Cahill Associates developed a variety of special tools for the 107.5 square-mile Little Lehigh Creek Watershed in Lehigh County, as part of the expanded Act 167 Storm Water Management Plan project. Working for the Lehigh Valley Planning Commission, the first challenge was to develop technical guidance explaining how to accomplish infiltration of stormwater in carbonate geology – without creating subsidence and sinkholes that have plagued so much of the Watershed. A second important issue has been protection of both groundwater and surface water quality, given the extreme sensitivity of limestone aquifers to contamination. Another major objective of this project was to develop specific engineering guidance that describes in as much detail as possible how to implement the various approaches to infiltration – specific Best Management Practices – which are available for development sites in the Little Lehigh Creek Watershed. Applicants need detailed, though straightforward, guidance – a BMP Infiltration Manual – which explains how to do what, where and when. Finally, all of this is tied together by a unifying watershed strategy, designed to achieve an ambitious “no increase” water quality objective in this Watershed already suffering from a variety of water quality problems.

Carbonate geology is both a blessing and curse. For some time, the fear of sinkhole creation has tended to convince many that water should simply be kept away from limestone, even though carbonate aquifers are wonderfully rich. Furthermore, the removal of water from carbonate in whatever manner ultimately weakens the rock and promotes subsidence itself and so is hardly a sound strategy. The management solution stated simply is to use infiltration BMPs carefully, in a way that mimics the natural hydrologic regime to the maximum extent through broad and even distribution of stormwater or wastewater effluent. If this approach is employed and other basic precautions are taken, sinkhole creation can be minimized and water quality can be protected.
Cahill Associates served as part of a nationwide team of consultants assisting the US EPA and NOAA in the development of programs for urban growth-related pollution sources within coastal drainage. The team’s efforts resulted in the 1993 release: *Guidance Specifying Management Measures For Sources Of Nonpoint Pollution In Coastal Waters*.

Cahill’s efforts involved the development of specific recommendation to reduce NPS from site development. Cahill Associates work focused particularly on nonstructural measures of pollution control – measures that prevent pollution rather than mitigate it. Cahill Associates provided information relating to effective structural management measures, such as the porous pavement/underground recharge bed technology and other recharge-oriented measures. A technique that Cahill Associates developed for the State of New Jersey’s coastal management program, **Minimum Disturbance/Minimum Maintenance** Land Development, was also incorporated into this new EPA/NOAA guidance.

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**C. Site Development Management Measure**

Plan, design, and develop sites to:

1. Protect areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss;
2. Limit increases of impervious areas, except where necessary;
3. Limit land disturbance activities such as clearing and grading, and cut and fill to reduce erosion and sediment loss; and
4. Limit disturbance of natural drainage features and vegetation.
The New Jersey Department of Environmental Protection, Division of Coastal Resources, wished to develop a Reference Guide or Design Manual which could be used to review and evaluate proposed storm water management systems for new development in the New Jersey Coastal Zone. The quality of water in the 2,000 square mile coastal zone has over the past ten years been degraded by both point and non-point pollutant sources originating from an assortment of land development activities along the coast. The issue of the effects of these pollutants on the coastal environment was of immediate concern and specific management guidelines were needed.

Cahill Associates (CA) was selected by the state for their expertise in non-point source pollution (NPS) mitigation. CA prepared a detailed review of current practices and evaluated new storm water management technologies for their suitability in the New Jersey Coastal Zone. These Best Management Practices (BMPs) would be incorporated into the Division of Coastal Resources permit review process to reduce or prevent further degradation of coastal marine environments. The resultant manual carefully analyzed and discussed in detail the sources of NPS loadings in the Coastal Zone and recommended many innovative techniques to be applied to the Atlantic coastal drainage to improve coastal water quality.
Cahill Associates (CA) was the prime contractor for the Act 167 Stormwater Management Plan for Neshaminy Creek Basin, involving 35 municipalities in rapidly developing portions of both counties. The Bucks County Planning Commission and Bucks County Conservation District directed the study which was published in 1986.

CA developed computer models for storm flow analysis and applied and calibrated these models in the Basin. In addition to conventional stormwater concerns involving reduction of peak rates of discharge, CA also evaluated water quality parameters carefully. Stormwater management techniques to increase groundwater recharge were considered for use and adoption by participating municipalities. This plan was the first 167 plan in the state to seriously address the issues of water quality and volume, and served as a model for subsequent plans to address these issues.
SUSTAINABLE WATERSHED MANAGEMENT ~
A River Conservation Plan for Northern Chester County Watersheds

Green Valleys Association
Chester County, PA

Northern Chester County is an exceptionally beautiful area that has, until recently, remained largely rural. The area is known for its high quality streams and “green valleys” that contribute to the quality of life. Intense development pressures, however, threaten to rapidly destroy and degrade the natural environment, especially the water resources in this largely groundwater dependent area.

