Re-Evaluating Stormwater

The Nine Mile Run Model for Restorative Redevelopment

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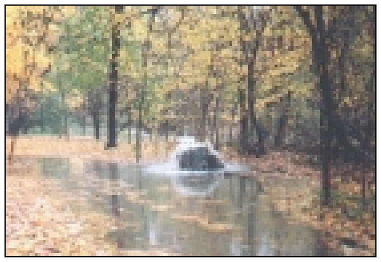
Executive Summary

This report presents a model for resolving a history of chronic sewer overflows into the public streets, parks, and waters of the Pittsburgh region, while simultaneously restoring and revitalizing the region's urban communities and watersheds.

The key to doing so is to embed the healing process into the redevelopment process. The idea is to solve problems of sewer overflows, stormwater runoff, and urban revitalization at the source—in the urban areas where the rain falls and the people live—by absorbing a large part of the cost into the incremental redevelopment of urban areas.



Surcharged with stormwater, a manhole structure on a sewer line in Frick Park overflows, spilling contaminated water into the park. Photograph by Mike Lichte, Allegheny County Health Department.

This model uses physical measures that remove stormwater from sewers and produces additional benefits—beautification of neighborhoods, creation of public recreational amenities, support of wildlife habitat, cleaning and cooling of urban air. These strategies can help downsize or displace costly single-purpose infrastructure such as larger pipes and expanded treatment plants. Moreover, they can assist in compliance with state and federal regulatory actions.

The model was developed by a panel of 60 local and national designers, engineers, artists, planners, and policy analysts, with participation from local citizens. They collaborated in a "charrette"—an intensive design workshop—for three days in October 1998. The charrette focused on the 6.5 square mile watershed of Nine Mile Run in central Allegheny County. Participants sought proposals that would have immediate benefit. But they also looked decades into the future, using all appropriate technically and financially feasible approaches to restore the watershed's natural processes and revitalize its communities.

The charrette's results illustrate a "restorative redevelopment" approach to the sewers, ecosystem, and communities, showing that retrofit and redevelopment projects that are technically and economically feasible can improve the value and livability of the city while effectively restoring the watershed's natural functions.

Techniques of restorative redevelopment

A variety of measures are available for removing stormwater from sewers and restoring beneficial natural processes. These strategies include:

- **Capturing roof runoff** in tanks or cisterns for irrigation or indoor graywater use;
- **Disconnecting pavement and roof drainage** from sewer lines and directing it to adjacent vegetated soil or to infiltration basins;
- **Engineering infiltration basins**—"water gardens," dry wells, and subsurface recharge beds—to collect runoff and percolate it into the soil;
- **Planting trees** to intercept a portion of rain water;
- **Rehabilitating soils** to increase infiltration rates and pollutant-neutralizing microbial activity;
- **Reconfiguring driveways, parking lots, and streets** to turn more of a site over to pervious, vegetated soil;
- **Using porous pavements**—special varieties of asphalt, concrete, masonry, and other materials with open pores that allow water to pass through;
- **Routing runoff through vegetated surface channels**—"swales"—to slow its velocity, remove pollutants, and infiltrate it into the soil;
- **Restoring historic streams** by excavating culverts and creating naturalized open channels.

Four sample designs

The charrette's sample designs for four sites in the Nine Mile Run watershed reuse, restore, and revitalize their sites by resolving existing site-specific issues, adapting techniques of construction and stormwater management to Pittsburgh's fine-textured soil, frequent frosts, steep hillsides, and unstable geology. They infiltrate or detain the runoff from a "2-year, 24-hour" storm on-site, within a construction budget of $2 per gallon of hydraulic capacity. These parameters are consistent with standards and conventional project costs established in Allegheny County in recent years.

Each design integrates several stormwater management strategies into the built environment of its site. And each exemplifies restorative redevelopment by integrating the physical strategies into the social and economic life of the site and its neighborhood:

- The design for Hunter Park links watershed restoration with revitalization of a previously neglected park and neighborhood, and celebrates the unique coal mining legacy and cultural history there.
- Edgewood Crossroads integrates restorative stormwater management with a busy street intersection and proposed transit node, where a historic train station, storefront building, church, town hall, and other features form the civic heart of the community. The design also addresses runoff contributed by uphill residential areas.
- The Sterrett School design illustrates the educational use of a variety of working watershed restoration measures, and integration of these measures with single-family homes sharing the same city block.
- The Regent Square Gateway design coordinates economic revitalization of an underused commercial building with management of stormwater runoff from upslope city streets, creation of functional and symbolic structures at the outfall of the watershed's largest culvert, and provisions for a proposed new entrance to Frick Park.

Patterns of restorative redevelopment

Although each of the four sample designs is site-specific, together they illustrate patterns of restorative redevelopment that should be repeated in many places throughout the watershed and the region. These patterns include:

- multi-functionality of components;
- full use of the available space;
- use of freely available natural processes;
- disconnection of storm drainage from sewers and reconnection with the soil and vegetation;
- interdisciplinary cooperation;
- deliberate finding out of the full range of what is possible; and
- engagement between professionals, decision makers, and local citizens.

Future retrofit and development projects that follow these patterns can have both an immediate effect on sewer overflows, and add incrementally to the watershed's long-term, broad-based ecosystem rehabilitation and urban revitalization.

How to make these things happen

The charrette identified policy objectives and action plans to support restorative redevelopment. These include:

- **Establish a permanent coordinating body** with the authority and financial security to plan, maintain, and manage the watershed's interrelated infrastructure, natural processes, and urban land uses. The organization must transcend municipal boundaries. It unites the responsibilities of infrastructure management and ecosystem protection.
- **Manage the watershed's sewer and stormwater infrastructure** for efficiency, reduced costs, and reinforcement of natural processes and community vitality. Implementing "green infrastructure"—an approach that broadens the conception of stormwater infrastructure to include the capacities of soil and vegetation to absorb water and filter pollutants—would focus limited community resources on effective systems that produce multiple benefits.
- **Restore the watershed's hydrologic and ecological processes** in a manner that utilizes and supports infrastructure rehabilitation and community redevelopment. This includes rehabilitating urban runoff by reconnecting storm drainage with the natural capacities of the watershed. It also includes restoring natural stream, wetland, and forest habitats in critical areas.
- **Enable, support, and require economic revitalization** that reinforces infrastructure management and watershed restoration. Communities, agencies, and developers can structure redevelopment programs and projects in ways that support sewer rehabilitation and restoration of beneficial natural processes.

The restorative redevelopment approach manages precipitation as close to where it falls as is physically and economically feasible, using freely available natural processes to do the work of stormwater storage and treatment. By embedding sewer and watershed restoration in community revitalization, it reduces or eliminates problems that public works agencies would otherwise struggle to solve in isolated efforts by downstream engineering.

SECTION I
INTRODUCTION

In Pittsburgh's first "renaissance" the region emerged from the smoke of old industries. The self-image and the economic revival of the city were staked to the cleanliness of the air.

Today the people of Pittsburgh, with their customary skills and work ethic, are building a new economic foundation as productive and constructive as the old. In this time of change and hope, the hills and the streams of Pittsburgh's natural environment deserve to be part of the region's physical, spiritual, and economic rebirth. It is a challenge, but it is possible.

In the past, the region's rivers and streams have failed to meet the "fishable and swimmable" objectives set for them by federal standards. Pollution control agencies have recently taken legal action against 82 communities and ALCOSAN (The Allegheny County Sanitary Authority). ALCOSAN estimates costs to fix sewer overflows and rehabilitate collector systems at nearly $3 billion.*

Big public works projects—storage tanks, detention basins, pipelines, treatment plants—are a feature of regional and local proposals to fix the problems. These single-purpose technical programs would burden future generations with operating and maintenance costs and the paying off of hundreds of millions of dollars in construction bonds. Their large regional storage facilities, treatment plants and high capacity pipelines may conflict with pre-established urban land uses. They add nothing to the civic life of the community and provide no new habitat or other ecosystem values. These facilities would only treat the downstream symptoms by increasing capacity and throughput, and would generate substantial long-term treatment and maintenance costs. The source of the problems, upstream in the watershed where the rain falls, would still be generating the same amount of runoff and pollutants. There has to be a better way.

RESTORATIVE REDEVELOPMENT

This report presents a model for simultaneously restoring and revitalizing the urban watersheds of the Pittsburgh region. The technical key to doing so is to remove stormwater from sewer systems and reintroduce it to the soil and vegetation. The humanistic and economic key is to embed the healing process into the redevelopment process—to integrate infrastructure improvements, community development desires, and ecosystem needs.

Redevelopment will happen. One of the few things we can confidently predict about the future is that the times will change, as they have always changed in the past. Retrofit and redevelopment initiatives are diverse and incremental. At the time this report was being written, within an area of a few square miles, developers were making new plans for an underutilized commercial building and its parking lots, transportation agencies were proposing to add a regional busway on an old railroad bed, a community was sponsoring the redevelopment of a local park and its neighborhood, and hundreds of homeowners were renovating and adding to their homes. Incremental retrofit and redevelopment projects are constantly being initiated by the many private parties and public agencies that work with the area's infrastructure, housing, transportation, recreation, services, and economic development. There will continue to be new economic cycles, new populations moving through, new scientific insights, new public initiatives, new kinds of energy sources. Significant redevelopment of an area as large as a watershed will take many human generations; it will be continuing nevertheless.

As redevelopment progresses, pavements will be relaid; buildings will be renovated and reconstructed; transportation will be reorganized; and utilities will be maintained and replaced. These changes are opportunities for correcting, healing, educating, and starting anew, within the pattern of redevelopment itself. While the system is changing and evolving, let us make sure that it includes changes that restore the communities and ecosystems of the urban watersheds to health and vitality. Let us create a sewer and stormwater infrastructure that serves additional functions: beautification of neighborhoods, creation of public recreational amenities, support of wildlife habitat, cleaning and cooling of the urban air, and generation of jobs.

**Nationally, 950 communities experience combined sewer overflows, and hundreds more have sanitary sewer overflows. The U. S. Environmental Protection Agency estimates national CSO remediation costs at $45 billion. As this report went to press, SSO remediation costs were put at $78 billion in initial estimates being prepared for the EPA.*

DEFINITIONS

Base flow: The flow of a stream in dry weather. It comes from the watershed's ground water. In urban streams base flow is characteristically low because so little water reaches the watershed's soil.

Bioengineering: The use of living plants in combination with nonliving materials to stabilize channels and hillsides.

Bioretention: Detention, treatment and infiltration of stormwater in vegetated basins.

Catchment: A small watershed—all the land area that drains to a given stream or low point.

Combined sewer: Sewer carrying a combination of sanitary sewage and storm runoff. Combined sewers are the urban wastewater design alternative to separate sewer systems. The design intent was to consolidate the infrastructure of stormwater and sanitary sewage into a single system of conveyance. (The short term benefit of consolidation has resulted in long term costs as cities now treat the increased flow of combined sanitary sewage and stormwater.)

Combined sewer overflow (CSO): Overflow of a combined sewer into a stream as a result of excess stormwater during wet weather.

Culvert: A pipe designed to bury a stream and carry stormwater to a downstream location. In old urban watersheds such as Nine Mile Run, culverts may be contaminated by CSOs and SSOs during wet weather.

Detention: Temporary delaying of flow of water in a reservoir, in order to reduce peak flows or overflows downstream.

First flush: The first runoff from impervious surfaces during a storm. This runoff typically contains high concentrations of pollutants as a result of their accumulation on the surfaces during the dry weather before the storm.

Green infrastructure: Landscape features, ranging in scale from large open spaces to individual plants, that provide functional benefit to human communities through biological and physical processes. Green stormwater infrastructure takes advantage of the capacities of soil and vegetation to absorb water and filter pollutants.

Hydraulic capacity: The volume of water that a swale or reservoir can hold for treatment and management.

Impervious surface: Roofs and pavements where rain water flows as runoff over the surface and does not soak in.

Infiltration: The soaking of water into the soil, resulting in ground water recharge and water quality improvement in the soil ecosystem. (Public works agencies use the same term to refer to the entry of water into leaky sewer pipes from the surrounding soil, contributing to overflows downstream.)

Infrastructure: public utilities, electrical and phone lines, sewer systems, streets and bridges, streets, drainage systems, and other supporting systems in cities.

Recharge: The replenishment of ground water.

Redevelopment: Rehabilitation or reconstruction of an urban site to expand or revitalize its uses and benefits.

Restorative redevelopment: Retrofit and redevelopment projects that improve the value and livability of the city while effectively restoring natural processes and functions.

Retrofit: A repair or renovation of an existing feature of the built environment, typically without major structural alteration or disturbance to current use.

Runoff: Rain water that flows across the surface of the land, especially across impervious surfaces.

Sanitary sewer: Sewer carrying sanitary sewage. May carry roof leader runoff by design or from illegal connections. Often accompanied by a separate storm sewer for street runoff.

Sanitary sewer overflow (SSO): Overflow of a sanitary sewer into a stream as a result of excess stormwater entering during wet weather from roof leaders, cracked and disjointed pipes, etc.

Storm sewer: A system of pipes and (sometimes) open channels carrying urban runoff.

Stormwater: All the water that occurs on the land and in the soil during storms. In urban watersheds most stormwater is runoff.

Swale: A low area or open channel that carries water in wet weather.

Two-year, 24-hour storm: A storm lasting 24 hours that is big enough that a storm of equal size occurs on the average only once every two years. In the Pittsburgh area, a two-year, 24-hour storm has 2.5 inches of precipitation. Typically about 60 smaller storms take place between occurrences of the two-year storm.

Watershed: all the land area that drains to a given stream or low point.

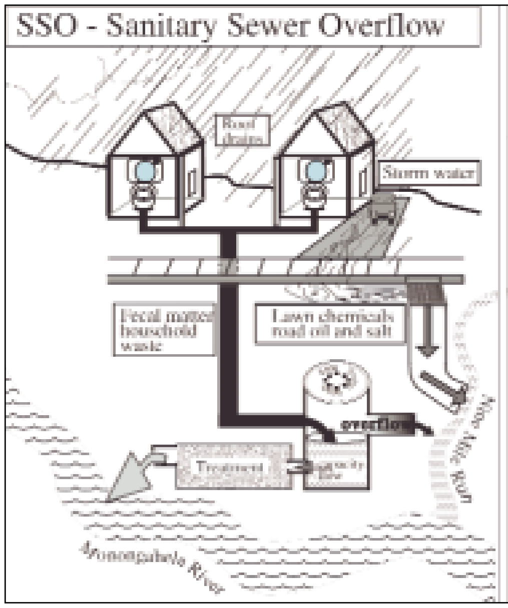
For further background on the technicalities of watersheds and urban design, see the "Resources" listed at the end of this publication.

Stormwater sources and solutions

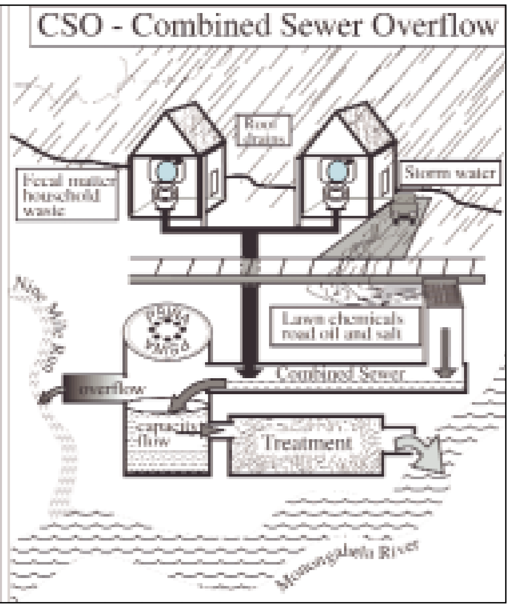
Sewer overflows and high stream flows begin with the excessive production of stormwater in the watershed. Urban watersheds are characteristically heavily covered—40 percent and more—with impervious surfaces: the pavements and roofs that cause rain water to run off the surface, and prevent it from infiltrating the soil. Impervious surfaces deflect rain water into surface channels, where it concentrates into erosive downstream floods. The runoff water carries with it oils from cars, parking lots, maintenance yards and storage areas, and heavy metals from old construction materials. Stormwater gets into the sewers, often producing overflows of raw sewage into the stream flow.

Urban impervious cover generates excessive runoff during storms, which is conventionally routed into pipes or concrete channels, robbing the soil of moisture and bypassing its absorptive capacity. In contrast, rain infiltrates into vegetated soil, recharging ground water and supporting plants.
Drawing by Jen Uncapher, RMI.

If we think of our overflowing sewer system as a bucket that is spilling over, we have two options: 1) buy a larger bucket or, 2) reduce the amount and slow the flow of water going into the bucket. Investing in increased sewer conveyance and treatment capacity without carefully examining the many ways of removing water from the system would be unwise. Reducing stormwater flows into the sewers can cost less, and it can produce additional benefits to the environment and the quality of life of the people living here.



In a separated sewer system, water from inside of buildings flows into sanitary sewer lines. Street drains flow into storm sewer lines. Roof drains often discharge to storm sewers, but in older portions of Allegheny County they are often connected to sanitary sewers. Water may also enter sanitary sewers from cracked or disjointed pipes. Sanitary sewer overflows result when wet weather surcharges sanitary sewer lines and contaminated water escapes at regulator structures (and sometimes at manholes and cracks in pipes). Drawing by STUDIO for Creative Inquiry



In a combined sewer system, water from inside of buildings, roof drains, and street drains all join in combined sewer lines. Water may also enter the system through cracked or disjointed pipes. Combined sewer overflows occur when wet weather surcharges the pipes and contaminated water escapes the system at regulator structures. Drawing by STUDIO for Creative Inquiry

Urban retrofit and redevelopment projects can disconnect stormwater drainage from combined and sanitary sewers, and reconnect it with the vegetation and soil. A range of measures can use natural processes to reuse, infiltrate, treat, and detain rain water within individual sites and neighborhoods.

The soil in Pittsburgh's watersheds is porous and permeable. It has capacities to infiltrate most of the water that comes into contact with it, filter solid particles out of the infiltrating water, and build them into the soil matrix. Microorganisms decompose pollutants and turn them into nutrients for the living system. Storage in the soil and the deeper ground water turns intermittent pulses of rainfall into a perennial moisture supply discharging slowly, almost steadily, months after the rain falls, to the streams and wetlands where aquatic organisms survive over dry summers. Even after a soil has been churned and compacted by construction, nature tends to restore these kinds of processes wherever it is allowed to work freely. Recently environmental economists have begun to refer to natural conditions and processes as "natural capital," and "environmental services," assigning dollar values to them.

Taking advantage of natural processes to store and treat stormwater brings additional benefits. Recharging the ground water supports riparian vegetation, providing wildlife habitat and opportunities for human interaction with the natural world. Reductions in impervious surfaces and tree plantings help moderate urban temperatures, increasing human comfort and reducing building cooling loads. Porous pavements can be designed to improve pedestrian access to desirable places. Revegetation of landscapes beautifies neighborhoods.

The informed, creative retrofit and redevelopment of urban places could solve Pittsburgh's watershed problems at the source, while revitalizing older communities. It can reduce impervious cover; it can disconnect storm drains from sewers; it can build storage and treatment features into the fabric of urban places; it can educate the residents about where they live; it can allow natural processes to operate again.

Much of greater Pittsburgh's buildings, streets, land uses and infrastructure has been in place for years. Their functions and performance were adequate for the standards of their time. But standards change over time. Today's generations are re-evaluating the obsolete technical systems they have inherited and counting the mounting costs of potential reconstruction. At the same time, the people of today value the human scale and comfort of old urban places, and seek a way to bring them to full health and vitality.

Some of the measures that are available for restoring watershed function within individual urban sites and neighborhoods

Reuse of rain water: Capturing roof runoff in tanks or cisterns allows it to be used for lawn and garden irrigation, preventing the runoff from being part of peak flows during storms and infiltrating it into the soil during dry weather.

Green roofs: Also known as "eco-roofs," (modern variants on sod roofs but with lighter weight and lower maintenance) green roofs capture a portion of rain water and replace some of the functions of the vegetation a building displaces from the watershed.

Disconnection of roof drainage: Disconnecting roof downspouts from sewers and discharging it into rain gardens, dry wells, and vegetated swales reconnects rain water with native soil and vegetation.

Disconnection of pavement drainage: Pitching the drainage of driveways, sidewalks and parking lots onto adjacent vegetated soil and not onto other pavements or into storm sewers brings the runoff back into contact with soil and vegetation.

Infiltration basins: Carefully engineered depressions in the landscape, "rain gardens," dry wells, and subsurface recharge beds collect runoff from roofs and pavements and percolate it into the soil.

Tree plantings: Tree branches and foliage intercept a portion of rain water.

Soil rehabilitation: Aeration and the addition of organic matter and dense vegetation increase infiltration rates into soil.

Reduction of impervious surfaces: Reconfiguring driveways, parking lots, and streets to reduce unnecessary pavement turns more of a site over to vegetated soil, which infiltrates rain water.

Porous pavement: Special varieties of asphalt, concrete, masonry, gravel, and other materials have open pores that detain runoff, filter pollutants, and allow water to infiltrate the underlying soil.

Vegetated swales: Earthen drainage channels, as alternatives to pipes, slow the velocity of runoff, remove pollutants, and infiltrate water into the soil.

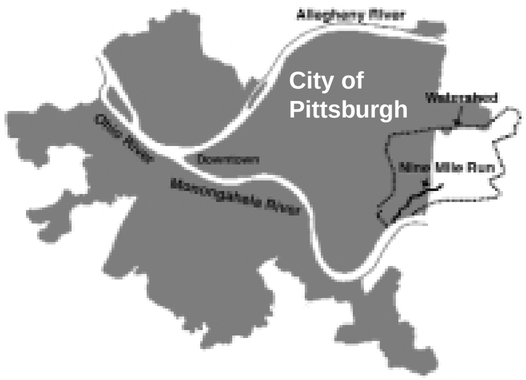
Daylighting: Restoring or replacing historic streams by excavating culverts and creating naturalized open channels slows the velocity of runoff and brings the flow into contact with the soil, vegetation, air, and sunlight, allowing the natural ecosystem to treat and infiltrate the running water.

To bring these changes about is a challenge. Restorative redevelopment is a technical problem involving hydrology and engineering. It is also a social, economic, and aesthetic problem involving the communities of people and the way they live. Every square inch of an urban watershed, and every person, is an active participant in the watershed's processes, and in the life of the city.

The development of the Nine Mile Run model

This model of urban watershed restoration and community revitalization was developed by a panel of 60 design and policy experts convened in Pittsburgh in October, 1998 by the Heinz Endowments, the Rocky Mountain Institute, and Carnegie Mellon University's STUDIO for Creative Inquiry.

The panel focused on the watershed of Nine Mile Run, a stream that drains from the Wilkinsburg and Squirrel Hill areas to the Monongahela River. Nine Mile Run is typical of urban streams and watersheds in Pittsburgh, and in other cities in the United States. It overlaps four different municipalities, with widely different financial constraints. Substantial portions of the watershed have high proportions of impervious surfaces. Much of the original stream has been culverted.



The Nine Mile Run watershed in the Pittsburgh region. Map by STUDIO for Creative Inquiry

As in other urban watersheds, every rain fall brings the diverse pollutants of a city to Nine Mile Run; oils, trash, salts, pesticides and fertilizers all end up in the stream. Culverts convey abrupt pulses of floods, eroding the stream channels. Flood flows from roof and street runoff get into the combined and sanitary sewers, producing sewer overflows that create human health hazards. When the rain is not falling, the base flow of the stream is almost nonexistent, drying up at times because the water has never entered the soils of the watershed.

