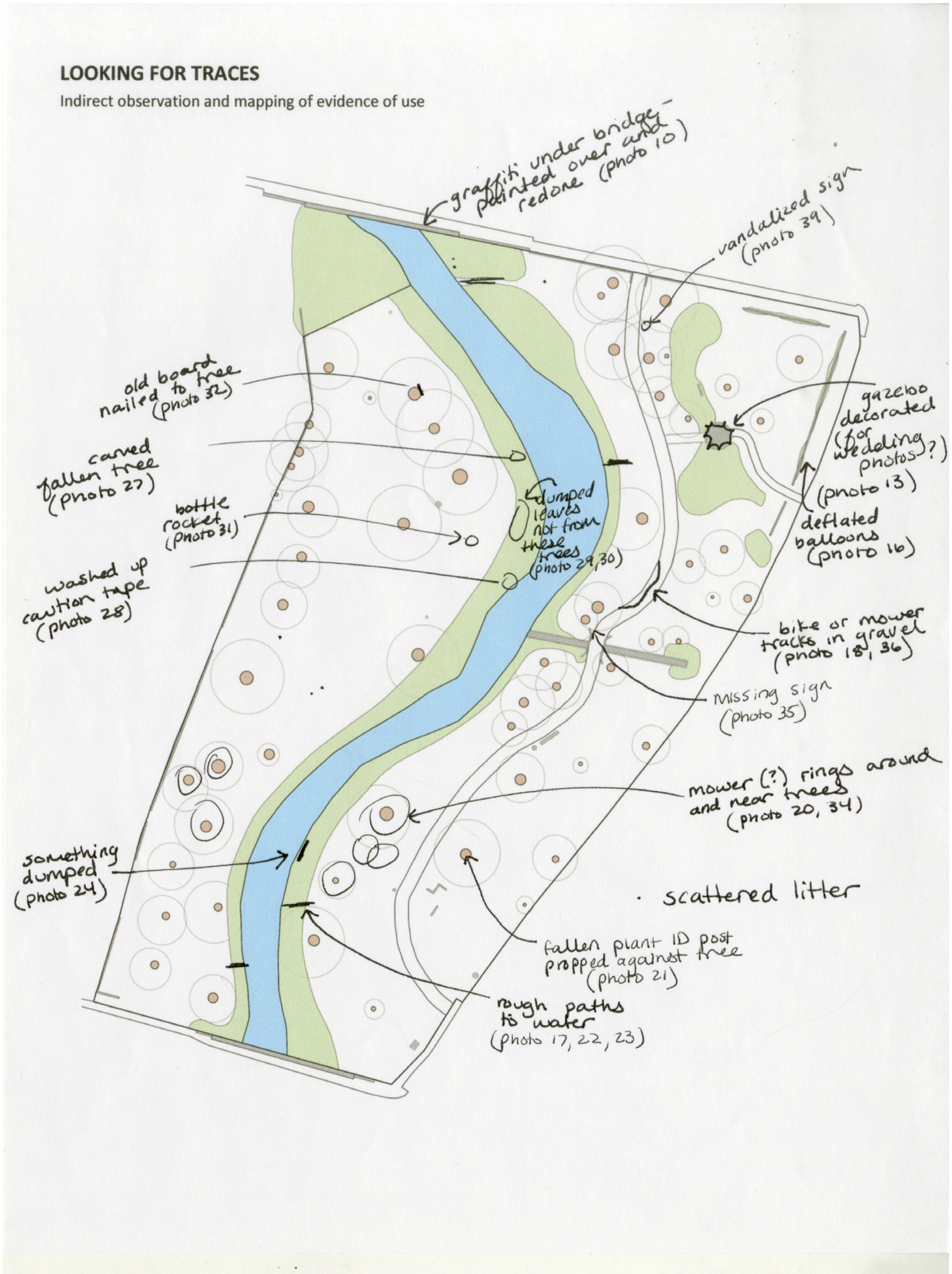

starbucks
Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles


Borough Hall
Hospital
School
Train Station
YMCA
Peter's Brook
0 0.125 0.25 0.5 0.75 1 Miles

II. Appendix: Examples of data collection sheets



MAPPING

Map stationary activities in site at a selected hour.

Hour: 7:15 - 8:15 PM

TRACING

Observe site users for 1 hour during selected time period.

Map movement patterns of users.

Hour: 1:30 - 2:30 PM

NO USERS SEEN

COUNTING

Watch and count (tally) users on site for 10 minutes every hour.
If there are too many people to count at once, record video and count later.

Hours:		
	Morning:	7am 8am 9am 10am 11am
	Afternoon:	12pm 1pm 2pm 3pm 4pm
	Evening:	5pm 6pm 7pm 8pm 9pm

	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5
Total People	4	3	1	1	1
Male	III		I	I	I
Female	I	III			
Children	II				
Teenagers					
Adults	II	III	I	I	I
Seniors					
Moving	IIII	III	I		
Staying				I	I
Alone	II		I	I	I
In Pairs	II				
In Groups		III			
On Phone					
Dogs	II		I		
Bicycles	II				

HABITAT ASSESSMENT FOR *HIGH* GRADIENT STREAMS

VAN FLEET

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. 69	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORE

