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Fixing the Flow

Flood control, restoration, and creating public space

BY CAROL BRZOZOWSKI

Be it for flood control, aesthetics, or habitat restoration, streambanks throughout the globe have been getting a face-lift, and, in many cases, projects installed years ago are demonstrating continued success.

Each time an engineering firm is presented with the challenge of repairing streambanks, the primary consideration is what type of liner or approach will best suit the long-term site needs. Water volume from a five- or 10-year storm is one consideration, as well as soil type.

Water volume plays another role if further development is expected upstream, increasing the amount of impervious surface and thus the volume of runoff. Another consideration is whether the channel merely conveys water or also infiltrates or treats stormwater.

As with many projects these days, cost considerations in choosing soft armor or hard armor come into play, as do local regulations that may seek a more natural-looking technique.

Enlarging Antelope Creek

When the Lower Platte Natural Resources District (NRD) and the city of Lincoln, NE, set out to control flooding along the Antelope Creek, they had two objectives: to take homes and businesses out of the floodplain and to preserve and improve a nearby bike path.

The two entities partnered on the $2.5 million project, featuring new retaining walls along Antelope Creek's west bank. Other improvements included additional box culverts under a bridge, a detention cell to temporarily hold water in a park, two flood control berms, and a wider recreational trail.

Flood reduction was the primary purpose of the project, which is part of a larger effort in Lincoln called the Antelope Valley Flood Reduction Project.

In this case, the channel between two streets was a restriction point that needed to be widened to convey larger storm flows.

"Antelope Valley is a built-out watershed," says Don Day, P.E., water resources group leader for Olsson Associates, the design/specifying engineer for the project. "That's the reason there's a lot of flooding. When this watershed was developed, there weren't a lot of flood planning regulations or stormwater regulations. The purpose of this project was to handle the increased runoff from the built conditions."

Day had the challenge of finding the appropriate solution for lining the creek channel. There was no room to excavate for geogrid. The NRD and the city initially considered using a poured-in-place wall and sheet piles.

After meeting with local Redi-Rock manufacturer and retailer Workman Precast, the NRD and city chose Redi-Rock Ledgestone walls, allowing engineers to design gravity retaining walls up to 16.5-feet tall to create a channel for Antelope Creek.

"The challenge was trying to widen the stream in a built environment," says Day. "On one side we have a major street and on the other side we have the Lincoln Children's Zoo. There was confined space."

The traditional approach would be to widen the bank by sloping the channel bank back. "In this case, we didn't have room," Day points out. "We had to come up with a solution where we had a more vertical bank. We looked at different types of products, including reinforced concrete and some other retaining wall products. In this case, the lack of space and cost is the reason we went with Redi-Rock."

The appearance of Redi-Rock's new Ledgestone was an added benefit. "Aesthetically and with the location, we thought it would be a better product to use," says Day. "It allowed us to widen the channel by having a near vertical wall there, and it gave us more capacity to help reduce the floodplain."

"The purpose of this project was to handle the increased runoff from the built conditions."

Minimal excavation was required, made possible by the large size of each Redi-Rock block. That permits walls to be built closer to property lines. In the case of the Antelope Creek project, the gravity solution preserved space that could be used for widening the bike/pedestrian path.

Another benefit is fast installation, as the Redi-Rock blocks stack like giant Legos, requiring an excavator and a small crew. Each block is made of wet-cast, 4,000-psi, air-entrained concrete.

Ledgestone blocks have the same dimensions and engineered capabilities as other Redi-Rock blocks, but with the look of natural, stacked ledgestone, creating walls that look like natural, random stone walls.

The project required 14,000 square feet of Redi-Rock retaining walls along 2,000 linear feet of Antelope Creek. The NRD estimates that when all phases of the project are complete, the flood control measures will take about 100 homes and businesses out of the 100-year floodplain.

M.E. Collins, a general contractor, and Leick Landscaping installed the wall.

The final phase of the project, scheduled for completion this year, includes replacing the South Street Bridge, additional channel stabilization, water main relocation, and sanitary sewer construction.

