Flexible Permeable Reactive Barrier to Reduce Metals Contamination in Runoff Water

Problem

Small arms firing ranges (SAFRs) located on Department of Defense (DoD) facilities are, in many cases, constructed next to wetland areas, including rivers, ponds, lakes, and streams. These receiving waters and their associated wetlands represent a potential point of regulatory interest as they are at risk of heavy metal contamination in the runoff water from the adjacent active ranges. Access to wetland areas (especially forested wetlands) is typically limited due to a lack of roads. Standard environmental remedial options and monitoring techniques are expensive to implement due to the nature of the terrain, scarcity of land, and seasonal changes in water flow.

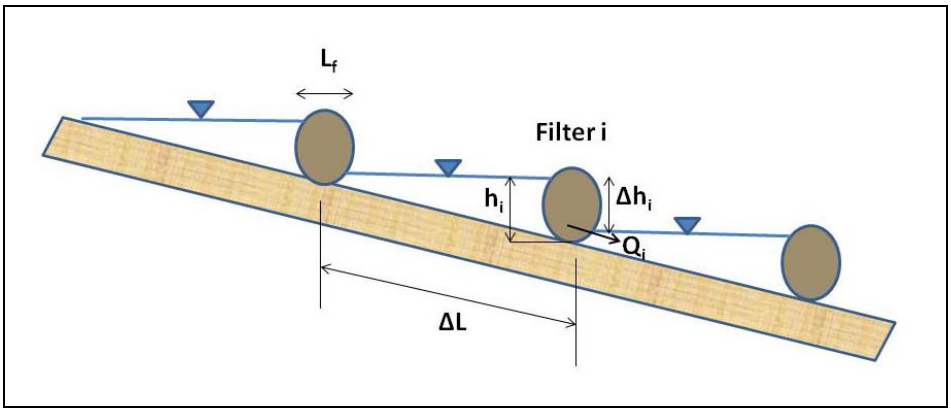

Figure 1. Conceptual design of the Flexible Permeable Reactive Barrier

Technology

This project addressed the contamination of surface receiving waters by metal-contaminated runoff water from training ranges. The flexible permeable reactive barrier technology (see Figure 1) combines the proven use of geotextile fabric woven into a tubular shape (a "sock") filled with sand and with the addition of metal-adsorbing amendments. The filter sock is National Pollutant Discharge Elimination System (NPDES)-approved for use on construction sites in order to control transport of sediment in surface water. The runoff water from the tested firing ranges contains—in addition to suspended sediment—soluble metals and suspended solids with associated metals such as lead (Pb), zinc (Zn), and copper (Cu) with antimony [Sb]. The combination of sand and amendment can remove all three sources of contamination. A commercial amendment combined with the sand was evaluated during the field demonstration. The weight of a filled sock (approximately 40 pounds per linear foot with an 8-inch diameter, depending on the fill material) effectively prevented sediment migration beneath the sock. Given the large land area to be protected, and the high cost to install and maintain most current runoff water management best management practices for metals, the low-cost, passive, in situ reactive barriers offer a solution for improving the quality of surface receiving waters located adjacent to training ranges. Application of a surface water runoff model designed to decrease sediment transport was used to determine placement of the reactive filter barriers on the ranges.

Application

The reactive barriers were placed on the North and Center Kinder Ranges of Fort Leavenworth, KS. Installation for both ranges, including grading of the North Range berm, required one day of labor. The model was used to calculate barrier placement on the North Kinder Range; placement on the Center Range was by "educated guess." On the North Range, the reactive barriers were placed on a gentle grade, in series, to accommodate overtopping during a heavy rainstorm (see Figure 2). Reactive barriers on the Center Range were placed at the bottom of the berm slope behind the targets with another series of reactive barriers placed in the target trough. A heavy rainstorm occurred two days after installation. On the North Range, runoff water was treated and sediment was adsorbed by the barriers, with little buildup upstream of the barriers. On the Center Range, the target line barriers were overtopped for their entire length and runoff water spilled into the target trough. Because of this, within the trough, some portion of the reactive barriers always had to perform as the primary reactive barrier instead of treating the water in series. There was considerable sediment buildup upflow of the reactive barriers in the trough. Upflow sediment and reactive barrier fill material was sampled from each range prior to demobilization for determination of metals concentrations and Toxicity Characteristic Leaching Procedure (TCLP) determination. Reactive barriers from both the North and Center Kinder Ranges passed the TCLP for disposal in a non-hazardous landfill. Once the lifetime of the filter sock has been reached, the fill material can be removed, properly disposed of, and replaced if necessary. Certain amendment combinations have been demonstrated to pass the TCLP requirement for disposal in a non-hazardous landfill or returned to the site.

Figure 2. Flexible Permeable Reactive Barriers in operation on the North Kinder Range (Fort Leavenworth, KS) during a rainstorm

Design Considerations

Cost drivers when considering implementation of this technology are the concentration of sediment in the runoff water, the average annual volume of runoff water on the site, and the velocity of the runoff water as it meets the reactive barriers. High concentrations of sediment will clog the barrier more rapidly requiring either faster change-out times or more filters in the series. High volumes of runoff water may require more reactive filters or simply a change in placement. The model is useful for this determination. High velocity runoff water may damage the reactive filter barriers and may require additional engineering controls.

A comparable technology would be a silt fence, which can hold back several tons of sediment and allow through passage of the runoff water. However, a silt fence does not treat the heavy metal-contaminated runoff water or the contaminated sediment. Metals in solution are currently held in large concrete detention ponds where the contaminated sediment is allowed to flocculate and the contaminated water is treated by ion exchange. This results in two contaminated waste streams: the sediment and the ion exchange brine. The reactive filter barrier treats both contaminated sediment and runoff water, requires less infrastructure, and reduces the need/cost of hazardous waste landfilling.

Benefits

The expected benefits to DoD with the use of flexible permeable reactive barriers include a reduced potential for heavy metal impact on surface receiving waters from small arms training. It is estimated that there are more than 3,000 active SAFRs at DoD facilities in the United States used for military training and recreational purposes. Other benefits of the technology include the following:

- Allows rapid installation in remote areas (i.e., forests, over entire watersheds);
- Allows coarse sand with the proper amendments to pass the TCLP;
- Reduces cost of hazardous waste disposal;
- Is a containment system for metals, metalloids, and metals bound to suspended solids found in surface water runoff from training ranges;
- Is flexible and transportable;
- Provides an inexpensive approach to controlling runoff contaminants; and
- Is easy to replace at the end of its useful lifespan.

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