New York State Department of Environmental Conservation
Division of Mineral Resources

New York State Revegetation Procedures Manual

Surface Mining Reclamation

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Cover Photo:

Warm season grasses used to reclaim mined land in the Town of Newcomb, Essex County, New York.

NEW YORK STATE
REVEGETATION PROCEDURES MANUAL
For Surface Mining Reclamation

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NEW YORK REVEGETATION PROCEDURES MANUAL
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PART 1. INTRODUCTION

1.0 Scope and Purpose of Manual

This manual was compiled and written by Mined Land Reclamation Program staff to provide technical information to landowners, land-use planners, consultants and mine operators. We urge mine owners to use this manual as a resource in developing an environmentally and financially sound mine. While the manual presents a broad overview, please note that it is not a comprehensive document and should not necessarily be considered the final word. Reclamation of mines, especially large mines, is a complex multi-disciplinary undertaking that goes well beyond the scope of this guide. Trained professionals such as biologists, landscape architects, soil scientists, geologists and engineers can provide invaluable assistance in planning and completing a mining project. In addition, mining and reclamation are not static subjects, but disciplines that will continue to evolve and improve.

This manual does not include information on vegetation management, weed control, herbicide application, or remediation of hazardous spills or acid drainage. The manual does include brief references to physical conditioning of sites, grading, haulageways, drainage and erosion control structures, and disposition of materials. However, for more detailed information on these requirements see the NYS Department of Environmental Conservation (DEC) publication entitled, “Mined Land Reclamation Program - Applicants Guide”. Another DEC publication, “Technical Guidance for Creating Wetlands as Part of Reclamation Unconsolidated Surface Mining” provides assistance on creating useful long-term wetlands as part of the reclamation process.

2.0 Essential Background

The mining of sand and gravel for construction materials is the most prevalent type of surface mining operation in New York State. Sand and gravel pits have often been abandoned with little or no reclamation, particularly areas mined before the advent of the Mined Land Reclamation Law (MLRL) which was enacted in 1975 and later amended in 1991.

Unconsolidated surface mining operations usually require the removal of vegetative cover combined with the stripping of topsoil, overburden and spoil materials. These activities, along with construction of access roads, usually result in severe disturbance or complete destruction of soil structure, landscapes and vegetation. Without proper management and regulation, additional adverse impacts may include loss of topsoil and plant cover, changes in the quality and quantity of surface water and groundwater, and decline of wetland habitat.

There are over 2,000 regulated sand and gravel mines in New York State.

Reclamation of lands affected by mining is a mandatory component of the New York State Mined Land Reclamation Law. Reclamation is the process of conditioning affected lands to make them suitable for a productive use upon completion of mining. Proper reclamation ensures that: 1) equivalent or improved land capability is restored, 2) affected land is contoured, reconditioned and stabilized, 3) excavation equipment and buildings are removed, and 4) all the requirements specified in the regulations are met.

The Mined Land Reclamation Law only applies to mines as described in the box at the right. However, the Division of Mineral Resources strongly encourages operators of all mines, regardless of their regulatory status, to use information in this manual to help them reclaim their mine sites, maintain compliance with other DEC regulatory programs (Water, Wetlands, Solid Waste, etc.) and improve their standing with the surrounding community.

The following mines are subject to the requirements of the Mined Land Reclamation Law.

- **More than 1,000 tons or 750 cubic yards of minerals excavated in 12 consecutive months.**
- **More than 100 cubic yd. of minerals excavated in or adjacent to any body of water not classified as "protected" by Article 15 of the ECL.**

Lands affected by mining before 1975 and not re-affected by later mining are not subject to the Mined Land Reclamation Law.

3.0 Timing of Reclamation

The timing of reclamation is a very important issue. The MLRL requires that all reclamation must be completed within a two-year period after mining has terminated at the site. In the past operators often failed to initiate reclamation until all the site's mineral resources were exhausted. This has been particularly true for small-scale operations (less than ten acres).

