Long-Term Performance: Multi-Component Containment System for Contaminated Sediment in North Portland [excerpted from EPA/CLU-IN Technology News & Trends Fall 2014 newsletter]

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Cleanup over the past 18 years at the 64-acre McCormick & Baxter site on the shore of the Willamette River in north Portland, Oregon, involves an integrated system of multiple components for contaminant containment. The entire site is capped, with an upland cap that extends to the riparian area along the shoreline where it meets a 23-acre sediment cap beneath the river. The soil and sediment caps operate in conjunction with an impermeable vertical engineered barrier (VEB). Results of the site's third five-year review, which was completed in 2013, indicate the remedy is performing effectively after resolution of problems associated with escape of non aqueous-phase liquid (NAPL) from the river sediment.

McCormick & Baxter Creosoting Company operated at the site between 1944 and 1991, treating wood products with creosote, pentachlorophenol (PCP), and a variety of water- and ammonia-based solutions containing arsenic, chromium, copper and zinc. Process wastewaters were discharged directly to the Willamette River, and other process wastes were dumped in several onsite areas. Site investigations beginning in the late 1980s revealed high concentrations of heavy metals, polycyclic aromatic hydrocarbons, and PCP at depths reaching 80 feet below ground surface (bgs) in soil and groundwater and to 35 feet below the riverbed sediment surface.

Initial cleanup work at this National Priorities List site included excavation and offsite disposal of approximately 32,604 tons of contaminated surface soil and debris. NAPL releases to the subsurface from former aboveground tanks that stored creosote and other wood-treatment chemicals was recovered through a pilot-scale extraction and treatment system in 1989-2000; manual NAPL recovery was then conducted until early 2011. In 2003-2004, a subsurface VEB was constructed to fully encompass 18 acres containing NAPL-impacted groundwater and the main contaminant source areas, including the former tank farm and disposal areas; the total length of the wall is 3,792 linear feet, and the depth varies from approximately 45 to 80 feet bgs.