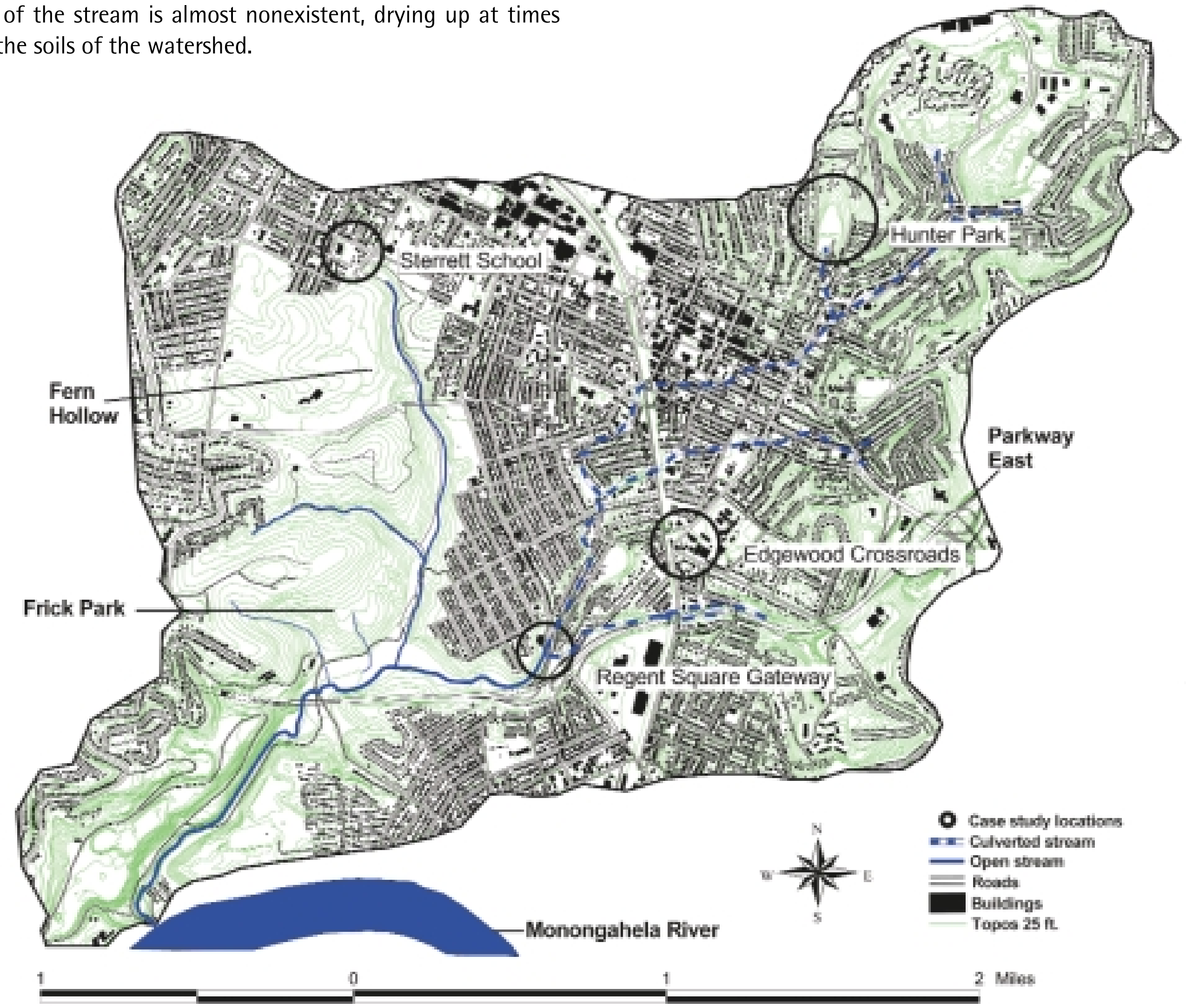
But Nine Mile Run also displays the values of Pittsburgh's old urban places: strong neighborhood identity, pedestrian-friendly sidewalks, and numerous solidly built homes. It has vigorous native ecosystems in which porous, fine-textured soil, full of microorganisms, is awaiting exploitation for stormwater infiltration, treatment, and storage. And local organizations and federal and state institutions have taken an interest here in ecosystems, infrastructure and the economic opportunities for sustainable solutions.

The Nine Mile Run panel met in a "charrette," which refers to a short, intense design and problem-solving event. The charrette convened at the Hosanna House in Wilkinsburg in October, 1998.

The panel was interdisciplinary, bringing together practitioners of landscape architecture, architecture, civil engineering, environmental policy, art, geology, public works, and planning. Some of them were award-winning national experts; others were recognized for their expertise and knowledge of the specific conditions of the Nine Mile Run Watershed. Representatives of local communities were also invited to attend.

The outfall of the main Nine Mile Run culvert at low flow...

...and after a rainstorm, when the runoff carries raw sewage and other urban pollutants with erosive power. Photographs by STUDIO for Creative Inquiry.



The Nine Mile Run watershed, showing impervious streets and buildings, topography, and the charrette case study sites. For municipal boundaries, see the map on page 26. GIS map by STUDIO for Creative Inquiry.

The panel formed five teams to address focused problems. Four of the teams illustrated the potential for restorative redevelopment by designing potential retrofit and redevelopment projects on sample sites within the watershed. The fifth team focused on policy, recommending institutional and regulatory changes that could make restorative redevelopment happen throughout the watershed and the region.

The panel had access to a library of publications on ordinances that apply to the Nine Mile Run area, the geology and soils of the area, and engineering standards and formulas. Participants used a bank of computers for GIS, imaging, and CAD. Each design team had a site base map, drafting equipment, and assistance in graphic production from design students from regional universities.

During the charrette, each team periodically reported its questions and insights to the whole panel. The teams also met with the public to inform them about the project, and to receive their input.

The charrette participants sought proposals that would have immediate benefit. But they were not to be limited by short-term political feasibility: they looked a hundred years into the future, using all appropriate technically and financially feasible approaches to restore the watershed's ecology and revitalize its communities. Their mission was to find what is right and possible in old urban watersheds, so that policies and institutions can go in that direction.

The results

The charrette's results show that retrofit and redevelopment projects that are technically and economically feasible can improve the value and livability of the city while effectively restoring natural watershed functions. This report presents the conclusions of the charrette in the following sections.

Section II presents the four sample designs, illustrating the potential results for a range of specific sites. The section begins by presenting the engineering and economic guidelines the teams were asked to work within. The designs show how site-based stormwater management can be consistent with and even enhance other objectives for economic vitality and quality of urban life.

Section III presents seven general patterns of restorative redevelopment that the sample designs and the charrette process exemplify. Following these patterns in future retrofit and redevelopment projects can assure that the results are feasible and effective despite the distinctive challenges of urban watersheds.

Section IV summarizes policy and institutional recommendations from the charrette. Establishment of a watershed-wide organization to integrate sewer and stormwater management, ecosystem protection, and community revitalization is one key proposal. Additional action items in each of these areas outline a comprehensive program for restorative redevelopment.

A separate technical appendix to this document presents further background materials and additional information on the design and policy recommendations of the charrette participants. To obtain the appendix, see page 31.

Successful application of the Nine Mile Run model can simultaneously regenerate watersheds and communities. Stormwater management techniques that are embedded in the layout and materials of inevitable retrofit and redevelopment activity can exploit the natural ecological processes that are already operative in these hills and valleys. Their implementation assists the region's efforts to eliminate sewer overflows, restore water quality, reduce flash flooding, control erosion, and restore base flows. At the same time, through integrative urban design, they can improve pedestrian access, conserve energy, create parks and comfortable streetscapes, moderate urban temperatures, improve recreational opportunities, reinforce the sense of local community, and revitalize local economies.

The Nine Mile Run Watershed:

Area:	6.5 square miles (4,200 acres)
Stream Length:	2 miles culverted in upper watershed, 1.5 miles open in lower watershed
Receiving River:	Monongahela
Municipalities:	Pittsburgh, Wilkinsburg, Swissvale, Edgewood
Major Public Features:	Frick Park, Parkway East, proposed regional busway
Homes:	18,600
School Districts:	City of Pittsburgh, Wilkinsburg, Woodland Hills
Major Commercial Districts:	Edgewood Towne Center, Regent Square, Penn Avenue

"Today we learned about watersheds, brownfields, and grasslands. I learned when it rains so much, all of the water pipes cannot hold all of the water. So the people at the water systems place shut that pipe off. When the toilet water comes down with the rain water it goes in the stream and makes it smell bad. Ewww! . . . I think in the future when we clean it up, it will be a beautiful place. There will be clearer water and more people and animals will want to go there. Aren't you excited! I know I am."

—6th grade student, Dickson School, during Nine Mile Run Education Program class with the STUDIO for Creative Inquiry.

One of the charrette teams at work in October, 1998. Photograph by STUDIO for Creative Inquiry.

Other charrette participants discussing issues and opportunities for one of the sites. Photograph by STUDIO for Creative Inquiry.

Section II
Four Sample Designs

The following case studies test and demonstrate the effectiveness and feasibility of restorative redevelopment on specific urban sites. They represent a range of types of old, vital Pittsburgh places: a neighborhood school, a neighborhood park, a historic train station at a commercial center, and an underutilized commercial site. They display a variety of urban land uses, municipal jurisdictions, sewer system configurations, and site features.

The design program for each site was to reuse, restore, and revitalize the place by resolving existing site-specific issues, adapting to ongoing change, and participating in the restoration of natural processes throughout the watershed. The designs were to be sympathetic with existing land uses and community values, consequently they involve few significant demolitions or replacements of structures. Instead, through combinations of retrofitting and redevelopment, they selectively implement stormwater management techniques shaped by and embedded in the revitalization of the place.

The designs illustrate the incremental retrofit and redevelopment of the watershed to mitigate the quantity and quality of stormwater and its drainage into sewers, culverts, and streams. They show the management of precipitation as close to where it falls as is physically and economically feasible, using freely available natural processes to do the work of stormwater storage, treatment and management. They concentrate on permanent solutions, including those that are built up incrementally out of myriad incremental steps. By linking watershed restoration and community revitalization, they share costs across multiple functions and increase overall benefits compared to downstream sewer and stormwater solutions.

Sample site	Municipal jurisdictions	Major features
Hunter Park	Wilkinsburg	Neighborhood park, residences, local streets
Edgewood Crossroads	Edgewood	Historic train station, active railroad corridor proposed for mass transit, busy pedestrian and vehicular intersection, town park, old commercial buildings, churches, schools, residences
Sterrett School	Pittsburgh	Middle school, residences, central culvert, Frick Park
Regent Square Gateway	Swissvale, Edgewood & Pittsburgh	Open Nine Mile Run channel, highway access, entrance to Frick Park, underutilized commercial building

Feasibility criteria met by the designs

The following requirements were imposed upon the projects at the start of the charrette, and the teams met them through interdisciplinary design.

Soil and frost conditions

Every technique of construction and stormwater management was adapted to the specific site where it is placed, including the distinctive conditions of Pittsburgh's fine-textured soil, frequent frosts, steep hillsides, and unstable geology. To assure this, every design team included practitioners from the Pittsburgh area experienced in local conditions and practices. Each team had access to detailed soil and geologic data from published sources and participating scientists.

Hydrologic performance

All the designs infiltrate or detain (in that order of preference) and treat the runoff from a 2-year, 24-hour storm on-site. A facility with the capacity for the 2-year storm also adequately manages the runoff from all the smaller, more frequent storms. This design threshold encompasses most of the rain that falls during a year, most of the erosive high flows, and essentially all of the "first-flush" pollution events. Managing this volume of runoff reduces the frequency and extent of sewer overflows, restores water quality, and replenishes ground water aquifers. On the other hand, storms larger and less frequent than the two-year storm exceed the capacity of the on-site systems; to anticipate these occurrences, the designs provide overflow to streams or sewers. This approach is consistent with standards in the Monongahela River Watershed Stormwater Management Plan adopted by Allegheny County in 1993. Some of the sites also receive runoff from off-site; the plans manage this extra water in appropriate ways. Given the short design time of the charrette, the engineering of the recommended stormwater and sewer measures is preliminary, and would require careful validation and specification prior to implementation.

Budget

All designs meet the hydrologic performance criterion within a construction budget of $15 per cubic foot ($2 per gallon) of hydraulic capacity for on-site infiltration, detention, or treatment. This amount is within the range of costs for conventional detention tanks, basins, and bypass systems in the Pittsburgh region in recent years. The accomplishment of hydrologic objectives on-site yields a cost saving in downstream conveyance, storage, and treatment.

In addition to this stormwater management budget, each design utilizes an unspecified retrofit and redevelopment budget proportional to the non-stormwater benefit foreseen for each site-specific design. The non-stormwater budget would come from a housing, public works, or urban redevelopment agency, or a homeowner or developer, interested in supporting or investing in other aspects of each site-specific proposal.

For example, proposals for porous pavements can take advantage of pavement rehabilitation schedules necessary during the life of almost any street, sidewalk or parking lot. When property owners or municipalities replace deteriorated impervious pavements, the owner bears the bulk of the cost for reasons other than stormwater management. The stormwater management budget funds the incremental cost of porous materials over those of nonporous materials that would not have a stormwater management benefit.

Dispersed, on-site, multi-functional facilities are maintained by multi-purpose parks agencies, street departments, and homeowners' associations. These non-stormwater agencies are motivated to maintain their facilities as amenities for functional, aesthetic and recreational reasons; the maintenance cost is covered by those budgets.

The short, intense charrette process did not allow time for detailed cost estimates that would have to take into account, among other things, the costs of design, land acquisition, legal work, maintenance, operations, and replacement. Instead, the charrette procedure placed trust in the experience and judgment of the team members to assess the rough magnitude of potential costs and to calibrate their designs to the given budget.

Hunter Park

Charrette Team

Robert Bingham; Artist; STUDIO for Creative Inquiry; Pittsburgh, PA
A.B. Carl; Planner; Pittsburgh, PA
Sandra Heard; Architect; MacLachlin, Cornelius & Filoni; Pittsburgh, PA
Walter Hood; Landscape Architect; Hood Design; Oakland, CA
Andy Otten; Landscape Architect; Pennsylvania State University; University Park, PA
Fernando Pasquel; Engineer; CH2MHill; Herndon, VA
Ken Tamminga; Landscape Architect; Pennsylvania State University; University Park, PA

Summary: The design for Hunter Park exemplifies the Nine Mile Run model by using revitalization of a previously neglected urban park and its neighborhood as the catalyst and organizer for watershed restoration. The design stores, treats and infiltrates stormwater from the park and adjacent residential blocks, in ways that are integrated with renovated and expanded recreational and cultural facilities. A "bioretention" area, a constructed wetland, and a series of swales treat inflowing runoff. Reopening a once-culverted stream creates an amenity and focal point for a new public square. Pervious parking bays along streets around the park provide new parking spaces and infiltrate street runoff. In surrounding residential areas, the drainage from roofs and streets is disconnected from storm sewers and diverted into swales in and around the park.

The "dolphin" fountain in the lower portion of Hunter Park, and nearby houses. Photograph by Richard Pinkham, RMI

Looking down on the upper ballfield. The tennis courts in the fenced area are in poor condition and are used as a composting facility. Photograph by STUDIO for Creative Inquiry.

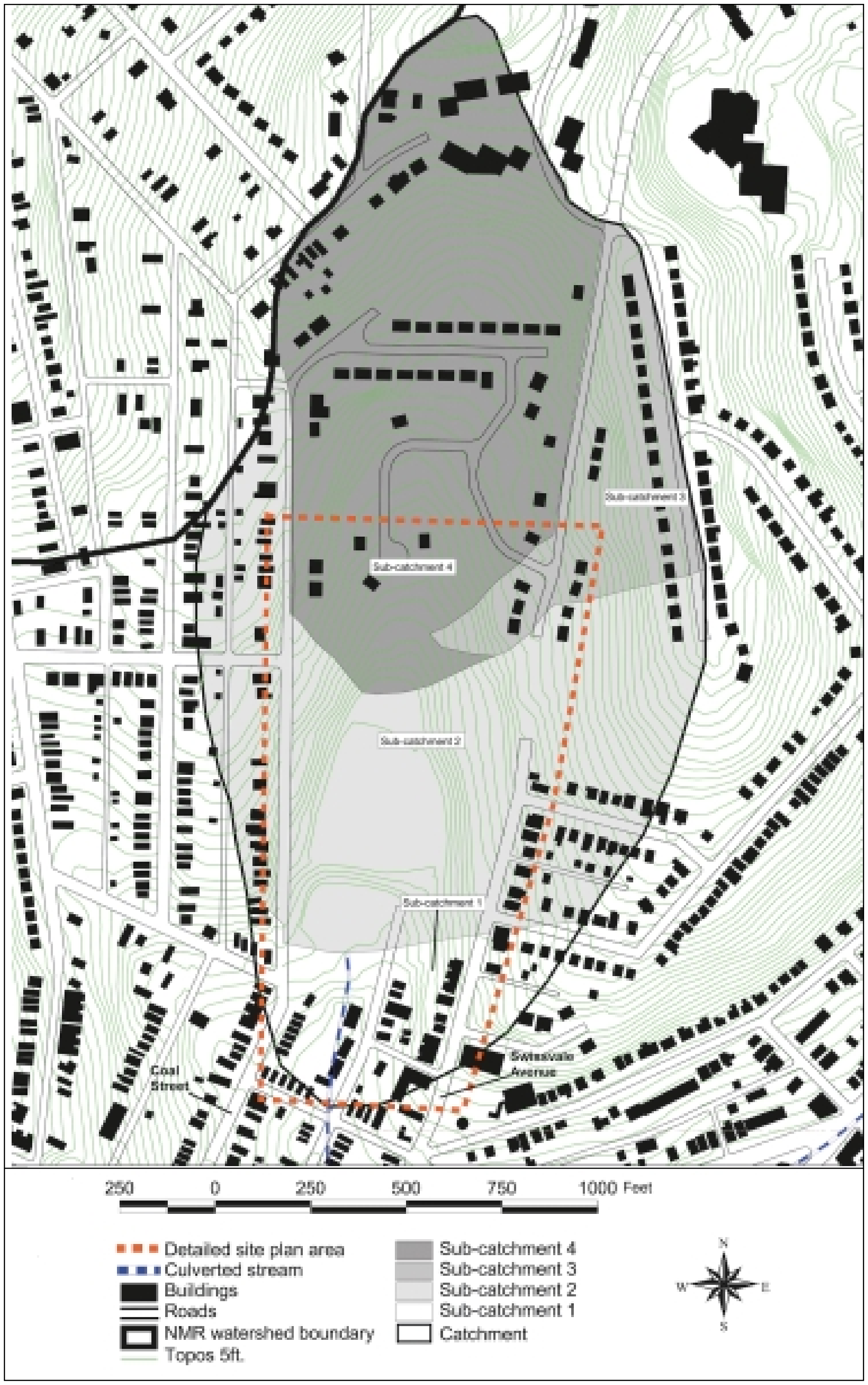
Hunter Park is located near the headwaters of the Nine Mile Run watershed. It is a neighborhood park in Wilkinsburg, at the northern terminus of Swissvale Avenue. This is a low income area; neighborhood streets and sidewalks are in poor condition. The park's ball field, wading pool, basketball courts, and small playground are in disrepair, although all are heavily used in season.

The bulk of the park is in pervious turf, although it hides the culverted remains of a natural stream. In contrast, the surrounding residential blocks are mostly impervious with densely built houses, streets and sidewalks.

Most of the runoff from the impervious surfaces drains into sewers, contributing to downstream flood pulses, sewer overflows, water pollution, and reduced base flow. Diverting runoff out of Wilkinsburg's sanitary and storm sewers and into its soil and ground water would contribute to cleaner water downstream in the Nine Mile Run watershed.

A meaningful history

Despite the currently neglected condition of the Hunter Park area, it has a vigorous past that symbolizes the industrial development of the region and the character of its people. Its present configuration, uses, problems and promises are the accumulation of its chronological development and intertwining ecological, economic, and social issues. The park deserves to have its story told through physical patterns and symbols and programmed public activities. It deserves care for the sake of the neighborhood residents who use the park today and long to participate in a hopeful future.



The Hunter Park site, catchment, and surrounding area. GIS map by STUDIO for Creative Inquiry.

Before settlement of the area, the site was a V-shaped headwater stream valley. In the nineteenth century a coal mine filled and flattened the site with yards and spoil piles; the stream was diverted around the periphery. The mining industry brought in a working population and built company housing nearby. The present-day Coal Street, for example, was one location of company housing.

In the early part of the twentieth century, the industrially created land forms served as a baseball field for the Negro League. Some of the best baseball players in the country played as semi-pros at "Hunter Field."

Beginning in the 1950s, a series of developments gradually transformed the site into a recreational park. To the baseball field were added a children's playground, basketball courts, and tennis courts. The stream was culverted. In the 1970s the Little League played baseball here under American Legion sponsorship. By 1980 Hunter Park was one of four parks under the responsibility of Wilkinsburg's Recreation Department.

Today, the local neighborhood depends on its park. The "dolphin" fountain is small, but when it is turned on, neighborhood kids climb all over it all day long. The bold landforms present unique open spaces and potential for multiple use. However, the park's edges are ambiguous, parking is inadequate, and there are no formally defined entry points.

The site is in a valley with a drainage area of 59 acres, of which impervious roads and rooftops cover approximately 9 acres or 16 percent. Most drainage inlets are clogged with sediment; some drainage pipes are broken. Some grass swales in the park improve water quality to a degree, but are undersized even for the small amount of water they carry. Concentrated runoff from nearby impervious surfaces has eroded some of the park's drainage swales and steep side slopes.

The underlying geology of the "Casselman Formation" forms the site's steep valley slopes and the coal seams that fed the nineteenth century mine. This formation is a mixture of shale, sandstone, and other sedimentary rocks typical of large parts of the Pittsburgh region. Its considerable modification over the years by earth-moving and construction is typical of old urban and industrial areas.

The proposed design is a convergence of history, hydrology, recreation, and neighborhood revitalization, wedding the site's social history to its hydrologic future. Water is brought through a sequence of historical-recreational spaces, and celebrated at the end. The hydrologic strategies are given form by the park's natural and cultural history; in turn the forms illuminate the park's environmental and historic features.

Integrated restoration strategies

The design filters, detains, and infiltrates runoff to remove pollutants, reduce runoff contributions to sewers, and solve drainage and erosion problems. Because the site is at the headwaters of the Wilkinsburg and Nine Mile Run sewer systems, everything that is done on this site to reduce and treat runoff reduces overload and improves water quality in all the systems downstream.

The design uses complementary strategies for various portions of the catchment. At the upper end of the park, a woodland "bioretention" area consists of sand and soil mixtures planted with native plants. It includes a pretreatment area to dissipate the energy of inflowing runoff, and to collect coarse sediment.

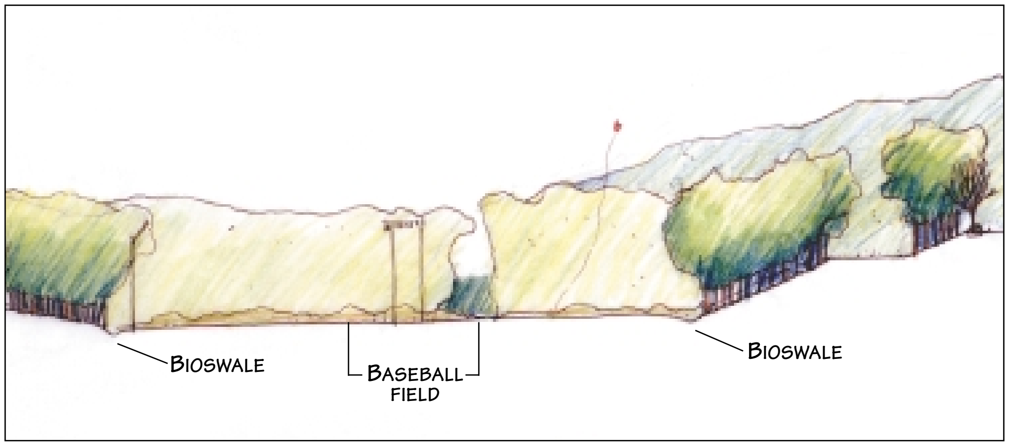
Then a constructed wetland treats water at the upstream end of the ball field. It is planted with emergent and scrub-shrub plants in a complex microtopography. It filters pollutants, reduces peak flow rates, and stabilizes the flow of water into the grass swales below.

Swales take overflow drainage from the wetlands, and runoff from the fields and surrounding slopes, around the ball field and through the lower part of the park. The swales have grass and other vegetation, which help remove pollutants from runoff. For further infiltration and filtering, they are enhanced with beds made of sand and topsoil 1 to 2 feet deep and 10 to 15 feet wide.

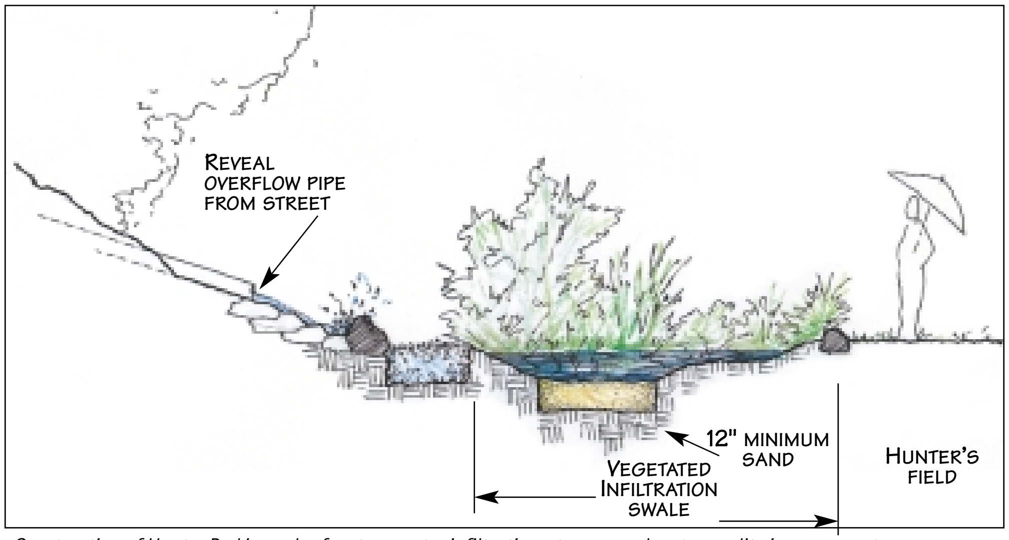
Plan for Hunter Park rehabilitation. Drawing by charrette team.

At the bottom of the park, the area where coal mine shanty houses once stood is made into a public square for the neighborhood. The once-culverted stream is reopened ("daylighted") through the square to convey stormwater in restored stream habitat as an amenity and focal point for the park. The square includes a stage for public plays and festivals, adding a cultural role to the recreational park. One type of festival could annually celebrate the watershed with stream "cleanups." The stream is expected to carry 45 cfs during the two-year storm. The stream's meanders are dimensioned for natural "dynamic equilibrium" with the flow. Bioengineering (the use of living plants in combination with nonliving materials to stabilize streams and slopes) is used to protect the banks during 2-year and 10-year storms. The daylit portion of the stream could continue into the residential block immediately south of the plaza.

