Strategic cropping land policy and discussion paper submission

Ambre Energy Limited

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Submission to the Queensland Government's *Strategic cropping land policy and planning framework* discussion paper

12 March 2010

Approach to this submission

Ambre Energy Limited is a Brisbane-based mining and technology company proposing a coal-to-liquids project on the Darling Downs.

The Queensland Government's release of the *Strategic cropping land policy and planning framework discussion paper* evidences a commitment to ensure the state's best cropping land is conserved and managed appropriately.

Ambre Energy supports land use planning decisions using transparent and scientifically-based criteria, and welcomes the opportunity to provide comment plus research on international experience with mining rehabilitation that will add further rigour to the discussion and decision-making process.

The Queensland Government is seeking responses to a number of questions and concepts in order to develop and implement a framework in this important area. This submission relates most directly to those issues which may impact on industrial and mining projects such as that being developed by Ambre Energy.

Discussion

Ambre Energy's proposed project is located 30km south west of Toowoomba and 10km south east of Pittsworth. It comprises a high-tech coal gasification facility for the production of liquid transportation fuels, and an adjoining open cut coal mine to provide the feed coal for the facility.

Over $9 million has been invested in project development to date, including $1 million spent in surrounding towns such as Pittsworth and Toowoomba, and our environmental studies are continuing. A $20 million bankable feasibility study is due to commence shortly.

Given that Ambre Energy's project site includes some land capable of cropping, the company would benefit from swift, yet considered action to establish a framework outlining clear standards for what constitutes strategic cropping land and what further constraints are to be imposed on industrial and resource development on such land. The company supports the integration of this framework into the existing appraisal mechanism – the Environmental Impact Statement (**EIS**).

The EIS process already imposes an intense (and increasing) level of scrutiny on large industrial and resource projects. This is appropriate given the potential impacts involved and the need to protect the environment. Just as importantly, the high value of these projects makes what is invariably an expensive EIS process an affordable safeguard against unacceptable impacts. Hence, the high cost of the process would not normally undermine the commercial viability of a large industrial or resource project or deter investment in such projects.

It is important to note that much of the appraisal and assessment work that would facilitate the controlled reinstatement of even our best cropping land is already required as part of the EIS process.

An enhanced focus on the productivity of the land and the opportunity for companies to demonstrate that they can avoid permanent alienation by fully reinstating the land to its previous productive capacity should provide a transparent means of addressing legitimate community concern over land use competition.

Ambre Energy believes that a policy framework providing certainty for the advancement of its project and similar projects is essential. This will ensure that the mining and petroleum industries continue to make an outstanding contribution to Queensland's prosperity, especially in regional areas.

While it is clear that recent demand for Queensland's mineral and gas resources has helped sustain regional economic development, particularly through times of drought, this does not detract from the fact that Queensland's agricultural sector has been the backbone of the state's development since its inception, and continues to be a source of food, employment and prosperity.

There is also no doubt that the agricultural sector has underpinned the social fabric of regional Queensland and, in common with the mining industry, has benefitted from technological advances and updated practices. It is Ambre Energy's view that these two pivotal industries can co-exist, and there is no need to miss out on the benefits of either.

Co-existence can be achieved through a policy framework that considers the important contribution made to our state by both industries.

While only 2.2 per cent of Queensland is currently utilised for crops, less than 0.1 per cent of the state is utilised by mining operations.

It is a worthwhile goal to ensure that mining is a short-term land use, by returning cropping land to productive capacity through effective rehabilitation, as has been done in some other parts of Australia and in other countries such as Germany and USA.

Australia has limited agricultural resources where both climate and soils are suitable for crop production. Ambre Energy is acutely aware of its social and environmental responsibility to avoid permanent alienation of these limited resources. As a demonstration of this awareness, representatives from Ambre Energy have investigated the rehabilitation of prime farmland first-hand in the NSW Hunter Valley and the US Midwest states of Illinois, Indiana and Kentucky.

In the 1970s, the USA faced a similar conflict between agriculture and mining to that which Queensland is experiencing today. The debate exposed similar arguments, with many involved in agriculture and environmental protection doubting the mining industry's claims that mined land could be successfully rehabilitated.