99

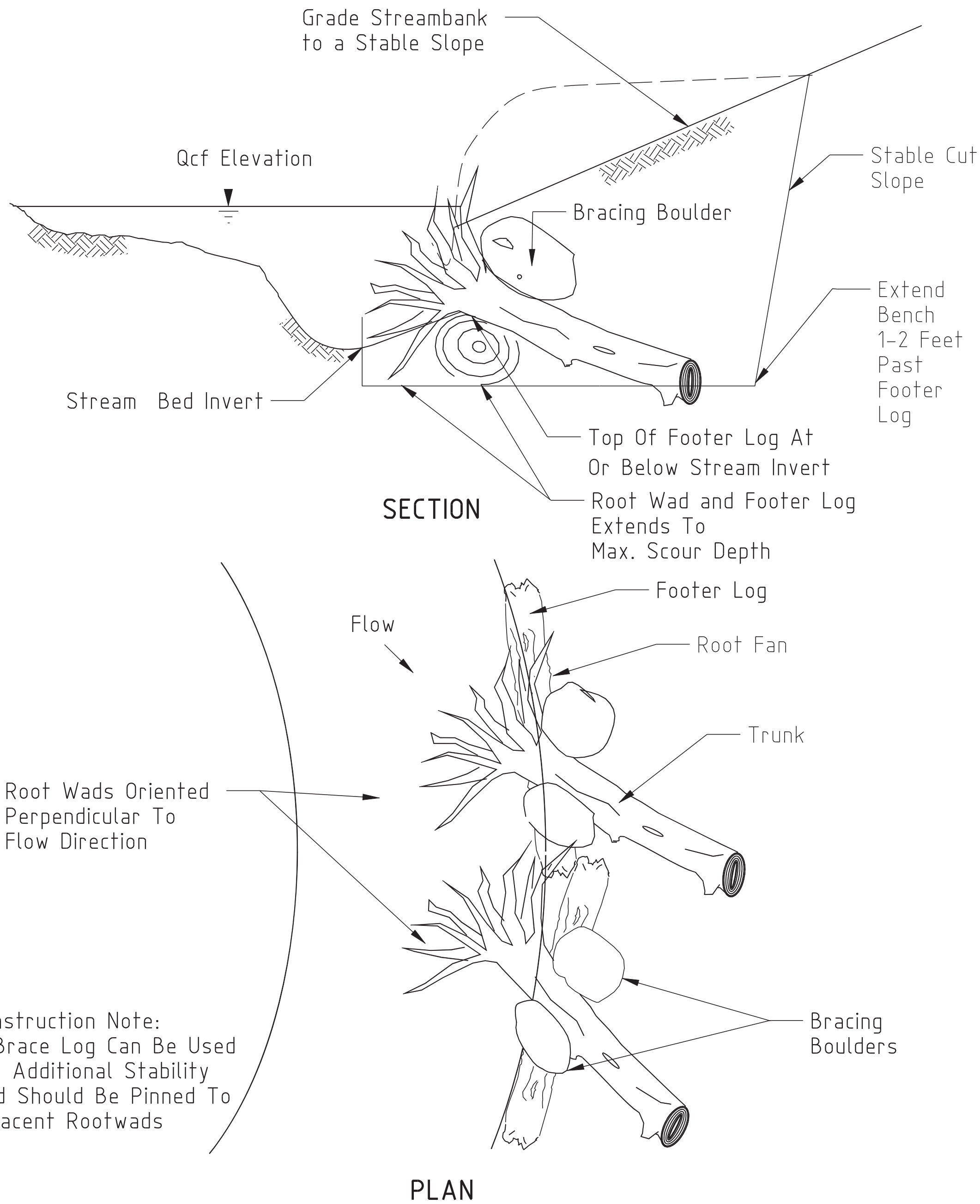
HABITAT SCORES	VALUE
OPTIMAL	160 - 200
SUB-OPTIMAL	110 - 159
MARGINAL	60 - 109
POOR	< 60

