Project Title: Sulphur Creek Mining District, Abandoned Mine Reclamation

Location: Colusa County, Northern California

Client: Homestake Mining Company/Central Valley Regional Water Quality Control Board

Client Reference Contact: Peggie King, 707-245-3573, pking@barrick.com

Role and Responsibility of Key Member: Professional Engineer in Responsible Charge/Engineer of Record

Project Description:

The Homestake Mining Company implemented a remediation project at the site of a mercury mining district dating back to the 1860s and operating as late as the 1940s along Sulphur Creek in Colusa County, California. The site was located largely on private property associated with an existing, active vacation resort facility (the Wilbur Hot Springs Resort) that would need to remain in operation during the extent of both the investigation and construction/implementation. At issue were mercury laden sediments and mine waste materials located immediately adjacent to the creek which were at risk of being transported by erosion into Sulphur Creek and on downstream into the Bear Creek drainage. The California Gold Rush which began in the Sacramento area in 1848 led to the development of many mercury and/or gold mines in the local mining district during the 1860s and 1870s. Gold extraction technologies at the time frequently involved the use of mercury. It is estimated that approximately 170 tons of mercury was extracted between the 1870s and the 1940s. The project involved the removal of approximately 17,000 cubic meters of mercury-impacted mine waste at five (5) different abandoned mine sites within the district and placement of the material in an on-site repository which was then stabilized against erosion. Due to uncertainties associated with potential mine waste volume, the repository was designed to be flexible and capable of accommodating from as little as 15,000 m^3 to as much as 30,000 m^3 without the need for delays associated with design modifications.

The design further assured that the finished repository would be self-sustaining and visually indistinguishable from the surrounding terrain. The repository slopes were designed to feather into existing, natural slopes on the south edge so that no drainage channel with concentrated flow would be created. A shallow rock lined swale would be required only on the north edge of facility. The top of the repository would be rounded and crowned with a low peak allowing it to visually blend in better with the existing topography along the ridge line.

The site also contained abandoned mining equipment including retorts that offered the possibility of the presence of elemental mercury. A temporary, berm and lined inspection area was provided to permit inspection of mine equipment and determine if some materials would require off-site disposal as hazardous waste. Once inspected and cleared as Group C waste, the materials were relocated to the on-site repository. Mine waste removal sites were stabilized using various best management practices (BMPs) and some mine waste deposits with difficult access where disturbance was likely to be excessive were stabilized in place. Erosion control techniques used in the project included facines, straw mats, coir log barriers, straw bale dams, hydroseeding with native grass species, grass filters, and a self-deploying riprap barrier (protecting one of the mine sites from being undermined by active erosion on the outside of a meander bend on Sulphur Creek).

Additional levels of complexity at the site involved the presence of historical and archaeological sites. Some of the mine structures and facilities on the site were actually protected as historical resources. The western end of the site which included access to the West End Mine location was designated an Environmentally Sensitive Area (ESA) due to the presence of a cultural site (a Yawi Village archaeological site). Within this area there could be no grading of access roads, although additional gravel could be placed above existing roadway surfaces if needed. An additional complicating factor at the West End mine involved the discovery of a colony of Townsend's Big Eared Bats roosting in the mine adit. This brought a series of restrictions on the work schedule and the establishment of a buffer zone of up to 75 m within which no heavy equipment could be operated during certain dates and times of day.

Project design also included contingencies for potential use of in-stream structures including rock vortex weirs for the stabilization of high gradient stream beds and a sediment control dam for the collection of fine grained mine waste below areas where excavation and removal were simply impractical. Equipment access across the

active perennial stream channel of Sulphur Creek was accomplished using temporary bridges that were removed at the end of the project. The crossing of an ephemeral channel was accomplished using a temporary ford which was also removed at the end of the project. All roads not present prior to project design and other facilities required for access or construction had to be reclaimed or "erased", leaving the final site as undisturbed as possible.

A key element of the project's success was flexibility. The contractor had to be willing to stand down for a four week or greater period in the middle of the construction season to accommodate roosting bats. No work would be permitted after dark. All equipment would need to go through a decontamination process prior to leaving the site. Construction personnel would have to accommodate the needs of resort personnel and guests. Contractor preferences would need to be accommodated where possible. For example, the contractor elected to use fiber rolls in lieu of silt fence irrespective of the slope characteristics. Alternative routing into waste locations for collection and removal suggested by the contractor were reviewed by Homestake's representative and engineering staff and approved where possible. As the nature of the many uncertainties during the design phase were revealed in the construction phase, collaboration between the contractor, engineer, and Homestake was undertaken in an attempt to produce the best possible outcome.

Success of the stabilization methods are being monitored with multiple site visits during the rainy season and vegetative surveys before and after stabilization (biological surveys, drone photography, and GPS).

This project received an award from the American Society of Civil Engineers (Sacramento Section) and was designated ***"Environmental Project of the Year"*** for 2016.