In some parts of the USA, mining companies have to demonstrate in permit applications similar to our EIS process that their mining method can restore 100% crop productivity in a reasonable amount of time. The industry there soon reached a point to support the old adage that “a person who says something can’t be done is often interrupted by someone already doing it”.

Experience shows that US federal and state legislation has proved successful in allowing both mining and agriculture to co-exist without permanent alienation of the land. However, this required the US coal industry to thoroughly 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.

As part of Ambre Energy’s submission, we offer a series of articles by US soil scientist and rehabilitation expert, Dr Dave Ralston. Dr Ralston is a foundation figure in this field. He is well respected for his contribution to the success of prime farmland rehabilitation in the US Midwest over the past 35 years.

Four articles have been developed for Ambre Energy and are attached to support and inform the Queensland Government’s policy development.

1. *Prime farmland rehabilitation in Illinois and Indiana* - The introduction of national legislation, the *Federal Surface Mining Control and Reclamation Act* (SMCRA) in 1977, has seen a change in mining equipment and technology which is enabling crop lands to be fully restored following mining. Today the agricultural resource is preserved for future food production while the energy resource is harvested to meet current energy needs.

2. *Developing the technology to rehabilitate cropland* – As a result of SMCRA, the American mining industry has invested in technology and education to ensure best practice for the mining and rehabilitation of cropland soils. Successful outcomes have involved defining soil physical and chemical properties, selecting the best mining equipment and applying good agronomic management to bring soils into their full crop potential.

3. *Soil characterization – physical and chemical properties* – For coal mining to be a short-term land use, the agricultural resource must be accurately defined prior to mining, i.e. the physical and chemical properties of the soil must be thoroughly understood. This article proposes a number of tests for Ambre Energy’s project area to support a post-mining land use plan.

4. *Post mining land management* - This article details how, with good conservation practices and agronomic management, mined soils can be brought back into crop production.

It must be clearly stated that Ambre Energy does not believe the successful rehabilitation of cropping land is easily achieved. Our research reinforces the understanding that our technologies and methods must be refined and precise for the duration of the project to ensure minimal impact on the environment. It highlights the importance of up-front planning and stringent governance to ensure that all aspects of rehabilitation are properly managed.

We are also aware that the transposition of experience from one geographical location to another will not automatically guarantee success. However, the challenges unique to each location have been overcome through painstaking work around soil characterisation, appropriate soil handling and storage, consideration of rainfall patterns, rehabilitation scheduling, and continued nurturing of cropping land back to productive capacity.

The lessons learned in the USA are valuable and can be applied to addressing the challenges Australian operators face in mining cropland soils.

In developing Queensland's response to competing land uses, the strategic cropping land policy should clearly define the precise location of the state's best cropping land. A broadstroke approach to land classification, leading to the sweeping exclusion of mining activity across entire regions, may lead to the unnecessary lock up of vast resource reserves.

An effective policy would assess projects on a case-by-case basis and take into account the proportion of cropping land considered 'strategic' as part of an overall proposed project footprint. One of the criteria for defining strategic cropping land should be the economic viability of the land, as influenced by factors such as scale. Ambre Energy is seeking clarity on whether a relatively small amount of cropping land within a larger project area would restrict the development of a high-value industrial project.

Making room for a case-by-case approach within a policy framework also avoids the problems associated with a "one size fits all" approach which is sometimes necessary in other industries where the cost and delays associated with an EIS process are not affordable. The agricultural sector itself has suffered from the inevitable shortcomings of a less flexible approach in activities such as land clearing.

Ambre Energy welcomes the opportunity to present a responsible environmental management plan that will address all environmental and community concerns.

Summary

Ambre Energy is seeking:

- land use planning decisions using transparent and scientifically-based criteria
- well-defined mapping of the areas to be classified 'strategic'
- consideration for each project on a case-by-case basis
- swift yet considered action to establish a policy framework and guidelines for development assessment
- the opportunity to address environmental concerns through an environmental management plan.