L – 80/180 R – 87/180

III. Appendix: Best Management Practices specifics

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

DETAIL 1.2: ROOT WAD REVETMENT

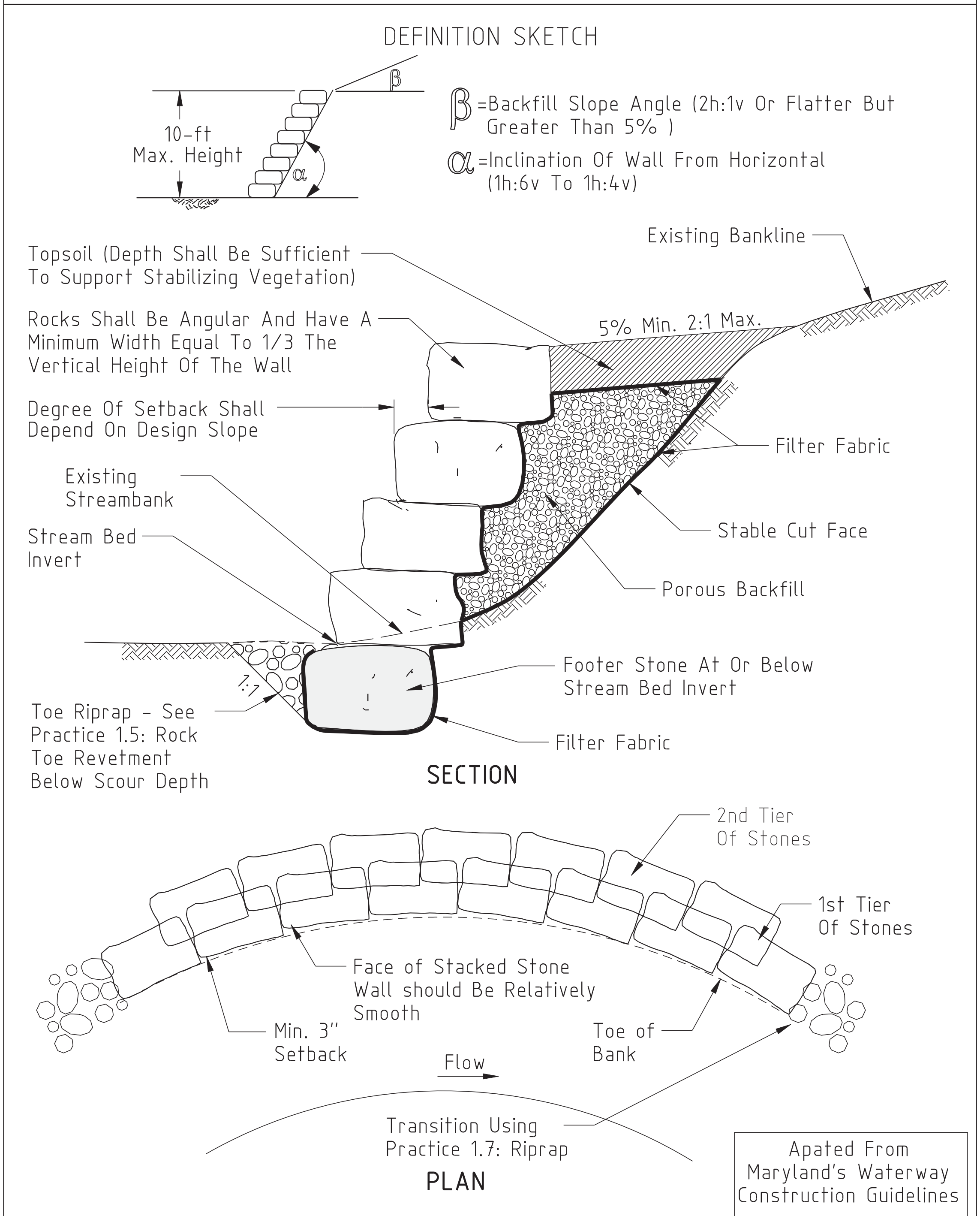


Section & Plan Views Adapted From Rosgen (1999)

BANK PROTECTION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

DETAIL 1.3: STACKED STONE



BANK PROTECTION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

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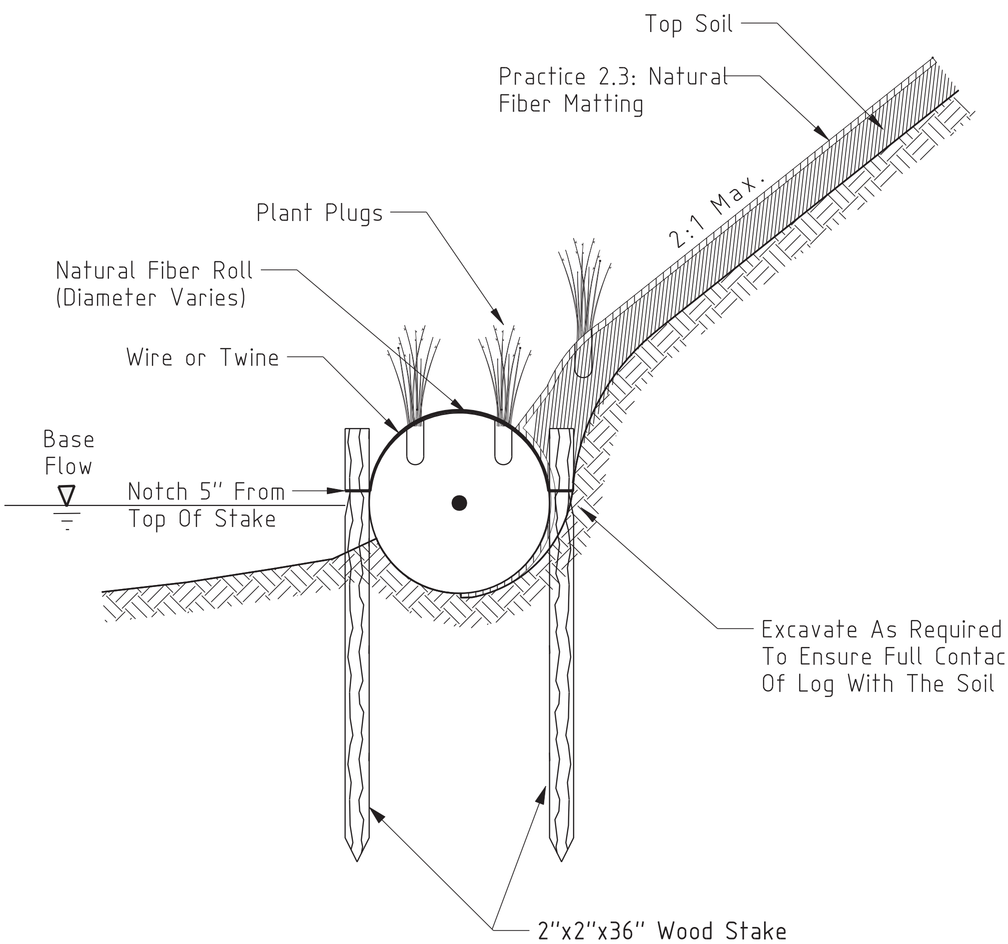
DETAIL 2.1: NATURAL FIBER ROLLS



