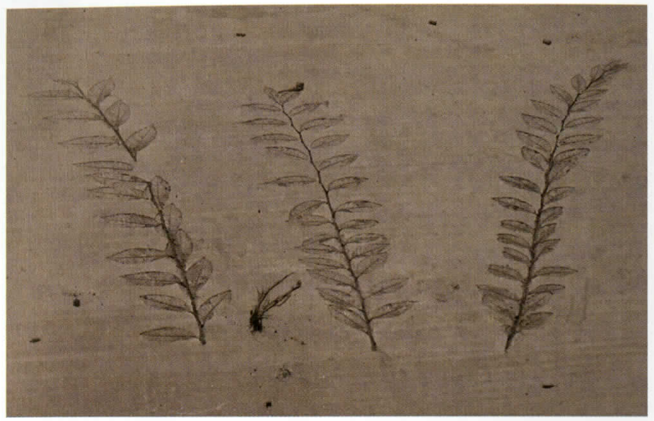


FIGURE 4.37 *Parents at Sherman School in San Francisco, California, pressed real leaves and branches into their new concrete path while it was still wet to create interesting plant patterns.*

FIGURE 4.39 *Young children visiting the Bay Area Discovery Museum build "nests" big enough to sit in, using loose sticks supplied onsite.*

FIGURE 4.38 *The Lookout Cove exhibition's outdoor playground at the Bay Area Discovery Museum in Sausalito, California, includes a child-sized "spider web" climbing structure that rests among tall blades of "grass."*

their learning and play spaces. Paved pathways, for example, can be imprinted with leaves, wildlife "tracks," or other creative ornamentation. Some schoolyards and children's centers also use wildlife themes to encourage imaginative play. (Figures 4.37–4.39)

Wild Schoolyards

Wildlife habitats on school grounds are a reflection of their local context and are as varied as the schools that create them. Small demonstration-sized plantings can teach students about native plants and visiting wildlife, while providing food for neighborhood birds and pollinators. Larger installations go further to create environments that immerse students in the plantings and patterns that are unique to their geographic region—while simultaneously improving the living conditions for creatures large and small. They help to shape a school's sense of place and connect it to indigenous natural communities in the region.

All of these projects on school grounds have valuable educational and social components that contribute to making each schoolyard unique and memorable. Wildlife sanctuaries on school grounds allow children a closer and more personal view of native plant communities and living creatures in a way that helps them include the natural world as part of their developing self-identity. Animated by seasonal changes and individual creatures that come and go, wildlife zones pique children's curiosity and capture their hearts.

5 *Schoolyard Water Systems*

Water Stewardship as a Teaching Resource

Most of our communities' water systems are underground, hidden from view, and unnoticed by urban and suburban residents, young and old alike. Where does our water come from? Where does it go? How does it get there?[1] Are we managing our water systems in ways that are ecologically sound and sustainable?

Clean, fresh water is a precious resource. It comes to our schools and communities through municipal plumbing systems and natural waterways and in the form of rainfall. It leaves school grounds through man-made stormdrains,sewer networks, and by running over the landscape and percolating into the soil. In most cases, water from these sources is relatively clean when it arrives on school grounds and dirtier when it leaves.

School communities have the power to improve their local water systems and to use them as educational resources at the same time. Water is a dynamic teaching tool that can be harnessed to enrich the curriculum across disciplines and grade levels. Many schools around the world are teaching their students to act as watershed stewards and to use water responsibly. Some schools are taking control of stormwater flows across their landscapes, others are reducing the amount of water they consume, and a few are purifying some of the wastewater and runoff they produce.

The case studies that follow focus on schools with water projects that range from watershed education to water purification and conservation. They teach lessons about the water cycle and other fundamental processes that everyone should understand in order to be ecologically literate and to be able to steer our communities toward a more ecologically sound future.

Site-specific Design for Water Conservation and Purification

The design of schoolyard water systems varies with the climate and precipitation levels of each region, the school's location in its watershed, the shape of surrounding topography, and the size of the school building and grounds—but this is a topic that all schools can address in some way, because water is present and consumed at every school.

Schools in wet regions of the country, or in heavily paved neighborhoods, are frequently interested in finding ways to prevent flooding and slow down water movement so it percolates into the ground instead of overflowing the stormwater system. Some Los Angeles schools participating in the Cool Schools program, for example, found that they could reduce flooding by removing asphalt on their playgrounds and by planting "thirsty" trees where water pooled.[2] Schools in other areas are using living roofs to absorb part of their stormwater and slow its release to stormdrains.

By contrast, schools in dry regions frequently desire a system that conserves the precious water they have and makes good use of every drop. Designers of water systems for these schools frequently adopt dry gardening principles, selecting native plants that are adapted to local rainfall patterns and avoiding plant species that are "water hogs." These schools sometimes use rain barrels or cisterns to capture and store rainfall and water-conserving drip irrigation methods to efficiently water vegetation that requires supplemental moisture.

Schoolyard water systems in any geographic location are complemented by water conservation measures implemented *within* school buildings, such as low-flow faucets and toilets or simple, but effective, programs that instruct the school community to turn off water when it is not in use. These conservation programs often result in long-term financial savings by reducing water bills.

In most climates, schools can also cleanse stormwater and wastewater flows onsite. Stormwater purification systems that use low-tech, plant-based water purification techniques such as swales (vegetated "ditches") and wetlands can improve water quality. They are particularly important in urban, suburban, and agricultural areas where stormwater runoff is likely to be polluted—and are an engaging way to get students involved in improving the water quality of local streams and lakes. Wastewater treatment systems process water from sinks and, sometimes, toilets, purifying them onsite using constructed wetlands and treatment systems, and then reusing the water for irrigation and other purposes. These purification systems are often practical, as well as environmentally responsible and educational.

Schoolyard water resources, created for ecological and academic purposes, can be beautiful assets that contribute to curb appeal and school pride. For example, planted swales used for stormwater purification add ribbons of attractive greenery to the landscape when artfully designed. Stormwater detention ponds, usually an unappealing, utilitarian feature of many communities, can be reinterpreted as living wetland ecosystems or stepped plazas that double as seating areas in the dry season. Often a detention pond or a wetland, planted with native aquatic species, will also attract wildlife and be suitable for use by science, math, art, or other classes.

The best schoolyard water systems are sensitive to local water cycles and climate. They incorporate plant-based stormwater and/or greywater purification methods to reduce the school's contribution to local water pollution and to conserve water. Schoolyard water systems should favor onsite rainwater retention and groundwater recharge instead of sending stormwater into municipal drainage systems. Water conservation measures, such as dry gardens and low-flow water systems, can significantly reduce a school's annual water bills and its impact on the local environment. Building schoolyard water systems with student involvement, maintaining them with student assistance, and connecting them to the existing curricula maximizes their educational value as exceptional scientific resources.

What Is a Watershed?