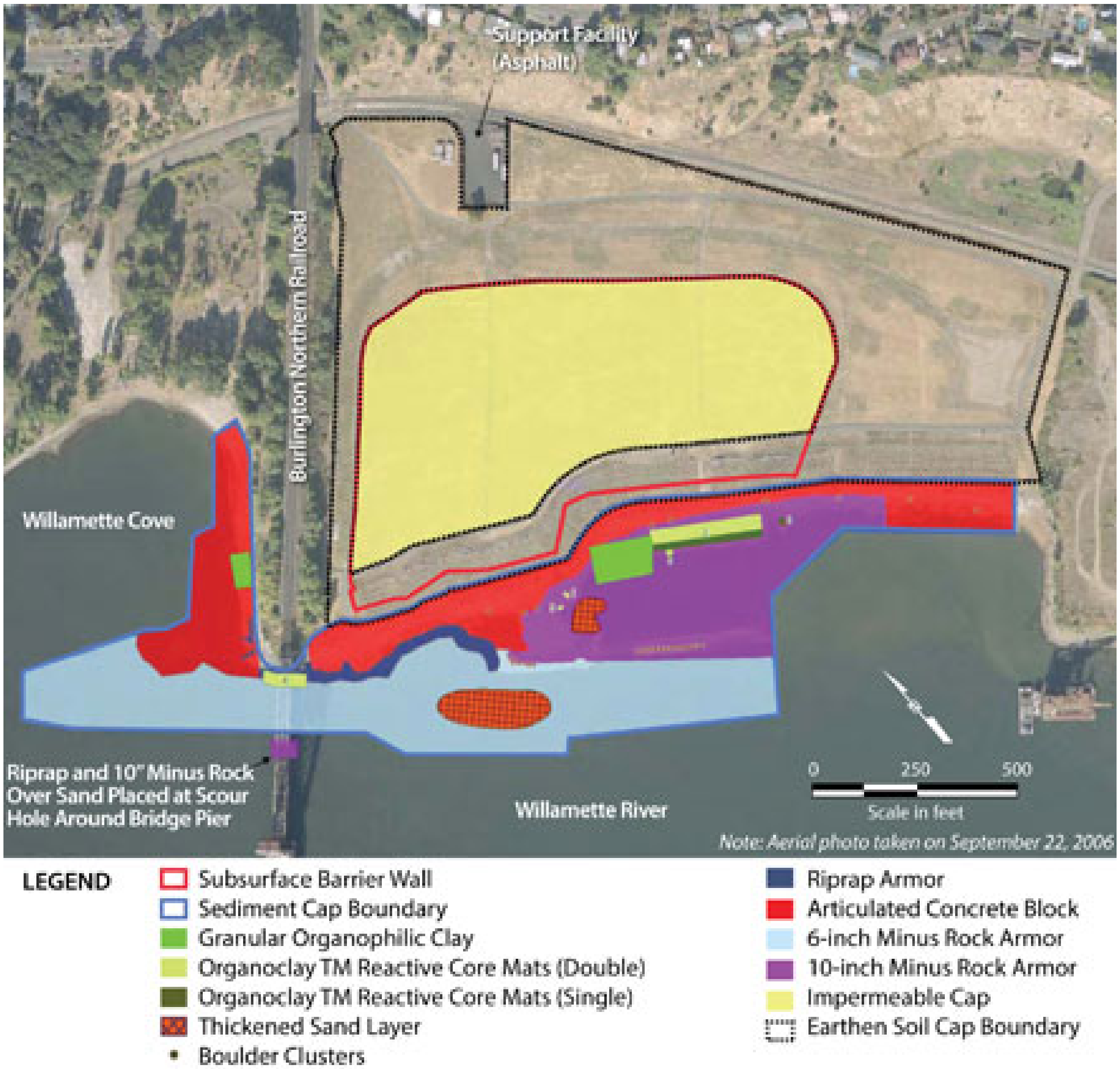

Figure 1. *Aerial schematic of multi-component containment system operating at the McCormick & Baxter site.*

A RCRA-compliant impermeable cap was then constructed over contaminated soil in an upland area covering approximately 15 of the 18 acres contained within the VEB (Figure 1). The remaining three acres, located in the riparian zone along the river, were covered with an earthen cap as part of the sediment cap construction. Eighteen monitoring wells within the 6-acre riparian zone were abandoned to assure continuity of the cap. Thirty-six other monitoring wells were modified to meet Oregon water resource requirements; for example, well casings were added and surface casings were raised to accommodate the soil cap thickness.

The earthen soil cap consists of a minimum 2-foot-thick layer of imported topsoil installed on 19 acres outside of the VEB area and on an additional six acres of soil in the riparian zone. A swale in the cap conveys stormwater directly to an onsite retention/infiltration pond. Several thousand native trees and shrubs were planted throughout the drainage swale and riparian zone to help stabilize the soil against stormwater erosion and river flood erosion, and to evapotranspire rainwater to reduce percolation into groundwater.

Figure 2. *Exposed ACB and sand cap armoring at the McCormick & Baxter site.*

The 23-acre sediment cap consists of a 2-foot-thick layer of sand over most of the cap footprint; a 5-foot-thick sand layer was placed in several more highly contaminated areas. Over four months in 2004, approximately 131,000 tons of sand was placed. In the former tank farm area with NAPL seep, as well as the Willamette Cove, the cap incorporated 600 tons of bulk organophilic clay (ET-1 Activated Clay®) to prevent breakthrough of NAPL through the cap. Organophilic clay generally consists of bentonite or hectorite that is modified to increase hydrophobic properties and affinity for organic compounds.

The sediment cap incorporated different types of armoring to prevent erosion of the sand and organophilic clay layers. The specific armoring material and where it was installed depended on the expected hydraulic and physical environments such as currents and wave or erosive energies. Articulated concrete block (ACB) mats were installed along the shoreline and in shallow water where erosive forces would be the greatest due to wave action (Figure 2). Sizing of rock emplaced as armor included 6-inch-minus, 10-inch-minus, and riprap. All shallow water 10-inch-minus and ACB armoring layers were underlain with a woven geotextile fabric and a 4-inch-thick layer of 3-inch-minus filter rock (Figure 3). This fabric and rock layer was installed to hinder sand migration through the larger and more porous armoring layer(s).