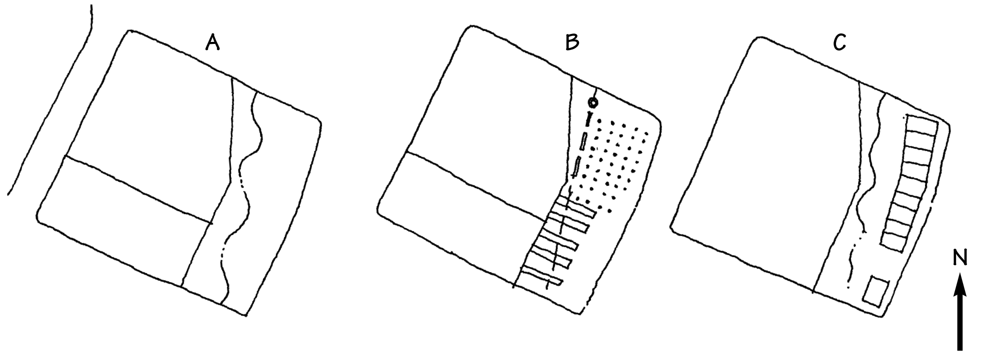
	Drainage area (acres)	Impervious cover (rooftops and streets)	Treatment Capacity (cu. ft.)	Treatment Capacity (gallons)
Bioretention	6.7	19%	10K	75K
Constructed wetland	30.2	14%	25K	187K
Enhanced grass swales	23.0	15%	20–30K	150–225K



Swales adjoining Hunter Park's renovated ball field. Drawing by charrette team.



Construction of Hunter Park's swales for stormwater infiltration, storage, and water quality improvement. Drawing by charrette team.



Options for stream restoration, flood prevention and redevelopment where the stream leaves Hunter Park and enters downstream residential blocks. ("Block A" on the site plan.) The housing on the east side of this block is in poor condition and needs replacement or relocation.

A: Remove structures, daylight stream,

B: Remove structures, introduce urban agriculture and forestry,

C: Replace structures, daylight stream.

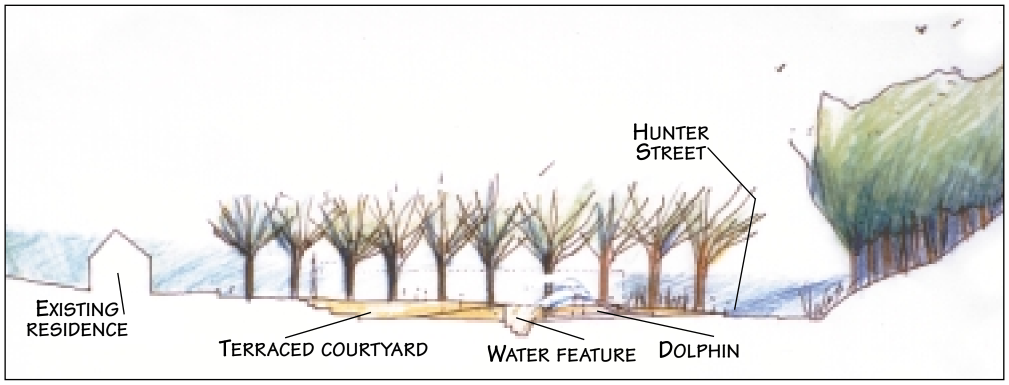
Drawing by charrette team.

Community participant: "I'd like to see Hunter Park fixed up, like the hoops court, make the ballfields more for different uses, baseball, soccer, basketball, Frisbee. Maybe a stage for music."

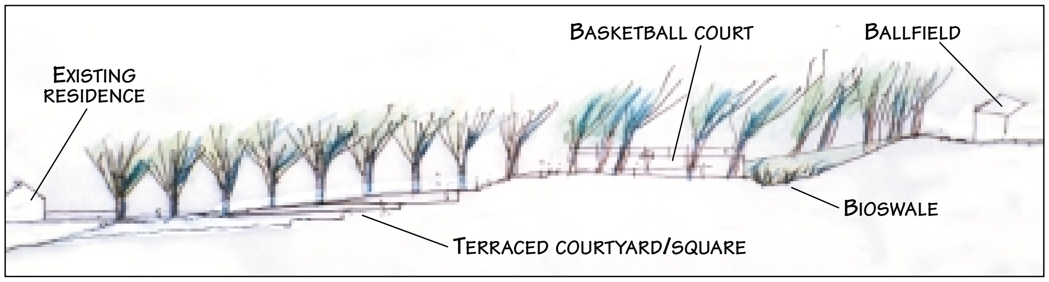
Design team member: "Suppose ideally Wilkinsburg had lots of money for a park, what would you do?"

Another community participant: "Music, art. Lots of people would come, people would gather, invited from other neighborhoods for talent shows and comedians. People would be happy. There is a music project at Hosanna House; it could be a good opportunity to move it outside. I like music and the thought of having sessions outside to give me a better place to learn."

—**Exchange in the design team's meeting with neighborhood residents**



The public square at the foot of Hunter Park. Cross-section looking north, up into the park, from James Street. Drawing by charrette team.

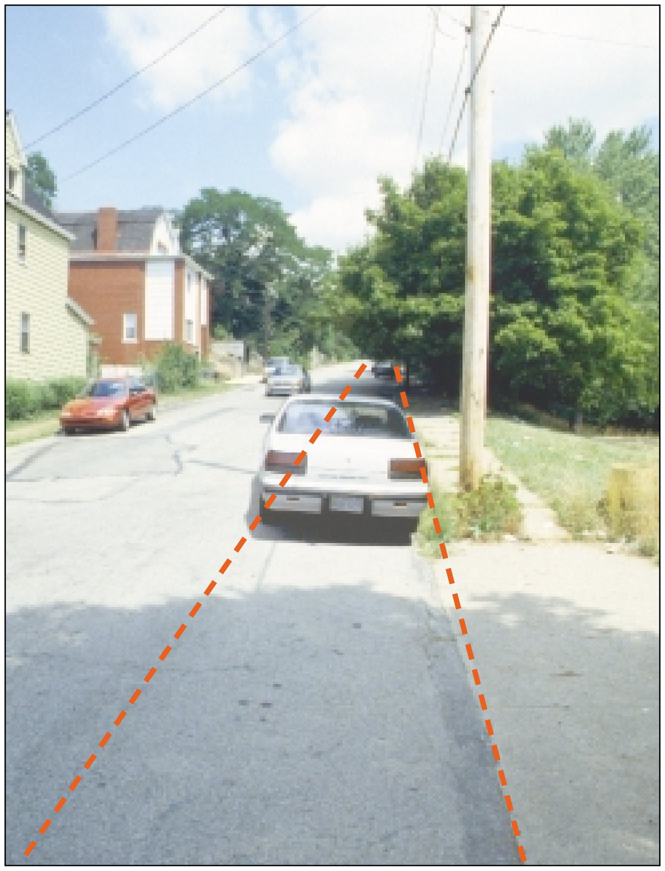


The sequence of land forms and drainage features proposed for Hunter Park. Long section looking west, across the park. Drawing by charrette team.

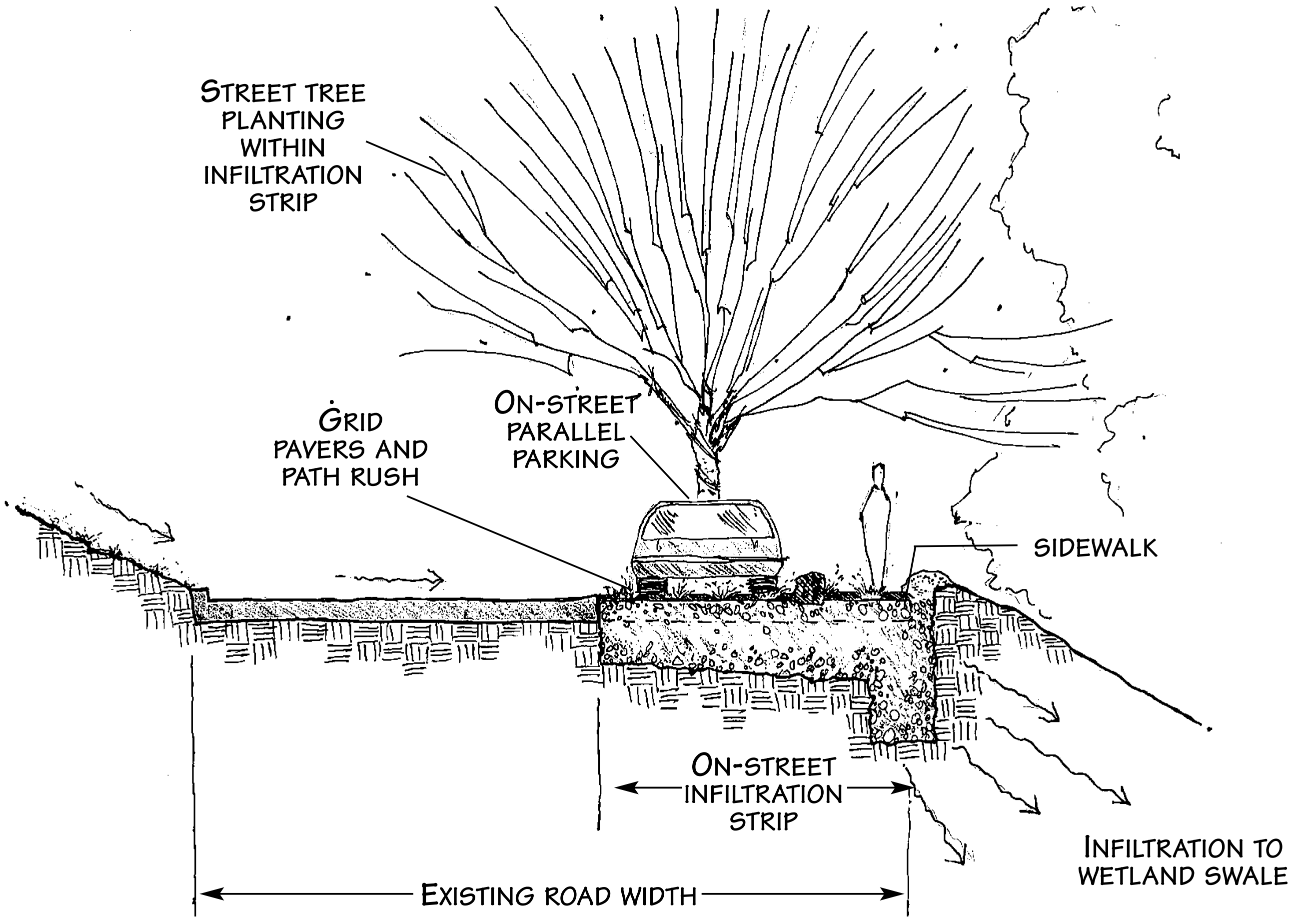
Around the edges of the park, street pavements are narrowed to reduce impervious cover and allow infiltration while adding more parking spaces on permeable edges. The pervious parking stalls are made of concrete pavers with grass, over a gravel bed. The open-celled paver surface and the deep gravel storage basin beneath it adapt the pavement construction to the region's frequent frosts and fine-textured, slowly permeable soil. Although porous pavement removes and treats some water from the site's drainage, the amount was not counted in the total capacity of the site's restoration features or in establishing the capacity of downstream swales; it is an "extra" benefit.

In the residential areas all around and above the park, roof leaders, street gutters and drainage inlets are disconnected from the storm sewer system. Their drainage is diverted into swales and across vegetated slopes in and around the park. Excess runoff remaining in the streets is conveyed to the park's wetlands and swales for treatment.

Stone "traces" through the park mark lines of old mining features. Street trees are added for air and water quality improvement. The combination of strategies preserves and celebrates the natural and cultural history of the area. The improved access to the park promotes its use. There are opportunities to learn about the hydrologic strategies through interpretative signs and guided tours.



A typical street by Hunter Park. The superimposed line indicates the border of the proposed pervious parking strip in the diagram below. Photograph by Richard Pinkham, RMI.



*Modification of a Hunter Park street to reduce impervious surface and increase infiltration, while increasing tree canopy and the availability of parking. Note the gravel-filled storage/recharge bed under the parking stall and sidewalk, surfaced with a permeable system of block pavers with path rush, (*Juncus Tenuis*, a grass-like plant that tolerates wet or dry conditions) planted in the joints between blocks. Drawing by charrette team.*

Edgewood Crossroads

Charrette Team

Bill Browning; Green Development Specialist; Rocky Mountain Institute; Snowmass, CO
Tom Cahill; Engineer; Cahill Associates; West Chester, PA
Rebecca Flora; Planner; Green Building Alliance; Pittsburgh, PA
Michael Hough; Landscape Architect; Hough, Woodland, Naylor, Dance, Leinster; Toronto, Ontario
Alex Hutchinson; Engineer; Hutchinson and Sons Engineering; Pittsburgh, PA
C. Noel Kennard; Architect; Burt Hill Kosar Rittelman Associates; Pittsburgh, PA
Suzanne Lami; Architect; Lami Grubb Architects; Pittsburgh, PA
Choli Lightfoot; Architect; Kingsland, Scott, Bauer Associates; Pittsburgh, PA
Henry Prellwitz; Geologist (Ph.D. Candidate); University of Pittsburgh; Pittsburgh, PA
Larry Ridenour; Landscape Planning and Trails Consultant; Pittsburgh, PA

Summary: The design for Edgewood Crossroads illustrates restorative redevelopment at the other end of the income scale from Hunter Park. It also illustrates the aggregate economic benefits that can be obtained by repeating on-lot measures in many small individual retrofit projects. The design for this site integrates water systems and community values. It centers on a new plaza in a small community park facing a historic train station. A public seating and gathering area there also serves as an infiltration basin during and shortly after large storms. Permeable pavers reinforce pedestrian access across the street intersection to the plaza. In nearby parks and institutional grounds, ground water recharge beds constructed under open lawns and playing fields collect runoff from areas uphill of the site. Diverting rooftop runoff into on-lot residential infiltration basins reduces inflows to the sewers. A one-time grant of $1,000 per home to subsidize the installation of these infiltration beds would be paid off in 8 years from potential savings at the treatment plant.

Edgewood Crossroads is located near the center of the Nine Mile Run watershed. It is the public center of the Borough of Edgewood, where a historic train station fronts on busy Swissvale Avenue. The old train station is the only one that the famous nineteenth-century architect Frank Furness designed on this side of the Allegheny Mountains. Across the street are old storefront commercial buildings, a church, and a school. Nearby are Edgewood's town hall, public library, community swimming pool, and numerous well-kept old residences.

Residential streets converge from several directions. Public buses stop at the street intersection; the old railroad bed is slated to become the route of a regional busway. Numerous pedestrians, especially children, move between their homes and community facilities along the sidewalks, across the street intersection, and through the railroad underpass.

Edgewood has dozens of civic groups, and the social closeness almost of a village. In the minds of the local Edgewood people, the cluster of streets, structures and open spaces around the old train station is the unified center of their community. Protecting and enhancing the sense of community is the central task of any urban design here.

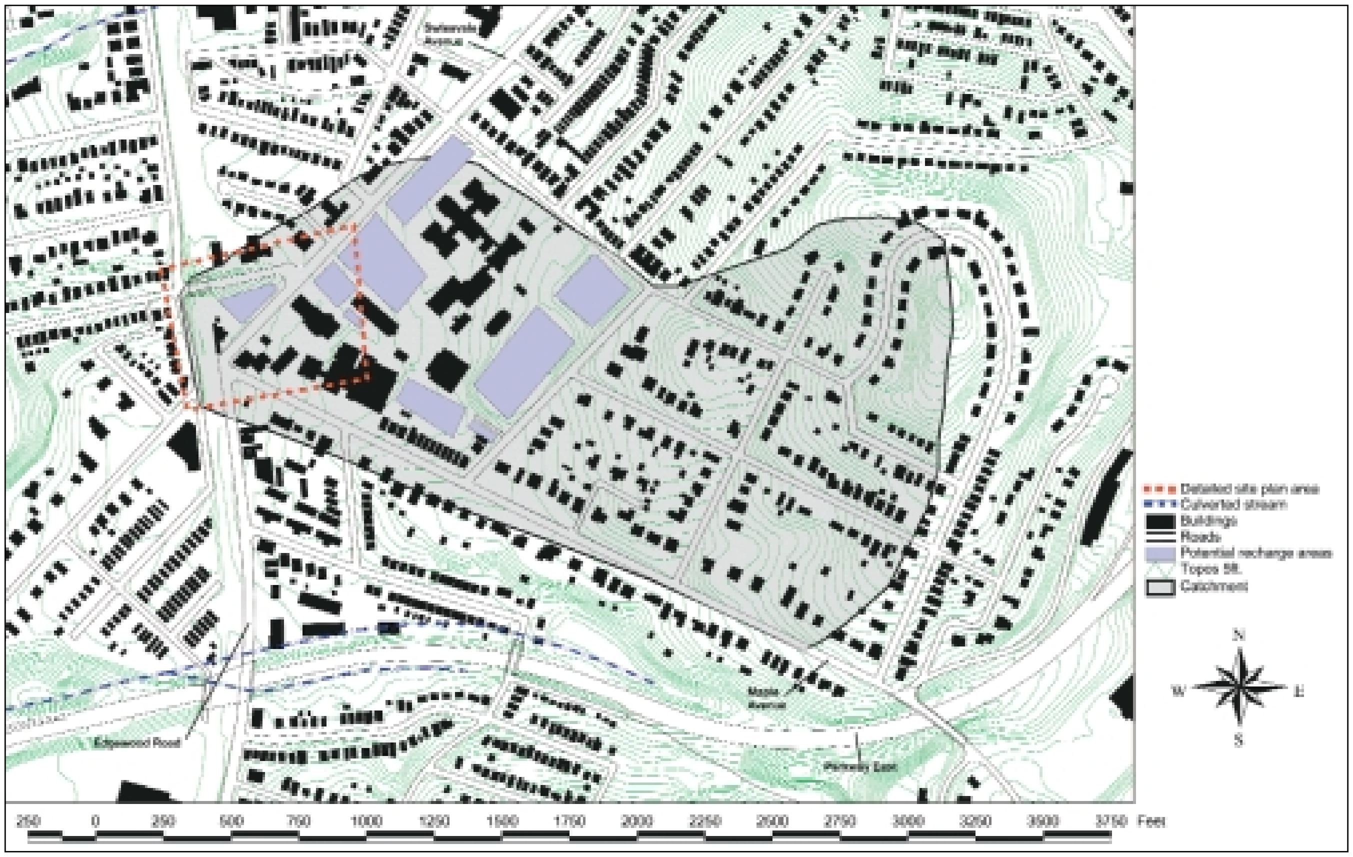
The underlying geology at the crossroads is based on an ancient river bed that left behind a relatively level "terrace" of gravel, sand, and clay over large areas in the central part of the Pittsburgh region. In the catchment uphill from the crossroads, the land is characterized by steep slopes; a geology of shale, siltstone, sandstone, and other sedimentary rocks; and fine-textured soil that typify the rest of the Pittsburgh region. The modification of the soil over the years by construction is typical of old urban places.

The impervious streets, roofs and sidewalks of the site and its catchment generate runoff that ponds up in the street intersection, disrupting pedestrian and vehicular traffic. Eventually it flushes into storm sewers, carrying oils and other pollutants, while denying recharge of ground water. As in many parts of the Pittsburgh region, some roof leaders here are connected to sanitary sewers, contributing to sewer overflows downstream.

The design for this site is based on relationships between water systems, urban design, and social values. It integrates the following community issues: reinforcing the social and physical sense of community, preserving public open spaces, reinforcing pedestrian access, eliminating street flooding, and bringing Edgewood into compliance with federal water quality standards by separating storm drainage from the sanitary sewer system.

The train station as seen from the intersection of Maple Avenue and Edgewood Avenue. This intersection floods during large storms. Photograph by STUDIO for Creative Inquiry.

Looking up Swissvale Avenue from the train station. Note the storefront building and church on the right, and the small park to the left; all are part of the site. Photograph by Richard Pinkham, RMI.



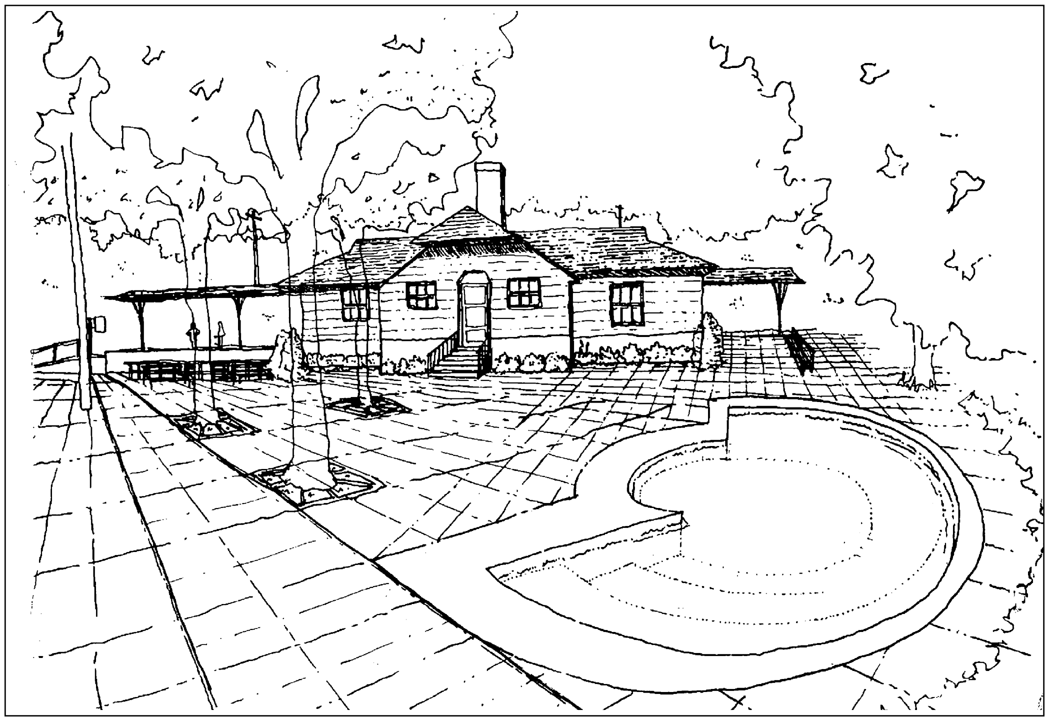
The Edgewood Crossroads site, catchment, and surrounding area. GIS map by STUDIO for Creative Inquiry.

The Crossroads

In the small community park facing the train station, a plaza is developed to be the gateway to the public greenway being developed in the new transit corridor. Here a prominent stormwater restoration facility integrates stormwater solutions and public education with urban design. The center is a depressed bowl, with a porous block bottom that retains and infiltrates stormwater. During rainfall, about 30 days per year, the depression diverts flood waters off the street and the surrounding plaza; it fills and then slowly drains over a one- or two-day period through an infiltration bed beneath the plaza. On dry days, the plaza and the bowl are for communal gathering and play; the wall around the bowl is for sitting. Permeable unit pavers continue from the plaza across the street intersection, to strengthen pedestrian connections.

In the rest of the park, steep slopes are reforested to increase infiltration. Tree canopies absorb some rainfall before it reaches the ground, and reduce air pollution and the cooling energy requirements of nearby buildings.

For the railroad right of way, a public agency currently proposes to pave a 40 foot width for express bus service to downtown Pittsburgh. An alternative greenway option would emphasize nonvehicular transportation, which would eliminate vehicular emissions and minimize the demand for paved streets and parking areas throughout the greenway region. The greenway right of way would hold a 5 feet wide pedestrian path, a 10 feet wide cycle path, and two rows of trees and plantings. This would maximize infiltration for the full length of the right of way. Another alternative would emphasize light rail. Light rail tracks would allow infiltration across the entire right of way width; the permeable surface could be planted with grass to reduce ambient temperature. The light rail vehicles' ability to accept riders from both sides would allow a central island for embarkation, which would leave enough space for a pedestrian greenway within the remaining right of way space.

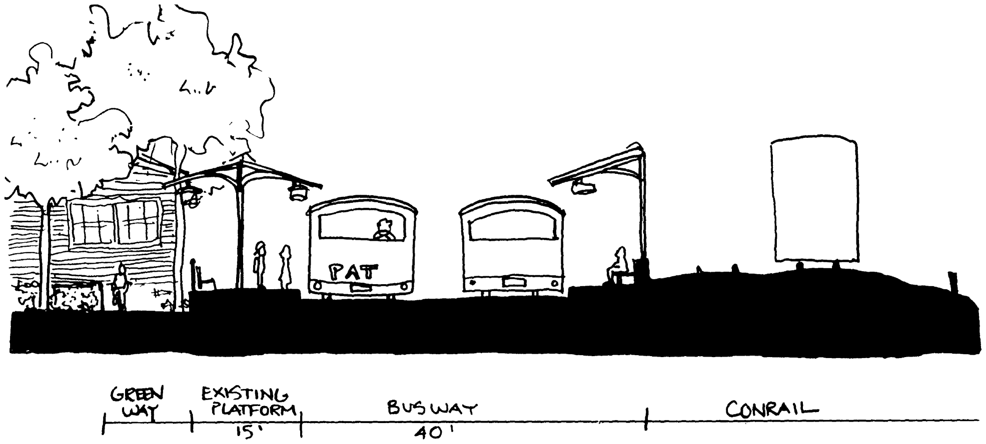


The demonstration infiltration basin in Edgewood Crossroads' public plaza. The basin provides a community gathering place; during large storms it captures runoff, which percolates into the subsoil within one to two days. Drawing by Christine Brill.