A watershed is a stormwater drainage basin—an area of land that shares a natural drainage network of creeks and rivers. Its boundaries are the high points in the landscape—the tops of gentle hills or tall mountains—that cause rainwater to "shed" (flow downhill) toward the center of the basin where it forms creeks and rivers. Rainwater that falls in a single watershed drains to the same receiving water body—such as a river, pond, lake, or ocean—at the end of its downhill journey.

Watershed Education

Every school is located within a watershed and has access to rainfall during wet seasons—yet the educational potential of these resources remains untapped in most places. From an early age, children can be entrusted with reducing their school's environmental impact by taking charge of the water they use, conserving it where possible, and helping to ensure that rainwater is clean when it leaves the schoolyard to flow into nearby waterways. By tapping into this local educational resource in a manner that captures students' imaginations, schools help their students become good stewards of their community's ecological infrastructure.

Most students study the water cycle in an abstract way in elementary and middle school, following arrows on a simple diagram in a book. Connecting this type of water cycle curricula with the landscape at your own school brings these central concepts to life, and makes them relevant to students who ask, "Why is this important to me?"

Teachers might begin their investigation of water systems with a basic discussion about the school's own watershed, followed by a model-building project that illustrates how rainwater moves through their own local topography. Students can step outside to consider how rainwater moves across their schoolyard and ask questions about where the water flows when it leaves the grounds. Some schools also extend these lessons to incorporate related discussions about mapping techniques, climate patterns, geography, hydrology, and geology, depending on the students' grade levels.

Make the most of rainfall. Take children out into the drizzle and let them watch it as it flows down hills, across the pavement, through their garden, and into the stormdrain. Ask them where it comes from, where it goes, and what it might pick up on its journey through the schoolyard (and the city!). Use maps, models, and field trips to help them find their school's place in the watershed and bring these lessons to life. Plant rainwater gardens to clean water flows onsite and create ponds to observe aquatic creatures. Teach students responsible irrigation practices, remove some asphalt from your schoolyard to let water soak into the ground, and experiment with the properties of this fascinating liquid.[3]

Schoolyard watershed models

Some schools use hands-on projects to enliven watershed studies for their students and to illustrate how stormwater travels through the neighborhood. Students at Monarch Grove Elementary School in Los Osos, California, for example, worked with the local San Luis Obispo 4-H chapter to build a large-scale model of the entire 48,000-acre Morro Bay watershed on their schoolyard. To create the model, children and their parents used foam insulation boards covered with layers of cement and colored cement stucco. Approximately 12 feet square at the base with the highest peaks in the watershed almost 3 feet tall, the model reflects the 2,400-foot topography, rendered with a vertical exaggeration of 3x in order to make it easier to use. The model is used to teach the school community about water quality and how to keep local waterways and estuary clean. Some classes also use the model as a resource for teaching about the water cycle, local geology, and Native American history.[4] (Figure 5.1)

FIGURE 5.1 *The model at Monarch Grove Elementary is durable enough to walk on. Classes can spray it with a garden hose to simulate rainfall and erosion processes.* Judy Neuhauser

Lockwood Elementary School in Oakland, California, is surrounded by busy streets and a mostly flat, paved urban environment. It is only a mile from San Francisco Bay, but the water can't be seen from the school. From the playground, the most prominent and visible natural features are the Oakland hills, about three miles inland.

In 2001 the school had the opportunity to redesign its schoolyard and bring awareness of natural systems onto the grounds. The playground design that I helped to create in collaboration with the Trust for Public Land includes a "watershed" model painted on the asphalt, oriented along the approximate path that rainwater follows across the playground. My original design concept called for this pathway to be a functioning swale network or stormwater runnel, but it wasn't feasible to have flowing surface water present on this school site.[5] (Figure 5.2)

Make stormwater flows visible on school grounds[6]

The built environment in urban and suburban landscapes often obscures the underlying natural systems that predate them. Typically, urban creeks are channeled into pipes that run under our streets, houses, and schools. Though hidden from view, they continue to receive rainfall through our stormdrains. In some places, creeks are left above ground but are forced into narrow, steep-sided, engineered channels that make the water flow faster, deeper, and straighter than nature intended. Urban development often pushes up against these channelized creeks,

FIGURE 5.2 *The painted creek at Lockwood Elementary "flows" downstream from the hills (and kindergarten building), east toward the bay.*

FIGURE 5.3 *This tile mosaic mural at Rosa Parks School depicts the natural world, including a soil profile with an artistic representation of the buried creek, shown in the lowest layers of the mural.*[7]

FIGURE 5.4 *The painted markings next to this schoolyard stormdrain in Oakland, California, help students to recognize buried Sausal Creek as an asset the school should help to protect.*

so they are frequently locked behind tall fences and treated as hazards, rather than revered as vital life-giving systems.

Visit your local historical society or map library to find old maps of your school's neighborhood. Ask students to look for any historical creeks that run close to the school. If a creek once flowed in your neighborhood, can you locate it now?

If you find a hidden waterway in your midst, try to bring it back into the school community's consciousness in some way and make it easier for everyone to see. In urban areas with creeks buried underground in pipes, schools can mark the ground surface in a way that traces the water's flow, or paint signs near the stormdrains that lead to these underground waterways. If there is a channelized creek near your schoolyard, it might be possible to provide students with safe visual and/or physical access to the water.

Channeling rainfall from school rooftops into onsite water features, such as ponds, wetlands and swales, is another way to make part of the watershed visible and improve water quality at the same time. These man-made additions to the schoolyard can be artfully designed to celebrate the beauty and educational value of rainwater.

Mark the location of buried waterways onsite. In 2006 I worked with Rosa Parks School in Berkeley, California, to create a green schoolyard master plan that now guides the gradual transformation of the school grounds. (See chapter 2, Figure 2.3) Urban development placed a small historical waterway in pipes under the schoolyard, making it physically inaccessible to the students. As the schoolyard design is implemented, we plan to raise awareness of the buried creek using schoolyard artwork above the buried waterway and elsewhere onsite. In spring 2009, students worked with local artists to create a tile mosaic that incorporates this theme. In the future, we also hope

FIGURE 5.5 *Sometimes it is possible to seek access to a hidden or blocked water flow onsite. A fifteen-foot fence separates this school from a nearby creek, which runs along the edge of its playground. The students engaged in a green schoolyard design process that investigated the possibility of creating visual or physical access to the waterway. In the meantime, to raise students' awareness of the hidden stream, the school painted a creek mural on the asphalt in front of the fence.*

