Topic PT-4

White Paper Topic: In situ treatment: Alkaline Amendments, Foundation Drains and Reactive Barriers

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Problem Definition:

Overburden identification and classification may result in overburden handling and placement plans that must be followed to prevent the production of acid mine drainage. These plans, depending on the nature of the overburden, may include selective handling, the addition of alkaline materials that may either retard pyrite oxidation or neutralize generated acid, and the use of foundation drains. Reactive barriers may be placed in situ, but usually after a problem has developed.

Limestone or other alkaline materials may occur in the overburden, but if calcareous materials are deficient, limestone may be imported and incorporated into the overburden handling and placement plan. The alkaline material has been used and incorporated into mine sites in a variety of ways to achieve a similar objective (non-acid, low metal concentration discharges), but differences stem from site specific mine characteristics. Alkaline material use has included blending alkaline material or imported limestone to neutralize potentially acid producing overburden or to neutralize acidity in topsoil materials to aid vegetation and improve soil moisture quality. It has also been used to create zones of alkaline rich waters, which infiltrate by controlled seepage and increase alkalinity of the groundwater. in situ treatment is usually undertaken where AMD has already formed or when it may be anticipated. These in situ technologies treat the acid producing rock at the point of acid generation by retarding or neutralizing the acid production prior to discharge from the backfill whereas normal treatment technologies treat the discharged water either with passive or active treatment, but post discharge.

Due to the nature of the alkaline additions, these technologies can either be used concurrent with the mining operation or can be incorporated in post mining sites.

A. Placement of Alkaline amendments: concurrent with mining:
    1. On the surface of the backfill (potential concerns: insufficient CO_2 to increase alkalinity significantly unless very low acid conditions)
    2. Immediately below the soil layer (higher CO_2 levels (perhaps) resulting in higher alkalinity generation
    3. On the pit floor (constant water source for alkaline generation, but water quality may be iron and acid rich; issue of anaerobic vs. aerobic conditions)
    4. As a cap over potential acid horizons
    5. As an alkaline conduit (i.e., alkaline trenches, funnels or infiltration beds) for alkaline water into the backfill

B. Placement of alkaline amendments: post mining
    1. Alkaline conduits within the backfill (if constructed post mining, must excavate and dispose of overburden)
    2. Anoxic Limestone Drains at seeps where gradient is sufficient; are the parameters for successful implementation adequately identified (metals leading to clogging, flow rates, etc.)
    3. Anoxic Limestone Vents – For groundwater seeps which result from upwelling; limited success (Geidel, 2005) – why?

Draining water away from overburden materials quickly may prevent water from reacting with pyrite and forming acid products. Several types of drains have been used for this purpose including: placement of coarse material around tightly packed pyritic material to form a porous envelope; installation of drains to convey water from the backfill or valley fill through a durable, high column of sandstone (chimney drain); highwall drains collect water along permeable channels and are constructed of either sandstone or limestone; French drains are usually small and constructed in disturbed material often on the pavement, to move the water out; and blanket drains are constructed by placing a coarse, permeable rock layer on the pavement to allow water to drain out. In most cases, drains would need to be constructed concurrent with mining.

Reactive Barriers have been used in a number of scenarios for reclamation of contaminated groundwater. This technology has not been extended to mining situations to any significant degree, but some work with injection of sulfate reducing bacteria fits into this category. For existing contamination, barriers can be installed post mining, either down-gradient of contamination plume or surrounding the contamination. These may prove to be cost effective in situ treatments when space is minimal and insufficient for a passive system such as a wetland.

Objectives:

Studies evaluating the effectiveness of in situ technologies would provide beneficial data and results to improve mine reclamation planning. Many field sites have used alkaline amendments and drains; however, little of this data has been reported. Developing a method to collect the data and to assess these treatments would provide valuable information on the success and failure rates of these technologies.

Approach:

A. *Alkaline Amendments:*

While alkaline amendments have been placed at numerous locations in and on reclaimed mine sites, the effectiveness of each of the technologies listed above has not been compared. Is it more effective to blend alkaline material or to create alkaline infiltration zones? Is improved water quality only a measure of the alkaline addition or do the synergistic effects of multiple treatments coupled with various hydrologic components affect the water quality.

When alkaline amendments are used post mining in trenches, funnels, infiltration beds, is the improvement in water quality due to:

a. the water budget (i.e. greater alkaline vs. acid load)
b. changes in pore gas composition both in alkaline and acidic zones,
c. displacement of iron oxidizing bacteria in favor of other bacteria

Can alkaline amendments be used in conjunction with processes increasing sulfate reducing bacteria activity?

B. *Foundation Drains:*

In moving the water away from the pyritic material, do drains provide avenues for O2 exchange, thereby enhancing oxidation or does the CO2 production overwhelm the O2 aeration?

C. *Reactive Barriers:*

They may be able to be constructed to sequester specific metals and decrease acidity; are they cost effective for mine water improvements?

Course of Action:

Alkaline Amendments:
Data from numerous alkaline amendment sites should be compiled, reviewed and analyzed. The analysis should evaluate pre-treatment water quality, post treatment water quality, type of alkaline amendment, flow, thickness (volume), etc. Ideally results would provide data to construct a model for use of various types of amendments and success rates.

Foundation Drains:
To evaluate the effectiveness of foundation drains, in situ studies of water quality parameters and gas composition at various locations within drain should be conducted.

Reactive Barriers:
This technology is being used at a number of hazardous waste sites and groundwater contamination sites. Pilot studies for the effectiveness of such technologies (including reactive permeable and impermeable barriers) for reclamation of waters from overburden, deep mines, waste piles, refuse dams, etc., should be conducted and the results analyzed for use at full scale.

Cost of Project:

Provide Cost estimate: $200,000- $300,000

Proposals and costs are preliminary and significant portion of budget would be devoted to reactive barrier pilot tests.

Time Required:

1. Analysis of existing alkaline amendment placement and development of model or plan for most effective placement or use.

   Analysis – 6 months,
   Plan or Model development- 6 months

2. Foundation Drain monitoring and evaluation:

   Instrumentation of foundation drains would most likely have to occur during construction of drain. Time frame would be predicated on locating a suitable drain currently under construction and placing monitoring instrumentation in the drains. The anticipated results could be modeled and the instrumentation used to validate model.

   2-3 years

3. Reactive Barriers

   Pilot tests: Select locations; install pilot scale barriers; and monitor.

   Depending on Groundwater flow rates – 1 to 1.5 years.

Literature Survey:

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