Although concurrent reclamation is not mandated, the MLRL clearly states that it should be done where possible. The Division of Mineral Resources strongly promotes concurrent reclamation, particularly for larger mines (greater than ten acres). Throughout the entire life of the mine, operators should continuously refer to their approved mining and reclamation plans to minimize affected land and maximize the amount of land concurrently reclaimed. Reclamation of a mined-out area should start as soon as operations move to a new section of the mine.

Concurrent reclamation is almost always economically feasible and has a number of advantages. Chief among these are the reduced potential for negative environmental impacts (dust, erosion, sedimentation), and the improved standing of the mine in the eyes of the surrounding community.

Concurrent reclamation is a great public relations tool!

4.0 Reclamation Choices and Community Acceptance

Landowners and mine operators have the flexibility to select reclamation objectives from a wide variety of final land uses such as: farming, pasture, forestry, recreation, industrial, commercial or residential use. However, some potential final land uses may be limited or precluded by the mine's geographic location, physiographic conditions and climate. Future land-use choices should also be compatible with local land-use requirements. Many mining operations are located in rural settings and reclamation objectives should be compatible with the surrounding countryside. However, as urban sprawl continues to extend outward, mining operations and residential communities must find ways to coexist.

Community Consultation

The mined land-use plan should attempt to describe how the proposed reclamation land use(s) relate to county and local plan(s) and zoning ordinance(s).

Community acceptance of a new mining operation plays a critical role in its success or failure. It is vitally important for the mine sponsor to seek public input, especially during the early stages of planning. Carefully planned mining and reclamation activities may make the proposed mining activity more acceptable. These efforts may include final land-use proposals beneficial to the surrounding community, such as recreation and open space lands donated to the community or held under a conservation land trust agreement. A project sponsor's ability to improve public relations and provide a measure of confidence that reclamation will start as soon as practical will help move the permitting process forward without major delays.

5.0 DEC Assistance with Reclamation Plans

An applicant for a Mined Land Reclamation Permit must submit a mined land-use plan which includes the applicant's reclamation plan. Reclamation plans can either be simple, involving a single final land use or complex, combining several final land-use objectives. More diverse and integrated land-use plans are usually more culturally acceptable and environmentally beneficial.

Regional Mined Land Reclamation Specialists can provide planning assistance during pre-application meetings. These meetings are optional, but highly recommended. In addition, staff from other NYS DEC divisions can often provide guidance and/or information on more complex reclamation objectives. DEC staff can assist in providing answers about forestry practices, water pollution control standards, fisheries and wildlife habitat improvements and other programs.

Table 1 lists addresses for other helpful information that can be found at the Division of Mineral Resources' website.

Table 1 - DEC Division of Mineral Resources Web Information
Regional Offices - Contact information for the Division's regional offices and the counties they cover can be found at http://www.dec.state.ny.us/website/dmn/divorg.htm
Law - The New York State Mined Land Reclamation Law can be found at http://www.dec.state.ny.us/website/dmn/mlrl.htm
Regulations - New York State Rules and Regulations on mining and mined land reclamation are available at http://www.dec.state.ny.us/website/dmn/minereg.htm
Technical Guidance - Technical Guidance on the regulation's mine setback requirements is found at http://www.dec.state.ny.us/website/dmn/tgmn961.htm
Forms - Forms for mining permit applications, permit renewals and modifications can be downloaded from http://www.dec.state.ny.us/website/dmn/mineform.htm
Wetlands Creation - The DEC publication "Technical Guidance for Creating Wetlands as Part of Unconsolidated Surface Mining Reclamation"is at http://www.dec.state.ny.us/website/dmn/wetland.pdf

6.0 Other Useful Sources of Information

This manual is the culmination of a multi-year effort by a wide range of DEC Mined Land staff to provide assistance to mine operators and other parties interested in mine reclamation. In the course of researching this document, staff consulted numerous reference materials. The section on "References and Suggested Reading" that starts on page 55 lists dozens of paper-based references. In addition, staff did extensive website research. Appendix VI on page 89 lists a number of useful web sites where the reader can find additional information on topics covered in this manual.

