Ecological Riverfront Design:

Restoring Rivers, Connecting Communities

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Old Cities/Green Cities

. 2002. 123 .

Old Cities / Green Cities highlights innovative ways of managing vacant urban land, including large-scale greening systems and promoting reuse. Case studies focus on the Green City Strategy in Philadelphia. Stunning color photographs enhance this useful work. An appendix provides a list of contacts to many community development corporations active in the area of urban greening.

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not overburdened with buildings, roads, and other concrete infrastructure) should be a goal for all cities. Indeed, in many instances, it makes better sense, economically and ecologically, to remove old structures and keep new development out of the floodplain and away from sensitive river areas.

In most instances, the ideas and ecological principles put forth in this report can, and should, be applied to river edges being considered for new development. Having said that, we strongly encourage communities to resist extensive new development in the floodplain and along the urban riverfront. Communities should instead seek to maintain a more natural, undeveloped river edge. It is still possible, and often just as desirable, to place housing, commercial space, restaurants, shops, and other amenities near, but not on, the urban riverfront.

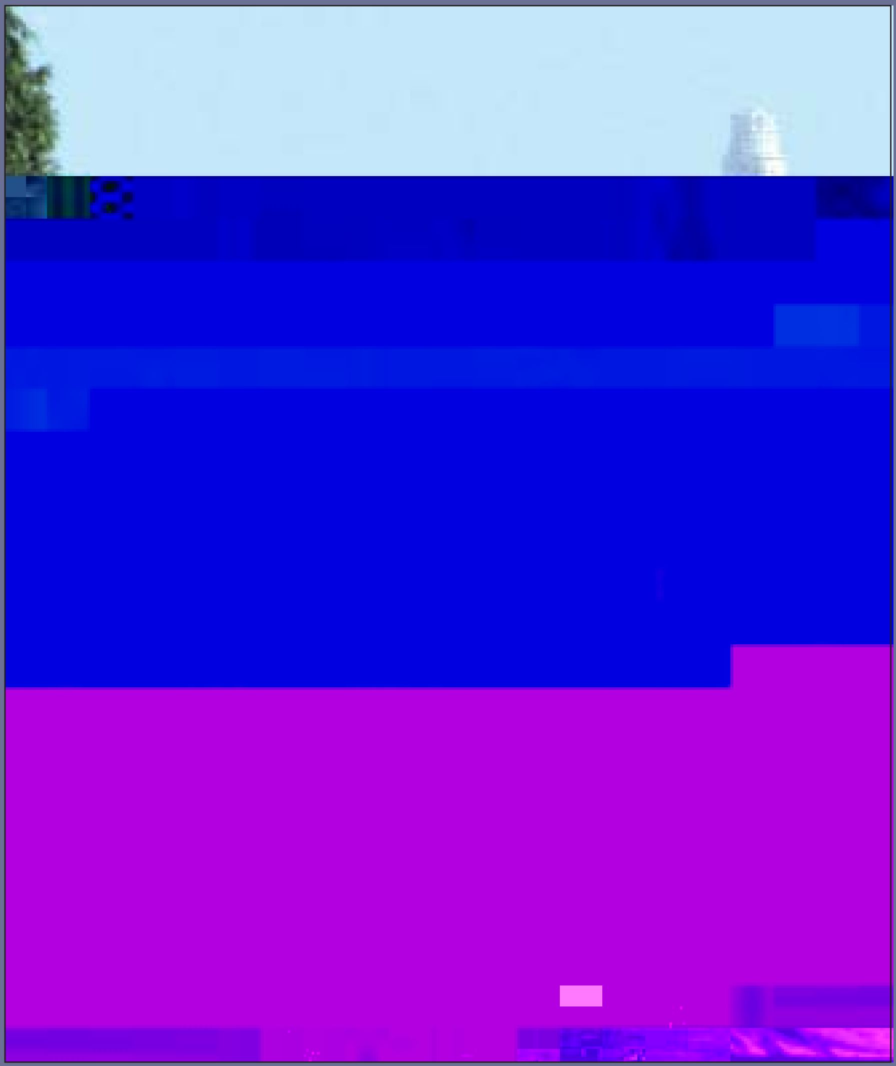
Chapter 1 gives some very general background on and history of urban riverfront redevelopment efforts and briefly addresses the benefits of more fully integrating ecological considerations into urban riverfront projects.

Chapter 2 provides background on urban river health, including a basic primer on the key components of river ecosystems that communities should consider as they plan and design riverfront developments. Discussion of any of these components could easily fill a book and is given only a brief overview in this report.

Chapter 3 is the heart of the report. It offers guiding principles for ecologically sound urban riverfront development, including some general perspectives, a set of planning principles, and a set of related, more detailed, design principles.

Chapter 4 gives an overview of the economic benefits of including strong river protection and restoration elements in community riverfront projects.

Finally, Chapters 5 and 6 present two in-depth case studies for the Chicago River and the Willamette River in Portland, Oregon. Both cities have attempted to infuse their urban riverfront revitalization efforts with a stronger ecological focus, and the stories of what they are trying to accomplish and how they are doing it are valuable and vivid reading.



Peg Henderson

CHAPTER 1

A C c e H f
U ba R e f De e e

Rivers have been hard at work for urban settlements in North America for more than four centuries. The earliest cities were established along the coasts and inland navigable waterways because the movement of people and goods depended heavily on water transportation. As settlers moved west, new river towns served as links between the backwoods and the larger seaport towns. The emerging transport network in North America was a complicated mix of water and overland routes, but rivers were always the most important element: during the early nineteenth century, for example, westward-bound goods were shipped by covered wagon from eastern seaports to Pittsburgh, where barges then carried them along the 1,800-mile length of the Ohio and Mississippi Rivers to New Orleans (Wrenn 1983).

Peg Henderson

Many cities along coastal rivers from New Jersey to the Carolinas were established at the "fall line"—the geologic meeting point between the flat coastal plain and the Appalachian Piedmont region of inland hills. Because this point represented the limit of navigation for ships, a number of important ports emerged there linking the ocean with inland regions. In some instances, the effective fall line was extended far to the west when canals were dug to bypass non-navigable sections of rivers and to create a more controllable, two-way link between the coast and such inland bodies of water as the Ohio and Mississippi rivers and the Great Lakes. The collision of the Piedmont's harder metamorphic rock with the coastal plain's softer sedimentary rock formed an erosion line that also created waterfalls which powered manufacturing. Both factors were central to the founding of such major port cities as Philadelphia, Baltimore, Washington, D.C., and Richmond, Virginia (USGS 2000).

Throughout the nineteenth and twentieth centuries, river cities—whether smaller inland cities, like Pittsburgh and Cincinnati, or major ports with ocean access, like Philadelphia and Portland, Oregon—have grown in a relatively consistent pattern. Because this pattern has determined today's riverfront land uses and will deeply influence future urban development patterns, uses, and functions, it is important for planners to understand the history of river town expansion. Despite their similarities, however, each town incorporated waterfront uses and development patterns that reflected its unique physical setting as well as the unique needs and commercial interests of its residents.

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THE HISTORY OF A RIVERFRONT CITY

A typical river city was established in the early nineteenth century with a simple wooden jetty, which later grew to include multiple piers and a street network that linked the waterfront to commercial buildings as river traffic increased. Growth occurred whenever this pattern—more piers, followed by more roads and more buildings—was repeated. As a result, growth was centered around transportation, general commerce, shipbuilding, and commercial fishing. Railroads entered most towns and cities by the mid- to late 1800s; accordingly, more river-edge lands were filled in to accommodate rail infrastructure, and warehouse and downtown commercial space increased. As transportation shifted from water to rail, the river edge became less important as a social and retail space, and the city's downtown moved away from the river. Yet the urban riverfront remained active and vital as an economic center. Warehouse, road, and rail infrastructure was expanded, concentrating large-scale commercial and industrial uses along the waterfront. These uses began to dominate many cities' waterfronts by the late nineteenth and early twentieth centuries (Wrenn 1983).

During the first half of the twentieth century, riverfront industry and railroads continued to proliferate. These uses were soon followed by elevated highways that further separated cities from their riverfronts. Urban riverfronts also became popular locations for sewage treatment plants. Even when the plants themselves were not located on the river edge, sewer overflows were commonly found on urban waterfronts discharging untreated sewage during storms directly into rivers. Similarly, urban waterfronts were highly altered by efforts to keep downtown and industrial areas from flooding. The U.S. Army Corps of Engineers had oversight over many of these projects, which typically straightened and deepened channels, removed vegetation, and added bulkheads and floodwalls, completely severing the river from its floodplain.

By the late 1950s, technological changes caused profound shifts in waterfront land use. First, ports were in decline for reasons that included:

- shifts in international travel from passenger ships to transcontinental jet aircraft and in local commuter traffic from ferries and streetcars to private automobiles;
-

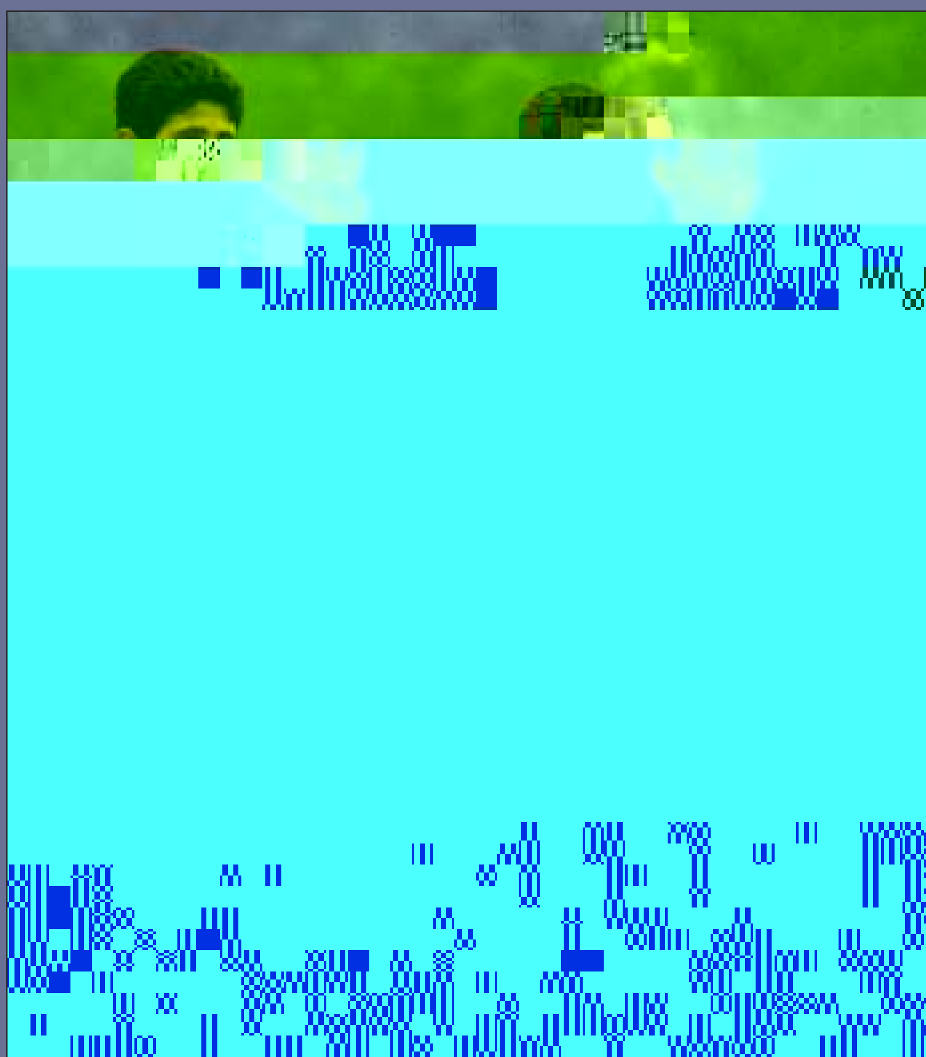
R e I e . In 1938, the U.S. Army Corps of Engineers undertook the cement channelization of the 51-mile Los Angeles River and its tributary streams. Afterwards, Los Angeles turned its back on the river: industrial development soon lined the river and, by the 1980s and 1990s, had left brownfields in its wake. Excessive hardscape and concrete-lined riverbanks have resulted in poor water quality caused by urban runoff and the destruction of native habitat. The concrete system was designed to move water out to the ocean as quickly as possible, but that objective is being reconsidered given the region's dependence on imported water, the depletion of groundwater, and the impacts of stormwater pollution on state beaches. Despite intense urbanization, Los Angeles remains a hot spot for biodiversity. Much of this rare and threatened habitat is centered in its rapidly disappearing riparian areas.

Wha I Be g P a ed. The Los Angeles River Master Plan was developed in the mid-1990s with assistance from the Rivers, Trails, and Conservation Assistance program of the National Park Service.

residential development alongside a 103-acre Los Angeles River State Park. Additional funding for completion will come from both private and public sources, including the city and county of

WHAT'S DRIVING URBAN RIVERFRONT DEVELOPMENT TODAY

The renewed attention to waterfronts in the 1970s coincided with a growing interest in historic preservation and with efforts to counteract suburban flight by reviving the urban core. These early urban riverfront initiatives thus sparked a redevelopment trend that accelerated in the late 1970s and boomed in the 1980s and 1990s. The first years of the twenty-first century will likely see as much as $500 million spent on downtown river revi-



Greg Kriss, Riverfront Recapture

CHAPTER 2

U ba R e Hea

Human activities have had an indelible impact upon rivers. We have come to depend on them for transportation and commerce, to provide food and other substances, and, most problematically, to assimilate and carry away our wastes. Centuries of hard wear have shown their effect most acutely on urban rivers.

Now there is a growing interest in restoring damaged urban rivers and in protecting those river reaches that have not yet been affected by negative impacts from human development. And because rivers are resilient, urban rivers can be remarkably responsive to efforts to protect and improve their physical condition.

If we are going to do a better job of planning and designing riverfront development, we must first understand the history and current state of urban river health. We must also recognize the threats to these rivers, including the essential components of a healthy river, and the prospects for rehabilitating rivers as living ecosystems.

URBAN RIVER HEALTH IN HISTORICAL CONTEXT

Urban river health declined steadily through the first 70 years of the twentieth century due to massive physical alterations of riverbanks, overharvesting of fish and other aquatic animals, and the dumping of larger and larger volumes of sewage and industrial pollutants into rivers.

In general, a river's health is determined by the [illegible] properties of its water as well as the river's [illegible] and [illegible] properties. All three components are explicitly written into the Clean Water Act, and togeants ie explicit

- The dumping of about 1 billion pounds per year of toxic pollutants was eliminated.

Despite significant progress in cleaning up point sources of water pollution, the Clean Water Act's sweeping goal has not yet been achieved. As the U.S. EPA acknowledges in its 2000 National Water Quality Inventory report to Congress, river and stream quality is still seriously threatened:

- Of the nation's roughly 3.6 million miles of rivers and streams, 39 percent of assessed rivers are "impaired" (and only 19 percent of the

Over the past 10 years, the U.S. Geological Survey has been conducting in-depth research on the water quality of 40 urban watersheds and has found some startling results. Among its findings:

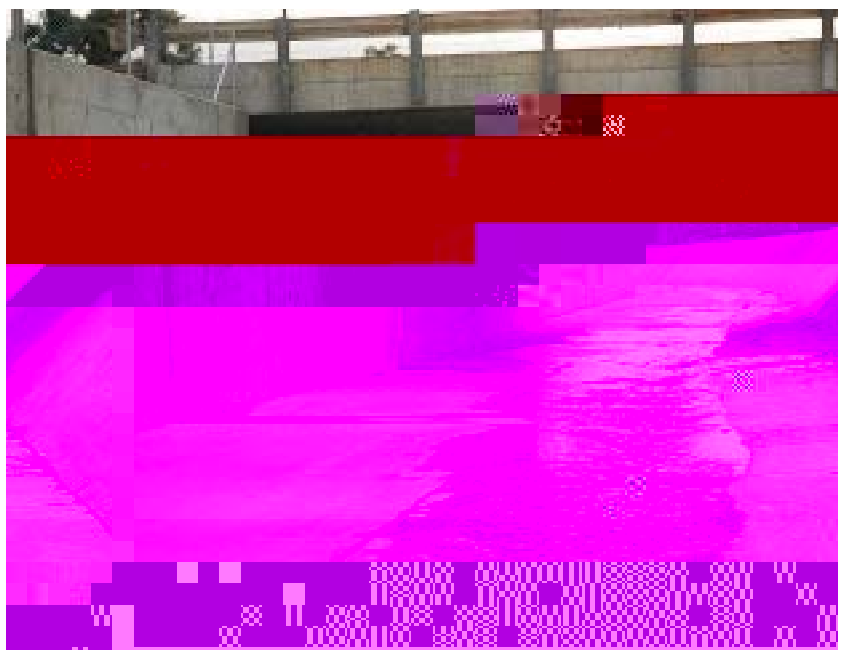
- Concentrations of fecal coliform bacteria commonly exceed recommended standards for water-contact recreation.
- Nearly 80 percent of urban stream samples contained five or more pesticides. Herbicides were detected in 99 percent of urban stream samples, with the most common being those applied to lawns, golf courses, and road right-of-ways, such as atrazine, simazine, and promenton.
- One or more organochloride compounds were detected in 97 percent of fish tissue samples at urban sites. In 10 percent of these samples, the compound levels exceeded guidelines to protect wildlife.
- Concentrations of total phosphorus are generally as high in

enormous impacts on river ecosystems. They also produce substantial infrastructure and human consequences.

Da . In the United States, there are an estimated 75,000 dams taller than six feet and at least tens of thousands of smaller dams, according to the U.S. Army Corps of Engineers (American Rivers et al. 1999). Virtually all large rivers of the contiguous 48 states are highly modified by dams, with fewer than 50 rivers free-flowing for more than 120 miles (Cushing and Allan 2001).

Many of these structures are old, in poor condition, and no longer serve a useful function. There is a growing movement to remove unnecessary dams and those whose environmental costs outweigh their economic value, including a number in urban locations (American Rivers 1999). Dam removal has become an important new emphasis in river restoration across the country. At the same time, however, new or larger dams for flood control, water supply, and hydroelectric power are being proposed across the country, despite their huge negative impacts on rivers. (See Chapter 3, Design Principle 3 for more information on the impacts of dams on rivers.)

Cha e a , d edg g, a d he h ca a e a . The Army Corps of Engineers—the nation's chief public works agency responsible for modifying rivers—estimates that it has installed, and currently maintains, 10,790 miles of navigation channels and 8,500 miles of levees and countless revetment, dike, and seawall projects. The Army Corps also dredges significant amounts of river material from the nearly 11,000 miles of channels it maintains, with 285 million cubic yards of sediment and other material removed in 2000 alone (U.S. Army Corps of Engineers 2002).



Army Corps of Engineers

Head a e a d e a d de c . The loss of river headwaters—which generally include wetlands and the smallest continuously flowing, ephemeral, and intermittent streams—to urban development has been another significant negative physical impact for urban rivers. Often wetland loss has gone hand in hand with channelizing rivers and disconnecting them from their floodplains, where many wetlands are located.

Due to more aggressive wetland policies and public education campaigns over the past 15 years, the rate of wetland loss has slowed dramatically since the 1950s, from just under half a million acres per year to a little more

In urban environments, once-common aquatic species are no longer present because their physical habitat has been altered, water quality is too poor (e.g., high sediment loads, low oxygen, and increased temperatures and toxics), and invasive species have overwhelmed them. Fish and other aquatic life can rebound when river conditions improve, however. In the past, little more than carp lived in the Chicago River. Today, with significant water-quality improvements, the river sustains 50 species of fish (City of Chicago Department of Environment 2003).

[illegible]

U.S. Fish and Wildlife Service

COMPONENTS OF A RIVER ECOSYSTEM

River ecosystems are complex, with many interacting components. In order to understand how an [illegible] river functions, it is first essential to understand the basic components of a [illegible] river ecosystem. To do so requires information from many scientific disciplines and an appreciation of the ways in which various river components are deeply interwoven.