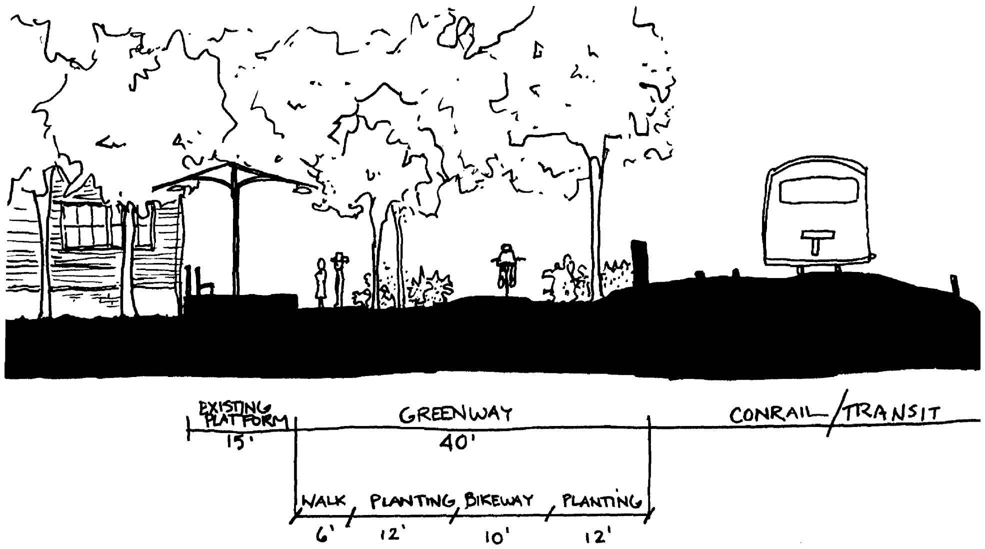
Plan for Edgewood Crossroads' restoration and redevelopment. Drawing by charrette team.

Contributing parts of the catchment

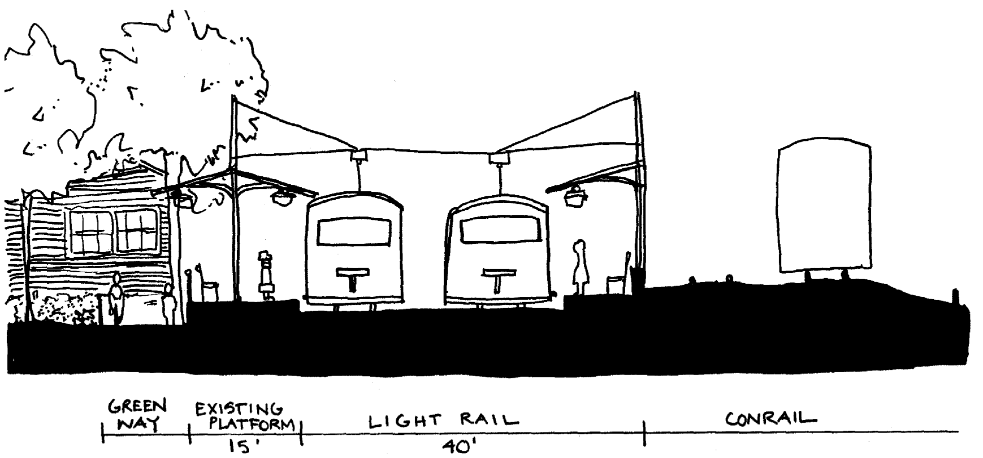
The street intersection receives stormwater runoff from a catchment around and uphill from the crossroads. The 73 acres of the catchment are occupied by the community center area, several schools and churches, and numerous, relatively large, Victorian single-family homes. While some of the local storm sewers currently divert stormwater out of the catchment, the proposed design manages all stormwater within the catchment.



The bus option for regional transportation on Edgewood's old rail bed. Drawing by Christine Brill.



The alternative greenway option for regional transportation on Edgewood's old rail bed. This option dramatically improves infiltration and reduces runoff relative to the busway option. Drawing wy Christine Brill.

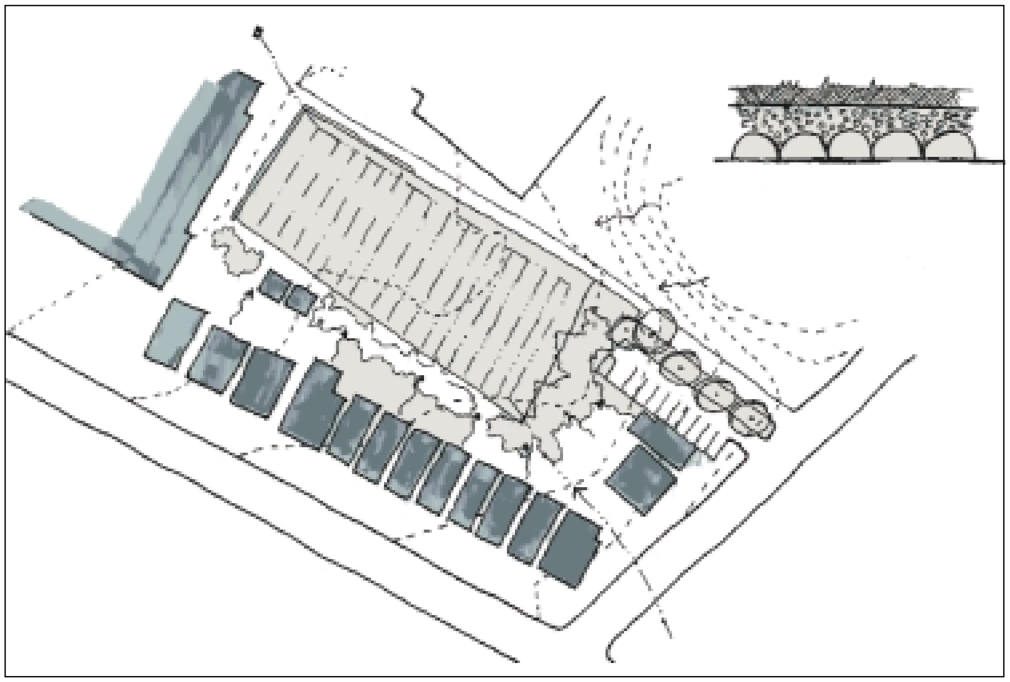


The light rail alternative for Edgewood's old rail bed. Drawing by Christine Brill.

Open lawns and play fields in the catchment's small parks and institutional grounds such as the grounds of the School for the Deaf are open spaces that can serve the dual purposes of recreation and runoff control. Ground water recharge beds could be constructed under these areas, while maintaining their surface uses for sports and parks. For example, retrofit of a playing field to maximize infiltration would include aggregate beneath the turf. If a bed of gravel 18 inches deep with 40% storage volume were provided over the entire 6.2 acres of reasonably available area, it could infiltrate the entire volume of a 2 year storm collected from an area of 18 acres. An alternative construction of pre-formed "infiltrator" chambers could provide the same capacity.

	Acres	Percent of catchment area
Rooftops	10.1	14
Streets	6.4	9
Driveways, sidewalks (est.)	2.0	3
Total impervious*	18.5	25
Total pervious	54.9	75
Total catchment	73.4	100

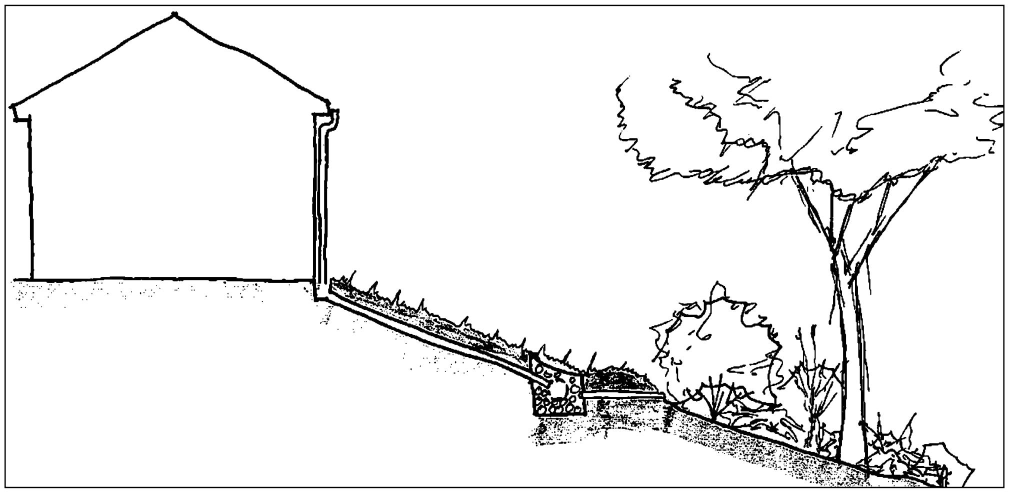
* The actual impervious area is somewhat greater—parking lot areas were not measured or estimated.



Construction of recharge beds under Edgewood Crossroads' playing fields and institutional lawns. Plan view: surrounding buildings, streets, and hillsides drain to a recharge bed. Top right: cross section of recharge bed constructed of aggregate and infiltrator chambers under turf grass. Drawing by Choli Lightfoot.

An additional strategy diverts the runoff of residential roofs into on-lot infiltration basins to significantly reduce stormwater inflows to the sewers. Infiltration and recharge features can be shaped to each individual lot. For example, a large residence has half of its 2,500 square foot roof area draining to the front and rear yards, respectively. For each half of the roof, a bed of aggregate or infiltrator chambers with a storage capacity of 208 cubic feet (1560 gallons) would infiltrate all the runoff from all rain events up to and including the 2-year storm. The bed or trench must be properly spaced away from the house to avoid leaking of water into the basement.

During an average year, residential roofs yield runoff from over 40 inches of precipitation. If 50% of the residential roofs in the catchment—an estimated 2.5 acres of rooftop surface—are currently connected to sanitary sewers (the precise proportion of roof leaders connected to sanitary lines is unknown) then the proposed residential recharge beds would remove from sanitary sewer lines 372,000 cubic feet (2.78 million gallons) of stormwater per year. This could yield an annual cost saving at the sewage treatment plant of about $5,500, based on treatment costs of $2 per 1,000 gallons. This long-term annual saving would justify subsidizing the installation of private recharge beds. A one-time 3-R ("Rooftop, Retention, and Recharge") grant of $1,000 per home would cover most or all of the installation cost. The cash value of the investment would be paid off in 8 years, and would continue to be paid again every 8 years thereafter.* Moreover, a program to disconnect roof leaders from sanitary sewers and properly manage these flows will address the recent Pennsylvania Department of Environmental Protection order for reduction of stormwater inflows to sanitary sewers.

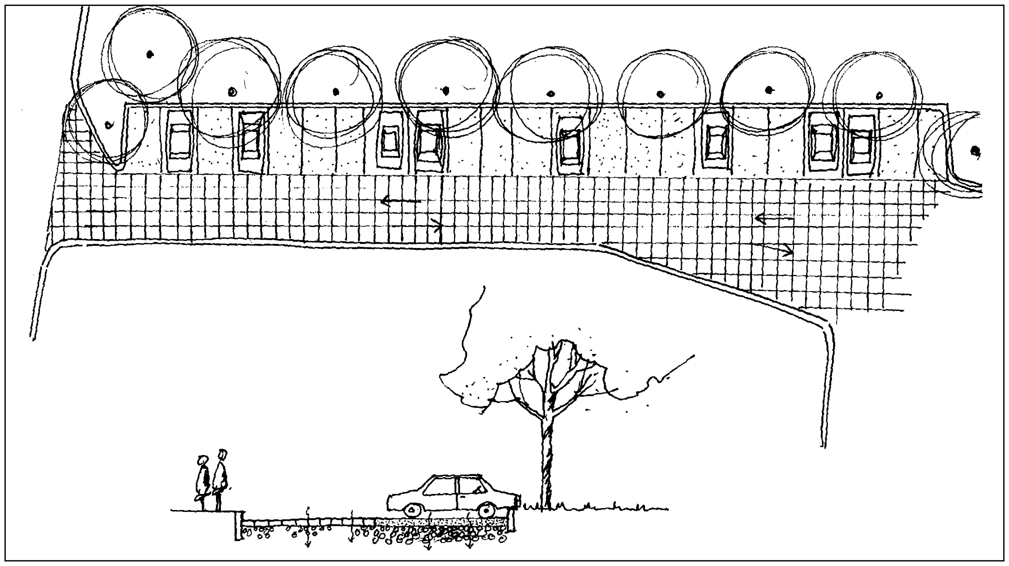


Retrofit of a typical Edgewood residence to disconnect the roof leaders from the sanitary sewers and recharge the roof runoff into the ground water using an infiltration trench. Drawing by Choli Lightfoot and Noel Kennard.

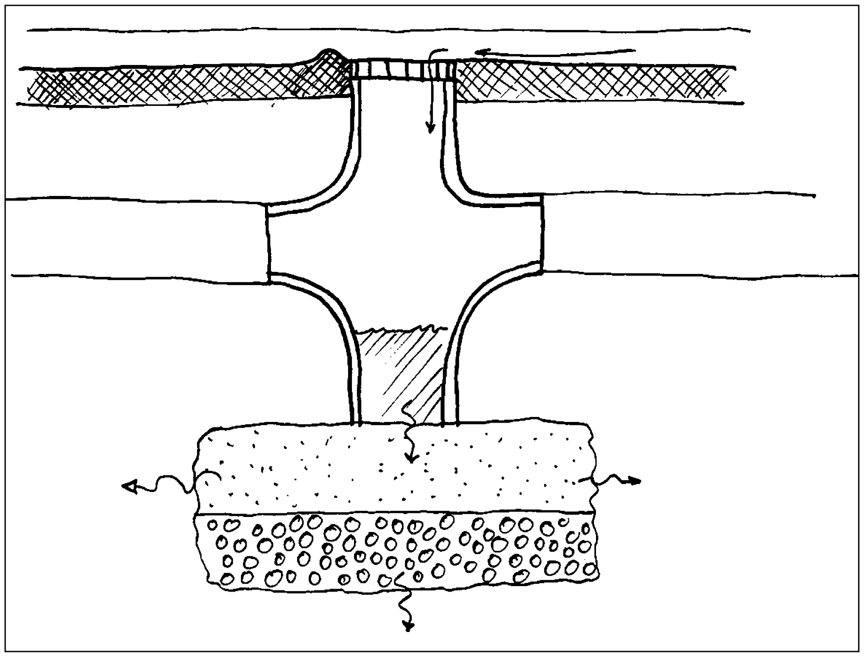
Porous pavements at the parking lots of churches and other public places infiltrate additional stormwater. Among the alternatives in porous pavement construction suitable for local soils, frosts and traffic loads are masonry pavers with open joints, a bituminous mix with open-graded aggregate, or gravel with a layer 4 inches deep of #89 fines over a layer 24 inches deep of uniform-graded aggregate 2 inches in diameter.

Throughout the catchment, drainage inlets can be modified to permit infiltration by adding a gravel bed or perforated PVC pipe that extends away from the basin to infiltrate water into the surrounding soil. An open grate design and a slight berm in the pavement help the inlet to capture a large proportion of the surface runoff.

Finally, increasing the urban forest reduces runoff, moderates urban climate, improves air quality, and reduces noise. A dense vegetative structure such as that of trees, shrubs, and native ground covers absorbs more rain water than a turf slope, and is more resistant to erosion during intense storms.



Porous pavement to be retrofitted into the church parking area at Edgewood Crossroads. Drawing by Larry Ridenour.



Section view showing a typical modification of a catch inlet by adding a gravel storage/recharge bed to infiltrate street runoff into the soil and prevent it from entering combined sewers downstream. Drawing by Choli Lightfoot and Tom Cahill.

* *Where the savings accrue depends on institutional structures and sewerage systems. Currently, area municipalities do not pay wet weather surcharges to ALCOSAN, and much of the wet weather flow does not reach the treatment plant due to combined and sanitary sewer overflows.*

Sterrett School

Charrette Team

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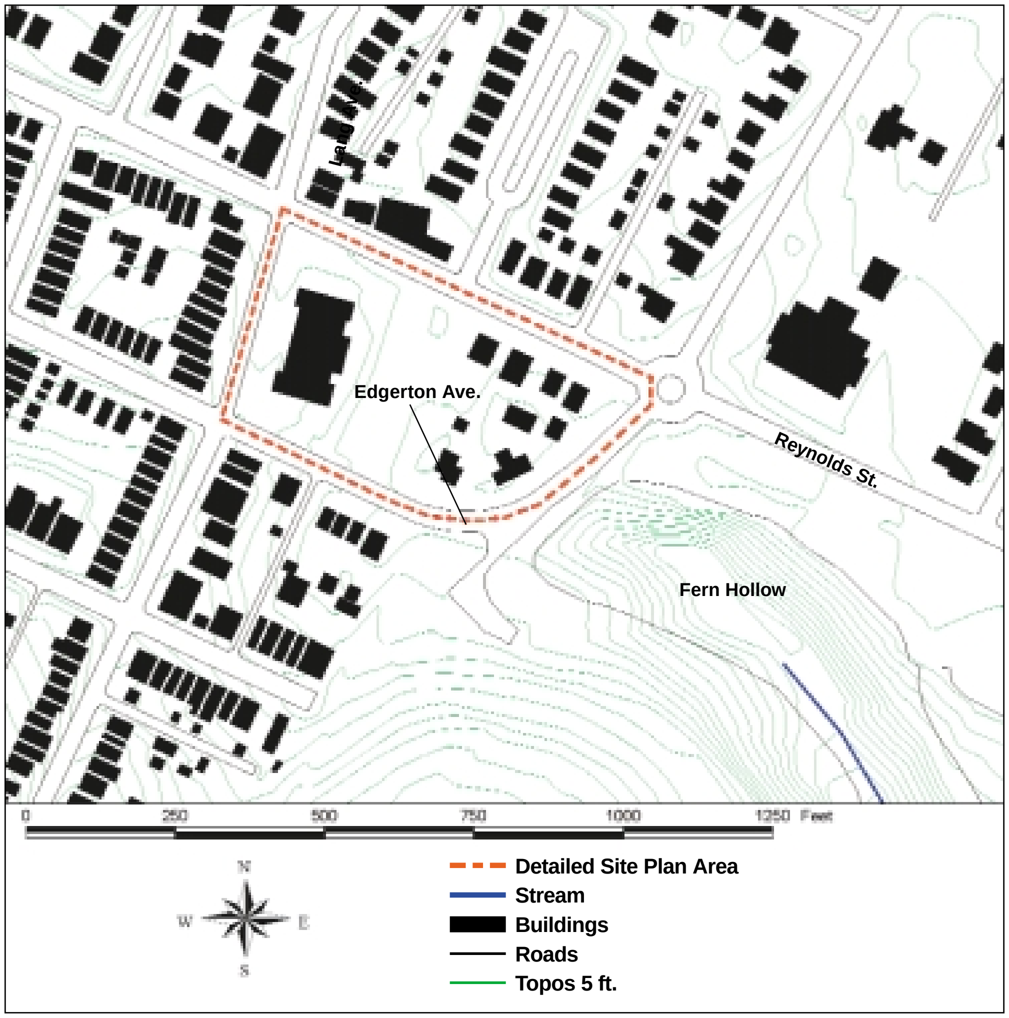
Sandra Mallory; Architect; Slippery Rock University; Slippery Rock, PA
Suzanne Meyer; Landscape Architect; Image Earth; Pittsburgh, PA
Neil Weinstein; Landscape Architect; Low Impact Development Center; Ellicott City, MD

Summary: The design for Sterrett School and the residences it shares a city block with illustrates the functional and educational use of a variety of working watershed restoration measures. Cisterns collect runoff from the school's roof; diverting this large volume from combined sewers has a big effect on downstream overflows and pollution. The collected water is put to use irrigating the school's gardens and ball field. Excess flows pass through a channel made of tiles showing children's poetry and images of animals and leaves. As water flows farther from the building, a meandering channel of earth and plants assures recharge into the ground water with a gravel infiltration trench. Nearby vegetated bioretention basins capture sheet flow from parking areas and sidewalks and off the street. Replacing a street embankment with a pedestrian bridge restores natural drainage and eliminates flooding in the basements of nearby homes.



The Sterrett School site and surrounding area. GIS map by STUDIO for Creative Inquiry.

Sterrett School is located near the headwaters of Fern Hollow, Nine Mile Run's largest tributary. It is a middle school in the midst of Pittsburgh's South Point Breeze neighborhood, adjacent to Frick Park. Sidewalks connect homes, shops, and the school grounds safely and conveniently; pedestrians use them actively. The school shares a city block with eight homes.

In the low area between the houses, a combined sewer line follows the course of the original streambed of what was once called Salamander Creek. Drainage inlets between the houses sometimes back up and flood. Local culvert overflows contribute to flooding in the basements of homes. The site's impervious roofs, streets and sidewalks, driveways and parking lots dump runoff into the combined sewer, contributing to polluting overflows downstream in Fern Hollow and Nine Mile Run.

The geology here is an ancient river "terrace" like that at the Edgewood Crossroads and in other parts of the central Pittsburgh region. Beneath the terrace material is a layer of sandstone similar to sedimentary layers elsewhere around Pittsburgh. The fine-textured soils and modification of landforms over the years by urban construction, including fill in the old stream channel, are typical of the region.


The Sterrett School, looking north from Edgerton Avenue. Photograph by Bruce Ferguson.

Watershed restoration features

Cisterns collect runoff from the roof of the large school building. The 16,000 square foot roof generates a lot of runoff—3,300 cubic feet (25,000 gallons) of water during the 2-year storm. Diverting this large volume into the cisterns by disconnecting the school's downspouts from combined sewers has a big effect on downstream overflows and pollution.

From the cisterns, the water from the two-year storm and all smaller storms during the year is put to productive use on the school grounds, irrigating the school's gardens, greenhouse, and ball field. Water is also put to indoor "gray water" uses such as flushing toilets and urinals.

One possible form of cistern is a transparent "water wall" that would let students monitor the water level in relation to rainfall and water use. Some water can also be permanently stored in the building's attic as a "thermal battery" to moderate indoor temperatures.

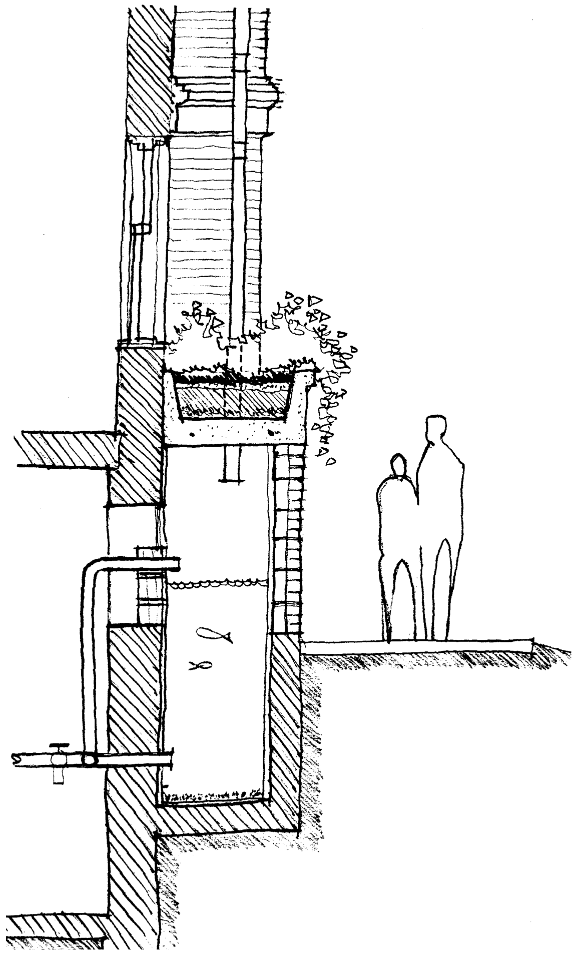
Runoff from a storm larger than the two-year storm, or a rapid succession of smaller storms, will exceed the capacity of the cisterns. Overflow from the cisterns will flow through the school grounds along an "Art Creek." The creek follows the path of water with a mosaic of tiles, embedding children's poetry and images of animals and leaves.

Community participant: "That's such a huge building, there ought to be some way to trap the water off that roof."

Design team member: "Well that's one of the ideas we're kicking off, to do something more constructive with that water than let it go straight into the soil. That's why we're doing this. Also since people talked about the need to irrigate the field and the gardens."

Another community participant: "It's a shame all that water is going to waste, you know, that could be reused and retained."

— **Exchange during the design team's meeting with neighborhood residents**



Cisterns for collecting roof waters in the form of a transparent "water wall" alongside the school building. See also the drawing on page 24. Drawing by Charrette team.

Redevelopment and restoration plan for Sterrett School and nearby residences. Drawing by charrette team.