7.0 Acknowledgments

Special thanks go to Mined Land Reclamation Specialists Dr. Peter Huang and Daniel Morris in the Division of Mineral Resources. Thanks also to Cornell for permission to use information on their Forages website and to staff at the both Cornell and the U.S. Department of Agriculture PLANTS database for research on specific topics.

PART II. MINED LAND RECLAMATION LAW AND REGULATORY REQUIREMENTS

> ***"To foster and encourage the development of an economically sound and stable mining industry, and the orderly development of domestic mineral resources and reserves necessary to assure satisfaction of economic needs compatible with sound environmental management practices."***
>
> **— State Policy in MLRL §23-2703**

The MLRL requires mining operators to reclaim all lands affected by mining to make them suitable for productive use including, but not limited to, the planting of grass, trees, or crops, and the protection of wildlife or aquatic resources. All mining operations must comply with the requirements in 6NYCRR Part 420-425. The following section provides introductory information on basic reclamation requirements.

1.0 Basic Reclamation Requirements

Reclamation is the process or processes of conditioning affected lands to make them suitable for a productive use upon completion of mining. Affected land means the sum of that surface area of land or land under water which has been disturbed by mining since April 1, 1975, and has not been reclaimed, and land which is to be disturbed by mining during the term of the permit to mine. In order to prepare the affected land to a condition which is either similar to and compatible with that which existed prior to mining, or to a condition which encourages future productive use, operators of mining facilities in New York State must meet certain minimum requirements for mined land reclamation in accordance with the Mined Land Reclamation Law and its attendant regulations. Basic reclamation requirements include:

- Grading and slope treatment,
- Disposal of refuse or spoil,
- Drainage and erosion control, and
- Revegetation.

1.1 Grading and Slope Treatment

All mine faces and openings must be graded and contoured to blend in with the natural contours of the adjacent land. The objectives are two fold: 1) to minimize the possibility of rock falls, slope failure and collapse, and 2) to prepare the site for the post-mining land use described in the approved mined land-use plan. The maximum slopes for grading are based on both the type of surface material and the intended land use. Slopes may be measured in degrees, proportional slope ratio form (horizontal to vertical) or gradient (percent). To convert information from one type of slope measurement to another, see Appendix I (page 60).

All Grading - The following applies to all grading done at the mine site:

- Grading should not be conducted when soil moisture content is high.
- Graded slopes should be blended into adjacent areas to prevent shelves or steep troughs.
- Topsoil should be graded using a cleat track equipped machine to increase surface roughness which improves both soil moisture retention and seed retention during storm events.
- Revegetation applications including fertilization, liming, seeding and mulching should be completed within 48 hours of the final grading.

Mine-Floor Grading Angles - The final mine floor surface should be graded to a slope of 1 to 5 percent in several directions to foster surface drainage.

Side-Slope Grading Angles - Final side-slope contours should be compatible with future land-use expectations as identified within the approved mined land-use plan, as well as blending in with the surrounding landscape. The maximum allowed angle for side-slopes depends both on the type of surface material and the final land use. Unless artificial slope stabilization methods are used, all ridges, peaks and slopes must be left no steeper than the maximum slopes listed in Table 2.

Table 2 - Maximum Slopes Based on Surface Material*

	Gradient (% Slope)	Degrees	Proportional Slope (Horiz. to Vert. Ratio)
Fine Sand, Silt and Clay	50%	26°	2 / 1 slope
Coarse Sand and Gravel	67%	33°	1.5 / 1 slope
Talus or Broken Rock	80%	37°	1.25 / 1 slope
Rock Ledge or Bedrock		90°	

* Unless artificial slope stabilization methods approved

If the site will be used for forage production or pasture, and occasional cultivation will be necessary, the maximum slope should not exceed 5:1 (20 percent gradient) to reduce erosion potential. Land for production of row crops should have a maximum slope of 10:1 (10 percent gradient) in order to avoid severe topsoil erosion, and to allow safe and efficient farm machine operation. See Table 3 for the range of percent slopes that are appropriate for different final land uses.