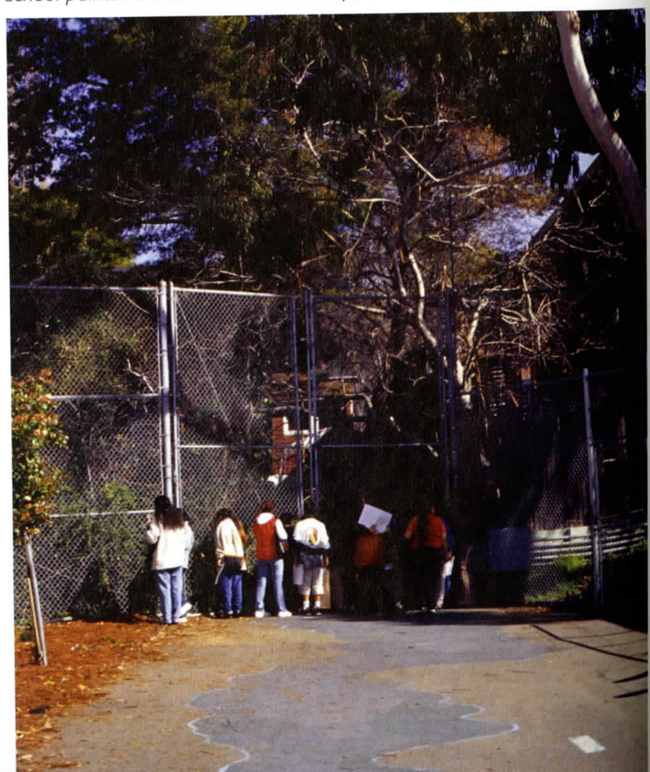


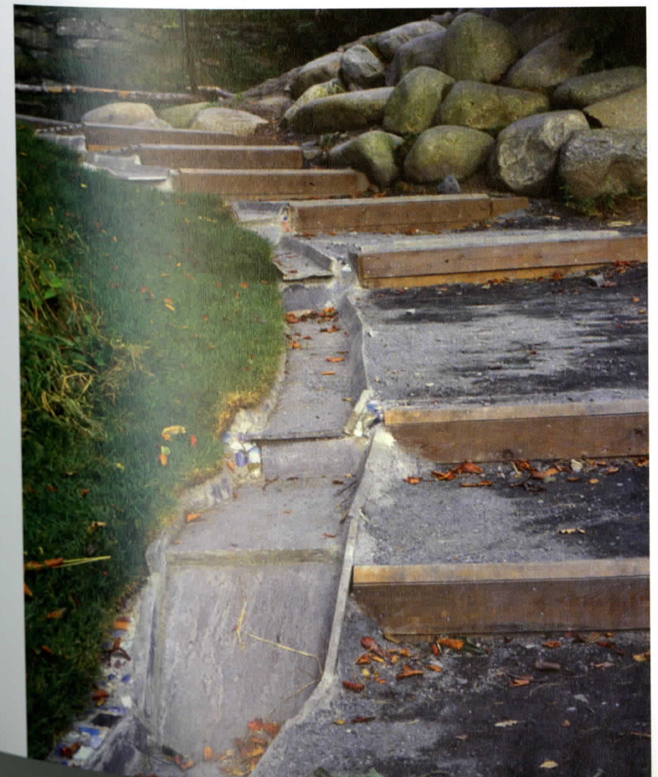
FIGURE 5.6 *Rainwater-fed pond at Bergen Steiner School.*

FIGURE 5.7 *Mårten School in southern Sweden has a small pond fed by runoff from the school's roof. The stormwater flows across the roof, down the building's downspout, and through a long winding channel at ground level before filling the pond.*[9]

to develop a "listening station" near the stormdrains to allow auditory access to the underground creek. (Figures 5.3–5.5)

Connect downspouts to schoolyard water features. At most schools, students do not follow rain patterns closely enough to be able to tell if a given year is a wet year or a dry year. At Bergen Steiner School in Norway, however, rainfall patterns are directly connected to a schoolyard pond. When it rains, roof runoff flows across a rain gutter, directly into the pond. When the pond is full, the excess water spills into the adjacent garden and is absorbed by the ground. When the weather has been dry for a while, the students monitor that pattern

FIGURE 5.8 *Playful drainage system at Bergen Steiner School.*



through direct observation of the pond's water level, and refill the pond with water from a hose. This system not only emphasizes the importance of rainfall to natural systems, but also focuses the students' attention on how much rainfall they receive.[8] (Figures 5.6 and 5.7)

Use stormwater flow in an artful manner. Parents at Bergen Steiner School built a simple, playful stormwater art piece onsite. When it rains, water drains from a stairway into an adjacent channel and cascades downhill in a series of small waterfalls. This feature keeps the stairs from flooding and provides an interesting, attractive play element for the children.[10] (Figures 5.8 and 5.9)

FIGURE 5.9 *The cobblestone runnel at Svendstuen School in Oslo, Norway, directs stormwater as it flows downhill and keeps the stairs free of puddles.*

Cam Collyer

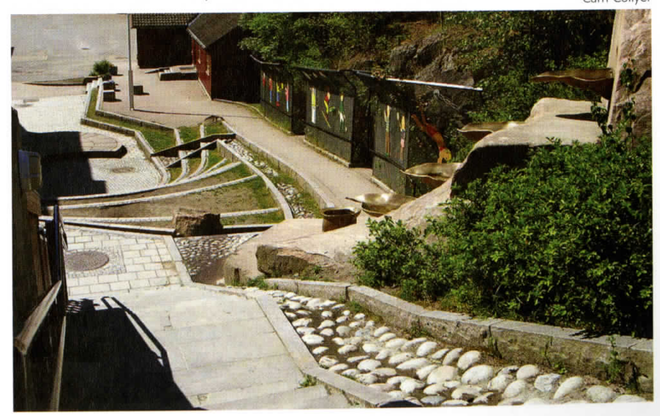


FIGURE 5.10

FIGURE 5.11 *Argyle Primary School in London, England, channels a portion of its stormwater across the paved schoolyard in a meandering, colorful, mosaic-covered runnel, decorated with water-themed artwork. At the end of the channel, children may observe the water disappearing underground through a round stormdrain.*[12]

Cam Collyer

Grünerløkka School in central Oslo, Norway, includes artful stormwater features that double as enticing play elements. Water from the downspouts and an outdoor drinking fountain is directed into an intricate network of surface-flow channels that guide it under small bridges, through swirling pathways, and ultimately into the stormdrain. (Figure 5.10) This complex arrangement must be cleaned regularly to prevent clogging.[11]

Teaching Water System Ecology through the Design of the Schoolyard Landscape

After students understand watershed and water cycle processes, they can begin to use their own schoolyard to mitigate the effects of urban development on local water systems. The first step in this process is to analyze the school grounds to see where water is flowing from, where it is going to, and what it might be picking up on its journey. Next, school communities should consider how they can (1) modify water flows to increase rainwater infiltration; (2) slow and filter stormwater to make it cleaner and less likely to flood the stormdrain network; and (3) conserve as much municipal tap water as possible. Achieving these goals often requires some physical modifications to the school site, but as the examples in this section illustrate, these are worthwhile and achievable tasks.

Many of the following projects incorporate multiple water conservation and purification strategies in an integrated manner. I have highlighted particular characteristics of these systems to bring them to your attention.

