WATERSHED MANAGEMENT ON RECLAIMED LANDSCAPES[1]

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Traditional watershed management concepts can be applied to reclaimed landscapes. Satisfactory watershed conditions, as defined by the public land manager or private land owner, should be incorporated as watershed management objectives into post-reclamation land management plans. Opportunities may exist for improving the hydrologic function of reclaimed lands over that of undisturbed lands.

INTRODUCTION

Watershed protection is rarely found in reclamation plans as a post-mining land use. I believe it should be included in all reclamation plans--like boilerplate--and regarded as an equal to the other post-mining land uses. Water is the life-blood of the Great Plains and good watershed management then is the immune system. I do not mean to infer that the authors of SMCRA failed to account for watershed management concerns. The intent is definitely in the legislation--site stability, sediment control, restoration of hydrologic balance, etc. My concern, and the subject of this paper, is that watershed management objectives are often not given adequate attention in mine reclamation plans and, in fact, some surface mine reclamation regulations run counter to sensible watershed management.

I will discuss some trends observed in hydrologic variables on reclaimed mine sites. Then I will define the concept of watershed condition, as it is being applied by the major Federal land management agencies. That will provide a basis for discussing watershed management opportunities and objectives for surface-mined lands.

I will conclude by presenting some guidelines for managing reclaimed lands from a watershed management viewpoint.

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POST-RECLAMATION TRENDS IN HYDROLOGIC VARIABLES

SMCRA is now 10 years old. In theory we should have several years of hydrologic data at some sites reclaimed under the new regulations. Unfortunately, published results comparing the hydrologic character of reclaimed land with that of undisturbed areas are very scarce. However, I noticed a few papers in the hydrology session of this conference that looked quite promising on that subject. In a few more years we should be in a good position to discuss, for some mine sites anyway, measured trends in hydrologic variables.

So what I have to say on this topic is largely speculative, bolstered by a few of my field observations and what others have reported at professional meetings over the past couple of years.

We can expect some changes in minesoil physical properties over relatively short periods of time. Settling and particle redistribution begin immediately and bulk density is increased proportionately. Organic matter will increase in the rooting zone as the vegetation develops through several growing seasons, normal root die-off occurs, soil micro- and macro-organism activity increases, and mature plant communities evolve.

Infiltration is influenced by soil structure, surface bulk density, soil texture, and the type and amount of ground cover. Infiltration often increases on newly reclaimed sites in response to seedbed preparation and vegetation establishment. With bulk density increasing over time and the possible decrease in ground cover after fertilizer effects diminish, infiltration rates may decrease slightly on reclaimed sites. Percolation rates of

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the spoil material below the topsoil will be low initially if clay content or sodicity is high. Residual coal particles in the spoil may develop a water repellency characteristic (Scholl 1986).

Sandy or stony spoils usually have very low water-holding capacities. Minesoils are frequently lacking in their organic fraction. In those cases sewage sludge or other organic matter may be incorporated into the mine soil. As organic matter content increases over time, water-holding capacity likewise should increase.

Subtle changes in topography occur on reclaimed lands. Following reclamation the land surface is comparatively rough and provides considerable depression storage for water. Over time the rough micro-topography "melts down" and runoff potential increases. If runoff increases significantly, we would expect to see rills develop--a natural response since rill and gully development are related to runoff rate (Wallace and Lane, 1976).

Watershed cover, defined as the areal cover provided by plant basal parts, surface litter, and rock fragments, steadily increases from near zero for a recently seeded site to a maximum level three to five years later. Depending on site characteristics and fertilizer treatments, cover will either decline slightly or level off to some equilibrium point after reaching a peak. Actually, even on undisturbed sites cover is rarely constant from year to year, fluctuating around a mean value in response to climate and other environmental factors.

Surface erosion depends on the amount and type of ground cover and on the frequency of high-intensity rainfall and overland flow. Increases in runoff or substantial decreases in cover might also initiate rill development. Surface and rill erosion should not be a problem on reclaimed lands as long as the post-mining land uses do not significantly change ground cover or infiltration. Sediment delivery from a reclaimed mine is initially controlled by sediment retention ponds. Under most state regulations, these ponds will be removed and the site regraded to approximate original contour and then revegetated. Assuming that upstream sediment production remains approximately the same before and after pond removal, sediment delivery below the pond sites should increase when that sediment storage capacity is lost.

THE CONCEPT OF WATERSHED CONDITION

Watershed condition is the existing capability of a watershed in relation to its potential to maintain favorable conditions of water flow and soil stability and productivity. Favorable conditions of water flow include, for purposes of this discussion, both water quantity and quality.