Table 3. Side-Slope Gradient Ranges for Various Potential Land Uses

Potential Land Uses	Gradient Range (% Slope)
Agriculture	
Row crops	2 - 10
Forage or pasture	2 - 20
Nursery	2 - 4
Forestry	
Tree farm	2 - 15
Woodland	2 - 50
Wildlife habitat	2 - 30
Open space	2 - 50
Recreation	
Golf course	2 - 15
Golf driving range	2 - 7
Camp site	2 - 20
Regional park	2 - 50
Industrial uses	2 - 4
Commercial uses	2 - 4
Residential uses	2 - 4

Sources:

Green, Jeffrey E. et al., *A User Guide To Pit And Quarry Reclamation in Alberta,* Alberta Land Conservation and Reclamation Council, Canada, 1992.

Schellie, Kenneth L., Editor, *Sand And Gravel Operations - A Transitional Land Use,* National Sand & Gravel Association, Silver Spring, MD, 1977.

Side-Slope Dividing and Blending - Side slopes steeper than a 3:1 slope (33 percent) should be divided on the contour by benches, terraces, or diversions to reduce concentrated overland flow rates and slope failure.[1]

Graded slopes should be blended into adjacent areas to prevent shelves or steep troughs. When blending slopes together to produce more natural contours, the procedure that produces the best long-term results is constructing toe and crest contours that meander instead of following a straight line. This technique, illustrated in Figure 1, produces optimal conditions when future development of the land consists of some form of public-private recreation facility or wildlife habitat refuge.

1 Figure 5B.26, Landgrading Details, *New York Guidelines for Urban Erosion and Sediment Control*, p. 5B.52, April 1997-Fourth Printing.

Figure 1.
Meandering Slopes vs. Rectilinear Slopes

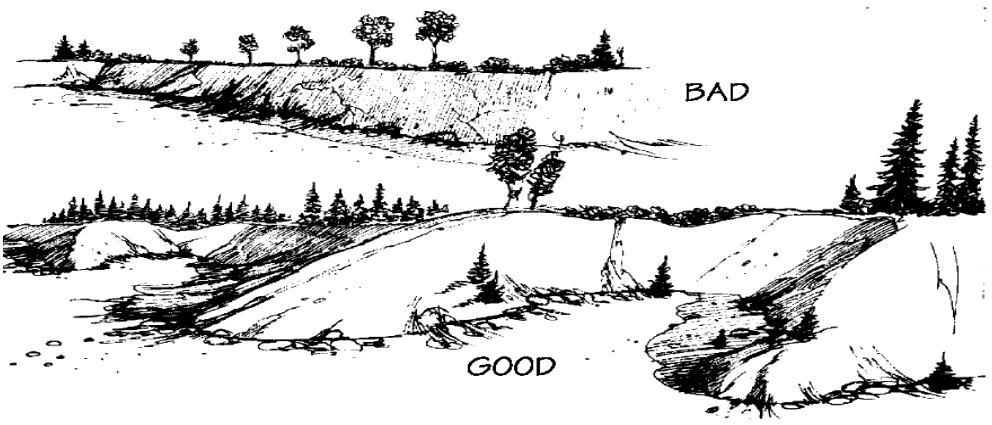

Illustration from: Norman, D. K., Wampler, P. J., Throop, A. H., Schnitzer, E. F., Roloff, J. M., December 1997, *Best Management Practices for Reclaiming Surface Mines in Washington and Oregon,* Washington Division of Geology and Earth Resources, Open File Report 96-2.

1.2 Disposition of Materials

All refuse, spoil, unused mineral stockpiles and personal property must either be removed from the permit area or utilized during reclamation of the affected land:

- Spoil and surplus mineral stockpiles may be used to blend areas of sharply contrasting slopes or to provide a cover material consistent with the approved reclamation plan.

