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TECHNICAL MEMORANDUM

TO: Vince D'Aco, Mary Caruso - Quantum Management Group

CC: Russ Downey - Pfizer, Inc.

FROM: Michael Battistelli, Paul Porada - Woodard & Curran

DATE: July 10, 2013

RE: **American Cyanamid Superfund Site, Bridgewater, New Jersey**
Proposed Berm Protection for Impoundments1 & 2

Wyeth Holdings Corporation (WHC), a subsidiary of Pfizer, is proposing to install berm-reinforcing material on the exterior slopes of Impoundments 1 and 2 to enhance erosion protection on the earthen embankments. The primary objective of the proposed reinforcement is to provide additional stabilization to the existing berms and further stabilization in the event of future flooding. The Raritan River has overtopped its banks and surrounded the impoundments during prior flood events, as well as overtopped Impoundments 1 and 2 during extreme flooding. The presence of moving water against the berms has the potential to cause erosion, thus it is the desire of WHC to put measures in place to enhance the protection against berm erosion. Reinforcing the berms may be especially important during implementation of future planned remediation activities which will involve the placement of new structures that could potentially increase water flow velocities near the impoundments during flood events.

RECOMMENDED SOLUTION

Based upon assessment presented herein, Woodard & Curran recommends the use of Turf Reinforcement Mat (TRM) for protection of the exterior slopes on both Impoundments 1 and 2. The TRM is suitable for the anticipated water velocities, is compatible in low pH applications, offers comparable level of erosion to a hard armoring/reinforcement techniques, such as concrete or stone, and can be installed in a timely fashion without need for large equipment. In addition, the TRM method minimizes disruption to the existing berms, is much more tolerant to subsidence and subsurface seepage (and far less prone to undermining), and will not produce increased stormwater runoff rates that may be associated with other hard armoring solutions.

Further details of the options evaluated and our basis for selecting TRM is provided below.

SUMMARY OF OPTIONS

A conceptual design approach and a selection of the proposed reinforcement material was derived from a May 24, 2013 Technical Memorandum, Berm Armoring Flow Estimates and Conceptual Design Considerations, prepared by CH2M HILL. This memorandum contains a basis for selecting a water velocity range of 4 to 8 feet per second (ft/sec), and design considerations regarding the extent of armor placement. In addition, the memorandum also presents a summary of proposed options including a detailed description of the stabilization products and the advantages and limitations of each.

Based on our review of the overall design considerations including the estimated flow velocities anticipated during flood events, Woodard & Curran has evaluated two separate reinforcement scenarios, which are described in detail below.

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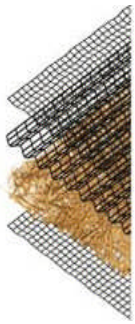
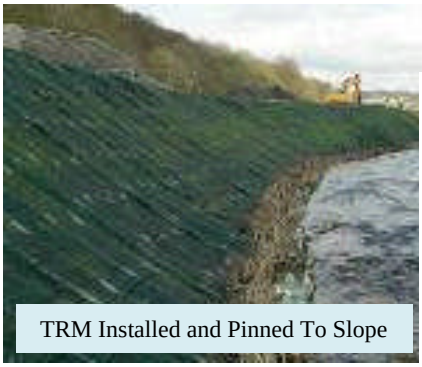
Erosion Control / Turf Reinforcement Mats

The Erosion Control Mat (ECM) proposed is a high-strength, UV-stabilized, multi layered, three-dimensional synthetic matting with fiber matrix material to permanently control erosion and reinforce vegetation. It is also referred to as Turf Reinforcement Mat (TRM). The matting structure is placed in intimate contact with the prepared ground surface and anchored in place with pins at regular spaced intervals. Seeding of the mat establishes vegetation to effectively interlock the mat to the soil. The mat itself resists flowing water shear stresses to allow establishment of vegetation within it. Once established the vegetation roots and stems function together, increasing the permissible shear stress of the permanent vegetative, and further armoring the surface against soil loss.