As water flows farther away from the building, the artificial tiles give way to a meandering water course of earth and plants, bringing water into contact with the ground. It flows through a vegetated swale with a gravel infiltration bed, ephemeral ponds, and community gardens for residents.

A concept for Sterrett School's "Art Creek," to be composed of tiles designed by school children. Drawing by charrette team.

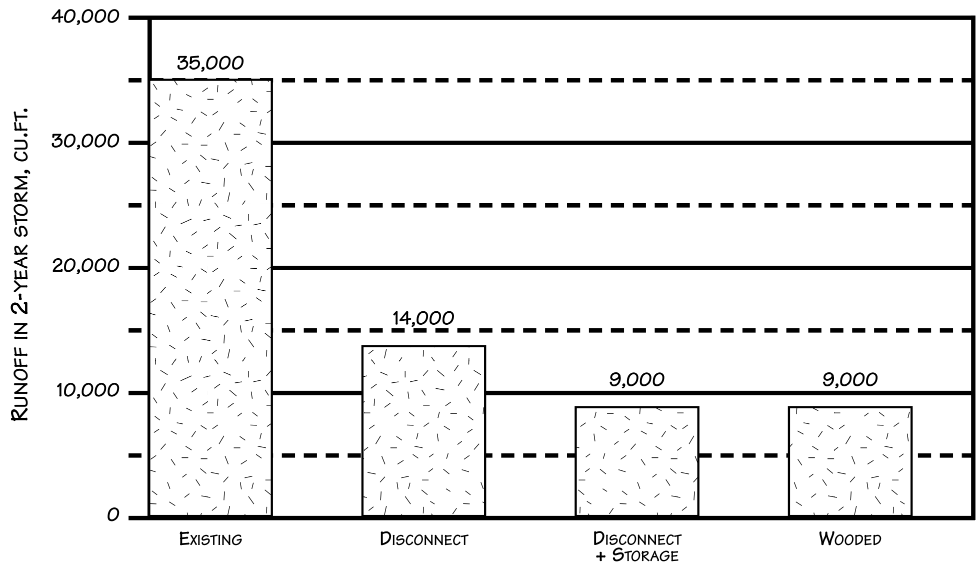
Where South Homewood Avenue crosses the path of the old stream, it has barred the movement of water. Water that would have flowed naturally into the Fern Hollow ravine flows instead in combined sewer lines and is not available to the ravine ecosystem. Closing off the street and regrading to remove the street embankment would prevent local basement flooding and restore natural drainage. The water would enter the ravine via a boulder cascade under overhanging willows. A pedestrian bridge would maintain access along the old street alignment. Restoring the channel allows the possibility of connecting a creekside greenway all the way from the school, down the Fern Hollow valley in Frick Park, to Nine Mile Run and the Monongahela River. The disconnection of downspout drainage from combined sewers and the infiltration of stormwater into the soil restores the base flow of water to natural streams in Frick Park.

Porous materials replace impervious pavements in the school's parking lot, playground, and sidewalks. The runoff will be further reduced by tree plantings, where the canopy intercepts rain water during small, frequent storms at the same time it moderates air quality and temperature.

Hydrologic result

The chart shows that the design reduces the runoff from the site to the level of that from a naturally wooded site. The principal effect comes from disconnecting stormwater drainage from the combined sewer system: diverting the roof runoff into cisterns and vegetated swales, and allowing water to infiltrate as it flows over grass slopes and in broad open swales, instead of buried culverts. These measures, together, disconnect the drainage from 90 percent of the site area, reducing the 2-year runoff into the culvert to only 40 percent of its previous volume.

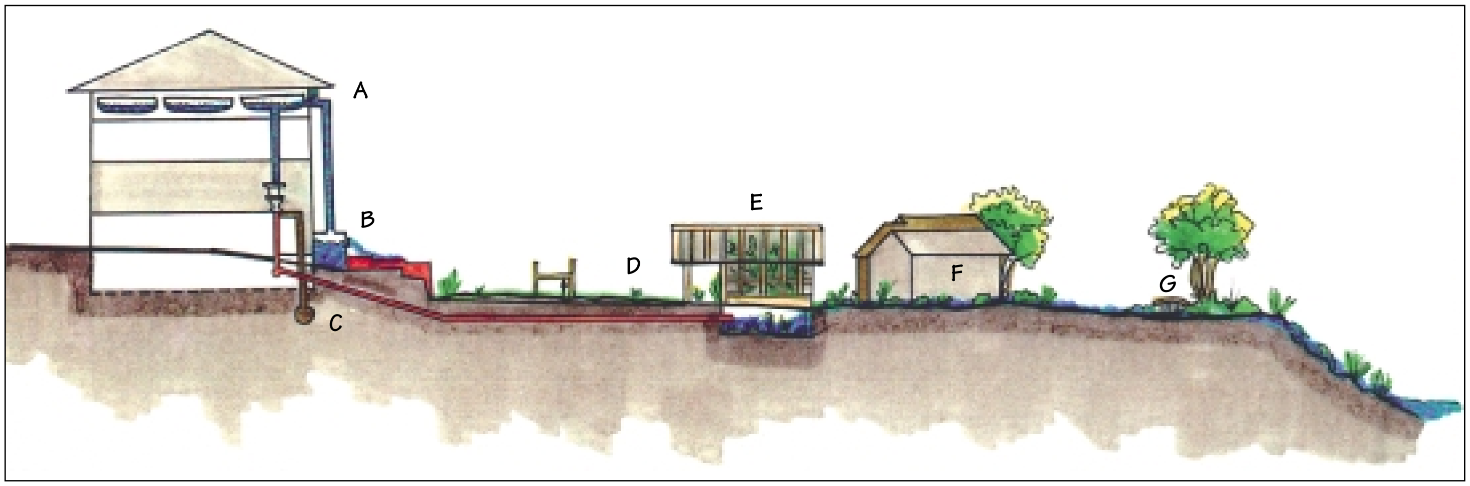
Further runoff reduction comes from specially constructed storage facilities. The design for the infiltration swale illustrates how a quantity of storage is created. A gravel-filled infiltration trench running under the 500 foot length of the swale provides 2,800 cubic feet (21,000 gallons) of storage, based on a depth of 4 feet, a width of 4 feet, and a storage ratio (volume of stored water per total volume of gravel-filled trench) of 0.35. On the swale surface, during large storms



The hydrologic result of "disconnects" and stormwater storage at the Sterrett School during a 2-year, 24-hour storm.

"I have recently seen these paintings on streets near the sewer—this stenciling to indicate where the sewers flow to, it captures your attention. It is a wonderful awareness tool and the fact that has been done for years in other communities, again demonstrates how far behind we are in Pittsburgh."

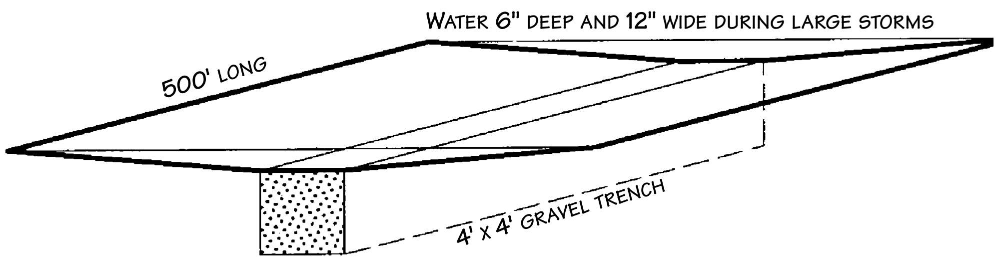
—A community participant in the policy team's meeting with the public



The sequence of drainage features proposed for the Sterrett School site. A: Roof runoff is routed to attic bladders and school-side cisterns, and used for toilet flushing and irrigation. B: Overflow from cisterns runs along the "art creek" (represented here on the east side of the building). C: Graywater from fixtures could be routed to the greenhouse for bioremediation; blackwater is routed to sewers. D: Art creek and field runoff passes along a vegetated swale around the play field. E: A greenhouse puts some runoff water to productive and educational use. F: Runoff continues along a naturalized surface channel between the houses east of the school. G: Removing the street embankment allows the open channel to continue to a cascade into Fern Hollow. Drawing by Jen Uncapher, RMI, after drawing by charrette team.

ponding up to six inches deep and 12 feet across in a gently banked channel provides an additional 2,000 cubic feet (15,000 gallons) of storage. The total storage in the swale is thus 4,800 cubic feet (36,000 gallons). Because of the gravel and sandstone substrate, infiltration is probably feasible, but if necessary an underdrain system could be added to release the stored water slowly after the peak of the storm.

The combination of "disconnects" and stormwater storage reduces the runoff to only 26 percent of its existing amount, an amount equal to that from a naturally wooded site. These calculations do not take into account additional reductions due to mulching, pervious pavements, tree plantings, or bioretention cells (vegetated infiltration basins that capture sheet flow from parking areas, sidewalks and paved play areas). These are all "extra" restoration capacities.



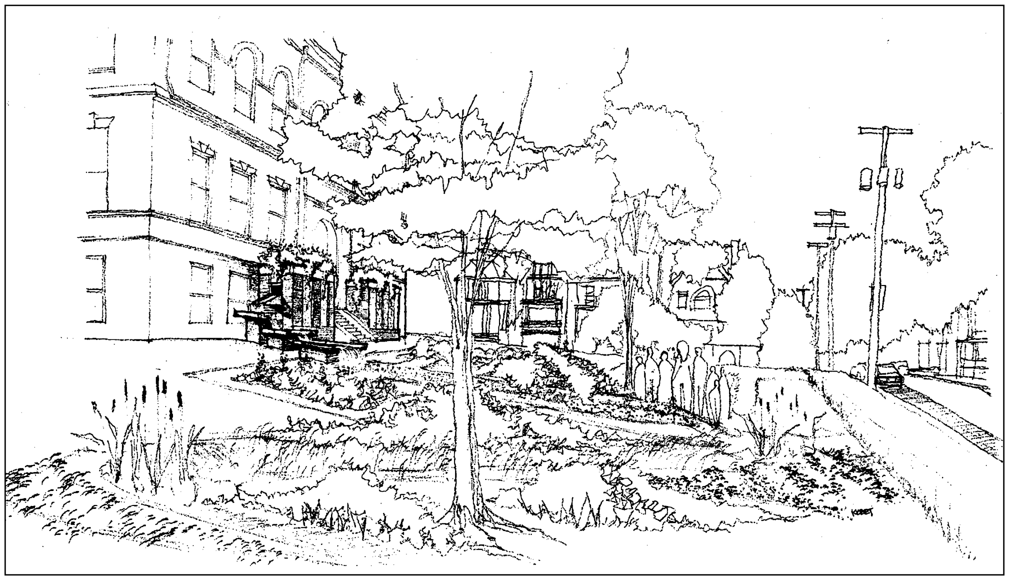
The swale at the Sterrett School generates storage and infiltration capacity with a gravel-filled trench and gently sloping banks.

Summary of measures to be applied at the Sterrett School site							
	Function or benefit						
Feature	Recharge of ground water	Reuse of captured runoff	Disconnection of storm drainage from sewers	Reduction in storm runoff volume	Improvment in runoff quality	Watershed quality	Habitat creation and maintenance
Separate sewers				x			
Cul-de-sac creation			x	x	x		x
Regrading	x		x				
Greenhouse		x	x	x	x	x	x
Cisterns	x	x	x	x	x	x	x
Bioretention	x		x	x	x	x	x
Bioswale	x		x	x	x	x	x
Habitat landscaping	x			x	x	x	x
Restore channel	x		x	x	x	x	
Sheet flow	x		x	x	x		x
Bioretention cells	x		x	x	x		x
Playground surfacing	x			x	x		x
Planting	x			x	x		x
Pervious parking	x			x	x		x
Green islands	x			x	x		x
Porous paving	x			x	x		x
Afforestation	x			x	x		x
Art Creek mosaic						x	x
Brochures						x	x
Watershed curriculum						x	x
Tours						x	x
Paint storm drain inlets						x	x
Demonstration project						x	

Education

Features where naturally flowing water is visible are resources for educating school children about how watersheds work and the possibilities for protecting and restoring them. The school is a demonstration site for multi-functional restoration techniques that could be applied elsewhere.

School personnel have expressed interest in employing on-site watershed restoration features in the school's educational curriculum. A greenhouse utilizing water collected from the school's roof would be a teaching tool for explaining the water cycle and the role of the school and the neighborhood in the watershed. The Art Creek is a student-designed mosaic that would provide artistic expression, and information on the watershed's hydrologic cycle and native flora and fauna. The various water courses would carry water during rainfall events and remain dry at other times, while the water level in the cisterns rises and falls. The combination of facilities could be used to teach about watersheds and the role of cities in them.



Education and demonstration in Sterrett School's "water garden." Drawing by charrette team.

"I think education is very important. People who grow up in rural areas with septic systems have a very different understanding of their situation than those who grow up in the city. I think a goal should be that every child in Allegheny County should essentially understand what happens when they flush the toilet, where the water goes. Those who grow up in rural areas with septic systems certainly know, they know the limitations, they know the conditions, they know the costs. It is something that is discussed. Just paying the bill to ALCOSAN is not enough education. This is a long-term solution, but it could certainly start with education in the school system."

—Community representative during the policy team's meeting with the public

Regent Square Gateway

Charrette Team
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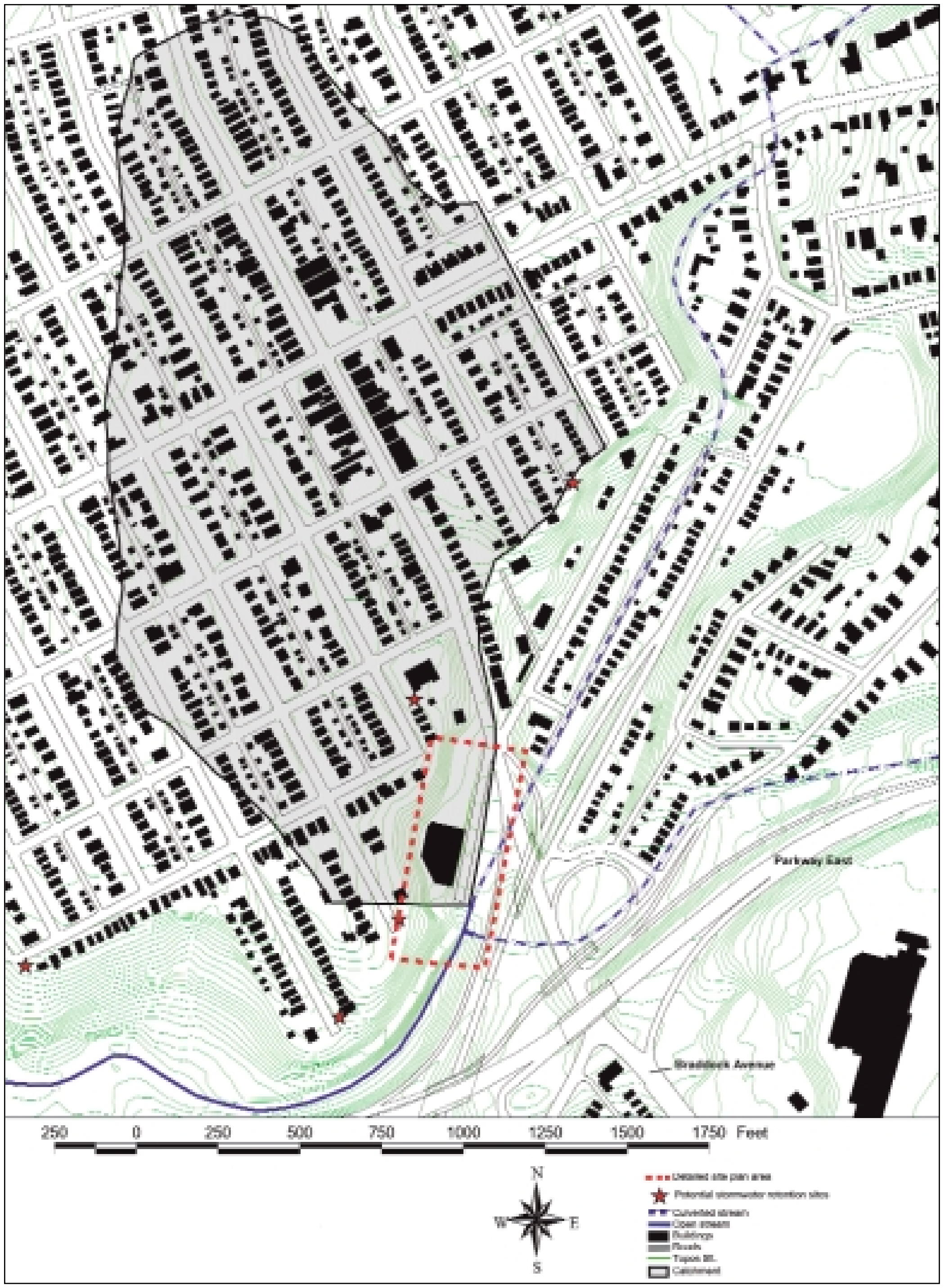
Christine Mondor; Architect; Gardner + Pope Architects; Pittsburgh, PA
Peter Richards; Artist; Tyron Center for Visual Art; Charlotte, NC
Michael Stern; Architectural Planning Consultant; Pittsburgh, PA
Bill Wenk; Landscape Architect; Wenk Associates; Denver, CO

Summary: The design for Regent Square Gateway reiterates the Nine Mile Run model of restorative redevelopment by using economic revitalization of a neglected facility as a stimulus for incremental restoration of the watershed. It uses technical ingenuity and sculptural composition to corral the site's powerful hydrology into the city's day-to-day perception, recreation, and economy. The large upper story of an under-utilized commercial building is profitably re-used as a retail store. Runoff from the retail parking lot flows onto grass filter strips, and percolates through banks of aggregate filter material. Concentrated runoff from Braddock Avenue is diverted into a series of earthen filter banks sculpted in symbolically flowing terraces. Just downslope, where the Nine Mile Run culvert opens to the daylight and into Frick Park, a series of plazas and steps opens recreational access to low flows and permits safe views during dynamic storm events. A new greenway parallels the open stream channel. Filtered "spring" flow trickles into the culvert outfall from the site's filter embankments, symbolizing the restoration of natural process through revitalizing retrofit and redevelopment.

The Gateway site is located low in the Nine Mile Run watershed, where the main Nine Mile Run culvert discharges for the first time into an open channel. Here the borders of Edgewood, Swissvale, and the City of Pittsburgh converge, by a neighborhood named Regent Square. At the site, Braddock Avenue's on-ramp enters I-376, (the Parkway East) and the abandoned alignment of Old Braddock Avenue abuts an underutilized commercial building.

This seemingly neglected place is in fact an extraordinary focus for the Nine Mile Run watershed and its people, for here the culverted stream first comes into full view in an open channel, and here the historic plan for Frick Park has always foreseen a major eastern public gateway.



The Regent Square Gateway site, catchment, and surrounding area. GIS map by STUDIO for Creative Inquiry.


The parkway ramp and the underutilized commercial building at the Regent Square Gateway site. Old Braddock Avenue runs alongside the building and terminates at the Wilkinsburg Culvert outfall hidden in the trees to the left. Photograph by Richard Pinkham, RMI.

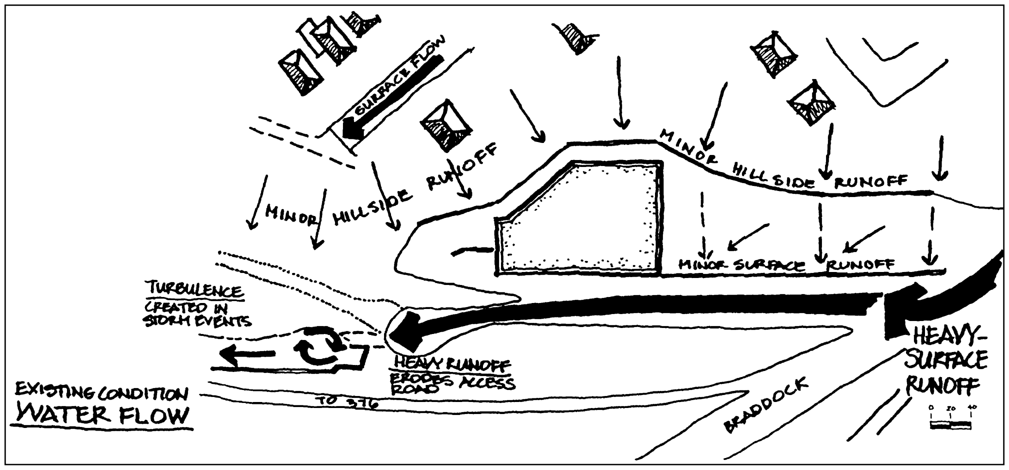
This is the junction between the upper, developed, urban portion of the watershed, and the lower, open, natural part in Frick Park. This highly visible place is the physical confluence of the watershed's stream flows, municipal jurisdictions, and—potentially—community and watershed consciousness. It deserves to be revitalized as a special kind of public space with vast symbolic and educational value. This should be the main entrance to a Nine Mile Run Greenway, the symbolic release of the Nine Mile Run water to the light and air of the free-flowing ecosystem, and an educational and functional resource for the citizens of all the municipalities in the Nine Mile Run watershed.

The geology underlying the steep side of the Nine Mile Run valley—the alternating layers of shale, siltstone, sandstone, limestone, and coal of the "Glenshaw Formation"—is typical of large areas in the Pittsburgh region. The man-made fill under the site's various roads and highways is typical of stream valleys in old urban areas.

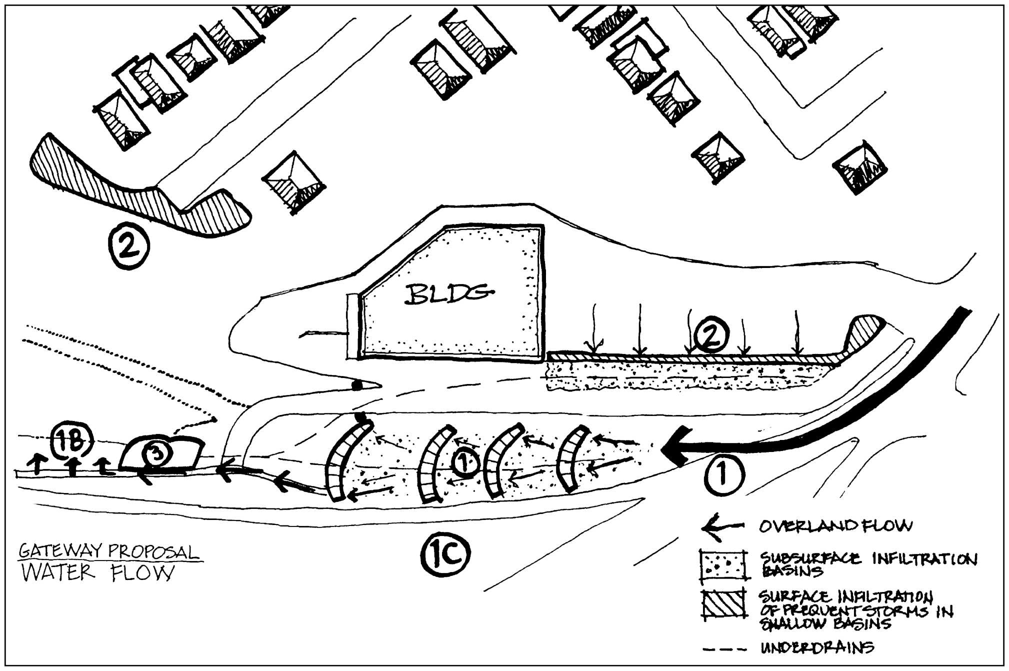
Local runoff comes through the site from a 64 acre catchment, densely built up with residences. Impervious rooftops and streets comprise 41% of the total area of the catchment. In the restoration plan, small ephemeral ponds (500 to 3,000 square feet in area) are located wherever there is adequate open space, sufficient drainage area, and appropriate soil for infiltration. They filter the runoff that occurs during small storms and the first flush of large storms. Stormwater detention during large storms is not their purpose; high peak flows are allowed to pass through without additional ponding, so they will not combine with relatively long, slow peak flows on the main stream. In contrast with existing storm sewers, which convey all runoff immediately to the stream during all storms, these ponds will treat runoff during every storm, replenish ground water to support stream base flows, and allow only the excess water from occasional large storms to enter the stream directly.

During intense storms, a large part of the local runoff currently bypasses inlets due to the steep slope of Braddock Avenue, and will continue to do so during occasional large storms even after construction of small infiltration basins in the neighborhood upstream. The excess water drains across the surface of the site; its flow may have reached 60 cubic feet per second (450 gallons per second) during some very large storms. Where this runoff reaches the bottom of the site, it has eroded the edges of the Nine Mile Run channel.