SITE DESIGN GOAL #1: *Reduce stormwater runoff by increasing infiltration on school grounds.*

Asphalt and concrete are two of the most commonly used materials in our playgrounds. Unfortunately, they are not healthy choices for our watersheds. Rainwater that falls on these impermeable surfaces runs off quickly before it can soak into the ground to recharge the water table, disrupting stormwater flow patterns and causing erosion due to the water's high speed. Rainwater flowing over asphalt or concrete also picks up pollutants such as oil that drips from cars, pollution that settles out of the air and accumulates on the ground, and other materials that are spilled on the ground. Pollutants are washed off the pavement and into the stormdrains when it

Clare Miller Watsky

FIGURE 5.12 *Sherman School's playground, September 2006, before construction began.*

FIGURE 5.13 *Sherman School's green schoolyard, April 2009, after plants have grown for one year.*

rains, eventually ending up in our rivers, lakes, and oceans where they harm sensitive aquatic environments. Sometimes stormwater pollution also threatens the quality of our drinking water, as well.

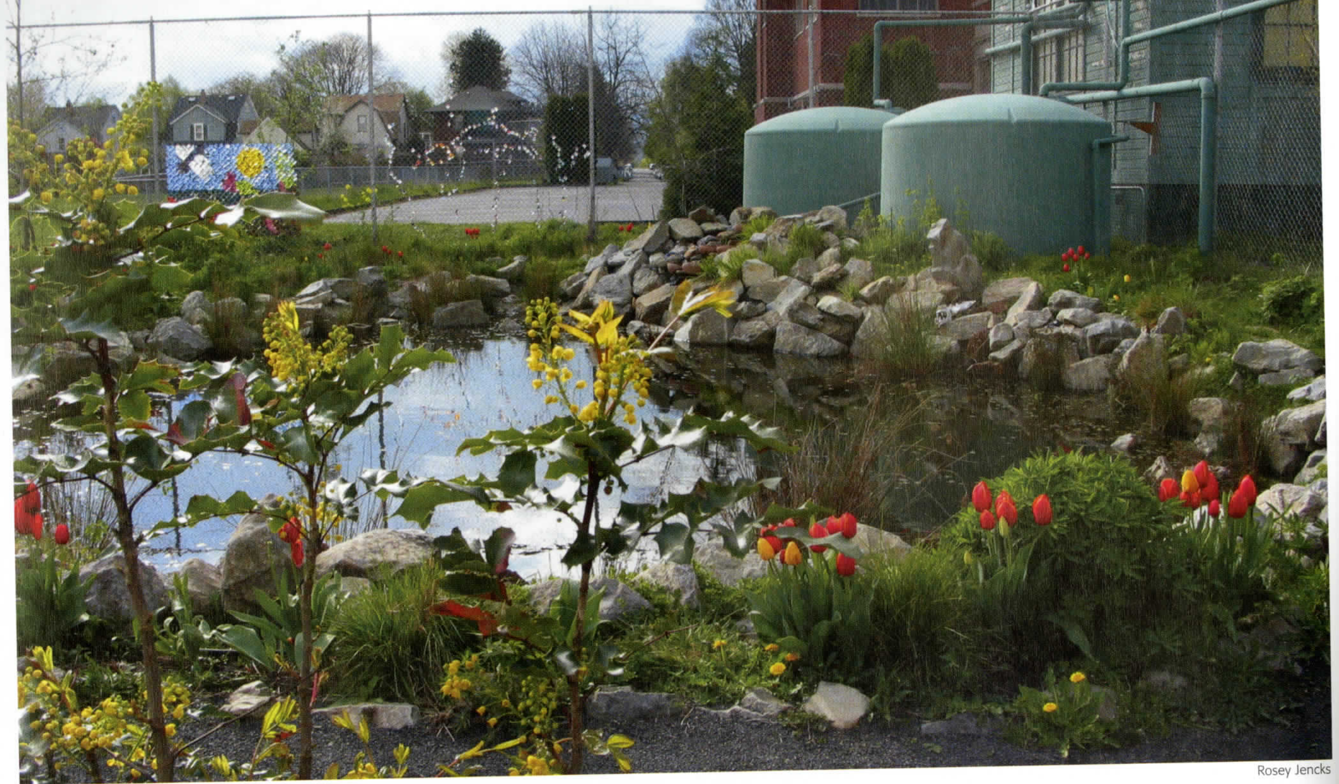
To alleviate these problems, some schools are removing asphalt and concrete to increase the amount of permeable (water-absorbing) surfaces onsite. Permeable pavement may be used for pathways and other areas that need to remain accessible for wheelchairs or vehicles. Permeable pavement options include decomposed granite (similar to firmly-packed course sand), and bricks or flagstones set on sand. Hard surfaces may also be replaced with soft, child-friendly ground coverings that are conducive to play, such as planted areas, wood chips, or sand. "Rain garden" wetlands that allow water to soak into the ground can also be used to achieve stormwater infiltration goals. Larger, more technical water infiltration projects, with underground pipe systems, can be employed to alleviate flooding.

Rain gardens and stormwater wetlands. Rain gardens are wetlands or ponds that are connected to a building's downspout or drainage swale that receives stormwater runoff when it rains. They are generally placed on permeable surfaces to encourage rainwater to soak into the ground. Small-scale stormwater ponds are useful for processing small quantities of rainwater in a manner that is attractive and educational. (See Figures 5.6 and 5.7)

Schoolyard asphalt removal. Sherman School in San Francisco, California, is a dramatic example of the power of schoolyard asphalt removal to change the character of a schoolyard landscape. As part of a large green schoolyard renovation project, the school removed 68 percent of the impermeable surfaces on one of their playgrounds.[13] The renovation replaced approximately 9,500 square feet of flat asphalt with a rolling hillside filled with plants, mulch, and permeable decomposed granite pathways that allow rainwater to soak into the ground. The new design also features a wheelchair accessible concrete pathway that meanders through the yard and a curved asphalt patio along the school building, totaling approximately 4,500 square feet.[14] (Figures 5.12 and 5.13)

SITE DESIGN GOAL #2: *Slow and filter schoolyard stormwater flows*

Stormwater moves through urban environments with greater speed than nature intended, running off rooftops, streets, sidewalks, and ground surfaces that resist water absorption. During



Rosey Jencks

FIGURE 5.14 *Surface water in the garden at da Vinci Arts Middle School provides habitat for beneficial insects and supports a great variety of plants and wildlife.*

large rainstorms or in places where a high percentage of the land is paved, the resulting water surges can overwhelm the stormdrain network and pollute the receiving water bodies.

These problems can be addressed by providing areas where stormwater can soak into the ground and by reducing the water's speed. Densely planted areas slow stormwater runoff because leaves and branches partially block the water's path. As the water slows, particulates drop out of the water column and settle to the bottom of the planted zone. Plants also collect nutrients from the water, and they can be used to filter or remove other water impurities, if the proper species are selected and placed appropriately. Water that does not soak into the ground during its slow passage through vegetation is often released from the end of a swale or wetland with improved quality, and at a speed that stormdrains can manage.

Schools can help repair their watersheds and protect their local streams, lakes, and oceans by designing their landscapes to (1) slow down stormwater, so it can soak into the soil, (2) filter stormwater by using planted swales and wetlands, and (3) create living roofs on their buildings to help moderate peak flows.