Even though this was primarily a flood control project, local bikers and pedestrians are appreciative of the project's results. The bike path had always been located within the floodplain, and there wasn't enough room to move the path to higher ground.

"If there's a flood, the bike path will be under water," Day says. "There might be a little less use during a flood, but this was a flood control project, so the first priority was to get more capacity in the channel. The bike path was a secondary priority."

Building Olympic Park

In 2006, the site that was to become Olympic Park for the London 2012 Olympic and Paralympic Games was home to a mountain of old refrigerators, a landfill, railway sidings, concrete plants, bus garages, and abandoned industrial sites, including a chemical works, plastic and glue factories, an oil refinery, and a tar distillery.

"The Olympic Park has been built on a formerly derelict site where encroachment into the watercourse led to steep and overgrown banks, strewn with rubbish," explains Mike Vaughan, a river edge engineer with Atkins, the official engineering design services provider for the London Olympics. Atkins has a specialist department with engineers and scientists skilled in hydrology, hydraulics, geomorphology, ecology, environmental science, botany, and biology.

The company led the transformation of 246 hectares of heavily contaminated industrial land into what would become Olympic Park. That included demolishing existing buildings, excavation and cleansing of the land, and a program to revitalize the rivers, canals, and natural habitats across the Olympic Park.

The team's charge was to provide a parkland setting "worthy of an Olympic Games," notes Vaughan. In order to do so, rivers were to be brought into the park and used as a focal point, attracting both visitors and the local wildlife.

Atkins provided river edge engineering services, including the design of wetlands and wet woodlands. The company also played a key role in the relocation of wildlife during the site clearance and the creation of new habitats in accordance with the Olympic Delivery Authority's biodiversity action plan.

During the site clearance, 140 archaeological trenches were dug, uncovering artifacts including a 19th century boat, an 18th century highway, skeletons from the Iron Age (approximately 800 B.C. to A.D. 43), and a hut from the Bronze Age (approximately 2000 B.C. to 500 B.C.).

During Atkin's streambank repair efforts at Olympic Park, part of the task was to replace or restore 7 kilometers of river wall. More than 200,000 cubic meters of contaminated groundwater had to be treated. The equivalent of 10 football fields' worth of the invasive Japanese knotweed was cleared from the site.

The four-year wetlands and river edge engineering project covered 8 kilometers of riverbanks, 2.6 kilometers of soft bioengineered banks—including reed beds, wetlands, and wet woodlands—2 hectares of ponds, 20 hectare of grassland, 9,000 square meters of rare native woodland, 45 hectares of new habitat, and 310,000 native plants comprising 28 species. At 18,000 square meters, this is the largest wetland and wet woodland planting scheme ever undertaken in the United Kingdom.

Atkins restored the rivers by re-landscaping the terrain, slackening all the edge slopes, and lowering the land about 10 meters.

A new Olympic Bowl was created, containing two larger areas of reed bed wetland.

"There are two areas of wet woodland and three ponds, all set amongst a visually appealing landscape," says Vaughan. "All the river margins have been restored and replanted."

Atkins conducted a 12-month planting trial along a 50-meter stretch of the River Lee to identify which species coped best with the site's tough conditions and to determine the best way to plant the vegetation. The team concluded the most successful method was to plant the 310,000 seedlings into coir mats—made from coconut fibers—a year before they would be installed in the park. Having established roots made them less vulnerable when being transported, and the mats themselves helped trap nutrients and stop weeds growing through so they could flourish, the team found. The 18,000 square meters of planting were pieced together like a giant jigsaw puzzle during the summer of 2010.

"We used simple bioengineering techniques to restore the riverbanks and create the wetlands, providing edge complexity for a myriad of flora and fauna," Vaughan says. "Predominantly, we used coir rolls and matting of coconut fibers stuffed into rolls 3 meters long and 300 millimeters in diameter, or 2-meter-by-1-meter mats contained inside netting."

In other areas, the company used woven timber water fences (spilling) to retain wetland channels and backwaters, and hazel fascines for ecological connectivity.

