Closure at the San Manuel Plant Site
How Closure Aligned with the Goal of Environmental Sustainability[1]

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Introduction

Environmental sustainability involves integrating and meeting economic, social, and environmental goals with respect to planning and implementing mining activities. Active mine or processing facilities offer an operator various opportunities to incorporate environmental sustainability goals in the mine planning and production process. Closure and post-closure planning for a mining operation must also factor in environmental sustainability goals. BHP Billiton (BHP) applied its Sustainable Development Policy as part of the closure of the San Manuel Plant Site in Arizona. BHP strives for "Zero Harm", which describes its goal of no harm to people, host communities, and the environment. Each of these aspects was considered during the closure of the San Manuel Mine and Plant Site facilities.

The San Manuel Plant Site is located adjacent to the Town of San Manuel in Pinal County and consisted of the Plant Area (milling and processing facilities) and the Tailings Area (tailings impoundments). The Plant Site processed ore from the San Manuel Mine (Mine Site) and other BHP Copper Inc. (BHP) operations and performed custom smelting of concentrates from other copper producers from 1953 to 1999. More than 700 million tons of copper sulfide ore were mined and shipped by railroad to the smelter complex located 8 miles from the mine. Underground and open pit mining operations and smelting ceased in 1999 and formal closure was announced in 2003.

In terms of sustainability, the primary goals for closure were to promote the efficient use of resources, to reduce and prevent pollution, and to assess and consider ecological values and land use aspects in closure activities. Regulatory oversight of the closure was under the jurisdictions of the Arizona Department of Environmental Quality and the Arizona State Mine Inspector. Other stakeholders, such as the local community and other government agencies, were consulted during the closure process and continue to be involved in the redevelopment planning.

Post-Closure Land Use for the Industrial Area at the Plant Site

Prior to detailed closure planning for the industrial area, BHP evaluated several post-closure land uses based on existing infrastructure and applicable county zoning regulations. Existing infrastructure includes paved road access via state highways as well as a railroad siding. The Plant Site is serviced by a 115 KV electrical substation suitable for light industrial manufacturing or similar activity. BHP also maintains water rights for withdrawals from the San Pedro River for potable or industrial use.

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BHP worked within the Pinal County Comprehensive Plan (2005) as well as local economic development agencies to identify appropriate land use options and opportunities for the Plant Site. In areas of former heavy industrial activity, BHP collaborated with the Arizona Department of Environmental Quality to establish appropriate soil remediation levels for site remediation. The operations are shown on Photo 1.

Photo 1 San Manuel Plant Site Operations (Aerial view pre-closure)

Soil and Groundwater Characterization

Soil and groundwater quality characterization are required under the Arizona Department of Environmental Quality operating permits for mining operations. On-going characterization was occurring when BHP formally announced closure, prompting the characterization program to apply to a closure permit, which also required assessment of future conditions.

Photo 2: Soil characterization trench

Soil Remediation

Previous work conducted at the Plant Area characterized soil conditions and assessed the remediation of the contaminated soils within the Plant Area. Contaminated soils were generated within material staging areas as well as within areas of heavy industrial activity. In some cases, contaminated soils were located below fill materials (Photo 2). The primary soil contaminants are metals.

Studies indicated that the metals that will remain in the Plant Area soils will not leach at concentrations that exceed the State of Arizona Water Quality Standards (AWQS) (based upon Synthetic Precipitation Leaching Procedure (SPLP) tests). Furthermore, characterization work performed to date indicates that the on-site soils are calcareous and have the capacity to further reduce the already low (i.e. below AWQS) concentrations of metals that can potentially leach from surface soils.

The selected remedial alternative is an engineering control, which will be a soil barrier, combined with access controls, will serve as the engineering control to manage human health risks that may be associated with the Plant Site soils that have metal concentrations above non-residential Soil Remediation Levels (SRLs) promulgated by the Arizona Administrative Code (A.A.C.) R-18-7-205. Use of an engineering control as a remedial option is consistent with the A.A.C. R18-7-206(D).

Groundwater Characterization and Modeling

Groundwater flow and transport models were developed to assess the impact from soils remaining on-site and from discharge from the tailings impoundments. Extensive geochemical testing indicated that the tailing solids within the primary impoundments will not produce acid-related constituents over time. Some evidence suggests that tailings solids within portions of the existing tailing embankments have oxidized and released acid-related constituents; therefore, the closure design included provisions for reducing natural recharge in embankment areas. Long-term vertical drainage of excess process water from the milling process presents the primary long-term source of elevated sulfate in groundwater below the tailing impoundments. The groundwater flow and transport model results were also used to design the long-term groundwater monitoring system (see Figure 1).