Stormwater gardens filter and capture rainwater to improve local water quality. The da Vinci Living Water Garden project, founded in 2001, is a collaboration between da Vinci Arts Middle School in Portland, Oregon, and Urban Water Works, a local nonprofit organization.[15] The goal of the project is to educate students and citizens about stormwater runoff and water quality, while celebrating the beauty of rainwater.

The project reroutes stormwater runoff from the school's roofs and parking lots into a 7,200 square-foot water garden that includes cisterns, a pond, a constructed wetland, and a bioremediation swale. Located on the site of an abandoned tennis court, the project was designed and built by the school's students, teachers, and parents. It now cleans and absorbs 100 percent of the water it captures, reducing runoff to the Willamette River, providing recreational and educational opportunities for the school and surrounding communities, and creating a model for stormwater diversion that can also be implemented on residential and commercial sites.

The rainwater harvesting system consists of two tanks capable of holding a total of 5,000 gallons of water, supplied by gravity-fed runoff from a 2,840-square-foot roof. In a region that gets over 30 inches of rain a year, just 3 inches of rain can fill the tanks. Overflow from the tanks is directed into the pond. The cisterns supply a gravity-fed garden irrigation system, which is used during dry summer months.

The garden also captures stormwater runoff from nearby parking lots and filters it though a bioremediation swale before it enters the pond. Plants in the swale slow the flowing water, allowing pollutants and sediment to settle out. Some of the water percolates into the ground during this journey, helping to recharge the water table. This system keeps the water garden clean, and removes some of the pollutants that would have otherwise entered the local watershed.

The da Vinci Living Water Garden is an attractive, clear demonstration of sustainable rainwater harvesting techniques and an important asset for the school. It provides a living laboratory, educational and recreational opportunities, and green space for relaxation. Students who participate in this project have a greater understanding of stormwater management methods and are empowered by the experience of transforming their immediate environment in a lasting, beneficial way. (Figure 5.14)

Living roofs on school buildings moderate stormwater flows. "Living roofs" are building rooftops, covered with waterproof drainage membranes, a thin layer of lightweight soil, and hardy, drought tolerant plants. Living roofs act as sponges when it rains, holding some of the water on the rooftop for a short time, before releasing it to the gutter and downspout systems below. This moderation of stormwater flows helps to protect stormdrains from sudden surges of water during rainstorms, which can help to keep them from overflowing.

FIGURE 5.15 *The barn at St. Hansgården in southern Sweden is part of an after-school permaculture center for the local school district. The building and its living, grassy rooftop were constructed by local middle school students, with the help of an architect.[16] (See Chapter 8.)*

Living roofs are also useful for insulating buildings, resulting in lower energy needs for winter heating and summer cooling. Rooftop plants also keep the surrounding outdoor environment cooler by reducing the "urban heat island" effect that is usually produced by traditional, dark roofing materials like asphalt shingles. Additionally, living roofs sometimes provide habitat for birds, butterflies, and other beneficial wildlife. They are visually attractive and help a building to blend in with other vegetation onsite. Large living roofs have more pronounced environmental benefits than smaller ones, but even tiny projects can be used as successful demonstration projects. (Figures 5.15–5.17)

FIGURE 5.16 *The living roof at Gunnesbo School in southern Sweden is planted with drought tolerant, waxy-coated sedums that are well-suited to hot, dry roof conditions.*

FIGURE 5.17 *This small, red tool shed included in our 2008 "Sustainable Schoolyard" exhibit at the United States Botanic Garden in Washington, DC, was built with a living roof and planted with sedums.[17]*

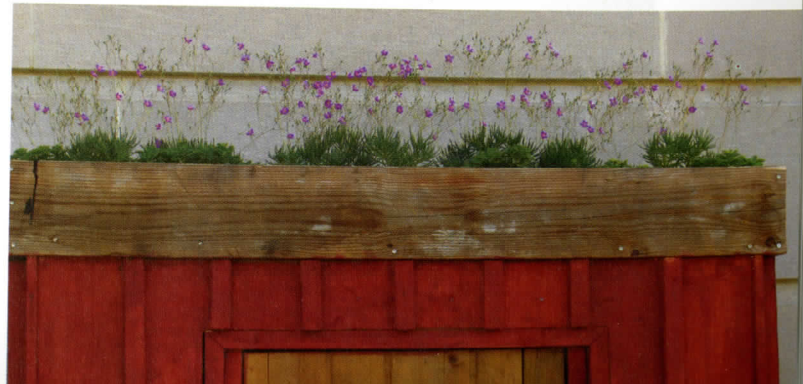


FIGURE 5.18 *Volunteers from Sequoia School in Oakland, California, planted a large hillside garden along their perimeter sidewalk, shown here during installation. The native plants will be watered using a drip irrigation system until they are established. The soil is covered with a layer of mulch to preserve moisture.*[18]

FIGURE 5.19 *Cowick First School in southwest England teaches its young students that water is a precious resource. This concept is noted on schoolyard signs and reinforced at the school with the use of low-flow bathroom sinks and toilets. A rain barrel also collects stormwater runoff from the school's roof for watering the garden.*[19]

SITE DESIGN GOAL #3: *Use as little potable water as possible*

Many of us take it for granted that purified water flows from our taps and "dirty" water goes "away," down the drain to be treated elsewhere. However, fresh water is in short supply in many places and a lot of energy is expended to make water clean enough for us to drink and use in our schools and homes.

Schools can choose to reduce the amount of fresh, clean water they import to their site from municipal water systems by instituting water conservation programs. They might also choose to capture and temporarily store rainwater in rain barrels or cisterns to supplement irrigation supplies or to flush toilets onsite. Schools can also recycle used water by filtering it in wetland gardens.

Improve water conservation with drought tolerant plants, drip irrigation and mulch. To conserve potable water, schools can initiate water conservation programs that include good landscape design choices, such as native and drought tolerant plants that are adapted to local rainfall patterns. Native plants benefit from irrigation in their first year after planting, but usually require very little supplemental moisture after they are established. Efficient drip irrigation systems coupled with water-retaining mulch on the soil's surface, to slow evaporation, often effectively reduces further water usage. (Figure 5.18)

Capture rainwater for use onsite. Stormwater can be captured and stored for later use inside school buildings or for landscape irrigation. The most common types of rainwater storage devices are rain barrels, which have a relatively small capacity, and cisterns, which tend to be larger. Each of these storage devices can be connected to a clean source of water, such as runoff from a building's metal rooftop. Storing water in closed containers, such as rain barrels and cisterns, helps keep the water clean and prevents mosquitoes from breeding in it.