All of the wetland channels were constructed directly onto the low-nutrient alluvial soils, says Vaughan. "The ponds are lined with a puddle clay liner to prevent loss of water. This is overlain with a low-nutrient soil for the aquatic plants to thrive in."

The development accounts for the impacts of climate change by considering the effect of increased runoff from both the site and the watershed upstream of the site, Vaughan points out.

"This is part of UK planning policy—the project had to demonstrate that there would be no increase in flood risk to the local communities both now and in the future," he says. "The ponds themselves are fed by rainwater discharges taken from the park's concourse and venues, conveyed through a series of bioswales. These ponds provide a small volume of attenuation storage."

Vaughan says that given the area's "dark past," the decision was made not to infiltrate any runoff into the ground but to directly discharge straight to the River Lee.

"The Lee itself conveys surface water to the River Thames," he says. "Whilst the wetland areas were not designed as treatment features for water quality, they do have a beneficial effect. The Lee has a high sediment loading, and the wetlands provide an opportunity for deposition. Furthermore, the large numbers of common reeds planted in this area will tend to improve water quality by absorbing nutrients and some contaminants."

While the budget for the project has been carefully controlled, Vaughan notes that the primary focus of the design work was on sustainability, reducing maintenance liabilities, and longevity for the legacy period.

There are many regulations to which the engineers have had to adhere. "The UK Environment Agency regulates all works alongside main watercourses and the dealings of water into and out of them," says Vaughan. "This covers flood risk, water quality, environmental impact, and environmental enhancement."

The river edges and wetland works started in January 2008 and were completed in spring 2012, just in time for the Olympic Games.

Saving Evansville's Parks

Some streambank projects installed years ago are demonstrating continued success.

Case in point: Evansville, IN, has a number of picturesque lakes in its parks that over time have experienced unsightly problems in the form of bank erosion, which had undermined footpaths and damaged other infrastructure.

In some places, up to 18 feet of land had been gradually lost to erosion. Erosion was evident around pipework and wing walls. So little work had been done to halt the erosion that a dramatic solution was called for.

Evansville's Parks and Recreation Department sought a solution that would not only reclaim the lost land but also be aesthetically pleasing and fit in with the park atmosphere. In looking at options, department staff considered the various types and volumes of rainfall the area receives and how many years it would be able to maintain the banks of the lakes.

"At Garvin Park, there were some erosion problems around the dam side of the lake," says Glenn Boberg, deputy director of the Evansville Parks and Recreation Department.

Maccaferri Inc. and its distributor, ERS Inc., offered the Green Terramesh modular system with a vegetating face. Green Terramesh consists of a one-piece fascia and geogrid reinforcement tail, manufactured from Maccaferri PVC-coated galvanized steel double-twist mesh.

"We needed to come up with a solution to help eliminate some of the bank erosion. We looked at different options and chose the Terramesh system because it has a solid foundation and gives us the ability to grow vegetation so we could have a foundation established for long period of time," says Boberg.

Over three days in June 2003, city employees installed a structure 170 feet long and 2 feet high with a 60-degree front face at Garvin Park. Having Parks and Recreation Department employees perform the installation saved the city money. There was a bit of a learning curve, Boberg says, but after employees had installed the first few parts of the system, it became easier. The city subsequently applied the approach to a local golf course.

Two months following the Garvin Park installation, an outside contractor installed a structure 1,750 feet long and 2.5 feet high with a 60-degree face over a period of 22 days at Diamond Park, where similar erosion problems were occurring. Where necessary, pumps were used to drain the lakes by 18 inches to facilitate construction in dry conditions.

After the Green Terramesh units were constructed, free-draining structural backfill was compacted onto the geogrid tails, locking them into place.

A bike path runs alongside the widened Antelope Creek.

REDI-ROCK

A MacMat N10 erosion control blanket was installed behind the 60-degree front face to prevent the backfill from washing out. That solution was chosen over a biodegradable coir blanket for its longer design life. Lightly compacted topsoil was placed immediately behind the erosion control blanket to provide the vegetation medium. The structure was constructed upon a Reno Mattress scour protection apron to keep it from being undermined. After the Green Terramesh structure was in place, it was hydroseeded to promote revegetation.