TRM Layers

2-Person Crew Installing TRM



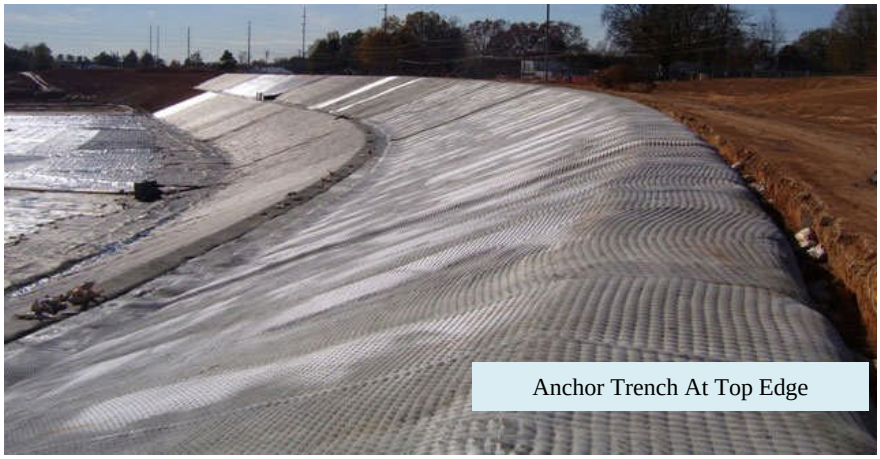
TRM Installed and Pinned To Slope

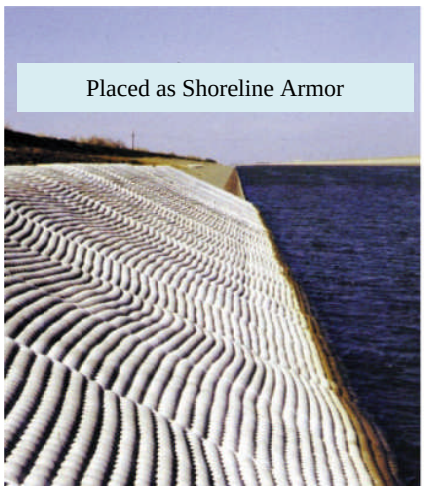
One Year Later

Turf Reinforcement Mat

Concrete Fabriform

The Fabriform® concrete filled mat product has been available for more than 40 years and is used for scour protection of embankments or shorelines. It consists of a sewn nylon fabric form. The forms are placed upon the prepared ground surface, then pumped full with a fine aggregate concrete mix and allowed to cure. The perimeter edges of the mat may be turned down into a shallow trench to prevent undermining of the mat by flowing water. The finished installation is a concrete pavement. Select photographs depicting typical applications are shown below.





Fabriform® Concrete Mat

The published TRM literature informs us the North American Green VMax³ C350 product mat has permissible velocities of 10.5 ft/sec for the mat on bare soil and 20 ft/sec when the mat is vegetated. Their heavier P550 product has permissible velocities of 12.5 ft/sec and 25 ft/sec respectively. The Fabriform® mats do not have specific published information. Their history of installation practices would confirm the mats can withstand water velocity in excess of 8 ft/sec.

Given that the two systems have permissible sustained water velocities greater than 8 feet per second; we have further evaluated the two options based on their ease of installation, their durability / longevity, and maintenance.

INSTALLATION

Both mat materials require that the existing surface be prepared by removing woody plants, grinding or cutting stumps, and filling of animal burrows. Existing grass would be cut down close to ground level.

The TRM is a manufactured product shipped as 6.5 foot wide rolls. It is deployed down slope, with overlap seams and anchored to the ground with manual or percussion driven pins. The seed mix is introduced into the placed mat where it germinates. The skill to install TRM can be quickly learned from the manufacturer's instructions. No large machinery is required, although a forklift to handle materials at the job site is desirable.

Fabriform® form sections are shop-assembled in predetermined panel sizes to fit site topography and then delivered. The delivered sections are sewn or zippered together when deployed at the site for filling with the concrete. Pre-measurement and mat fabrication are important for a proper fit. A shallow trench is excavated at the perimeter, the mat deployed, a concrete grout introduced to the mat by pumping, and then cured. Concrete trucks, a concrete pumper, and an excavator to handle the heavy mat are the minimum equipment for installation. Skill and experience with installing the product are necessary for a successful outcome. The fabric must be deployed with the proper slack for it to fill completely. Also, wet weather can complicate the installation – the nylon fabric form cannot get wet before it is filled because of a tendency to shrink.

