GEOMEMBRANES revive Pebble Beach reservoir

Pebble Beach's Forest Lake Reservoir

Originally constructed in the late 19th century, a reservoir near a scenic stretch of California coastline underwent a dramatic transformation in 2005, and is now poised to serve the irrigation needs of the 21st century Pebble Beach community.

Located on California's beautiful Monterey Peninsula, the Forest Lake Reservoir was designated for rehabilitation to retain recycled water by the Pebble Beach Community Services District. Nonpotable, recycled water from the reservoir will accumulate and be stored through the winter months. During the summer and autumn month it is used to irrigate some of the most prestigious names in golf, including prominent PGA tour venues Pebble Beach, Spyglass Hill, and Poppy Hills, plus five other courses and recreational green space on the peninsula.

The design of the reservoir rejuvenation project included a number of environmental sensitivities and engineering challenges. In particular, the California Department of Water Resources, Division of Safety of Dams, was concerned with stability issues in the event that sufficient quantities of surface water penetrated and weakened the earthen embankment. As a result, the project was subject to stringent design and permit requirements. The project specified the use of a high-performance, 5-ply scrim-reinforced geomembrane with a functional exposed service life of 25 years.

The contractor completed both the fabrication and the installation of 950,000 $ft.^2$ (21.8 acres) of the specially produced, tan-colored geomembrane and also black geosynthetic composite drainage system under that membrane.

The geomembrane material offers excellent UV and physical properties, including high tensile strengths and puncture resistance. With more than 40 years of application experience, it is a proven material often used in water-management applications for floating covers and liners.

Project: Forest Lake Reservoir
Location: Pebble Beach, California
Date: 2005
Geosynthetics: Geomembrane and geocomposite drainage system

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Geotextile TUBES

slow erosion and stabilize the beach

After years of pummeling by hurricanes and other storms, plus a history of erosion problems, it appears that a geotextile tubing system will help sustain the beaches at Stump Pass in Florida. Stump Pass is a scenic stretch of sand beach—a natural inlet on the south end of Manasota Key—that connects the Gulf of Mexico and Lemon Bay near Englewood, Fla. It is part of Stump Pass Beach State Park in Charlotte County in the southwestern part of the state.

History

In 1998, an $11 million dredging and beach replenishment project commenced at Stump Pass. The ambitious erosion-control project included the nourishment of three miles of badly eroding beaches adjacent to Stump Pass. All told, more than 800,000 yd.^{3} of sand were pumped onto surrounding beaches, making the pass 150 ft. wide and at least 9 ft. deep.

But the sand would continually shift. Nautical markers became misleading. And boaters who weren't familiar with the sandbars often went aground.

In June 2004 a team of beach restoration engineers gathered just north of Stump Pass to measure beach profiles, wind exposure, tide patterns, and current flows. Using the data, the team embarked on the assembly of a beach erosion-control system that was a first-of-its-kind in the United States. The engineers, working with Florida's Department of Environmental Protection (DEP) and with Charlotte County—designed an eco-friendly system of submerged, low-profile, sand-filled geotextile tubes intended to reduce sand drift into the channel and to stabilize the eroding portion of the beach.

To slow the annual rate of sand filling into the channel, the experimental system tubes create sand-deposit zones and reduce cross-shore sand movement. The tubes, which run from the dunes of Stump Pass Beach State Park to a spot 350 ft. into the Gulf, are buried under the beach or submerged under water, so only a portion can be seen. Since June, when three of six tubes were initially installed, 20 ft. of shoreline has been restored.
The tubes were manufactured using geotextiles. The external armor fabric was matched specifically for the sand color. They range from 150 to 375 ft. long.

Project: Stump Pass Beach State Park
Location: Stump Pass, Florida
Date: 2004
Geosynthetics: Geotextile tubes

Above: Treated beachfront at Stump Pass after the installation. The experimental system of tubes creates sand-deposit zones and cuts down on cross-shore sand movement. Thus, it slows the rate that Stump Pass channel fills with sand.

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GEOSYNTHETICS and Green Roofs

Multiple benefits, with geosynthetic technologies building up green roofs

Top: Chicago City Hall: The completed landscape design followed a formal garden plan instead of the more-common meadow environment. The roof, on average, is as much as 30º cooler than the surrounding roofs during the summer. Above: The Kansas City (Mo.) Central Library green roof included triangular skylights between railings.