Nine years later, Boberg says the approach is holding up well. “We’ve been able to hold up the bank and prevent future erosions from happening,” he says.

Not only has the system done its job, but it’s also aesthetically pleasing, he says. “Most people don’t realize what we’ve done, because we’ve been able to keep the vegetation of the surface of the units, so they just assume it’s part of the natural contours of the park and the lake, not really realizing there’s a structure there to help the dam hold itself and protect the environment.

“The natural ground cover masks the entire structure, giving it a great appearance. It makes it look more like a park-like setting. We’ve been able to maintain the integrity of the park.”

That is accomplished with very little maintenance. “We inspect it every year to make sure there is no other underlying erosion happening and that there is ample vegetation on the surface,” Boberg says. “The vegetation helps the Terramesh in two ways. It helps it to prevent future erosion, but it also covers it and keeps a pristine look.

"We're pleased with the units and the way they've held up. We continue using this at other areas where we've had erosion problems in our lakes and some other waterways."

Little White Oak Bayou

The Harris County Flood Control District in Texas is one of the largest flood control districts in the United States. It is responsible for the operation and maintenance of more than 750 miles of navigable waterways and drainage ways. One of those water bodies is the Little White Oak Bayou.

The area has a long and eventful history. On the east side of the bayou is Moody Park, which has been a fixture in the community since the 1940s or '50s and was the scene of a significant riot in the 1970s, notes Randy Wilkins, regional manager for L&M Regional GeoSupply and formerly with the C.E. Shepherd Co.'s Modular Gabion Systems. On the west side is Hollywood Cemetery, one of the oldest cemeteries in Houston, located less than 5 miles north of downtown Houston.

There had been a good deal of local pressure on the flood control district about the bayou because of the condition of its banks and an inability to mow and maintain them. It was turning into a public safety hazard and was becoming a site of gang activity, Wilkins says.

"In order to get it fixed in a fast-track way, Harris County Flood Control District came to Modular Gabion Systems and said they needed to do a design/build and move fast on it," Wilkins says. "They were under quite a bit of pressure from the local community that wanted the park cleaned up and usable and not a hangout for undesirables."

C.E. Shepherd got Pinnacle Design/Build Group in Texas involved from a design standpoint. Lesley Britton, vice president of engineering, says her firm designed a gabion retaining wall and a gabion mattress system to stabilize the bank, using Modular Gabion Systems as directed by the Harris County Flood Control District.

"Gabion mattresses were used on the upstream portion of the project by the bridge because the slope was flat enough, so they would work well," says Wilkins. "We were given a directive by Harris County Flood Control to revegetate or provide a gabion mattress that would revegetate as quickly as possible."

It was at the spot where the gabion mattresses ended and before the retaining wall started that the bank transitioned from a 5:1 to a 2:1 slope.

"The steeper portion of it is where they'd asked for mechanically stabilized earth gabion retaining walls to be installed in the transition area," says Wilkins. "They came in the bank every 50 feet and dug a trench that was 30 or 40 feet in length from the edge of the water back up the bank.

"It was perpendicular to the flow of the water. It was 3 feet wide and at its farthest point 30 or 40 feet away from the water; it was in some cases as much as 20 feet deep as it got to the steeper sections," he adds. "They filled this entirely with 3-inch by 5-inch rock, and it formed a rock vein."

The method was used to relieve the hydrostatic water pressure, as the water tables were higher than the flow line of the bayou.

The project was the first on which Wilkins worked with a soil-filled gabion mattress, using a turf reinforcement mat over the top of the gabion.

"The gabion was put in place. The rocks filled it. Then we filled the spaces between the rocks with topsoil and placed a turf reinforcement mat over that, and seeding, and then closed the lid of the gabion and tied it down so the topsoil, seeding, and turf reinforcement mat were under the lid of the gabion," he says.