SECTION

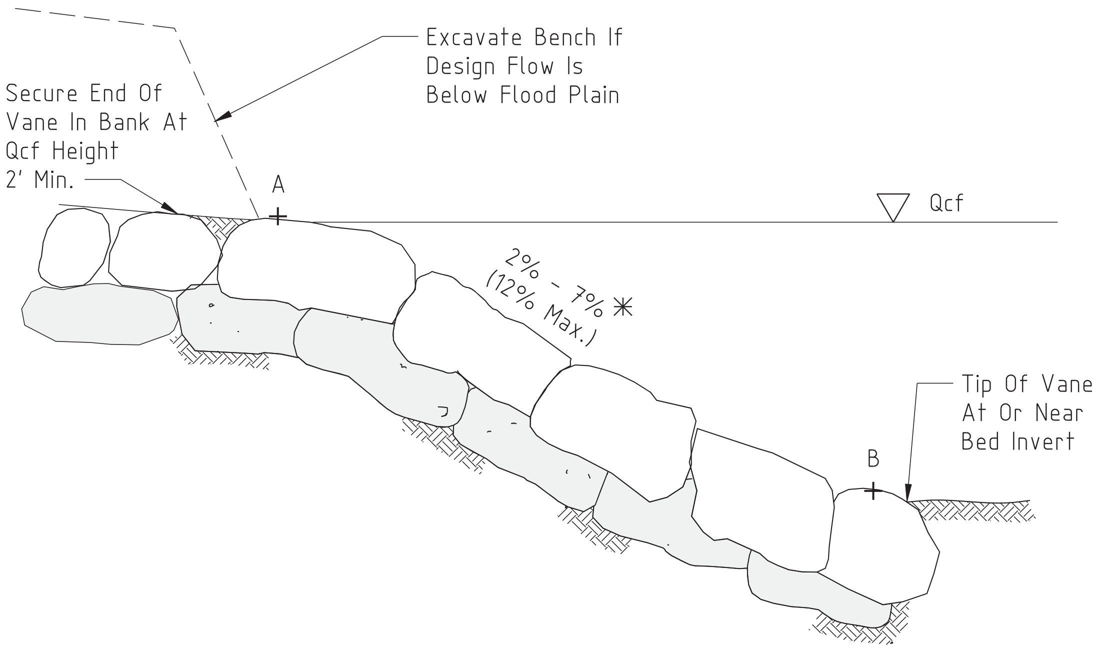
Source

KCI Technologies

BANK PROTECTION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

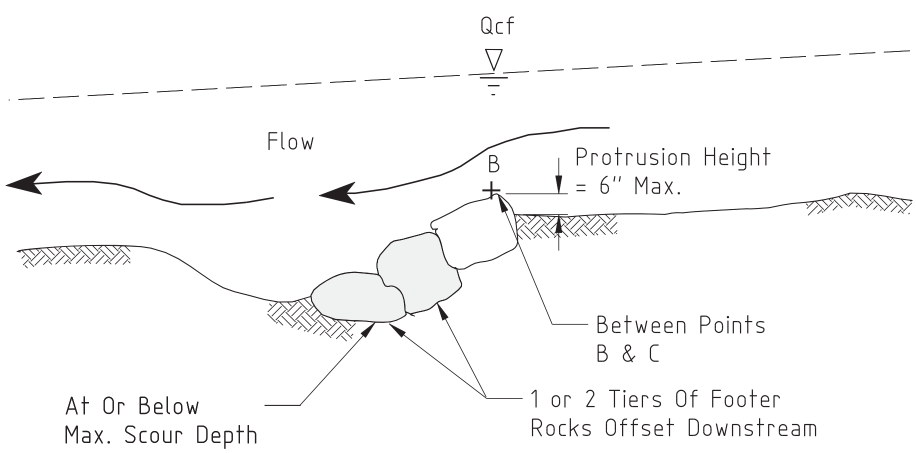
The Virginia Stream Restoration & Stabilization Best Management Practices Guide

DETAIL 3.1(b): ROCK CROSS VANES



PROFILE OF VANE ARM

*Provide Elevation and Offset for Points A and B



PROFILE OF
CENTER OF CROSS VANE

Source: Rosgen, 2001

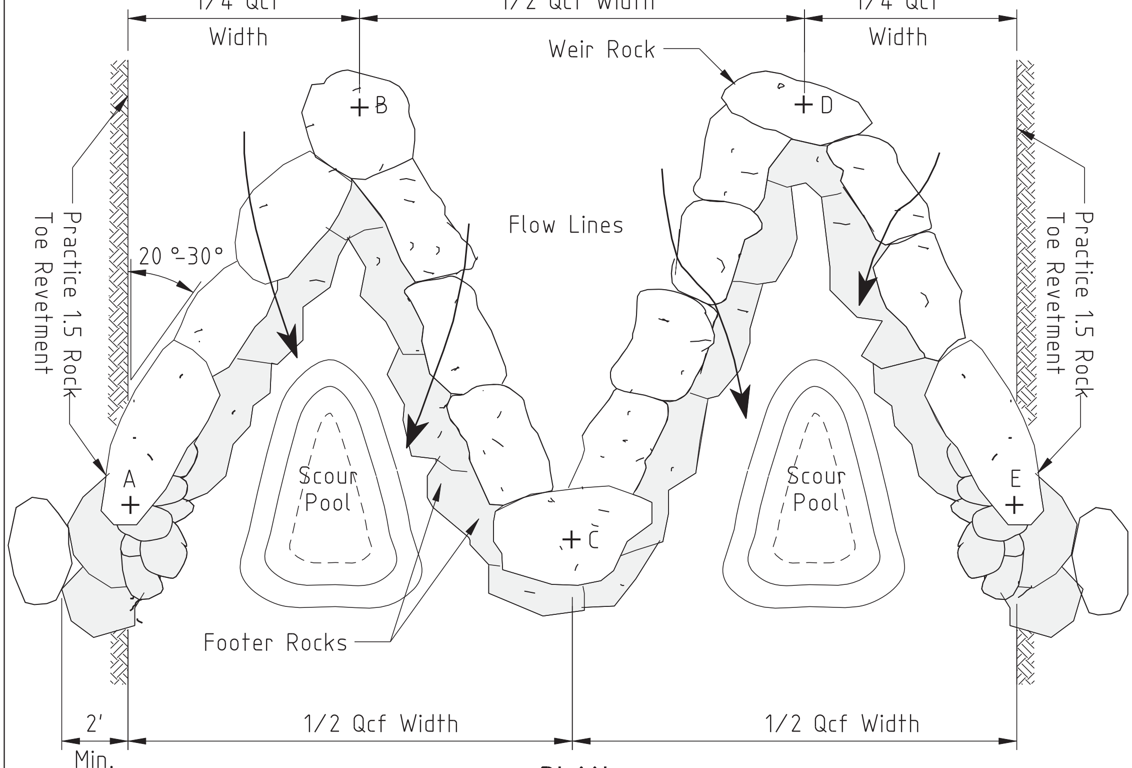
GRADE CONTROL STRUCTURES GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

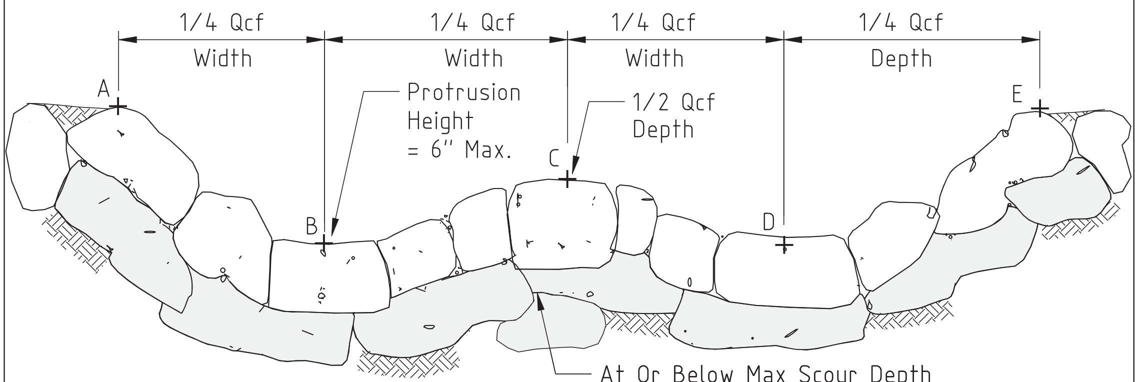
DETAIL 3.2(a): ROCK W-WEIRS

Seal All Structures per Fig. 3.2 for Streams w/ a Sand portion in the bed.