Green roofs are gaining in popularity as more people acquire knowledge on the subject. Awareness of green roofs as an eco-friendly concept is also being nurtured in the design and architectural communities. And building owners are not as dismissive of green roofs as they may have been only a few years ago.

Use of geosynthetics

Some geosynthetic products are being tailored for use in green roofs. For example, geotextiles and drainage geocomposites are the same products used currently in other civil and environmental applications. However, other products, for example geomembranes, will be quite different because of unique requirements of roofs.

The advent of landscapes weighing only a fraction of old plaza designs and offering a convincing natural environment on lightly built structures opens up a new area for design innovation in contemporary architecture. This new approach would not be possible without the use of high-performance fabrics and geocomposites.

Geosynthetic materials used in extensive green assemblies are diverse, including: waterproofing membranes, root-barrier layers, capillary fabrics, soil-reinforcement textiles, geocomposite drainage layers, and water-retention layers.

Project: Chicago City Hall,
Kansas City (Mo.) Central Library
Location: Chicago, Illinois and Kansas City, Missouri
Geosynthetics: Geotextiles, geocomposites, geomembranes

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GEOGRIDS in Retaining walls

A problem-solving wall project in Michigan

1. Under construction: The retaining wall was designed with looped geogrid placement.
2. Project completed-The finished wall included utilities through it and behind it.

Retaining wall, utilities merged in Michigan

Developers and engineers have long tackled the problems with hilly building sites and are ever in search of retaining-wall products to maximize usable space.

When an engineering firm in Grand Rapids, Mich. was charged with the task of specifying and designing three retaining walls at the Breton Woods North development, it faced several challenges. The most problematic was designing one section, which included geogrid placement, to accommodate utilities that had to be installed directly through and behind the wall.

Breton Woods is a multi-use development featuring single-family homes, multi-unit housing, retail and office space. The retaining walls were built across a location that was divided by an immense ravine. In addition, placement of all of the utilities including water main, electrical, storm sewer, and fiber-optic cables were intended within and behind the wall, making the design and construction difficult.

The top four courses, or six feet of the wall, is where the major challenges occurred, as this is where the utilities were tight behind the wall and where geogrid was required. To reinforce the wall and to leave room for utilities, the wall was designed with looped geogrid placement *(Photo 1)*.

The layer of grid below the utilities was sized to handle the soil above as a surcharge and the looped grids provided local stability for the wall units and any future excavation for utilities.

When completed, three retaining walls, the tallest a 27-ft. reinforced wall with utilities running through it and behind it, added to the beauty at Breton Woods *(Photo 2)*.

Project: Breton Woods North
Location: Kentwood, Michigan
Started: Spring 2005
Completed: Autumn 2005
Size: Approximately 10,000 ft.^{2} in three walls.
Wall height at its highest point: 27 ft.
Geosynthetic material: Geogrid

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GEOCELL, Grid, and reinforced-soil

in restoring eroded steep slopes

In October 2003, storm water overflows from an intense, short-duration storm eroded approximately 20,000 yds.^{3} of soil from the bottom and side slopes of a ravine between the Tacoma Narrows Bridge and a subdivision near Tacoma, Wash. The erosion ruptured two storm drains and left undermined slopes that continued to ravel and retreat. Measures were implemented to help stabilize the eroded slopes and prevent further retreat that could affect the Tacoma Narrows Bridge expansion project and a residence above the opposite ravine slope. The measures also addressed regulatory agency concerns about sediment-laden water discharging from the ravine into the Narrows that could damage sensitive sand lance habitat on the beach at the mouth of the ravine.

Ravine restoration measures consisted of constructing unreinforced soil, flexible geocell-faced reinforced soil, and geocell-geogrid reinforced soil slopes that mimic the former steep ravine. After slope construction, a mixture of drought tolerant and native vegetation was planted to provide erosion protection and restore the natural ravine environment. The geocells had the flexibility to fit against, and transition between variable slopes and create steep slopes with planting benches for trees, pockets for smaller plants, and terraces that slow storm water runoff. The perforated geocell walls allowed roots to spread. The geocell ravine repair design was an effective, economical solution that saved the customer the cost of potential litigation, satisfied regulatory requirements, and expedited construction, which was completed in less than 5 months during the 2004 construction season.