DURABILITY / LONGEVITY

The TRM and the Fabriform® mat are suitable for outdoor exposure during the 5 to 10 year period anticipated lifespan of the project. The TRM products carry a 10-year warrantee for sufficient structural integrity and the necessary physical properties to enable it to provide the claimed level of erosion control after installation. Experience from 25-years of product availability demonstrates TRM's can exceed this 10-year longevity period. Correspondingly, concrete can withstand more than 10 years of weather exposure without significant deterioration. At this location however, weather exposure is not the single concern.

A consideration for this application is the compatibility of the reinforcement material with the low pH contents of the Impoundments. Concrete is unsuitable for contact with acids because the lime based cement quickly decays when subject to acid contact. The perimeter of the Fabriform® mat is typically anchored into the ground to prevent surface water from undermining the mat (e.g., during a flood); however undermining from elevated groundwater table or impoundment seepage may also be a concern. If low pH, acid, groundwater were present then this mat anchoring could be susceptible to deterioration or loss. The TRM is manufactured from polypropylene plastic, a material which is resistant to low pH. Vegetation is not typically tolerant of low pH contact, yet if the vegetation is lost the physical matrix of the TRM remains to protect soil from erosion. In the context of this application, a visual assessment and the presence of vegetation on the berms indicates general plant vigor which would be anticipated to continue following placement of the TRM.

MAINTENANCE

The TRM will require periodic mowing to prevent establishment of woody plants. Cutting of the grass one or two times each year is sufficient. With a TRM berm, subsidence or seepage can be monitored visually, as necessary, and addressed. For most conditions, the seepage and subsidence can be tolerated with a TRM because it is permeable and flexible, and will move with the ground surface.

The Fabriform® is relatively maintenance free. The concrete mat prevents woody plants from establishing and is impenetrable to ground burrowing animals. However, ground subsidence, seepage or loss of soil beneath the rigid mat will be obscured, which could be a maintenance concern. As noted above, the potential for undermining, particularly at the toe of the berms and the bottom anchor trench, is also a concern.

SUMMARY & RECOMMENDATION BASIS

Based on the above information, we are recommending the use of TRM for protection of the exterior slopes around Impoundments 1 and 2. An overall summary of the proposed options for reinforcing the earthen berms surrounding Impoundments 1 and 2 is presented below.

Proposed Stabilization Method	Advantages	Limitations
TRM / ECM	▪ Product's functional longevity warrantied for 10-years. ▪ Compatibility with low pH water. ▪ Ability to withstand significant flow velocities (well in excess of anticipated flow under flooding conditions). ▪ Disruption to existing berm conditions/features is minimized. ▪ Ease of installation - less complex installation procedures using manual labor. ▪ Tolerant to potential subsidence and subsurface seepage (less prone to undermining).	▪ Vegetation necessary for maximum performance. ▪ A vegetation 'grow-in' period before full protection is achieved. ▪ Periodic mowing and maintenance.
Concrete Fabriform®	▪ Semi-permanent structure, life expectancy in excess of 10-years. ▪ Ability to withstand significant flow velocities (well in excess of anticipated flow under flooding conditions). ▪ Lower maintenance	▪ Concrete not suitable for contact with acids and low pH fluids. ▪ Complexity of installation, involves heavy machinery and excavation into berm soils. ▪ Longer lead time in obtaining customized materials. ▪ Potential for undermining if exposed to subsurface seepages. ▪ Anticipated to produce greater stormwater runoff rates and higher pollutant loading.

As previously stated, the primary objective of the proposed reinforcement is to provide additional stabilization to the existing berms and further stabilization in the event of future flooding. Based upon this objective and the results of the information presented herein, Woodard & Curran recommends the use of TRM for protection of the exterior slopes on both Impoundments 1 and 2. We do not recommend Fabriform based on the above limitations. The TRM is suitable for the anticipated water velocities, is more suitable in low pH applications, offers similar level of protection from erosion to a hard armoring/reinforcement techniques, such as concrete or stone, and can be installed in a timely fashion without need for large equipment. Ideally, this installation should occur during the summer months for prompt establishment of vegetation.