Provide Elevation and Offset for Points A, B, C, D and E



PLAN



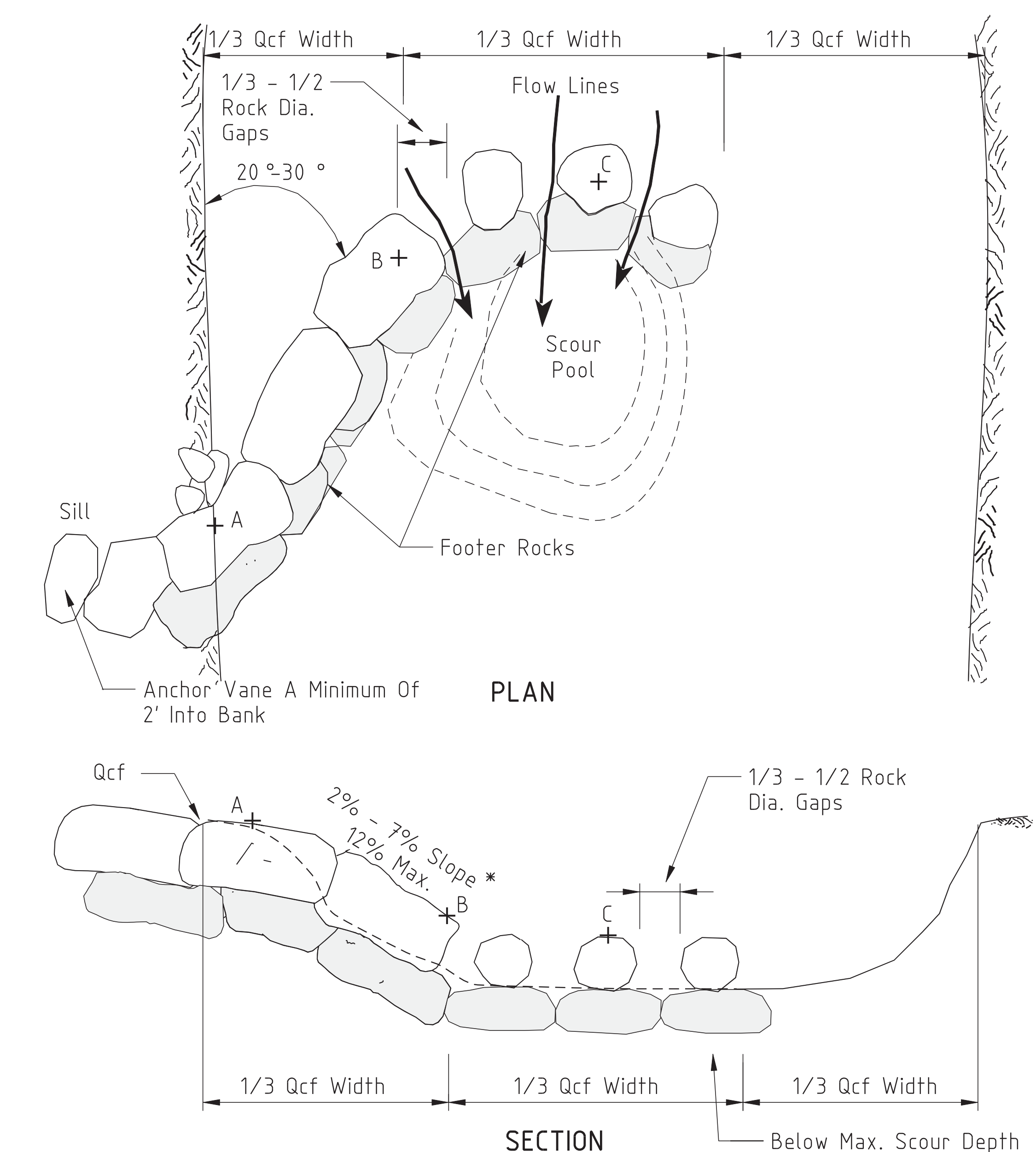
SECTION

Section & Plan Views Adapted From Rosgen (1999)