Top Left: Ravine erosion, note sediment trap at ravine mouth Top Right: Geocell placement on steep slope with confined work area Bottom: Completed 30m-high geocell slope

Project goals

The primary goals of the ravine repair were:

• prevent further erosion that could affect the bridge construction project and the residences above the opposite ravine slope.

• avoid damaging sensitive sand lance habitat on the Narrows beach at the mouth of the ravine.

Project: Tacoma Narrows erosion restoration
Location: Tacoma, Washington
Dates: 2004
Geosynthetic materials: Geocells, Geogrids

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GEOGRIDS
Erosion-Control
Hereford Inlet seawall repair project

North Wildwood, N.J.

Hereford Inlet is located on the New Jersey coastline, near the southeastern most tip of the state, near Cape May.

This project involved reconstructing the inlet's shoreline sea wall Portions of the structure were undermined by tidal scour and storm erosion. Failure of the seawall would pose a long-term threat to nearby buildings and other shoreline infrastructure.

Strong tidal currents, steep underwater slopes, and deep-water sections meant that traditional construction methods would have been difficult to implement. A conventional solution would have involved installing an unsupported geotextile fabric to contain eroding soil. That fabric would then have been capped with bedding and armor stones to prevent the material from shifting and settling. The U.S. Army Corps of Engineers concluded that this approach was impractical because of the challenging conditions at the site. The solution was to use a geogrid marine mattress to encapsulate and support the geotextile material.

Each mattress was lined with nonwoven geotextile fabric and filled with 1.5- to 3-in. stones. Installation of a top panel completed the mattress assembly. Up to five mattresses were tied together to form a 20-ft. x 32-ft. unit. The project crew used a 4-point lifting frame and a combination of shore- and barge-mounted cranes to lift and place each unit.

Crews placed more than 2,900 units. Each unit is anchored with armor stones weighing 500 to 800 lbs. each. "The system is ideal for the rough waters along the New Jersey coastline," said the project manager. "Traditional methods are much more challenging in these conditions."

The Army Corps is using the system on several other coastal projects, including the repair of the Townsend Inlet seawall in Avalon, N.J., 10 miles northeast of Hereford Inlet.

Project: Hereford Inlet Seawall
Location: North Wildwood, New Jersey
Installation: January 2005—November 2006
Geosynthetic: Geotextiles and geogrid marine mattress
Engineering: U.S. Army Corps of Engineers
(Philadelphia District)

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GEOCOMPOSITE
Drains & Geotextiles
Road realignment and a spring on country road county project

This project showcases the use of a geosynthetic drainage system used to drain a spring that was in the middle of a road realignment, built in Steele County, Minn., in 2006. In this example, the land usage was primarily agricultural, the watershed approximately 90 acres, and the disturbed area about 5 acres.

A spring was discovered in the road grade during the realignment of Dane Road. The project engineer chose a geocomposite road drain as the solution to building over the soft soils around the spring.

Project: Road realignment of Dane Road
Location: Steele County, Minnesota
Date: 2006
Geosynthetics: Geocomposite, Geotextile


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1. The roadbed was removed down to the water table. The material was so saturated that a dozer was unable to track through the area. **2.** To drain the area, a perforated polyethylene (PE) pipe drain with sock was selected. **3.** Plastic ties and glue were used during the installation process of the drainage sheets. **4.** Two feet of fill was placed over the drainage material. **5.** For additional stability a geotextile was added 3ft below the profile grade **6.** Roadbed compaction **7.** January 2007, 2 months after completion.


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GEOTEXTILES and Mechanically stabilized earth (MSE)

A signature hole is born at Trump National Golf Course

Trump National Golf Course, formerly named Ocean Trails Golf Course, is incredible for many reasons. It is the first and only ocean-front golf course in Los Angeles County. The public course sits high atop jagged cliffs with the waves of the Pacific Ocean crashing below, offering spectacular ocean views from all 18 of its fairways. Also, the course has one other very interesting feature: It is the most expensive golf course ever built, costing more than $250 million. The largest portion of this money went into just one hole, which is the focus of this article.