To make informed decisions regarding riverfront development, planners and riverfront decision makers should be aware of the fundamentals of river ecosystems. Each component of a river ecosystem is the subject of many books, articles, and much scientific study. The following section is adapted largely from material in the Federal Interagency Stream Restoration Working Group's extensive handbook, [illegible] (2001), and an excellent general resource, [illegible] (1998) by James MacBroom, a publication of the Connecticut Department of Environmental Protection.

It is important to note that the character of rivers differs greatly by geography and climate. These differences have a critical bearing on how rivers function, but space limitations restrict us to a very broad discussion here. We strongly recommend that planners consult local natural resource publications when they reach the detailed planning stage of any specific riverfront development for more specific information about the physical structure, function, and ecology of local river types.

Presented below is a basic primer on the component parts of a river ecosystem—watersheds and the hydrologic cycle, sediment cycles, headwaters, floodplains, and river channels—and the impacts of urbanization on each.

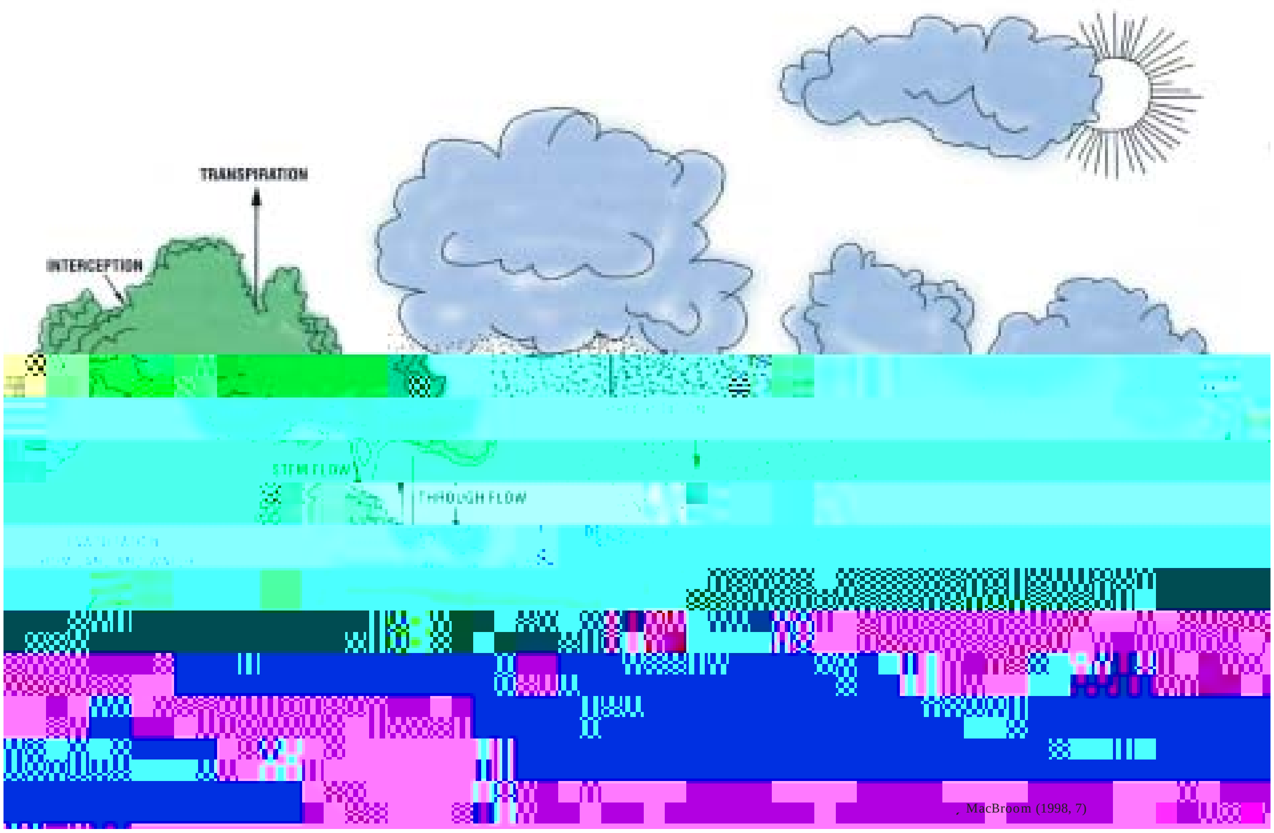
Watersheds and the Hydrologic Cycle

A watershed is the area of land that drains into a given stream, river, lake, or wetland. Water movement through a watershed begins with rain or snowmelt or groundwater that wells up to the surface of the land. It moves downhill (even in seemingly flat terrain, water will move in one direction or the other depending on the gradient of the land) over the ground as a sheet of water, then collects in small rivulets that erode shallow channels in the soil and feed small streams. These streams receive more runoff and groundwater discharge as they descend, eventually merging where their valleys intersect. In large watersheds, they join to form major rivers that ultimately empty into the oceans.

Watersheds, the hydrologic cycle, and rivers are all closely intertwined. The natural system by which water circulates through the Earth's atmosphere, over its surface, and beneath the ground is called the hydrologic cycle. Water vapor enters the atmosphere when the sun's heat causes it to evaporate from oceans, lakes, and streams, as well as directly from snow, ice, and soil, and through transpiration, which is the release of water vapor by plants during photosynthesis. It is returned to the Earth as precipitation, which soaks into the ground or runs over the surface and into streams as described above.

When a stream's water level is lower than the water table, groundwater seeps into the channel, replenishing the flow. (See Figure 2-5.) The U.S. Geological Survey estimates that, on average, 40 percent of annual streamflow comes from such groundwater discharges, also known as baseflows (Alley et al. 1999). In dry seasons and arid climates, groundwater may constitute nearly all the flow in a river. Groundwater from springs and seeps is also important to water quality and aquatic life, because it is usually cool, clean, and rich in dissolved oxygen.

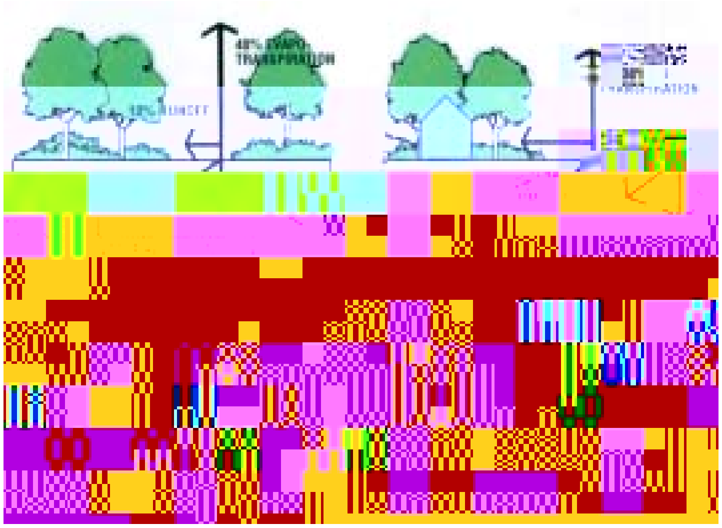
FIGURE 2-5. THE HYDROLOGIC CYCLE



MacBroom (1998, 7)

What occurs on the land in watersheds has a profound impact on the hydrologic cycle, and thus on rivers—from water quality to water-flow volumes and timing. For example, in undeveloped watersheds, rain and melting snow are intercepted by the leaves of trees and other vegetation; what does not evaporate is absorbed into the soil. In urban watersheds, precipitation hits hard surfaces, such as roofs, roads, and parking lots (all are called impervious surfaces), and rushes into storm sewers without being absorbed, thereby short-circuiting natural hydrologic processes. (See Figure 2-6.) As a result, larger amounts of water surge through streams and rivers in shorter periods of time. Studies have repeatedly shown that the percentage of impervious cover in a watershed has a direct impact on the physical integrity and aquatic life of rivers and streams

FIGURE 2-6. HYDROLOGIC CHANGES RESULTING FROM URBANIZATION



MacBroom (1998, 141)

Sediment Cycle

The sediment cycle starts as soils in the watershed erode and are transported by surface runoff that washes into rivers. Subsequent movement of sediments through river systems is a complex and extremely important aspect of how rivers function. Heavy sediment particles, such as gravel and cobbles (loose rock smaller than boulders), usually originate in the channel itself. Lighter, suspended particles of silt, clay, or sand may originate on the land or be scoured from the channel itself. The overall composition of sediments varies widely among regions of the country and can vary significantly along the same river (MacBroom 1998).

Most sediment is transported during periods of high-water flows and high velocities. Heavier sediments, such as gravel and cobbles, are pushed, dragged, and bounced downstream along the bed of the channel. Lighter sediments, such as clay and silt, can remain suspended in a river for a significant period of time—giving it a muddy appearance after a rainstorm—until water flows and velocities decrease sufficiently for the sediment to settle out and deposit on the river bed, bank, or floodplain. Sediment movement in streams is a natural process that can be significantly altered by human changes to channels, such as dams and flood-control structures, as well as changes in amounts and timing of urban runoff (MacBroom 1998).

Changes to sediment cycles in urbanizing rivers occur first during active construction phases, when natural groundcover or agricultural crop vegetation is removed for site grading and preparation. This releases tremendous amounts of sediment into nearby streams and rivers. Runoff from construction sites is by far the largest source of sediment in urban areas under development. Uncontrolled construction site sediment loads have been reported to be on the order of 35 to 45 tons per acre per year (U.S. EPA 1993).

As urbanization progresses and natural surfaces are paved over, runoff increases and surges more rapidly into receiving waters (Riley 1998). These altered urban flows carry strong erosive force and cause significant channel erosion. Researchers have documented that channel erosion constitutes as much as 75 percent of the total sediment in urban streams, particularly during periods of urbanization when the channel is still enlarging (FISRWG 2001).

State environmental protection agencies report that siltation, comprising tiny sediment particles, remains one of the most widespread pollutants affecting rivers and streams. Siltation affected 31 percent of "impaired" river and

HOW URBANIZATION AFFECTS STREAMS

Changes in stream hydrology resulting from urbanization include the following (Caraco 2000):

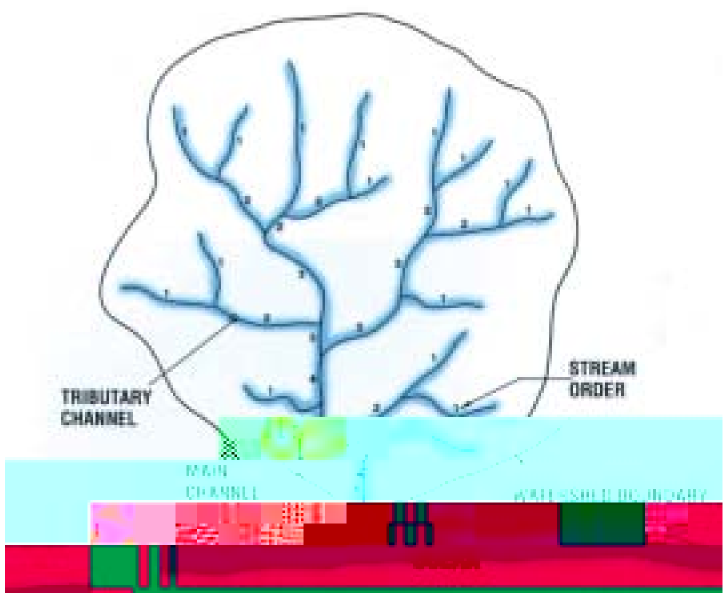
- Increased peak discharges compared to predevelopment levels
- Increased volume of urban runoff produced by each storm
- Decreased time needed for runoff to reach the stream, particularly if extensive drainage improvements are made
- Increased frequency and severity of flooding
- Reduced streamflow during prolonged periods of dry weather due to reduced level of infiltration in the watershed
- Greater runoff velocity during storms due to the combined effects of higher peak discharges, rapid time of concentration, and the smoother hydraulic surfaces that occur as a result of development

stream miles, according to the U.S. EPA. Siltation alters aquatic habitat, suffocates fish eggs and bottom-dwelling organisms, and can interfere with drinking water treatment processes and recreational use of a river (U.S. EPA 2002d).

Urban rivers with dams—and few rivers do not have some kind of engividual pools filled with water. Desert headwater streams can arise from a spring and run above ground only a few hundred yards before disappearing into the sand. Other spring-fed headwaters contain clear water with steady temperature and flow. Yet other headwaters originate in marshy meadows filled with sluggish tea-colored water.

Headwaters arise from different sources depending on the landscape. In mountainous regions, headwaters occur as snowmelt and rain, which flow in channels down slopes. Where the water table intersects the surface of the land, headwaters appear as springs and seeps, which form the headwaters of many small streams and wetlands (MacBroom 1998).

The majority of America's river miles—more than 85 percent—are small headwater streams, also known as first-order through third-order streams (Leopold et al. 1992). Even urban areas often have small streams feeding into major rivers, either directly or through a tributary into which the smaller stream feeds.



MacBroom (1998, 25–26)

Because they occupy the entire range of climatic and geological conditions found in the United States, headwater ecosystems collectively contain an enormous diversity of riparian and wetland plants and animals, with many unique species and communities. Individual headwater streams support hundreds to thousands of organisms, ranging from bacteria to bats. The species in a typical headwater stream include fungi, algae, higher plants, invertebrates, fish, amphibians, birds, and mammals. Some of these ani-

THE VALUE OF HEADWATERS

Because of their small size, headwater streams in some locations have been treated as mere water "conveyances" and have been ditched, channelized, moved, or even buried in pipes. Historically they have not been appreciated for their contribution to water quality. By their sheer numbers, however, they have important ecological and economic functions. They affect the ecological and economic viability of downstream rivers through the regulation of floodwaters, the maintenance of safe and high quality drinking water, pollution prevention, and numerous other ecosystem services.

—Ohio Environmental Protection Agency (2001)

Headwaters influence downstream conditions in a number of ways. Because of their intimate connection to the surrounding landscape, headwater streams deliver nutrients and organic material to downstream regions, providing an important base for aquatic life downstream (FISRWG 2001). Headwaters are also highly effective at capturing and filtering out sediments, as well as organic material and excess nutrients (Meyer et al. 2003).

Small streams provide much of the freshwater flow into downstream rivers, lakes, and estuaries. In the Great Lakes Basin, for example, the U.S. Geological Survey estimates that over 31 percent of the water entering Lake Michigan comes from indirect groundwater discharges to streams that then flow into the lake (Grannemann et al. 2000). In the Chesapeake Bay Basin, nearly 100,000 miles of interconnected streams, rivers, wetlands, and their riparian areas serve as a "circulatory system" for the Chesapeake Bay. Collectively, this network of small streams supplies 90 percent of the freshwater flow that drives the health of the nation's largest estuary (Center for Watershed Protection et al. 2002).

F d a

The riverside land that is periodically inundated by a river's floodwaters is called the floodplain. Floodplains serve important purposes. They:

- temporarily store floodwaters;
- improve water quality;
- provide important habitat for river wildlife; and
- create opportunities for recreation.

Natural floodplains help reduce the heights of floods. During periods of high water, floodplains serve as natural sponges, storing and slowly re-

reducing the velocity of the river and increasing the capacity of the river channel to move floodwaters downstream.

Many floodplain plants help to improve water quality by capturing excess nitrogen and phosphorous carried in floodwaters before these pollutants can reach the river. In addition to filtering out pollutants, floodplain trees and plants also anchor the river's banks, preventing bank erosion and providing shade, which reduces water temperatures.

Floodplains also provide fish and wildlife the places they need to feed

R e I e . The Guadalupe River has a long history of winter without destroying the streamside vegetation and trees. Maintaining the natural channel is critical to providing water temperatures cool enough to sustain the chinook salmon and steelhead populations in the river. While protecting the ecological integrity of the river, the system will have the capacity to divert significant amounts of floodwater to an existing floodplain.

Extensive mitigation planting also is part of the project, with many plants propagated from seeds gathered within the Guadalupe watershed. An extensive system of recreational trails will extend the length of the park and link to surrounding neighborhoods.

Playgrounds, picnic areas, and plazas for community celebrations will make the park a center of active urban life. Integrated into the plazas and along the trails will be interpretive information on the history, ecology, and hydrology of the project.

Be ef he R e a d C . The Downtown Guadalupe River Flood Control Project, the foundation of the Guadalupe River Park plan, has been extensively refined over the past 15 years to meet the ecological needs of the river and to preserve native fish habitat. These revisions have been a result of changing regulatory requirements, new legislation, protected species listings, threats of citizen lawsuits, and, most recently, a collaborative process launched to seek consensus among all parties involved. Rather than using traditional flood control mechanisms, such as channel widening and armoring, the partners have been able to maintain a more natural riparian corridor along most of the river that complements the recreational amenities offered by the park.

F e f a . . .

- See the Guadalupe River Park and Gardens and Guadalupe River Park and Flood Protection Project web site, www.grpg.org.

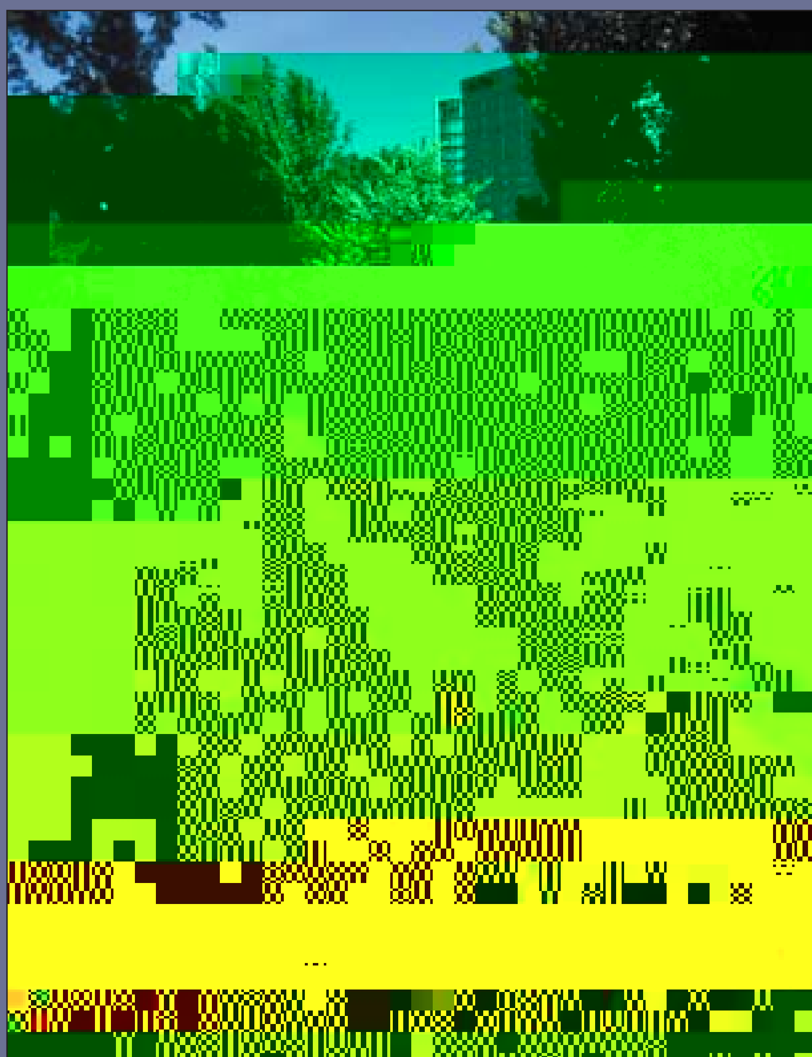
channel equilibrium and stream-flow. If one variable changes, one or more of the other variables must increase or decrease proportionally if equilibrium is to be maintained. For example, if slope is increased and streamflow remains the same, either the sediment load or the size of the particles must also increase. Likewise, if flow is increased (e.g., by stormwater surges) and the slope stays the same, sediment load or sediment particle size has to increase to maintain channel equilibrium. A stream seeking a new equilibrium tends to erode more sediment and of larger particle size. Streams that are free to adjust to changes in four variables—streamflow, sediment size, sediment load, and stream slope—generally do so and reestablish new equilibrium conditions. Streams with bedrock or artificial streambeds, such as concrete channels, are unable to adjust as they would naturally, which may cause more erosion or damage downstream (FISRWG 2001). In urban areas, artificial channels can often cause a chain reaction of more channel armoring downstream to protect against the energy of the artificial disequilibrium upstream.