Watershed condition is evaluated by determining the current status of four different components:

-soil stability and productivity
-sediment yield
-water quality
-water quantity (i. e. flow regime)

Soil stability is indexed by the rate of upland erosion (sheet and rill, wind, mass wasting, and gully sources). Sediment yield involves both on-site and off-site concerns. The water quality component refers to maintenance of water quality in compliance with applicable standards and in relation to any downstream uses of that water. Water quantity includes the consideration of flood peaks, low flows, streamflow volumes, and timing and duration of flow levels.

It is important to note that all the evaluation components can be measured and expressed quantitatively. Furthermore, each component is defined in terms of its existing, potential, or tolerance level. This concept is displayed schematically in figure 1. The area between tolerance (T) and potential (P) is considered to be satisfactory condition for that component. Anything below tolerance would be deemed unsatisfactory.

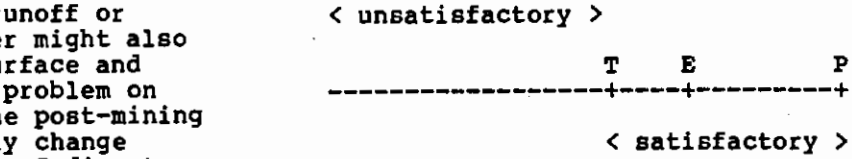

Figure 1.--A conceptual scale for watershed condition evaluation criteria. T=tolerance, E=existing, and P=potential.

Tolerance can be defined as either a resource tolerance threshold or as a management tolerance threshold (Solomon et al. 1982). The resource tolerance threshold is relatively fixed and depends on inherent watershed characteristics. Watershed conditions below that threshold would mean permanent resource damage.

Management thresholds, on the other hand, refer to variable threshold levels set by the land manager, in the case of public lands, in response to public concerns, legal or policy mandates, or land-use plans.

Management thresholds are actually specific management objectives and are set somewhere between the resource tolerance (a "worst-case" situation) threshold and the potential or optimum level for a selected watershed condition component.

Watershed condition becomes unacceptable if any one of the components falls below its tolerance level.

APPLICATION TO RECLAIMED LANDS

Tolerance thresholds or watershed management objectives can and have been set for surface-mined lands. Federal and state regulations, for example, have established standards for cover, sediment yield, and water quality. Normally, these standards must be met before reclamation bonds are released. But what happens after bond release? If watershed protection is a desired post-mining land use (either explicitly or implicitly), we must have watershed condition tolerances and watershed management objectives defined for the site after bond release. In short, as good land stewards we should be maintaining reclaimed lands in acceptable watershed condition well after the reclamation regulations have ceased to apply.

What is an acceptable watershed condition for reclaimed lands? Soil productivity, i. e. soil erosion rate, is a definite concern. Most state regulations require that ground cover be within 80 to 90% of the ground cover on a reference area. That requirement does not in itself guarantee an acceptable watershed condition from a soil productivity or watershed protection standpoint. Furthermore, if the relaimed land is used for livestock grazing, at what level should (or could) the watershed cover be maintained.

I would argue that we need to establish watershed protection requirements, in the form of tolerance thresholds for cover, on all reclaimed lands. Proper and reasonable watershed protection requirements are necessary for maintaining soil productivity and hydrologic function. In his classic paper on watershed protection criteria for wheatgrass and cheatgrass rangelands, Packer (1951) concluded that ground cover densities (plant basal area plus surface litter) of 70 percent were required to maintain overland flow and soil erosion at desirable levels. The Soil Conservation Service (USDA 1972) defines "good hydrologic condition" as greater than 70 percent and "fair hydrologic condition" as 30 to 70 percent cover, respectively. Maxwell et al. (1985) offer a technique for computing a threshold ground cover based on Horton's theories of overland flow and hydrologic stability.

Sediment yields from mined lands are monitored and controlled under state mine-permitting procedures. Sediment detention ponds are the usual method of trapping sediment on mine sites. However, some state regulations require that sediment ponds be removed and the area rehabilitated before final bond release. I would expect an increase in downstream sediment loads following the pond removal, depending on the site hydrology and sediment transport characteristics. Stream sediments are products of erosion from sheet, rill, or channel sources.

Establishment and maintenance of adequate ground cover will usually prevent or at least minimize sheet and rill erosion. Geomorphic stability and prevention of direct channel impacts are necessary to minimize channel erosion. The goal should not be to reduce sediment yields to zero, since sediment transport is a natural and necessary ecosystem process that facilitates nutrient transport. Furthermore, releases of relatively clear water can result in downstream channel instability (Wells and Potter 1986). Sediment yield tolerance thresholds, based on sediment yield characteristics of similar adjacent unmined watersheds and on management objectives, should be established for reclaimed lands.

Water quality standards for streams draining reclaimed lands should be the same as for similar but undisturbed streams in the same region. Federal, state, or local standards would then become the tolerance thresholds, unless the land manager decided to set a management threshold at a higher level (better water quality).