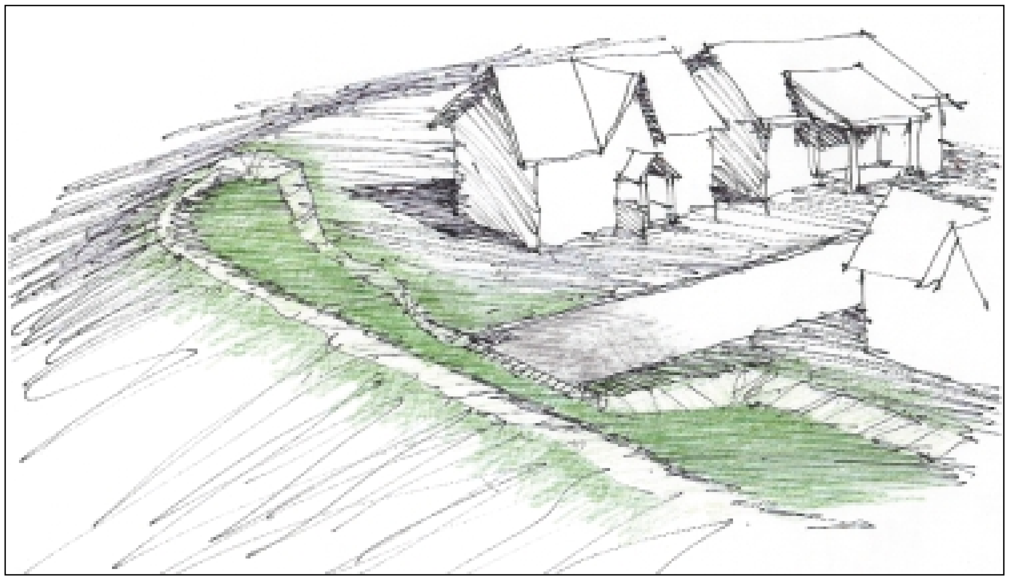
At the downhill end of the site, the discharge from the main urban portion of the Nine Mile Run watershed appears out of its culvert. Other, smaller culverts converge from all directions. Everything that goes on in the urban Nine Mile Run watershed, good and bad, is reflected in the discharge: sewer overflows, high peak flows, urban pollutants, and low base flows, as well as the potential for restoration.



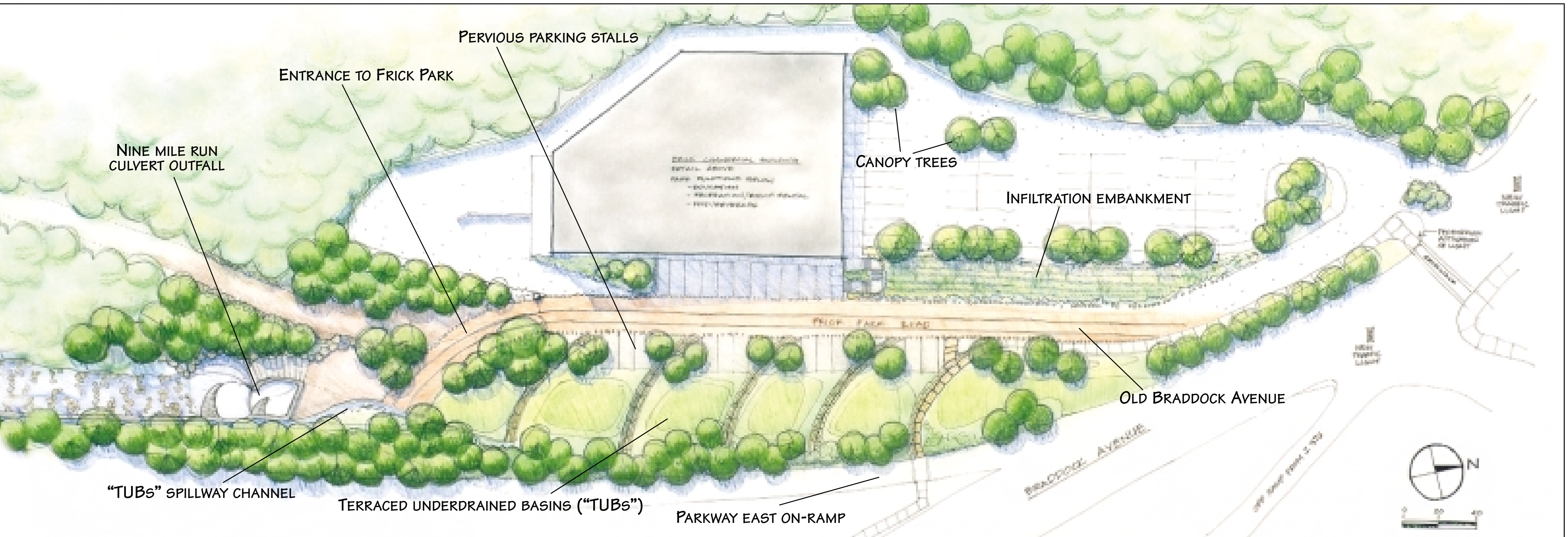
Combinations of stormwater flows as they now converge through the Regent Square Gateway site. Drawing by charrette team.



Sequence of features proposed to control water flows at Regent Square Gateway. 1: Overland flows from Braddock Avenue are directed in terraced underdrained infiltration basins. 1B: During large storms, overflows from terraced basins discharge into Nine Mile Run. 1C: Additional infiltration is possible at interchange. 2: Surface infiltration areas and shallow basins collect and treat first-flush runoff from nearby pavements. 3: The outflow structure in the main stream slows water as it discharges into the main open channel. Drawing by charrette team.



Typical shallow infiltration basin proposed for the neighborhood above the Regent Square Gateway site. Drawing by charrette team.

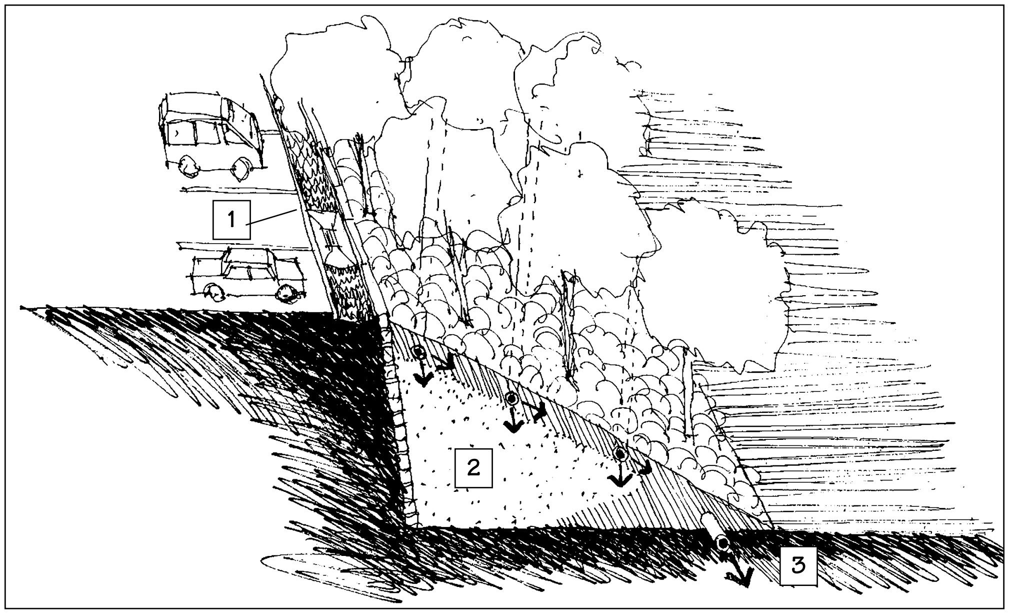


Plan for the rehabilitation and redevelopment of Regent Square Gateway. Drawing by charrette team.

Retail re-use of the building and its parking lot filter bank

The large upper story of the building is suitable for profitable re-use as a single-occupant retail store. The parking layout on the uphill side of the building accommodates that function. The proposed driveway layout separates this commercial activity from the greenway corridor centered below on Old Braddock Avenue.

Runoff from the retail parking lot flows onto grass filter strips to enhance water quality. Excess runoff passes through inlets and perforated pipes into banks of aggregate filter material. The material could be slag aggregate recycled from abandoned industrial dumps elsewhere in the watershed. The embankments are capped with topsoil for rooting of trees and other vegetation. An underdrain collects the filtered excess and discharges it like "spring" flow to trickle into the Nine Mile Run channel.



Embankments to filter parking lot runoff at Regent Square Gateway.
1: Grass filter strip and inlet. 2: Perforated pipes. 3: Underdrain. Drawing by charrette team.

Terraced underdrained basins

Surface runoff entering the site from Braddock Avenue is diverted into the formerly neglected area between Old Braddock Avenue and the parkway ramp. Here a series of terraced basins reclaim the area to filter the runoff. The filter material could be slag aggregate, overlain with soil for planting. The check dams that divide the terraces are constructed of clean fill as a foundation for pathways. The sculptural earth forms symbolize the fluvial processes with which they unite to mitigate the runoff from the urban watershed. Low flow and first-flush runoff infiltrates into the basins and is filtered. Underdrains collect the filtered water and add it to the "spring" flow for discharge to the stream channel. Larger flows spill gradually over the surface from one terrace to the next, discharging through a spillway before high peak flows arrive on the main stream.

Throughout the site, plantings of trees and shrubs intercept a portion of rainfall. Trees, shrubs and grasses transpire water through their leaves, consume carbon dioxide, release oxygen, and moderate urban temperatures.

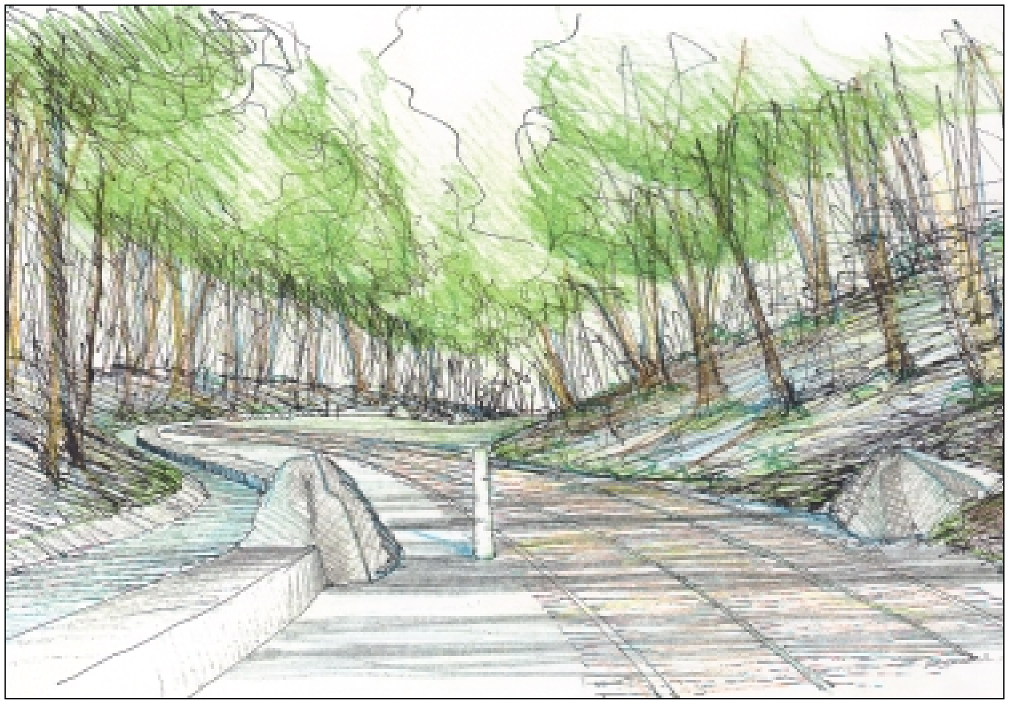
Entrance to Frick Park and the greenway trail

Regent Square Gateway's eastern entry to Frick Park will accommodate hikers, joggers, bicyclists and maintenance vehicles. The location already gets informal use. As the Nine Mile Run watershed approaches its full potential, this point will be the main entrance to a Nine Mile Run Greenway paralleling the open stream channel.

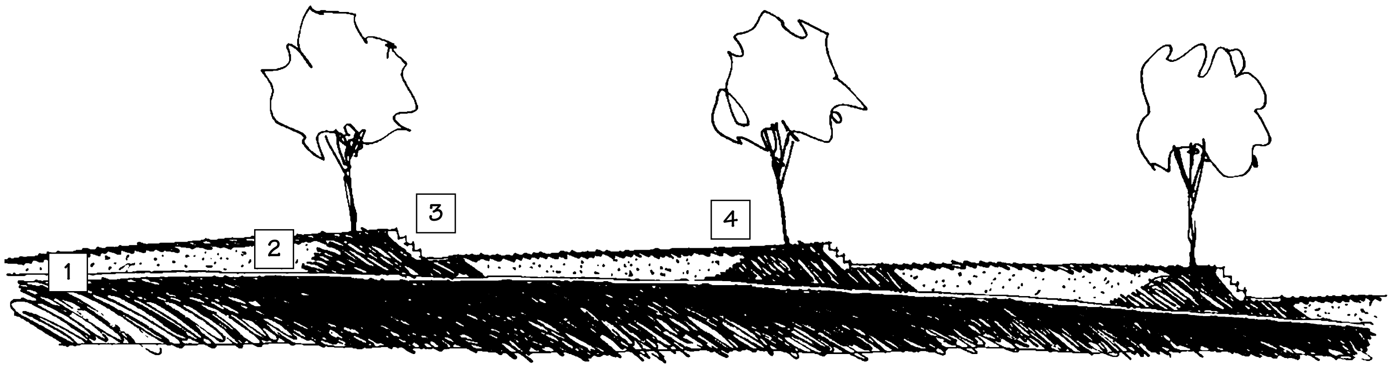
The lower levels of the old building can be re-used to serve visitors to Frick Park and the greenway. The city's parks department could use indoor space for watershed education and research. Private retailers could offer bicycle rentals and food services. At the trail head, the building's facilities could provide trail guide information, trash disposal and public restroom facilities.

At this point, Old Braddock Avenue's remnant trolley tracks disappear under a highway embankment, marking the end of a former era, while Nine Mile Run emerges from its culvert, marking the beginning of a new. Filtered "spring" flow trickles across the area from the site's filter embankments, symbolizing the restoration of the watershed's soil and streams through revitalizing retrofit and redevelopment.

Several details of the design provide safe, convenient public access to the site for pedestrians, bicyclists and motorists. A stairway for pedestrians from the Regent Square neighborhood reaches the greenway trail downstream of the outlet structure. The greenway trail continues upstream through the site to Braddock Avenue. At Braddock Avenue, the driveway entrance is configured for safe access, and a traffic light is added to help pedestrians cross the street. The same trail can be extended farther eastward in an urban form, joining the future regional greenway and busway at the Edgewood Crossroads.



The east entry to Frick Park, realized more than half a century after its original conception. View looking down into the park from the end of old Braddock Avenue. The overflow channel from the terraced underdrained basins is shown on the left. Its spillway into the Nine Mile Run channel is located just beyond the end of the remnant trolley tracks. Drawing by charrette team.



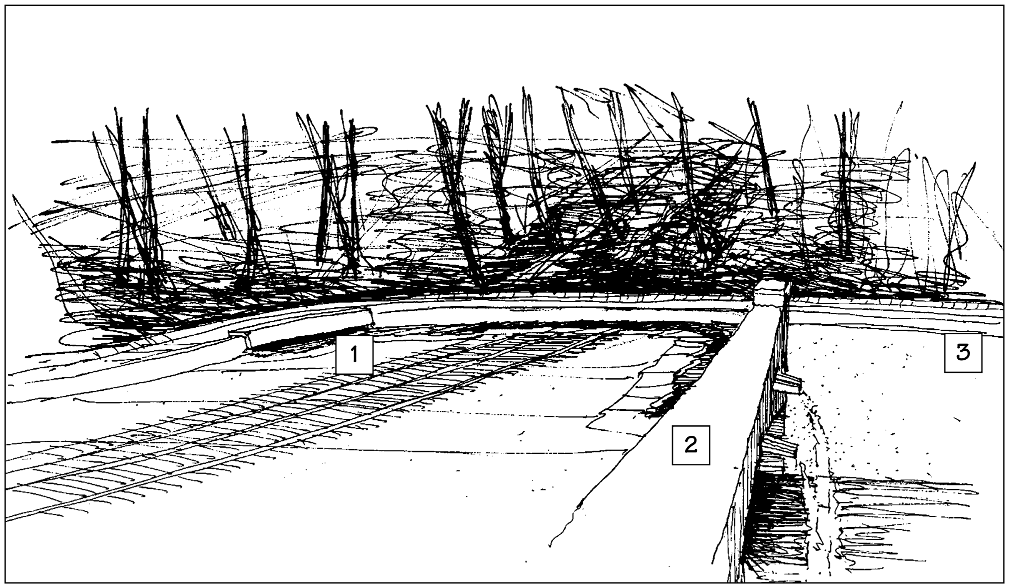
The sequence of terraces in Regent Square Gateway's underdrained basins. 1: Underdrain. 2: Constructed permeable soil. 3: Check dam. 4: Turf/planted cover.
For a bird's eye view, see the drawing on page 30. Drawing by charrette team.

Nine Mile Run outfall

Water moves into and through the main Nine Mile Run outfall in patterns that vary with the weather and with stream flow. The design for this area controls erosion, dissipates flow energy, opens recreational access to the water during low flow periods, and permits safe views of energetic high flow during storm events.

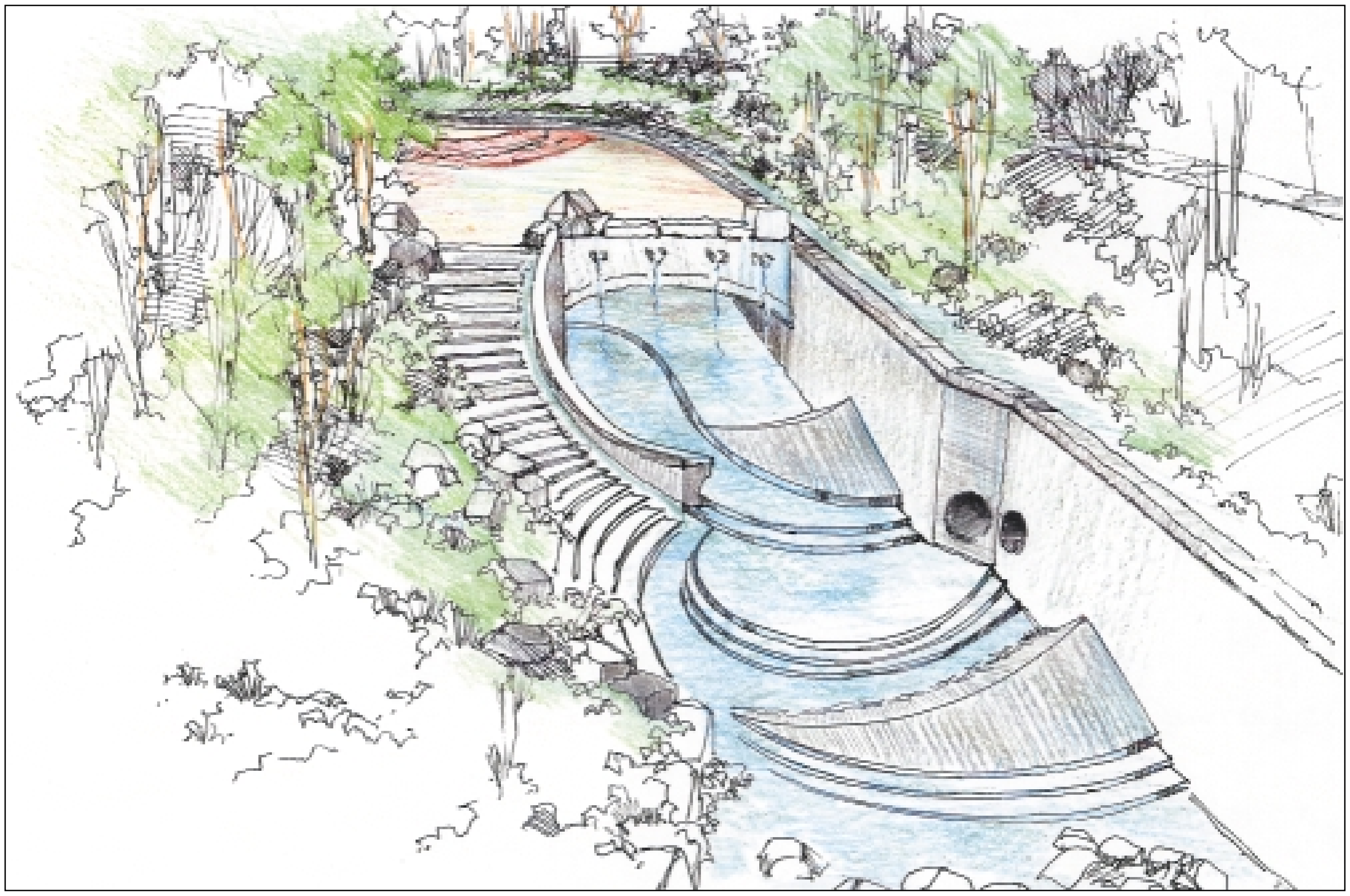
In dry weather, low-flow "spring" seepage from the filter embankments and underdrained terraces will trickle along channels in the culvert headwall and drip into the slowly flowing stream. Over the years, the base flow from Nine Mile Run and the other smaller stream culverts that discharge here will increase as upstream aquifers are restored.

During heavy storm conditions, this site will display the gushing power of the converging outfalls. From one side a spillway discharges excess flows overpassing the terraced basins into the channel. In the channel, a series of visually fluid sculptural elements dissipate the energy of high flows emerging from the culvert. Additional stone and concrete elements are placed along the channel to further prevent erosion.



"Spring" flow from Regent Square Gateway's filter banks: (1) emerges from the underdrain and, (2) spills through the scuppers in the headwall of the Nine Mile Run culvert outfall. Overflow from the terraced underdrained basins (3) flows in a spillway channel along the side of the outfall structure. The remnant trolley tracks of Old Braddock Avenue terminate just above the headwall. See also the drawing on page 25. Drawing by charrette team.

Existing conditions at the Nine Mile Run culvert outfall. Photograph by Richard Pinkham, RMI.



The outfall of the main Nine Mile Run culvert into the open channel at Regent Square Gateway. Smaller culverts emerge from the side walls. The sulptural structures in the channel celebrate the emergence of the stream and dissipate storm flow energy. Drawing by charrette team.

Section III
Patterns of Restorative Redevelopment

This section summarizes the patterns of site-specific restorative redevelopment that the four sample designs illustrate. It steps back from the details of individual sites to generalize about the physical techniques and design processes that can produce integrated, restorative, sustainable approaches to infrastructure, ecosystem, and community objectives.

The designs consistently embody the physical patterns of multi-functionality, full use of the available space, use of on-site natural processes, and diversion of storm drainage away from sanitary sewers. The design teams exhibited these patterns in their drawings, and stated them explicitly in their spoken presentations and written reports.

They also exemplify the process-based patterns of community engagement and interdisciplinary cooperation to find out the full range of what is possible. The charrette procedure was conceived to enable these processes, and the experience during the charrette event confirmed their contribution.

In future retrofit and redevelopment projects, these patterns should be applied to restore watershed processes while revitalizing specific urban sites. A project that follows these patterns can have an important effect on sewer overflows; add incrementally to the watershed's long-term, broad-based reduction in impervious surfaces and generation of stormwater; and contribute significantly to the economic and social health of the community.

Make components multi-functional

Everything that is done in a retrofit or redevelopment project should produce multiple, mutually reinforcing benefits. Making things multi-purpose brings them into the places where people are already taking care of their daily business. When a component is multi-functional, it attracts advocates promoting each of its several functions; it attracts broad community and political support.

For instance, stormwater has traditionally been moved off city roofs and streets through a single-purpose system of underground pipes. Instead, we can keep it on the surface, recreating a creek that was lost, or infiltrate it into the soil to recharge the ground water and nourish vegetation—in either case providing ecosystem benefits in terms of habitat for wildlife, human benefits in experiencing the beauty and wonder of natural systems, and financial benefits in reduced municipal costs of maintaining hidden infrastructure.

Cisterns proposed for the Sterrett School—shown here under thickly vegetated planters—collect roof runoff to keep it out of combined sewers, then put the water to productive use irrigating the school's lawns, gardens and ball field. Drawing by charrette team.

Whenever an important component of a project appears to be an undesirable "cost," seek ways to shape it so that it acquires additional desirable benefits. The project and maintenance budget is thereby enlarged as the cost becomes absorbed into the provision of other necessary functions. Multiple functions as various as water quality improvement, employment, housing, separation of storm drainage from sanitary sewers, parking improvements, noise reduction, pedestrian safety, temperature moderation, and social equity can and should be found in the design of every building, street, sidewalk, park, water course, drainage system, residential yard, and institutional landscape.