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Rehabilitation of agricultural land

Series of articles prepared for Ambre Energy Limited
March 2010

David S. Ralston, PhD, PSSc, CPAg/SSc

1. Prime farmland rehabilitation in Illinois and Indiana
2. Developing the technology to rehabilitate cropland
3. Soil characterization – physical and chemical properties
4. Post mining land management

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1. Prime Farmland Rehabilitation in Illinois and Indiana

Illinois coal basin contains abundant bituminous coal reserves that can be reached by surface mining operations around the rim of the basin (SW Indiana, W Kentucky, and southern and western Illinois) and by deep mining operations in central Illinois. Indiana and Illinois also contain loess, glacial, and lacustrine soils that are among the most productive cropland soils in America. This set up a major resource conflict between coal miners and farmers which came to a head in 1977.

Environmental and agricultural leaders proposed national legislation that would prohibit coal companies from mining on prime farmland until the mining companies could prove that crop production would be fully restored following mining. Since all Midwest surface mines contain some prime farmland, prohibiting mining would have shut down all surface mining operations and not allowed the critical time needed to develop the technology to move corn fields and to fully rehabilitate crop production.

Federal Surface Mining Control and Reclamation Act (SMCRA) was passed August 3, 1977. The law took effect in 1978 and was fully implemented by 1982. It allows mining of prime farmland, defined as USDA land capability class I and II, and includes most farm fields in crop production on slopes less than 6%. Mining companies have to demonstrate in their permit application that their mining method can restore 100% crop productivity in a reasonable amount of time.

The technology to move farm fields and fully restore crop productivity did not exist in 1977. Moving the soil was not the problem, but moving it so that crop productivity could be restored to pre-mining production levels was the challenge. The mining industry joined efforts with university and regulatory personnel to develop methods of moving and rehabilitating soils so that the coal mining would truly be a short-term land use. Harvesting the coal by surface mining would take land out of agricultural production for 5 to 10 years, but the ability to raise crops on the rehabilitated farm fields would be fully restored by the mining company. Bond posted by the coal company when the mining permit is issued is not released until crop production has been restored to the pre-mining yield capability.

When SMCRA was passed, many said that crop production could not be restored on the high-yielding soils of central Illinois, and there was little evidence to support the ability of the coal industry to rehabilitate crop fields. Compaction was quickly identified as the key soil issue. Where soil compaction could not be avoided, it would have to be mitigated by deep ripping with specialized equipment.

Since SMCRA was enacted, Illinois coal miners have met the crop standard on 23,000 acres of prime and high capability cropland. Indiana miners have met the standard on 24,383 acres of prime farmland cropland. Rehabilitated prime farmland looks so similar to unmined farm fields that many cannot tell which fields have been surface mined for coal recovery.

Key to cropland reclamation is good pre-mining characterization of the physical and chemical properties of the soil resources and identification of the most suitable soil horizons for use in rehabilitation. Topsoil is typically the best soil horizon to return to the surface, due to favorable seedbed physical and chemical properties, as well as the higher organic matter content. Subsoil is often not the second best horizon for use as rooting media. The B-horizon can be very acid and have undesirable fragic soil properties. Where loess is available in the profile beneath the subsoil, it is frequently the second best soil material. The hydraulic excavator operator can blend a more desirable soil by mixing the acid subsoil with the underlying neutral loess. The resulting soil mix provides a more favorable rooting media for the rehabilitated cropland fields.

<u>Equipment</u> – When SMCRA was passed in 1977, the coal industry did not have suitable mining equipment to selectively move and replace soil horizons. Draglines and stripping shovels could move large quantities of overburden at very low cost, but the equipment could not selectively load and place just the soil horizons. The one exception was the cross-pit bucketwheel excavator and belt system, but it, too, is no longer used because it was not flexible enough for most mining reserves.

The initial prime farmland reclamation was attempted using large scrapers that were available from equipment manufacturers when the law was passed. Twin-engine (CAT 637) scrapers are suitable for building roads, but they are certainly not good for rebuilding cropland fields. It quickly became obvious that tire traffic from the heavy scrapers caused the subsoil to be compacted, and the dense soil did not allow good root development. The resulting shallow-rooted corn was susceptible to drought stress during hot spells between rains, and the crop yields were reduced.