- Large blocks of rock, boulders, or other similar materials used in landscaping must be covered to a minimum compacted depth of 2 feet.

- Trees, brush, stumps, or other vegetative material remaining on the affected land may be burned, reduced to a mulch, or covered to a minimum compacted depth of 2 feet.

- All machinery, equipment, tools, and other personal property must either be removed from the permit area or incorporated into the final use of the land.

Offsite disposal of these materials may be subject to the Department's Solid Waste Management regulations. Burning of the material on the permit area will only be allowed if a restricted burning permit has been obtained from the Department. Contact the Regional Division of Solid and Hazardous Materials and the Division of Air Resources for additional information.

1.3 Drainage and Erosion Control

All water discharged to surface water or groundwater must comply with the Department's standards for purity and quality. Water courses or impoundments must be provided to transport, store, or remove surface water runoff and to reduce the potential for flooding, erosion, siltation and pollution of the nearby streams and lands. If water discharge occurs, waterways or outlets must be constructed to control erosion resulting from concentrated runoff. For outlets constructed across soils or other unconsolidated materials, the sides and bottom of the waterway must be stabilized as soon as possible by seeding with grasses or other methods specified in the approved reclamation plan. Rock riprap, concrete, geosynthetic liners, geosynthetic filters, soil cement, or other material must be used where necessary to prevent erosion. Culverts or bridges must be installed where necessary to allow access across water control structures and prevent damage that would alter their design efficiency.

Water may be impounded for wildlife, recreation, water control, or water supply purposes. All water impoundments must be constructed in accordance with acceptable engineering practices and applicable government standards. The impoundments constructed during mining must either be incorporated into the final land use or be reclaimed.

1.4 Revegetation

Replanting of vegetation on the affected land is essential to restore surface stability, site productivity, and scenic values. Most importantly, establishment of vegetation cover reduces erosion by eliminating or slowing surface runoff. The MLRL requires that a vegetative cover must be provided on the affected land where vegetation is indigenous to the area and where revegetation is consistent with the land-use objective in the approved reclamation plan. The remainder of this manual, starting with Part III, is devoted to providing more details on the revegetation aspect of mine reclamation.

2.0 Concurrent Reclamation Requirements

The reclamation of all affected land must be completed in accordance with the schedule contained in the approved mined land-use plan to the maximum extent practicable. Where possible, reclamation should be scheduled concurrent with mining to minimize both reclamation costs and damage to topsoil from multiple handling. The schedule should provide details on the relative timing for each phase of reclamation. This assists the Department in its effort to monitor compliance of the various activities scheduled to take place. See Section 3.0 on page 8 for more details on the Department's concurrent reclamation policies.

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PART III. MINIMIZING MINING IMPACTS ON TOPSOIL AND LAND PRODUCTIVITY

> "***Any area designated for revegetation shall be covered with an amount and type of material sufficient to support the growth of the proposed plant material. A minimum of six inches of a cover material with a soil composition capable of sustaining plant growth shall be provided on all land to be revegetated. The amount of soil cover may be reduced if the applicant or permittee can demonstrate that a lesser amount will be sufficient to support the growth of the proposed plant material ... .***"
>
> **— 6NYCRR PART 422.3(d)(2)(vi)(a)**

The New York State Mined Land Reclamation Law requires that soils affected by mining must be reconstructed through replacing layers of soil material or unconsolidated geologic material, or both, in a vertical sequence of such quality and thickness that a favorable growth medium for revegetation is provided. This section of the manual discusses the adverse impacts of mining operations on some important soil properties that affect revegetation success and how to minimize these adverse impacts. This section does not directly apply to rock quarries.