GRADE CONTROL STRUCTURES GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

DETAIL 4.2(a): J-HOOK VANES



* Designer to Provided Offset and Elevation for Points A,B,C

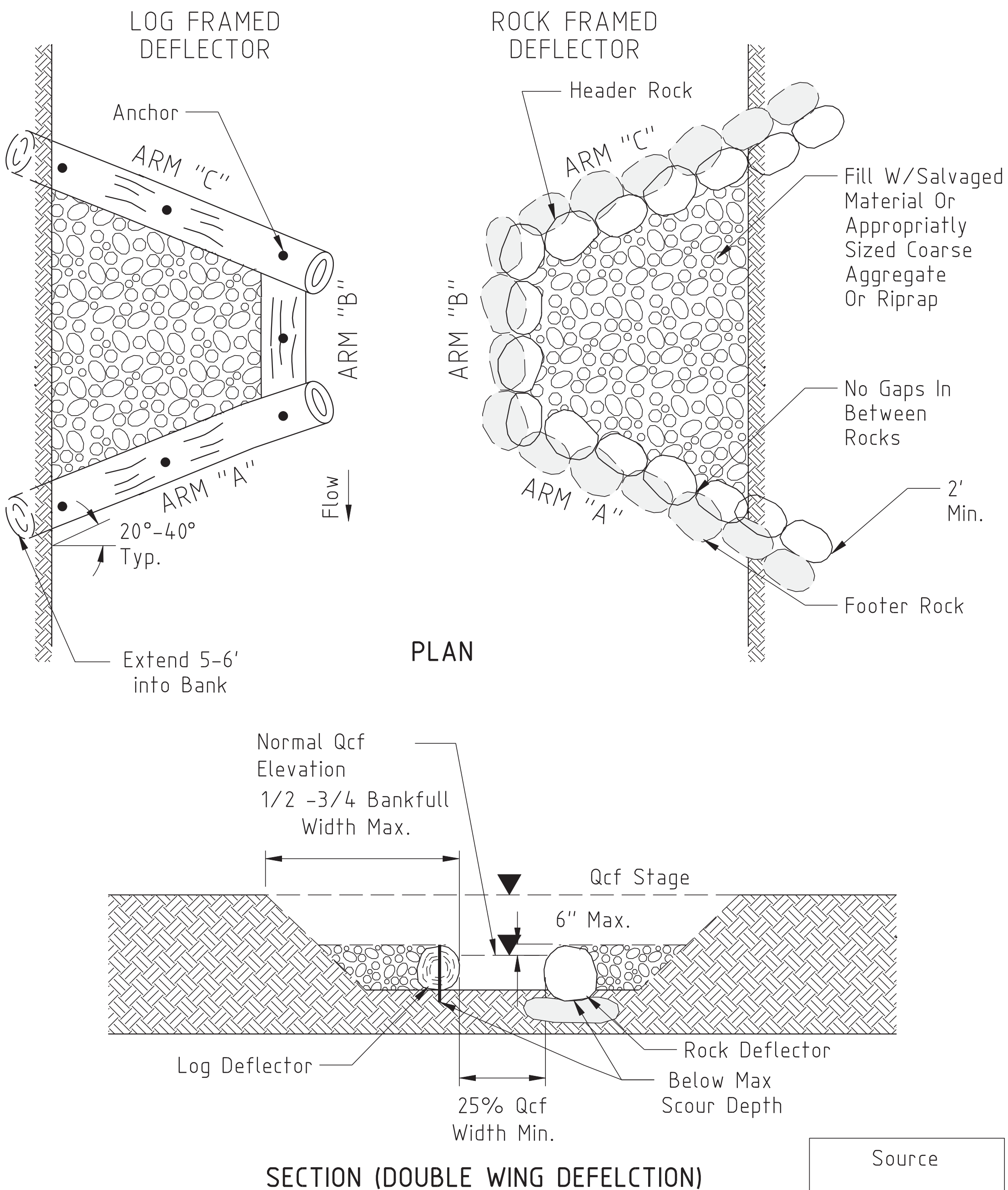
Seal All Structures per Fig. 3.2 For Streams with a Sand portion in the bed.

Section & Plan Views Adapted From Rosgen (2001)

FLOW DEFLECTION CONCENTRATION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

DETAIL 4.3: WING DEFLECTORS



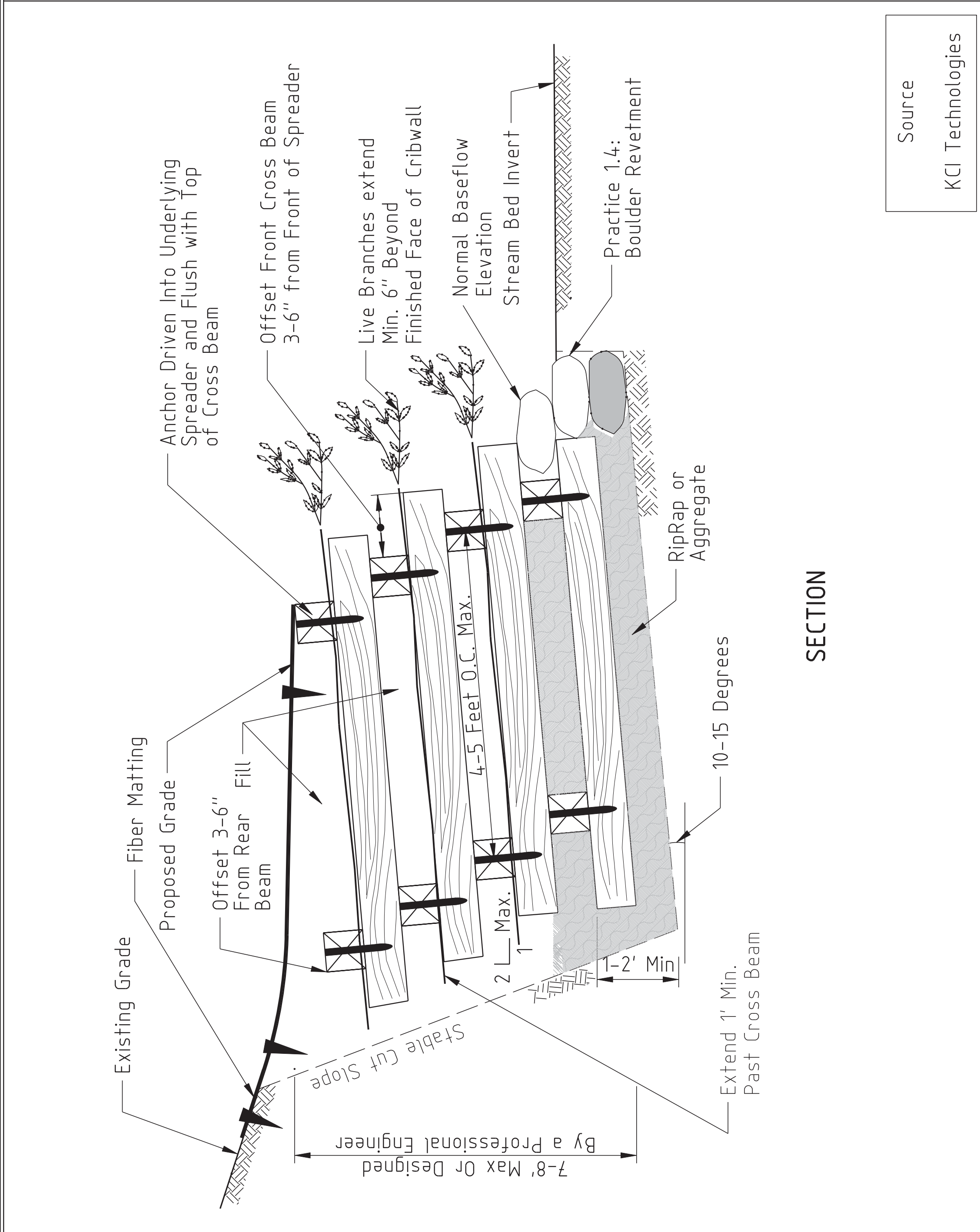
Source

KCI Technologies

FLOW DEFLECTION CONCENTRATION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