Compaction caused by twin-engine scrapers

Pan scrapers have reduced compaction issues

Conventional farm tillage equipment could loosen compaction in the top 40 cm, but the scraper-placed soils had severe compaction to 1.2 meters. Specialized deep tillage equipment was developed to loosen compaction to 1.2 meters so that the crop roots could explore the full depth of the replaced soil profile.

Mining equipment has changed since SMCRA was passed. Large draglines and stripping shovels no longer handle soils, and large scrapers are gone. Soil haulage is done by trucks and small pull-type scrapers. Hydraulic excavators selectively load trucks out of the soil bench on the highwall, with the loader operator telling the truck driver where to place each load. Pre-mining topsoil is often windrowed and loaded for placement into storage piles or direct placement on replaced rooting media. Subsoil and loess to a depth of 3 meters are loaded by the excavator for placement as rooting media on the graded rocky spoil. Keeping truck traffic on rocky spoil and dumping the full thickness of subsoil avoids compaction, so full thickness tillage equipment is not needed.

The interface between the replaced topsoil and rooting media can be reached by conventional agricultural tillage equipment to loosen compaction. The ideal slope for rehabilitated cropland is 1 to 4 percent. Some slope is needed to work out micro-settling issues that appear due to spoil settling in the first few years following reclamation. Contour terraces are needed as the slope increases to reduce the slope length and to help control erosion on the farm fields.

The coal mining industry supported research by U. of Illinois agronomists to identify key issues with initial efforts to reclaim cropland. When miners converted to haul-back equipment that could selectively place the best soil horizons with minimal compaction, the rehabilitation of prime farmland became routine. The old adage that “a person who says something can’t be done is often interrupted by someone already doing it” applies. The coal industry went through a process to define the key issues and then changed material handling methods to avoid problems and achieve the goals set out by SMCRA. Coal mining in the United States is truly a short-term land use, generally less than 10 years out of crop production. The agricultural resource is preserved for use in food production for future generations while the energy resource is harvested to meet our current energy needs.

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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.

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3. Soil Characterization – Physical and chemical properties

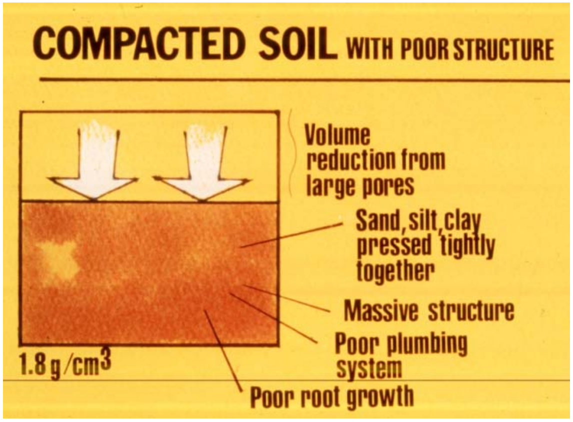
The first step in any resource evaluation is to accurately define the physical and chemical properties of the resource. For the soil resources overlying coal reserves, the process starts with preparing an accurate soils map for the reserve on which soil sampling and analysis can be based. Then samples need to be obtained to the depth of the potential borrow in such a way that combinations of horizons can be evaluated for agronomic suitability. Both favorable and unsuitable physical and chemical properties need to be documented for representative soil profiles within the area to be mined.

For our Illinois and Indiana coal mines, the USDA Natural Resources Conservation Service (NRCS) had already generated accurate soils maps on an aerial photo base prior to passage of SMCRA in 1977. The county soil survey maps provide a good basis for field sampling and coal mine permitting. Overlaying the soils onto the proposed mining plan allows accurate evaluation of what soils will be affected vs. those that are in support areas outside the mining plan. Typical crop target yields are available from the NRCS for each soil mapping unit. Weighted average of the target crop yields can be calculated for each permit so that the permit target yield for each crop is determined prior to mining.