Landslide

The course is located within a known ancient landslide area and an environmentally sensitive coastal bluff reserve that is home to the endangered California gnatcatcher bird. In early June 1999, the 17-acre area of the ancient landslide area re-activated in a single rapid event. The slide saw downward movement of almost 10 ft. and horizontal (seaward) translation of about 50 ft. The slide took with it most of the 18th hole (fairway and green), bluff edge, pedestrian trails, bike path, and a portion of a major Los Angeles County Sanitation District sewer line.

Repair

Partial removal and rebuilding of the landward portion of the landslide was found to be the best alternative for repair using a mechanically stabilized earth (MSE) wall.

Top Right: A landslide took out most of the 18th hole. The rebuild created a signature hole and a signature geotechnical design. Top Left: Constructing the geosynthetic-reinforced MSE wall buttress.

Design

Extremely high-strength geotextiles combined with high soil interaction coefficients were essential to the design. Layers of geosynthetic reinforcement were to be placed at approximately 5 ft. vertical intervals with embedment lengths as much as 95 ft. High-strength geotextiles were used as the primary reinforcement to create a massive fabric-wrapped MSE wall buttress (100 ft.+ high). The face of the wall was designed with 18 in. high welded wire forms with a geotextile as secondary reinforcement that would line the interior of the welded forms to contain soil at the face.

The face of this massive MSE wall was to abut another reinforced triangular backfill. This second reinforced fill mass abutted existing slide material/native soils of the seaward portion of the landslide, which was left in place to maintain the natural environment, hide the face of the wall, and protect the wall structures from the Pacific Ocean's rage. This composite of soil and high-strength fabric serves as a giant stable soil block that will stop any future movement and protect the rest of the golf course from falling into the ocean.

A clay cap was placed over the entire filled area to keep water out. A layer of topsoil was placed over the clay cap so vegetation and landscaping could be planted. The entire reinforced fill structure is now covered by a beautiful grass fairway, putting green and sand traps. As golfers take in the breathtaking view from the 18th hole, few will ever know that they are playing on the most expensive hole ever built. Even fewer golfers will realize that this hole is one of the safest coastal places standing as a result of the many layers of high-strength geosynthetics sitting below their feet. When asked about this reinforced hole by a reporter, course owner Donald Trump remarked, "If I'm ever in California for an earthquake, this is where I want to be standing."

Project: MSE wall at Trump National Golf Course
Location: Los Angeles County, California
Geosynthetics: High-Strength geotextiles

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GEOGRIDS

CalTrans freeway project in San Diego

In an effort to reduce traffic congestion and improve safety conditions in northern San Diego, the California Department of Transportation (CalTrans) is adding lanes and creating a truck bypass at the Interstate 5/805 junction. A unique portion of this project is the construction of a plantable, geosynthetic-reinforced retaining wall that transforms a simple slope into a vertical face that supports additional lanes of the reconstructed freeway. The project included the attachment of a massive retaining wall, with layers of engineered fill wrapped with high-strength, woven geogrid, to a concrete facing system that protects the exposed geosynthetic while a polypropylene geotextile holds loose plantable topsoil to facilitate vegetative growth.

The concrete facing portion of the wall has tiers of headers that extend into the geosynthetically reinforced backfill and stretchers that extend between headers to form the front face of the wall. These stretchers, with the help of nonwoven geotextile-bridged gaps between the stretchers, hold in loose topsoil so that vegetation will grow easily at the face of the wall. The tremendous soil forces generated behind the concrete tiers are sustained by layers of geogrids that extend up behind the stretchers and then back into the backfill. The end result is a massive, near-vertical retaining wall more than 65 ft. high that will be completely vegetated.

The foundation of the plantable geosynthetics-reinforced retaining wall also used geosynthetic reinforcement. Two layers of geogrid were placed within a gravel blanket to form a reinforced foundation mattress (geosynthetics helped keep the gravel from spreading laterally while under load) to support the retaining wall structure with minimal differential settlement. The entire blanket was wrapped in geotextiles.

When all the dust settled, approximately 1 million yards^2 of geosynthetics were used to construct this project. The total wall face is more than 200,000 ft.^{2} (18,581m^2) with heights of up to more than 65 ft. (21m) and a length of more than 3,000 ft. (938m). The project consumed a total of more than 815,000 yds.2 (681,422m^2) of geogrid products.

