

## **Natural Hydraulic Control of Petroleum Transport in a California Coastal Stream Setting**

Daniel Tormey<sup>1</sup>, James Waldron<sup>2</sup>, and Matt Carpenter<sup>1</sup>

<sup>1</sup>ENTRIX, Inc., Ventura, CA

<sup>2</sup>ChevronTexaco, Bakersfield, CA

[dtormey@entrix.com](mailto:dtormey@entrix.com)

Groundwater flux to the ocean is an important pathway for mass transport from the terrestrial to marine environment. Groundwater discharge often contains higher concentrations of contaminants than do rivers and streams, and thus can influence the health of coastal ecosystems. California coastal stream settings are typically complex, with flow fields influenced by highly variable hydrology, geologic controls, and ocean tides.

ChevronTexaco's Estero Marine Terminal, located on California's central coast near Morro Bay, received crude oil from San Joaquin Valley production operations and loaded it on to tankers for transport to the refinery. The terminal has been subject to assessment and monitoring activity on at least a quarterly basis for ten years. A plume of cutter stock (a diesel-like, heavy-oil thinner) mixed with heavy crude oil is at the water table, but the low solubility material has produced a narrow halo of hydrocarbon-bearing groundwater.

The terminal is located adjacent to a coastal stream and the Pacific Ocean. The study has elucidated a three-component flow field in the area of the cutter stock-oil plume. The first component is groundwater flow influenced by recharge preferentially along the basin boundaries, and is generally directed toward the stream and ocean. The second component is the coastal stream, which transitions from a gaining stream to a losing stream, with discharge to groundwater, as it approaches the coast. Where a losing stream, the direction of groundwater flow is diverted away from stream. The third component is symmetric tidal influence. Taken together with the influence of the other two components, the tides lead to a net zero or slightly seaward gradient. Away from the stream, the direction of flow is a two-component system directed ocean-ward.

The resulting flow-field provides a natural hydraulic control on contaminant migration. The track of the contaminant plume is away from the coastal stream and the ocean. The low-solubility, cutter stock-oil mixture does not leave this controlled zone. A spill of more mobile MtBE in 1999 followed the flowpath inferred from the hydrologic data.