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C S P 2

LAND APPLICATION DISPOSAL (LAD) GUIDELINES[1]

The land application of effluent from heap leach pads is commonly proposed by operators and regulators who desire to dispose of large quantities of water that have accumulated during mine operation, or in order to drain a heap leach process facility prior to final closure. It is also often proposed for long-term disposal of seepage through the heaps.[2] LAD is usually accomplished by spraying the effluent with common agricultural irrigation equipment, most commonly spraying, which also has the effect of evaporating additional water during application, but can also be accomplished by allowing fluid to drain into the ground through a drain system.

LAD is an attractive method of effluent disposal to mine operators because any discharges to groundwater usually have to meet only drinking water standards, which are much less strict than the aquatic water standards that are usually applicable to surface waters. However, it is difficult to predict the chemical and physical (e.g. leaching) impacts of LAD on the receiving soils and groundwater, so LAD should only be approved where there is no better disposal or treatment alternative.

The goal of the LAD should be that all of the water and contaminants in the effluent be taken up by the vegetation, evaporated, or remain permanently bound in the surface soils. The plants, and the soils in the surface layers, should be capable of utilizing and/or binding all of the chemical contaminants in the effluent. The water/effluent should not percolate into groundwater. In addition, no fluids that can be classed as hazardous waste (by Toxicity Characteristic Leaching Procedures) should be discharged by land application. LAD should not displace contaminants which may naturally exist in the soil, but which may be mobilized by the water or contaminants in the LAD effluent.

If LAD is proposed where the depth to groundwater is high so that the unsaturated zone will be used to attenuate in perpetuity the contaminants in the water, then the proponent should prove that a future hazardous waste site would not be created. This analysis must account for preferential flow patterns, fractures, and finger flow. The analysis should also account for the rate of attenuation and not assume that all of the contaminants will be uniformly distributed throughout the soil.

Treatment / Pre-treatment of the effluent to be land applied (e.g. for metals, nitrates or ammonia) should also be considered. Treatment can significantly increase the effectiveness of the land application by removing, or decreasing, one or more of the contaminants that may limit the amount of effluent to be land applied. Treatment may allow more effluent to be land applied over a long time, increasing the effectiveness of the LAD, than would be the case if no treatment were used.

A detailed understanding of the following general characteristics of the LAD site is needed in order to establish a baseline of soil and groundwater conditions prior to land application, and to provide data to calculate application rates, chemical uptake, etc.

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[1] This paper has been developed by David Chambers, C S P 2. It is recognized that the paper does not address all of the intricacies of LAD. Comments, and suggestions for improvements, are encouraged.

[2] Allowing effluent to drain into the subsurface/groundwater is usually aimed more at dilution of the effluent in groundwater, rather than at evaporation and binding the contaminants in the soil and vegetation. Dilution of the effluent in groundwater should be discouraged because it can lead to long-term contamination of groundwater resources.

A. Site Considerations

1. General Resource Issues

a. meteorology
b. cultural resources
c. wildlife resources
d. visual issues
e. reclamation plan
f. bond calculations

2. Geology and Geomorphology

a. site geology, stratigraphy, and hydrogeology (rock types, faulting, mineralization, etc.)
b. site slope, aspect and surface topography
c. proximity to surface waters
d. groundwater resources

3. Soil Properties

a. soil morphological properties
   1) soil types
   2) soil profile horizon characteristics[3]
b. soil physical properties
   1) texture
   2) infiltration rates
   3) available water holding capacity
   4) porosity
   5) bulk density
   6) hydraulic conductivity
c. soil chemical properties
   1) chemical composition
   2) paste pH and electro conductivity
   3) cation exchange capacity
   4) total exchangeable bases
   5) total organic carbon content

4. Soil Attenuation Capacity for Metals and Non-Metals[4]

Theoretical calculation of the cation and anion exchange capacity is the method commonly used by the mining industry to estimate the soil's ability to reduce contaminants by LAD.

However, calculation of the soils capacity for the sorption of dissolved metals (cationic) and non-metals (anionic) constituents is simplistic in that it does not address changes in chemical composition or equilibrium over time, either in rock drainage or soil solution. Changes in the chemistry and thermodynamics of both solutions will occur, altering the solute loading characteristics and soil attenuation potential. Chemistry of metalloids like arsenic is not taken into account.

[3] Separate data should be analyzed for A-horizon, B-horizon, and C-horizon characteristics

[4] URS Greiner Woodward Clyde, p. 4-10.

Calculations of soil attenuation capacity should be validated by column leach tests, and the calculation of ion adsorption isotherms for LAD soils.

5. **Vegetation Analysis**

   Collection of the following data is recommended in order to determine the potential of the vegetation for removing excess soil water by evapotranspiration, and attenuating dissolved metal concentrations by phytoremediation.

   a. a map of vegetation types, percent shoot cover, percent bare ground (including rocks)
   b. sensitive plant species
   c. noxious weeds
   d. tree density (number per hectare/acre), average tree girth, canopy height
   e. average rooting depth (from profile pits)

6. **Site Monitoring**

   Given all of the assumptions and generalizations that must be made in predicting how land application of an effluent will perform, it is critically important that site monitoring be implemented to insure that LAD is taking place as predicted.

   a. soil sampling before and after each LAD season
   b. water samples of the effluent – sampled daily, composited weekly
   c. flow being delivered to the LAD system
   d. piezometers[5] to measure soil saturation, both on and hydrologically below the site
   e. percolation samples collected from the piezometers
   f. rain gauges to measure daily precipitation

   A state-of-the-art LAD facility will incorporate automated response of the daily rainfall and lysimeter measurements to the daily flow being delivered to the LAD system. That is, if the daily rainfall, or the groundwater/saturation level as measured by the lysimeter exceeds the pre-determined level, then the delivery of effluent to the LAD system is reduced or shut off. Conversely, under extremely dry conditions, the amount of effluent being land applied may be increased.

References:

URS Greiner Woodward Clyde, Denver, CO, Luttrell Pit (Basin Creek Mine) Drainage Disposal by Land Application Final Feasibility Assessment for the Tenmile Creek Removal Assessment, Montana, December 1, 1999.

HydroSolutions, and Spectrum Engineering, Billings, MT, Proposed Landusky Land Application Area (LAD) Report, January 24, 2000.

[5] A piezometer is used to measure hydraulic head, the standing water level at a point in an aquifer. A piezometer is normally screened only at the very bottom of the hole, so the level that water rises in the piezometer represents head at that point.

Note: The term piezometer is often confused with lysimeter. A lysimeter is a device for measuring evapotranspiration. It is similar to a circular evaporation pan, which is filled with a known weight of soil and planted with vegetation generally representative of the surrounding area. The pan is balanced on a device for detailed weight measurement. If all inputs are properly weighed, including water, the weight change not accounted for was lost to evapotranspiration.