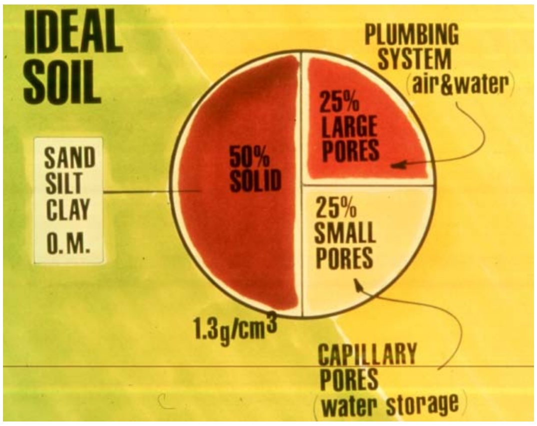
The mining permit application must take into consideration both the positive and the negative features of the existing soil resource. Physical features are somewhat easier to manage than are the chemical characteristics. Color is often used by equipment operators to segregate soil horizons, as a feature that can be identified from a distance is much easier to segregate and manage. Unless chemical features change the color of a horizon, segregating the layer can be difficult for the excavator operator. Technology is available to layer strip using the GPS-guided controls on a dozer or loader, but the task is easier if the soil horizon has a distinguishing feature that the operator can use when selectively loading trucks.

Physical properties – Soil texture is a key physical property, since the texture does not change when the soil is moved. Soils developed in loess, lacustrine, and glacial till in Illinois and Indiana generally have silt loam, silty clay loam, and clay loam textures. Silt loam is the most favorable texture, especially for topsoil replacement, since silt loam has a good balance of sand, silt, and clay needed for seedling establishment and for supplying plant-available water. Clay contents for upland soils generally range from 25 to 35%, and for lacustrine and glacial soils from 25 to 50%. In general, clay contents for Midwestern soils are lower than those found in soils on the Darling Downs.

Soil Structure – Unlike soil texture, which is easy to quantify in the laboratory, soil structure is challenging to evaluate. Structure describes the way the sand, silt, and clay particles are arranged to form soil peds. Structure is also the arrangement of the peds that form the plumbing system for air and water movement in the soil profile. Compaction occurs when the peds are pushed tightly together, eliminating the macropores that are essential for air and water movement. When soil structure is compacted, roots cannot reach the depths needed for obtaining adequate water to survive dry spells, and the resulting stress reduces crop yields.



Properties of compacted soil



Properties of ideal soil

Moving soils can have a drastic negative impact on soil structure. Soil compaction from equipment traffic is the leading cause of reduced crop yields for reconstructed mine soils. The goal should be to minimize traffic for reconstructed soils, especially for subsoil or rooting media at depths that cannot easily be cultivated. Single lift dumping of rooting media from trucks that drive on graded rocky spoil has worked best for Midwest mining operations. The only traffic on the rooting media is for topsoil replacement, and it can be replaced in triple-thick windrows and pushed both directions to spread using low ground-pressure dozers. Stockpiling of topsoil and subsoil is necessary when a mining pit is being opened or when providing soils for reclaiming the final cut, but the goal should be to haul and direct place as much of the soil as possible.

Chemical properties – Characterization of soil chemical properties provides the data necessary to evaluate suitability of horizons for use in reconstructing the mine soils. Nutrient deficiencies are far easier to manage than are the excess levels of elements that can adversely affect plant growth. Lime and fertilizer can be added to compensate for depleted nutrient levels in reclaimed soils, but it is not practical to remove toxic elements in reconstructed soils if they restrict root development. Alluvial terrace soils can have increases in saline or sodic levels with depth, so soil analysis should be used to identify the maximum depth of borrow so the elements do not cause chemical problems for plants. Defining these layers is necessary to establish the suitability of the soils for use in reconstructing the soil profile on reclaimed areas.

Graham Tuck, Soil Scientist with GT Environmental Services, prepared the initial Felton soil resources report, entitled “Proposed Felton Project Areas Soil and Land Suitability” for Ambre Energy Pty. Ltd. (February 2009). The field survey procedure followed guidelines proposed by Queensland Department of Mines and Energy (DME) in 1995 that are regarded as the established standard for soil survey in Queensland. The Felton project soils were mapped at an approximate scale of 1:15,000, and one observation site was made at approximately every six hectares. In total, 107 sites were described over 711 hectares. Sites were described and sampled from both hand auger borings and backhoe excavations.

