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2. Developing the Technology to Rehabilitate Cropland

This article will review the process that the mining industry went through to develop the technology to rehabilitate cropland after SMCRA was passed in 1977. Understanding the process is the key to addressing the challenges that the Australian mining industry faces in learning how to mine the cropland soils on the Darling Downs. The first step is to fully understand the soil physical and chemical properties involved. Integrating soil rehabilitation as an integral part of the mining and reclamation process is critical to finding cost effective solutions to the challenging soil issues.

Mining equipment – Draglines and in-pit stripping shovels have been replaced by more mobile equipment that can selectively load trucks. Draglines are still used to mine rock and interburden strata for deeper operations, but the soils for reclamation are exclusively handled by haulback equipment. When SMCRA was passed in 1977, mining engineers preferred the more cost-effective draglines to handle the entire overburden. Self-propelled scrapers were purchased to selectively move thin soil layers, but they turned out to cause more soil problems than they solved.

Driving on the soils to load, stockpile, and spread caused serious compaction that made it difficult for plant roots to reach through the profile to reach needed plant-available water. The shallow-rooted crops were drought sensitive and resulted in lower yields. Unmined farm fields had adequate plant-available water to survive between summer rains with little yield reduction, but compacted reclaimed soils would go into severe stress. Irrigation was not an option, so if stress from high heat and infrequent rains came during the pollination period for corn, the kernels would not set, and yield was drastically reduced.

Compaction had less effect on wheat, since moisture stress was generally not as much an issue during the winter and spring months. However, slow drainage due to compaction could cause standing water that would cause problems for all crops. Soybean production can be affected by reduced root depth due to compaction, but the plants can withstand more drought stress than corn. For this reason, corn must be one of the three test crops that meets the 100% target yield.

Large scrapers were gradually phased out as the primary equipment choice for moving soils, and shovel-truck fleets became the equipment of choice during the 1990's. Hydraulic excavators are extremely flexible for layer-loading soil horizons. Thin topsoil can be windrowed by dozers and located so that the excavator can load the trucks. Subsoil, loess, and lacustrine sediments can then be loaded for the rooting media blend for reclamation. The excavator and truck fleets can then mine the rock overburden down to the coal. The flexibility of the excavator and haulback equipment has become the standard for coal mining operations, both large and small.

Soil loading using hydraulic excavator

University Research – When SMCRA was passed in 1977, environmental groups did not trust the mining industry or the regulatory personnel to really restore 100% crop productivity. The mining industry was required to prove that they could do it—but we were not sure how to do it. Enter the university researchers. The mining industry set up a field research program with Dr. Ivan Jansen, University of Illinois, to develop replicated test plots built by the various mining techniques in both Southern and Western Illinois. Annual field days allowed all interested parties to see and compare crop yield data on the various rehabilitation options. Problems were documented and various solutions were evaluated as progress was made and the technology evolved.

Dr. Jansen saw mining as an opportunity to build a better soil in Southern Illinois, where the upland soil has a fragipan that is acid and root restrictive. The underlying loess has better agronomic properties, and Jansen felt that blending the acid B-horizon with the neutral loess would improve crop productivity. However, the first test plots failed to make yield, due to compaction from the tire traffic by the scrapers used to construct the plots. Once the problem was identified, the research went in two directions. The first task was to find equipment that could move soils without compaction, and the second was to find ways to loosen compaction in the entire 48-inch replaced profile for areas that had already been reclaimed.

Tillage Equipment – Conventional agricultural tillage equipment will loosen compaction to about 40 cm, with some subsoilers on large farm tractors extending to an effective depth of about 60 cm. No farmer had equipment that could effectively cultivate 120 cm deep. Mining dozers had rock rippers that could go 1.2 meters, but the straight shanks would pack the side walls of the slot and cause even more soil compaction. The only direction that the soil can go to alleviate compaction is up, and that requires a parabolic shank subsoiler with wide sweeps.

German TLG 12 Tiller – SMCRA required that the coal industry demonstrate that they could restore 100% crop productivity or stop mining prime farmland, so the industry had to find a solution to the compaction problem. The ultimate solution was to convert to trucks and avoid

German TLG 12 Tiller

the compaction, but thousands of acres had already been mined that had to be fixed in order to get bond release. Amax Coal purchased a Kaeble-Gmeinder TLG 12 from Germany in 1982 to loosen compaction in the deeper profile. The cut-lift action of the vibrating shanks did an effective job of eliminating compaction, but the shank length only allowed tillage to about 80 cm. The TLG 12 had many lower-shank hydraulic seals and moving parts that were high maintenance and expensive to repair, so it was not a practical solution to alleviate soil compaction. It bought time, though, until the industry could find a less complicated tillage tool to loosen compaction. The University of Illinois test plots showed that the TLG plots had higher crop yields, but still not the 100% goal needed to meet SMCRA.

DM 1 and DM 2 - In 1985, at a university winter meeting, I met Bill Dietrich, agricultural equipment designer from Goodfield, Illinois. When I explained our problem of wanting a tillage tool to loosen 1.2 meters of replaced soil, he said that he could design and build it. The DM 1 prototype had a single parabolic shank with a sweep point with wings. Pulled by a 450 HP CAT dozer, it would loosen the soil 1.2 meters deep for about half the width of the dozer. The DM2 was somewhat larger and stouter to deal with the challenges in reclaimed soil, and it did loosen the full depth of soil replacement. The DM 2 was used on several thousand acres of scraper placed soils to achieve full restoration of crop productivity.

DM2 Tiller loosens compaction 1.2 meters deep

DM 2 Tiller at work

In summary, the process that the American mining industry took in developing the technology to rehabilitate cropland was to define soil physical and chemical properties, select the best mining equipment to selectively load and replace the soil horizons on reclaimed areas, and apply good agronomic management to bring the soils into their full crop potential. Hydraulic excavators that can layer-load the soils and trucks that can selectively place the soils have replaced less precise mining equipment. Avoiding compaction by not driving on the replaced soils except to spread the topsoil is the goal. Conventional agricultural tillage equipment can then be used to loosen soil if the compaction is close to the final surface.