Figure 3. *Cross-section of sediment cap installed at the McCormick & Baxter site.*

Approximately 23,250 tons of 6-inch-minus cobble were placed over the sand cap and as edge treatment where the 6-inch-minus cobble areas abutted the ACB. Approximately 23,300 tons of angular 10-inch-minus rock were placed in the near-shore embayment. The riprap used for the boulder clusters and the rock mound is composed of durable angular boulders less than 3 feet in diameter. Approximately 558 tons of riprap was placed along the shoreline and on an offshore shoal between the embayment and the river. Each boulder cluster consisted of six to seven boulders.

Installation of the sediment cap was completed in 2005. Post-construction inspections revealed ebullition-induced sheen on surface water directly above the sediment cap. In the following year, sheen also was observed along the site's shoreline. The observations prompted examination of the potential migration pathways for contaminants (Figure 4.)

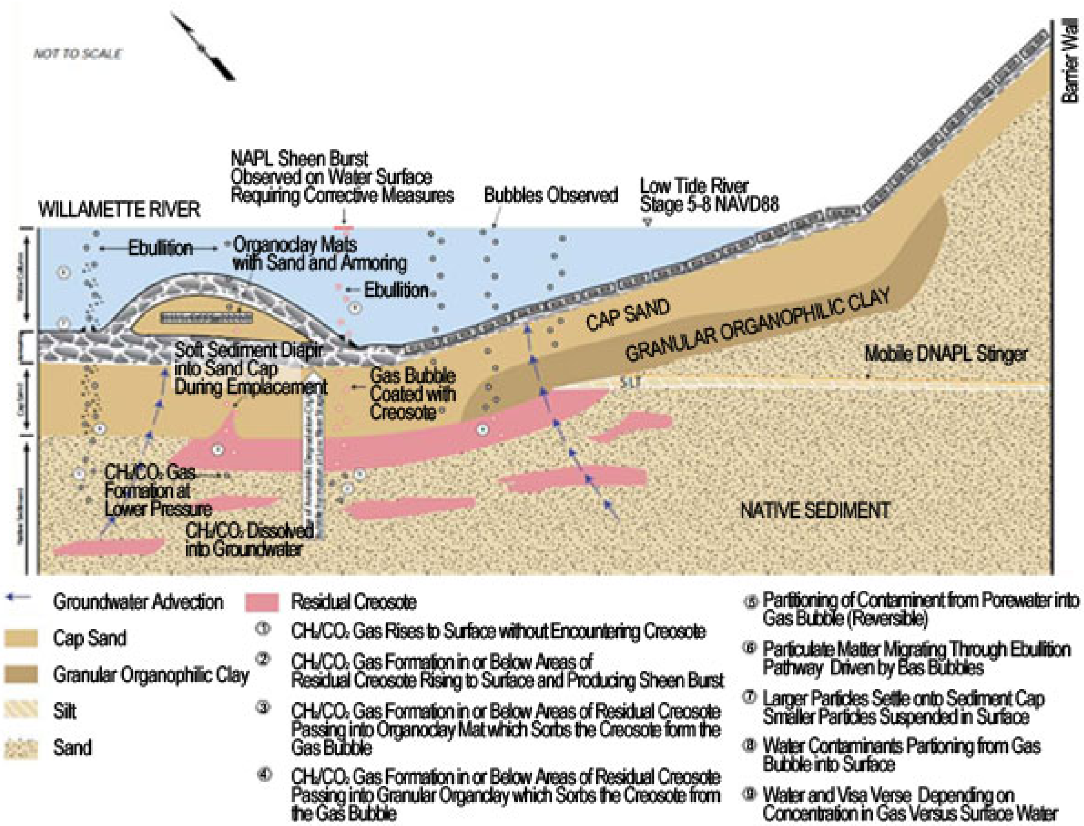

Figure 4. *Conceptual Model of Contaminant Transport at the McCormick & Baxter site.*

To mitigate the sheen, approximately 24,150 square feet of laminated matting containing Organoclay® (Reactive Core Mat™) was emplaced in three target areas along the shoreline and within shallow near-shore water and covered with sand and rock armoring. A comprehensive study was conducted from 2007-2009 to determine the potential source and nature of the sheen; the study included porewater and sediment core sampling and chemical and biological sheen analysis in the vicinity of sheen observations. Flux chambers were deployed in select locations to collect surface water and air samples. A high correlation was found when comparing observed locations of ebullition/sheen to areas where bulk organophilic clay had been placed in the sediment cap. In these areas, it was determined that degradation of the organic material within the organophylic clay periodically released gas that created a pathway for NAPL to surface water where it was expressed as small but visible sheen bursts. It was concluded that sheens found along the shoreline were most likely due to higher concentrations of iron in groundwater discharge. To date, no further sheen bursts have been observed in surface water, and the rate of ebullition through the cap has diminished significantly.