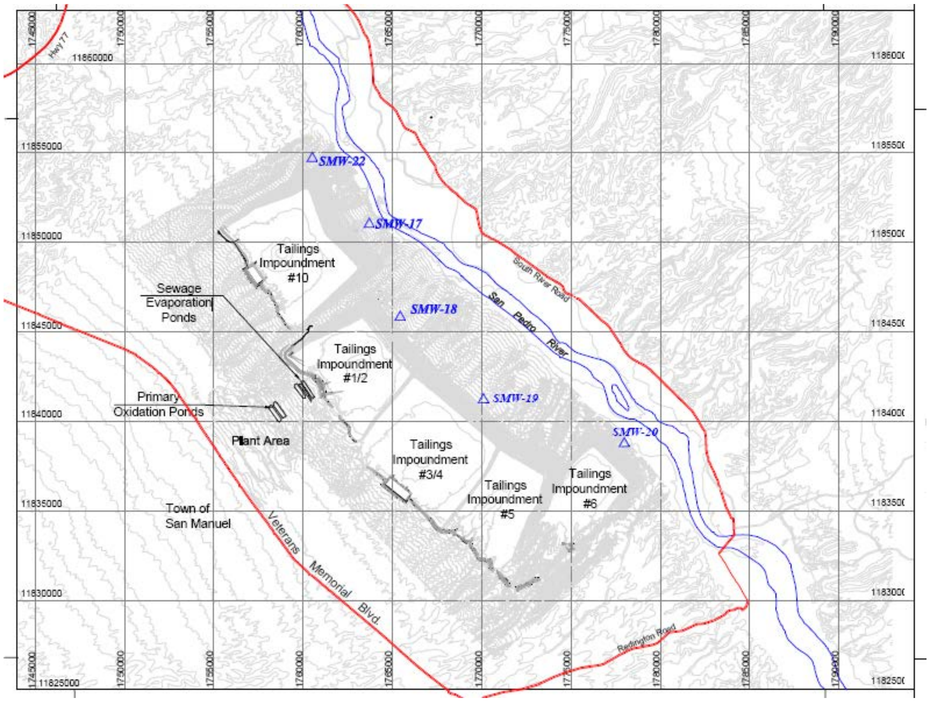

Figure 1: Groundwater monitoring wells

Demolition of Structures and Reclamation Activities

Closure activities involved removal of structures and concrete high walls, stack demolition, concrete burial, ripping of asphalt surfaces, heavy earthwork regrading, placement of soil cover, scarification of cover material, and revegetation.

The closure of the structures such as the smelter involved inspecting, dismantling, and salvaging the machinery and equipment; razing structures; salvaging recyclable scrap materials; and removing and safely disposing of demolition debris. Concrete foundations and structural members were penetrated for good drainage and were buried in place.

Each building was prepared for demolition following an environmental assessment. Asbestos siding, roofing, and insulation were removed prior to the building demolition where practical and safe. The asbestos was disposed of at the on-site permitted asbestos landfill. Equipment and areas where potential contaminants were handled were cleaned prior to salvage or demolition. Oils and grease were sent to a recycler or licensed waste disposal facility. Construction debris found to contain contaminants exceeding regulated levels was disposed of in an appropriate manner (such as incineration or disposal in a landfill).

Photo 3: Transite pipe disposal in asbestos landfill

Where practical and economically feasible, equipment and machinery was salvaged for sale. Demolition debris and other materials that have no value for reuse or scrap were transported to an appropriate, on-site solid waste facility. Some inert materials, such as wood, concrete, and masonry, were sent to the solid waste landfills on site. Scrap metals were shipped off site and recycled. Waste shipment manifests document the materials removed from the Plant Site. Wastestreams generated are listed in Table 1.

Table 1: Summary of Wastes Removed during San Manuel Operations Closure

Waste Description	Total Weight or Amount	Amount Recycled	Comments
Mixed batteries	307 tons	100%	Truck batteries
Fluorescent bulbs	18,645	100%	Contain mercury
Mixed explosives	26.4 tons	None	Detonators and binary
Oil	118,750 gallons	65%	Includes oils with PCBs
Lab Packs	860 drums	None	Incinerated
Cyanide salts/pipe	85 drums	None	Handled as toxic waste
RCRA debris	735 tons	None	Incinerated; includes poly-wrapped acid-mist filters, treated wood and asbestos/RCRA waste pipe
Refractory brick	2,226 tons	None	Stabilized and landfilled
Vanadium pentoxide	942 tons	None	Stabilized and landfilled
Transformers	303.3 tons	55%	Recycled (non-PCB) or incinerated (PCB)
PCB ballasts, switches and caps	31 tons	75%	Recycled/incinerated
Soil with PCBs (mine site)	490 tons	None	Landfilled
Soil with PCBs	6,613 tons	None	Landfilled
Asbestos wastewater	6,713 gallons	None	Stabilized and landfilled

The last structures scheduled for removal were the two smelter stacks, which required special handling of asbestos material identified in a portion of the stacks. The smelter stacks were demolished and buried in-place with cover material.

Regrading and Contouring

After the demolition program finished, the Plant area was regraded and filled to achieve a slope configuration of greater than 1% slope (100H:1V) but no steeper than 3H:1V over a majority of the area. Concrete slabs received one foot of compacted fill as an extra layer for plant growth. The entire area was then covered with a minimum of one foot of clean soil as part of the soil cover specified as an engineering control for remediation.