In some rivers, particularly large Western rivers with heavy sediment loads, the river naturally moves across a wide meander plain depending on floods and other streamflow events that change the previous stream channel equilibrium. In these cases, the best policy is to keep development out of the floodplain, allowing rivers to meander and the channel to realign (Committee on Riparian Zone Functioning and Strategies for Management et al. 2002).

Urbanization changes stream channels directly and indirectly. To accommodate buildings and infrastructure, urban stream channels are often straightened or moved altogether.

To move rainwater down these channels more efficiently, vegetation, meanders, backwaters, boulders, dead trees, and other natural structures are removed or "improved" for maximum speed of floodwater conveyance. In many instances, channels are dredged and deepened to facilitate commercial and recreational boat traffic. All of these direct alterations can have significant negative impacts on river habitat and health.

But at the same time, urbanization indirectly causes rivers to widen their channels or cut deeply into their streambeds (downcutting)—or both—to accommodate more frequent, higher-volume flows. Exactly how channels change through urbanization depends on such factors as channel slope, bedizatis ree to
which the surrounding watershediis sewered (FISRWG 2001). Urban stream channels often enlarge their cross-sectional areas by a factor[Exa wo to five times, depending on these factors. In addition, streams can adjust to urbanization by changing their gradient (channel slope)aiffcmeander pattern, making it difficult to plan activities along the river corridor[and downstream



Friends of Guadalupe River Park and Gardens

CHAPTER 3

P E S

R D

Renewing urban riverfronts entails restoring natu-
ral river systems, redeveloping riverfront sites, or
both. Restoring e78 0 0mr system such asg riverbaks aund
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TAILORING THE PLAN TO THE RIVERFRONT CORRIDOR AND ITS WATERSHED

Too many urban riverfront plans suffer from a "me-too" mentality. Politicians and planners mistakenly want their urban riverfront to become just like the San Antonio Riverwalk or Baltimore's Inner Harbor. They soon find that attempts to transplant ideas from other places often don't work.

Every urban riverfront is different and requires planning solutions appropriate to its unique conditions. Before considering how to apply these principles, planners must carefully define their urban riverfront, including its characteristics, measurements, and boundaries. Factors to consider are described in the following sections.

R S G

Each riverfront corridor has its own geometry, including length, width, and high-water mark, established by common site constraints such as floodplain, public infrastructure, municipal landownership, and historical development patterns. The riverfront corridor can be delineated and mapped on the basis of such factors.

R C

ture can also play an important role in revitalizing a river: water quality, wildlife habitat, and public access can all benefit, for example, from reconfigured sewers and stormwater systems that reduce combined sewer overflows (CSOs).

W P

Riverfront corridor planning must also consider the river's watershed, or the land area drained by a river and its tributaries. The health and vitality of a river cannot be improved without the comprehensive treatment of stormwater and other erosion and pollution sources across the whole watershed (Schueler 2003).

OVERVIEW OF ECOLOGICAL PRINCIPLES

This chapter provides an overview for planning and designing riverfront renewal and discusses the comprehensive, holistic, and regionally specific

GENERAL PRINCIPLES

Riverfront reclamation has begun to transform some of the nation's most polluted, neglected, and forlorn waterfronts. Five general principles set the stage for planning success.

GENERAL PRINCIPLES

General Principle 1: Ecological goals and economic development goals are mutually beneficial

General Principle 2: Protect and restore natural river features and functions

General Principle 3: Regenerate the riverfront as a human realm

General Principle 4: Compromises are necessary to achieve multiple objectives

General Principle 5: Make the process of planning and designing riverfronts broadly participatory

GENERAL PRINCIPLE 1:
E

Public and private development that brings people to the waterfront to live, eat, shop, relax, recreate, and participate in cultural events builds a sense of connection and stewardshiy01 w 78h riv agreements have ensured minimum flows to support wildlife habitat, fishing, and boating. Rafting chutes were built to span check dams and other river obstacles. In 2001, the city of Denver built the $30-million Commons Park in Lower Downtown on a 20-acre tract that had been a rail yard.

As a direct result of municipal investments, the Central Platte Valley, some 650 acres of once-derelict industrial land just above the floodplain, has become valuable urban property and a prime spot for private investment. About 1,100 people now live in 1,600 condos and apartments in eight residential projects, and 1,600 people work in this once-barren area. All told, the revitalized Central Platte Valley has attracted $1.24 billion of public and private investment in the last 10 years.

Since 1995, the Central Platte Valley has become the setting for a new

General Principle 2:

P

By 2002, the U.S. Army Corps of Engineers had already reclaimed 42 acres of wetlands by regrading portions of the Anacostia's bank. To provide access to new park lands, the U.S. EPA and the District of Columbia have committed $8 million toward environmental restoration of Poplar Point, a former nursery site contaminated by remnant fertilizers, herbicides, and pesticides. Washington's mayor, Anthony Williams (2002), has set a goal of swimming and fishing in the Anacostia "within our lifetime."

Key elements of the plan are currently moving ahead. In 2003, the U.S. Congress approved $10 million toward design and construction of a 12-mile riverfront trail system. To remove major barriers to the waterfront, infrastructure such as bridges, highways, and sewers have been reconstructed. Canoe trails are planned through restored wetlands.

Environmental restoration is being closely tied to economic redevelopment, which included $1.1 billion committed in private funds and $600 million in public funds by June 2003 (Berger 2003). At that time more than a dozen riverfront projects were completed or underway with a goal of revitalizing commercial areas, preserving historic buildings and homes, and adding 10,000 new homes near the river for people of different income levels. For example, the U.S. Navy has invested $200 million to restore historic structures at the Navy Yard, which has also brought 5,000 new jobs to the riverfront. The U.S. Department of Housing and Urban Development has committed $35 million toward rede-

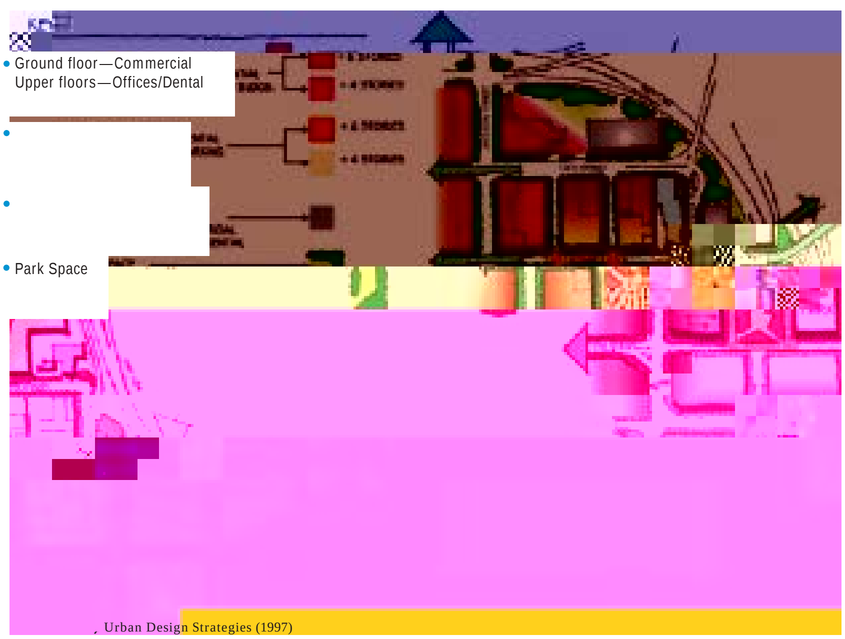
they needed a comprehensive strategy to fill the economic gap. The SPRC commissioned architect Ben Thompson—a Saint Paul native who designed Boston's Faneuil Hall Market and other successful "festival marketplaces"—to forge this new vision for downtown based on riverfront revitalization. That effort led to development of the [illegible] (Urban Design Strategies 1997), which was fleshed out by the [illegible] (Close Landscape Architecture et al. 2000).

The [illegible] divided this urban section of river into seven types of landforms. It identified areas suitable for development and opportunities for natural restoration and enhanced water quality through wetlands, ponds, improved tributary streams, and underground sand filters (Martin 2001).

As a result of these planning efforts, since the mid-1990s the city's riverfront has seen the construction of new cultural facilities, businesses, and thousands of homes. Meanwhile, shipping continues to thrive on this working waterfront . Roads have been moved to increase access to the river through five miles of new trails and 92 acres of new parks, including a newly revitalized historic park on Harriet Island (SPRC 2003).

Although these efforts have included construction of some concrete banks and a U.S. Army Corps of Engineers levee, the revitalization planning also has reclaimed seven miles of industrial lands along the river. Here the non-

FIGURE 3-1. SAINT PAUL NORTH QUADRANT PRECINCT PLAN



Urban Design Strategies (1997)

profit organization Great River Greening (GRG), which works on Mississippi restoration in the Twin Cities region, has leveraged $1 million in funding and the work of 10,000 volunteers to clear weeds and plant 35,000 native trees. Volunteer projects also are being harnessed to restore native vegetation to two eroded river bluffs in Saint Paul (Karasov 2002).

GRG and the city's Department of Parks and Recreation are collaborating on a master plan for ecological management of 16 city parks along Saint Paul's 17 miles of riverfront. These will be managed as complementary ecosystems rather than as discrete, stand-alone parks. One of these park units, the 500-acre Crosby Natural Area, a rare riverfront ecosystem that hosts endangered species such as the Blandings turtle, will have its own management plan to balance preservation, restoration, and human use (BRW, Inc. et al. 1999; Karasov 2003).

General Principle 5:
M

Riverfront planning and design must include the participation of a wide variety of community members. The process must extend beyond identifying traditional stakeholder groups and reach out to neighborhoods that historically may not have used the riverfront. The needs of various neighborhoods and constituencies may differ. Riverfront designs will be more vibrant, inclusive, and successful when they consider these different priorities. Local officials and developers, as well as planning staff, must participate in public meetings to ensure that everyone works toward the same vision, and that all important considerations are made known.

The Schuylkill River Development Council (SRDC) put this principle in practice. In 2001, SRDC, armed with nearly $3 million in foundation and state grants, launched a nine-month process to create a master plan for 8.5 miles of the Schuylkill, a tidal river flowing through Philadelphia. SRDC made concerted outreach efforts to involve residents of river neighborhoods, which included both gentrified and low-income areas. Rather than simply scheduling public meetings, SRDC interviewed city officials to identify target audiences and then made special presentations to church, community, and school groups. A measure of success emerged when Vare Middle School, a public school in South Philadelphia, integrated Schuylkill River projects into its curriculum.

Recognizing that not everyone uses e-mail or the Internet, the SRDC informed residents about meetings by [illegible]

In 2002, a critical first phase of this park was constructed: a $6.7 million, 1.8-mile greenway stretching from the historic Fairmount Waterworks to Locust Street. This greenway provides many residents with their first-ever safe access to the riverfront. The project incorporates plans for many other river improvements, such as retrofits of auto bridges with ramps and stairs to allow pedestrian access to the waterfront, ramps over railroad tracks, $600,000 of new docks at Fairmount Waterworks, and fish ladders on dams (Torres 2003).

PLANNING PRINCIPLES

Planning for riverfront revival must consider regional development patterns, natural and cultural history, flood control, public access, recreation, and education. The following five principles should be integrated into master plans and implemented through zoning and building codes, engineering standards, and site plans and designs.

PLANNING PRINCIPLES

Planning Principle 1: Demonstrate characteristics of the city's unique relationship to the river in the riverfront design

Planning Principle 2: Know the river ecosystem and plan for a scale larger than the riverfront

Planning Principle 3: Because rivers are dynamic, minimize new floodplain development

Planning Principle 4: Provide for public access, connections, and recreational uses

Planning Principle 5: Celebrate the river's environmental and cultural history through public education programs, riverfront signage, and events

PLANNING PRINCIPLE 1:
D

Every river city has a unique relationship and history interwoven with its river. San Antonio and Chicago, for example, have very different riverscapes, scales of development, and historic uses along their rivers. Riverfronts should have a look and feel that evokes and celebrates their city's special character and relates directly to their natural history.

Citizens must understand that their city's river is a place that grants their region its identity, one that provides wildlife habitat, recreation, drinking water, and jobs. When citizens value these factors, they become advocates for protecting and restoring their riverfronts.

The St. Louis region, for example, plans a 40-mile Confluence Greenway and Conservation Area linking cities and towns to the spot where Lewis and Clark launched their 1804 expedition. The project will knit together cultural and natural resources into a 200-square-mile park system in Missouri and Illinois. Stretching from downtown St. Louis at the Gateway Arch areas, parks, neighborhoods, river towns, agriculture, and commerce. The Confluence Greenway will stimulate recreation and tourism dollars by offering extensive waterfront access.

At the confluence, the new Edward "Ted" and Pat Jones-Confluence State Park is being developed in St. Charles County, Missouri. The state's Department of Natural Resources is creating access through entry roads and trails that lead to the confluence while providing opportunities for wildlife observation and river recreation. The park will also interpret the historical significance of the rivers. Park development will be linked to the Lewis and Clark bicentennial celebration of 2004.

The project aims to restore and protect environmentally sensitive land, plants, and wildlife, while assisting flood control and reducing stormwater runoff. Community members will be trained as trail rangers to provide information about the river.

In January 2003, this project took a major step forward. A partnership of 13 local, state, and federal agencies and private organizations collaborated to expand Confluence State Park from 253 acres to 1,118 acres. For example, a $1 million federal grant made under the North American Wetlands Conservation Act allowed the Missouri Department of Natural Resources to

- hydrology (water flows and timing);
- water chemistry; and
- the biological needs of wildlife, including insects, fish, amphibians, reptiles, birds, and mammals.

It is also important to understand how a river's structure has been altered and how it may change in the future. Rivers are affected by what happens in their watersheds, and riverfront activity, in turn, affects areas beyond the river's edge. Planners must keep in mind the consequences of riverfront design and activities on [illegible] areas of the watershed. Each river has a water-

Throughout the region, the GIS database records such elements as land use, tree canopy, slopes, soil conditions, water quality, and areas with invasive plant species. The data is used to create benchmarks for factors such as tree cover, impervious surface, and stormwater filtration for different types of urban, suburban, and natural landscapes (Karasov 2002, 2003).

Completed in December 2002, this database is available for free on CD-ROM to Twin Cities communities through the Trails and Open Space Partnership, a project of the MNRRA. Established in 1996, the partnership works with more than 50 government agencies, institutions, nonprofits, and private landowners toward the goal of a continuous 72-mile greenway within the MNRRA. The GIS database allows communities to earmark funds to acquire the most sensitive natural areas and build the most critical trail connections. Communities also can download this information as PDFs and zoom in on individual parcels for detailed information. The information allows communities to evaluate development proposals based on their potential to damage or to enhance sensitive natural areas.

By 2003, nearly 50 miles of public trail were built in the MNRRA corridor, with plans to acquire another 2,000 acres of public parklands. By thinking regionally, the Trails and Open Space Partnership has attracted $7 million from government agencies and nonprofit organizations to help realize these projects (Overson 2002).

Davenport has moved to expand its floodplain and to “flood proof” its downtown. (The city owns and controls six of its nine riverfront miles, which signficantly enables these efforts.)

Numerous downtown businesses have been moved to higher ground, with the abandoned sites converted to open parkland that enhances recreation and tourism. The city has bought and removed 65 residences and retrofitted another 20 historic buildings in the floodplain with waterproof gates and sump pumps (Lloyd 2002).

In addition, River Action, Inc., a nonprofit group that addresses riverside beautification and flood control, is participating with the U.S. Environmental Protection Agency to cleanse the 513-acre Nahant Marsh within city limits on the riverfront. Under a 1998 master plan adopted by the city council, River Action has acquired 252 acres of the flood-absorbing marsh with plans to open this riverfront area to the public with a boardwalk, interpretive areas, and staging areas for field trips (Wine 2002, 2003).

The city realizes flooding is a riverwide problem that it cannot solve alone. Thus River Action is working with 12 riverfront communities in Illinois and Iowa to encourage healthy river designs that will enhance flood control (Wine 2002).

Despite these efforts, Davenport has not been exempt from flood dam-

practical to revise and update signs. The costs of the construction and installation of stanchions ($1,000 each) have been donated by local governments and the utility company PSE&G. The artist also donated 3,500 hours of work. Erected in 1998, the Hackensack River Stories Project has given residents a new perspective on the potential to regenerate one of the nation's most polluted and threatened rivers (Mills 2000, 2002).

DESIGN PRINCIPLES

"First, do no harm" summarizes the ethic of the Hippocratic Oath. Planners for riverfront revival must also follow this dictum. The best way to ensure the health of an urban waterway is, first, to protect its healthiest features, whether they are water quality, wetlands, or urban forests. Allowing development to disturb these features and then attempting to reconstruct them—even using best management practices—is no substitute for protecting the intact elements of a healthy ecosystem.

DESIGN PRINCIPLES

Design Principle 1: Preserve natural river features and functions

Design Principle 2: Buffer sensitive natural areas

Design Principle 3: Restore riparian and in-stream habitats

Design Principle 4: Use nonstructural alternatives to manage water resources

Design Principle 5: Reduce hardscapes

Design Principle 6: Manage stormwater on site and use nonstructural approaches

Design Principle 7: Balance recreational and public access goals with river protection

Design Principle 8: Incorporate information about a river's natural resources and cultural history into the design of riverfront features, public art, and interpretive signs

This section provides an overview of some of the most effective preservation techniques, including protective zoning, buffer conservation, and open space preservation programs. It also describes the best practices for reconstructing the ecological features of urban rivers, including efforts to remove dams, reduce pollution from runoff, rebuild in-stream habitat, and restore healthy, natural riverbanks.

DESIGN PRINCIPLE 1:
P

Preserving the natural features and functions of America's 3.6 million miles of streams and rivers contributes greatly to urban riverfronts. Through zoning, land preservation practices, and careful site design, communities can protect sensitive areas of rivers and streams from development. As part of the preservation process, communities should determine ecological goals for urban riverfronts and identify missing or altered natural features.

RIVER PRESERVATION TOOLS FROM THE PLANNER'S TOOLBOX

In recent years, Maryland, New Jersey, Oregon, and Washington have enacted smart growth legislation to encourage revitalization of cities and towns while preventing sprawl. Municipalities such as Portland, Oregon, and Boulder, Colorado, have established urban growth boundaries.

Some municipalities offer incentives for development in higher-density areas. Others refuse to subsidize development in "greenfield" areas through public construction of sewers or roads. Or they may impose development moratoria or limitations on the number of building permits issued.

The most successful programs combine incentives for infill or brownfield redevelopment with strategies to protect or enhance natural areas and open space.

Comprehensive regional planning helps mitigate the environmental and economic impacts of urbanization. Especially when combined with effective stormwater management, concentrating development within a metropolitan region can reduce the region's overall impervious surface. The most heavily urbanized sites with the greatest concentration of impervious surface, however, may still require substantial structural stormwater measures. But as long as these measures are carefully designed, a compact metropolitan area guided by smart-growth principles will generate fewer negative impacts and preserve more of a river's natural features than an area dominated by sprawl (Lehner et al. 2001).

Transit-oriented development (TOD) concentrates development around public transit, bike and pedestrian routes, and carpooling facilities. Commercial uses located near transportation nodes can reduce vehicle miles traveled as well as the number and land area of roads and parking lots. TOD thus produces less impervious cover, stormwater runoff, and pollution discharge. Transportation-related hard surfaces account for more than 60 percent of the total imperviousness in many suburban areas (May et al. 1997).

Traditional neighborhood design minimizes the impervious footprint of a neighborhood through compact development patterns that feature narrower roads, smaller lots, shorter front setbacks, shared alleys, and protected open space. New Urbanist developments go a step further by varying housing types and densities and featuring mixed uses. Stores, offices, schools, daycare centers, recreation facilities, and mass transit are included on site or within walking distance, which reduces reliance on automobiles and thus reduces the impervious cover generated by streets and driveways.