Since 1995, Cahill Associates and the Brandywine Conservancy EMC, working for Green Valleys Association, have been developing a program of “Sustainable Watershed Management” for the watersheds of French Creek, Pickering Creek, Stony Run, Pigeon Creek, and portions of the Schuylkill River. The primary goal of “Sustainable Watershed Management” is to sustain the essential values that distinguish these watersheds. When the wave of development pressures overtaking these communities has worked itself into a new landscape township by township, the quality of the water and the land will remain largely intact. That is the essence of sustainability.

The essential goal of Sustainable Watershed Management is to first evaluate the capabilities and limits of water resources—both quality and quantity—within the Watersheds and then develop land use management strategies that are compatible with these limits.

Because land use decisions directly affect water resources, and because land use decisions are made at the municipal level, a critical element of this effort is working with the municipalities. The land use strategies have involved working directly with the municipalities and the Northern Federation of Communities, a multi-municipal organization comprised of nine of the northern Chester County municipalities. Key elements of this work have included development of a Model Stormwater Ordinance to maintain groundwater recharge, and direct work with individual municipalities to review comprehensive plans and zoning, water and sewer infrastructure programs.
Development adversely impacts water resources in a variety of ways. Substantial quantities of water are pumped from watershed aquifers, lowering the water table, jeopardizing existing wells, and reducing stream base flow. The newly “developed” land surface generates increased stormwater runoff, worsening flooding during storms. At the same time, less water is returned to replenish aquifers already stressed, further reducing stream flow during critical dry periods. Streams may even dry up completely.

Nonpoint source pollutants are washed from roadways and parking lots and from artificial landscapes maintained with frequent applications of noxious chemicals. Wastewater effluent often is discharged into the streams.

Through development and application of a computer-based Geographic Information System (GIS), CA projected future land development throughout municipalities within the Watersheds. Using state-of-the-art technical models, the essential water-related impacts from this development are analyzed. For example, a Low Flow Maintenance Model was developed and applied in order to guarantee that first order streams maintain their flow during critical dry periods. The Dry Year Nitrate Impact Model was designed to ensure that unsafe nitrate levels, especially stemming from wastewater effluent, do not contaminate water supplies.
Technical results from these analyses constitute the critical legal basis of the management program being developed. The GIS includes an array of different types of information such as geology, soils, existing land use, and zoning.

This program of Sustainable Watershed Management has been supported by major grants from the William Penn Foundation and the Pennsylvania DCNR Rivers Conservation Program, as well as support from the local municipalities.
MORRIS ARBORETUM NEW ENTRANCE ROAD AND POROUS PAVEMENT PARKING

The Morris Arboretum of the University of Pennsylvania
Philadelphia Pennsylvania

As consultants to the Morris Arboretum, Cahill Associates provided innovative, sustainable site engineering and design services for enhancement of the 175-acre historic State Arboretum located in the Chestnut Hill section of Philadelphia. The new entrance road crossed a stream and floodplain, and required a bridge design that would avoid placing fill in the floodplain, and would allow flood waters to pass naturally.

Parking had to be invisible to the garden visitors. To achieve this, the parking lots were graded flat and tucked into the hillside below the crest. This design reduced the visual impact and also worked to the advantage of the porous pavement and recharge beds placed under the parking. Stormwater runoff from the entrance driveway is also recharged into the ground by the use of perforated pipe in gravel filled trenches, which convey runoff from the stone gutters at the edge of the road and infiltrate it into the meadow. This low impact design maintains the natural water balance at the Arboretum, and is one of the earliest porous pavement installations in the Philadelphia area.
The Parole Growth Management Area in Anne Arundel County, Maryland required guidance in managing future growth, rewriting stormwater ordinances, and preserving green space to minimize the environmental impacts from development occurring within the Chesapeake Bay Watershed. This area is experiencing an explosion of development that is common throughout the mid-Atlantic region. With continued growth comes increased impervious surfaces that cause an increase in stormwater volume and NPS pollutants. These changes require more creative stormwater management techniques that preserve and protect streams and riparian corridors, as well as reduce pollutant transport into the Chesapeake Bay.

Cahill Associates was asked to review the future Parole Growth Plan, as well as several specific site development plans within Anne Arundel County to find environmentally friendly solutions for stormwater management and the preservation of environmentally sensitive areas. Cahill Associates worked with County Planning Department to develop more effective Stormwater Management Alternatives using groundwater recharge as a system of retention, infiltration, and stream protection. These stormwater systems provide both a reduction in stormwater runoff volume and water quality benefit.
Though a project called Heritage 2000, Ford Motor Company has become an industrial leader with a new commitment to the environment at the Rouge River Complex. During a 200 billion dollar plant renovation, William McDonough & Partners Architects and Cahill Associates (CA) were brought on as part of the environmental leadership on site.