Quantity and timing of streamflows are influenced by surface mining and reclamation. Restoration back to the pre-disturbance flow duration, and high- and low-flow regimes may be impossible. However, through reclamation design, peak flows may be reduced and low flows increased over the pre-disturbance condition. The reclamation plan should reflect management objectives for the post-mine land use. With all due respect

for the hydrologic restoration requirement of SMCRA, perhaps flood peaks should be reduced or low flows increased as a result of the reclamation process. These objectives would then be continued, with tolerance levels established, as part of the post-reclamation land management.

OPPORTUNITIES FOR WATERSHED IMPROVEMENTS ON SURFACE-MINED LANDS

In the preceding discussion I alluded to improvements that could be made in the watershed stability and hydrologic function of mined and reclaimed lands. In many respects, SMCRA has limited us in terms of watershed management improvement opportunities. For example, under some state regulations permanent water impoundments may not be permitted. The law also requires (although this has been relaxed somewhat) a return to original topography.

Based on several decades of research and practical experience, we know how to manipulate the landscape and use structural measures to achieve peak flow reductions, low flow increases, and improve infiltration and detention storage in small watersheds (Van Haveren 1986). Surface mining in many respects affords an opportunity to reconstruct portions of watersheds for improved watershed condition or hydrologic function.

Reclamation regulations call for the establishment of a permanent and diverse vegetation cover. If site stabilization is to be an immediate objective of reclamation and watershed protection one of the post-mining land uses of any mine site, then plant species selection should be based in part on the watershed protection capabilities of vegetation. McKell et al. (1982) give the following watershed-related criteria for seed-mix species selection:

1. Favorable below-ground growth rate
2. Favorable growth rate of, and cover provided by, above-ground parts
3. Well-stratified rooting characteristics, including some species with taproots, some sod-forming species, some species with spreading root systems, and some rootsprouters

If infiltration initially decreases following reclamation, we should include in the reclamation plan measures to offset the resultant tendency towards increased surface runoff. Such measures might include a surface roughening treatment, such as gouging, pitting, or contour furrowing, to provide more depression storage.

Scholl (1986) reported greater wheatgrass production and soil water contents on plots treated with a combination of contour furrowing and organic amendments. Land imprinting also holds promise for providing depression storage and increasing effective precipitation on mined lands (Dixon 1982).

Terracing is used in mountain-top removal coal mines in Appalachia to break up long steep slopes. Terraces constructed in spoil at a bench-strip coal mine in Kentucky improved vegetation cover and reduced peak flows and sediment yields (Curtis 1971). Contour terracing on 10-percent shale badland slopes in New Mexico more than tripled plant cover and productivity as compared to adjacent natural plant communities (Ferraiuolo and Bokich 1982).

Incorporation of geomorphic principles in the reclamation plan would insure long-term watershed stability (Schaefer et al. 1979; Law 1984; Toy 1984). Rather than returning to original contour as a general rule, slopes could be regraded to optimum length and gradient for minimizing erodibility. Permanent sediment traps, in the form of topographic features, wetland-riparian areas, or lakes and ponds, should be considered in the preparation of the reclamation plan.

I firmly believe we need more flexibility in the regulations for creating a variety of "waterscapes" on surface-mined lands. Wetland and riparian ecosystems established on mined lands could provide new habitat niches for aquatic and terrestrial organisms and improve water quality by trapping sediment and other pollutants (Olson and Barker 1979). Both running and standing water bodies add diversity to the landscape and provide water supplies for wildlife and livestock.

FUTURE LAND-USE CONCERNS AND WATERSHED PROTECTION

Livestock management, wildlife management, road maintenance, and off-road vehicle use are the principal land-use concerns for reclaimed areas. Infiltration rates are known to decrease under heavy grazing pressure (Gifford and Hawkins 1978). Removal of plant cover and soil trampling result from heavy use by either livestock or wildlife. Ground cover must be maintained at or above the threshold level established in the watershed management objectives for a reclaimed area. Proper livestock distribution over an area can be facilitated by providing permanent water sources--especially impoundments, which can double as water or

sediment control structures. Wildlife populations may have to be artificially controlled if watershed conditions decline due to big-game overuse of an area or abnormally high small mammal populations.

Proper design and maintenance of permanent roads and regulation of off-road vehicle use on reclaimed lands will be necessary to maintain an acceptable watershed condition. Unpaved haul roads can be detrimental to water quality even in unmined watersheds (Woods et al. 1986).

IMPLICATIONS FOR RECLAMATION PLANNING

Proper land-use management does not stop at bond release. Management of reclaimed lands, although perhaps not as intensive as management during mining and reclamation, must be at least as accountable and continue to follow principles of good land stewardship. Watershed protection should be a "built-in" post-mining land use of all surface-mined lands.

Reclamation plans and objectives should recognize and take into account probable watershed responses following reclamation. State regulations should allow for flexibility in designing post-mine landscapes to insure watershed stability and optimum hydrologic response and should provide incentives for creating new aquatic ecosystems.

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