Clustering concentrates homes on a limited portion of a site and leaves the rest for open space and wildlife habitat. This approach also includes narrower roads,

In stable streams and rivers, natural equilibrium controls the water flow and sediment supply. Yet many urban rivers have been greatly altered by dams and flood-control structures. Preserving natural river features and functions means avoiding the use of new dams and other engineering solutions, developments. Some municipalities expand the concept to treat native landscapes as functional elements of a development. In such cases, open space, often through restoration and management practices, is used to treat stormwater, enhance biodiversity and wildlife habitat, and provide an enjoyable environment for residents (Lehner et al. 2001).

The Land Trust Alliance's 2002 census recorded 6.2 million acres of natural lands in the United States protected by 1,263 local and regional land trusts. These lands are in addition to those protected by the nation's top land conservation organizations: the Trust for Public Land (TPL), the Nature Conservancy, the Conservation Fund, and Ducks Unlimited (Aldrich 2003; Land Trust Alliance 2003a). Since 1972, TPL alone has helped protect more than 1.4 million acres in 45 states, from recreation areas to small city parks. In June 2002, the Conservation Fund helped transfer 860 acres worth $4.5 million along Plum Creek in Louviers, Colorado, from the DuPont corporation to Douglas County's open space program. These lands, featuring mature cottonwoods and undisturbed riparian areas, preserve a key wildlife corridor for the region, and create a greenbelt for Louviers, a historic company town formerly owned by DuPont (Macy 2002).

Conservation easements are legal agreements between a landowner and a land trust or a government agency that permanently prohibit or limit land uses to protect conservation values. Conservation easements allow landowners to continue to own and use the land and to sell it or pass it on to heirs. By removing the land's development potential, the easement lowers its market value, which in turns lowers estate tax. If the landowner donates the easement, and the donation benefits the public by permanently protecting important conservation resources while also meeting other federal tax code requirements, it can qualify as a tax-deductible charitable donation. The amount of the donation is the difference between the land's value with the easement and its value without the easement.

Conservation easements are popular and commonly used. From 1990 to 2000, local and regional land trusts in the U.S. protected 2.6 million acres through easements (Land Trust Alliance 2003a; Palone and Todd 1998).

Transfer of development rights (TDR) programs allow municipalities to preserve unique and environmentally sensitive natural areas. A form of overlay zoning, TDRs protect landowner property values because landowners are per-

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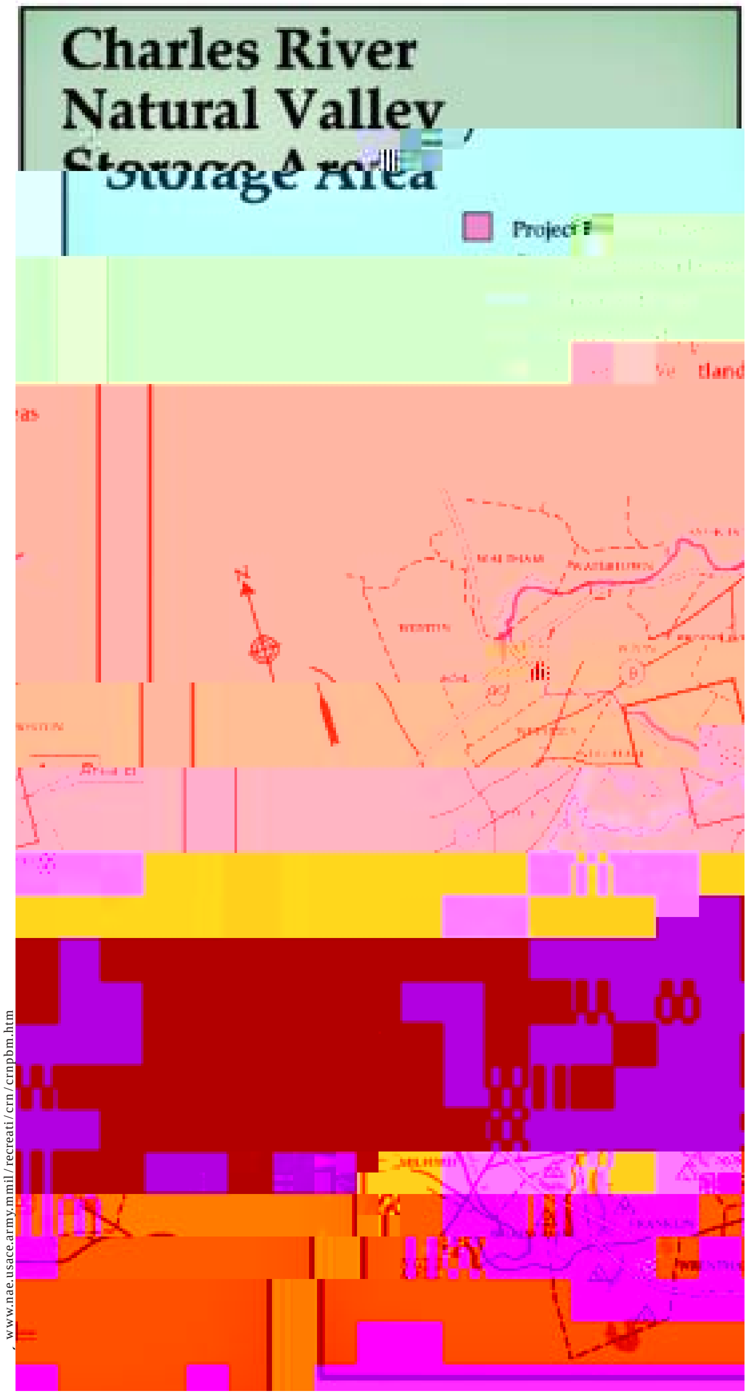
such as straightening, channelizing, or placing streams in underground pipes and culverts.

Fully restoring the ecological features and functions of most urban rivers and streams may be impossible. Yet communities have numerous opportunities to preserve critical areas that support a more natural riverfront. Many urban rivers retain surprisingly rich and extensive predevelopment features, such as forested banks, fish and bird habitat, and wetlands. Preservation of these natural watershed features also can save money.

The U.S. Army Corps of Engineers, for example, found that buying land or easements to preserve a network of natural wetlands in the Charles River Valley outside of Boston cost $8 million, compared to the estimated $100 million cost of building a dam. Maintaining these natural wetlands benefited the aesthetic and ecological qualities of the floodplain and increased the value of adjacent properties (Lehner et al. 2001).

FIGURE 3-3. THE CHARLES RIVER NATURAL VALLE STORAGE AREA



www.nae.usace.army.mmil/recreati/crn/crnpbm.htm

Working with the Charles River Watershed Association, the Corps studied marshes, swamps, and meadows throughout the upper watershed. These wetlands act like huge sponges, storing floodwaters and slowly letting them go over several weeks. The Corps determined that, compared to constructing a dam or levees, preserving the wetlands would not only cost less but would also result in greater storage capacity. These wetlands could temporarily store 10 vertical feet of water.

In 1974, Congress authorized the Charles River Natural Valley Storage Area to acquire and protect 17 wetlands throughout the watershed. By 1979, the Corps had purchased 8,103 acres and today maintains the wetlands. The Massachusetts Division of Fisheries and Wildlife manages some of the acres as open space (Zimmerman 2003).

D R D

Poorly conceived urban development can degrade a river's natural processes and destroy or fragment wildlife habitat. Development generally increases impervious surfaces, which in turn increases stormwater runoff. The greater volume and velocity of stormwater runoff erodes riverbanks and enlarges river and stream channels. The combination of erosion and channelization increases sediments, destroys aquatic habitats, and creates an unstable channel that can increase flooding downstream.

Damage can also occur when infrastructure—including water and sewer mains and transmission lines—is installed in the hyporheic zone, the area below and surrounding the stream channel where critical chemical, biological, and habitat functions occur (see Chapter 2). Digging in these sensitive areas causes severe long-term damage. Riverfront development plans should be especially careful to preserve these less-visible natural features.

Low impact development (LID) is a stormwater management approach that seeks to integrate the built environment with a functioning part of the ecosystem. LID mimics a site's predevelopment hydrology through design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. This approach relies on engineering technologies to maintain or restore a watershed's hydrologic and ecological functions. Such techniques include permeable pavers, bioswales, and maintaining buffer zones. The results control pollutants, reduce runoff volume, and manage runoff timing (Low Impact Development Center 2003).

L P S

Communities can help determine the quality of urban streams and rivers through their land-use decisions. The following strategies for land protection can be a part of a program to maintain the ecological integrity of urban rivers and riverfronts.

Wa e hed a g. Watershed planning considers all resources in the watershed as a single, interrelated system. A watershed is an area of land that drains water, sediment, and other materials downslope to the lowest point. The water moves through a network of drainage pathways, both cover, rather than population density, is the best measure of growth impact and future stream quality.

Watershed planning begins with an evaluation of current and ideal conditions for each body of water in the watershed, as well as comprehensive mapping of land-use practices. Planners then determine land uses that promote healthier rivers, streams, wetlands, and lakes. Public officials, residents, and other stakeholders create a watershed plan and land-use ordinances that designate the locations, levels, and types for new development or redevelopment that will protect or enhance the watershed (Lehner et al. 2001).

I f a d b f e d de e e . Infill and brownfield development recycles urban infrastruc()l.

(1) a fixed buffer, which prohibits development within a certain distance of the high-water line of a perennial stream, or (2) a floating buffer, which varies in width depending on site, soil, and runoff characteristics (Palone and Todd 1998).

- *Z -* . Large-lot zoning is low-density zoning. In some areas, this reduces density to one home per two acres; in other areas, it reduces density to one home per 35 acres. Ostensibly created to disperse the impact of development and reduce stormwater runoff, largeened animal or plant species. Geographical information systems (GIS) and aerial photos are the most effective tools for identifying buffer sites of more than several miles. Buffers should be recorded on official maps and protected through conservation easements, regulations, and signs.

In the Twin Cities region, Great River Greening (GRG) is working to identify, protect, and restore buffers. With the help of a staff landscape ecologist, aerial photos, and GIS technology, the organization has identified the highest-quality buffers along a seven-county stretch of the Mississippi River. Using this information, GRG formulates priorities for ecological restoration, protecting and buffering natural areas, and preserving and creating wildlife habitat, especially for songbirds (Karasov 2002).

GRG also has worked with the Friends of the Mississippi River and more than 100 landowners to protect and enhance buffers. A prime example is their plan to create the 1,300-acre Pine Bend Bluffs Natural Area overlooking the Mississippi. This area includes 700 acres owned by Flint Hills Resources, an operator of local oil fields and refineries that is participating in restoration efforts. Although largely untouched since the nineteenth century, the area was choked by nonnative plants when efforts began in 2000 to restore original oak savanna, oak forest, and prairie habitats. Vol-

B S

How big should a buffer be? To protect stream quality and aquatic habitat a minimum stream buffer of at least 100 feet is recommended (Stormwater Manager's Resource Center 2003). Often even that is too narrow to protect ecological values, depending on the size and topography of the river, nearby land uses, and the purpose of the buffer.

The Federal Interagency Stream Restoration Working Group (2001, 8-12) notes that "most local buffer criteria require that development be set zone is located 100 to 200 feet from the water's edge. This outer zone provides additional river protection but can also accommodate low-impact human activities (MacBroom 1998; University of Georgia Institute of Ecology 2003; Washington County Soil and Water Conservation District 1999).

Planning ordinances specify either fixed or variable buffer widths. Fixed-width buffers typically express a political compromise between protecting a natural resource and minimizing the impact on development and private-property rights. Variable buffers, which become wider in critical natural areas and narrower in stretches of more urbanized development, can be more ecologically sound, but are often more difficult for jurisdictions

prepare the Port Lands' underused and contaminated land for redevelopment and construct a subway platform and a street to connect the waterfront with transit. In summer 2004, the revitalization of Cherry Beach in the Port Lands' Central Waterfront will debut. The Toronto Waterfront

Beyond the Port Lands, decade-long efforts have been underway to revitalize other parts of the Don watershed, which is more than 80 percent developed and home to more than 800,000 people. In 1992, the Metropolitan Toronto and Region Conservation Authority formed a task force (later called the Don Watershed Regeneration Council), which published 40 recommendations on restoring water quality, natural areas, and community access to the river. The Council issues a report card every three years that charts the region's progress (Don Watershed Regeneration Council 1994, 2000).

Design Principle 3:
R

Restoring riparian habitat requires action far beyond simply replanting indigenous plants. First, planners must address watershed and regional factors to establish healthy hydrological cycles and water quality. For example, planted buffer zones must be created and maintained, stormwater controlled and cleansed, and new dams and reservoirs avoided or removed where possible. Likewise, in-stream flows from reservoirs and dams must be managed to protect wildlife habitat.

It is also necessary to conduct research on upstream and downstream natural communities to identify likely restoration areas and habitat types for fish, birds, and other animals. Planners should consider these areas in the context of the larger river system (for example, the relationship of smaller feeding or nursery areas to larger upstream or downstream habitats). After water quality and habitat are improved, native fish and other species dependent on healthy aquatic ecosystems can be reintroduced.

Successful habitat restoration projects should combine at least four major elements:

1. [illegible]. A rebuilt channel should closely resemble its original, natural shape. The reconfiguration and reconstruction of a degraded channel should allow for meanders and other elements of a naturally flowing river or stream.

2. [illegible]. New boulders, gravel, logs, and other natural materials can be deposited to create river features such as riffles, pools, and rapids.

3. [illegible]. Vegetation management includes removing exotic plants and replanting native species, enforcing no-mow zones in riparian buffers, and working with businesses, homeowners, and public agencies to remove impervious surfaces and to promote native plantings in watershed landscapes.

4. [illegible]. Native plants and other natural materials can stabilize and rebuild eroded banks. Live woody cuttings or poles of readily sprouting species can be inserted deep into the soil of a bank or anchored by other means. Bioengineering is discussed as part of Principle 4.

This section addresses natural channel design, daylighting creeks, in-stream habitat structures, dam removal, and vegetation management.

N C D

BRONX RIVER N , N

CASE STUD

R. e I e. After three centuries of development and industrialization, the Bronx River was considered an "open sewer." More recently, abandoned industrial areas, neglected parklands, channelization, and riverbank erosion have only added to the stresses on the river. Few tidal wetlands remain, and riparian habitats have been destroyed. In addition, excessive stormwater runoff, flooding, and nonpoint source pollution have contributed to the ecological damage to the river.

Brooklyn Bridge Coalition

Wha Ha Bee Acc hed. The Bronx River is the only freshwater river in New York City. For much of the twentieth century, the reality of a river flowing through the Bronx was ignored and forgotten as the city grew up around it. More often, the waterway was perceived as an open dumping ground for trash, abandoned cars, and appliances. The last quarter century, however, has seen a revitalization and transformation of the Bronx waterfront to a place where people in the city can go for recreation, education, and enjoyment of nature. To redress current threats to the river, local groups have developed joint strategies to mobilize greater community involvement in the restoration of the river and the city's parks.

The Bronx River Alliance serves as the new voice in restoring and protecting the Bronx River. Starting with the Bronx River Restoration Project in 1974, there is a rich history of restoration work in the area. The goal of the Alliance is to: "serve as a coordinated voice for the river and work in harmonious partnership to protect, improve, and restore the Bronx River corridor and greenway so that they can be healthy ecological, recreational, educational, and economic resources for the communities through which the river flows."

Emphasizing the focus of public participation and community involvement, the Bronx River Alliance serves as the coordinated voice for the river. The Alliance is made up of more than 75 community groups, government agencies, schools, and businesses. Among the major partners are the Bronx River Working Group; Partnerships for Parks, Waterways, and Trailways; Bronx Riverkeeper Program; and New York City Department of Parks and Recreation.

engineered flood control projects. Leopold, possibly the leading hydrologist in the past century, inspired later research by scores of scientists, who determined that these natural features also maintain water quality and create wildlife habitat, especially for fish.

In Leopold's wake, many other projects have revived the benefits of natural river and stream channels. For example, a 2001 U.S. Forest Service handbook on stream corridor restoration catalogues techniques to reconstruct a waterway's "profile" to create optimal habitat for fish, plants, insects, birds, and mammals. In assessing conditions for restoration projects, the handbook emphasizes the importance—and suggests careful measurement—of such factors as bank slope, the ratio of the stream length compared to the length of its valley, and even the size of pebbles and other materials in the streambed (FISRWG 2001).

Natural channel reconstruction should include the following steps (adapted from FISRWG 2001, 8-28–8-31):

Cleanup of the waterfront, which began in the late 1970s, continues to this day. Trash piled upwards of 20 feet high along the banks is being removed along with the multitude of items in the riverway itself. Over the years, the Bronx River Working Group has worked tirelessly to reclaim sections of the river and replant them with greenery. With funds secured from federal, state, and local sources, the Working Group has a grand vision for the restoration of the Bronx River. Included in this vision are greenways and parkways along both sides of the river, hiking and biking trails, construction and restoration of wetlands, and projects to contain the overflow of sewage and stormwater. At the heart of this cleanup project is community involvement. Special events such as the Bronx River Golden Ball, where a 36-inch golden orb symbolizing the "sun, energy and spirit of the river" is floated down the river, serve to unite the community and draw attention to the wide variety of areas the river traverses.

[illegible]. These efforts have increased public awareness of the ecological value of Bronx River habitats in supporting commercially and recreationally important fish species. Also, the river is recognized as a valuable natural resource that is central to the well-being of local communities.

[illegible] . . .

- See the Bronx River Alliance web site, www.bronxriver.org
- The Bioengineering Group, Inc. 2000. "Bronx River Preliminary Restoration Plan." [Accessed February 26, 2004.] Available at www.bioengineering.com / tbg_website.htm.
- Clean Water Action Plan. 2000. "The Bronx River Watershed: Community Cooperation in Urban Watershed Restoration." *[illegible] -2000.* [Accessed February 26, 2004.] Available at www.cleanwater.gov / success / bronx.html
- "A River Rises," *[illegible]*, December 3, 2000, Section 14, pp. 1, 26.

- ***[illegible].*** Reconstruction should emulate the channel's natural width and depth, hydrology, size of bed sediments, and riparian vegetation.
- ***[illegible].*** Find another stable and ecologically healthy reach of the same waterway to use as a reference point for the dimensions of natural channel design. Ensure that the information captured includes the chemical, physical, and biological make-up of the healthy reach—not just the habitat structure, but also the mix of creatures in it.
- ***[illegible].*** These will create habitat and "armor" the waterway against erosion.
- ***[illegible].*** Natural channel designs must be able to handle flood control. Analyze flows and adjacent land uses to help select the channel location, alignment, width, depth, and floodplain size.

In Montgomery County, Maryland, near Washington, D.C, the 13.3-square-mile Sligo Creek watershed, in poor condition before 1990, has benefitted from a reconstruction effort. More than 60 percent of the watershed was paved or impervious surface. The creek was polluted by combined sewer overflows (CSOs) during storms. As a result, only a few fish species—none of them native—survived in Sligo Creek.

From 1991 to 1994, Sligo Creek received one of the nation's most extensive watershedwide restorations—one that combined many techniques described in this section. The creek and its tributaries were improved by separating storm and sanitary sewers to eliminate CSOs and through revegetation, bank stabilization, and reconfiguration of in-stream flows. Upstream, three connected ponds were built to detain runoff for up to 36 hours, which allowed pollutants and sediments to settle out. The downstream channel was completely rebuilt with 19 native shrub species reintroduced to the riparian zone. Volunteers then reintroduced native fish by the bucketful. By 1996, fish species had increased from three to 16, including native and pollution-sensitive fish. Fish deformities, lesions, and tumors dropped 75 percent. New greenway trails provide access to this revitalized resource (Thompson 1996).

D C

Creeks channeled into underground culvert pipes destroy a healthy natural environment. Small streams are highly efficient in scrubbing pollution from runoff and auto emissions and thus are critical to the health of the entire watershed (Peterson et al. 2001). Piped creeks lose this capacity to clean runoff. They can dump polluted water into rivers at high velocity, also causing erosion. Culverts often create bottlenecks in stormwater conveyance systems that lead to flooding. Piped creeks also have no value for wildlife.

Creeks that have been encased in pipes or hidden beneath decks can be “daylighted.” A daylighted creek is one whose channel has been excavated and restored. Daylighting seeks to restore creeks to their original channel or to thread them in a new, open channel between buildings, parking lots, and ballfields. Stormwater pipes also can be daylighted or replaced with naturalized swales, constructed wetlands, or rehabilitated estuaries (Pinkham 2000).