DME (1995) recommends that analysis by NATA-approved facilities be undertaken for key profile horizons of soils deemed representative of major soil mapping units. Tests should include:

- Electrical conductivity, pH, and chloride (all samples),
- Exchangeable cations, particle size, NPK (surface horizons only),
- Micronutrients, Al, Fe, Avail. N, Org. C, Rep. K (surface only), and
- Heavy metals if toxicity is suspected

Soil physical and chemical properties should be evaluated to the full depth of potential suitable borrow material. Supplemental rooting media sources need to be evaluated to identify all sources of borrow soil for use in rehabilitation. Unless sources of supplemental rooting media and topsoil are located during the soils investigation, all soils will need to be recovered and stockpiled to ensure adequate soils are available to meet the requirements of the post-mining land use plan.

Soil stockpiles are grass-covered to avoid erosion

In addition to physical and chemical analysis of soil horizons to determine suitability for borrow, the land suitability assessment for cropping and grazing should be made for the mining reserve per the DME (1995) Environmental Technical Guidelines for Mining in Queensland. A five-class system is used to assess pre-mining land suitability that ranges from Class 1(high quality land with few or very minor limitations) to Class 5 (unsuitable due to extreme limitations). The main limiting factors which determine crop and grazing suitability class are plant-available moisture (m), nutrient deficiency (n), soil physical factors (p), erosion susceptibility (e), workability (k), and susceptibility to flooding (f). The land suitability provides an overview of the limiting factors for cropping and grazing on which the post-mining land use plan can be based.

For coal mining to be a short-term land use, the agricultural resource must be accurately defined prior to mining. The soil physical and chemical properties are the key to identifying both the favorable and unsuitable horizons to provide criteria that can be used by equipment operators to selectively reconstruct the soil resource following coal removal. Agricultural limitations such as erosion susceptibility due to steep slope can be improved by creating a landscape that has terrace benched fields with reduced slope. The goal is to design a post-mining plan that can restore the capability of the soils for future farming operations.

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4. Post Mining Land Management

Rehabilitated cropland fields require careful management during the initial years following reconstruction. Mining companies in the US have a minimum five year responsibility period for prime farmland reclamation. The management period starts when the first crop is planted, and the bond can be released after five years if the required target yields have been demonstrated.

The initial crop planted on rehabilitated soils is typically small grain, such as wheat, rye, or millet, depending on the season when topsoil is replaced. Contour terrace berms with down drains are usually installed when the soil is being placed to reduce slope length and to help control erosion during the early years when the mine soil structure is redeveloping. Mulch may be needed on steeper slopes to provide early protection to the young seedlings and to help protect topsoil from erosion. The goal is to get vegetative cover as soon as possible to stabilize the topsoil.

Reclaimed farm fields can have uneven settling that will occur over time. This settling can cause depressions that will pond water and require additional grading. Cropland fields are typically reclaimed in the 1 to 4 percent range to allow for easier grading to correct for uneven spoil settling. These gentle slopes can be managed with minimal land leveling and can be deep tilled or ripped without serious erosion problems.

Organic matter additions – One of the most effective management tools available to the reclamation agronomist is animal manure. It provides both plant nutrients and organic matter essential for biological activity in the developing soils. Reclaimed farm fields that have received poultry manure recover faster from the shock of reconstruction and have better crop yields when compared with farm fields that do not receive manure. Large quantities of manure are needed and availability can be an issue, but manure is a valuable resource when applied to the mine soils.

Conservation practices – Drainage control structures are needed to manage erosion on longer slopes. Steeper slopes may require terraces or berm structures to be installed to stabilize the soil. Mine soils tend to be highly erodibile and will benefit from a cover crop of legumes and grasses.

Cover crops are an important management tool to reduce the erosion potential. Managing an area as a hay field for several years will build organic matter and reduce soil erodibility. Conservation tillage should be implemented on reclaimed farm fields. A residue ground cover of 30 to 70 percent is needed to provide maximum protection against wind and water erosion. Minimum or reduced tillage operations should be used to reduce exposure of rehabilitated soils to erosion and to enhance infiltration and movement of water into the soil.

Residue management is important year-round as part of a conservation system to support reduced erosion, maintain tilth, conserve soil moisture, and reduce off-site transport of sediment and nutrients.