Owner: California Department of Transportation

Location: Interstates 5/805 junction, San Diego County, California.

Project duration: 2002–2007

Geosynthetics: High-strength geogrid and a nonwoven geotextile

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This is an abridged version of an article that was published in Geosynthetics magazine ©2005-2007.

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Geosynthetic SHEET-DRAIN system
is the correct call for Louisiana wood plant

A new engineered-wood manufacturing facility is up and running this year, thanks in part to a comprehensive geosynthetic sheet-drain system. Martco Limited Partnership, the manufacturing arm of the Roy O. Martin Lumber Co., completed a new oriented-strand board (OSB) plant near Oakdale, La., this year that is the largest of its kind in North America. OSB is often used as sheathing in roofs, walls, and subfloors.

The construction plans for this facility included a "press pit" requiring a 30-ft.-high, 23,000 ft.^{2} underground wall. The original design called for an intricate drainage system using pipe and stone. But with geosynthetic sheet-drain technology, a more efficient and cost-effective system was proposed and eventually built.

Specified in this project was a two-part, prefabricated soil sheet drain consisting of a formed polystyrene core covered with a nonwoven, needle-punched polypropylene geotextile on one side of the core. The geotextile is bonded to each dimple to prevent soil intrusion into the water channel, and allows the water to pass into the drain core while restricting the movement of soil particles that might clog the core. The core provides compressive strength and allows water to flow to designated exits *(Photo 1)*.

Sheet drain is designed primarily for vertical, one-sided, sub-surface drainage applications requiring an increased compressive strength and a high flow capacity. For this installation, the core side was placed against the wall surface of the foundation, providing full-coverage protection to waterproofing materials *(Photo 2)*.

Sheet drain products typically are used where large surface areas require drainage. Vertical applications include foundations, basement walls, and retaining walls. Horizontal applications include plaza decks and green roofs.

The entire surface area can be covered to provide maximum drainage capacities. Sheet drains usually are made in 4-ft. (1.2m)-wide sheets in rolls 50-100 ft. (16-33m) long. The core can be ¼- to ½-in.(6-12mm) thick. Most sheet drains also serve as protection for waterproofing material (Photo 3)—as seen here at this new OSB facility—thereby eliminating the cost of a separate protection board.

Project: Roy O. Martin Lumber Co. Oakdale (La.) OSB Plant
Location: Pawnee, La.
Dates: October 2005–January 2007
Geosynthetic products: Geosynthetic sheet drain

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TURF REINFORCEMENT mat to the rescue in Riverside County

Turf reinforcement mat triumphs in California water-harvesting project

This project had been planned to capture storm water and excess agricultural flows during the Southern California rainy season, then reuse this water to replenish the area's groundwater basin during times of drought.

The 50-ft.-wide x 8,000-ft.-long, 12-ft.-deep channel was constructed under the guidance of the owner, the Riverside County Flood Control and Water Conservation District (RCFCWCD). The initial design used the available sandy soil, reinforced with a hydroseeded native grass and plant mix on the slopes and floor of the channel.

In November 2004, a superintendent for the general contractor was in the process of closing out the contract on the project, when a single torrential storm severely eroded many of the 2:1 slopes (particularly the radii) and scoured the floor of the channel, leaving the functionality of the channel in question.

Concrete, rock, and grout were the initial methods considered to repair the damaged channel. But time and budget constraints forced the lead engineer to search for other protection options for the channel.

A turf reinforcement mat (TRM) was the solution for this situation. A TRM is a geosynthetic netting (in this case permanent) that sandwiches natural fibers such as coconut to provide a multi-year protection for the drought-tolerant seed mix to establish itself. The TRM solution was noted for its ease of installation, and the substantial time and money savings associated with the product compared to other options for this project.

The first delivery of the matting, 50,000 yard^2, arrived on the job site the first week of December 2004, just prior to the record-setting Southern California rainfall that would soon be on the way. Because of the sandy, non-cohesive soil composition, extra long 12-in., 9-gauge staples were used to anchor the mat to both the side slopes as well as the channel floor.