The first of many improvements at the Rouge River Plant was a new vehicle storage and staging lot. CA designed a system using porous pavement, subsurface storage, and water quality swales to capture and treat stormwater runoff. Additional similar systems will be applied through the Rouge Plant renovations, to include vegetated roof covers on the new million square foot assembly plant, storage, and an open surface constructed wetland for water quality. Together the team has integrated stormwater management with landscaping and building layout and design for an environmental vision of the future.
ALCOA ENGINEERED PRODUCTS

Aluminum Company of America (ALCOA)  
Lafayette, Indiana

ALCOA – leader in the aluminum industry – has dedicated their efforts in transforming a number of plants nationwide and worldwide into “sustainable sites in terms of stormwater and industrial process water discharges”. ALCOA is striving toward a goal of “zero discharge” for all facilities including industrial discharges and stormwater.

The ALCOA Lafayette, Indiana facility has been in operation as an aluminum extrusion plant since the 1940’s. The 172-acre facility is comprised of various manufacturing, office and laboratory space, as well as several large fabrication and extrusion structures. Approximately 90 acres of the site is covered by impervious building rooftop, roadway and service areas. The remaining area not currently in impervious cover totals some 82 acres, and consists almost entirely of grassed lawns.

Cahill Associates (CA) has developed a concept plan to make ALCOA’s zero discharge goal a reality. The first series of improvements at the Lafayette, Indiana plant include a retrofit of the rooftop structures to convey stormwater runoff to the recharge beds beneath the grass areas. CA is developing systems that will utilize rooftop conveyance, porous pavement, subsurface storage, and water quality swales to capture, treat and infiltrate stormwater runoff. These systems will be designed to overflow, in the event of larger storms, to the municipal stormwater infrastructure. By utilizing this storm sewer as an overflow, the plant will remain operational in the larger, less frequent storms, at a cost savings to the client. A similar system will be applied throughout other areas of the facility, to include vegetated roof covers in combination with the rooftop conveyance to onsite grass recharge areas. Together the team is integrating stormwater management, with landscaping and building layout for an environmental vision of the future.
The new Visitor Center for the Pennsylvania State University and the Centre County Visitors and Convention Bureau has been designed as a “sustainable” building, and in keeping with the concepts of sustainability, Cahill Associates designed a stormwater system for the new Visitor Center that essentially serves as a demonstration site for a variety of vegetative and infiltration BMP’s.

BMP’s include,
- A sub-surface infiltration bed that receives runoff from an existing building and parking lot, see Figure 1;
- Porous bituminous pavement in the parking areas, underlain by a stone filled storage/recharge bed, see Figure 2;
- New sidewalks constructed of porous concrete, see Figure 3;
- Bioretention basins – small depression carefully planted to improve water quality, see Figure 3, and
- A shallow infiltration trench that receives roof runoff, see Figure 4.

The use of these features will both maintain the groundwater recharge and reduce the discharge of non-point source pollutants to streams and waterways. The system has been designed to capture and infiltrate the net increase in the volume of runoff for all storms of a two-year frequency or less. Because over 95% of the rainfall that the State College area receives occurs in storms that are smaller than the two-year storm event, there will be no increase in either the rate of runoff or the volume of runoff from the site after development for these storms. The infiltration and recharge of groundwater that now occurs at this site will be maintained. These BMP’s were successfully built despite the limitations of a shallow soil mantle underlain by carbonate geology.
LID and STORMWATER INFILTRATION FOR NEW DORMITORIES

Pennsylvania State University – Berks Campus
Spring Township, PA

In 1999, the Pennsylvania State University Berks County campus in Reading developed a Dormitory Building for some 400 resident students, situated in a wooded knoll on the attractive campus. This facility required additional parking area for 320 cars. The campus had been hindered in prior development by the formation of sinkholes in the Carbonate bedrock, which underlies the campus at shallow grades. An existing detention basin had suffered from severe sinkhole problems.

Cahill Associates applied Low Impact Design concepts to the new dorms, which were carefully situated along the contours in the woods. This preserved important trees and minimized earth disturbance, which was limited to within 15’ of the structures. Roof leaders discharge to stone-filled stormwater storage/infiltration beds beneath the walkways, or into a perforated pipe that is situated laterally along the contours in the woods. This maintains soil moisture for the woodlands and prevents the erosion or disturbance of the hillside. Cahill Associates also designed the parking lots using porous pavement underlain by groundwater recharge beds, which prevents the concentration of stormwater runoff downhill and allows the incident rainfall to pass directly through the parking bays, slowly percolating into the soil and aquifer system.
SMITHKLINE BEECHAM CORPORATION
CLINICAL LABORATORY COMPLEX

Valley Forge Business Center
Montgomery County, Pennsylvania

Cahill Associates provided the civil and environmental engineering for SmithKline’s $17-million, 135,000 square-foot office and laboratory on a 40-acre site in West Norriton Township, Pennsylvania.