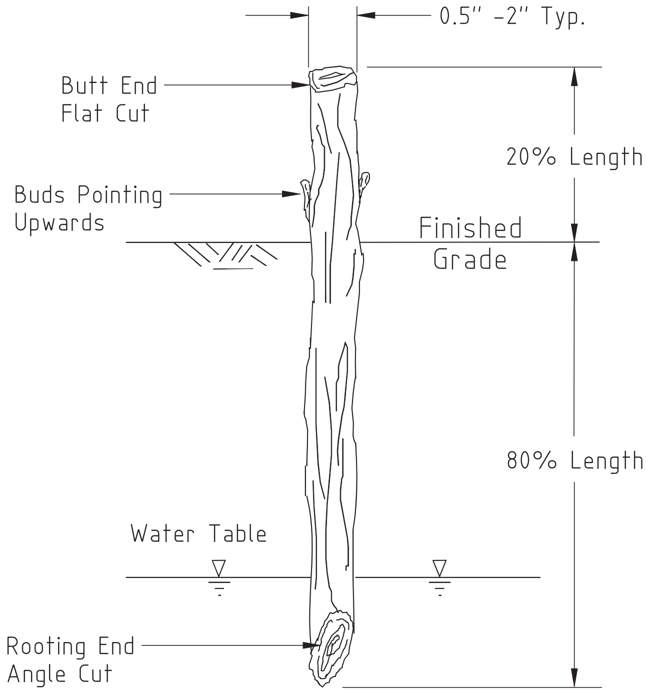
DETAIL 1.6 (a): LIVE CRIB WALL



BANK PROTECTION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

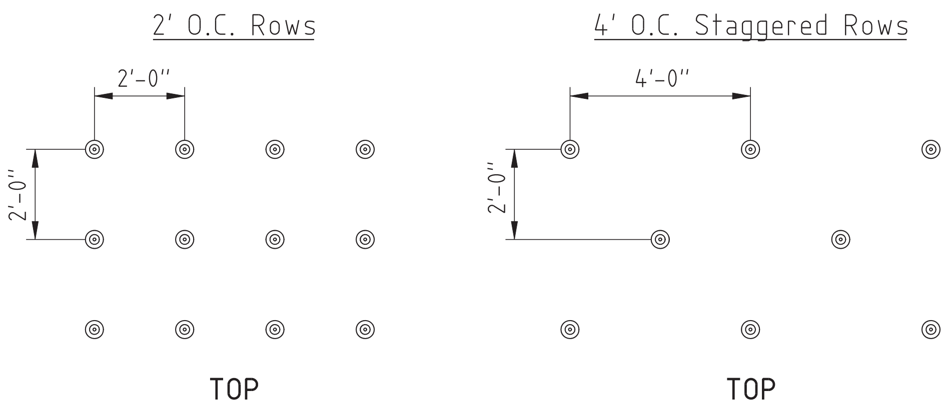
DETAIL 2.6: LIVE STAKES



DETAIL

Live Stakes Should Be Long Enough To Reach Below The Groundwater Table. Typically 2 - 3' Long.

After Installation, Cleanly Cut Exposed Stake To Approximately 3" In Length. Cut At Slight Angle.



Adapted From USDA-SCS (1994)

BANK STABILIZATION GUIDELINES	DECEMBER 2003	VIRGINIA DEPARTMENT OF CONSERVATION RECREATION

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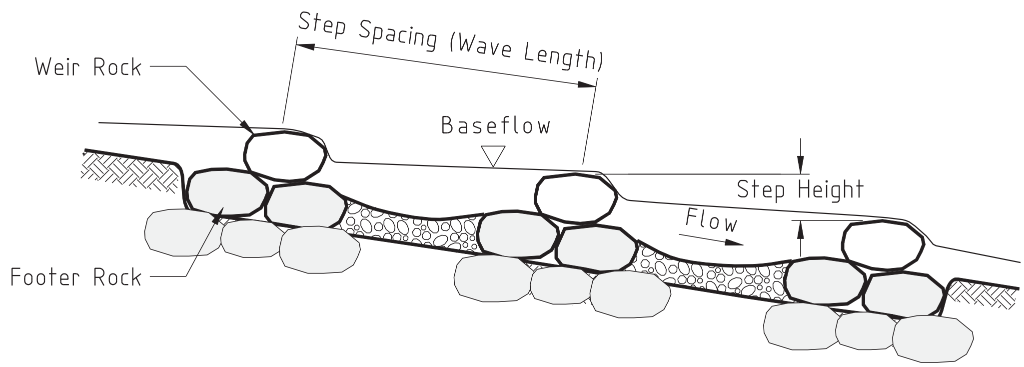
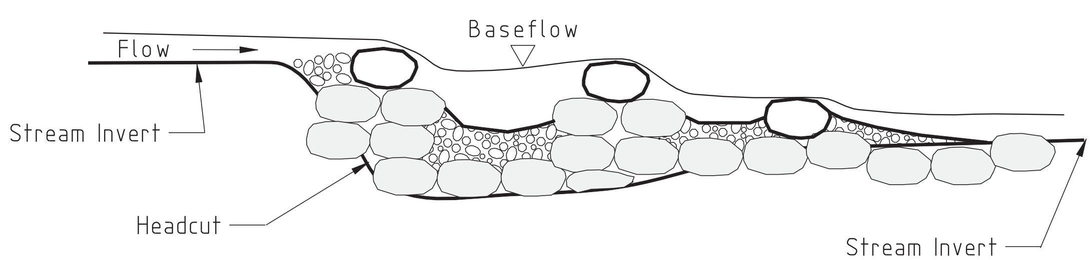
DETAIL 3.4(b): STEP POOLS