Figure 5. *Sample collection in sub-armor of the sediment cap at the McCormick & Baxter site.*

Solid phase micro-extraction (SPME) passive samplers were deployed in 2010 at 22 locations overlying the sediment cap and at two background surface water locations to establish a monitoring baseline. Each point was sampled 6 inches into the armoring layer as well as 6 inches and 12 inches into the sand cap layer (Figure 5).

Sediment cap monitoring has also involved several bathymetric surveys and diver inspections. Differencing survey images and inspections led to cap improvements such as placement of additional rock armor and Organoclay reactive core mats in some areas. In addition, visual inspection of the ACB in the sediment cap has revealed gaps in some areas due to accumulation of sharp objects and debris. Significant gaps have been filled with grout; in areas highly susceptible to ongoing wave action, gravel also may be added.

Overall, the sediment cap remains effective, with no evidence of significant contaminant breakthrough to the near surface environment. Mean concentrations of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in surface water, for example, decreased from 0.33 micrograms per liter (ug/L) in 2002 to 0.015 ug/L in 2010 (Figure 6).

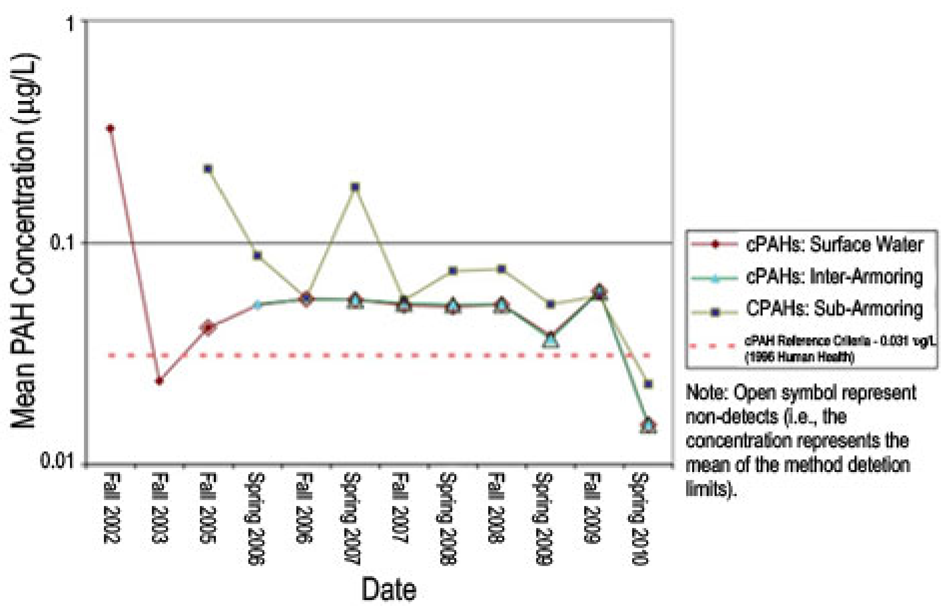

Figure 6. *Mean concentrations for total cPAH in surface water, inter-armor water (collected within the rock armor), and sub-armor (sand cap) water of the sediment cap at the McCormick & Baxter site.*

Through a U.S. EPA grant received in 2014, Oregon State University researchers will soon begin to measure Willamette River contaminants within the Portland Harbor Superfund site. Passive sampling techniques in water and sediment can better assess pollutant concentrations in specific locations over time. Oregon State University is currently working on a plan to use passive samplers at McCormick and Baxter to determine sediment cap performance as part of the next five-year review to ensure that the remedy remains functional and protective as designed. That sampling will be conducted in late summer 2015.