The slopes were hydroseeded with a drought-tolerant native grass and flower mix, and then the TRM installation commenced. After approximately 20,000 yard^2 of installation, the record-breaking storms of December 2004/January 2005 sloshed Southern California. The weather would momentarily clear, the crews would rush out and continue installation of the matting, only to have the job site subsequently at a standstill for days at a time because of the torrents of rain.

The unvegetated installation area was closely monitored for failures during this period. Much to the satisfaction (and relief!) of all concerned, there were no slope or channel-bottom failures where the matting had been installed; however, the areas that did not have any TRM protection did sustain damage.

Top Left: Channel during TRM installation–Note protected and unprotected slope conditions.
Top Right: More rain–Note rock in place failure, with intact TRM. .

The final installation segments were slated for completion by March 15, 2005, and by that time, much of the channel already had a strong stand of vegetation. The seed mix was kept in place despite months of unusually heavy rainfall.

Having overcome all of these obstacles—poor soils, and extremely inclement weather—the reinforced matting for this project performed far beyond expectations.

"Incredibly, much better than I ever thought it would," said Mike Luna of the RCFCWCD.

Owner: Riverside County (Calif.) Flood Control and Water Conservation District
Project: Master Drainage Plan, Line E, San Jacinto Basin
Geosynthetics: Turf reinforcement mat (TRM)
Date: 2004-2005

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GEOSYNTHETICS use in food production

Harvest time

Autumn is harvest time in the northern United States. Corn for cattle feed withers to bone white, then is harvested and stored in silos or under tarps for winter use. Late-year berries are collected from bogs. And hardy vegetables, such as cabbage and carrots, are picked.

Geosynthetics are at work throughout the food industry, from initial irrigation to rainwater harvesting and conservation; from animal waste containment to methane conversion; from harvest methods to industrial processing. The roles these materials play may be more difficult to recognize, but they are significant. Here are two examples:

Cranberry season

The states of Wisconsin and Massachusetts produce the lion's share of cranberries in the United States. Cranberries are a very durable fruit of northern wetlands. They have a shelf-life of nearly two years and hold up after baking, which makes them ideal in the food industry for creating juices and various fruit products (especially after flavoring them with less durable fruit flavors). This multi-billion dollar harvesting industry is dependent on both the preservation of bogs—layers of sandy soil, peat, gravel and impermeable clay supplied with nearly an inch per week of fresh water—but efficient harvest methods for what is not an easy fruit to collect. The growing season runs May through October and harvesting requires flooding a bog. Farmhands must wade out and rake in the berries.

Geosynthetic booms, however, have greatly improved collection. Using the same technology that has become standard for surface containment of oil in waterways, growers use easily deployed booms to separate cranberry zones, gradually drawing the fruits into more accessible, harvesting circles. From small independent bogs to more corporate farms with bogs the size of small lakes, this same approach is used to gather nearly 300,000 tons annually.

Cherry processing

Discovering the means of food production, and particularly processing, can make eating seem a little suspect. The scientific names of processing elements alone on a packaged food's ingredient list can cause considerable brow furrowing for those of us without a chemistry background. It's common practice, though, and in many areas of the food industry, a very profitable business. The industrial handling of sweet cherries, such as maraschinos, is an adventure, one that requires lined pits for ground- and surface-water protection. Often, food-grade PVC geomembranes provide this protection.

Sweet cherries are bleached and preserved with sulfur dioxide or sodium metabisulfite. Calcium chloride is added as a firming agent for further processing and cooking. The cherries are then flavored, re-colored (as the bleaching removes the red) and sold often as maraschino or candied cherries. Roughly 40 lb. of calcium chloride is used to brine one ton of sweet cherries. Nearly 240,000 tons of sweet cherries are harvested annually.

Project: Food production

Geosynthetics: Geosynthetic booms; geomembranes

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GEOSYNTHETIC Clay Liners Save Money

The Monterey Peninsula Landfill (MPL) is a Class III sanitary landfill that covers an area of approximately 126 ha (311 acres). MPL is operated by the Monterey Regional Waste Management District. The landfill reached capacity, and the district selected an engineering firm to prepare the design, technical specifications, and construction drawings for the expansion of the landfill.

As part of the solicitation of proposals, the district identified as being a critical factor in the expansion design the presence of a perched water zone within the proposed excavation. In addition, the district requested that a cost/benefit analysis be conducted in regard to the design parameters developed during previous module designs.