California, for example, which has lost 95 percent of its riparian habitat since presettlement times, is now reclaiming hundreds of culverted and piped streams. One of the first was Berkeley’s Strawberry Creek. In 1984, a 200-foot-section of Strawberry Creek buried beneath an abandoned rail yard was re-exposed. As an 80-year-old culvert was dug out, the rehabilitated channel was modeled on the width, depth, and meander pattern of a healthier creek section several blocks upstream. Banks were replanted with native willows, cottonwoods, pines, manzanitas, and other species that require little maintenance or irrigation once established. The creek became the centerpiece for a four-acre, $580,000 city park. Daylighting represented less than 10 percent of that cost (Pinkham 2000).

Strawberry Creek has been an ecological, social, and economic success. While the native riparian vegetation thrives, Strawberry Creek has withstood numerous major storms that would have overwhelmed the culvert. Hundreds of people visit the park and its natural areas daily. Neighborhood property values have risen, and nearby buildings have been redeveloped. The Strawberry Creek project’s success has led to several spin-offs of other creeks in Berkeley.

In Pittsburgh, the daylighting of Nine Mile Run has created an attractive and ecologically diverse new setting on the Monongahela River. For 60 years, Nine Mile Run was buried under a growing 20-million-ton slag heap that covered 238 acres at the stream’s confluence with the Monongahela. In 2001 and 2002, this slag heap was regraded to create a platform for a new residential community called Summerset at Frick Park. The regrading of the slag (an inert byproduct of steel production) also uncovered Nine Mile Run, which is now undergoing an $8 million restoration.

More than 200,000 tons of topsoil have been layered over the regraded slag to sustain newly naturalized landscapes. These will be connected to Frick Park, a 455-acre forest preserve, and to new riverfront trails. Nine Mile Run is also becoming a major amenity for Summerset, which represents a $210 million investment into a formerly underused riverfront site (Bonci 2001, 2002; Ermann 2003).

5. [illegible]. Structures should produce aquatic habitats at a wide range of flows. Generally structures should be low enough so they are almost submerged during high waters.

6. [illegible]. Structures should not contribute to flooding by creating barriers to water conveyance.

7. [illegible]. Model the effects of structures on erosion and sedimentation.

8. [illegible]. Materials may include stone, fencing wire, posts, and felled trees. Use natural materials when possible, especially stone or trees from the site.

9. [illegible]. Track changes in wildlife populations, water temperature and quality, and percentage of area covered with native plants, including tree canopy.

10. [illegible]. Incorporate a management plan with funding into the design.

In Redmond, Washington, the Sammamish River lost much of its riparian vegetation when it was engineered into a deep trapezoidal channel in the 1960s. In the 1990s, a stretch of river was refurbished through downtown. The project combined bioengineering, in-stream habitat construction, and weed removal. The floodplain was enlarged by 50 feet through sculpted riverbank “benches” planted with native vegetation.

Behind City Hall, the river’s meanders and curves have been revived by adding boulders, root wads, and gravel bars to the once-uniform channel. The restored riverfront has become the centerpiece of a new 16-mile trail that connects to a regional greenway system. Salmon, steelhead, native trout, and upland riparian species have returned to the river and its banks (Holt 2002).

D R

Dams block fish migration, disrupt water flow, change water temperature, and generally wreak havoc on the food chain in rivers. They limit public access to rivers and harm the natural and aesthetic quality of their settings.

[illegible]

Parametrix

Efforts to remove unneeded, unsafe, or obsolete dams have been gaining momentum. Of the 75,000 dams identified in a U.S. Army Corps of Engineers inventory, about 66,000 are on rivers. Studies indicate that about 1 percent of these dams are obsolete or unsafe and might be considered for removal. Many communities have low-head dams that no longer serve a purpose, but block fish migration and cause hazards for boating and other recreation. As operating licenses expire and more dams become obsolete, the opportunities to remove dams will increase. By 2020, about 85 percent of all dams will exceed their life expectancy of 50 years.

In recent years, more than 465 dams have been removed across the country. Removing dams where the benefits of removal outweigh the benefits of repair or replacement is the most effective way to restore rivers, save taxpayer money, revitalize riverside communities, and improve public safety.

Removing dams can dramatically regenerate river ecosystems, often in a matter of months. In Hampden, Maine, a dam built to power a grist mill pa365 Tw[(Engineers sal Ha (e ay)1shgraupst the coeo pspawnher)]ivers52020ng an ar fir0 t /otf migrating fish were caught in the river above Augusta for the first time since 1837 (American Rivers et al. 1999).

Downtown Augusta also experienced an economic resurgence following dam removal. Working cooperatively with the state, the city formed the Capital Riverfront Improvement District (CRID) to protect the scenic character of the river, provide public access, and bring additional economic development to a one-square-mile historic riverfront district. Since 1999, the CRID has attracted nearly $10 million in public and private investment, including the award-winning conversion of historic City Hall, vacant for 15 years, into 28 apartments for seniors. The CRID also has raised $3 million for the first phase of an eventual $8 million riverfront park. The park will recycle a remaining brick building from the Edwards Mill as an interpretive center. It will also interpret nine areas of natural and cultural history.

In 2002, the city dedicated the first two miles of a riverfront rail-to-trail conversion through downtown. Already popular, the trail will soon be extended another seven miles toward an eventual 20-mile loop covering both sides of the river and connecting Augusta to neighboring communities (Bridgeo 2003).

V M

Native vegetation helps filter runoff, controls flooding, and reduces or eliminates erosion. Native plants provide shelter and food for wildlife. Canopy trees shading creeks help lower the water temperature and therefore create more favorable conditions for native fish.

Nine Mile Run Greenway Project

REVEGETATION TECHNIQUES

The following techniques can be combined to revegetate conditions that suit a particular stretch of river (Riley 1998):

- Create the conditions for native plants to “reinvade” a site. For example, remove invasive species through weeding programs, dredging, or controlled burns. Remove levees or regrade to allow for natural reseeding.
- Layer dead brush, trees, or tree stumps to stabilize the bank and capture sediment that will become a growing medium for native plant communities. Plant live cuttings from native species such as willows and dogwoods that regenerate readily. These “pioneer” species stabilize banks and create habitat for other riparian vegetation.
- Transplant native vegetation from areas being altered by development.
- Plant nursery-grown natives to emulate the number, density, and relationships of plant species within a riparian community.
- Preserve and enhance existing vegetation, including snags and dead trees, through purchase, conservation easements, floodplain zoning, and ecological management.
- In extremely urban situations with a narrow floodplain and channel, use hybrid engineering methods such as riprap and gabion walls that are packed with soil and planted.

Weeds and other nonnative plants generally provide little or no habitat compared to natives. They can create monocultures with no ecological diversity. The most visible example may be the exotic phragmites reeds that choke and provide many urban wetlands almost no wildlife habitat.

Along the river's edge and in the floodplain, native vegetation can be reestablished through a number of methods. Effective riparian restoration provides wildlife habitat, improves water quality, and anchors soil to control erosion and flooding. Yet even the best projects will not replicate a natural, presettlement river. Replanting "pure" native landscapes next to urban areas may be difficult because native plant communities may not survive urban runoff and pollution. In urban areas, native planting schemes must be installed in specially prepared environments and adapted to the site's water levels, contaminated soils, and levels of runoff.

Revegetation requires a complex process of analysis, planning, design, installation, monitoring, and maintenance. It should be undertaken by an experienced team that includes aquatic and plant ecologists, civil engineers, and landscape architects. The team should first identify, survey, and inventory a stream reference corridor—a healthy riparian habitat with similar hydrology, ecosystems, and climate. Often this corridor will be located on a different reach of the same waterway. Studying the stream reference corridor creates benchmarks for plant density, diversity, and placement.

Once study is complete, revegetation projects can pursue several different strategies. Some begin with canopy tree planting; others with understory plantings; others with grasses and other nonwoody plants that allow a natural succession into mature woodland.

Weed removal and control is equally important. Weeds may be removed by hand pulling (a good volunteer project), cutting, burning, or selective use of herbicides (Pinkham 2000).

Sally Petrella, Friends of the Rouge River

With proper planning, design, and leadership, volunteers can play a key role in revegetation efforts. In the Twin Cities region, Great River Greening gets citizens involved in reclaiming their riverfronts. Since 1995, the organization has trained 460 volunteer "restoration leaders" who have directed another 10,700 volunteers to plant more than 35,000 native trees and shrubs and 16,500 prairie grasses and wildflowers in Mississippi River valleys (Karasov 2002).

In Salinas, California, a group called Return of the Natives built six greenhouses that produced 30,000 native plants. Local schoolchildren seeded,

the town of Napa. A major bridge has been replaced by a longer bridge with footings removed from the floodplain. Another similar bridge replacement is scheduled.

Levees have been removed to allow the river to recapture 400 acres of natural floodplain. Floodwalls and other structures are being removed, bridges altered, and levees pulled back to give the river room to expand during floods. Trees and other vegetation have been restored to the riverbank. Marshy terraces and wetlands will replace cement terraces. No reseeding is needed since tides on this estuary are reestablishing native wetland plantings. On the river's edge, programs to replant native oaks and buckeyes are underway.

Through downtown, the district has pursued a compromise approach. One riverbank remains engineered with a floodwall. The opposite bank is being naturalized and widened by several hundred feet. Redevelopment on this riverfront is being encouraged with design guidelines for suitable setbacks, limited impervious surfaces, and native plantings.

Developers are also being encouraged to embrace the river by providing visual and physical access. As pelicans and other native shorebirds return to the area, residents are excited about seeing the renewal of the Pacific Flyway's vast ecological richness (American Rivers 2003b; Malan 2002).

Few projects approach the comprehensive scope of the Napa River effort, but all rivers can benefit from nonstructural solutions used there.

Clark Country, Washington, Department of Public Works

B

One alternative to hard engineering—bioengineering (also known as soft engineering)—has gained acceptance among civil engineers and public works departments. Bioengineering uses plants to stabilize watershed slopes, a practice that may date as far back as ancient Roman times (Riley 1998).

While held to the same performance standards as hard engineering, bioengineering uses plants and other natural materials to simulate natural forces that, in turn, control floods, maintain water quality, provide access to recreation, reduce erosion, and create wildlife habitat.

Bioengineering minimizes structures like levees in favor of natural floodplain storage through riparian and wetlands restoration. Instead of riprap, concrete, or steel walls, a bioengineering approach uses naturalized bank slopes, broad floodplains, riverbends, and floodplain forests and wetlands to stabilize riverbanks and prevent erosion. Wetlands can be enhanced or created to filter stormwater and reduce flooding. Natural riverbanks often feature gently sloped banks with access for boating and fishing.

Bioengineering minimizes

Successful bioengineering requires the cooperation of an interdisclplinary team that includes engineers, ecologists, hydrologists, planners, landscape architects, landscape contractors, and an engaged public. Bioengineering must begin with planning at the watershed level. Elements such as the percentage of impervious surface and nonpoint pollution sources should be analyzed, cataloged, and addressed. Once study has been completed, bioengineering projects can be scheduled throughout the watershed, much as public improvements are staged for urban infrastructure through an annual capital improvements budget. Areas receiving attention first might be those with the greatest potential to engage public interest and support, such as public parks, urban waterfronts, and the edges of schoolyards. Or priorities may be based on the need to control floods or to halt and repair erosion.

Bioengineering reverses the degradation of creeks, streams, and rivers. For example, unstable or eroded banks can be bioengineered to simulate the slope, vegetation, appearance, and ecological function of a natural bank. Bioengineering is generally less expensive to construct than hard engineering, which can cost $1,400 per linear foot for a technique like steel sheet piling (Hartig et al. 2001). An Ontario study found consistently lower costs for bioengineering compared to riprap or concrete walls (Patterson 2000).

Long-term maintenance costs of soft engineering can also be lower because over time these “living structures” mature and stabilize, rather than deteriorate. For example, a stable, naturalized riverfront—unlike a channelized river with floodwalls and other hard features—will need almost no bank repairs, will suffer less damage from flooding, and will not collect sediments that must be dredged (Wenk 2002).

The following techniques can be combined as appropriate within the same riverbank (adapted from Riley 1998, 374–84):

- [illegible] are oblong bundles of cuttings planted on angle to stabilize a slope and slow runoff as it enters a stream. Bundles are staked in rows parallel to the waterline. The cuttings (often native cottonwoods, dogwoods, and willows) will sprout and fill in to cover the bank.
- [illegible] are live cuttings laid on terraces that will take root in the banks.
- [illegible] consist of live cuttings held in place by a staked mat.
- [illegible] involves stuffing clusters of live stakes to stabilize gullies.
- [illegible] can be used in conjunction with synthetic geotextile mats or natural cotton, jute, sisal, and coir mats that will biodegrade.

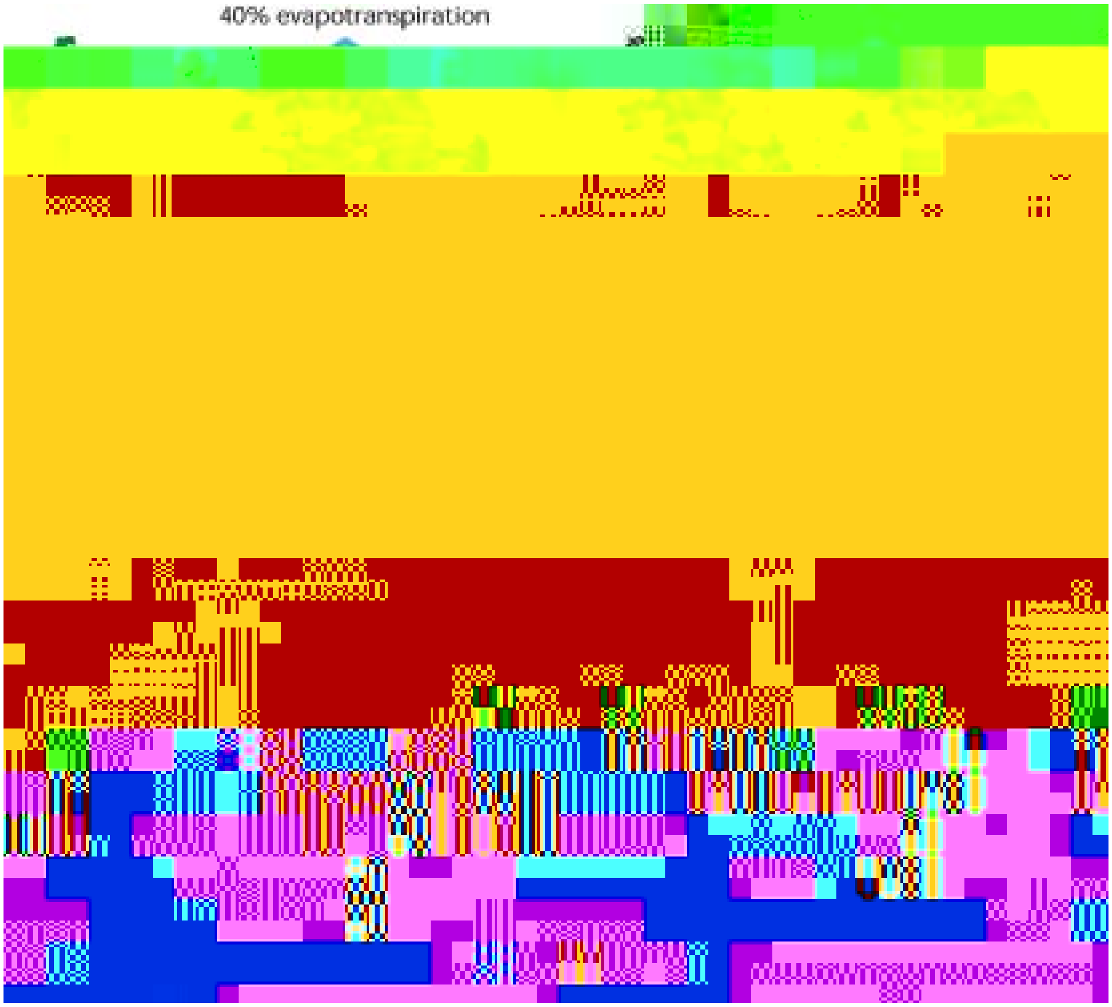
Bioengineering works best in concert with channel designs that restore natural floodplains and bank grades. Yet urban riverfronts are more difficult to restore with nonstructural alternatives because virtually no urban rivers flow through their original floodplains. Tributaries and creeks, on the other hand, generally are easier to adapt for nonstructural alternatives, including bioengineering and natural floodplain design.

Throughout the United States, efforts are underway to add natural features to urban rivers, even in extreme circumstances. For example, the Willamette River is encased in a huge seawall as it flows through Portland, Oregon. Most of the former natural floodplain is now built up as downtown Portland.

Reconstructing the river's natural features in this highly altered environment is impossible. Yet the city's [illegible] suggests numerous strategies to "soften" the seawall and other hardscape features (City of Portland 2001). Given to property owners who submit plans for waterfront development to a design review board, the [illegible] provides alternative designs intended to improve conditions for fish (including endangered stocks of Pacific salmon), other wildlife, and people.

The [illegible] suggests several techniques to add native plantings to the seawall. One calls for the installation of a "timber grid," a latticework that extends beneath the waterline on the seawall and supports aquatic plant species. The grid creates new habitat by providing cover for young fish. Other strategies include attaching root wads to timber pier pilings and creating "floating planters" for native upper-shore plants. These relatively low-tech methods may cost tens of thousands of dollars rather than the millions required for large-scale engineering. Property owners who implement the [illegible]'s ideas benefit from streamlined review and may have a better chance of complying with the Endangered Species Act (Fishman 2002).

Design Principle 5: [illegible]



contribute to pollution when stormwater washes surface oils, fertilizers, heavy metals, bacteria, and other contaminants into rivers and streams.

Watershed experts generally divide impervious surfaces into two categories: habitats for people, such as buildings and sidewalks, and habitats for cars, such as roads, parking lots, and driveways. In suburban areas with big-box stores and sprawl, parking lots and other car habitats represent most paving. In urban areas with structured parking and multilevel garages, human and car habitats are about equal as hardscape factors (Brown 2002). A third category is impaired pervious surfaces, or urban soils such as suburban lawns, which are natural surfaces that have become compacted through human action (Lehner et al. 2001).

Imperviousness is one of the most useful measures of the impacts of land development. Research studies conducted in many geographic areas, concentrating on many variables and employing a wide range of methods, have reached a similar conclusion: at a relatively low level of imperviousness—around 10 percent of cover in a watershed—streams become ecologically stressed. Stream stability is reduced, habitat is lost, water quality degrades, and biological diversity decreases. Imperviousness of 25 percent significantly impairs the stream. At 40 percent, it becomes damaged, and at 60 percent, a stream is severely damaged (Schueler 1995a; Center for Watershed Protection 2003a).

BETTER SITE DESIGN
FOR SUBURBAN DEVELOPMENT

A collection of planning practices known as “better site design” can conserve natural areas, reduce watershed pollution, save money, and increase property

BETTER SITE DESIGN FOR SUBURBAN DEVELOPMENT ( )

8. Reduce overall parking lot imperviousness by providing compact-car spaces, minimizing stall dimensions, and using efficient parking lanes and porous materials for spillover parking.
9. Provide economic incentives for parking garages and shared parking.
10. Provide stormwater treatment for parking lot runoff with naturalized retention ponds, swales, and other features that can be integrated into landscaped areas like medians and traffic islands.

L D

1. Protect the watershed by advocating for open-space design subdivisions with smaller lot sizes that will minimize total impervious area, reduce construction costs, conserve natural areas, and provide recreation space.
2. Relax side-yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.
3. Promote more flexible design standards for residential subdivision sidewalks. Consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.
4. Reduce overall imperviousness by promoting alternative driveway surfaces and shared driveways to two or more homes.
5. Specify how community open space will be managed and designate a sustainable legal entity to be responsible for managing natural and recreational open space.
6. Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas, and avoid routing rooftop runoff to roadways or the stormwater system.

Center for Watershed Protection (2003b)

standard cul-de-sac layouts, reduce site imperviousness 10 to 50 percent (Schueler 1995c).