1.0 Importance of Topsoil and Impacts from Mining

Unconsolidated surface mining usually requires the removal of vegetation, topsoil and overburden as well as the development of processing and loading facilities and service areas. These activities usually result in severe disturbance or even complete destruction of both landforms and soil structure at the mine site. While soil compaction and other changes to a soil's physical, chemical and biological characteristics may not be readily apparent, they can have dramatic impacts such as increased erosion, changes in water infiltration, reduced biological activity and reduced soil fertility. These mining phase impacts can all contribute to poor revegetation results. In addition, oversights during the reclamation phase can further decrease the chances of plant survival. Failure to replace adequate topsoil, as well as the practice of mixing topsoil with subsoil, are two of the most common reclamation factors that limit revegetation success.

Topsoil is generally considered to be the uppermost layer of the soil profile, where the bulk of the rooting zone is located. Compared to subsoil materials, healthy topsoil usually has a higher organic matter content, more nutrients, higher aggregate stability, lower bulk density and a more favorable pore size distribution. Topsoil also acts as a seedbank which is often an important source for revegetation with native species.

However, from a reclamation point of view, topsoil is a material that serves as a medium capable of sustaining plant growth without continued additions of soil amendments such as fertilizers. Thus, subsoil material may be included in the topsoil category. The terms topsoil, cover material, and growth medium will be used interchangeably in this manual.

2.0 Stripping Topsoil and Overburden

Topsoil is the very essence of revegetation; topsoil's availability and condition are the most critical elements in reclamation success. Topsoil must be carefully handled and replaced to ensure the establishment of successful vegetation.

Topsoil should be salvaged from all affected areas wherever practical and economically feasible. Mine operators should identify poor quality overburden and store and replace it separately. These efforts require careful planning. Before mining begins, the operator must provide details in the mined land-use plan on topsoil removal, storage of stripped topsoil, protection of the stockpile and the procedures for replacing the soil on the reclaimed site. The operator should investigate the topsoil layer to determine its profile, depth and basic texture to determine how deep to strip off the topsoil layer. Particular care must be taken in the Adirondack and Catskill Mountains where topsoil layers tend to be shallower.

When it comes time to reclaim and revegetate the mine site, a minimum of six inches of topsoil should be used to revegetate the affected land, or as a general rule, the depth of topsoil replaced should be the same as the topsoil depth prior to mining.

3.0 Soil Compaction and Other Soil-Handling Problems

The depth of soil with a favorable structure is often a good indicator of expected site productivity. Most soils that remain on-site at the end of mining have very poor structure. The structure affects the movement of water and air through the soil as well as the ability of growing plants to extend their roots. Soil structure is negatively affected by: 1) compaction associated with mine operations, and 2) grading, backfilling and other movement of surface materials.

Soil compaction is caused by vehicles, mining equipment, mining operations and even people and animals. Compacted layers are often found in the floor of a mine, but compaction can be an issue throughout a mine site. The problem can also occur during initial development of the site, mine operation or the reclamation stage.

Compacted soil has increased bulk density, decreased porosity, decreased aeration and decreased water infiltration. Infiltration is critical for plant and soil health. If water can't move into the soil quickly, then it will pond and run off, increasing soil erosion and leaving plants dry and dying. It is also very difficult for the roots of plant seedlings to penetrate into and extend through compacted soils.

Grading and backfilling activity can also have significant adverse effects on soil structure. Rock fragments and bridged voids are commonly found in the soils affected by mining due to improper disposal and backfilling. While leaving larger voids may improve soil aeration, it also reduces the soil's water holding capacity and interferes with moisture movement.

3.1 Prevention and Remediation of Soil-Handling Problems

While movement of soil is an inevitable part of almost any mining operation, steps can be taken both to prevent and remediate the associated problems. The following list applies throughout mine development, operation and reclamation:

- Avoid handling topsoil during wet conditions. This bears repeating - Avoid handling topsoil when it is wet!

- Minimize double-handling of topsoil whenever possible. For example, topsoil stripped from other areas should be used progressively for reclamation. Direct placement of topsoil also enhances vegetation establishment through the presence of viable native seeds in fresh topsoil.