Cut slope decisions

The existing design for the internal cut slopes of expansion modules at MPL called for a cut slope of 3:1 with an overlying composite liner composed of HDPE geomembrane and compacted clay. The western slope of the proposed expansion contains approximately 232 linear meters of internal cut. A cost/benefit analysis was conducted on this internal cut slope to determine the feasibility of increasing the slope from 3:1 to 2:1.

By using a geosynthetic clay liner (GCL) it was possible to increase the slope to 2:1 and save a significant amount of money. A GCL is made of two layers of non-woven geotextiles with a layer of bentonite clay in between. This product can be applied to a steeper slope than the geomembrane and compacted clay. Both applications provide the specified protection for a landfill.

The increase in volume gained by cutting the west slope of expansion from 3:1 to 2:1 results in approximately 40,000m^3 (52,320 yard^3) of airspace. The increase in airspace will result in increased waste revenues of $770,000. In addition to the increase in disposal volume, the sand that is excavated from the cut slope also has value for the district. The excavated sand has a commercial sales value of $193,000. Therefore, the total revenue generated from cutting the west slope to 2:1 versus 3:1 is $970,000.

Project: Monterey Peninsula Landfill
Geosynthetic: Geosynthetic clay liner
Date: 2004

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San Diego Bay gets an underwater facelift

Geotextile cap is a key to this novel seafloor remediation project

This project included aquatic remediation of a former shipyard area consisting of approximately 3,500 tons of underwater demolition, 35,000 yards^3 of dredging of contaminated material with upland disposal, and placement of a new structural cap consisting of layers of geotextiles, sand, gravel, and armor rock to contain the remaining contaminated sediments.

Beginning in the 1880s, the Campbell Shipyard site—adjacent to the under-construction Hilton San Diego Convention Center Hotel in downtown San Diego—was used for industrial activities including shipbuilding, the manufacturing of bulk petroleum, and gas waste disposal. Consequently, extensive environmental remediation has been required to clean up the site for development.

In the first phase of remediation, the Port treated or removed more than 80,000 yards^3 of contaminated soil from the upland portion of the project site. During the current and final phase of remediation, 9.2 acres of waterside sediment was capped with 5 feet of geotextiles, sand, gravel, and rock. Included in the capping phase are 1.6 acres of mitigation area to replace eelgrass habitat lost by the project.

The geotextile for this project is a polyester/polypropylene fabric with a specific gravity of 1.07. It is woven from high-tenacity, long-chain polymers composed of at least 95% by weight polyesters that form a stable network such that the filaments retain their dimensional stability relative to each other including selvages. It does sink, albeit slowly.

To aid in the deployment and accurate placement of the fabric on the seafloor, the contractor attached #4 rebar encased in PVC pipe with capped ends. The rebar was attached perpendicular to the fabric about every 10 yards prior to being rolled off a floating sectional barge into the water.

The largest portion of the capped area is an engineered cap designed for permanent isolation of remaining environmental pollutants in bay sediments.

The engineered cap is composed of a geotextile overlaid by 2 ft. of sand for isolation of pollutants in existing sediments; a 1-ft. layer of well-graded, gravelly aggregate material to act as a filter layer between the overlying armor stone and the underlying sand, while also protecting against bioturbation; and then a final layer of 2 ft. of armoring stone to protect against erosive forces that may be imposed on the capping system.

Additional foundation support, in selected areas overlaying unconsolidated bay sediments at the edge of the cap, was strengthened by placement of a layer of "dumped rock foundation."

The habitat cap is a 1.6-acre eelgrass environment. The design of the habitat cap includes a base layer of sand overlaid by a geotextile layer and topped by a final layer of 2 ft. of sediments with grain sizes ranging from medium to coarse sand to provide a suitable substrate to support the overlying eelgrass habitat.

The function of the geotextile is as a separation layer to help isolate any underlying residual environmental pollutants and to protect against bioturbation into the underlying sediment.

Another structural element is a rock containment berm to protect and enhance the stability of the entire cap system.

Project: Sediment remediation and aquatic enhancement at the former Campbell Shipyard site
Location: San Diego Bay; San Diego, California
Start date: September 2005
Completion date: 2007
Owner: San Diego Unified Port District
Geosynthetics: Woven geotextile

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