Zoning ordinances that allow fewer parking spaces for commercial and residential development make sense for sites near public transportation, or when existing parking can be shared with other new development. Narrower roads—even four-foot reductions from the standard 26-foot width—create much less runoff.

On commercial and municipal sites, developers can reduce paving with alternative parking designs. Businesses with parking demands at different times, such as a medical practice and a restaurant, can share the same parking lot. Other alternatives include planning lot capacity for average rather than peak parking demands, placing parking beneath commercial buildings, and constructing multistory parking garages (Lehner et al. 2001).

Portland, Oregon, has reduced its parking lot standards. City regulations formerly required 24-foot-wide aisles and 9-by-19-foot stalls, with some smaller

SMART SITE PRACTICES FOR REDEVELOPMENT AND INFILL PROJECTS

Urban redevelopment and infill projects can help revitalize city centers and provide opportunities for environmentally friendly growth. Because of the potential impact of such projects on urban rivers and streams, however, planners should consider the site location and other factors such as stormwater runoff, water quality, air quality, and natural habitat, along with building and zoning codes and regulations.

The Center for Watershed Protection convened the Redevelopment Roundtable, a group of national and local stakeholders, to develop Smart Site Practices for redevelopment and infill sites. The group issued the following 11 practices, which are adapted with permission from the (CWP 2001b):

1

Brownfield and other legislation generally requires that infill and redevelopment sites be subjected to a site history, surface soil and water testing, and clean-up. Bank loans also often carry such requirements. Even when not required by law or loan terms, developers should prepare a thorough environmental site assessment. To address environmental constraints and highlight opportunities for restoration and reclamation at a site, this assessment should include a base map that outlines existing buildings, transportation networks, utilities, floodplains, wetlands, streams, and other natural features.

2

Impervious cover has a direct impact on annual runoff volume and increases pollutant loads, flooding frequency, and stream channel degradation. Some impacts can be mitigated by reducing or using existing impervious cover efficiently, and by managing stormwater runoff on site.

3

stalls for compact cars. While SUVs are big, they actually are shorter and narrower than the vehicles driven when the standards were written decades ago. In 2002, the city unveiled standards for "hybrid" spaces that fit most vehicles. Developers now have the option of building narrower, 20-foot-wide aisles and smaller, 8.5-by-16-foot stalls. Developers like the code because it reduces construction costs. An added incentive is lower fees. Portland charges commercial and multifamily developers a stormwater management fee based on square footage of impervious surfaces. In 2005, the city will begin discounting this fee for reduced paving. The city intends to begin the discount in 2005, retroactive to a year to be determined (Liptan 2002, 2003).

A P

Alternative paving surfaces—also called alternative pavers—are permeable or semipermeable surfaces that allow varying degrees of water infiltration. Alternative paving materials are an important component of low-impact development that can achieve stormwater management conditions close to nature. They can be used to infiltrate rainwater on site and reduce runoff leaving the site, which in turn help decrease downstream flooding, the frequency of combined sewer overflow events, and the temperature of stream water.

Studies by William James at the University of Guelph, for example, found that pavers made of interlocking concrete blocks can significantly reduce the surface runoff loads of such contaminants as nitrite, nitrate, phosphate, phosphorous, metals, and ammonium. They also reduced runoff temperatures by two to four degrees Celsius compared to asphalt paving. The Low Impact Development Center (2003) summarizes the benefits of alternative pavers: they "can eliminate problems with standing water, provide for groundwater recharge, control erosion of streambeds and riverbanks, facilitate pollutant removal, and provide for a more aesthetically pleasing site." In some cases, they can eliminate the need for underground sewer pipes and conventional stormwater retention and detention systems.

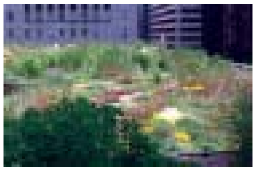
Alternative pavers can replace asphalt and concrete in parking lots, fire access roads, driveways, and walkways. Paving blocks are one type of alternative paver: these blocks are cement or plastic grids with voids that can be filled with gravel or grass and used for parking and driveways. Gravel, cobbles, brick, or natural stone arranged in a loose configuration can also be used to construct driveways. Wood mulch is appropriate for walking paths. Traffic volume and type, access for the handicapped, and climate considerations like soil and snow removal may limit the use of some of these alternatives. For example, alternative pavers are best used for overflow parking

Stormwater soaks into the ground and seeps into Papermill Run, a 20-foot-wide urban stream on the property (Franklin and Franklin 2002).

of the basin. Infiltration trenches, generally filled with rocks and gravel, create a reservoir for water that will be infiltrated to surrounding soil. French drains, another widely used infiltration technique, are small infiltration trenches at the bottom of gutter downspouts. These allow water to infiltrate on site rather than passing into the storm sewer system (Lehner et al. 2001).

Although less natural than bioretention ponds or swales, infiltration basins can still provide water-quality benefits. These basins temporarily store runoff until water percolates slowly into the soil. Infiltration basins reduce peak flow and recreate to some extent the natural pattern of water infiltration. They can handle up to 98 percent of stormwater and remove significant amounts of pollutants. They can cool stormwater significantly, to 55 degrees, as it infiltrates into the ground, and they thus reduce the damaging effects of heated stormwater on aquatic environments.

Successful projects require soil that is capable of infiltration. One study suggests such soil can contain no more than 30 percent clay. Yet other studies of infiltration basins suggest a high rate of failure, mostly due to clog-



City of Chicago

Considering the savings associated with deferred maintenance and reduced energy consumption, green roofs compare in cost to conventional roofs.

Also in Portland, the Water Pollution Control Laboratory harvests rainwater directly from the lab's gutterless roof. Scuppers that extend from the roof shoot rainwater in a trajectory into a wide, rock-lined bioswale several feet from the edge of the building. Planted with ornamental wetlands grasses and other plants, the bioswale offers an artistic approach to stormwater management (Thompson 1999).

G ee R f . Rooftop gardens are another solution that minimizes runoff volume by absorbing stormwater. Widely used in Europe, so-called green roofs are beginning to sprout in American cities. Green roofs are a lighter modern variant on sod roofs and can capture 15 to 90 percent of stormwater, depending on soil, rooftop cover, and weather conditions (Low Impact Development Center 2003).

Green roofs also can improve water quality by filtering pollutants such as nitrogen, which breaks down in soil and is absorbed by plants. Green roofs provide extra insulation that can reduce energy costs for heating and cooling, and can extend the roof's life span by preventing exposure to ultraviolet rays. Considering the savings associated with deferred maintenance and reduced energy consumption, green roofs compare in cost to conventional roofs (Low Impact Development Center 2003).

They also soften and beautify urban skylines with flowers and shrubs that draw birds and butterflies, which, beyond their aesthetic and ecological value, can raise property values. They can even produce vegetables and fruit.

Green roofs are not merely container gardens. They completely cover roofs with lightweight planting material and have an additional layer impenetrable to roots, sharp objects, and water seepage. Because urban rooftops in many regions can have a desert-like microclimate, they often do best with drought- and heat-tolerant plants with shallow roots. Designed and installed properly, with the help of engineers who specialize in green roofs, they pose little risk of collapse or water damage.

Green roofs come in two general types. An garden—basically a meadow planted on a thin layer of planting medium—requires little or no irrigation or maintenance and usually is not accessible to the public. An rooftop garden is landscaped with trees, water structures, walkways, and other elements of a traditional garden that may need frequent irrigation. Some green roofs rely on a simple plant palette, such as native grasses.

In 2001, the North American Premier Automotive Group, a division of Ford Motor Company, installed a 45,000-square-foot roof garden on one wing of its new 300,000-square-foot headquarters in Irvine, California.

The garden atop the one-story building features drought-tolerant groundcover plants. Ford hopes the roof will produce oxygen, create a habitat for bees and butterflies, reduce stormwater runoff, extend the roof's life, and help reduce interior heat. Although the rooftop is not being monitored formally, the property manager reports that air conditioning costs are lower compared to other buildings (Borghese 2003; Roofscapes, Inc. 2003).

Spanning 20,300 square feet atop an 11-story building, the green roof of Chicago City Hall includes walkways and 20,000 plants covering a range of landscape environments from native meadows to trees and shrubs. Completed in 2001, the design ranges from 3.5-inch-deep extensive areas to 24-inch-deep intensive areas. Rooftop weather-station monitoring indicates the gardens have lowered surface temperatures. For example, on one August afternoon in 2001, the air temperature was in the 90s. The roof garden registered between 91 and 119 degrees Fahrenheit, at least 50 degrees cooler than the black tar roof on the adjacent Cook County building. The green roof saves $3,600 per year in energy costs (City of Chicago 2003).

C e . Cisterns are a less common but promising detention measure. A "green" house at Carpenter Village, a New Urbanist development in North Carolina, features two underground cisterns that supply irrigation water. The yard contains two in-ground pump tanks connected to gutters. Downspouts direct rainwater to the cisterns, which hold up to 1,250 gallons each. The cisterns work by pressure, pumping out water for irrigation, car washing, and other exterior uses. For $4,000 to install the system, the cisterns

Motorized boating presents a more direct threat to habitat. Eighty-five percent of the 29 million gallons of oil dumped into America's waterways each year comes from the two-stroke engines used in many boats and personal watercraft (PWCs), often known by the brand names Waverunner or Jet Ski. Even small spills measured at parts per trillion are toxic to fish and aquatic plants (Committee on Oil in the Sea 2003).

PWCs also create noise pollution and pose safety challenges. Only 10 percent of the motorized boats registered in the United States are PWCs, yet they account for 30 percent of accidents, of which 80 percent are collisions. In recent years, some communities have banned or restricted PWCs. In 1995, San Juan County, Washington, which includes the San Juan Islands, became the first jurisdiction to ban PWCs outright. San Francisco County enforces a 1,200-foot setback from shorelines for PWCs, except for limited access to boat ramps. The National Park Service has restricted or banned PWCs on portions of the Colorado, Missouri, and Rio Grande Rivers (Smith 2002).

Powerboats and marinas also present user conflicts and environmental concerns. No-wake zones help canoeists and anglers coexist with powerboats. Yet, some communities have rejected proposed marinas because of concerns about disturbing wildlife habitat and threatening endangered marine mammals.

Human health issues are another access challenge. Some 300,000 miles of rivers and streams do not meet state water-quality guidelines. Even with advances since the Clean Water Act, many urban rivers are not clean enough for swimming or to produce edible fish. The EPA and other regulatory agencies are struggling to control such pollution sources as urban runoff and combined sewer overflows (U.S. EPA Office of Water 2000).

S A E

Greenways and river trails combine recreational access with environmental enhancements and can often be incorporated into other infrastructure c16.7o8.6(s. Ev200 we9T-)]330 -1.5263 2*-0.0265 Tt stasetbaco pntr 2000)nt

Greenways and river trails provide a “green infrastructure” by incorporating flood control, river buffer zones for filtering stormwater, and transportation. In Boulder, Colorado, where a 60-mile greenway system links neighborhoods to schools, jobs, and shopping, about 12 percent of the population commutes by bike, or about 12 times the national average.

After a major flood, Louisville, Kentucky, in 1946 created the Metropolitan Sewer District (MSD) to build dams and levees, channel streams, manage sewers, and build wastewater plants. In the 1990s, MSD officials admitted that many of its engineering measures were ineffective. The river still flooded, and surging stormwater brought pollution into the river and its tributaries.

Regional support for protecting the river led to passage of an innovative riverfront housing, commercial development, and a minor league baseball stadium (Calkins 2001). The park is located entirely within the 100-year floodplain. The first 50-acre phase withstood a 1998 flood with no major damage (Croce 2002; Flink 2002). Since then the master plan for Waterfront Park has been updated to dovetail with Jefferson County's greenway master plan.

These riverfront and tributary improvements have enhanced nearby property values. In the Louisville region, real estate with visual and physi-

Burke-Gilman Trail found no difference in crime rates when the trail area was compared to the rest of the city. Property values for homes near the trail enjoyed a 6 percent premium (Little 1995).

W T :A G M

A water trail is a stretch of river, shoreline, or ocean that has been designated to provide educational, scenic, and challenging nature-based experiences to recreational boaters. For communities across the country, water trails are a valuable tool for promoting a healthy economy and a high quality of life while preserving natural systems and cultural heritage. Water trail projects can inspire individuals, unify communities, provide hands-on experience for recreation and city planners, and serve as outdoor classrooms for students and educators.

Inaugurated in 1998, a 24-mile stretch of the Susquehanna River between Halifax and Harrisburg became Pennsylvania's first water trail. It incorporated four access sites and 10 river islands for day use and primitive camping. The trail is managed by a partnership of the Pennsylvania Fish and Boat Commission, Pennsylvania Department of Conservation and Natural Resources, the Pennsylvania Game Commission, the city of Harrisburg, and the Alliance for the Chesapeake Bay. Volunteer groups have already adopted islands and access sites. Members serve as trail stewards and are responsible for maintaining the trail, monitoring resource impacts, and analyzing public use. Today this trail is a part of the 51-mile Middle Susquehanna River Water Trail, which is one of Pennsylvania's 16 state-designated water trails (Pennsylvania Fish and Boat Commission 2003).

Design Principle 8:
I ,

Ecological interpretation and education are important along urban rivers because so many natural systems and references have been erased. The river's history and function may not be obvious to the public. An informed public that understands river ecology as well as the potential for regeneration will support efforts to improve and protect its river. Citizens also need to know how to use their river safely and should be informed about water-quality issues and hazards to swimming and boat navigation.

Riverfront wayfinding and other sign systems explain the river's unique characteristics and the region's natural assets. People of all ages, income levels, and ethnic backgrounds should be invited to participate in riverfront interpretation and activities. Public art initiatives, concerts, open-air movies, or other cultural events can draw people to explore the riverfront. So can sporting events, outdoor recreation activities, and festivals. Outreach efforts can include hiring river guides and interpretive experts from varied ethnic and economic backgrounds, interpreting riverfront cultural sites orprecr

R e I e. The Sammamish River

rate ramps (PLAE, Inc. and USDA Forest Service 1993). Native-plant scent gardens and sound recordings can explain elements of the river to visually impaired visitors.

Signs and graphics are most effective when they use a consistent design with the same typography, graphics, colors, styles, sizes, materials, and construction techniques. While signs need to catch a visitor's eye, they should also blend into the landscape; they will blend in more effectively if they are constructed from natural materials found locally and employ colors that complement nearby geology and plant life.

Near Joliet, Illinois, at the Midewin National Tallgrass Prairie, two rivers and two prairie creeks are being interpreted through low signs incorporated into landforms. Designed to be durable and resistant to vandalism, the signs do not impede the sweeping prairie view. They are constructed from native dolomite limestone quarried from the nearby Des Plaines River. The stone is etched with information as well as images of the site's natural and cultural history, including prairie grasses, Native American motifs, symbols of farming, and images from the site's use as the Joliet Arsenal during and after World War II (OZ Architecture and USDA Forest Service 2000).

Behind city hall, engineers have recreated the river's meanders and curves, and added boulders, root wads, and gravel bars to the once-uniform channel. To the west of city hall, the bank was graded into a series of earth benches. The top of the bank was moved back from the river about 50 feet at its maximum point. These benches were planted with native vegetation and provide the potential for different habitat zones. They also are helping to maintain the river's flood-flow capacity.

Tying these restoration projects together is Redmond's new riverwalk, a thoroughfare for joggers, bikers, and shoppers. The Sammamish River Trail links the communities of the Sammamish Valley with the King County trail system. The county hired JGM-Landscape Architects to develop a master plan that includes trails, fishing opportunities, planting buffers, and wildlife habitat enhancement. Currently underway is a water conservation demonstration garden where local residents can learn low-water use and environmentally friendly gardening techniques as part of public stewardship of the river's ecology.

Be ef he R e a d C . Development of the master plan for the Sammamish River Trail includes a commitment to creating a more natural waterway that is accommodating to people and wildlife, and that includes systems of flood control.

F e f a . . .

- See the Parametrix web site, www.parametrix.com, and the JGM-Landscape Architects web site, www.jgm-inc.com/sammamish.htm

P A S E

Other forms of public art, sometimes quite whimsical, can attract private support and public funding to river improvement projects.

In 1999, an alliance of community interest groups in and around New York City organized the first journey of the Golden Ball. Paddling alongside or walking the shore, residents followed a floating 36-inch golden orb down the Bronx River to a festival at Starlight Park. Since then, the event has grown significantly. In September 2002, the Bronx River Alliance—composed of more than 65 community organizations and agencies—coordinated the fourth annual journey, which drew media attention to this polluted waterway, the city's only freshwater river (Wichert 2002). The event is aimed at building support for water-quality improvements, debris removal, and habitat restoration. The Alliance has also used more traditional approaches to bring attention to the river. For example, it has organized canoe trips and nature walks for residents from low-income neighborhoods that line the river.

In the Pacific Northwest, a group of artists spent two-and-a-half years creating the Soul Salmon project to celebrate the region's most famous wild fish and its habitat. The project distributed eight-foot-long fiberglass salmon to dozens of artists, who then decorated the salmon for display at special events in Puget Sound communities over six months. Maps and other information about regional ecosystems were available at the events, whose aim, the organizers stated, was to "inspire local salmon culture and generate charity to save native salmon" (Soul Salmon 2002). After the event's completion in April 2002, an auction of 11 Soul Salmon raised $43,000 for daylighting a creek buried under a shopping mall.

Bureau of Planning, City of Portland, Oregon

CHAPTER 6

T e W a e e R e :
A Re a a ce e Ma

Called Willampth, or “green water,” by its first inhabitants, the Willamette River in Oregon nourished surrounding wetlands, prairies, and forests. Its waters were home to the salmon that provided physical as well as spiritual sustenance. It was the source of life. Today, the river remains a source of life: millions rely on it for water, food, transportation, and recreation. With 13 major tributaries, the river drains a watershed of approximately 12,000 square miles, almost one-eighth of Oregon’s total area. The Willamette flows 187 miles from the river’s source, south of Eugene, northward to the Columbia River at Portland.

Over the past 200 years, the Willamette has been degraded, cleaned up, and degraded again. For the people of Portland, the river has alternately been a source of pride, shame, uncertainty, and hope. Mayor Vera Katz has summed up its history best: “The story of the Willamette reads like a potboiler romance—one of love, abuse, neglect, partial redemption, and unrequited promises” (Katz 2001).

Bureau of Planning, City of Portland, Oregon

Now Portland is embracing a massive effort known as River Renaissance that aims to end this cycle of ups and downs and set the river on a positive course for the future.

Two significant dates helped focus and galvanize the city and its citizens. The year 2001 marked the 150th anniversary of the city's founding on the banks of the Willamette. The year 2005 will mark the 200th anniversary of Lewis and Clark's arrival at the mouth of the Willamette as they floated down the Columbia. If the River Renaissance project succeeds, the city hopes that its completion will someday be the cause for another anniversary celebration—the year the Willamette became the centerpiece of the city's riverfront neighborhoods and its thriving economy.

CITY SNAPSHOT

Over the 17.5 miles that it flows through Portland, the Willamette River divides the city into east and west. Because the river is such an integral part of the city's identity, many Portlanders refer to their home as River City.

Perhaps it is the influence of the river, or the surrounding forests, or the snow-capped volcanoes of Mt. Hood and Mt. Saint Helens in the distance, but Portland's citizens have long been known for their environmental awareness and affinity for natural places. One mayor in the early 1900s is said to have proposed ripping out the buildings on every other street and replacing them with rose beds.

Portland is nationally renowned for its high quality of life. Gil Kelley, director of the city's bureau of planning, describes Portland as "a city in nature, nature in the city" (Kelley 2002). More than 200 parks, an urban wildlife refuge, bicycle and pedestrian trails, and boat launches illustrate Kelley's characterization. Portland also offers an award-winning mass transit system and many urban amenities.

As Robin Cody, a travel columnist for the 7, writes, "A great sustaining notion of this place is that salmon and steelhead still surge through the heart of a metro area of 1.6 million people. One of America's great fishing holes lies within view of a Merrill Lynch office. Here is a heron rookery within paddling distance of NBA basketball. I can dock the boat and stroll to the world's best bookstore" (Houck and Cody 2000).