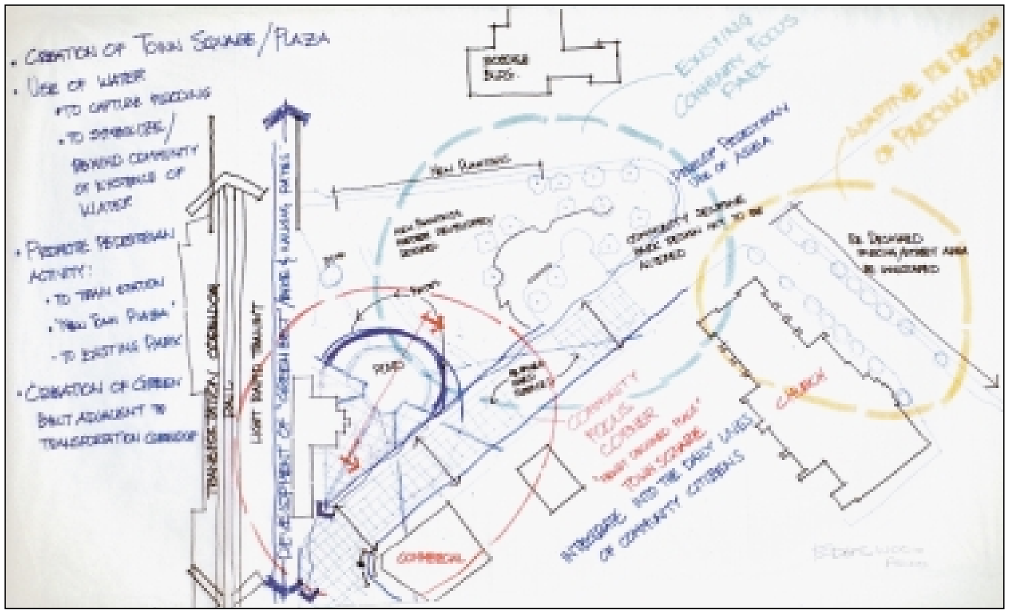
One of the functions that every restorative redevelopment should have is the education of people about natural processes and on-site connections to the watershed. Stormwater systems should be a visible and tangible part of the urban framework of the watershed.

Use every square inch

Cities are crowded places. The solution to a watershed-wide problem has to be on-site, on every site, because there is nowhere else to go. Successful restoration and revitalization depends on utilizing every square inch of a retrofit or redevelopment project for positive, multiple functions. Every component is in the midst of community life, and must have positive community benefit in addition to technical function.

As our older cities were built, the cumulative impacts of transforming the landscape mounted, and municipalities had to replace natural systems with cost-intensive infrastructure. Now, when much of the older infrastructure fails to perform to today's or even yesterday's standards, we have an opportunity to reconsider the form and function of the urban landscape—and ultimately integrate each site into a seemlessly operating whole.

The retrofit or redevelopment of every site can contribute incrementally to the restoration of watershed process. For example, retrofitting of a single house with separation of roof drainage from sanitary sewers contributes only a small amount to the reduction of sewer overflows somewhere downstream—but the impact is both immediate and maintainable over generations. The solution to a watershed-wide problem requires the contribution of many similar projects throughout the watershed. The cumulative public benefits are enormous. There must be a constant search for restoration and revitalization opportunities on additional sites. Once started, the endeavor must be maintained with purpose over many human generations.



An early, concept-testing drawing generated by the Edgewood Crossroads design team as they defined zones for provision of safe pedestrian access, stormwater management demonstration, and physical reinforcement of the sense of community. The team sought to put "every square inch" to multi-functional stormwater and civic use. Drawing by charrette team.

Use freely available natural processes

Freely available natural processes are capable of working for the great benefit of watershed restoration. Vegetated soil absorbs rain water, and the chemical and microbial processes of the soil capture and degrade most pollutants that may be present. The infiltrated water recharges ground water tables and restores flows to streams. These processes reduce peak flows and erosion, eliminate sewer overflows, prevent and mitigate pollution, and sustain watershed ecosystems.

The regenerative capacity of soils and ecosystems is strong everywhere in the Pittsburgh region. Natural processes are waiting to perform essential services. Taking advantage of them enacts a new concept of stormwater infrastructure. The idea of "green infrastructure" broadens the conception of stormwater infrastructure to include the capacities of soil and vegetation to absorb water and filter pollutants. This is a "smarter, cheaper" approach to infrastructure because it puts nature to work, and reduces the work humans must do, in contrast to the more active systems of pipes and facilities for conveyance and mechanically-dependent treatment.

Use disconnections and reconnections

Sewer overflows are usually the biggest pollutant sources in the watersheds where they exist, such as Nine Mile Run. To the degree that stormwater is diverted out of sewers, downstream overflows and sewage pollution are eliminated. Separating stormwater drainage from sanity sewage conveyance is a basic and essential task for restoration of old urban watersheds.

Urban runoff filtered by falling through an embankment of recycled industrial slag emerges as "spring" flow to enter Nine Mile Run at the Regent Square Gateway site. (Shown here with the remnant trolley tracks of Old Braddock Avenue in the foreground.) Drawing by charrette team.

In particular, the drainage from impervious surfaces should be disconnected from sewers at every opportunity, no matter how small. In urban areas the drainage from impervious surfaces is the great bulk of runoff, and it carries significant amounts of urban pollutants. To disconnect rooftop drainage, each downspout can be detached from sewers and routed to dry wells, water gardens, and cisterns. To disconnect pavement runoff, the drainage from driveways and walkways can be pitched away from street gutters, and onto vegetated soil; large parking areas can be broken up with "infiltration islands" or served by underground storage/recharge beds; street drainage inlets can be detached from combined sewers, and their stormwater diverted into vegetated swales.

Drainage that is "disconnected" from sewers in these ways is "reconnected" with its natural path in contact with soil and vegetation. The reconnection with natural processes reduces the volume of surface runoff, filters the pollutants, replenishes the ground water, and maintains stream base flows. The volume of stormwater, which once seemed a hazard and a nuisance, is turned into a resource and a productive public benefit.

Cooperate among disciplines

In the process of conceiving and implementing retrofit and redevelopment projects, members of different professions have insight into different problems and opportunities of watersheds and communities, and different types of skills for analyzing and developing them. All of them need to be members of the project team.

The choice of individual participants may be important to a project's success. Individuals must be open to the unanticipated insights of members of other disciplines, and willing to work with them in design.

During the Nine Mile Run charrette, some distinguished, experienced professionals commented that this was the first time they had worked on truly interdisciplinary teams. They said they had discovered how much the insights of other disciplines could count. They learned that history, society, economy, quality of life, art, engineering, and ecology do in fact interact in retrofit and redevelopment projects, because all these processes share the same urban environment. Taking them all into account, as an interdisciplinary team, produces a sound multi-functional result.

Find out what is possible

Diverse, flexible, economical techniques for treating and storing stormwater within urban retrofit and redevelopment projects have been proven in applications throughout the United States. Developers, public officials, and citizens in the Pittsburgh region need to be aware of the alternatives that are available.

Permeable open-celled "grass pavers" and low impervious coverage for a driveway in the Sterrett School area; examples like this prove that there are more options in restorative design and construction than are being fully utilized today in the Pittsburgh area. Photograph by Bruce Ferguson.

The Nine Mile Run charrette brought together experts in restorative design and policy from various parts of the country with Pittsburgh natives profoundly experienced in unique local conditions. Their work served as modeling experiments that tested the question, are these kinds of ideas feasible in the specific conditions of the Pittsburgh region? The results demonstrate that numerous techniques, old and new, can be applied in the Pittsburgh region, and specifically in the old urban neighborhoods, in ways that are economical, effective, and supportive of economic vitality and quality of life. Infiltration or detention of the two-year storm is possible within budgets no bigger than the already-accepted cost of "doing business" in the region, when the design process is informed of the full range of what is possible. These techniques also contribute to progress on other local agendas, including ecosystem restoration and community social and economic development.

Engage the community

Most leaders and professionals recognize that decisions having profound impacts on people and places—infrastructure choices, facility sitings, provision of public amenities, policy development, and more—should be made with the full substantive participation of those who will bear the fruits (or potentially the costs) of those decisions. Moreover, each city and its respective communities has a unique social and political history, style of governance, method of public discourse and capacity for action. We must carefully define local application of potential solutions and seek locally integrated forms of innovation. In that process we build cohesive cultural forces invested in long term success.

The Nine Mile Run charrette was preceded by and integrated with a multi-year, continuing effort by the STUDIO for Creative Inquiry of Carnegie Mellon University, in cooperation with several local agencies, to engage residents and leaders in the Nine Mile Run watershed in a community dialogue on the future of a major redevelopment project, a proposed greenway, and the watershed generally. (See the Resources section for related publications.) During the three days of the charrette, the designers and policy analysts met with citizens twice at the workshop facility, and some teams met on-site with residents and neighbors of the case study areas. The professionals and the community members discussed local problems, desires, visions, and concerns regarding potential approaches.

Collaborative, community-based efforts are key to developing sustainable approaches to issues as broad as sewer overflows, ecosystem restoration, and community development. If functions and benefits in these areas are to be coordinated and maximized, everyone must be involved in the search for solutions. The opportunity awaits for Pittsburgh's urban watersheds to live again—but only as long as leaders, citizens, and professionals cooperate to imagine and implement integrative solutions.

SECTION IV
HOW TO MAKE THESE THINGS HAPPEN

CHARRETTE POLICY TEAM:
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TIMOTHY COLLINS; Artist; STUDIO for Creative Inquiry; Pittsburgh, PA
PATRICK CONDON; Landscape Architect; Moriarty/Condon Ltd.; Vancouver, British Columbia
MIKE FOREMAN; Policy Specialist; Governor's Center for Local Government Services; Pittsburgh, PA
DAVID FRENCH; Planner; L. Robert Kimball & Associates; Coraopolis, PA
KEVIN GARBER; Attorney; Babst, Calland, Clements and Zomnir; Pittsburgh, PA
CAREN GLOTFELTY; Policy Analyst; Pennsylvania State University; University Park, PA
PETRA KUEHL; Landscape Architect; Toronto, Ontario
PAUL LEONARD; Aquatic Ecologist; EDAW, Inc., Atlanta, GA
TONY MOTTLE; Planner; Pennsylvania Department of Community and Economic Development; Pittsburgh, PA
JAN OLIVER; ENGINEER; Allegheny County Sanitary Authority; Pittsburgh, PA
RICHARD PINKHAM; Policy Analyst; Rocky Mountain Institute; Snowmass, CO
ED RITZER; Engineer; Pennsylvania Department of Environmental Protection; McMurray, PA
JOHN SCHOMBERT; Manager; Three Rivers Wet Weather Demonstration Project; Pittsburgh, PA
DAN SENTZ; Planner; Pittsburgh City Planning Department; Pittsburgh, PA
JENNIFER SMITH; Engineer; Post, Buckley, Schu and Jernigan; Bowie, MA
JOHN STEPHEN; Attorney; STUDIO for Creative Inquiry; Pittsburgh, PA

The patterns of restorative redevelopment exemplified in the four sample designs will solve Nine Mile Run's watershed-wide problems only if they are followed in many places across the watershed for many years into the future. This section presents a program for making these things happen, developed by the charrette's policy team.

The relevance—even urgency—of these recommendations is reinforced by recent regulatory actions. For instance in November of 1998 the Pennsylvania Department of Environmental Protection ordered the four Nine Mile Run communities to develop corrective action plans to address inflows to sanitary sewer lines and reduce the resulting sewer overflows.

In Pittsburgh, as in many other cities, policies and institutions that monitor and guide infrastructure, environmental quality, and community vitality have developed over time piecemeal, in response to specific local needs and momentary crises. Their accumulation over the years has left a mishmash of laws, codes, regulations, departments, and districts that do not work well together. Many agencies are reactive rather than proactive in approach, and their actions often ignore important problems and solutions that are outside the scope of their responsibilities.

Today the Pittsburgh region is facing a sewer overflow "crisis" caused by historical ways of doing business. We now know how to do better. The fixing of problems that once seemed narrow, technical, and frustratingly costly can in fact be a low-cost investment in long-term, multiple, mutually reinforcing benefits.

A COMMUNITY PARTICIPANT: "Girty's Run is building an expensive retention basin at a cost of $14,000,000, probably $1,000 - $2,000 per household; that's a lot of money. And what are they getting for it. Basically a concrete box underground. It's not actually multi-functional or aesthetic."

ANOTHER PARTICIPANT: "That is an example of what you want to avoid here. What you have in Girty's Run is five communities, four of them are a part of the sanitary authority. But the authority's charter was so limited, that the communities have not even done the basics of aggressively dealing with the private part of the problem, the roof drains, the driveway drains, the house laterals. ... They are spending money on tankage while that same amount of money spent in the private sector would have brought a lot more water out of the system."

—EXCHANGE IN THE POLICY TEAM'S MEETING WITH THE PUBLIC

The vision of the Nine Mile Run model is to resolve today's problems in ways that make the city and its watershed live again. The result of innovative policies like the ones described here is cost-effective infrastructure and the creation of natural amenities that are at the doorstep of all citizens. These amenities are treasures to the area because they function to sustain the watershed and allow the community to reap the health and economic benefits now, and long into the future.

The ultimate goal is to restore human conditions and the natural ecosystem in the Nine Mile Run watershed to health and vitality. Meeting this vision requires both ambitious long term objectives and realistic, affordable short term initiatives. It also requires an integrated program of information generation, discussion, and planning on the part of citizens, elected representatives, and public agency staff. Policies that are intended to follow this type of model must be comprehensive and mutually reinforcing.

The charrette identified the following four policy action areas:

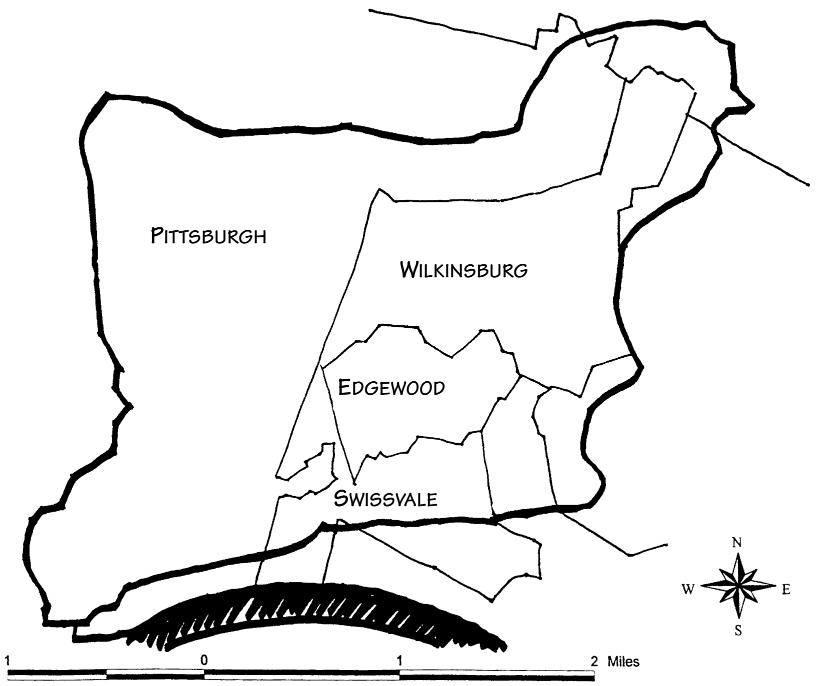
1. Establish a coordinating body with the authority, long-term purview, and financial security to plan, maintain, and manage the watershed's interrelated infrastructure, natural processes, and urban land uses.
2. Manage the watershed's sewer and stormwater infrastructure to improve efficiency, reduce costs, and utilize and reinforce beneficial natural processes.
3. Restore the watershed to a more natural hydrology and healthy riparian and aquatic ecosystems.
4. Enable, support, and require economic revitalization that reinforces infrastructure management and watershed restoration.

The following pages outline each of these action areas. The report's technical appendix provides additional detail. (To obtain the appendix, see page 32.)

ESTABLISH A COORDINATING BODY

A permanent coordinating body is required to carry out the programs and projects in an integrated and mutually supportive way. Sewer lines, stormwater pipes, stream channels, and ground water flows do not begin and end at the affected municipal boundaries. The policy team agreed that some type of "watershed management entity"—an authority, utility, district, or other body organized along watershed lines—is necessary to effectively plan for and manage remediation of the sewer overflow problem, improve the health of the ecosystem, and encourage integration of infrastructure solutions with community revitalization.

At least approximate precedents for such an organization have been successful elsewhere in the country. For example, the Denver (Colorado) Urban Drainage and Flood Control District, the City of Portland (Oregon) Bureau of Environmental Services, and the City of Bellevue (Washington) Stormwater Utility successfully manage stormwater drainage and other types of infrastructure, and also participate in functions such as water quality monitoring, open space preservation and development, fish habitat restoration, guidance of development, and public education.

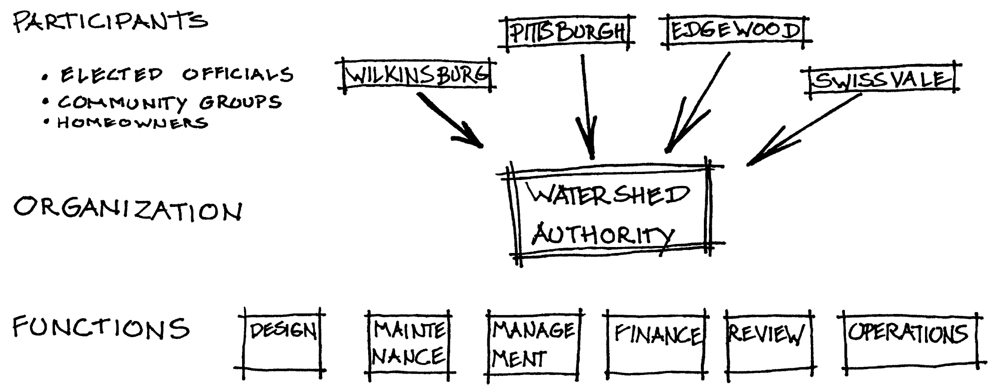


A watershed-wide organization is needed to coordinate across municipal boundaries. Drawing by charrette team.

Several institutional forms are available. A utility has the ability to provide public services and to be permanently funded through reasonable user fees. It could be enabled by legislation to centrally manage and support infrastructure, and to fulfill other related objectives. Other potential institutional structures are districts and authorities. Each type of organization is appropriate for a specific combination of purposes and sources of funding.

A general manager would oversee the organization's efforts. The organization would be staffed and funded to effectively fulfill its objectives, and would have the authority to hire contractors.

Through an appropriately organized body, citizens and elected officials would shape watershed-scale policies and actions. The organization's board of directors would approve plans for infrastructure construction and reconstruction submitted by the municipalities, set base rates for infrastructure connections, publish codes, and describe the required practices for redevelopment. It could also design an incentive plan based on infrastructure cost reductions from handling stormwater on-site. The organization would interact with the public and all levels of government, opening the lines of communication and providing maximum support to the infrastructure.



An organizational plan for a Nine Mile Run watershed coordinating organization. The legal form could be an authority, utility, district, or other structure. Drawing by charrette team.

In the past, sewer and stormwater infrastructure have been impacted by unseen failures, hidden obsolescence, mistaken cross connections, and a variety of debilitating human and natural events. Independent regulatory agencies have attempted to enforce the management of infrastructure by reactive testing, and irregular spot checking of receiving waters. When a situation becomes critical, the prescribed actions often leave unaddressed many problems and solutions that are related but outside the scope of an agency's responsibilities or current regulations.

In this new model, the watershed management entity would unite the responsibilities of infrastructure management and ecosystem protection into a single system. The organization would monitor the ecosystem, providing a consistent cause and effect overview of infrastructure management and allowing the management team to act on problems before they become critical system failures. Over time, as this monitoring increases understanding of the functioning of the infrastructure and the ecosystem, managers will be able to refine strategies and infrastructure plans, further reducing long-term costs. By stewarding the ecosystem the watershed management entity becomes a more effective manager of the infrastructure.

An integrated ecosystem-infrastructure entity would take the analysis and information that is typically used to reactively regulate and enforce, and move it to where it can be used directly and proactively. This approach puts the monitoring responsibility where it belongs and creates a clear trail of accountability when and if the regulators are brought in due to a citizen complaint.

Manage the infrastructure

The immediate imperative for infrastructure management is to eliminate existing human health hazards from overflows of sanitary sewage into local waterways. Sanitary sewer overflows (SSOs) are illegal under the federal Clean Water Act. Combined sewer overflows (CSOs) are in a legal category that is only slightly less stringent: they must be identified in Clean Water Act discharge permits for future reduction and elimination.

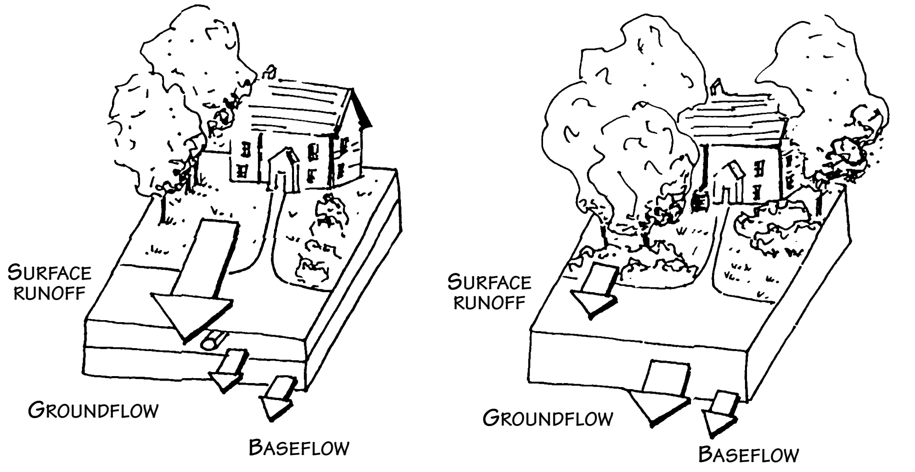
Actions to reduce sewer overflows must be consistent with the way stormwater is managed. A watershed-wide coordinating organization can assure that stormwater management measures are designed to diminish sewer overflows, reducing or eliminating the need for expensive single-purpose fixes such as regional detention tanks.

The watershed organization would enact a new concept of stormwater infrastructure. The idea of "green infrastructure" broadens the conception of stormwater infrastructure from that of inlets, catch basins, pipes, outfalls, and treatment plants, to include the capacities of soil and vegetation to absorb water and filter pollutants. Using natural capacities to advantage can cut peak stormwater flows and reduce sewer overflows more cheaply and reliably than regional detention tanks and treatment plants. In addition, by recharging water into the ground, green infrastructure supports summer stream flows and urban vegetation that provide recreational and aesthetic values to the community, and ecological values to the watershed restoration effort. Infrastructure of this type serves the long-term economic, social, and environmental necessities of cities that are beginning new cycles of redevelopment. It focuses limited resources on multiple benefits, and can be designed to be affordable to implement and sustainable over the long term.

There are several levels of action required to implement green infrastructure:

- At the watershed scale, the watershed management entity would pursue improved efficiency of infrastructure form, function, and maintenance; and undertake long range planning for ecosystem restoration. A short term objective is to enable all citizens and elected officials to participate in discussions that shape watershed-scale goals, policies, and actions. Short term actions would include abatement of sewer overflows through strategic disconnections of stormwater sources from sanitary and combined sewer lines. The long-term goal is the greening of the entire system. This requires a program of planned maintenance and replacement of infrastructure coupled with targeted environmental investments. The watershed management entity would also coordinate any large scale retention and recharge systems involving multiple municipalities or properties.
- At the community scale, the municipalities, with assistance from the watershed management entity, would lead the implementation of green infrastructure measures for their streets, parks, and schools. Projects in prominent locations should be considered public demonstrations of the multiple public and private values of green infrastructure, and be accompanied by educational programs and publications for children and adults alike. This effort should include publications to educate individual property owners. It is important to realize that given the diversity of buildings, streetscapes, parks and other elements of the watershed, green infrastructure at the community scale will have to be targeted and applied as appropriate. Some communities will require outside funds, others may be prepared to self-finance programs.
- At the individual property scale, broad implementation of measures to maximize infiltration to the soil and minimize wastewater flow is crucial to increasing the value and functionality of the green infrastructure. Implementation can be leveraged with a variety of monetary incentives and infrastructure user fees, administered by the watershed management entity, the municipalities, or other agencies. The "3-R" program proposed for residences in the Edgewood Crossroads area (see page 15) is an example of a self-financing investment in on-lot retrofits.

A simple "disconnect" of residential downspouts away from sewers, and reconnection with natural soil and hydrology. Drawing by charrette team.



A simple retrofit "disconnect" and revegetation at an individual residence alters the contribution of the lot to the watershed's hydrology. Drawing by charrette team.

> "The way to make these ideas work is make it economically viable for a user to unplug from the system. Two thousand dollars to install, diminished utility costs for life, and then they have money left over for Christmas. The net benefit for the region is that there is incrementally less material to deal with down the pipe. For example: a homeowner needs sewer service. You call the watershed authority, someone from the utility answers and they say 'Here is your menu of options: baseline sanitary service, or baseline plus estimated runoff from your roof and other impervious surfaces'. This is a win-win situation: potentially less material for the utility to deal with, less transport problems for the regulators to deal with, and a sense of personal satisfaction, responsibility and cost savings for the homeowner. Use the economics to drive a system of alternatives which are as relevant at the individual homeowner level as they are at the municipal or watershed level."
>
> **—A POLICY TEAM MEMBER DURING ONE OF THE TEAM'S PUBLIC MEETINGS**

RESTORE THE WATERSHED'S ECOSYSTEMS

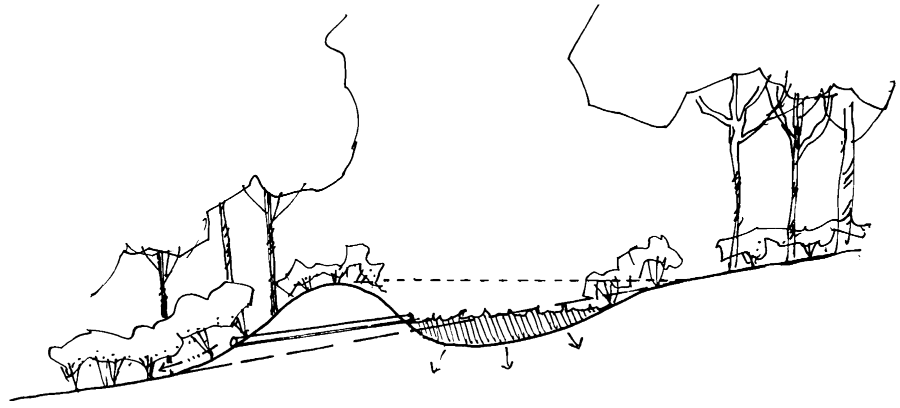
Ecosystem restoration addresses both the hydrologic cycle and biological integrity of the watershed. It means reconnecting urban drainage with the natural processes of the watershed, while utilizing those natural capacities to control runoff, biodegrade pollutants, and restore stream flows. It also means restoring selected natural stream, wetland, and forest habitats. These objectives recognize both the immediate needs related to infrastructure remediation, and the long-term vision of a sustainable urban landscape—a landscape that may take as many as 100 years to emerge.