Rain barrels are most frequently installed outside schools at the base of a downspout, where they can be easily seen and used for educational purposes. Due to their relatively small storage capacity, rain barrels are most useful in places that receive intermittent rain year-round, so they will be refilled frequently. Cisterns can be buried under the playground, placed in school building basements, or installed in gardens, where the water is needed. They can be used for much larger irrigation tasks

FIGURE 5.20 *In San Francisco, California, Alvarado Elementary School has a large metal cistern that collects rainwater from the adjacent classroom rooftop. The water is used to irrigate plants in the neighboring "secret garden," tucked into a corner of the schoolyard.*[20]

such as storing winter rains for summer irrigation, watering wide expanses of thirsty grass, or storing water for other school gardening or pond-related uses. (Figures 5.19 and 5.20)

Sagano Elementary School in Kyoto, Japan, employs several different methods to reduce its need for potable, municipal water. The school collects roof runoff in a 528-gallon (2,000 liter) wooden cistern, used to irrigate flowers in the schoolyard, and (Figure 5.21) the children leave empty buckets out in the rain to collect smaller amounts of water for hand-irrigation. (Figure 5.22) They also use a well in their culinary garden to water crops.[21] (Figure 5.23)

FIGURE 5.21

Sandra Koike

FIGURE 5.22

Sandra Koike

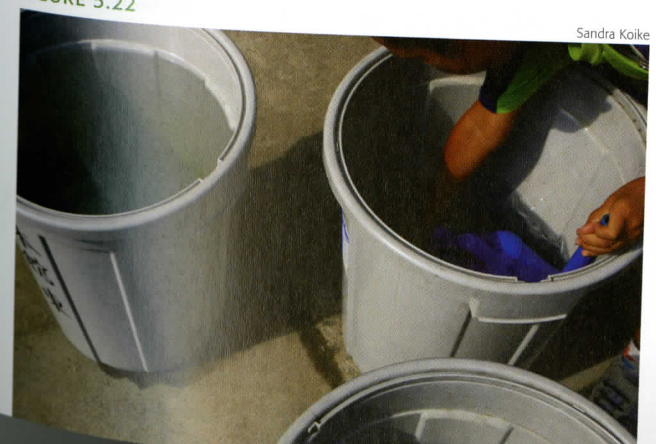


FIGURE 5.23

Sandra Koike

FIGURE 5.24

Michael Lyon

Roy Lee Walker Elementary School, in McKinney, Texas, has an impressive rainwater harvesting system that captures runoff from the school's entire roof area. Six large stone cisterns hold a total of 68,000 gallons of rainwater when they are full. (Figure 5.24) Students monitor the amount of stormwater held in the cisterns using a gauge in their main hallway. The collected stormwater irrigates buffalo grass plantings and other native vegetation. A 30-foot-tall windmill in front of the school powers a filtration system for the collected stormwater and circulates it to the irrigation network. The school building also has an extensive solar panel array that meets most of their needs for hot water. Other ecology education features—sundials, a pond, and a weather station—help students tune into the natural cycles around them.[22]

The grounds at Open Charter Elementary, near Los Angeles, were renovated to convert acres of impermeable asphalt into an asset for the school community and the local watershed. In 1999, the school created vegetated swales (planted depressions) to absorb part of the site's stormwater and planted 88 trees to absorb water and provide shade. In 2002, the school installed a substantial 110,000-gallon underground cistern, and an accompanying stormwater treatment device, that removes oil residues and other pollutants from the stormwater before storage. The water collected in the cistern irrigates the school's ball field and other vegetation during Los Angeles's long, hot, dry season.[23]

The cistern, water treatment filter, and plantings at Open Charter Elementary work together to provide a comprehensive approach that accomplishes the project's stormwater management goals. "All stormwater on the site is either percolated in the tree wells and swales; collected, treated in a sedimentation basin and stored in an underground cistern for later use; or treated and released to the stormdrain system if the cistern is full."[24] Students at the school also benefit from the beautiful shady, green learning and play space. (Figures 5.25–5.27)

Melinda Kelley, TreePeople

Rebecca Drayse, TreePeople

FIGURE 5.25–5.27 *Open Charter Elementary shown before and after schoolyard renovation. Underground cistern during construction (below).*

TreePeople

Conserve water by recycling it onsite. Most of our communities and schools are *designed* to waste water—using it only once before sending it down the drain to be cleaned in energy-intensive treatment plants far away. Some of the water that currently runs down our drains can be reclaimed by savvy school communities and put to additional uses onsite, conserving water and energy in the process.

The water that flows down our bathroom and classroom sinks, usually only lightly "dirty" from hand washing, is called "greywater." Greywater may be reclaimed relatively easily for landscape irrigation if simple protocols are followed to maintain hygiene. The water flushed in our toilets usually has a more complex load of contaminants and is referred to as "blackwater." Blackwater can also be reclaimed using thorough, but manageable, water purification processes. Schools can illustrate these treatment processes for their students by installing wetland-based treatment systems on their grounds.

When Östratorn School in southern Sweden expanded to accommodate more students in 1997, they chose to create a building addition that showcases green practices. Among its wide array of exemplary features—from recycled materials to renewable energy—is an innovative system that combines rainwater collection and onsite blackwater treatment to reduce use of potable municipal water. (Figure 5.28)

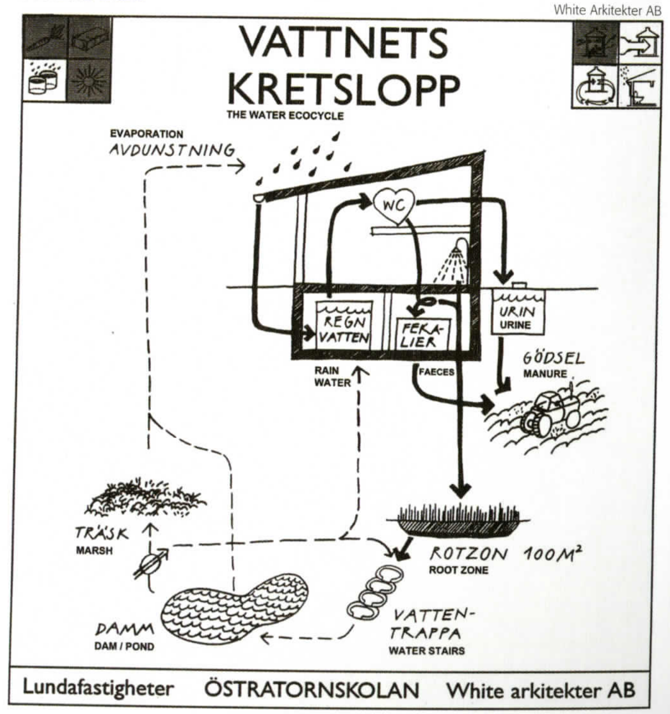
At Östratorn School, rainwater is collected from the building's roof and channeled into its basement where it is stored in two large cisterns that hold a total of 18,000 liters (4,755 gallons) of water, used to flush bathroom toilets. The toilets are a two-chambered variety that separate urine and feces, and use *very* little water for each flush. A mere two deciliters (6.8 fluid ounces) of water is used to flush urine and four deciliters (13.5 fluid ounces) to flush feces—a dramatic savings over standard toilet models that use up to six liters (202.8 fluid ounces or 1.6 gallons) of fresh water for each flush.