Portland has received national praise for its planning efforts. According to magazine, "It sometimes seems as if the whole country is looking to Portland as a role model for twenty-first century urban development" (Ehrenhalt 1997). In 1997, the 7 named Portland one of the nation's "10 Most Enlightened Cities" (Walljasper 1997). Three years later, Portland made that magazine's top-10 list of most environmentally friendly cities (Utne 2000).

T be R e C

Over the past several decades, however, the key foundation for that "enlightened" reputation—a healthy natural environment—has been eroding. Local rivers and streams have been especially affected. As the Portland area has grown, roughly 388 miles of streams have been buried, according to a concept map study (Lowthian 2003). And as of 2002, 994 water bodies in Oregon had been declared "water quality impaired," including the entire length of the Willamette for temperature, pollutants, biological criteria, or a some combination thereof (Oregon Department of Environmental Quality 2003).

Portland's relationship to its river has been like that of many U.S. cities. For much of the last century, the Willamette was choked with waste and hidden behind seawalls, buildings, rail lines, and streets. While Portlanders prided themselves on their environmental stewardship, the river flowing

"It's time to look our history straight in the eye and admit the sad truth: a disfigured and sickly river still runs through Portland," said Katz in January 2001. "We have dammed it and diked it, filled it and diverted it, choked off its tributaries, and paved over much of its watershed, floodplains, and habitat. We've used it as a ditch, as a dumping ground, and a sewer and waste conveyor."

P a a d Ec

The Willamette River basin is the fastest-growing region of the state. The Portland area alone is home to 44 percent of the state's population. Recent studies project the five-county region's population will increase by nearly 60 percent, to almost 3 million, by 2030 (Portland Metro Data Resource Center 2002).

The basin is also the state's most economically developed region. Agriculture, forestry, and business activity in the basin make up nearly three-quarters of Oregon's economic output. The largest employers in Portland include the service industry, wholesale and retail trade, manufacturing, and government.

The Port of Portland is a significant economic asset to the city and is the region's link to the global marketplace. The port exports more wheat than any other port in the country and is the fourth largest port on the west coast of the North America. In the Portland and Vancouver area, the maritime activity associated with the port generates over 21,000 jobs (Daly 2003; Martin Associates 2001).

HISTORY OF THE PORTLAND RIVERFRONT

People have lived along the Willamette's banks for approximately 10,000 years. But the maj w ho›0 (P1.2e hu1 Renai'ast of kly rid" snot b5.7n003;

l i

T e T Sea

Portland was ideally situated to become a thriving port. "Improvements" were necessary, however, to maintain a navigable shipping channel. Snag removal and riverbed dredging began in 1891. Dredging has continued ever since: today, the Port of Portland maintains a 40-foot deep navigation channel on the lower Columbia and Willamette rivers—and wants to increase it to 43 feet.

Portland's early harbor was soon crowded with wharves, warehouses, and cargo ships. The Willamette became a major conduit for transporting goods to California, Alaska, Asia, and beyond. Most of the early waterfront development took place on the west bank, where steeper banks allowed boats to dock and kept damaging floods to a minimum. Flooding was more of a concern on the east bank, where wetlands prevailed. It wasn't long, however, before the east bank's wetlands and farmland were overtaken by warehouses and mills built on pilings.

Toward the end of the 1800s, the bustling waterfront suffered several damaging blows. After two fires destroyed downtown buildings, a flood discouraged redevelopment. The downtown center was moved from the waterfront to a safer location several blocks away. The waterfront's transformation from a community center to a forgotten industrial district had begun.

The arrival of the railroad substantially changed the character of the riverbank. In order to make way for rail lines and other commercial development, the rail companies filled many of the ponds and marshes in the floodplain with material dredged from the riverbed. Guilds Lake was filled in, as was Mocks Bottom, a haven for waterfowl. Significant changes to the river continued as the port authority deepened the Willamette's channel west of Swan Island and joined the island to the east bank.

f c d a d Tc T e b f dee a a d TD ad a a a

Olmsted laid the groundwork for the creation of Portland's 5,000-acre Forest Park, the largest wilderness park within any American city. Today, the park is home to more than 100 species of birds, 60 species of mammals, and 140 plant species.

Olmsted also proposed the creation of a system of parks linked by a network of trails and greenways. His plan was never completed, but his idea of "interconnected natural features" laid the groundwork for future efforts.

During the 1970s, the city took many of its first river-friendly planning steps. One of these steps was the decision in 1974 to demolish Harbor Drive, an expressway that dominated the waterfront, and replace it with a public park that would connect people to the river. The act generated national praise and became a source of civic pride. Today, the west bank's Tom McCall Waterfront Park is a popular place for picnickers, sunbathers, joggers, and concertgoers.

The 1970s also saw the creation of Portland's first urban wildlife refuge. Michael Houck, executive director of the Urban Greenspaces Institute and urban naturalist with the Portland Audubon Society, 6(e efh2632ulu.. Sx vu63M81 Tua2633 TD-0.0186 TW)55 las first Rrban ring th increased public access; and conservation of natural riverbanks and habitat. The plan called for the establishment of greenway trails that would provide recreation and transportation along the length of the greenway.

The plan also established a greenway boundary, located at least 150 feet from the river's low-water line. Any new development within the boundary was—and still is—required to meet specific standards. In addition, a greenway setback was created, a minimum of 25 feet measured from the top of the bank. All new developments must dedicate a right-of-way or easement for a greenway trail within this setback.

Finally, the newly formed, four-county Metro Government established an urban growth boundary in 1980 in fulfillment of state land-use requirements. The boundary, adjusted more than 30 times since but expanded only about 2 percent, has had major consequences—some good, some bad—for Portland (Portland Metro 2003). While the growth boundary was designed to limit sprawl in the city's outlying rural areas, Gil Kelley of Portland's planning bureau feels it may have had an unintended consequence. He says some now have the perception that "all nature exists outside of the boundary, and there's nothing natural within." Combating that perception remains a challenge as planners and conservationists strive to preserve natural areas and create new ones within Portland's city limits.

Imagine a vibrant city centered on a healthy Willamette River. Look to the future of Portland where a natural river system thrives and links together industry, habitat, business districts, and neighborhoods.

—Portland Mayor Vera Katz
January 2001

A NEW VISION: RIVER RENAISSANCE

While Portland has taken steps over the past 40 years to establish parks, trails, and cleanup plans, they haven't been enough for the Willamette. Since the 1972 Z Z Z: cover story, Portland has faced continued issues with the river's water quality, primarily because of combined sewer overflows, runoff from urban areas, and lasting effects of industrial and other development practices. The problem has gotten so serious that Portland now faces a mandate from the state to clean up the river.

The city is under federal scrutiny as well: a six-mile stretch of the Willamette that flows through Portland harbor was declared a Superfund site in December 2000. A century of industrial and maritime activity has contaminated river sediments with toxics such as PCBs, dioxin, mercury, and several pesticides. Many Willamette River fish suffer from deformities, lesions, and tumors. The Oregon Department of Environmental Quality has warned residents against eating the fish because the toxics pose a cancer risk.

As if that weren't enough, in 1999 two species in the Willamette—the steelhead and the Chinook salmon—were listed as threatened under the Endangered Species Act. As these fish travel from the ocean, they use the Willamette to reach upstream spawning grounds. The river is also important to the juvenile fish, which need food and refuge as they migrate downstream. Portland is required by law to restore habitat for these species.

These factors have created the impetus that drives the River Renaissance project. As Kelley (2002) explains, these realities are "forcing us to deal with the issues that have been facing us for a long time [and] to step back and take a holistic look at what will fix it for the long term." The river's troubles indicate deeper problems in the city, he suggests. "For years, we've ignored our very reason for being—the soul of our city, the river," he says. Because "the river is so symbolic and meaningful in terms of its ability to focus us, it made sense to rotate the river up to the highest priority." When Kelley talks about River Renaissance and Portland's next 200 years, he says it should be a time of "rediscovering pieces of our past."

Kelley's sentiments are echoed by Portland's current mayor, Vera Katz, who is urging Portlanders to unite and "recapture the heart of our city." The mayor says she wants to make the river Portland's "front yard."

development at Buckman Heights in southeast Portland was designed to allow 100 percent of its stormwater to infiltrate into the ground. As a result, thousands of gallons of runoff never entered Portland's combined sewer system. Rooftop gardens and other "green roof" designs already gaining popularity in Portland will likely become more prevalent. Several additional demonstration projects were completed by 2003, including the Multnomah County Building's ecoroof and a bioswale parking lot at the Oregon Natural Resource Council. The Portland Department of Transportation has also adopted best management practices in erosion control, pollution prevention, water quality, and runoff management.

In addition, residents will be encouraged to plant native vegetation in bank was to include paths, overlooks, a boathouse, and much-improved river access. But the National Marine Fisheries Service raised concerns that the park and associated activity would damage important shallow water salmon habitat. The city has modified its plans for Crescent Park to address habitat concerns (Lozovoy 2003). In early 2003, Portland also finalized an agreement with federal permitting agencies to streamline future project reviews.

The city's proposals for larger setbacks also concern some private landowners. In response to these concerns, the Clean Streams Initiative slowed down its implementation schedule to consult streamside landowners and revise its ecological inventory.

A city-sponsored design handbook published in 2001 gives guidance for projects that affect the riverfront. Its purpose is "to establish a common frame of reference and common goals for all who are concerned with development at the river's edge," and "to guide riverbank design in directions that have multiple natural resource and urban benefits." The design notebook summarizes current riverbank conditions that affect endangered species, lists scientific "pathways and indicators" toward species recovery, and recommends design objectives and a process to meet them (City of Portland 2001).

Despite the challenges posed by restoration plans and the need to balance the river's health with residents' interests, Houck hopes River Renaissance will combine "financing schemes with planning processes to make sure we treat places as interconnected. You can't look at one restoration project without thinking about the other one downstream."

R e Re a a ce G a 2: Ma a a d e ha ce he g ha b a d f a c e. River Renaissance promises that the Port of Portland will remain a vital economic asset. To follow through on its pledge, the city will need to maintain this asset while it also restores river health. But the harbor and its users will also face challenges as they adapt to the river's expanded natural and recreational functions.

The city aims to explore and adopt new technologies, designs, and industrial practices that can exist in harmony with habitat and water-quality restoration. The Superfund designation will also be an opportunity to create new partnerships as well as new environmental cleanup industries and technologies.

"As we are doing cleanup to mitigate for the damage, we can identify great opportunities and help the city identify projects," explains Jim Middaugh, a Portland Endangered Species Act program leader. "We can take restoration work that is required and apply it to projects that would aid in salmon recovery."

Some of the freeways, cargo docks, and rail lines that currently dominate the riverfront will likely be redesigned and better integrated into the larger built and natural environment. Already, the Port of Portland took advantage of a Toyota distribution center's most recent lease renewal to redevelop the company's 100-acre property. More than 1,000 feet of pavement were pulled up, and the riverbank was replanted.

In addition, regional transportation objectives linked to the harbor are to be integrated into river protection activities. One possible project is the burial of the interstate that currently crowds the east bank, just as Harbor Drive was transformed to Waterfront Park in the 1970s. As mayor, Katz has appointed a steering committee to review possible improvements to Portland's expressway infrastructure in coming decades. The redevelopment plan for the South Waterfront district also includes extensive transportation upgrades, from a streetcar extension to new city streets to an overhead tram.

R e Re a a ce G a 3: E b ace he e a P a d' f a d. While the river is already a city centerpiece, the River Renaissance Vision aims to make the river even more accessible to residents so that it becomes an integral part of everyday life.

More destinations and access points will be created along the river corridor. Ramps, boat slips, docks, and marinas will provide new opportunities for boating, fishing, swimming, and other activities. Trails, bike paths, and view corridors will connect new and existing neighborhoods to and across the river. An expanded trail network will encourage walking and biking and will thus reduce car traffic and the toxicity of street runoff that reaches the river. The Greenway Trail will connect accessible riverside segments, with the goal to create a continuous recreation and transportation corridor along both banks of the river.

Historically, most of the riverfront redevelopment has occurred on the west bank. But that changed in May 2001 when the Eastbank Esplanade officially opened. The Esplanade, which cost roughly $30 million to build, is a narrow linear trail for foot, bicycle, and other pedestrian traffic

Bureau of Planning, City of Portland, Oregon

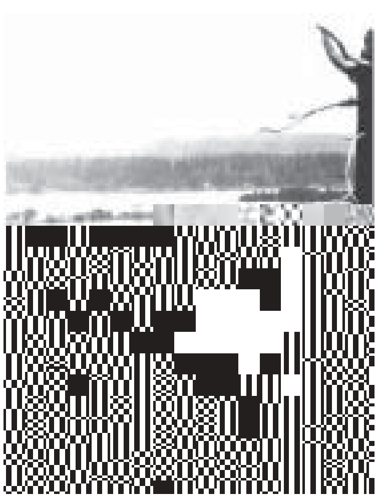
that follows the riverbank. It gives residents more access to the river, but many feel the project fell short because it didn't include riverbank or habitat restoration. But residents concede that, even though the noisy interstate dominates the Esplanade, the trail is a first step toward east bank riverfront access.

A three-mile extension of the Esplanade called the Springwater Corridor opened in 2002. It follows a rail corridor and provides pedestrian access from the city's north side to Oaks Bottom, on the south side. At the July 2003 grand opening celebration, volunteers gave rides on historic steam engine trains while joggers, walkers, bicyclists, and others traveled the trail. The area also features restoration efforts to replace invasive Himalayan blackberry with native dogwood, elderberry, Indian plum, and willows. Along the path, an art installation depicts geological strata.

The city recognizes the need to acquire lands for parks and natural areas. In spring 1995, Portland metro-area voters approved a bond measure that created a one-time $135 million fund to acquire important natural areas. As of July 2003, Metro, the regional governing body, had acquired 7,935 acres of open space in 251 separate property transactions, incorporating the land into 14 regional natural areas and six regional trail and greenway projects throughout the four-county region. But acquisition can only go so far. As Houck says, "Acquisition alone is never going to cut it—there's never going to be enough money."

Travis Williams, executive director of the river advocacy group Willamette interpretation. Festivals, regattas, and sporting events will build awareness of and celebrate the river.

Existing riverfront developments, such as River Place, built in the 1980s, feature a mix of marinas, shops, restaurants, outdoor seating, and art galleries. What places like River Place lack are any benefits for the natural river. The riverbank there is riprapped and offers no physical connection to the river, except via the marina docks. River Renaissance plans to take the proven, successful model of mixed-use development embodied by River Place several steps further to incorporate ecosystem needs.



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LOOKING FORWARD

River Renaissance is arguably the most ambitious river revitalization effort in recent U.S. history. It seeks to tackle the needs of a growing population as well as of endangered salmon. It encompasses restoration goals for streambanks, streets, and residential yards in downtown Portland as well as for distant watershed locations. It must serve as the umbrella for a variety of local, state, and federal programs. It requires the collaboration of diverse parties, from the industries that use the harbor to private landowners to conservationists.

But if any city is likely to succeed with such a task, it is Portland, a city known for its long history of planning and environmental stewardship. The Willamette was a model for restoration in the 1970s, and it can be again.

APPENDIX A

M e l f a R e Ec e

It is important for local communities to consider the specific functions, processes, and characteristics of their rivers so that restoration and management approaches that make sense in, for example, the coniferous forest watersheds of the Pacific Northwest are not applied to Midwestern prairie rivers without careful consideration of each river's special requirements. For more information about different river types, consult Cushing and Allan (2001) and Federal Interagency Stream Restoration Working Group (2001).

The first section of this appendix on geographically distinct river types, is adapted with permission from [illegible] by Colbert E. Cushing and J. David Allan (2001). The second section, "Habitats and River Ecosystems," is the work of American Rivers.

GEOGRAPHICALLY DISTINCT RIVER TYPES

There are several types of rivers that are characteristic of different regions and unique settings. The particular physical, chemical, and biological character of each will not be discussed here. Nor does this report address distinct river types with respect to how their urban riverfront challenges may vary. But it is important for local communities to consider the specific functions, processes, and characteristics of their rivers so that they can apply the most appropriate restoration and management approaches.

De e R e f eS e

Major streams in arid regions receive their water from areas of high elevation, often many kilometers upslope, where precipitation is high and usually persis-

Wa -Wa e R e f e M d e

The small streams and rivers of America's heartland have fewer advocates and have

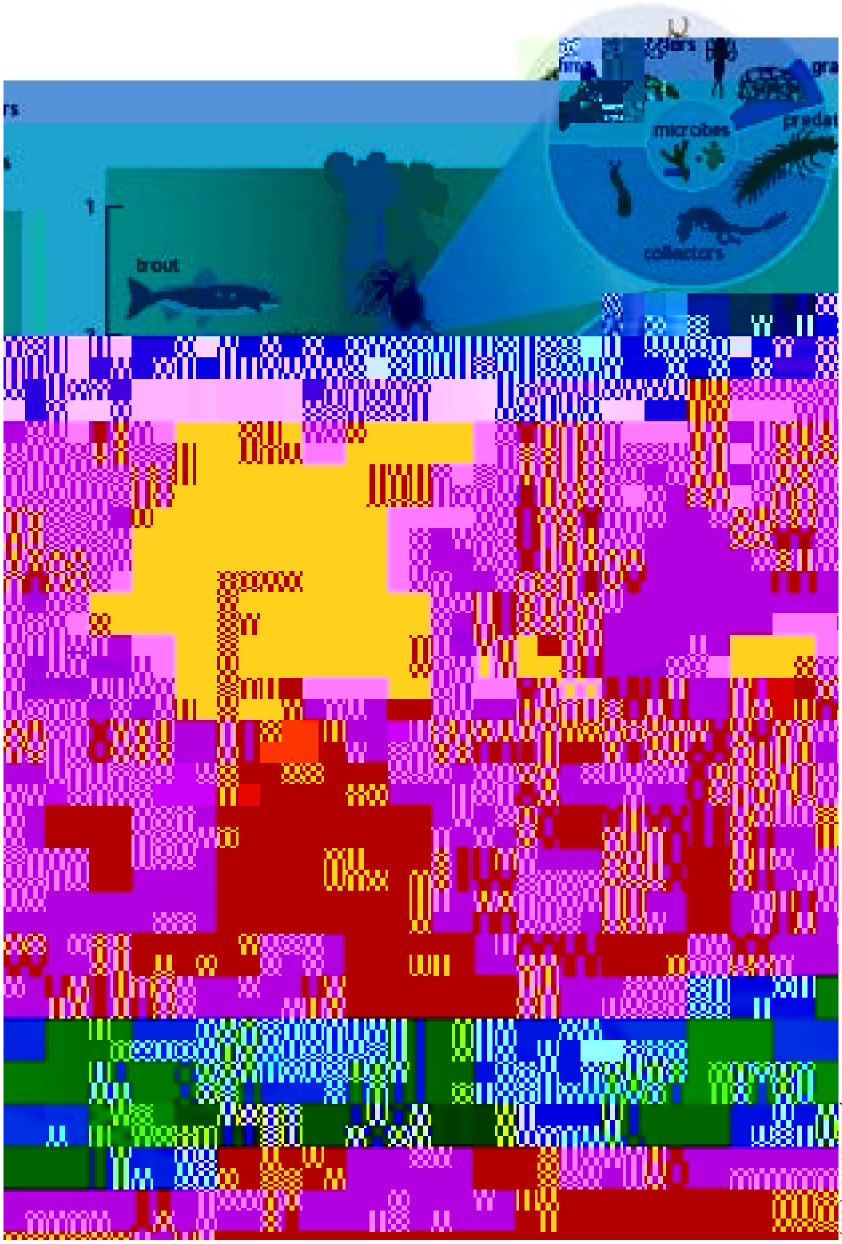
A a cZ e

River habitats vary with local conditions. Animal and plant species will differ between a shaded, swift-flowing mountain stream and a deep, broad river with warm, slow-moving water. Ecosystems also vary along a river's length as it grows from small head-water streams to large floodplain rivers. The plants and animals within a river's aquatic zone, therefore, can vary significantly between headwaters and mouth.

This way of thinking about rivers is known as the river continuum concept. It helps to explain the unique connectivity of biological processes within rivers and streams: where organic matter comes from, how it moves, how it is stored, and how it is consumed by biological communities.