- Select equipment to minimize its weight and try to minimize traffic over the site to the extent practical. For example, use of small excavating shovels in combination with end-dump trucks will result in less compaction of topsoil during stripping and stockpiling.

- Loosening or ripping the soil layers mechanically may improve the soil condition. Tillage is used primarily to decompact the soil and re-establish soil porosity, allowing plant roots to penetrate deeper into the soil. Ripping the overburden will create a rough surface and thus help to keep topsoil in place. Also, ripping allows downward percolation of absorbed surface water and deeper root penetration.

- Planting grasses and deep-rooted legumes, such as switchgrass and alfalfa, will also help alleviate compaction through the action of root penetration.

3.2 Stockpiling Topsoil: Specific Techniques

In addition to the basic soil handling techniques described above, the creation of topsoil stockpiles requires additional care to prevent problems at the reclamation stage. Stockpiling topsoil affects its physical, chemical and biological properties. Anaerobic conditions are created in the deeper portions of the stockpile. Decreases in microbial activity and mycorrhizal infection potential of stockpiled soil are also common. As a result, seeds may die as the stockpiled topsoil ages. To help prevent these problems:

- Build low-profile topsoil stockpiles (4 to 6 feet in depth) because they tend to maintain topsoil quality better than thicker piles.

- Protect topsoil stockpiles from wind and water erosion. Roughening the surface helps hold soil and seeds in place. Plant a conservation seed mixture on the stockpile that includes a cool season grass, a legume and annual rye.

Stockpiles should be identified with signs to protect them from waste disposal, construction, traffic or other such disturbances.

4.0 Managing Impacts on Soil Biological Activity

In addition to mineral particles, soil supports a diverse community of organisms, including ants, earthworms, snails, snakes and mice. Healthy soil also contains abundant microorganisms such as nematodes, algae, bacteria, fungi and yeasts. This broad range of animal life performs important environmental functions, particularly for vegetation. They range from the regulation of soil structure and water regimes to degradation of pollutants, nutrient cycling, and ecosystem purification. An undisturbed healthy topsoil layer naturally contains a network of hyphae or filamentous mycorrhizal fungi which perform symbiotic functions necessary for survival of most types of vegetation.

Surface mining operations degrade the physical condition of soil resulting in water deficiency and higher soil temperature. In turn, these changes dramatically impact the numbers and types of soil organisms and reduce the beneficial impacts they provide. Following the soil and stockpile handling techniques in Sections 3.1 and 3.2 will help reduce the loss of organisms and once the land is reclaimed, fauna diversity and numbers should improve. In addition, research has shown that when newly reconstructed soil profiles are inoculated with mycorrhizal fungus, favorable growing conditions are established more quickly. The benefits include improved plant nutrient recovery and increased plant resistance to drought.[2] For details on legume inoculation see Part V on page 45.

5.0 Managing Impacts on Soil Nutrients and Organic Matter

Plants require certain elements from the soil, such as nitrogen, phosphorus, potassium, sulfur, calcium, iron and magnesium, as well as an assortment of micronutrients. In turn, the organic content of soil influences its nutrient retention capacity, the infiltration and retention of water and other air and water relationships. At many surface mines, soils are low in both plant nutrients and organic matter. Therefore, before starting revegetation, it is important to investigate and determine whether soil amendments will be needed (example - fertilizer, lime, organic matter). Soil amendments generally have a beneficial reputation, but they are really double-edged swords that may be good in some cases, harmful in others. Lime is a perfect example.

Liming Soil - To quote a soil science textbook (Buckman and Brady[3]) from 1969 that is still held in high regard "The old idea respecting lime was that of a *cure-all* - that there was no harm in trying it; and perhaps it would be beneficial. Such an attitude should now be a thing of the past as it may lead to a waste of money" (cost of lime, cost of spreading, cost of seeds/plants, costs to replant). Unfortunately, there is ample evidence that this *old-fashioned* idea about liming has persisted to this day.