Water resources related concerns posed the most serious constraints. As engineered in other successful projects, stormwater was handled by collecting it in gravel filled recharge beds underneath the parking lots that were paved with porous asphalt. This approach eliminated the need for a detention basin and saved an existing mature Oak/Beech forest. The project also involved the design of recreated wetlands and the use of innovative vegetation management techniques.

Construction Cost:
$17-million

Project Completed:
1987

Planning Merit Award, 1990,
Montgomery County Planning Commission

Cahill Associates
Environmental Consultants
SITE ENGINEERING and DESIGN for CORPORATE HEADQUARTERS

Sieman’s (former Shared Medical Systems, Inc.)
Malvern, Chester County, PA

Constructed in 1983, the porous pavement parking lot at Sieman’s is one of the oldest large porous pavement systems in the United States. This is especially significant considering that the underlying geology is carbonate. Constructed of a series of “beds” benched down the hillside (see photo below), this site served as an early example of “how to” for porous pavement on slopes.

After 20 years, the system continues to outperform nearby conventional parking lots. In the picture above, taken years after installation, heavy precipitation falling on the porous pavement in the foreground immediately disappears into the underlying bed; conventional pavement in the rear produces substantial runoff.

Above, construction of the subsurface infiltration bed; below, 15 years after installation.
Conventional stormwater management requires a large area of land be dedicated to a basin.

During hurricane Hugo, the porous pavement (upper portion) drained, while the conventional pavement had significant runoff.

Recharge scenario with runoff directed to recharge beds under parking lots and preserved forest/stream corridor.

**CAMPUS MASTER PLAN FOR DUPONT’S AGRICULTURAL CHEMICALS WORLDWIDE HEADQUARTERS**

*The Dupont Corporation  
Wilmington, Delaware*

Faced with severe stormwater management issues and a massive site construction program that threatened to obliterate scenic woodlands, the Dupont Company decided to immediately reassess site development plans in order to preserve site amenities at their Barley Mill Plaza office campus, outside Wilmington Delaware. Cahill Associates analyzed the entire stormwater management system and revised plans for roads and parking, and landscape plantings to achieve the goal of preservation and enhancement of site aesthetics.

Using computer models to simulated the complex hydrologic impact of the development as well as the contributing watershed upstream, the team apples a combination of groundwater recharge and surface impoundment technologies to minimize stormwater facilities and maintain existing woodlands.

Stormwater recharge beds were situated below porous-paved parking bays. The landscape plantings were native plants and bioengineering was used to stabilize streambanks. Preservation of the existing forest offered an opportunity to create a woodland trail to be used by Dupont employees.
In 1983, Cahill Associates designed a stormwater management system based on infiltration for a major office park near Allentown, Pennsylvania. Landmark Associates asked Cahill Associates to evaluate site needs for this mid-rise office complex proposed for Landmark’s 49-acre site. The project required careful analysis of both surface drainage as well as groundwater movement and soil characteristics. A major concern was to locate elements of the stormwater system so as to avoid sinkhole problems in the limestone formation.

We fast-tracked the project and completed conceptual, preliminary, and final plans in less than six months. The feat is made more impressive by the fact that the site straddled two municipalities – South Whitehall and Upper Macungie Townships – involving two parallel municipal land development permit processes. And after over 15 years, this system continues to perform with no evidence of any sinkhole subsidence.
The Darby Creek Watershed originates in a highly urbanized, densely populated region of southeastern Pennsylvania, just west of the City of Philadelphia. The Darby Creek, and her main tributary Cobbs Creek, are part of the Lower Delaware Watershed and join the Delaware River after flowing through the John Heinz National Wildlife refuge at Tinicum near the Philadelphia Airport. The entire watershed drains through 4 counties, 31 municipalities, spanning over 77 square miles. Within the Darby, remarkable opportunities are balanced by an intimidating array of problems. Cahill Associates developed a River Conservation Plan to unify the energies and resources of this complex watershed of contrasting elements and build programs that will restore the Darby Creek Watershed.

A variety of resource inventories were developed for the RCP; these resource inventories are critical when taken and understood individually, constituting important independent resource elements in the Watershed. However, their significance is even greater when these resources are linked and viewed together, forming a kind of *ribbon of green*.

This *ribbon of green* is the core of the Darby Creek Greenway vision at the heart of the RCP. The RCP provides a program to protect and enhance the impacted Watershed.