When flushed, the urine is sent to two underground storage tanks that are emptied periodically by a local farmer who uses this nitrogen-rich material as fertilizer for his off-site fields. Feces and its flush water are sent down a different set of pipes. The feces solids are collected in a basement composting unit where they are processed for use as fertilizer for the same farm. The feces flush water, called blackwater, is separated from the solids and is treated onsite in a constructed wetland built specifically for this purpose. (Figure 5.29 on the next page)

The blackwater is pumped from the toilet system into a lined, constructed wetland filled with gravel and planted with tall reeds in front of the school. The plants' roots slowly filter the nutrients out of the water and the water is gradually released

FIGURE 5.28

White Arkitekter AB



from the wetland. (Figure 5.30) This area of the wetland is fenced off from the schoolyard to prevent children from digging in it—but there is no surface water visible above the gravel, and I did not detect any odors from it when I walked nearby.

After the water is released from this subsurface wetland, it flows downhill in an attractive, waterfall-like series of "flow form stairs," which aerate it. Next, the water crosses through the root zone of an adjacent shrubby area and into a beautiful, small pond in front of the school. Water then evaporates from the pond, and perhaps falls again as rain on the school's rooftop. The water in the pond is clean enough to use again in the toilet flushing system, if desired.[25]

FIGURE 5.29

FIGURE 5.30

Comprehensive Model

In 2006 Sidwell Friends Middle School in Washington, DC, completed a major building expansion that resulted in a large new addition and a substantial renovation of existing school buildings. Following the environmental stewardship philosophy and Quaker values of the school, the new construction and renovation were designed to be as green as possible; they achieved an impressive "Platinum" rating from the LEED® Green Building Rating System—the first K-12 school in the United States to achieve this distinguished status.

Green building systems are thoroughly incorporated into every facet of the building, but the design's close attention to water systems is truly exceptional because it includes onsite blackwater treatment and addresses water systems in three other ways as well.[26]

The most unusual water-related feature onsite is the substantial blackwater treatment system that cleans and processes wastewater from the building's toilets, sinks, floor drains and janitor basins so that it can be later reused in urinals, toilets and the building's cooling tower. This saves a substantial amount of water and energy in comparison to standard offsite treatment systems.

FIGURE 5.31

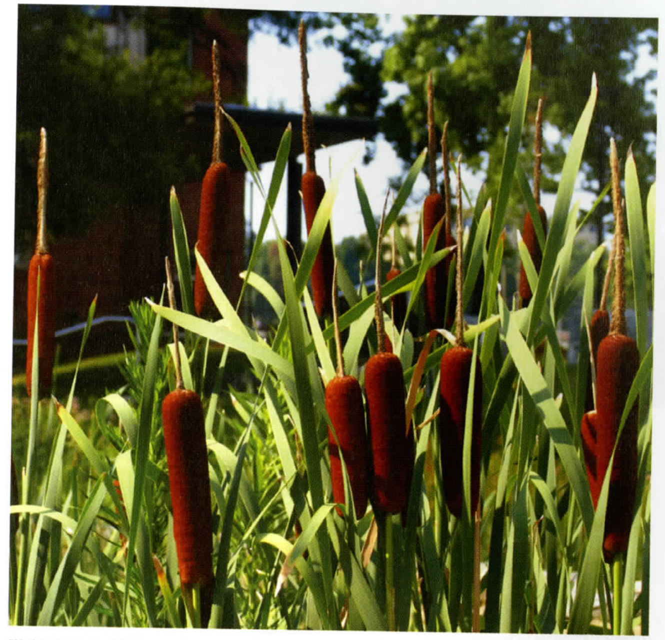
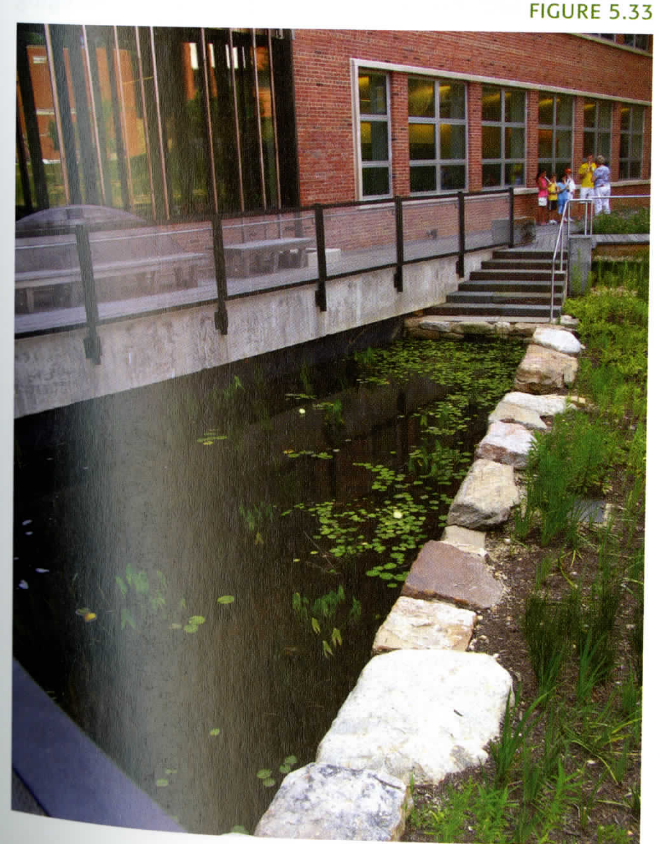


FIGURE 5.32

FIGURE 5.33



After the water runs down the building's drains, it enters an underground settlement tank where liquids and solids are separated. The liquids proceed to an attractive wastewater treatment wetland garden just outside the building. (Figure 5.31) The wastewater circulates through the garden repeatedly, passing through three tiers of subsurface flow wetlands where cattails (*Typha* spp.) (Figure 5.32), bullrushes (*Scirpus* spp.), and other plants rooted in deep, odorless gravel beds remove nutrients from the water. As it circulates through this system, the water also cycles through a trickling filter that aerates it and removes excess ammonia. The purified water passes through a sand filter on its way to the building's basement, where it is further treated using three filters and a UV disinfectant system. The resulting water is clean enough to meet municipal wastewater treatment standards, but its use is restricted by health codes; it is only used in the building's cooling tower and the toilet flush system, where it then repeats the cycle.