Note: Slope > 6.5%, Typical Step Spacing < 1 Channel Width (Qcf)
Slope 3-6.5%, Typical Step Spacing < 1-4 Channel Widths (Qcf)
Step Height And Spacing May Be Adjusted To Achieve Desired Channel Slope

PROFILE



PROFILE- For Head Cut Repair

Source

KCI Technologies

Endnotes

[1] Hester's theory is complex, and for full understanding should be read in its entirety.
[2] According to the National Park Service, *conservation* aims to use nature properly for natural resources, while *preservation* aims to protect nature from human interference.
[3] Meine, Curt. (2004). Correction lines: Essays on land, Leopold, and conservation. Washington, DC: Island Press. Page 20.
[4] *Ibid*. 19
[5] *Ibid*. 30
[6] The National Park Service currently manages approximately 80 million acres of public land; the National Forest Service currently manages approximately 192.9 million acres of land.
[7] Leopold, Aldo, & Schwartz, Charles W. (1966). A Sand County almanac. With other essays on conservation from Round River. New York: Oxford University Press. Page xviii.
[8] Hester, Randolph T. (2006). Design for ecological democracy. Cambridge, MA: MIT Press. Page 419.
[9] The dashed lines in the diagram in Figure 1 represent the interconnectedness of the fifteen principles of Hester's ecological democracy.
[10] *Ibid*. 3
[11] *Ibid*. 4
[12] *Ibid*. 8-10
[13] *Ibid*. 21
[14] *Ibid*. 50
[15] *Ibid*. 77
[16] *Ibid*. 97-100
[17] *Ibid*. 117-118
[18] *Ibid*. 146
[19] *Ibid*. 171
[20] *Ibid*. 201-202
[21] *Ibid*. 227
[22] *Ibid*. 254
[23] *Ibid*. 281
[24] *Ibid*. 301
[25] *Ibid*. 325
[26] *Ibid*. 363-375
[27] *Ibid*. 387
[28] *Ibid*. 389
[29] *Ibid*. 419-421
[30] National Environmental Policy Act of 1969, Title 1 § Section 101, 1969
[31] For any portions of the site that were purchased with Green Acres pass through monies, or Federal Land and Water Conservation Fund monies, the NEPA provision for public participation does apply.
[32] The researcher lived in Somerville, New Jersey from 1986 through 2008.
[33] The southern most park in the chain (Chambres Park) is just outside of the Somerville border - it is technically located in the neighboring municipality of Bridgewater, but is operated and maintained by the Borough of Somerville.
[34] Somerville, New Jersey. (n.d.). Retrieved April 04, 2016, from http://www.city-data.com/city/Somerville-New-Jersey.html
[35] NJDOT Transit Village Initiative Overview, Community Programs. (2014, April 1). Retrieved April 04, 2016, from http://www.state.nj.us/transportation/community/village/
[36] History. (n.d.). Retrieved April 04, 2016, from http://www.somervillenj.org/content/580/default.aspx
[37] Saltel Consultants, LLC. (2008, May). The Borough of Somerville Historic Preservation Plan Element [PDF].
[38] History. (n.d.). Retrieved April 04, 2016, from http://www.somervillenj.org/content/580/default.aspx
[39] Somerville, New Jersey. (n.d.). Retrieved April 04, 2016, from http://www.city-data.com/city/Somerville-New-Jersey.html
[40] Park visitation data was requested from the town, but usership has never been recorded.

[41] Deak, Mike. (2016, February 22). Somerville riding the wave of redevelopment. Retrieved April 04, 2016, from http://www.mycentraljersey.com/story/news/local/somerset-county/2016/02/21/somerville-riding-wave-redevelopment/80500030/
[42] NJDEP, Division of Watershed Management. (2003, September 29). Total Maximum Daily Loads for Fecal Coliform to Address 48 Streams in the Raritan Water Region [PDF].
[43] This information was learned during conversations with the Somerville Recreation Department and the Somerville Environmental Commission.
[44] USDA, National Resource Conservation Service. (n.d.). Web Soil Survey. Retrieved April 04, 2016, from http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
[45] Gehl, J., & Svarre, B. (2013). How to study public life. Washington, D.C.: Island Press.
[46] *Ibid*. 3
[47] FEMA. (2007, September 28). Flood Insurance Rate Map, Somerset County, New Jersey [PDF].
[48] Rosgen, D. L. (1996). Applied river morphology. Pagosa Springs, CO: Wildland Hydrology. Rosgen's morphology classification technique is detailed and complex and would require additional resources to complete.
[49] NJDEP, Division of Water Monitoring and Standards, Bureau of Freshwater & Biological Monitoring. (n.d.). Rapid Bioassessment Protocol. Retrieved April 04, 2016, from http://www.state.nj.us/dep/wms/bfbm/rbpinfo.html
[50] Waller Creek Conservancy. (n.d.). Vision. Retrieved April 04, 2016, from https://www.wallercreek.org/vision/. Design and image credits: Michael Van Valkenburgh Associates, Inc. and Thomas Phifer & Partners.
[51] *Ibid.*
[52] Siteworks, Charlottesville, VA. (2009). Rockefeller Park Strategic Master Plan, Cleveland, OH. Retrieved April 04, 2016, from https://asla.org/2009awards/532.html
[53] *Ibid.*
[54] Amy S. Green Environmental Consultants, Inc. (n.d.). Live Cribwall Installation: Case Studies - Peapack Brook & Musconetcong River, Northern NJ [PDF].
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[56] Wenk Associates, HNTB. (2008, May). Boneyard Creek Master Plan [PDF].
[57] Mill Creek Watershed Council. (n.d.). Beaver Run Riparian Corridor Restoration Project [PDF].
[58] Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation. (2004). The Virginia Stream Restoration & Stabilization Best Management Practices Guide [PDF]. Pages 77, 81 101, 137, 143, 167, 171, 177.
[59] *Ibid.* 155

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