The re-establishment of natural drainages was done wherever practical. When it was not practical, drainage patterns were developed that best suited the affected areas, enhanced and supported revegetation activities, complemented the natural drainages, and minimized on-going maintenance requirements. The contouring of the slopes minimized the loss of soil; improved germination of seeded species; increased the ability of the soil to absorb moisture; and slowed and dispersed surface water runoff.

Stormwater runoff from the industrial area was captured on the tailings impoundments and then evaporated. Separate diversion berms and channels were constructed on the regraded and covered areas. The diversion berms and channels manage storm water and limit erosion through collection and diversion of storm water runoff from the covered area to natural drainages. Drainage patterns from the Plant Area towards the tailing impoundments will continue after closure of the Plant Area and Tailings Area; however, drainage from the Plant Area will be captured upgradient of the tailing impoundments in the clean water diversion channels and discharged off site (Photo 4).

Photo 4: Installation of rock armor on 6 Dam

Several underground structures on the site were buried in place. The foundations of buildings that were below final grade were left in place, and concrete protruding from the regraded surface was demolished. Basements were perforated to permit incidental water to pass through. The basements were backfilled with the broken concrete and materials excavated from the site and adjacent borrow areas.

Asphalt roads and parking lots were scarified in place and cut to fill according to the grading plan. Culverts within the regraded limits of the Plant Area were buried in place. Concrete foundations and slabs on grade were perforated to avoid standing water. Reclaimed unpaved roads and yards were covered with a minimum of twelve inches of clean fill.

Earthen cover material used for the Plant Area was excavated from the southeast, east, and northeast sides of the Plant Area in engineered diversion channel alignments or native ground. Soil cover was placed to a minimum thickness of one foot over scarified asphalt and buried concrete, and a minimum thickness of one foot was placed over impacted soil (i.e. no cut zones). Over the remaining areas of exposed concrete foundations and slabs, a minimum of two feet of cover was placed and the first one foot of cover was compacted.

The main channels were excavated after the placement of the cover material over regraded areas. Excess materials from the excavation of the channels were used as fill in areas that had not yet been regraded or uncovered. The excavated channels were re-lined with a foot of cover material to ensure the minimum cover thickness and then armored with riprap to reduce erosion.

The diversion berms were constructed from placed cover material over the regraded areas. A cut and fill balance created a compacted diversion berm to divert storm water to the main channels. Extra fill was taken from the selected Plant Area borrow. The diversion berms were lined with compacted rock armor.

The finished regraded surface was prepared for seeding by scarifying the surface. The seed mix was drill seeded without amendments. The seed areas were covered with straw mulch and tackifier was sprayed on top to aid the moisture retention and seed protection until germination. Wattles were installed on 3H:1V slopes to reduce sediment erosion and promote germination.

Remaining Structures and Materials

Materials remaining at the Plant Site include the tailings impoundments, an electrical power substation, a concentrate transload facility (for use in conjunction with operations at a separate mine), and the sewage treatment plant and ponds. The wastewater treatment plant (WWTP), which includes the sewage treatment plant and evaporation ponds was transferred to a private operator that will continue to provide service for the community of San Manuel. The electrical substation is owned by a private company and will continue to operate.

The tailings impoundments were characterized, evaluated for various closure options, and closure plans were designed. The closure of the tailings included regrading the tops and sides to control run-on and runoff; covering the tops with clean fill and the side slopes with rock armor and soil to restrict erosion and prevent the release of tailings material and impacted storm water runoff to the environment; constructing downstream sedimentation ponds; and revegetation. These closure activities restrict liquid migration to and from the facility. The tailings meet the residential and non-residential soil screening criteria for the State of Arizona for all parameters except arsenic, which exceeded criteria in a limited number of samples. Based on the conceptual geochemistry model, metal concentrations will be attenuated. The closure design of the tailings impoundments ensures that future predicted discharge will not exceed State of Arizona groundwater screening criteria.

Photo 5: View of former Plant Area (August 2007)

Post-closure Monitoring and Maintenance

BHP has implemented monitoring and maintenance of the soil cover and groundwater quality, and has routine reporting requirements as part of the environmental compliance requirements.

Five groundwater monitoring wells were installed and monitored to establish baseline conditions and calculate aquifer quality limits (AQLs) and alert levels (ALs). Annual compliance groundwater monitoring in each well is required as part of the long-term environmental compliance under the Aquifer Protection Permit issued by the Arizona Department of Environmental Quality.

Alert levels are established in the permit for closure issued by the Arizona Department of Environmental Quality, for discharges from the facilities (such containment structure failure or unexpected loss of fluid such that stormwater runoff is released to the surface or to the vadose zone), and for groundwater quality.

Summary

BHP considered environmental sustainability principles throughout planning and implementation of the final closure design for the industrial area, as well as for the combined mine and plant sites. Post-closure monitoring and maintenance prevent endangerment to public health and the environment. It also is intended to reduce, to the greatest extent practicable, any potential discharge from the facility and (or) exceedances of regulatory screening levels stated in the site-specific environmental permit issued for the site by the Arizona Department of Environmental Quality.

References

Pinal County Board of Supervisors, Pinal County Comprehensive Plan, December 19, 2001, Amended November 29, 2006, 76 p.