To help achieve these ecosystem restoration objectives, the policy team developed an action plan that is designed to:

- Provide the community, the political leaders, and the watershed management entity an understanding of the existing hydrologic and biological conditions. These baseline conditions will serve as a measure of watershed ecological function and how well the watershed restoration actions are working.
- Develop inventory, analysis and modeling tools that make it possible to both understand and manage the watershed now and in the future. This system must be able to evolve with technology and changing community goals. The community should be involved in the environmental inventory and the programs that follow from it.
- Provide an ecological basis to identify critical areas and use this information to set priorities and develop attainable restoration goals. A well-constructed monitoring program is also necessary to provide sound environmental input to the community planning and redevelopment process.

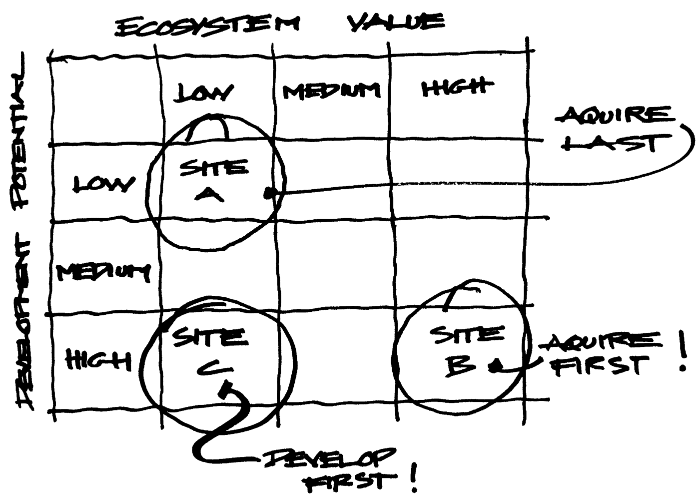
Specific action areas, many of which would be undertaken or coordinated by the watershed management entity, include:

1. **RESTORE THE HYDROLOGIC REGIME.** Precipitation and stream flow can be monitored with a network of gauges in selected locations; the results can be used to calibrate a watershed hydrologic model. This model can be used to identify inflows to and outflows from sewer and stormwater infrastructure, to update floodplain maps and identify flood protection strategies, to establish attainable hydrologic criteria for redevelopment of urban properties, and to analyze and prioritize opportunities for infiltration and detention measures.



A simple vegetated infiltration basin returns stormwater to its natural path in the soil and ground water. Drawing by Choli Lightfoot and Larry Ridenour.

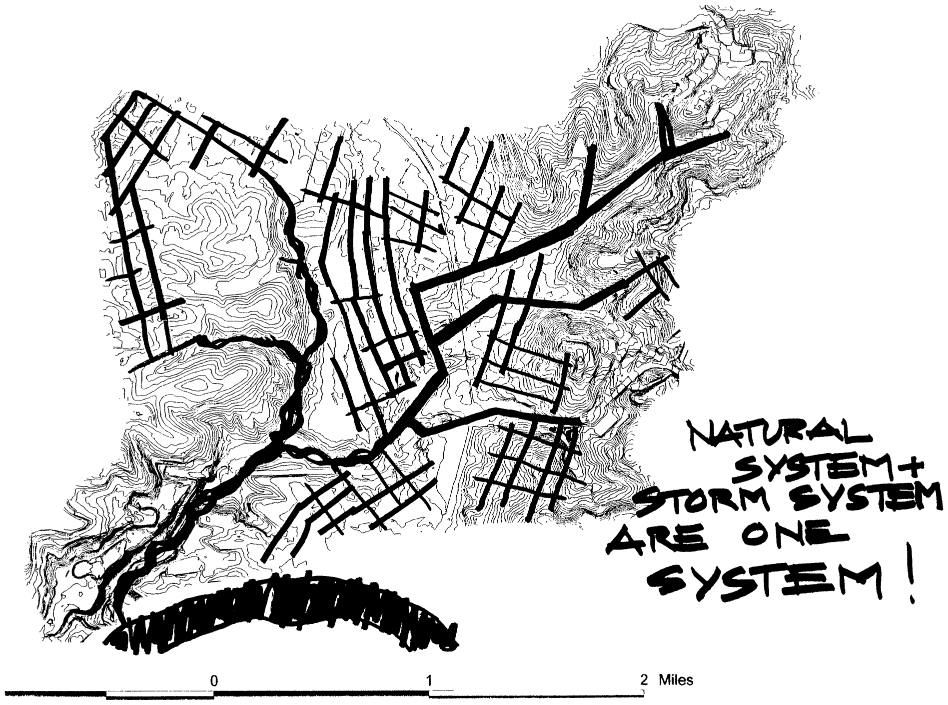
2. **IMPROVE THE STREAM CHANNEL AND FLOODPLAIN.** Geomorphic analysis and sediment transport modeling can help identify current and future channel stability problems. Major bank erosion problems can then be addressed, and a long-term channel and floodplain restoration plan developed that anticipates changes in the flow regime as restorative redevelopment occurs in the watershed. Development of a stream buffer policy and implementation of a greenway program are also key steps.
3. **CONSERVE URBAN WATERSHED HABITAT.** Redevelopment and community revitalization is a continual process of change, which provides the potential for targeting specific place-based changes over time. Taking advantage of this phenomenon requires a prioritization scheme for protection of urban watershed lands. A critical areas analysis would follow an inventory of the natural resources of the watershed, and lead to development of short and long term land management strategies and land acquisition and easement programs.



The identification of critical areas for conservation activities, showing a prioritization scheme for acquiring land, easements, or property management agreements. Drawing by charrette team.

4. **MONITOR WATER QUALITY AND BIOLOGY.** Water quality can be monitored using chemical and biological indices; the results can be used to calibrate a model of watershed water quality. The model can be used to predict the efficacy of load reduction strategies. This will help ensure water quality goals are attainable, and can aide development of pollution prevention programs.

5. **Integrate and acquire feedback.** All monitoring results should be shared among community residents, municipal leaders, and the watershed management entity. As comments and concerns from this communication loop emerge, the monitoring objectives, environmental priorities, and attainable conditions can be modified to measure and ensure the success of watershed restoration programs vis-a-vis human health and the environment. The public can be further involved in stream monitoring and cleanups, storm drain stenciling, planting for habitat restoration, and other actions. Experiences in the field educate the public and foster consensus and stewardship.



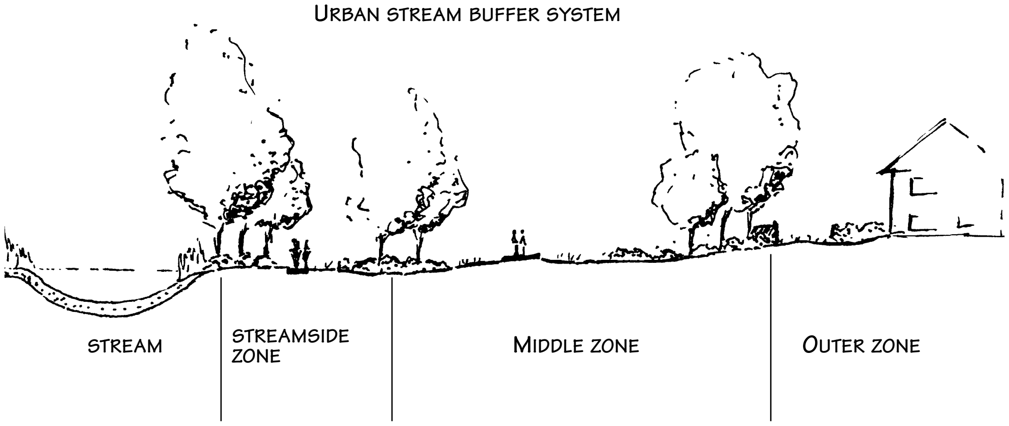
In the Nine Mile Run watershed, natural streams and artificial storm drainage connect to make a single system. Drawing by charrette team.

Revitalize the communities

There are many linkages between sewage and stormwater infrastructure and the social and economic conditions of watershed communities. Infrastructure approaches requiring huge expenditures on single-purpose systems can be a substantial economic drain on communities. On the other hand, investments in green infrastructure measures produce improved landscapes, beautified streets, recreational amenities, wildlife habitat, and other results that generate economic value for communities.

As the sewer and stormwater infrastructure is renewed in coming years, costs can be reduced and local social and economic conditions improved by implementing the stormwater management techniques illustrated in this report. At the same time, public and private development organizations can assist rehabilitation of infrastructure and restoration of watershed processes. It's a two-way street. Whether we approach restorative redevelopment from an infrastructure focus, or from a community development perspective, the objective is the same: improving the value and livability of the city while simultaneously restoring natural processes and functions.

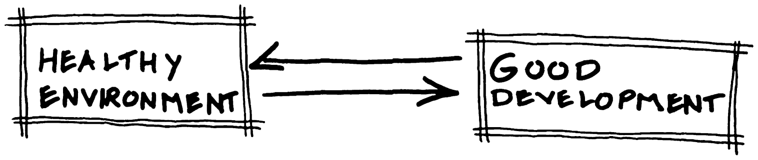
Urban stream buffer system



Stream buffers like this one can relieve flooding, improve water quality in the channel and the water approaching the channel from the side, maintain riparian habitat and provide amenities that boost community development. Drawing by charrette team.

The charrette's policy team gave considerable attention to ways community development policies and institutions can support restorative redevelopment. The team offered the following general principles:

- Recognize the watershed impacts of redevelopment activities. How will runoff, infiltration, and base flow be affected? Does a project or program contribute to restoration of natural watershed processes?
- Follow the patterns of restorative redevelopment identified earlier in this report. Make project components multi-functional, use every square inch, and pursue the other patterns to integrate and maximize stormwater, social, and economic benefits.
- Coordinate the planning of development that has multi-municipal impacts on stormwater and sewage infrastructure, roads and traffic, other infrastructure, zoning, land use, public participation and outreach to citizens. The watershed management entity could conduct or coordinate such reviews, particularly to examine impacts on stormwater and sewage infrastructure, streams, and riparian areas.
- Assure development occurs as planned and agreed upon to enhance and fit with desirable existing watershed conditions and other, pending development providing watershed benefits. Achieving watershed objectives requires consistency in implementation and follow-through.
- Accommodate unplanned-for private initiatives and new opportunities that serve watershed objectives. Community development institutions must have the flexibility to accommodate unanticipated opportunities to further restorative redevelopment.



Specific action areas include:

1. **Reconcile zoning and land use ordinances** of the watershed municipalities for compatibility with watershed objectives and goals. These ordinances may now allow or require juxtaposition across municipal boundaries of conflicting land uses, or may contradict integrative approaches to watershed restoration.
2. **Review other local codes** (*e.g.* building, plumbing, drainage, street design, property maintenance, *etc.*) and procedures for consistency with watershed objectives and green infrastructure measures. Code requirements that preclude the techniques illustrated in this report (e.g. prohibitions against shallow temporary ponding of water on landscapes) should be eliminated or modified.
3. **Identify existing development constraints** (legal, physical, financial) caused by inadequate infrastructure. Understanding the many costs of failing infrastructure will motivate action to correct the problems.
4. **Develop a coordinating mechanism** for municipal redevelopment plans, to assure projects do not contradict each other and overall ecosystem/development objectives. For instance, the watershed management entity could review municipal redevelopment plans and approvals to assure one project does not contradict others in meeting watershed-wide restoration and redevelopment goals.
5. **Enhance the existing Act 167 Stormwater Management Plan** to reflect watershed needs, enable green infrastructure, and facilitate community, social, and economic benefits. The plan largely addresses new development. Changes to encourage retrofits and watershed-friendly redevelopment should be examined.
6. **Educate citizens, officials, and developers** that good development and a healthy environment are compatible and reinforcing. The more the linkages are understood, the greater the chances of realizing them. A well-conceived, proactive, and sustained educational campaign is essential to achieving restorative redevelopment.

Section V
The Outcome That Could Be Created

In the suburban development of recent decades, Americans have been paving or repaving almost a quarter of a million acres every year of once-pristine lands. Today, we turn away from that type of progress. We look with affection at the old cities, where streets are at human scale, neighbors see each other face to face, transportation is not a daily burden, and a public street is a good place to walk along. The city deserves our attention and our care because it is our home.

The people who built old urban areas like those in the Nine Mile Run watershed did the best they could with the resources they had. But times have changed, and the knowledge of impacts and feedbacks that our forebears could not possibly have foreseen has slowly accumulated. At the same time, many aspects of the urban places our forebears built are useful, beautiful, and enduring.

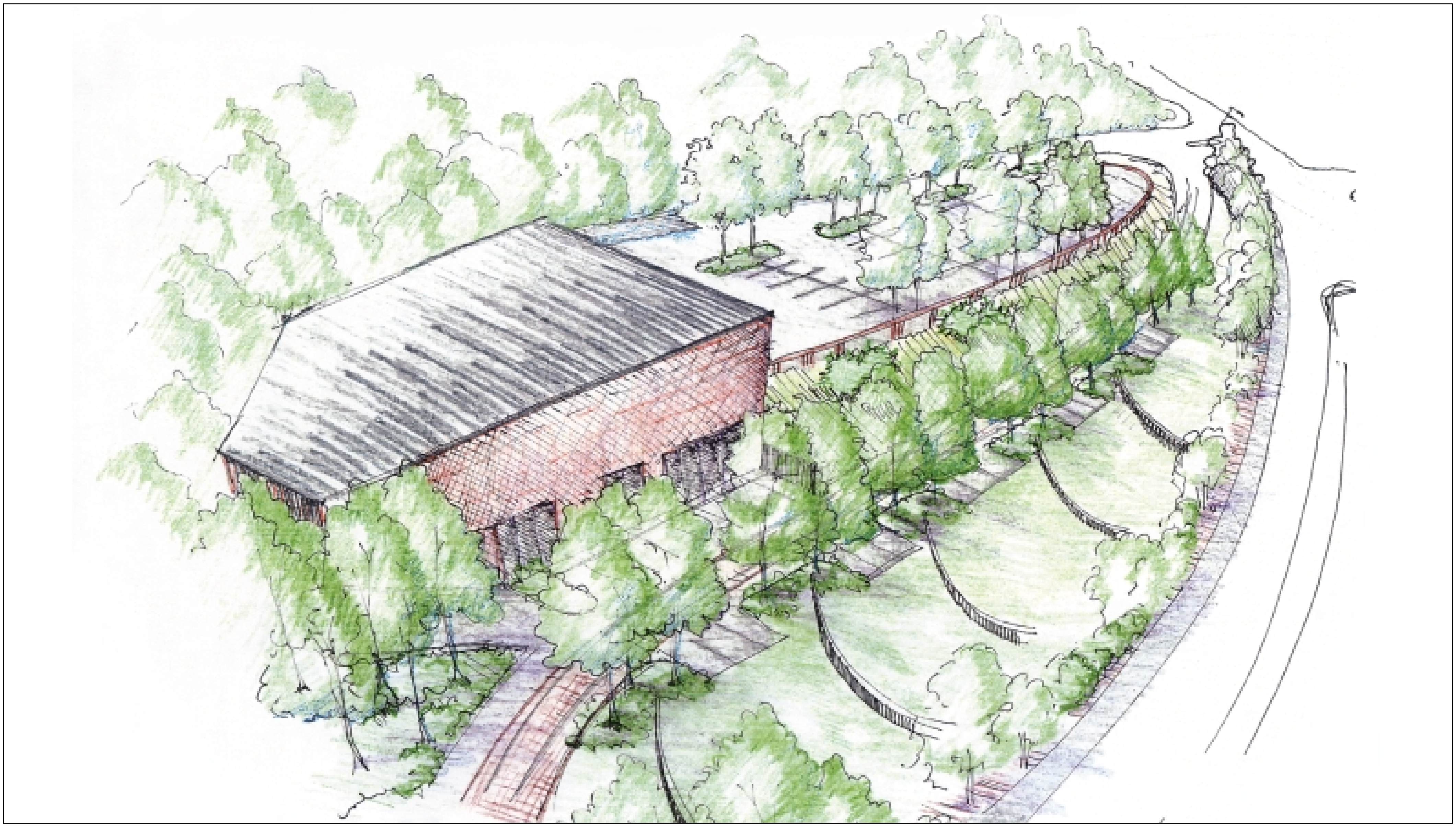
Today, old systems of sewerage, drainage, transportation, and pavements are being re-evaluated, while cities and the people who live in them are more important than ever.

It is a time of renewed possibilities. Nine Mile Run, chosen for a city park in the past century for its natural beauty, has become famous for its sewer overflows and eroded stream channel. Now it is famous for another reason: it is a place with a hopeful future. Some day, Nine Mile Run shall flow calm and clear. And the watershed's people will live, work, and play in vibrant neighborhoods that support a robust ecosystem.

There is a terrific regenerative power in this place. Pittsburgh's gray skies bring moisture here, year-round. This green place is trying to regrow; it knows how to make itself healthy. If we would let nature work on our side, and let natural processes of the soil and vegetation work for us, then we will arrive at a city as healthy as were the hills before they were developed.

To heal and care for the places where we live requires knowledge, sensitivity, and sympathy with the lives of the people who share this city with us. It requires collaboration. It requires creativity, ingenuity, and aggressive leadership. Every square inch is a part of the problem and of the solution. And everything that happens on each site in the watershed is part of the problem and of the solution.

The sustainable rehabilitation of old urban watersheds is a new and challenging endeavor. It is one in which Pittsburgh deserves to be a leader, as it has been a leader in the past in building things that last. The people of Pittsburgh are proud to be part of this place and of what it is able to accomplish and what it is able to build. They are hopeful, hard working, and generous. In this time of hope, they are capable of building new purpose and new life.



The restorative and symbolic land forms proposed for the Regent Square Gateway site. Drawing by charrette team.

Resources

Technical literature on stormwater management and urban design

CH2MHill, *Pennsylvania Handbook of Best Management Practices for Developing Areas.* Prepared for the Pennsylvania Association of Conservation Districts, Inc.; Keystone Chapter, Soil and Water Conservation Society; Pennsylvania Department of Environmental Protection; and Natural Resources Conservation Service, 1998

Debo, Thomas N., and Andrew J. Reese, 1995, *Municipal Storm Water Management*, Boca Raton: Lewis.

Ferguson, Bruce K., 1994, *Stormwater Infiltration*, Boca Raton: Lewis.

Ferguson, Bruce K., 1998, *Introduction to Stormwater: Concept, Purpose, Design,* New York: John Wiley and Sons.

Hough, Michael, 1994, *Cities and Natural Process,* New York: Routledge.

Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection, 1997, Palo Alto, CA: Tom Richman & Associates, for the San Francisco Bay Area Stormwater Management Agencies Association.

Steiner, Frederick, 1991, *The Living Landscape, An Ecological Approach to Landscape Planning*, New York: McGraw-Hill.

Watershed Protection Techniques, Newsletter available from the Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043, 410-461-8323.

Selected references about Pittsburgh's environment

R.P. Briggs and W.R. Kohl, 1975, *Map of Zones Where Land Use Can Be Affected by Landsliding, Flooding, and Undermining, Allegheny County, Pennsylvania,* Miscellaneous Field Studies Map MF-685 D, Pittsburgh: U.S. Geological Survey.

A.R. Geyer and J.P. Wilshusen, 1982, *Engineering Characteristics of the Rocks of Pennsylvania*, Environmental Geology Report 1, Harrisburg: Pennsylvania Topographic Geologic Survey.

B.J. O'Neill, Jr., 1974, *Greater Pittsburgh Region Construction Aggregates*, Mineral Resource Report 67, Harrisburg: Pennsylvania Topographic Geologic Survey.

U.S. Soil Conservation Service, 1981, *Soil Survey of Allegheny County, Pennsylvania*, Washington: U.S. Soil Conservation Service.

W. R. Wagner et al., 1970, *Geology of the Pittsburgh Area*, General Geology Report 59, Harrisburg: Pennsylvania Topographic Geologic Survey.

W. R. Wagner et al., 1975, *Greater Pittsburgh Region Geologic Map and Cross Sections*, Map 42, Harrisburg: Pennsylvania Topographic Geologic Survey.

Publications about Nine Mile Run

Ample Opportunity: A Community Dialogue, 1998, Pittsburgh: Carnegie Mellon University.

Nine Mile Run Rivers Conservation Plan, 1998, Pittsburgh: City of Pittsburgh; Carnegie Mellon University; Carnegie Museum of Natural History; Pennsylvania State University; and Commonwealth of Pennsylvania, Department of Conservation and Natural Resources, Rivers Conservation Plan Program.

http://slaggarden.cfa.cmu.edu

Agencies and programs

Allegheny County Sanitary Authority (ALCOSAN)
3300 Preble Avenue
Pittsburgh, PA 15233-1092
412-766-4810

Green Building Alliance
64 South 14th Street
Pittsburgh, PA 15203
412-431-0709

Pennsylvania Department of Environmental Protection
Pittsburgh Region
400 Waterfront Drive
Pittsburgh, PA 15222-4745
412-442-4000

Pennsylvania Department of Community and Economic Development
Pittsburgh Region
300 Liberty Avenue
Pittsburgh, PA 15222
412-565-5002

Three Rivers Wet Weather Demonstration Program
3901 Penn Avenue
Pittsburgh, PA 15224-1347
412-578-8040

U.S. Environmental Protection Agency
Region III
Community Liaison Office
1060 Chaplone Street
303 Methodist Building
Wheeling, WV 26003
304-234-0231

For further information, contact:

Rocky Mountain Institute, 1739 Snowmass Creek Road, Snowmass CO 81654, 970-927-3851, FAX 970-927-4510.

Rocky Mountain Institute is an independent, nonprofit research and educational organization established to foster the efficient and sustainable use of resources as a path to global security. RMI believes that understanding interconnections between resource issues can solve many problems at once. The institute focuses its work in several main areas: corporate practices, community economic development, energy, real estate development, security, transportation, and water. RMI's water program develops and disseminates information on water-efficient technologies, integrated resources planning, and stormwater management through research, public outreach, and consulting. Through its Green Development Services group, RMI assists real estate professionals in integrating energy-efficient and environmentally responsive design into projects in the private and public sectors.

STUDIO for Creative Inquiry, Room 111, College of Fine Arts, Carnegie Mellon University, Pittsburgh PA 15213-3890, 412-268-3673, FAX 412-268-2829.

The STUDIO for Creative Inquiry is an interdisciplinary center in the College of Fine Arts at Carnegie Mellon University. Founded in 1989, this center serves as a focus for experimental activities in the arts at Carnegie Mellon. The Mission of the STUDIO is to facilitate work in two major areas: artistic creation and the development of educational tools. Within those two categories all work at the STUDIO strives to:

- Bond creative activity with intellectual inquiry,
- Reflect and engage the comprehensive contemporary environment,
- Become manifest through public gestures, and
- Communicate and collaborate with creative inquiry worldwide.

Snowmass, Colorado

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Bruce Ferguson, School of Environmental Design, University of Georgia, 609 Caldwell Hall, Athens, GA 30602-1845, 706-542-4704, Fax 706-542-4236.

Bruce Ferguson is a Professor of Landscape Architecture and Director of the MLA program at the University of Georgia School of Environmental Design. He is the author of Stormwater Infiltration, the standard professional reference in its field, Introduction to Stormwater, and 130 scientific and professional papers on environmental management of urban watersheds. He has participated in the setting of urban design guidelines to protect runoff quality through the International Life Science Institute's stream restoration program in Atlanta, the Second Nature charrette in Los Angeles, the Start at the Source manual for the San Francisco Bay area, and additional projects in Florida, Georgia and New York. He is a Pittsburgh native who received an MLA degree at the University of Pennsylvania and practiced in the Pittburgh region for several years before commencing his academic career.

A technical appendix is available. The appendix and other information for this project can be viewed and downloaded from the STUDIO for Creative Inquiry's web site (http://slaggarden.cfa.cmu.edu/publications).

About the cover: Nature replicates its forms and processes widely. The background of the cover looks much like ripples on a puddle, but is in fact a photograph of a branch scar on a tree trunk, turned blue by a computer for effect. Inset Photo: Overflowing manhole structure along Nine Mile Run in Frick Park. Photograph by Mike Lichte, Allegheny County Health Department.

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