In its first, uppermost section, typical of headwaters streams, a stream receives organic material directly from the adjacent landscape through leaf-fall and woody debris. In the second, organic material is also produced within a stream's aquatic zone through the growth of plants and algae. In the third, the river contains all of the organic material and energy from the upper sections, and receives most of its organic material in the form of sediment from sources upstream and direct land runoff

FIGURE A-2. THE RIVER CONTINUUM CONCEPT



Vannote et al. (1980)

The [illegible] is the area immediately adjacent to a river. It is the transition between the stream and its upland. It may consist of wetlands, relatively level upland, or steep hillsides that slope to the water's edge. Even if riparian areas are relatively dry and are thus not strictly wetlands, they are critical to the entire river. Riparian vegetation is the main source of organic detritus for headwater streams, and is thus the basis of the food chain.

The riparian zone also helps shade the water, lowering temperatures and providing cover for fish and terrestrial animals. If it is healthy and of adequate width, the riparian zone provides important physical habitat for many mammals, birds, and other animals. It can also offer a connected corridor for animal movement, particularly in landscapes fragmented by human activity. Healthy riparian zones also slow and filter contaminants from upland runoff, and the roots of riparian vegetation help to stabilize riverbanks and thus prevent erosion (FISRWG 2001).

[illegible] are often found directly along rivers as well as in upland areas near the river. A wide variety of wetlands exists across the United States because of regional and local differences in hydrology, vegetation, water chemistry, soils, topography, climate,

APPENDIX B

List of References

"Additional Acreage for Wetlands in New State Park." 2003. [illegible], January 12. Available at www.slfp.com/STC-News010803.htm.

______. 2000. "National Flood Programs in Review 2000." [Accessed August 12, 2003].

Calkins, Meg. 2001. “Return of the River.” [illegible], July, 74–83.

Ecological Society of America. 2003a. “Ecosystem Services Fact Sheet.” [Accessed June 3]. Available at www.esa.org / ecoservices / comm / body.comm.fact.ecos.html.

______. 2003b. “Key Points.” [Accessed June 3]. Available at www.esa.org / ecoservices / wate / body.wate.keyp.html.

“Economic Benefits of Open Space, The.” 2002. [Accessed October 16 at www.openspace1.org / OpenSpace / ISSUES / economicbenefitopenspace.htm]. No longer available.

Ehrenhalt, Alan. 1997. “The Great Wall of Portland.” , May. Also available at www.governing.com / archive / 1997 / may / growth.txt.

Garton, Nicole. "River of Life." 1999. [Accessed June 3, 2003]. Available at www.redding.com/specials/River_of_Life/river_091399_02.shtml.

Garvin, Alexander. 1996. [illegible]. New York: McGraw-Hill.

Georgia, University of, Institute of Ecology. 2003. "Tools for Quality Growth: Riparian Buffers." Fact sheet. [Accessed December 1]. Available at http://outreach.ecology.uga.edu/tools/fact_sheets/riparian%20buffers1.pdf.

Gobster, Paul H., and Lynne M. Westphal. 1998. [illegible]. Milwaukee, Wisc.: Rivers, Trails, and Conservation Assistance Program, National Park Service.

Government Finance Officers Association. 2003. "Issue Brief: Brownfields." May. Also available at www.gfoa.org/flc/briefs/112403/brownfields.5.03.pdf.

Grannemann, N.G., R.J. Hunt, J.R. Nicholas, T.E. Reilly, and T.C. Winter. 2000. [illegible]. USGS Water Resources Investigations Report 00-4008. Lansing, Mich.: U.S. Geological Survey. Also available at http://water.usgs.gov/ogw/pubs/WRI004008/.

Grant, Peter. 2000. "This Plan Has a Catch." [illegible], October 18, B1.

Great River Greening. 2003. "Pine Bend Bluffs—Oak Savanna, Dry Prairie, and Mesic Prairie Restoration." [Accessed August 14]. Available at www.greatrivergreening.org/project_pinebend.asp.

Grillmayer, Rick. 2000. "Soil Bioengineering for Streambank Protection and Fish Habitat Enhancement, Collingwood, Ontario." In [illegible], edited by Andrew D. Caulk, John E. Gannon, John R. Shaw, and John H. Hartig. Detroit: Greater Detroit American Heritage River Initiative, pp. 62–65.

Gustaitus, Rasa. 2001. "Los Angeles River Revivial." [illegible], Autumn, 2–14.

Hansen, Norma. 2001. "Participation Figures in Human-Powered Outdoor Recreation." [illegible], Summer, 16–17.

Hart, Barbara. 2003. Community Affairs Manager, River Renaissance Program, City of Portland, Ore. Personal communication with authors, July 21.

Hartig, John H., John K. Kerr, and Mark Breederland. 2001. "Promoting Soft Engineering along Detroit River Shorelines." [illegible], November/December, 24–27.

Heat-Moon, William Least. 1999. [illegible]. Boston: Houghton Mifflin.

Hellmund, Paul Cawood, and Daniel S. Smith, eds. 1993. [illegible]. Minneapolis: University of Minnesota Press.

Herricks, Edwin E. 1995. [illegible]. Boca Raton, Fla.: CRD Lewis Publishers.

Hodge, Tiffany. 2002. Public Relations Specialist, Schuylkill River Development Council, Philadelphia. Telephone interview with authors, June 18.

Hoffman, Diane. 2003. District Administrator, Northern Virginia Soil and Water Conservation District, Fairfax County, Va. Interview with authors, June 17.

Holt, Gordy. 2002. "Redmond Helps Give Salmon a Little 'Re-leaf.'" [illegible], September 9. Also available at http://seattlepi.nwsource.com/local/86121_sammamish09.shtml.

Houck, Michael. 2003. Executive Director, Urban Greenspaces Institute, and Urban Naturalist, Audubon Society of Portland, Ore. Personal communication with authors, July.

Houck, Michael C., and M.J. Cody, eds. 2000. [illegible]. Portland: Oregon Historical Society.

Hough, Michael, Beth Benson, and Jeff Evenson. 1997. [illegible]. Toronto: Waterfront Regeneration Trust.

Leopold, Luna B. 1994. . Cambridge, Mass.: Harvard University Press.

Leopold, Luna B., M. Gordon Wolman, and John P. Miller. 1992. -

Massengill, Pat. 1998. "The 1965 Flood of the South Platte River." [Accessed August 13, 2003]. Available at www.littletongov.org / history / othertopics / flood.asp.

May, Christopher W., et al. 1997. "Effects of Urbanization on Small Streams in the Puget Sound Ecoregion." [illegible] 2, no. 4: 483–494.

Mazziotti, Don, and Cheryl Tweedy. 2003. Executive Director, Portland Development Commission, Portland, Ore., and Senior Development Manager, Portland Development Commission, Portland, Ore. Presentations to Portland City Council, July 10.

McCormick, Angela. 2002. Principal, Acadia Development, Boulder, Colo. Interview with authors, June 10.

McCormick, Kathleen. 1991. "We Don't 'Do' Wetlands." [illegible], October, 88–90.

McHugh, Erin. 2003. Administrative Assistant, American Recreation Coalition, Washington, D.C. Interview with authors, June 23.

McNulty, Robert. 2000. [illegible]. New York: McGraw-Hill / Partners for Livable Communities.

Meyer, J.L., and J.B. Wallace. 2001. "Lost Linkages and Lotic Ecology: Rediscovering Small Streams." In [illegible], edited by M.C. Press, N.J. Huntly, and S. Levin. Oxford: Blackwell Science, pp. 295–317.

Meyer, J.L., R. Beilfuss, Q. Carpenter, L. Kaplan, D. Newbold, R.D. Semlitsch, D. Strayer, M. Watzin, C. Woltemade, J. Zelder, and P. Zelder. 2003. [illegible]. Washington, D.C.: American Rivers and Sierra Club.

Middaugh, Jim. 2001. Program Leader, Portland Endangered Species Act Response Program, Portland, Ore. Personal communication with authors.

Miller, Joe. 2001. "Whitewater Parks Offer Thrilling Twist and Turn in City Planning." [illegible], November 3, 1A.

Mills, Richard. 2002. Artist, Teaneck, N.J. Telephone interview with authors, July 2.

______. 2000. [illegible]. Teaneck, N.J.: Return of the Bald Eagle Press.

Milner, George R. 2001. "Cost / Benefit Analysis: Conventional vs. Naturalized Detention Basin." [illegible], November / December, 45.

Moore, Barbara J., John D. Rogner, and Drew Ullberg. 1998. [illegible]. Milwaukee, Wisc.: Rivers, Trails, and Conservation Assistance Program, National Park Service.

Moore, Roger L., and Christos Siderelis. 2003. "Use and Economic Importance of the West Branch of the Farmington River: Final Report." Research report, American Rivers and National Park Service. January. Also available at www.nps.gov / ncrc / portals / rivers / farm.pdf.doc.

Morrison, Patt. 2001. [illegible]. Santa Monica, Calif.: Angel City Press.

Motavalli, Jim. 1998. "Chattanooga on a Roll: From America's Dirtiest City To Its Greenest." [illegible], March-April. Also available at www.emagazine.com / march-april_1998 / 0398curr_chattanooga.html.

Muddy River Restoration Project. 2002. "Charlesgate Dredging: Boylston Street to Charles River." [Accessed May 22, 2003]. Available at www.muddyriverproject.org / Charlesgate_dredging.html.

Munch, Jim. 2002. City Planner, City of Pueblo, Colo. Interview with authors, June 12.

Myers, Mary. 2000. "Retrofitting Rocky Branch: Applying Natural Features in Urban Stream Design." [illegible], March, 44–49.

Napa County Flood Control and Water Conservation District. 2002. "The Napa River Flood Protection Project: Progress and Plan Summary." [Accessed August 13, 2003]. Available at www.napaflooddistrict.org/brochure.pdf.

"Napa River Watershed: Managing Land Use and Development in a Riverine Estuary System." 2000. In [illegible], September. [Accessed January 14, 2004]. Available at www.cleanwater.gov/success/napa.html.

National Park Service. 1995. [illegible]

PLAE, Inc. and USDA Forest Service. 1993. [illegible]. Berkeley, Calif.: PLAE, Inc., and MIG Communications.

Palone, Roxane S., and Albert H. Todd, eds. 1998. [illegible]. Rev. ed. Radmar, Pa.: USDA Forest Service.

Patterson, Tim. 2000. "Comparison of Soil Bioengineering and Hard Structures for Shore Erosion Control: Costs and Effectiveness." In [illegible], edited by Andrew D. Caulk, John E. Gannon, John R. Shaw, and John H. Hartig. Detroit: Greater Detroit American Heritage River Initiative, pp. 21–24.

Pennsylvania Fish and Boat Commission. 2003. Pennsylvania Fish and Boat Commission homepage. [Accessed August 14]. Available at http://sites.state.pa.us/PA_Exec/Fish_Boat/watertrails/trailindex.htm.

Pennsylvania Economy League, Inc. 1997. "Understanding the Economic Value of Schuylkill River Park." Report No. 689. [Accessed June 3, 2003]. Available at www.peleast.org/images/Schuylkill_River_Park.pdf.

Peterson, Bruce J., et al. 2001. "Control of Nitrogen Export from Watersheds by Headwater Streams." [illegible], April 6, 86–90.

Pinkham, Richard. 2000. [illegible]. Snowmass, Colo.: Rocky Mountain Institute.

Pittsburgh, City of. 2003. [illegible]. [Accessed May 29]. Available at www.city.pittsburgh.pa.us/rfp/.

Portland, City of. 2002. "Framework for Integrated Management of Watershed and River Health." Draft report, November. Also available at www.fish.ci.portland.or.us/pdf/FIMWRH_Doc.pdf.

Portland, City of. 2001. [illegible]. [Accessed June 3, 2003]. Available at www.pdc.us/pdf/dev_serv/pubs/willamette_riverbank_design_notebook.pdf.

Portland, City of, Bureau of Environmental Services. 2003. "Going Deep for a Cleaner River." Brochure, West Side Big Pipe project.

Portland, City of, Bureau of Planning. 2001. River Renaissance Vision website. [Accessed December 22, 2003]. Available at www.river.ci.portland.or.us/mainpages/vision/vision.htm.

Recreation Roundtable. 2003. "Key Findings of the 1996 Recreation Roundtable Survey: Outdoor Recreation in America." [Accessed June 3]. Available at www.funoutdoors.com / research.html.

______. 1998. "Outdoor Recreation in America 1998." [Accessed June 3, 2003]. Available at www.funoutdoors.com / roper98.html.

______. 2002. "Participation Increases for Most Recreational Activities." Press release, January 8. Also available at www.funoutdoors.com / news / news1_02.

Reed, Mike. 2003. Biologist, Portland Endangered Species Act Response Program, Portland, Ore. Personal communication with authors, July 25.

Return of the Natives. 2003. Return of the Natives Restoration Education Project homepage. [Accessed August 14]. Available at http: / / watershed.csumb.edu / ron / .

Riley, Ann L. 1985. [illegible]. Sacramento, Calif.: Department of Water Resources, Urban Stream Restoration Program.

______. 1998. [illegible]. Washington, D.C.: Island Press.

Riverfront Recapture. 2002. [illegible] 2001, 2002 [illegible]. Hartford, Conn.: Riverfront Recapture.

______. 2003. "Construction Update." [Accessed June 19]. Available at www.riverfront.org / construction.asp.

______. 2000a. "New Plaza To Reunite Downtown Hartford with Riverfront on Labor Day Weekend." Press release, n.d.

______. 2000b. [illegible] 2000 [illegible]. Hartford, Conn.: Riverfront Recapture.

Rivers, Trails, and Conservation Assistance Program. 1996. [illegible]. Washington, D.C.: National Park

Takesuye, David. 2003. "REI Denver Flagship Store: A Reuse Example."

______. 2002d. [illegible] 2000 [illegible]. [Accessed August 19, 2003]. Available at www.epa.gov/305b/2000report.

______. 2003a. "New York City and Seven Upstate New York Counties." [Accessed June 11]. Available at www.epa.gov/safewater/protect/casesty/newyorkcity.html.

______. 2001a. "Nonpoint Source Pollution: The Nation's Largest Water Quality Problem." Pointer No. 1 (fact sheet), EPA841-F-96-004A. Also available at www.epa.gov/owow/nps/facts/point1.htm.

______. 2003b. "Proposed Portland Harbor Superfund Site Timeline." Draft report, January 9.

______. 2001b. [illegible]. Washington, D.C.: U.S. EPA. Also available at http://cfpub1.epa.gov/npdes/cso/cpolicy_report.cfm?%20program_id=5.

______. 2002e. "Streambank Modification Successful in Utah." [Accessed May 29, 2003]. Available at www.epa.gov/OWOW/NPS/Success319/UT.html.

______. 2001c. "Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures: III. Urban." EPA 841-B-00-007. [Accessed December 1, 2003]. Available at www.epa.gov/owow/nps/urban.pdf.

______. 1995b. "Wetlands Fact Sheets." EPA 843-F-95-001. Also available at www.epa.gov/owow/wetlands/facts/contents.html.

U.S. Environmental Protection Agency, New England Region. 1996. "A Healthy Charles River Contributes Over $100 Million To Local Economy." Press release #96-7-6, July 10.

______. 2002. "Woonasquatucket River Overview: A River on the Rebound." [Accessed May 29, 2003]. Available at www.epa.gov/region01/ra/woonas/.

U.S. Environmental Protection Agency, Office of Water. 2000. [illegible] 2000 [illegible]. Washington, D.C.: U.S. EPA. Also available at www.epa.gov/water/liquidassets.

______. 2002. "Projects Funded By Five Star Restoration Program in FY00." [Accessed May 29, 2003]. Available at www.epa.gov/owow/wetlands/restore/5star/fy00grants.html.

U.S. Fish and Wildlife Service. 1998. "1996 National and State Economic Impacts of Wildlife Watching: Based on the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation." April. Also available at http://fa.r9.fws.gov/info/publish/rpt_96-1.pdf.

______. 2002. 2001 [illegible]. Washington, D.C.: GPO. Also available at www.census.gov/prod/2002pubs/FHW01.pdf.

______. 2001. [illegible]. Washington, D.C.: GPO. Also available at http://wetlands.fws.gov/bha/SandT/SandTReport.html.

U.S. Geological Survey. 2000. "A Tapestry of Time and Terrain: The Union of Two Maps—Geology and Topography." [Accessed August 19, 2003]. Available at http://tapestry.usgs.gov/features/14fallline.html.

Urban Design Strategies. 1997. [illegible]. [Accessed December 1, 2003]. Available at www.riverfrontcorporation.com/asp/page4.asp.

Urban Land Institute. 2003. [illegible]. Washington, D.C.: Urban Land Institute.

Urbonas, Ben R., ed. 2001. [illegible]. Alexandria, Va.: American Society of Civil Engineers.

Utne, Leif. 2000. "Green Living: America's 10 Most Environmentally Friendly Cities." [Accessed December 1, 2003]. Available at www.utne.com/webwatch/2000_203/news/1498-1.html.

Van Metre, Peter C., Barbara J. Mahler, and Edward T. Furlong. 2000. "Urban Sprawl Leaves Its PAH Signature." [illegible] 34, no. 19: 4064–70.

APPENDIX C

American Planning Association Policy Guide on Water Resources Management

INTRODUCTION AND FINDINGS

Water is a finite resource. Although three-quarters of the earth is covered with water, 97.6 percent our water is salty and 1.9 percent is frozen into the polar ice caps. This means that only about half a percent of our planet's water resources is fresh water. Of these fresh water resources, 0.02 percent is found in rivers, lakes, and streams while the rest, 0.48 percent, is groundwater. These water resources are used for water supply, ecological, recreational, navigational, and waste disposal purposes, and these diverse uses are currently managed under a large number of federal, state, and local laws.

The U.S. Geological Survey (USGS)—in its report, [illegible] from another aquifer to flow into the freshwater aquifer). The overpumping of alluvial or surficial aquifers may also reduce their base flow discharges to surface water bodies, thereby reducing stream flows and also indirectly affecting stream quality (as ambient pollutant concentrations increase).

Both groundwater and surface water resources can be disrupted by contamination. Pathogens, minerals, and organic and inorganic chemicals polluting the groundwater can cause surface water to become polluted and vice versa due to the interconnections

- environmental impacts and mitigating factors;
- analysis of existing and required legal and institutional arrangements, and roles and responsibilities of appropriate levels of government in carrying out the plan, including the use of intergovernmental or interstate agreements;
- a land-use framework for land located near sensitive water resources; and
- financing strategies for needed improvements, along with a system for monitoring or evaluating the attainment of plan objectives.

[illegible]

A minimum 20-year planning horizon is proposed to enable capital investments in water-related infrastructure to be recovered through financing mechanisms while ensuring a planning period that would allow for reasonably accurate demographic and other projections affecting water demand. The need for water users to repay bonds for water supply capital improvements or to repay state loans within a time period long enough to stabilize water utility rates suggests the need for longer-range rather than shorter-term water resource management planning. Although some states (e.g., Arizona, under its 1983 Water Use Act) may require that water for urban uses be secured for a century as a precondition of assessing water transfers, a 20-year planning horizon allows for more accurate longer-term need projections prior to making infrastructure investments.

2. APA and its Chapters support legislation to establish requirements for state comprehensive water-use permits issued pursuant to policies and criteria set forth in state comprehensive water resources and supply plans. State (and / or regional, in those states where multijurisdictional water districts exist) permit reviews should incorporate thorough environmental and socioeconomic review of applications for new or increased use of surface water and groundwater resources for consumptive and nonconsumptive uses prior to state approval or denial. State (and / or regional) requirements should be made pursuant to a public hearing process that involves all appropriate levels of government and allows public input to the decision-making process.

[illegible]

ments, ratified by appropriate legislation, to resolve issues regarding water allocations and to develop water resource management systems on an aquifer or watershed basis, to the greatest extent possible.

[illegible] Kansas v. Colorado, [illegible] 2001 [illegible]

12. APA and its Chapters support legislation providing opportunities for the integrated management of groundwater and surface water supplies, and funding for research on strategies for the integrated management, monitoring, and use of surface and groundwater. Whenever possible and appropriate, the planning area of such management programs should be based on natural hydrologic features, such as watersheds and aquifers. APA and its Chapters also support and encourage the development of land-use variables within water resource models.

[illegible]