"The US Army Corps of Engineers and state DOTs use gabion mattresses. They just fill them full of rock and leave them," Wilkins adds. "There will be some silting and soil deposition over time that ultimately allows them to fill in, but this is the first one I've been associated with where the soil filling was done on purpose and it was intended to be vegetated from day one."

One of the lessons Wilkins learned on the project was how to get topsoil down in between the rocks. "What the contractor ended up having to do was take top soil and dump it over the rocks and basically spread it so it was an inch or two thick over the top of the rocks, and then take a 2-inch water line and wash the soil down into the open spaces," he says. "It took a couple of repetitions of that to get them full, so it more or less became the recommended way after that."

Wilkins notes the contractors also applied some creativity to the retaining walls. "They poured grout and set flagstone on the tops of the retaining walls so they could be used for walking and a seeding area," he says.

In the years since installation, the gabion mattresses have been completely absorbed into the bank and have become a mowable surface, Wilkins says.

"You cannot tell that the gabions are even there," he says. "If you go down and stand at the water line, there's been such a deposition of silt and soil over time, the gabions have literally disappeared and it's like any other grassy slope."

Designing for the Long Haul

In determining what type of lining is necessary for streambank repair, the designer needs to consider a storm event, be it a five or 10-year storm, although most will look at a 25- to 50-year storm event in the stream, says Brian Whitaker of Fiberweb.

"You also need to take into account the topography of the stream. Does it have a very steep slope? Does it have a very gentle slope? Also, you need to take into account what the bottom of the stream consists of—is it a hard limestone rock or a soft sediment-based bottom?" he points out.

Another factor for streambank repair that needs to be considered is the severity of the slope of the bank, he adds. "Is it severe? Is it not so severe? Then we'll in turn see if it needs any type of vegetation or if you need to do some type of hard armor."

Soil plays a major role in the selection of repair and stabilization approaches.

"You need to make sure that the

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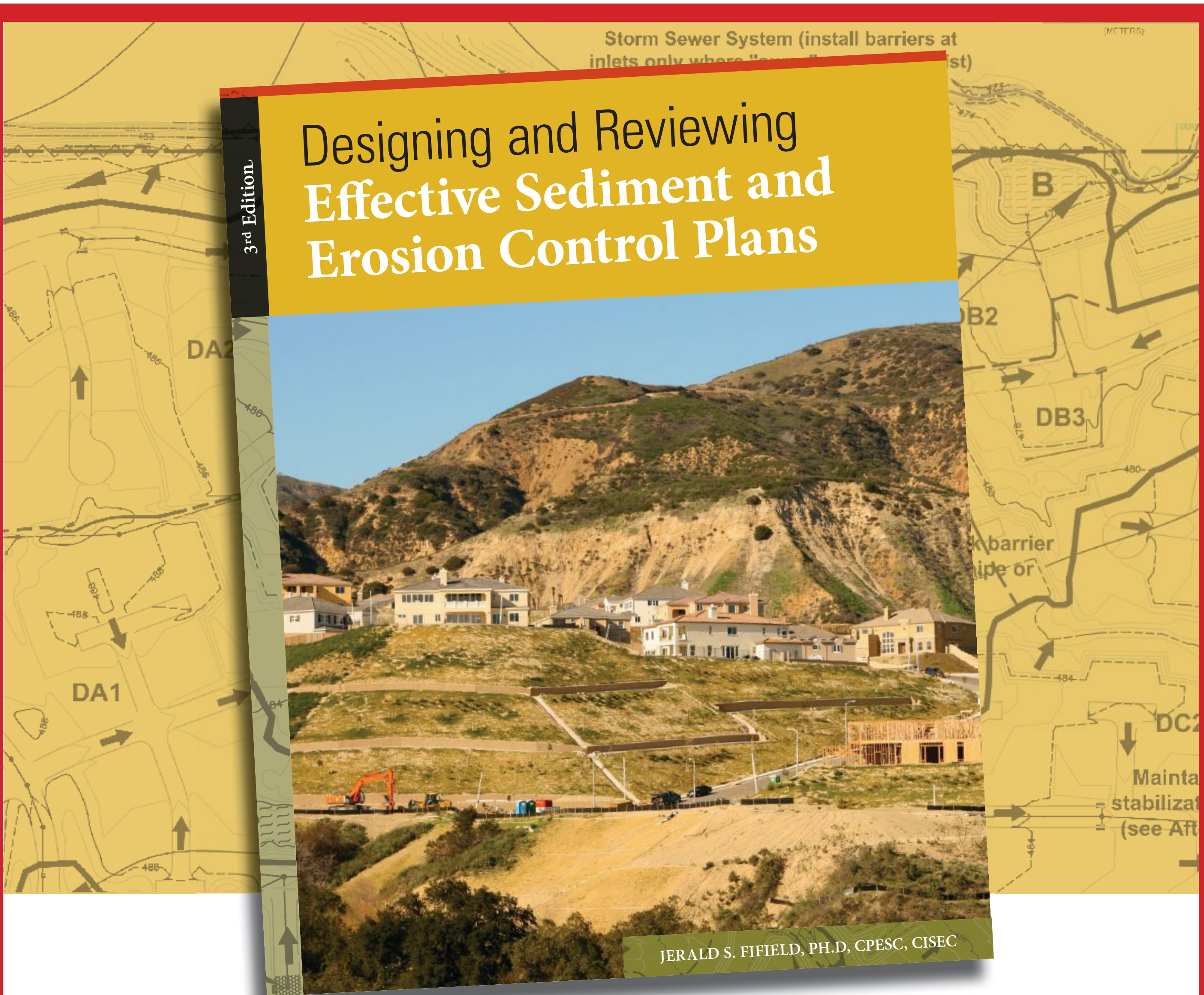
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erodability of the soils of the existing streambank is not high," Whitaker says. "If it is high, there needs to be some precaution taken with vegetation or a hard armor."