The addition of lime produces many complicated changes in the physical, chemical and biological nature of soil. The best known one is a reduction in soil acidity (higher pH), but this also indirectly

[2] Marx, D., L. F. Marrs & E. Cordell, *Establishment of Vegetation on Mine Sites by Management of Mycorrhizae*. Land &Water, September/October, 1998, pp. 13 -16.

[3] Buckman, H. and N. Brady, *The Nature and Property of Soils*, MacMillan Company, 1969, pp. 425-431.

affects plant uptake of nutrients, the toxicity of certain soil elements and the activity of important biological organisms in the soil. The most desirable pH range for the majority of grasses and legumes is between 6.5 - 7.5. Many shrubs and trees used in reclamation do well at those pH levels. When overliming occurs, even plants that would ordinarily respond favorably to lime are detrimentally affected instead. The danger of this occurring is especially high on sandy soils that are low in organic matter. Please note that this is a soil description that fits many (though not all) mine sites.

Once a decision to lime is made, the type of lime used is another important consideration. When comparing agricultural lime (ground limestone) to hydrated lime, there are differences to consider in the purchase and spreading costs, rate of reaction with the soil, persistence of treatment, and storage and handling needs (bag versus bulk). For soils that would also benefit from additional magnesium, a dolomitic limestone that contains magnesium can be a plus.

Some of the nutrients discussed above, such as calcium, magnesium, potassium and ammonium (nitrogen) are classified as cations because they are positively charged particles. The total level of cations that a soil is capable of reserving is known as its Cation Exchange Capacity (CEC). The CEC of a soil tends to increase with soil pH. Therefore, when a soil has a lower than desired pH, the addition of lime will also improve the CEC and nutrient availability to plant roots. CEC is also related to the soil particle size and distribution. In general, the larger the size of a soil particle, the weaker its attraction for cations and the lower its CEC.

Fertilizers - Use of fertilizers in surface mined land revegetation is not required as a general practice, but should be based on soil conditions and the revegetation goals for the mine site. Fertilizer is recommended for erosion control revegetation projects. The fertilizer is usually applied as a starter blended with the seed mixture. Subsequent application may be needed to maintain the vegetative cover. When a nutrient-poor organic amendment is used, fertilizer becomes necessary to provide sufficient available nitrogen for plant growth.

Nutrient-Rich Organic Amendments - Using nutrient-rich organic amendments is generally recommended. Such amendments include sewage sludge, urban refuse, dairy farm slurry, fish wastes, and manure. For many of these materials, composting before application helps to control detrimental side effects, such as the introduction of plant pathogens, weeds, or odors. The application of many of these amendments is regulated by The Division of Solid and Hazardous Waste. Before applying any nutrient-rich organic amendments, operators should consult with the Regional Mined Land Reclamation Specialist and 6NYCRR Part 360.

Nutrient-Poor Organic Amendments - Organic amendments with low nutrient content are available in all areas of the New York State. These include woodchips, saw dust, paper mill sludges, and some crop straws. Such organic amendments with high C:N (carbon to nitrogen) ratios can immobilize soil nitrogen as they decompose in soils. Therefore, nitrogen fertilizers, sewage sludge, manure, or other nutrient-rich materials are usually added at the same time to prevent nitrogen deficiency in plants.

Mulching

This section (Part III) of the manual has dealt with soil-related issues that must be addressed during pre-mine planning, mine operation and in preparation to reclaim the land surface. Mulching is another crucial step that directly relates to many of the soil protection goals in Part III. However, timewise it occurs at the end of the planting phase which is covered in Part V. **So to reduce duplication of text, the main section on mulching is in Part V on page 48** and just a summary list is provided below:

Mulching is Important to Topsoil and Land Productivity Because it Helps to:

- ✔ Conserve soil moisture
- ✔ Moderate soil temperature
- ✔ Prevent erosion
- ✔ Improve water infiltration
- ✔ Prevent soil compaction
- ✔ Rebuild organics in soil
- ✔ Improve nutrient retention