The school grounds also include a separate stormwater harvesting system that captures roof runoff to create a beautiful pond and rain garden. (Figure 5.33) When it rains, water flows from the roof through downspouts and chutes to the pond below. The pond is filled with fish and aquatic plants that are dynamic teaching tools for the science classes. To help the

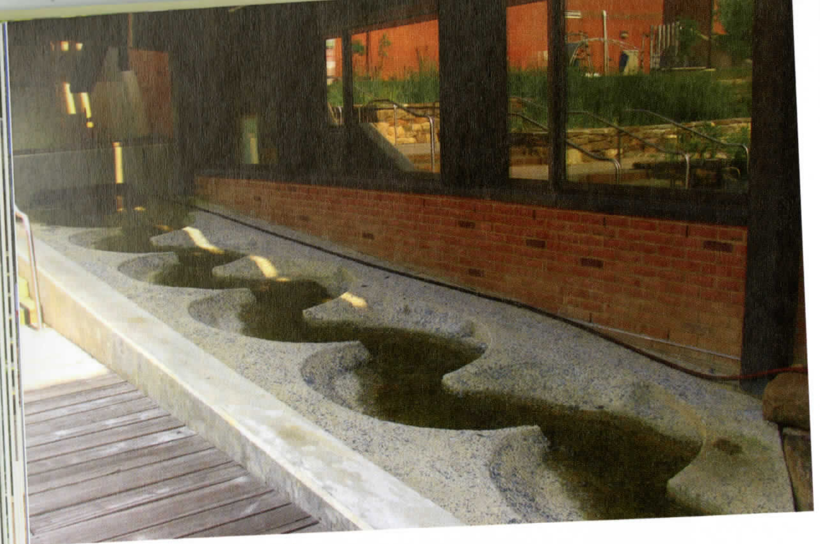
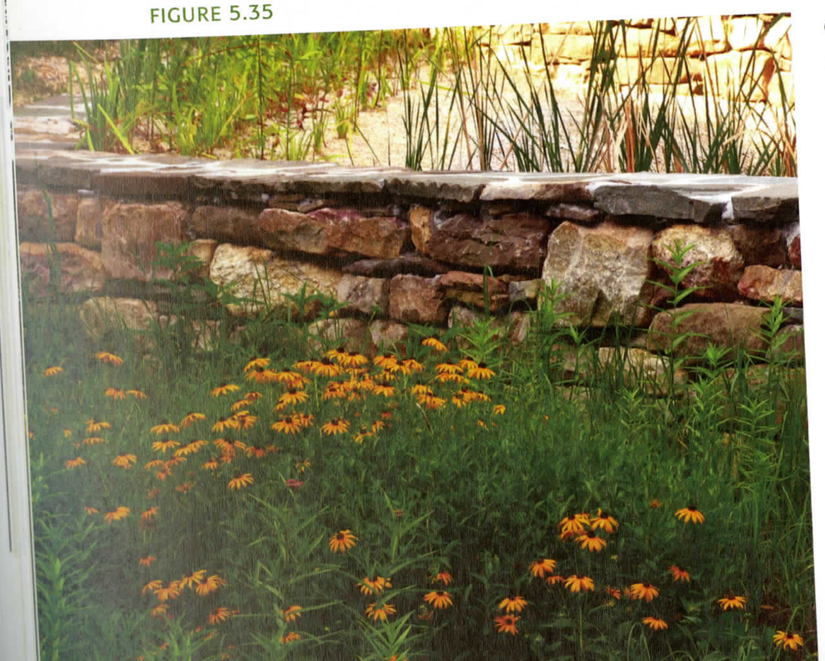


FIGURE 5.34

FIGURE 5.36

fish thrive, the pond includes a 4-foot deep section, protected by an underwater metal grate designed to allow fish to successfully over-winter. The pond water is continuously circulated using an attractive, swirling aeration system that deters mosquitoes. (Figure 5.34) After large rainstorms, the pond water spills into the adjacent rain garden's floodplain, where it percolates into the ground to recharge the water table. (Figure 5.35) Excess water from very large storms is channeled into the municipal stormdrain network. During dry periods, the pond can be refilled using an additional 3,000-gallon cistern nearby that is also fed by rooftop stormwater runoff.

FIGURE 5.35



The school building's innovative design includes a living roof that helps to filter stormwater and slow it down on its journey to the pond below. Composed of a 5-inch layer of lightweight soil, planted with drought-tolerant species, the living roof insulates the building and protects the waterproofing membranes and roofing materials from the sun, prolonging their durability. (Figure 5.36) The new building's rooftop also includes a raised-bed organic garden where students grow edible crops and other plants. Other portions of the roof, over the older building, hold solar panels and a weather station. Finally, the school's landscape design strongly emphasizes native plants, which are naturally adapted to local rainfall patterns and, therefore, need little irrigation. The school grounds also include an artificial turf field so students may play games on a soft surface without the high maintenance levels and large irrigation needs typically associated with a live lawn.

According to the school's estimates, their wastewater treatment wetland and the water efficient landscaping features reduce their use of municipal water by 93 percent, as compared to similar schools with conventional water treatment and usage.[27] Their stormwater pond and living roof improve the health of the local watershed in ways that are harder to quantify, but are equally important.

At this writing in 2010, it is fairly unusual to have all of these systems in place on a single school campus, but I hope that more schools will follow Sidwell Friends School's example in the future and take greater responsibility as stewards of their own water systems.

6 *School Energy Systems*

Energy issues are in the news on a daily basis as our politicians and communities ponder how to reduce their reliance on fossil fuels and curb global warming, while still maintaining our high quality of life. Our classrooms are filled with students who will grow up in a world where climate change is a central problem. Many schools are taking steps to educate their students about how to make a positive contribution to this field while they are young.

For schools, energy systems is a topic that hits close to home. They are substantial consumers of energy, using electricity, natural gas and other sources of energy to heat, light, and power school facilities; most of their inhabitants use fossil fuels to commute to school. Educating today's students about renewable energy systems and energy conservation practices will help our communities make smarter decisions about tomorrow's energy needs.

Every school has access to sunlight, wind, and other forms of energy, but most are not yet using them as renewable energy resources or educational tools. School communities can engage their students in reducing their facility's energy footprint, while teaching real life lessons about where energy comes from and what it takes to produce and transmit power. Students can also be encouraged to reduce their transportation-related energy usage by walking and biking to school.

Because power costs adversely impact tight school district budgets, sometimes forcing elimination of important programs, facility-related energy issues are of immediate financial importance to schools. Together, K–12 schools across the United States "spend more than $8 billion a year on energy, making energy the second-highest operating expenditure for schools after personnel costs."[1] In 2008 this enormous price tag translated to approximately $175 per student per year at conventionally designed schools.[2] We can do better than this.

Schools can reduce their facility-related energy expenditures without sacrificing the quality of educational programs or educational goals.[3] In fact, energy conservation practices and renewable energy generation systems on school grounds *add* to the educational potential of school facilities by giving students valuable hands-on resources to make their classroom lessons come alive. Some schools, with skillful design, construction, and management, may even be able to achieve some degree of energy independence by producing a portion of the energy they need to run their buildings. However, school energy systems do not need to be large to be effective and inspiring teaching tools.

Although energy systems encompass the entire school site, both inside and outside, our focus in this book is school*yards*, rather than school buildings. Accordingly, my coverage of indoor, facility-related energy systems is brief and general, designed to give you a taste of what's possible. There are hundreds of written documents available on this topic and many excellent national, regional, and local programs dedicated to addressing energy systems for school buildings.

Key Organizations

An ever-growing array of organizations are working to advance energy conservation and renewable energy systems in schools around the United States and abroad. In the U.S. there are several organizations that stand out as early leaders in shaping the direction of this emerging field.

At the national level, the United States Department of Energy (DOE) has an ambitious program called EnergySmart