Whitaker explains that in accounting for an increase in flow—such as further development that might occur upstream, which would increase the amount of impervious surface in the watershed and therefore the volume of runoff reaching the channel—the designer needs to calculate for safety and for increasingly stringent local regulations.

"The predevelopment flows must be equal to the post-development flows," says Whitaker. "Such measures as detention ponds and rain gardens put on existing development should help achieve that."

If the channel is meant to convey water or treat and infiltrate stormwater runoff, vegetation is the appropriate choice, says Whitaker.

"If it's just a water conveyance stream during storm events, then hard armor would be the way to go," he adds. "That should be determined based on factors such as soil types."

In comparing costs, a hard-armor system is comparable to a geosynthetic liner with vegetation, Whitaker says. "Where you're going to see an increase in costs is going to be associated with labor," he adds. "Using soft armor—geosynthetic—is going to be much more costly than a hard-armor system."

Most regulations now tend to favor green solutions, Whitaker says. "Most of the regulatory agencies I have dealt with want a vegetative green solution, but they understand that sometimes when you come in with a hard-armor solution, it's due to a characteristic of the stream and flows they're encountering," says Whitaker. "They also understand that a vegetative plan would be eroded away."

Fiberweb has a variety of products for streambank protection, including Typar Geocells, used as semi-hard-armor and soft-armor application. They serve as a confinement system, consisting of a series of heavy-duty geotextile fabric cells in a honeycomb formation. Each unit has a three-dimensional cellular design allowing for custom sizes, configuration, and adaptability to irregular terrain. The product's hydraulic properties are influenced by the fill material's type and compaction.

The units are folded into an accordion shape for transportation and are expanded onsite and filled with a ballast material such as sand, stones, soil of any type, mulch, or other material. The product functions as a coherent single unit and can be joined end to end or side by side and also can be built into self-supporting higher walls by stacking one unit on another filled unit in a vertical or setback fashion. Fiberweb also offers Typar Geocells GS for ground stabilization, which can be used for a streambank vegetative slope. **EC**

Journalist ***Carol Brzozowski*** *writes on erosion and technology.*

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