Compaction – Rehabilitated mine soils are subject to mechanical re-compaction, so equipment usage should be minimized. Tillage operations should be done when the soil is dry. Working the soils when wet is not recommended as this can increase compaction problems. Deep-rooted legumes can be used to help dry subsoils so that deep tillage can be more effective in loosening compaction. Caution should be taken when using ripping, because when a field is deep tilled it may act as a sponge down to the depth of the ripper.

Plant-available water – Rehabilitated soils are more sensitive to drought stress than unmined soil. Newly reclaimed farm fields do not have the plumbing system of macorpores that allow plant roots to easily explore the full depth of the rootzone. The reduced volume of soil available for water removal causes plants to be more stressed during dry periods. Tillage and natural cycles of shrink-swell can, with time, enhance the soil volume explored by plant roots and improve the amount of water available to the crops. Timely rains during the growing season are helpful for maximum crop production. Increasing the effectiveness of precipitation can be improved by the proper use and application of conservation practices.

Conservation Tillage – During the first few years, most fields require some tillage and grading to account for land settling and rill erosion. After the field is in normal production, conservation tillage practices are an option. Since water management is the key to crop production on rehabilitated mine soils, any farm practice that encourages water conservation in the soil profile should be considered. Conservation tillage practices, such as mulch till, ridge till, no-till , or strip till systems all encourage moisture conservation in the profile. Managing the amount, orientation, and distribution of crop residue on soil surface year-round can conserve moisture needed for crop production.

Contouring – Planting and tilling performed on the contour of the farm field slope can reduce erosion, reduce transport of sediment, and increase infiltration of moisture. Contour tillage is most effective on slopes between 2 and 10 percent.

Terracing – Contour earth embankments and channels constructed across a field slope are a management practice that can reduce soil erosion and conserve moisture. The key to installing and managing contour berms is to provide a stable down slope outlet channel or pipe that can safely move the water to the base of the slope.

Water and Sediment Control Basin (WASCOB) with an inlet pipe above an earthen berm can be utilized to safely take the water down the slope in a pipe. Management of down drains is important following storms to quickly clear any inlet blockage or to repair any berm damage. WASCOBs are used to control erosion in small drainage channels, whereas terraces are used to control water flow on long slopes.

Grassed Waterway – A constructed channel established with suitable vegetation can be used to safely move water down a slope without causing erosion, flooding or ponding. Vegetative filter strips can also be used to reduce suspended solids moving into streams.

Crop Management – Crop selection and management can reduce the effects of moisture stress through hybrid selection and through crop rotation. Corn hybrids on reclaimed soils tend to pollinate later in the season than on undisturbed soils. Soybean hybrids with a longer fill season can help productivity. Using hybrids that are productive over a wide range of conditions and are able to cope with droughty conditions is best. Soybeans are more tolerant than corn of a variety of moisture conditions. Plant populations are often reduced slightly compared to non-mined land. Also, timing of planting is more critical, since favorable windows can be shorter on reclaimed soils.

Rehabilitated mined land in southern Illinois

Consider using crops that produce lots of vegetation and litter. Adding more organic matter to the soil will benefit production, as well as benefit the populations of soil fauna and flora. As stated above, additions of animal manure are beneficial to mine soils both for their nutrient content and for stimulation of the microbial populations that are important for good plant vigor.

Corn grown on rehabilitated farmland near Farmersburg, Indiana

Crop rotations should be planned to maximize productivity, but also to take into account the potential for higher erosion on the rehabilitated soils. Initial crops should be used to increase the organic matter and build soil structure. Root structure of the crops should be considered for their ability to enhance organic matter production and improve soil health and structure.

Soil Testing – Nutrient additions to mine soils should be based on soil testing results, just as for unmined soils. Foliar testing may be needed to evaluate the crop response to micronutrient balance. Consider foliar testing every three years or when a specific problem is noticed.

Management of mine soils is a challenge. Newly reconstructed soils are subject to erosion and can be droughty. Plants can struggle to extend their roots deep into the soil profile to obtain needed water. Biological communities are being re-established in the topsoil, especially if the soil has been stockpiled. However, with good conservation practices and agronomic management, the mine soils can be brought back into crop production so that harvesting the coal resource can be considered to be a short-term land use.